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A Milestone of Aeromedical Research Contributions to Civil Aviation Safety: The 1000th Report in the CARI/OAM Series

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16. Abstract

A historical, largely photographic retrospective is presented in recognition of the 1000th published report emanating from the FAA aeromedical research center officially established as the Civil Aeromedical Research Institute (CARI) in August 1960. The publications include 57 CARI reports (1961-1963), 1 CARI technical publication (1963), and 942 reports (1964-present) under the aegis of the (now) Office of Aerospace Medicine (OAM). The retrospective includes an historical section on the early development of civil aeromedical research. Additional, theme-related sections provide an indication of some of the varied research contributions and safety achievements of the Institute and cite some of the many individuals who contributed to the Institute's accomplishments.

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Finally, we acknowledge the dedication and accomplishments across the decades of the CARI/CAMI research teams…not all of them happen to be specifically cited herein…but all have promoted aviation safety for nearly half a century.

Further Information

All CARI/OAM reports may be accessed on the Internet at the following address:

http://www.faa.gov/library/reports/medical/oamtechreports/

A cumulative index of reports (by author, title, and subject) is published periodically as part of the OAM series. The most recent index, as of this date, is OAM report number DOT/FAA/AAM-05-1 (2005).

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Preface

A Milestone of Aeromedical Research Contributions to Civil Aviation Safety: *The 1000th Report in the CARI/OAM Series*

This is report #1000 in a series that began with the establishment of the (then) Civil Aeromedical Research Institute (CARI). It is a celebration of the (now) Office of Aerospace Medicine and its Civil Aerospace Medical Institute (CAMI) in its 45th year – its dedicated personnel, its research accomplishments, and its contributions to the Federal Aviation Administration's (FAA) safety mission. Like the other main components of the Institute – aerospace medical certification, education, and occupational health – the aerospace human factors and medical research divisions focus on the safety, health, and performance of the human element in the civil aviation system. That includes civil pilots of all types – private, airline, and other commercial – aircraft passengers, air traffic controllers, other FAA employees, and designated non-agency support personnel (e.g., aviation medical examiners). And the research includes assessments not just of human performance, but also of the personal and environmental conditions under which aviation-related work or outcomes occur so that unsafe outcomes can be avoided and desirable performance enhanced.

The incorporation of research on the human element within the Office of Aerospace Medicine (OAM) provides a venue that assures the FAA of a capability that will maintain a broad human focus. Within OAM, that focus is not territorially narrowed to the support of mainly internal medical issues but is broadened so that the agency has a resource to deal with the additional complex issues of how individuals and groups of humans perform and interact with equipment, environments, organizational structures, and other people, and how those interactions can be improved to enhance aviation safety and optimal performance.

And for those research issues that most directly affect OAM, incorporation of the research capability in the Institute with the other major medical responsibilities of the FAA aeromedical program allows the most direct of interactions and ease of communication and data sharing. It also facilitates interactive support, e.g., occupational health (in addition to providing clinic services to thousands of Aeronautical Center employees), provides medical monitoring of the altitude chamber, physical examinations of subjects when required, medical support for any untoward event, and is a significant research presence on CAMI's Institutional Review Board; the aeromedical education staff operates both the altitude and the environmental chambers and utilizes research data and innovations in their safety presentations and educational brochures. That co-location also stimulates research for – and from – the various medical specialty interests in aeromedical certification – whose physicians are also available for research and clinical support – while providing a structure for the most immediate application of medical findings. And the in-house nature of the vast majority of the research assures a strong cadre of scientific staff and thereby fosters knowledge, currency, and "bench" insights. It also permits the very rapid addressing of new, urgent problems as they arise. The reports that emanate from this paradigm meet the purpose of science – to document publicly the methodology, data, and conclusions of research and thereby permit scrutiny, evaluation, and replication. That process is designed to assure the transfer of accurate knowledge.

The first section of this report is an historical narrative that outlines the major milestones in the pre-CARI/CAMI history of civil aeromedical research. The remaining sections are primarily a visual celebration of the Institute, highlighting some of its many areas of research contributions and achievements and showing some of the many people who contributed to its productivity. In that spirit, some important achievements may be somewhat summarily noted (where obvious or documented in CARI/OAM reports) whereas for other contributions, not otherwise so documented, more detail may be provided. Thus, the main thrust is not a definitive history of CARI/CAMI research, per se, but rather a loosely historical presentation of selected accomplishments and unique individuals whose dedication – and sometimes prescience – made important and useful contributions to the agency, to aviation safety, and to the scientific community.

And the sum total of those contributions, and their application, is not limited to the published, documented report findings. The contributions also live in thousands of additional scientific presentations, journal publications, consultations, analyses, memoranda, conferences, training sessions, lectures, and presentations to agency officials, professional aviation groups, and the public. It is all of those venues, in addition to support provided to the National Transportation Safety Board, to military and space programs, and to national and international organizations seeking to improve aviation safety, that comprise the Institute's scientific enterprise. ❑

Civil Aviation Medical Administrators
From the Department of Commerce to the Civil Aeronautics Administration to the Federal Aviation Administration

Medical Director
Louis H. Bauer, M.D.
Nov 1926 – Nov 1930

Image Not Available

Medical Director
Harold J. Cooper, M.D.
Nov 1930 – Dec 1931

Medical Director
Raymond F. Longacre, M.D.
Dec 1931 – Aug 1933

Image Not Available

Medical Director
Roy E. Whitehead, M.D.
Nov 1933 – Jul 1937

Image Not Available

Medical Director
Eldridge S. Adams, M.D.
Jul 1937 – Jul 1940

Medical Director
William R. Stovall, M.D.
Apr 1941 – Jan 1958

Civil Air Surgeon
James L. Goddard, M.D.
Aug 1959 – Sep 1962

Federal Air Surgeon
M.S. White, M.D.
Aug 1963 – Sep 1965

Federal Air Surgeon
Peter V. Siegel, M.D.
Sep 1965 – Sep 1974

Federal Air Surgeon
Homer L. Reighard, M.D.
Mar 1975 – Sep 1984

Federal Air Surgeon
Frank H. Austin, M.D.
Oct 1984 – Feb 1987

Federal Air Surgeon
Robert R. McMeekin, M.D.
Sep 1987 – Dec 1990

Federal Air Surgeon
Jon L. Jordan, M.D.
Sep 1991 – Jan 2006

Acting Medical Directors
Eldridge S. Adams, M.D.
Aug 1933 – Nov 1933

William R. Stovall, M.D.
Aug 1940 – Apr 1941

Acting Civil Air Surgeons
John E. Smith, M.D.
Feb 1958 – Jul 1959

Hilliard D. Estes, M.D.
Sep 1962 – Mar 1963

Homer L. Reighard, M.D.
Mar 1963 – Aug 1963

Acting Federal Air Surgeons
Homer L. Reighard, M.D.
Oct 1974 – Mar 1975

Jon L. Jordan, M.D.
Mar 1987 – Aug 1987
Jan 1991 – Aug 1991

CARI/CAMI Directors

Hilliard D. Estes, M.D.
Jul 1960-Apr 1961

Stanley R. Mohler, M.D.
Aug 1961-Dec 1965

J. Robert Dille, M.D.
Dec 1965-Dec 1987

William E. Collins, Ph.D.
Aug 1989-Jan 2001

Melchor J. Antuñano, M.D.
Jan 2001-Present

Acting Directors

George T. Hauty, Ph.D.
Apr-Aug 1961

Audie W. Davis, M.D.
Jun-Oct 1987
Mar-Apr 1988

William E. Collins, Ph.D.
Nov 1987-Feb 1988
May 1988-Aug 1989

Support Systems... Are People
...Some of the More Recent...

A Brief Early History of Aeromedical Research In the FAA

The beginnings of aeromedical research in what is now the Federal Aviation Administration (FAA) are sometimes associated with the creation of the Civil Aeromedical Research Institute (CARI - later CAMI) at the (Mike Monroney) Aeronautical Center in Oklahoma City. That association reflects in part the relatively sudden emergence and size of the enterprise at that time, including the construction of a unique edifice, designed by researchers from various scientific fields, and built specifically for aeromedical research across multiple specialties. Indeed, the creation of CARI did signal a marked change in the FAA's aeromedical research programs — significant increases in scope, funding, personnel, visibility, and responsibility. However, the aeromedical office of the FAA had a long, tortuous, and tenuous prior history of attempting to establish aeromedical research. That history, culled extensively from the work of Heber A. Holbrook (29), is summarized below. Underlying all of the sporadic early attempts to make civil aeromedical research a reality is the fact that aeromedical directors were faced with a variety of difficult medical, political, funding, and priority issues through the decades. Those various elements, not addressed here, are presented in detail by Holbrook (29) and Lopez (35).

Aeromedical Beginnings

In 1926, Louis H. Bauer, M.D., was appointed the first medical director of aeronautics within the Aeronautics Branch of the U.S. Department of Commerce. That appointment in the Air Regulations Division followed the enactment of the 1926 Air Commerce Act, which defined the U.S. government's responsibilities regarding civil aviation. Dr. Bauer was succeeded by Harold J. Cooper, M.D., in 1930, by Raymond F. Longacre, M.D. in 1931, and by Roy E. Whitehead, M.D., in 1933. It was during Dr. Whitehead's tenure that the Aeronautical Branch became the Bureau of Aeronautics (1934) in the Department of Commerce and government sponsored medical research began in civil aviation. That beginning took the form of a research project on oxygen deprivation at flight altitudes up to 22,000 feet in a simulator at the U.S. National Bureau of Standards (NBS), conducted jointly by Dr. Whitehead and NBS scientist James C. Edgerton (29).

The First Aeromedical Research Facility

In 1937, Eldridge S. Adams, M.D., succeeded Dr. Whitehead as medical director of aeronautics, serving until 1940. During his term, the Bureau of Commerce formed a new Safety and Planning Division (1937) that included research and development responsibilities and hired Wade Hampton Miller, M.D., as the government's first civil aviation medical research director — a position independent of Dr. Adams.

In 1938 the Medical Science Station – the first federal aviation medical research facility — began operation in Kansas City, Missouri with a main focus on Dr. Miller's specialty interest – airline pilot fatigue — as well as the effects of hypoxia and "more applicable" physical standards for all civilian pilots. The facility included a Link trainer, equipment to support simulated altitude studies, and medical examination equipment. Also in 1938, Dr. Miller negotiated the first federal aviation medical research contracts with Harvard University (the Harvard Fatigue Laboratory), Dartmouth University, and the University of Pennsylvania (29).

A Short Life

However, a confluence of political issues led to the closing of the Medical Science Station in mid 1940. Part of that confluence was the creation of an independent Civil Aeronautics Authority (CAA) by the 1938 Civil Aeronautics Act, which, among a variety of other changes, split medical responsibility into research and operations, with separate reporting heads. That circumstance lasted until 1940 when the CAA was placed back into the Department of Commerce as the Civil Aeronautics Administration (still CAA) with medical services combined under one Director – William R. Stovall, M.D., who replaced Dr. Adams and held the position for the next 17 years. The medical section (within the Certificate and Inspection Division of the Bureau of Safety Regulation) was nominally elevated in 1941 to the status of an aviation medical division, still, however, reporting to the director of safety regulation who reported to the CAA Administrator (29).

The Way It Was. Into the 1960s, prior to tricycle landing gears and the resulting higher aircraft profiles, eme rgency escape procedures were rudimentary. Some airlines used ropes and one carrier used a Jacob's ladder. The "telescape" pole (like a fireman's pole, but collapsible for storage) was another approach initially explored. The first escape slides were sheet-like and had to be held by those on the ground.

A New Research Start

In early 1941, the CAA Standardization Center – a training site for CAA field inspectors – opened in Houston, Texas. Seeing it as the potential site of a future CAA medical center, Dr. Stovall modeled a plan similar to the short-lived Medical Science Station in Kansas City and referred to it as the Houston Medical Center. Although the proposed medical facility seemed to gain favor with the CAA Administrator, the outbreak of WWII resulted in the conversion of the Standardization Center into a training facility for army ferry command pilots and precluded expansion of the medical concept (29).

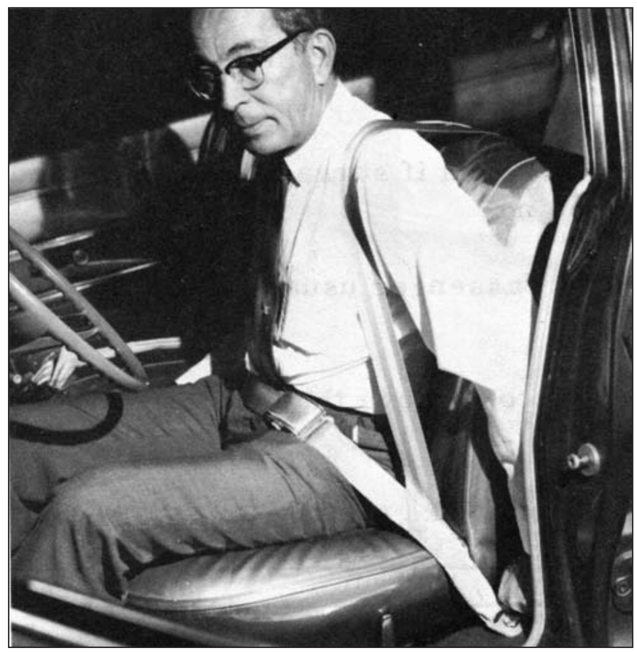
In early February 1943, Dr. Stovall submitted a postwar plan to the CAA Administrator that included an aeromedical research facility at the Standardization Center or, alternatively, on a university campus. In anticipation of postwar needs, the CAA reorganized in 1945 with the medical function in Washington renamed as the Aviation Medical Service (29). Then in 1946, the CAA Standardization Center was moved from Houston to Oklahoma City as the CAA Aeronautical Center.

While Holbrook (29) gives no rationale for the move (although he alludes to some later political fall-out), a 1949 Oklahoma City Chamber of Commerce publication (1) attributed the choice of location to the Aeronautical Center's "central geographic location in the United States which serves to reduce cost and time in the movement of CAA personnel and equipment, … the excellent year-round flying conditions here, and … the availability of suitable facilities which were formerly a part of the Army Air Base located on Will Rogers field"…A 1965 organizational survey of the Aeronautical Center included a history section that noted: "…The CAA Standardization Center at Houston was compelled to give up its facilities (caused by the returning National Guard) and the Administrator sought a central location at which to build a major civil aeronautical base. He decided upon Will Rogers Field at Oklahoma City, for reasons of good flying weather, aviation environment, and an enterprising offer by Oklahoma City officials to construct a modern physical plant to house such CAA organizations as would constitute the new CAA Aeronautical Center" (18). With respect to the latter, an FAA Historical Chronology item dated March 15, 1946, notes the move and concludes with "… Oklahoma City agreed to build an administrative building and two new hangers for CAA use" (47). Whatever the motivations, the CAA Administrator defined the Aeronautical Center as including an aviation medical research component among its six entities.

Thus, the "Aviation Medical Development Center" became part of the Aeronautical Center via CAA Administrative Order no. 57, August 2, 1946, but was unfunded and, in 1947 (until 1953), was renamed the Aviation Medical Branch (29). The branch was situated within the Aeronautical Center's Aviation Safety Standardization Division (18). Although a part of the Aeronautical Center, the medical research program received its guidance from CAA Headquarters where physiologist Barry G. King, Ph.D., had been designated (in 1947) as "Research Executive" for the Aviation Medical Service (29).

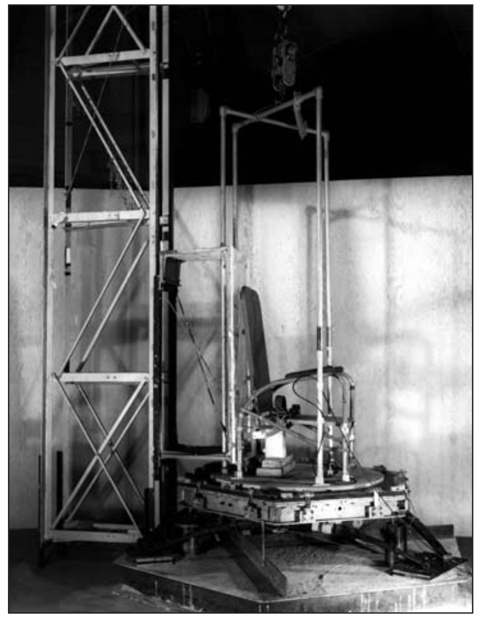
A Tentative Foothold

In October 1947, John J. Swearingen joined the Aviation Medical Branch as its senior scientist (29). Previously, in March 1947, Dr. Stovall had informed the CAA Director of Safety Regulation of the need to conduct scientific research on seats, safety belts, shoulder harnesses, and weight loads based on structural failures in several recent air carrier accidents. Swearingen, with prior U.S. Navy experience as a biomedical human factors scientist, was brought on board to conduct this type of research. However, research funding was a continuing



EARLY IMPACT. Swearingen in early tests of seat belts and seat harnesses and their capability to protect during crashes.

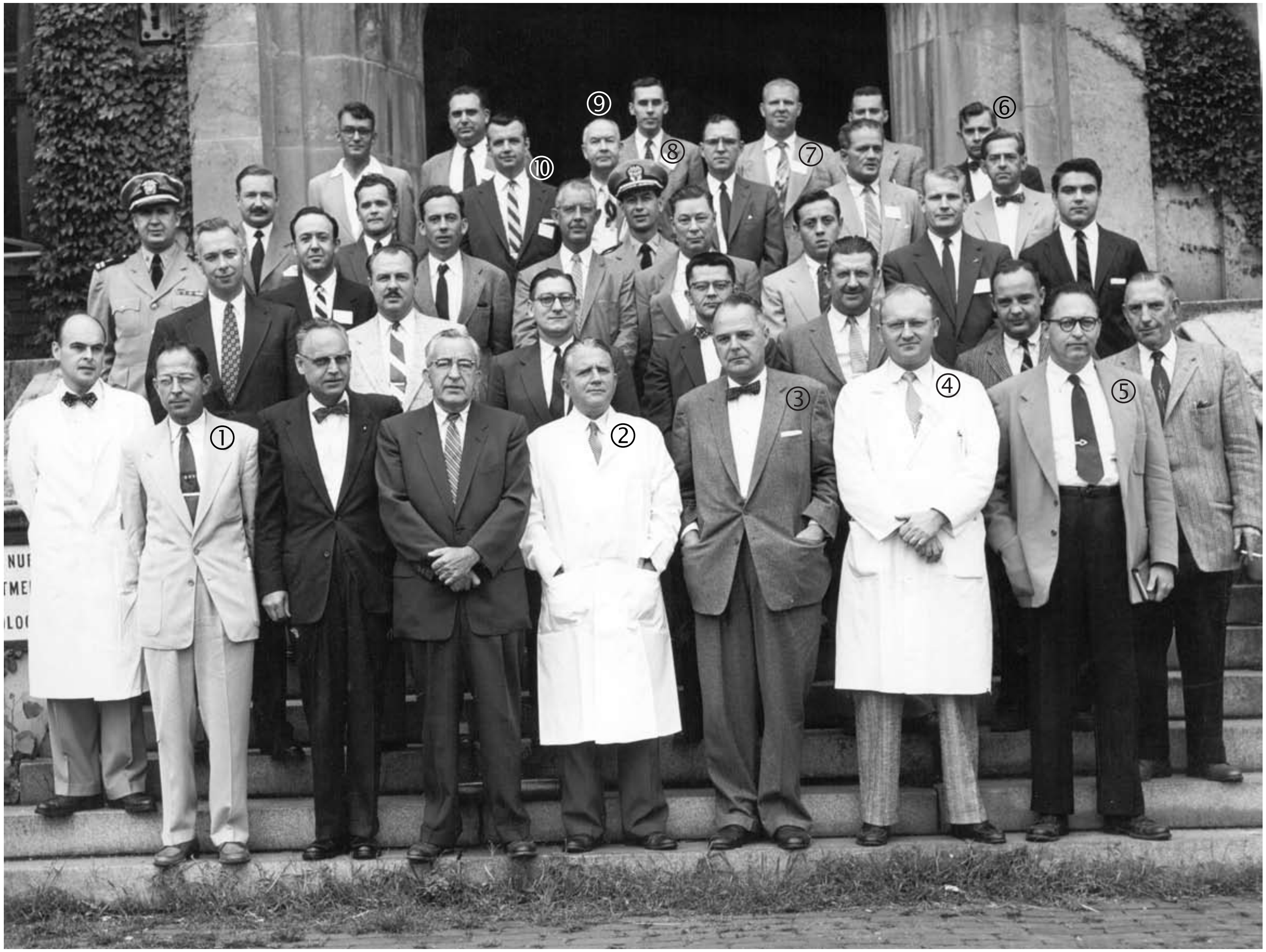
problem (both secretarial and administrative support were obtained from other Aeronautical Center branches) (28) and, although they were able to convert a former Army barracks building to an "Aeromedical Laboratory Altitude Chamber" (17), the ingenuity of the small team was regularly tested (allowing them to demonstrate skills that remained apparent in subsequent years) in their effective "make-do" solutions to research approaches. While the Aviation Medical Branch was defined as a research function, Swearingen established, within the small (2- or 3-person) branch, a laboratory as, at least nominally, a separate entity. As early as 1948, in a joint publication with Dr. King in the Journal of Aviation Medicine (31), Swearingen's affiliation was listed as the "Civil Aviation Medical Research Laboratories" (CAMRL). While he used this title quite regularly (at least once varying "Laboratory" with "Laboratories" [37]) to identify his organization in the text of formal reports (e.g., 53, 54, 55), the covers of those CAA reports regularly cited the origin of the work as the "Civil Aeronautics Medical Research Laboratory" at the Aeronautical Center in Oklahoma City (see also 23), despite the fact that the official organizational title "Aviation Medical Branch" was, according to Holbrook



Drop Tower. Swearingen used this vertical deceleration device (located in the Ohio State University football stadium) to test the effects of vertical impacts on spinal compression (assessed by spinal cord x-rays). Swearingen used himself as a subject for some of these tests as well as for wind blast tests and rapid decompressions.

You could learn a lot from a ...

A significant early Swearingen contribution was the development and use of articulated, anthropomorphic and (later) instrumented dummies – his were the first (Oscar (l) in 1949 and Elmer (r) in 1950) constructed for crash injury survival work. Both had joint articulation, calculated body and segment weight and centers of gravity, vertebral articulation, and some muscle resistance. Elmer also had a flexible torso and adjustable "muscle" tension in the spine. The dummies were used in hundreds of tests at CAMRL, Beech Aircraft, and the Air Force, and by the Atomic Energy Commission in A-bomb testing. Elmer can be considered the progenitor of modern anthropomorphic dummies.



Ohio State University: Annual Postgraduate Course in Aviation Medicine, 1956 (3, 7, 28, 40).

(1) John J. Swearingen, CAMRL, (2) Richard L. Meiling, M.D., Associate Dean of the College of Medicine, Director of Research and Education, Ohio State University, (3) Barry G. King, Ph.D., Research Executive, CAA Aviation Medical Service, (4) Earl T. Carter, M.D., OSU aviation medicine residency program, (5) William R. Stovall, M.D., CAA Aviation Medical Director, (6) J.D. Garner, CAMRL, (7) Ernest B. McFadden, CAMRL, (8) John G. Blethrow, CAMRL, (9) Kenneth E. Dowd, M.D., immediate past-president, Aero Medical Association, (10) Harry W. Orlady, Captain, United Airlines (first chairman of the medical committee of the Air Line Pilots Association).

A Strong Start. Garner began his CAA research career in Washington, D.C. working with John Smith, M.D., then head of the CAA medical standards branch, on ballistocardiographic research. That research was continued when he moved to Ohio State University to join CAMRL but was soon followed by his involvement in other projects. A seated Garner recorded sitting area measurements reported by Jack Blethrow and is shown testing the adhesive properties of an early model oxygen mask.

(29), retained until 1953 and the Aeronautical Center's Beacon magazine (51) referred to the Aviation Medical Branch in its reporting of research activities.

In July 1953, the CAA moved the medical research function to Columbus, Ohio, where (although Holbrook (29) mistakenly refers to the name as the Civil Aeromedical Research Laboratory) it was formally designated as the Civil Aeronautics Medical Research Laboratory – CAMRL (5, 47). That designation appears to have been primarily a title change in the official organizational chart since, prior to 1953, as noted above, the covers of the Aeronautical Center research reports all had used the CAMRL designation.

In Ohio, CAMRL was affiliated with the Ohio State University Medical School as part of that university's established plan for a wider-ranging "Institute of Civil Aviation Medicine" — a development for which Benford (2) assigned a primary role to Dr. Stovall. The University's plan was to "conduct research and provide a program of aviation medical education and training for civilian physicians and research investigators as a long-term and continuing activity to develop the technical manpower essential for the adequate support of civil aviation." There, Holbrook (29) indicates, Swearingen, J.D. Garner, Ernest B. McFadden, and Peter J. Sutro established a program comprising five research areas (sudden decompression effects on passengers, emergency oxygen administration, emergency aircraft evacuation, cockpit visibility and collision avoidance, and pilot fatigue) and began a series of injury studies "which extending over the next two decades would continue to form the basis for aircraft seating configurations for emergency evacuations, exit and window size and design, and human tolerances to impact forces." However, federal funding was very limited — as it had been in Oklahoma City — and in June 1958, "prompted by political maneuvering," according to Holbrook (29), the CAA Administrator, James T. Pyle, moved CAMRL back to the Aeronautical Center in Oklahoma City (47). Lopez (35, an attorney in the Medical Standards Division) authored an aviation medicine history for the Civil Air Surgeon in 1959 and attributed the move (with some apparent dissatisfaction) to the efforts of Roy Keely, the CAA director of flight operations and airworthiness, who worked "incessantly" — and, if so, successfully — for the return of CAMRL to the Aeronautical Center.

Congress Provides a Foundation

Meanwhile, in 1956, legislation had been introduced in the Senate and the House to modify the Civil Aeronautics Act of 1938 to define "civil aviation medicine" (the "Civil Aviation Medical Act of 1956"). It was neither sponsored nor supported by the CAA — and failed. The bill, which would have created both an Office of Civil Aviation Medicine directed by a "Civil Air Surgeon" and a medical facility — a Civil Aeronautics Medical Institute (CAMI!) — was reintroduced the following year. Hearings were held by Oklahoma Senator Mike Monroney but the bill (the "Civil Aviation Medicine Bill") languished in committee. Shortly thereafter, Senator Monroney began work on the bill that was to become, in August 1958, the "Federal Aviation Act of 1958" — to create an independent federal agency. In the meantime, during January, Dr. Stovall had resigned for health reasons as CAA medical director; his deputy, John E. Smith, M.D., had been made acting medical director. The Federal Aviation Agency began operation on December 31, 1958 (29).

ONLY TEMPORARY. Swearingen's relocated team occupied this large, former U.S. Navy gymnasium on the north campus of the University of Oklahoma until the CARI building opened. Similarly, other CARI recruits temporarily occupied adjacent barracks-type buildings.

CARI Takes Form

As part of the organizational changes that followed the FAA Act of 1958, an Office of the Civil Air Surgeon was established (to become the Bureau of Aviation Medicine, independent of the CAA, in 1960; the Aviation Medical Service in 1961; and the Office of Aviation Medicine in 1963). Dr. Smith served as acting Civil Air Surgeon until July 1959 when James L. Goddard, M.D., an officer in the Public Health Service, was appointed; Dr. Goddard named Dr. Smith as Chief of the Research Requirements Division (29).

On October 31, 1959, the FAA announced plans for a Civil Aeromedical Research Center to be established at the Aeronautical Center in Oklahoma City (5). Shortly thereafter, Robert T. Clark, Ph.D., a scientist from the U.S. Air Force (USAF) Aerospace Medical Center in San Antonio, Texas, was appointed by Dr. Goddard as the research chief and deputy director of the research function; by December, he was in Oklahoma City where he joined other early staff members of the nascent facility (30); they were initially housed on the second floor of Hangar 8 at the Aeronautical Center (9, 30).

Included in the new organization was the CAMRL contingent, that had relocated from Ohio to barracks buildings that had comprised the World War II Naval Air Technical Training Center in Norman, Oklahoma (21). Although Holbrook (29) indicates that here CAMRL took the title of "Aeromedical Research Institute (ARI)," it appears that the laboratory continued to be referred to as CAMRL (50) — or even as the Civil Aeronautical (vs. Aeronautics) Medical Research Laboratory (37) into early 1959, despite the change from CAA to FAA. Later, in a 1959 publication, McFadden, Swearingen, and Wheelwright (38) referred to their organization by the title Swearingen tended to use during his first stay at the Aeronautical Center — the Civil Aviation Medical Research Laboratory.

In November 1959, consistent with the FAA announcement a month earlier, the Aeronautical Center's Beacon publication (20) referred to the (short-lived title) Civil Aeromedical Research Center citing the same Aeronautical Center routing symbol (AC-266) as had been used previously in the Aeronautical Center's phone directories for September 1958 (9) and March 1959 (19) to designate either the "Civil Aeronautics Medical Research Lab" or Swearingen's preferred "Civil Aviation Medical Research Lab." By whatever prior name, Swearingen's protection and survival laboratory was the established core of the new Institute.

By February 1960, a group of researchers recruited from the USAF School of Aerospace Medicine had arrived (30); others soon followed. In May 1960, the growing group moved to Norman, Oklahoma, to the unoccupied World War II Navy buildings on the University of Oklahoma's North Campus (22, 30). A June 1, 1960 memorandum from FAA Administrator Elwood P. Quesada (48) to the Aeronautical Center authorized the negotiation for aeromedical space to comprise 133,000 sq. ft. split between two buildings (the smaller one, essentially the protection and survival laboratory, to be located near the flight line.) A subsequent memorandum from Administrator Quesada (49), dated July 28, 1960, changed the requirement to a single, larger building (146,000 sq. ft.).

Also in July, Hillard E. Estes, M.D., from the Lovelace Foundation, was appointed (and succeeded by Stanley R. Mohler, M.D., in August 1961) as director of the Oklahoma City medical facility, which had been renamed the Civil Aeromedical Research Institute — CARI. That change (from "Center" to "Institute") occurred no later than February 1960, based on references to CARI in a "projected growth at the Aeronautical Center" document (41) and in an Aeronautical Center Beacon magazine (21), both dated that February. The basis for the change was "to avoid confusion of two 'centers' at one location" (24). Despite all of this activity, remarkably, CARI was not formally created as an organization of the Bureau of Aviation Medicine until August 15, 1960, by Bureau of Aviation Medicine Order No. 60-2 (29).

Meanwhile, locations at the Aeronautical Center had been identified in 1959 for the new facility and design plans had been developed with primary input from the early research scientists. The size and major facilities of the building were approved by August 1960. However, the Airport Trust apparently constructed the building according to the plans submitted by the scientists. That approach resulted in a facility comprising 226,141 sq. ft. when completed (40, 45) instead of the 146,000 sq. ft. cited in Administrator Quesada's authorization letter. The move from the Norman barracks buildings to the Aeronautical Center was accomplished in October 1962 when the elegant new CARI building opened.

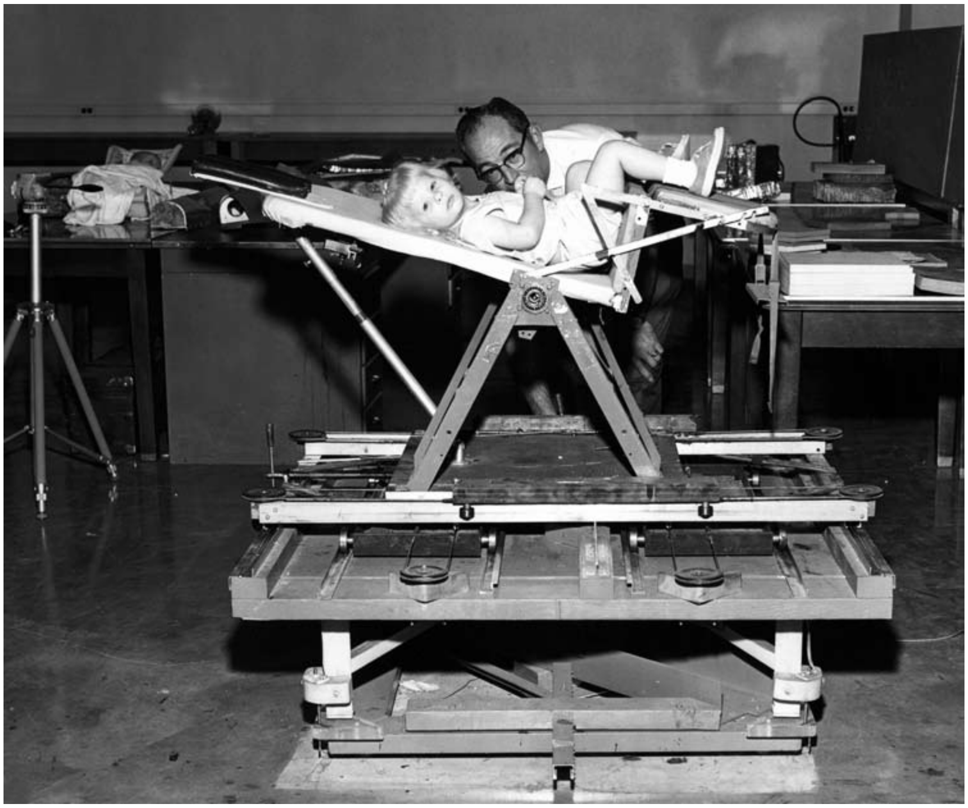
The speed and efficiency with which the CARI facility moved from concept to operation is attributable primarily to the fact that it was privately constructed — by the Oklahoma City Airport Trust. The Trust rented it to the FAA for a 25-year period, at the end of which time the cost of the building was totally paid; subsequent costs were for maintenance and improvements.

From CARI to CAMI

More detailed information regarding early developments within the Institute can be found in Holbrook (29)and in several historical vignettes published as an appendix to this report. For purposes of this brief history, it is necessary only to indicate that, in 1965, the Institute's organizational scope and structure were enlarged and, on October 1 of that year, it was renamed the Civil Aeromedical Institute — CAMI (29). The organizational changes resulted in all of the research laboratories that originally comprised CARI being designated as an aeromedical research branch along with aeromedical certification, aeromedical education, and a medical clinic branch that included national industrial hygiene responsibilities (17). In 1987, the aviation psychology laboratory acquired separate branch status (from the Aeromedical Research Branch) as the Human Resources Research Branch and became the Human Factors Research Division in 2002 (all of CAMI's branches were elevated to division status in 1998). In 2001, CAMI's mission was expanded to incorporate commercial space transportation and its name was changed (on May 24, 2001) to the Civil Aerospace Medical Institute (still CAMI by acronym) along with the change in function and name of its parent organization — from the Office of Aviation Medicine to the Office of Aerospace Medicine (25). ❑

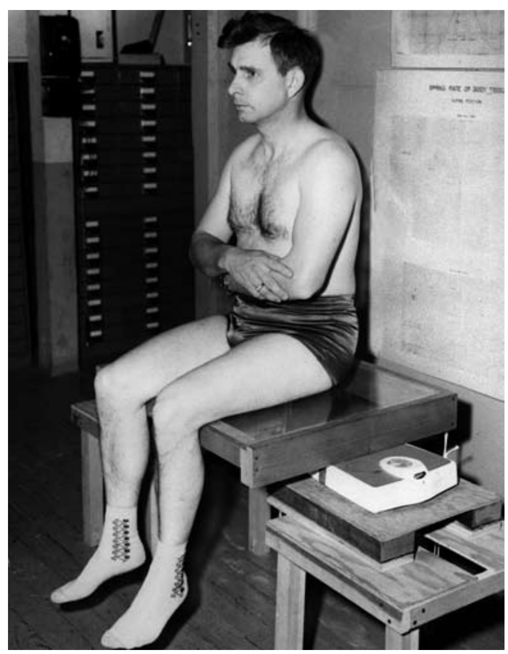
A World Class Facility. The CARI building (l) when it opened in 1962 and its setting in circa 1980 (r) after its renaming and other Aeronautical Center developments.

The Swearingen Legacy ... Continuity and Direct Applications



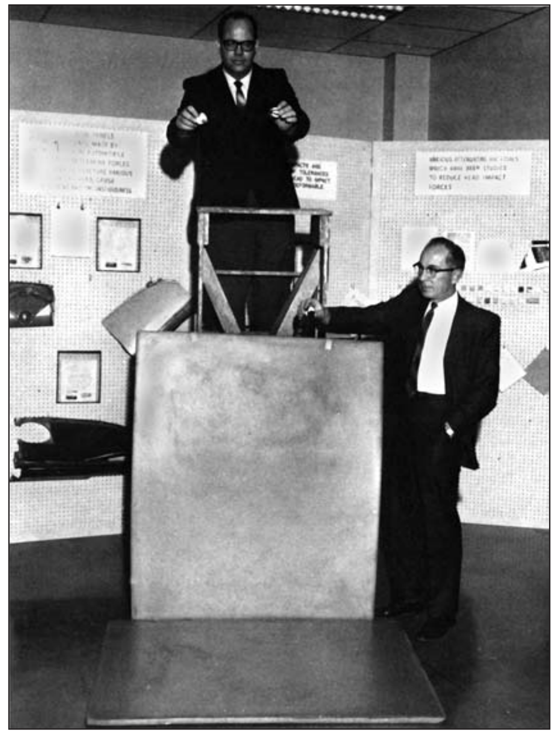
For the Least Able. John Swearingen, measuring the center of gravity for children.

While officially the second CARI report (the first in 1962), the study of sitting areas and pressures by John J. Swearingen et al. represented one aspect of a line of safety research that Swearingen had been conducting for 15 years with a small total staff of 1 to 4 associates (and an occasional collaborator) in his underfunded (and variously named) Civil Aeronautics Medical Research Laboratory. Some of that work from the late '40s to the late '50s was captured in a black-and-white motion picture film that was donated in year 2000 to the Smithsonian Air and Space Museum; a CD copy of the film is available from the CAMI library (52). The new CARI structure incorporating his protection and survival laboratory provided Swearingen with greater opportunities, funding, and support to pursue his research programs – a part of which came to be termed "cockpit delethalization." In addition to formally published reports, Swearingen, his team, and their successors conducted numerous unpublished studies at the request of agency representatives and safety groups. They interacted closely with industry and the agency to define safety shortcomings and support safety improvements.



Not Just for Comfort. Sitting pressures and areas on seats have an influence on seat design for safety, prevention of fatigue, and as a base for control movements.

Damage Control. Many of Swearingen's early tests used fuselages like this one to determine where (and what) protective materials might best be located.



Eggs-actly. This demonstration at a booth during a safety exposition in 1967 provided a directly observable indication of the importance of CAMI programs researching materials that would provide more protective surrounds in aircraft (and automobiles). Harry L. Gibbons, M.D., research branch chief, dropped fresh eggs from his position on the ladder, while Swearingen dropped an egg from shoulder height, onto a section of material that Swearingen was assessing in crash studies. The material cushioned the "blow" from the falling eggs so that none of them broke.

Early Impact Research

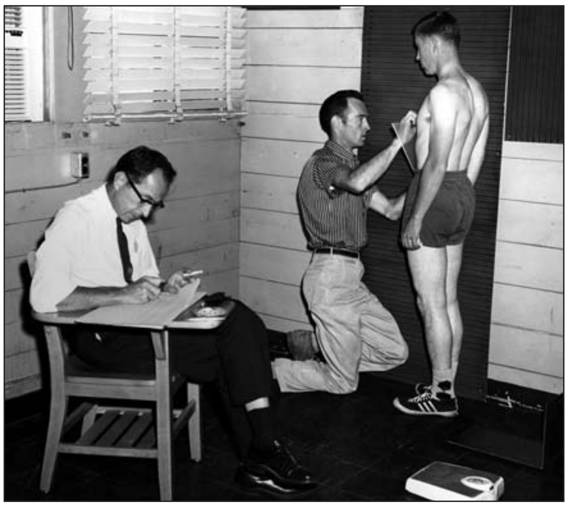
Swearingen's crash research tended to emphasize general aviation aircraft cockpits, although it included commercial cockpits and cabin interiors. That research was rooted in a program of accident investigation supplemented by the laboratory use of dashboards from crashed automobiles (in which the front seat passenger had been injured) and fuselage sections from crashed aircraft. Swearingen and his team subjected the dashboards to analyses based on the medical records of those injured in the accidents. He then secured undamaged dashboards from similar junked cars and worked at simulating the damage using instrumented dummy heads on a sled-catapult device he had constructed. Based on about 1,000 tests during a 3-year period, he determined the impact forces that could be tolerated by the head and face. He then sought force-absorbing materials and padding that could be used in the dashboards and fuselage sections to reduce injuries.

Swearingen extended the impact work using CAMI's 2-rail track to include the head and face injury potential of then-current airline seats. He also noted that some passenger injuries resulted because their seats came loose from the floor, a circumstance that was sometimes assisted by the forces applied when a seat was involuntarily kicked by the flailing legs of a passenger seated behind it.

The use of existing data regarding injury due to impacts was not limited to Swearingen's accident investigations. The laboratory's Richard G. Snyder, Ph.D., collected reports on a national basis about people who suffered significant free fall impacts (often from both successful and unsuccessful suicide attempts) and analyzed those reports for clues to survival. In addition, in collaboration with another CAMI anthropologist, Clyde C. Snow, Ph.D., Snyder conducted primate studies of impact injuries in pregnancy, from restraint system trauma, and from backward vs. forward facing vs. lateral body orientations with a lap belt restraint to develop criteria for protecting aircraft occupants. Those protection and survival studies were conducted during the mid-1960's at Holloman Air Force Base, using the U.S. Air Force's Daisy Decelerator. The Holloman AFB division chief in charge of the conduct of those tests was Richard F. Chandler (8). While that occasion was Chandler's first contact with CAMI, he would later join the Institute and subsequently succeed Swearingen.

Cutting a Wide Swath

From the start-up in the late 40s to the establishment of CARI, Swearingen successfully guided the tiny civil aeromedical research function through a trying period of more than a dozen years. That period involved two major (and one lesser) geographic moves and a consistent shortage of resources. Despite those difficulties, Swearingen and his small team successfully explored injury-reducing and life-saving solutions for general aviation and commercial aircraft. With the advent of CARI, he was able to build on that team and assembled and managed a skilled and productive staff dedicated to aviation safety research.



Measuring Success. Anthropometric measurements recorded by Swearingen were important elements in his efforts to protect aircraft occupants.

During those periods and until his retirement in 1972, Swearingen's own studies ranged from recording (and using) basic information on bodily centers of gravity at different life stages to exploring the effects of sudden decompressions on himself and on dummies situated next to various-sized windows (which led to his recommendation that windows be double-paned) in addition to his crash-injury investigations. He pioneered in studies of voluntary human tolerance to vertical impact, human strength requirements for operation of aircraft controls, and release mechanisms for emergency exits and doors, and in developing recommendations for reducing or preventing injuries from rapid decompressions. He designed a test device that allowed him to measure the range of motion for seated passengers wearing a safety belt, defined seat load distributions, developed maps of impact tolerance for the human face, and assessed the protective performance of instrument panels when they were subjected to crash loads. With collaborator Ernest B. McFadden, he developed and was awarded two patents (nos. 2,809,633, and 2,921,581) which described an adhesive oxygen mask and the drop-down mechanism to present the mask during decompression.

Successful Succession

When biologist Swearingen retired in 1972, he was succeeded by engineer Chandler who continued the established safety research thrusts as head of the protection and survival laboratory and brought to the research program his own special skills and perspectives. While Chandler is best known for impact-related work and the dynamic evaluation of aircraft seat and restraint systems, he, like his predecessor, involved himself in a variety of projects in other areas of research (e.g., the maximal control force capability of female pilots, issues related to the use of canes by blind passengers in aircraft cabins, and the development of appropriate dummies for impact testing). The protection and survival laboratory was in good hands. ❐

Explosive Decompression. An early study by Swearingen used Elmer – and a doll – to assess the effects of a rapid decompression from a blown-out window in an altitude chamber. Swearingen's recommendations related to window size, use of double panes, and an increased distance of the passenger from the window. In developing his recommendations, Swearingen exposed himself to a number of rapid decompressions.

CARI's First Report ... An Enduring Direction

The Beginning

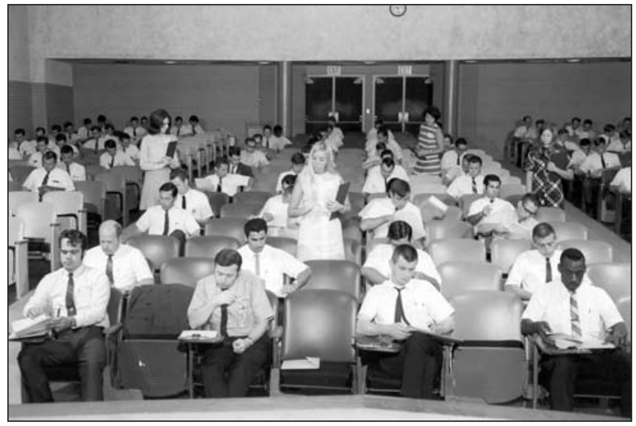
CARI's first report – the only one published in 1961 – involved close cooperation with the FAA Academy and its entrants into the air traffic control specialist (ATCS) training program. That report began the Institute's research programs, initiated by David K. Trites, Ph.D., on developing and validating tests for selecting ATCS trainees and on assessing Academy training and its measures as predictors of trainee success – an involvement that continues to date. Training–performance criteria for ATC students in the tower, center, and flight service options were also the subject of one of the first two CARI research contracts (the other was a vestibular investigation) with organizational elements of the University of Oklahoma; both contracts were completed in 1964 (6, 39).

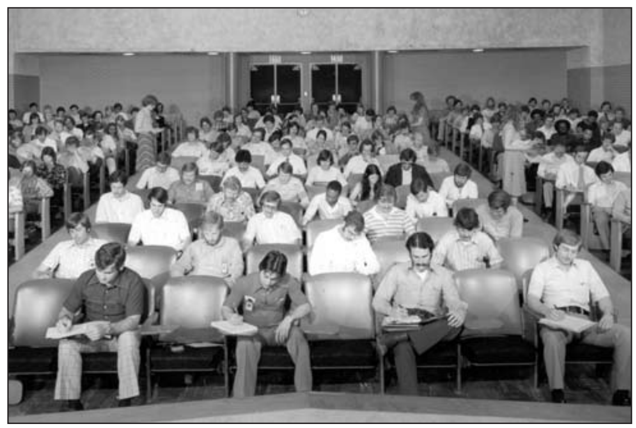
Note that CARI/CAMI tests comprised the official Office of Personnel Management selection battery (and later also included a CAMI-developed Occupational Knowledge Test). Passing that battery was required for eligibility to be considered for an ATC trainee slot; the ranking of successful candidates depended upon their test scores, education, and experience.

During most of the first two decades of CARI/CAMI's selection and training research, Bart B. Cobb was a driving force. He was frequently consulted by Washington Headquarters groups in the offices of air traffic and personnel for the information and special analyses of pertinent data that he provided by numerous letters and memoranda as well as his formal CARI/OAM reports.

In addition to developing new tests and scoring schema, effects of age, education, gender, prior experience,

First Hand. Bart Cobb (l) and CAMI director J. Robert. Dille, M.D., (r) during an air traffic control tower visit to directly observe ATC procedures.





Culture Changes. Recently-arrived FAA Academy students provided demographics and took CAMI tests of new items designed to improve future selection criteria. Cultural changes are evident in student make-up (top to bottom: ca. 1965, 1977, ca. 1983).

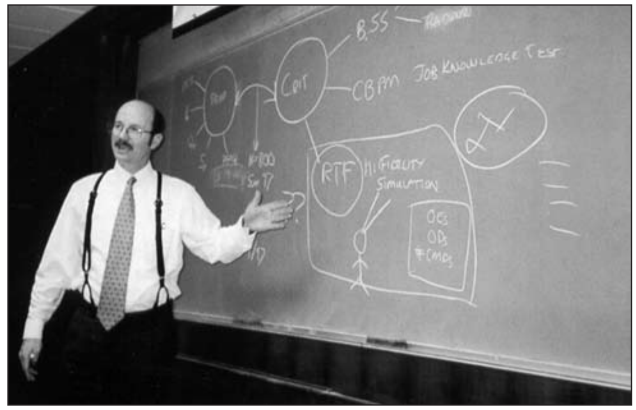
The Academy. Air traffic control classes in the 1960s (l) and the 1980s (r).

personality, potential test bias, and others have been researched through the years by Cobb and his psychologist successors – Drs. Mary A. Lewis, James O. Boone, Alan D. VanDeventer, Carol A. Manning, Pamela S. Della Rocco, Dana M. Broach, and Raymond King – a grouping that suggests the increased size of the air traffic controller programmatic research effort. The agency has been provided through the decades with criteria for the best candidates with the best chance to succeed and with updated selection and training criteria that are fair, reliable, valid, and cost effective. Updating refers not only to the advances in ATC systems that might change aptitudes and abilities required for success, but also to the delivery systems for assessing skills necessary for job performance and to the cultural changes that affect what applicants bring to the job. Included in that updating is another area that receives CAMI attention, primarily by David J. Schroeder, Ph.D., – viz., the assessment of varied approaches to defining personality-related elements as they relate to success in air traffic control work (including a continuation of the work of Roger C. Smith, Ph.D., on perceived stress and on "burnout").

The Academy's new RTF. Boone (top) during tests of "ghost pilot" demands for staffing the Academy's new Radar Training Facility (bottom).

Analysis. Manning reviewing air traffic student data for a briefing on the Academy program to Washington officials.

Documenting Outcomes. Della Rocco (l) provided analyses of Academy student outcomes to Dallas-Ft. Worth air traffic manager Joseph Kisicki and Britain's David Hopkin, an internationally noted expert on air traffic control work.



D.C. Discourse. Broach providing a briefing in Washington headquarters on conceptual relationships in air traffic controller selection.

The Academy

CAMI has also provided the FAA Academy with additional scientific support. Beginning in 1976, CAMI's relationship with the Academy became formalized in conjunction with a new pass/fail program. CAMI began to conduct analyses of various proposed selection and training scenarios and, at the request of the Academy, to brief visiting Washington officials as an "independent analyst" on statistical aspects of the air traffic program. And when support personnel were needed to operate the manual controller, remote, and three "ghost pilot" positions for each radar training sector of a new radar training facility constructed at the Aeronautical Center in 1980, Boone undertook studies to assess the training time and error rates of ATCS trainees, community persons, and physically handicapped persons. Results indicated that handicapped and community persons could perform effectively at the "ghost pilot" positions and recommendations that they be hired to do so were accepted. Another Boone study, conducted at the FAA Technical Center in Atlantic City, compared over-the-shoulder vs. computer-derived measures of student performance on the RTF and found better outcomes with the computer measures.

Maintaining State of the Art

With the aim of reducing the time required to establish trainee success or failure (several weeks of class work followed by simulated air traffic control in an Academy laboratory), a computerized pre-training screen (PTS) was developed. The PTS was used for about 3 years in the early '90s to hire 1800 trainees and reduced success/failure screening time from 9-12 weeks to five days. That screen was followed by development of the AT-SAT, a computerized aptitude test battery currently in use. The AT-SAT (Air Traffic Selection and Testing) battery was the product of a CAMI-Academy-Air Traffic collaboration with contractors and university experts; Della Rocco headed the CAMI effort that included participation in the validation of the battery with more than 1,000 en route field controllers. The AT-SAT replaces the written OPM test and provides a pre-training screen as well; testing/screening is accomplished in a single day. That improved efficiency (along with a retirement model prepared by Broach to identify future training requirements) will be significant in the plans and procedures being developed by the FAA to recruit and train a large, new group of controllers. The new group will be required to replace the controllers hired during the strike recovery period in the early 1980s, as the latter become eligible for retirement. Moreover, new technologies and procedures require constant re-evaluation of the defined knowledge, skills, and abilities for success in the air traffic controller occupation to assure safety in tomorrow's national air space system. Related recent work has been conducted on completing job-task analyses for airway facility specialists and for computer specialists in the air traffic service. ❑

AT-SAT At Last. Della Rocco and Manning displayed the first poster announcing the new test battery for air traffic controllers. Both were formally acknowledged for contributions toward success of the 4-year project with special recognition of Della Rocco by the AT-SAT Executive Steering Committee for her service as the scientific/technical representative, defining test validation requirements, and contributing to decision making on the scientific approach.

Aeromedical Certification ... and Health

The Priority Function

The top priority of the Office of Aerospace Medicine and of CAMI is not research but the recurrent aeromedical certification of all of the country's civilian pilots. However, the co-location of the research enterprise with the certification function encourages research from both entities. Some studies have described the performance effectiveness of aviation medical examiners; others defined disease prevalence and incidence among pilot populations; still others compared medical status variables among accident vs. nonaccident airmen.

From the certification staff, Charles F. Booze, Ph.D., was pre-eminent for more than two decades in tapping the extensive certification database and reporting his findings on a variety of certification topics. Similarly, beginning in the mid '70s, Shirley J. Dark initiated a series of studies on characteristics of medically disqualified airmen in general and air line pilots in particular.

Data, Data, Data. Charles Holmes in one of the many older racks of certification data files. A state-of-the-art electronic certification records system is now in place for immediate informational access.

Early Laboratory Research

Very early biodynamic studies by Bruno Balke, Ph.D., assessed work capacity, cardiorespiratory capacity, and physiological aging issues. That work led to research by Michael T. Lategola, Ph.D., on the early identification of coronary heart disease and physical fitness regimens that would help pilots who had experienced myocardial infarctions to restore their cardiovascular functioning so that they might regain their medical certificates. Other work by Lategola included the near term effects on psychomotor performance and physiological functions of physical exertion, of crash dieting, and of blood donations in conjunction with simulated altitude exposures.

Vision: A Major Research Issue

Studies from the research divisions have used certification data to develop profiles of pilots with regard to types of visual correction (contact lens use, aphakia,

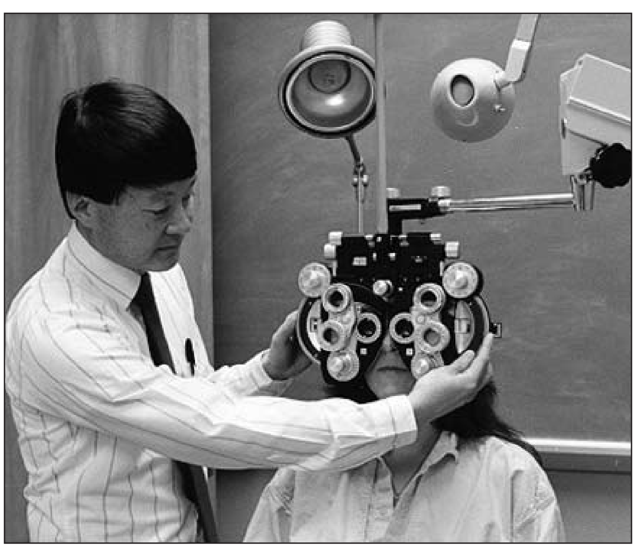
Medical Exchange. (upper) J. Robert Dille, M.D., CAMI director (l), a frequent research collaborator with Booze (seated), discussed certification data with two Russian Aeroflot visitors in 1978. A.W. Davis, M.D., (r) headed aeromedical certification. (lower) Shirley Dark explaining a new certification subsystem for medical data. Federal Air Surgeon Jon L. Jordan, M.D., is 2nd from left.

Basic Support. Balke's work capacity studies and Lategola's tilt-table tests supported certification goals.

radial keratotomy, radial keratectomy), and to develop tests, procedures, and data (e.g., on the x-chrom lens) to assist in aeromedical decision-making for pilots and air traffic controllers. These studies, conducted by Kenneth W. Welsh, O.D., and Van B. Nakagawara, O.D., have relevance to the fact that optimum vision is essential for pilots not just for detecting other airborne traffic and reading the instrument panel, but also for visual detection on the runway and taxiway and for reading maps and other printed material. Thus, Nakagawara has analyzed the influence on aviation safety of various types of refractive corrections and surgeries as well as assessing the influence of laser light exposure on pilots' vision and performance. In further support of the certification process, Henry W. Mertens, Ph.D., conducted studies validating clinical tests of color vision in predicting responses to practical tests, devising updated criteria for clinical assessments of color vision capability, and developing improved practical tests. Since the ability to distinguish colors has significance for both pilots and air traffic controllers, color vision is a component of their periodic medical examinations. Mertens' studies with Nelda T. Milburn, Ph.D., included validating cut-off scores on pseudoischromatic plate tests and other instruments, including the signal light gun, and the development of new practical tests for the air traffic controller occupation.

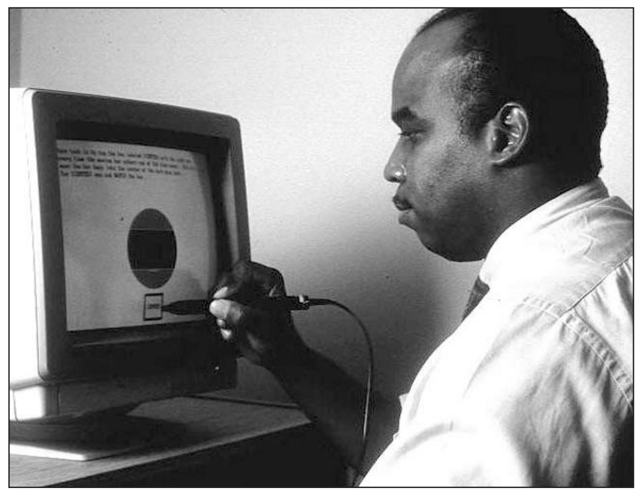
Noise and Hearing

Studies of the hearing profiles for aviation personnel and of cockpit and cabin noise exposures (to assess the risks of hearing loss based on exposure) were conducted by researcher Jerry V. Tobias, Ph.D., along with preventive guidelines and ratings of various types of ear protection. Cockpit noise intensities were determined in a variety of



Seeing It All. (above) Nakagawara checking visual acuity; (r) color vision testing for a study by Mertens.

Criterion Setting. (above) Nakagawara conducted retinal sensitivity tests under mild hypoxia in the altitude chamber. (r) Mertens used an air traffic control tower signal light gun in developing medical certification criteria for color vision tests.



Cogscreen. (r) The final touches being applied to the new cognitive test at CAMI.

Noise and Speech. Tobias measured speech intelligibility and noise-based hearing loss © 1970, The Oklahoma Publishing Company.

single and twin-engine aircraft to determine exposure-risk levels for hearing loss. And groups of aircrew personnel were tested to determine auditory profiles associated with their flight history. Recommendations for hearing conservation by use of earplugs were accompanied by tests and ratings of the effectiveness of a variety of ear protectors.

Head Trauma

During the ‘90s a government/academia contract team headed by Jerry R. Hordinsky, M.D., engaged in a competitive developmental effort to produce a sensitive screening battery specific to mild cognitive deficiencies – deficiencies that would be sufficient to potentially impair skill and aviation performance. From the viewpoint of aeromedical certification such a tool could be used to ascertain damage and to provide an objective (and relatively inexpensive) assessment for determining sufficient recovery from head trauma or brain disease to consider reinstatement of a pilot’s withdrawn medical certificate. The Georgetown University model, called COGSCREEN, was the result of that effort. The value of the test not only for aeromedical certification purposes but also for assessments of persons in a variety of occupations which require highly skilled cognitive capabilities is attested to by the patenting and commercialization of the test by Georgetown University; it thus represents another successful transfer of technology. ❑

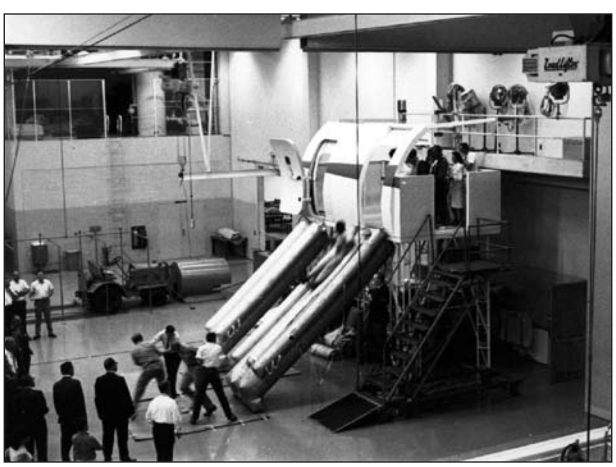
Protection and Survival ... Saving Lives

With the establishment of the Protection and Survival Laboratory in CARI, John Swearingen's small team from CAA days was increased and its capabilities expanded. The driving forces during the 1960s and '70s for areas other than the research by Swearingen were Richard F. Chandler, who became laboratory chief and CAMI's researcher for crash injury protection, J. D. Garner, who specialized in emergency evacuation issues, and Ernest B. McFadden, whose forte became oxygen equipment and flotation devices. It would be difficult to overestimate the significance of the contributions of all these men. Chandler significantly extended the testing of child seats including the development and use of scientifically adequate child dummies (until then, even automobile crash studies used dolls). He also evaluated a number of seat restraint systems for general aviation aircraft as well as an energy absorbing steering column technology for possible application to aircraft controls. Garner and McFadden, in addition to their specialty areas, had regularly worked together as a team in addressing survival of flight crews and passengers in commercial aircraft. They had tested smoke hoods and had begun assessing computer simulation of emergency evacuations as early as 1970. Later, they conducted escape studies with blind travelers using canes and with passengers who had mobility handicaps; they conducted studies evaluating the needs and effectiveness of infant and child flotation devices. After their retirements, research on oxygen needs and equipment was continued by physiologist E. Arnold Higgins, Ph.D., while studies of passenger emergency evacuation for the past decade-plus have been led by G.A. McLean, Ph.D. (including a Type III overwing exit study that used 2,544 subjects).

Communicating. McFadden (center) discussed results from the latest altitude chamber testing of oxygen mask equipment in a 1974 meeting of the SAE-A10 (aircraft oxygen equipment) committee held at CAMI. Committee chairman Jules Duval (TWA – Kansas City) and Humphrey Hamlin (Normalair – Garrett, Ltd., England) were the interested listeners.

Work in these various protection and survival areas has always been based in cooperation and coordination with aviation safety groups and equipment developers. Prime among these (oddly enough) have been the various specialty groups in the long-established Society of Automotive Engineers (SAE); now known as SAE International. Various committees within that organization's (now) Aerospace Division, such as SAE-S9 (cabin safety provisions), SAE-A10 (aircraft oxygen equipment), SAE-A20 (aircraft lighting), SAE-G10 (aerospace behavioral engineering technology), and the SAE Seat Committee,

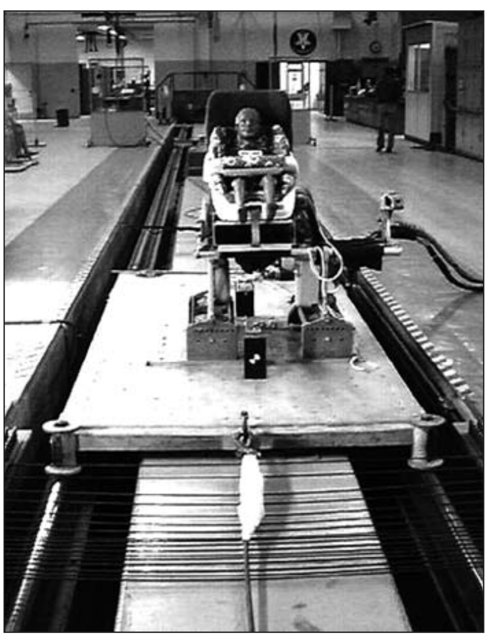
An Inside Job. Early CARI/CAMI evacuation tests were conducted in the high bay area. Tests using various door heights are shown below and at right.



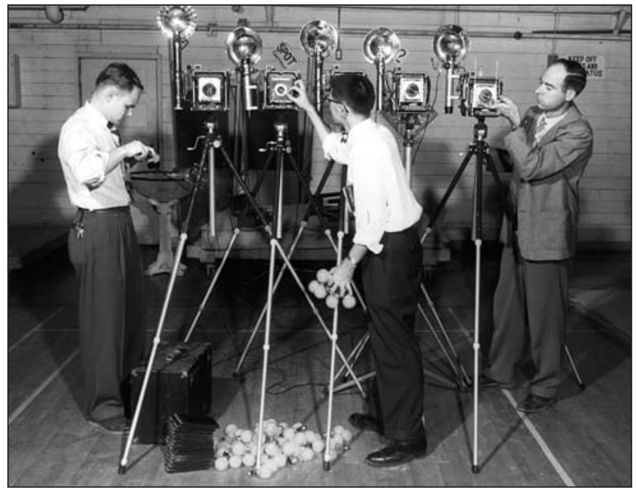
continue to be major sources of regular interaction for CAMI's scientists. These interactions help to account for the fact that, from its CAMRL beginnings to the present, so much of the protection and survival research has been translated into rules and regulations, improved safety systems, and improved manufactured products from oxygen masks and restraints to emergency lighting.

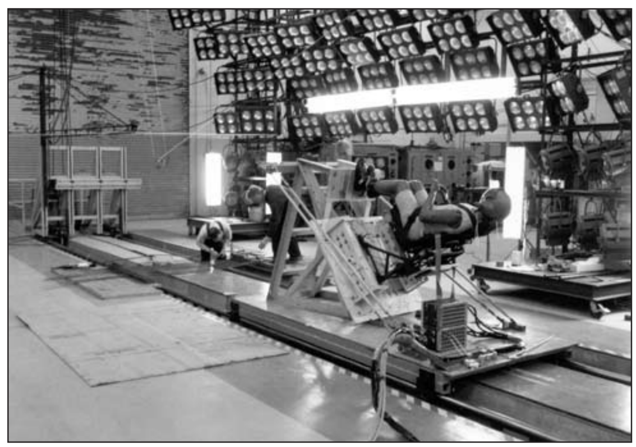
Crash Injury Research

Chandler introduced a new direction in CAMI's crash injury research programs. Part of that direction involved his upgrading of the 2-rail track that ran the length of CAMI's spacious high bay area. He designed unique test equipment, installed new instrumentation, and substituted heavier duty rails for the existing ones. "The Track" thus had the capability for the dynamic evaluation of seat and restraint system performance. Briefly described, two precision rails (140 feet long) with a winch and wire brake system accommodated a sled that could be propelled to a high speed and then brought to a sudden stop (in 200 milliseconds). The sled permitted the attachment of various seat and restraint configurations as well as instrument panels and cockpit enclosures, as desired, along with instrumented dummies. His development and use of dummies that would provide the best information on injury patterns permitted the formulation of recommendations regarding dimensions, location, and tie-downs that would prevent or reduce injuries and death from crashes.



"The (Right) Track." CAMI's sled tests used in crash impact studies conducted on "The Track," viewed here from the braking system at the end of a run.

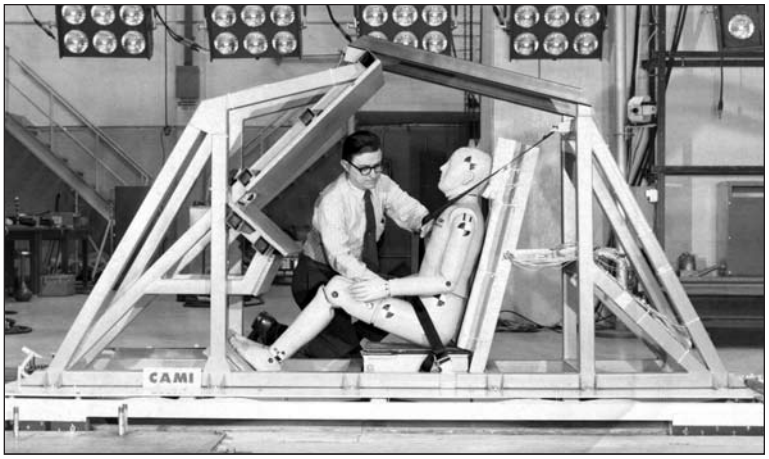




Then and Now. Early approaches to documenting impact tests involved a set of cameras with split-second timing sequences. With the advent of high-speed motion picture (then video) technology and other electromechanical advances, a state-of-the-art CAMI system was kept in place.

Chandler also extended CAMI's involvement with the military, testing prototypes of a 2-passenger helicopter seat for the U.S. Army Aeromedical Research Laboratory, and prototypes of energy absorbing helicopter seats for the U.S. Air Mobility Research and Development Laboratory, the U.S. Navy, and the U.S. Coast Guard, as well as an energy absorbing passenger seat for NASA. He also expanded cooperative development efforts for seats in civil aircraft by working with all of the major manufacturers. That work provided the basis for a complete revision of the FAA regulations for seat, restraint, and crash injury protection systems in aircraft. The new regulations were adopted in 1988 and represented the first significant revision since 1927.

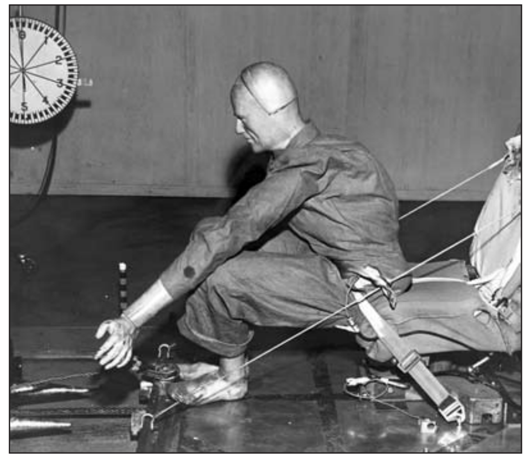
Chandler's personal involvement with impact issues and seat-and-restraint integrity was subsequently assumed by engineer Roy Van Gowdy who continued to add to

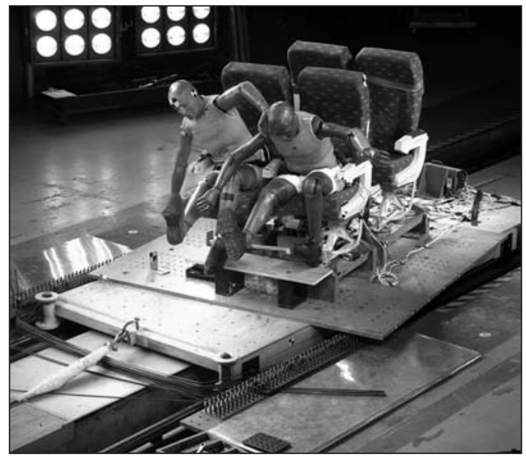


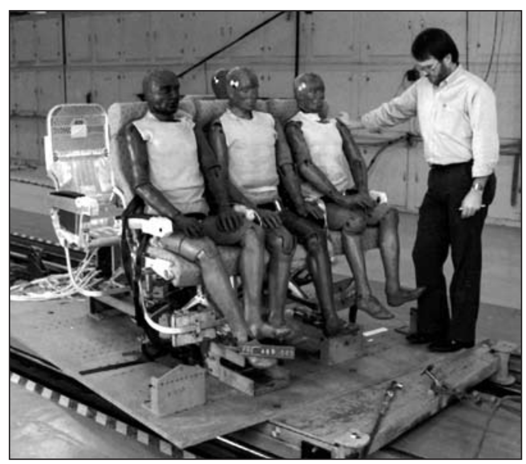
Keeping It Moving. Chandler expanded on Swearingen's impact studies and introduced improvements to "The Track"; he remained a widely sought expert on seat safety and restraint systems after his CAMI retirement.

CAMI's perceived excellence by the aviation industry and federal regulators through his extensive work with both U.S. and foreign airlines and manufacturers, with NASA, and as a major visiting consultant to other countries that were establishing their own impact test facilities. Those visits include his presenting classes on dynamic impact test procedures and FAA crash worthiness seat regulations at the Civil Aero Polytechnology Institute in Bejing, China, and to the Australian Civil Aviation Authority and aviation industry representatives in Sydney, Australia. Richard DeWeese recently succeeded Gowdy as head of that program.

NASA Needs. Impact tests conducted by DeWeese (l) and Gowdy (r) in support of the NASA program occurred during the '90s. A NASA flight suit (l) was used on the dummy in one set of trials.







More Is Better. With improvements in track materials, more seats and dummies could be tested at one time. Work by Chandler and Gowdy frequently used multiple "passengers."

"Smart" Dummies

A significant aspect of impact research involves appropriately constructed dummies. Oscar (retired in 1963) and Elmer (built by Swearingen in 1949 and 1950, respectively) were carefully weighted, articulated, and incorporated other elements that put those dummies in high demand for borrowing or copying by military and commercial laboratories. And, in perhaps one of the earliest substantive acknowledgements of diversity in

Like the Old Movie. (above) In a scene somewhat reminiscent of old black-and-white monster movies, Jack Blethrow repaired Elmer after a crash study. (r) Judy Anderson applied hair spray to Sierra Suzie – the first female model of a crash dummy used on "The Track."

technical aeromedical settings, a female dummy (Sierra Suzie) was in use at CAMI by the early 1970s.

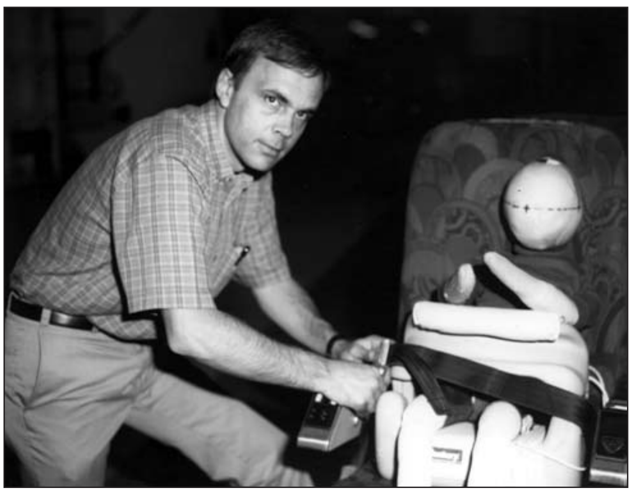
The development of impact research dummies that provided the best possible human representation was an ongoing effort. Designs developed at CAMI, particularly by anthropologists Clyde C. Snow, Ph.D., and Joseph W. Young, included criteria for head and face anthropometry, body forms for children, and an anthropometrically accurate pelvis structure, (the "golden pelvis") – the latter two efforts were in support of the National Highway Traffic Safety Administration (NHTSA). These advances were capitalized on by others (e.g. the U.S. Air Force) conducting crash research. An early cooperative program with the U.S. Air Force to determine mass distribution properties of the human body developed three dimensional anthropometric measurement techniques. The Air Force adapted that technology to computerized scanners and used it as the basis for Project CAESAR, the first world-wide survey of human body size to utilize three dimensional measurement. The design modeling of anthropomorphic test devices was a multi-decade CAMI effort that had applications to fields other than civil aviation.

Almost Real. (l) Young at work on the "golden pelvis." Accurate pelvis representations in dummies permitted a more precise evaluation of injury in various crash scenarios.

Focus on Children

Proper protection of children has always been a major consideration. Based on identified needs, dummies representing 6-month-old, 2-year-old, and 3-year-old children were both designed and used extensively by CAMI and also by NHTSA. And, stimulated by Chandler in the late '70s with the support of NHTSA, anthropological measures, including biostereometric mapping, by Young and Snow from groups of 2½ – 6½ year-old children led to the production of new 3- and 6- year-old body forms – NHTSA's "golden shells." These were not dummies in the usual sense but, rather, body forms to test the fit of restraint systems. Work to improve the information from the CAMI-developed dummies continued well past their first use. For example, in the mid-90s, DeWeese designed an experimental device to measure abdominal pressure in the 6-month-old and 2-year-old dummies in dynamic impact tests of child restraint devices.

CAMI's research with dummies on "The Track" had shown the hazards of a passenger holding an infant on her lap during an aircraft crash – the child cannot be held because of the G forces and becomes a projectile. The use of automobile restraint devices for children was initially thought to be an immediate solution, but CAMI research showed many of these devices to be acceptable for automobile use but inadequate for crash protection in aircraft. CAMI's work, led by Chandler and Gowdy, led to the defining of criteria and development of prototypes for proper infant and child protection in aircraft. In 1985, NHTSA began approving child restraint systems for use in autos that were also acceptable for use in aircraft, based on the CAMI data from tests on "The Track."



Child Care. Gowdy in one of his many tests of infant seat protection.

More Anthropology

Swearingen's somewhat circumscribed use of body measurements in research was extended by Richard G. Snyder, Ph.D., who collaborated with fellow anthropologist Snow in a mid-1960s study that involved extensive anthropometric measures of air traffic control specialists (ATCSs). The results were to provide a data base for the design of ATCS work space and equipment, a long-range study of the aging ATCS population, and to explore relationships between physical condition and performance effectiveness. Later, in the mid '70s, Snow initiated an extensive anthropometric study of flight attendants based on the perceived need to address the (then) stewardess' work station and surrounds with base line date (e.g., for determining the proper size, height, load relationships, fold-up criteria, and other features of the various types of seats used by flight attendants). That study drew a press conference response from Senator William Proxmire, who cited it for one of his many "Golden Fleece" awards. The "awards," which he periodically publicized for more than a decade, represented the senator's view that certain research projects represented frivolous uses of taxpayer money. The senator may not have been aware that the research was in response to findings of a study reported by the Air Line Pilots Association. That study comprised 103 accidents/incidents involving emergency evacuations in which flight attendants had identified 471 problems including various issues related to seat construction and location, inadequate restraint systems, inaccessible emergency equipment, megaphones that were too heavy, lack of head padding, and others. In any event, the CAMI study provided the anthropometric data for use by the aviation industry. Remarkably, almost three decades later, an editorial in the prestigious weekly journal Science addressed some recent political ridiculing of government funding for a variety of research projects and cited the CAMI study "of the physical characteristics of flight attendants that ultimately led to the development of life-saving safety belt configurations for them" (32) as an example of how short-sighted such criticism can sometimes be.

Parenthetically, Snow had worked on the development of forensic methods for identifying human remains from aircraft accidents (8). As his knowledge and skill in this area became known, he was often called upon by state and local law enforcement to assist in identifying remains. These interests led him to provide training and encouragement to one of CAMI's medical illustrators – Betty Pat Gatliff – whose avocational pursuits included proficiency in sculpture. Snow provided guidance and stimulated her to work on reconstructing facial features on skulls for forensic identification purposes. Gatliff became so skilled at the art that, following her retirement from the FAA, she became a nationally sought expert, lecturing around the country. And when Snow retired from federal service, he rapidly became an internationally recognized expert in forensic anthropology. He has been a key figure in major criminal cases in this country and in war crimes cases in other parts of the world.

Escape Procedures: Phoenix...and the SST

Some of the more exciting CAMI research involves tests related to the emergency evacuation of passengers from downed aircraft. During the '60s, much of that work was conducted inside, in the high bay area of the CARI building. One major exception was an evacuation study conducted with a crashed Lockheed L-1649. That study, in 1965, was part of an FAA crash test safety research program with the Flight Safety Foundation. Instrumented dummies, onboard during the actual crash a year earlier, were replaced by "passengers" who experienced a one-hour "flight" (including box lunches) and a "crash" simulated by use of artificial smoke and crashing sound effects and enhanced by some purposely jammed door and escape hatches. Motion picture cameras, remotely controlled both inside the aircraft and exterior to it, and precision timers provided much of the data. Results assessed some features of seat spacing and aisle widths and provided a planning base for future studies of evacuation procedures from a damaged aircraft.

They're Called "Slides." Not all proposals for using early versions of inflatable slides for emergency evacuation proved to be useful. CAMI research defined an ideal angle of 27° for safe, rapid evacuation (28).

A unique series of evacuation studies involved the configuration of a supersonic transport (SST). When a government contract to build an SST prototype went to Boeing and, later, the U.S. opted out of the international supersonic transport competition, CAMI secured the Lockheed model – a wooden structure – and Garner took advantage of the opportunity, in 1967, to assess escape procedures in an SST configuration that would accommodate 280 passengers and 9 crew members. Those tests used exits of various dimensions and resulted in support for establishing the Type A exit (minimal opening 42" x 72") for wide-body aircraft, such as the 747, and eliminated the Type IV exits (minimal opening 19" x 36") as being too small. The model was also used for other outdoor evacuation tests until CAMI acquired a C-124 fuselage and an attitude positioner.

Emergency Evacuation: The CAMI Facility

In 1970, with the acquisition by Garner of the C-124 Globemaster fuselage, donated by the Oklahoma Air National Guard, and the installation of a positioning system (at that time, the only one of its kind in the world and, currently, with features of size and flexibility still not duplicated anywhere), emergency escape procedures could be tested under conditions where the angle of the fuselage, the interior environment, and the complements of passenger load could be varied. Since then, studies of ground level evacuations and those using slides have been conducted in CAMI's Aircraft Cabin Evacuation Facility (ACEF) to test various specific aircraft conditions including the dimensions of exits, aisle widths, seat configurations, separation of seat rows, location of seated passengers, location of exits, use of spiral staircases vs. a straight staircase with a single 180° turn in double-deck aircraft, role of flight attendants, presence or absence of smoke, and other conditions. All of these studies contributed to the validation of dimensions, configurations, and procedures directly pertinent to the emergency evacuation of aircraft. (Also relevant to safe evacuations is the work of CAMI's toxicology laboratory on flammability and heat-induced toxicity of the materials used in aircraft cabin interiors.)

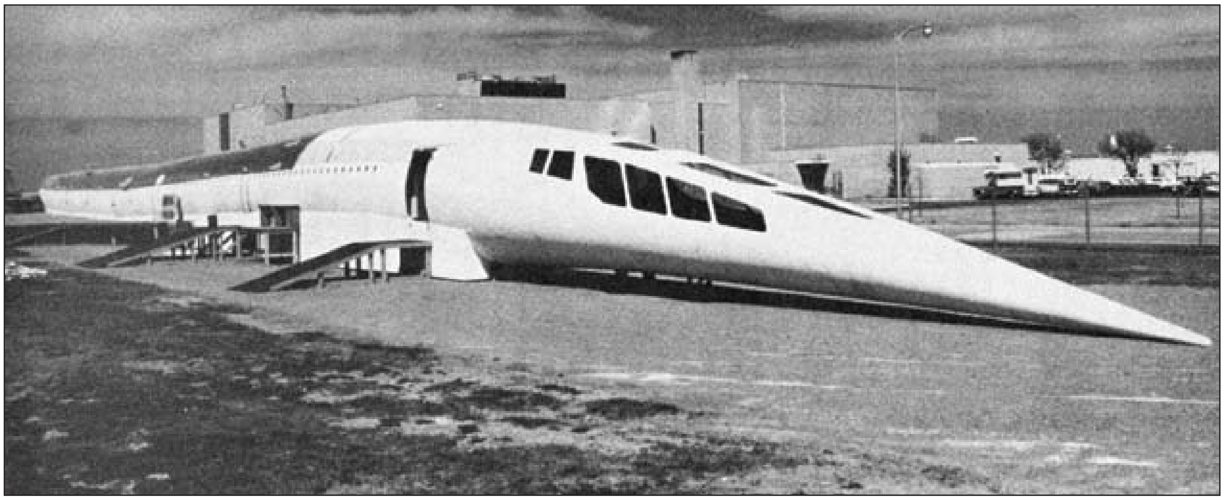
Useful Applications

A significant, related CAMI effort regarding emergency evacuation involves joint training and research agreements initiated by a member of the cabin safety team, Charles B. Chittum, with the USAF 552^{nd} Air Control Wing, begun in 1989, and with the USN Strategic Communications Wing, begun in 1993. Both military groups are located at nearby Tinker Air Force Base in Oklahoma City. Through 1999, Chittum provided, on a monthly basis, intensive aircraft emergency evacuation training (2 classroom hours plus 1 hour of experience in both a clear-air and a smoke-filled cabin); for their part, the airmen agreed to serve as research subjects for CAMI evacuation studies. By the time the 2000^{th} USAF airman had completed the course (1994), 500 of them had participated in three CAMI studies and another 8,000 "students" (from groups such as the American Association of Airport Executives, aviation medical examiners, Airport Travelers Aid, Explorer Scouts, high school and college students in aviation careers, and many others) had completed Chittum's program. To date more than 9,000 military airmen have been trained in the program, which is now conducted by Jerry R. McDown.

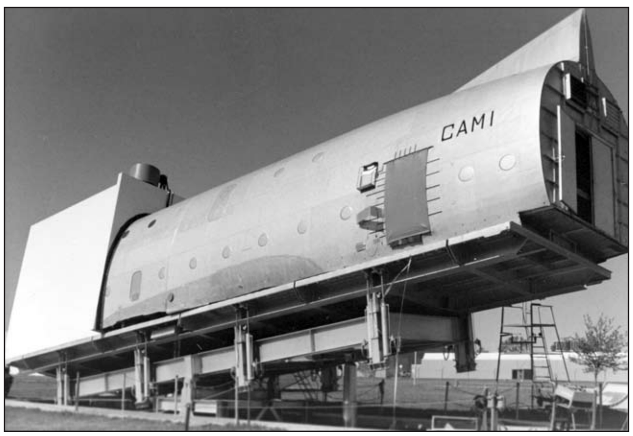
In 1964, the FAA crashed two "scrap" aircraft with dummies to test various survival issues.

THE "PHOENIX CRASH" TESTS

In 1965, a unique CAMI evacuation test (headed by J. D. Garner, below, far right) was conducted using one of the crashed planes.

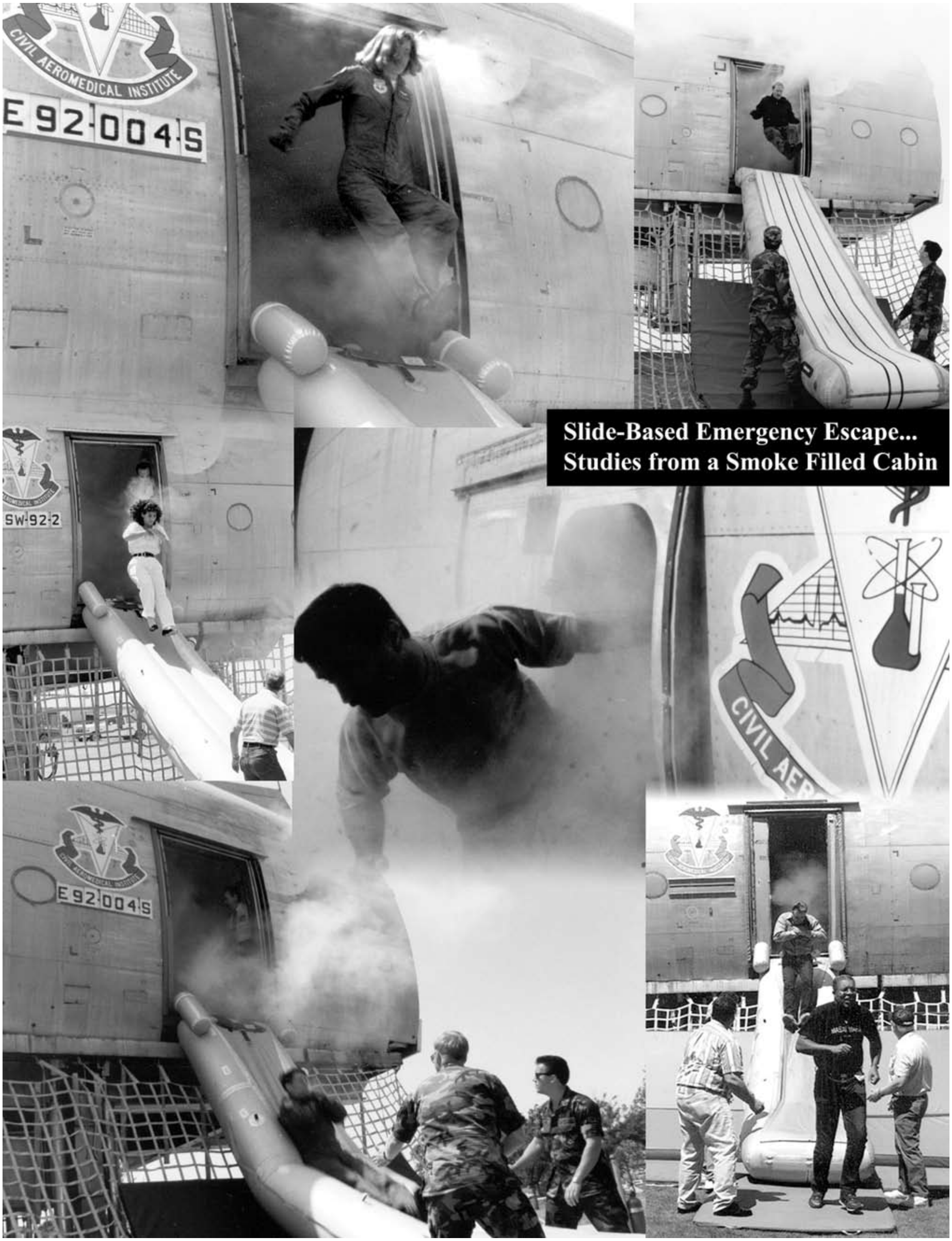


SST Escape Procedures



Getting Out. CAMI's unique Emergency Aircraft Cabin Evacuation Facility (ACEF) was developed with an eye to the future. The attitude positioner was designed to accommodate larger aircraft than the original Globemaster – i.e. wide-body jets. The first evacuation tests with the C-124 are shown here.

Ground-Based
Emergency Escape Studies



Slide-Based Emergency Escape...
Studies from a Smoke Filled Cabin

20,000 By 1999. Chittum briefed this group of aviation medical examiners prior to their experience in evacuating a smoke-filled cabin. By 1999, when he retired, groups of various sizes comprising a total of more than 20,000 persons had been exposed to his survival training.

Parenthetically, Chittum's evacuation training demonstrations and clearly delineated principles of survival were so well crafted and presented that his presentations became a focus for news media from around the country (particularly during TV's semiannual "sweeps week"). While CAMI's cabin evacuation capabilities had a long history of generating periodic media interest, 20 or so TV stations from various cities sent crews to CAMI through the '90s, and taped these briefings/demonstrations for showing as special evening news features on "surviving a plane crash." Additional teams taped Chittum's "how to survive" guidance for major network TV programs – Hugh Downs' "20-20," Peter Van Sandt's "CBS World News Tonight," Dateline, and a German TV news program, as well as People magazine, The Washington Post, and other media outlets. That safety information and assurance, based on CAMI research, reached millions of potential air passengers.

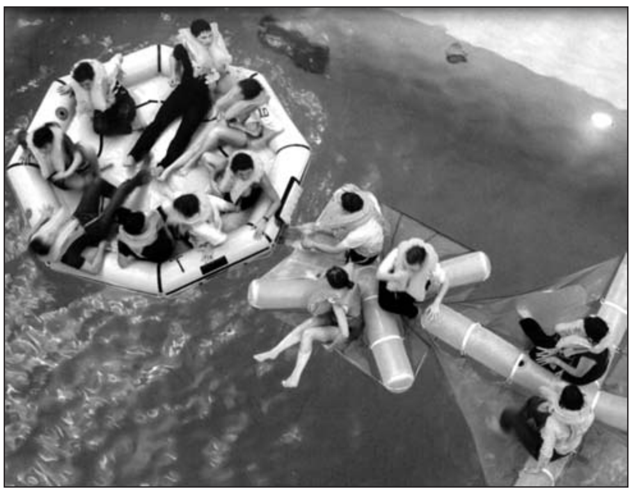
Another application from CAMI involved the 1975 development of Cabin Safety Workshops by Donell Pollard (whose background included experience as a flight attendant). The workshops were begun in earnest in 1976. Initially they were designed as a more efficient way of providing to frequent visitors from the airlines the type of safety and survival information they regularly sought from CAMI, and to make available to all the airlines specific useful information that each might have accrued individually (44). The concept became immediately popular with both the airline industry and the flight attendant unions. Thus, what was originally proposed as several small group workshops per year grew to several (sometimes more than a dozen) very large workshops a year with an average of 125 attendees annually (44). Ultimately there was participation from every U.S. airline and most major foreign carriers. The 3½ day sessions came to include the application of FAA policy, rules, and CAMI research. There was a structured exchange of information on airline emergency procedures, followed by related research findings presented by Pollard. (Pollard also used some of the discussion outcomes to suggest potential research questions to laboratory chief Chandler). Other topics included G-force dynamics and crash injury protection (restraint, bracing, and special needs of children), protective breathing equipment, and experience in the evacuation simulator (the smoke trials were considered particularly informative with regard to emergency lighting issues). These experiences were followed by physiological training (including altitude chamber runs), water survival, and presentations of other applicable research findings, including data from CAMI's aircraft accident investigators.

Attendees have included line flight attendants, emergency procedures instructors, pilots, crewmember union safety representatives, airline officers of several levels, FAA safety inspectors, and others with a specific interest in aviation safety. Pollard scheduled and conducted these workshops until 1987 when she transferred to FAA Washington Headquarters, but continued to participate in them until her retirement in 1999. Mark George, who had worked with her during 1984-1986, took responsibility for continuing the workshops, with her participation in selected sessions, until he joined the NTSB in 1998; he has been succeeded by David A. Palmerton.

Pollard also created a Cabin Safety databank, based on analyses of FAA accident/incident reports. The databank contained information on seat failures, slide malfunctions, occupant injuries during turbulence, evacuation related injuries, and other similar material. This information was used in the workshops and also in other FAA activities including policy development and research.

Water Survival

The conditions of a crash may require additional survival efforts after successfully evacuating a downed aircraft – as when a crash occurs in water rather than on land. CAMI's ditching pool provided McFadden with data regarding not only escape procedures, but also the efficiency of water survival equipment such as life rafts and flotation devices. Many other tests of rafts and flotation equipment were conducted in Oklahoma City area lakes by McFadden and his team. However, one set of studies was completed at Siesta Key, Florida – "laboratory" studies at the Mote Marine Laboratory using its captive sharks, and "field" studies in the See Sea, an underwater observation vessel of the Naval Undersea Research and Development Center, conducted in shark-infested wa-



Water Survival. Escape and survival equipment and procedures tested in the CAMI ditching tank ("pool"), on a clear lake, and in turbulent water.

ters off the coast of Florida. One particularly interesting finding was that sharks were attracted to some degree to the bright orange underside of rafts. McFadden's solution was to produce rafts with dark undersides and to replace some chrome and other reflective sections of life vests with black, non-reflective material.

Smoke Hoods

CAMI began developmental work on smoke hoods as early as 1965. This approach was designed to reduce or eliminate the likelihood of expiring from smoke inhalation while attempting to escape from a burning, downed aircraft. The specific genesis of these studies resided in two aircraft accidents within a one-year period in which a number of passengers who survived the impact died of smoke inhalation. A "get-me-out" device was the term used by McFadden to describe the purpose of this early work and the prototypes he designed and tested. In addition to providing a reasonable supply of air and protection from breathing smoke, the hoods would have to permit visibility and protect against both heat and fire. McFadden's confident demonstrations of one of his devices with a blowtorch applying a 1,200-degree flame directly into the face of the translucent hood covering his head were breathtaking. Although the hoods were not adopted for use at that time, interest was regenerated after the 1983 Air Canada in-flight fire that resulted in a landing at greater Cincinnati airport with half of the passengers dead from smoke inhalation. Then in 1985, 55 passengers died as the result of a fire aboard a Boeing 737 on the runway at Manchester, England. Those events spurred CAMI to conduct additional tests of more advanced designs. By the '90s, virtually all carriers had standard protective breathing equipment for crewmembers for fighting fires.

CAMI'S SMOKE HOOD INITIATIVES

Proof Testing. Successful evacuation tests of McFadden's early versions of a smoke hood were conducted in 1968 in an Aeronautical Center hangar using a borrowed commercial aircraft to provide a type of "proof of concept."

(Below) Following a resurgence of interest almost two decades later, additional tests were conducted in 1987 using CAMI's ACEF facility; smoke hoods had attached air supplies and the evacuation route involved small escape doors. Laboratory studies by McLean in 1989 assessed the integrity of the hoods by measuring respiration and heart rate while the wearer was stationary and during exercise in a chamber that exposed the wearer to gas combinations (oxygen and sulphahexafloride).

True Believer. McFadden's demonstrations of the capabilities of his smoke hoods to withstand heat and fire were memorable as well as convincing.

Smoke, Darkness, and Emergency Lighting

Thorough tests of lighting schemes to aid passengers in evacuating a downed aircraft that is dark and/or smoke-filled were significant CAMI contributions to improving safety. Around 1974, Garner and McFadden had apprised George Plumly, a successful Fort Worth, Texas, engineer/inventor with expertise in lighting, of the need for a lighting system that would significantly improve passenger evacuation rates in smoke-filled aircraft cabins (28, 34). Plumly agreed to explore the idea at no cost to the government and began an informal, intermittent working relationship with CAMI that lasted a decade or more.

Because the industry seemed reluctant to mount any system on the floor (perhaps because of perceived issues related to maintaining system integrity), Plumly (who's Plumly-F and Plumly-FX lighting systems had, by 1975, shown superiority to other systems) and CAMI (between 1979-1981) initially tested, in smoke-filled cabin conditions, a variety of spotlights, strobe lights, and self-illuminating markers, located at or below the cabin midpoint as well as lights in seat arm rests, and found them to be ineffective (43). These same elements and others, including strip lighting on the floor, were later tested at the FAA Technical Center facility using smoke from burning jet fuel in a totally gutted aircraft interior with an observation booth at each end of the cabin, including closed circuit television, and motion and still pictures (15). Because dense smoke in a cabin rises and stratifies, and its vision-restricting concentration takes longer to reach floor level, the foregoing sets of studies indicated the need for illumination in close proximity to the floor to aid passengers in exiting quickly and safely. (Parenthetically, as part of his last project before retirement in 1979, Garner had explored the utility of floor lighting by [shades of the old CAMRL!] placing flashlights along the aisle floor.) Then, in November 1984, Plumly conducted some "unofficial" smoke tests on a 20-foot functional prototype of his floor strip-lighting unit – the Plumly Advanced Egress Lighting System – in a static Boeing 707 at the FAA Technical Center followed by three sessions at CAMI, two of which followed installation of a complete floor strip system in the cabin simulator (42). While these tests were not described in any government research reports, they were described in formal reports by Plumly Airborne Products, Inc., (42), and the CAMI outcomes were observed by a number of interested parties including representatives of the American Society of Illumination Engineers and an FAA rule-making team (8).

Prior to the CAMI sessions, the FAA rule-making team, headed by Henri Branting (16), had participated in one test of a proposed solution to the egress problem: a small point of light, located on the armrest of each aisle seat. During the test conducted in pitch darkness, the FAA team's walk-through convinced them that such an arrangement was not effective. It provided no depth perception and gave the impression that each step was into a black hole (4). The later tests of the installed floor lighting and other lighting arrangements, provided to Branting on two occasions by Chittum and Chandler, used CAMI's smoke evacuation paradigm. CAMI's work showed that "passengers" could follow the floor lighting in a smoke-filled cabin and could recognize the exit from the aisle.

Those practical CAMI evacuation demonstrations in dense smoke influenced the Branting team positively regarding the value of floor strip lighting and gave them

Floor Lighting Works. As a cabin fills with smoke, it stratifies from the ceiling down. Thus, upper level emergency lighting is obscured well before the floor-lighting "pathway" to an exit.

Diversity Matters. (above) Safety procedures for emergency evacuation of the physically challenged and equipment that accommodates the youngest and the oldest have been studied. Pictured below are McFadden with one of his flotation devices for children and Snow testing force capability for push-button seat belt releases.

How Should "Precious Cargo" Be Carried in Emergency Evacuations?

"the confidence to proceed" with the implementation of the final rule (4). Floor proximity lighting became mandatory in 1986. But that did not end CAMI's interest in the area; with advances in photochemistry, the feasibility of using modern photoluminescent materials as lighting sources was re-evaluated by McLean in 1998.

The Young, the Old, and the Handicapped

Swearingen, Chandler, and Gowdy all worked with children as a special-need group with regard to seat/restraint integrity and all pioneered in the development and use of child dummies in aircraft crash protection studies. However, in addition to impact and evacuation studies, other CAMI research has focused on small children. For example, McFadden's work with flotation devices included special studies of the needs of infants and small children (air carriers did not then carry infant devices; a few now do). While buoyancy and stability are critical characteristics of any flotation equipment, infant flotation devices require reliable self-righting. McFadden's assessment of then-current life preservers for children indicated adequate flotation and stability in the unperturbed water of a test pool, but relatively simple movements (such as raising the arms above the head) could be sufficient to change a small child's center of gravity and cause the child to rotate and perhaps submerge its face. Another issue was water temperature. Compared to adults, small children exposed to cold water have a significantly reduced survival time because of their low total body weight (and, therefore, low body specific heat) and their large surface area per unit of body mass (2-3 times that of an adult).

Thus, McFadden went about creating devices that would address the needs for buoyancy, stability, self-righting, and thermal protection, as well as providing ventilation, impact protection (tested by a required self-righting of the device containing a dummy when released in an inverted position from cliffs 13-21 feet above the water), and protection against predatory marine life. McFadden evaluated various types of infant flotation equipment that he devised using an available anthropomorphic dummy, representative of a 3-year-old, and dummies that he developed to represent children from 4 months to 2½ years of age. Data from Swearingen's studies of the centers of gravity of small children and of infants were central to this process. McFadden's work provided a template for safe infant flotation designs. Later work with flotation equipment was headed by Gordon Funkhouser.

Evacuation studies have also dealt with small children, as well as the elderly and the handicapped. While elderly subjects have routinely been a part of the passenger age mix in most of CAMI's evacuation studies, special attention to infants and small children began with Garner in the mid '60s and continued with preliminary work by Chittum (unpublished data presented at a national meeting on child safety) followed by a recent set of studies by Cynthia L. Corbett. The first of this set evaluated evacuations using a single lane slide from a Type I exit; the second assessed the safety techniques for evacuating an infant through a Type III overwing exit. These studies used dummies representing children between 2 and 24 months of age and led to the identification of appropriate procedures and guidelines to recommend to passengers with infants.

Model Worker. Funkhouser working with one of CAMI's specially constructed child dummies in assessments of the performance of various flotation devices for infants and children. In addition to performance in the water, design features, such as strap locations, may influence donning time (which would require the assistance of a parent or other adult) – another critical safety issue.

Tough Sliding. An FAA employee wearing a faux cast tries to navigate an evacuation slide.

With respect to the handicapped, land evacuation studies have included the blind, with and without canes, and persons with a variety of other physical and mental conditions that might influence safe evacuations. Such subjects were recruited through various local organizations (e.g., the Oklahoma League for the Blind). In addition, various types of handicaps were simulated by FAA employees or other nonhandicapped subjects (e.g., by wearing faux arm or leg casts) and by the use of dummies that other "passengers" would have to "assist." Issues related to aisle widths, seat sizes, seating arrangements, floor slope, grouping of passengers, and other evacuation features were evaluated.

CAMI's 747. First Uses: (above) TSI training and (below) NASA's turbulence study.

New Thrusts

An additional research tool was added to the protection and survival programs in the late '90s. As part of an approved capital project headed by Jerry R. Hordinsky, M.D., (then head of the aeromedical research division), a retired Boeing 747 was procured and refurbishing begun under the direction of engineer Jeffrey H. Marcus who replaced the retired Chandler as head of the protection and survival laboratory. (Marcus was also overseer of the installation at CAMI of the United States' first – and clearly most advanced – new altitude chamber in 25 years). Refurbishing of the aircraft was completed in 2001 with some new lines of work defined by James E. Whinnery, Ph.D., M.D., the new Aerospace Medical Research Division chief. One of the new directions involves the capability of research on cabin airflow that will permit the assessment of air quality (e.g., dispersion of microorganisms and of air contamination from internal and external sources - including acts of terrorism).

The facility has already been used by the protection and survival staff (now headed by Robert Shaffstall) in support of a NASA contract to develop an early warning system for detecting air turbulence; that study determined times required to secure a passenger cabin following an air turbulence warning. The facility is also in periodic use as a training vehicle in support of courses conducted at the adjacent Transportation Safety Institute (TSI); that TSI training includes security personnel (dealing with potential hijackers and unruly passengers) and aircraft accident investigators.

Another new thrust deals with the establishment of bioinformatics research in which computer databases and models are being developed for the simulation of crash dynamics, cabin evacuation, cabin air flow, and the reconstruction of aircraft accidents and aerospace incidents. (The latter approach has similarities to that of CAMI's SATORI, used in investigating air traffic control operational errors and incidents.) An additional bioinformatics effort is the development of methods for analysis of large data sets – an approach that will have application to aeromedical certification in addition to protection and survival areas.

Another particularly timely area of new work was the assessment of the effects of laser lights on pilot vision and control of aircraft. Van Nakagawara, O.D., has examined both the clinical aspects of laser light exposure as well as the subjective effects of exposures (below levels that might cause tissue damage) on vision and operational performance in the Aeronautical Center's Boeing 727-200, Level C, full motion flight simulator. Nakagawara's work with issues related to laser lights beamed from the ground into cockpits during night-time flight operations was undertaken based on the accumulation of some initial reports and well before such dangerous events attracted national media attention. As a result of identifying the magnitude of the problem early, timely CAMI information and suggestions were available to the FAA and the Department of Transportation. Levels of laser light that would be unacceptable at different stages of flight were defined to assist in developing safety precautions. ❒

Air Traffic Controllers: Stress … and Sleep

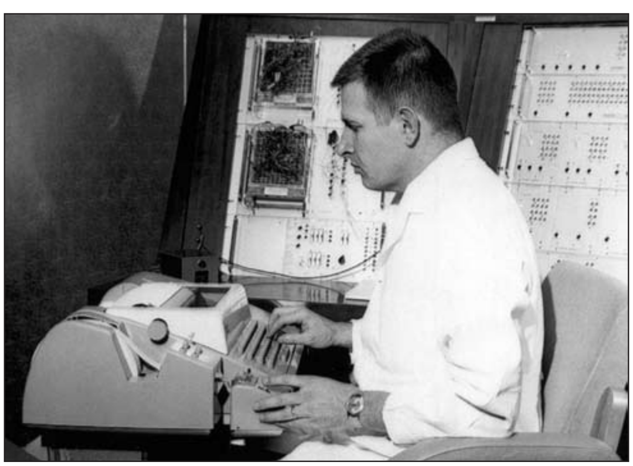
The Issue Was Job Stress

During the '70s, concerns regarding passenger safety, perceived work stress associated with the air traffic control occupation, and controllers' mental states became a media focus ("Sweaty Palms in the Control Tower" was the title of one such article during that time) and a major labor issue (11, 36). A team of CAMI physiologists, led by Carlton E. Melton, Ph.D., and a CAMI psychologist, Roger C. Smith, Ph.D., combined to perform an array of on-site studies that ultimately included a total of 402 air traffic control specialists (ATCSs). The studies embraced different types of air traffic facilities and permitted comparisons between them and between different shift schedules, different traffic volumes, and the effects of introducing ARTS-III.

Physiological tests were extensive and complemented by psychological assessments of job attitudes and of perceived stress. Data obtained included ambulatory electrocardiograms (ECGs), urine samples analyzed for 17-ketogenic steroids, epinephrine, norepinephrin, and creatinine, fatigue check lists, and questionnaires regarding medication usage, physical complaints, and sleep reports. Physiological results showed clear stress effects related to periods of increased traffic volume (i.e. increased workload) both within and between facilities, but no pervasive or unacceptable levels of general "stress-induced" outcomes.

The psychological tests resulted in profiles that showed controllers to be particularly well-suited to their occupation; their work preferences tended to be for moderate-to-heavy traffic rather than for lighter levels. They liked the difficulty of the work and the constant traffic change. They did not like light traffic, night shifts, and management. The research effort was wide-ranging. It included field studies at 22 air traffic facilities including the O'Hare air traffic control tower and facilities in

Measuring Stress. (above) Air traffic controllers were monitored for stress while performing their daily jobs; the device worn by this tower controller provided electrocardiographic information. (below) Melton with physiological data recordings and (below, l) Smith during analyses of job attitude and stress survey data.



Atlanta, Miami, Los Angeles, Oakland, Roswell, Oklahoma City, and others.

The sum of these studies documented anticipated physiological differences both within and between facilities related to variations in workload (e.g. by traffic count and radio transmission time). These differences appeared to be related more to general work activities than to excessive levels of stress associated with air traffic control work in particular.

Sleep, Performance, and Work Schedules

Intimately imbedded in the stress issue was the question of shift schedules and sleep. This relationship is particularly pertinent to the air traffic occupation since enroute and terminal facilities frequently use a 2-2-1 shift (2 afternoons, 2 early mornings, and 1 midnight shift), a 2-1-2 shift (without a midnight shift), or a combination of both. These shifts are characterized as being "rapid turn-around" counter-clockwise shifts that make unlikely, if not unattainable, a full 8 hours of sleep before at least one shift a week (usually the midnight shift). It should be noted that, while most experts on work schedules consider the 2-2-1 shift to be undesirable, controllers given the choice of shift patterns often select the 2-2-1 because it provides the equivalent of 3 days off per week. However, in addition to health and stress issues, the rapid turn-around shift schedule involves circadian periodicity and begs the question of quality of performance and safety.

Early CAMI laboratory studies had examined the effects on sleep itself of exposure to simulated sonic booms and the "jet lag" type performance effects of shifting sleep periods, while still others measured the performance effects of depriving individuals of a night's sleep or more. Sleep deprivation of this sort had clear negative effects on the performance of laboratory tasks.

At "Home"…. Studies in CAMI's laboratories assessed performance with the Multiple Task Performance Battery and the sleep effects of counterclockwise rotating shift schedules.

… And "Away". FAA air traffic controllers from the Miami Center and U.S. Army and U.S. Coast Guard subjects worked with Della Rocco on the field studies of rotating shift effects and the introduction of scheduled napping.

However, in the '90s, Pamela S. Della Rocco, Ph.D., initiated a set of laboratory and field studies to evaluate the potential need for and utility of fatigue countermeasures in air traffic control shift scheduling. The laboratory studies included assessments of performance, sleep, core body temperature, and neuroendocrine measures for conditions simulating counter-clockwise rotating shifts. The field studies were collaborations with the U.S. Army Aeromedical Research Laboratory (USAARL); testing was conducted at the Miami Air Route Traffic Control Center using FAA air traffic controllers, at USAARL using Army air traffic controllers, and later, in assessing duty-rest issues at Cape May, New Jersey, using volunteer Coast Guard pilots as subjects.

One feature of those studies was an assessment of some ways to counter potential fatigue effects from reduced sleep times, viz., the separate effects of structured napping (20 minutes, 45 minutes, and 2 hours) and of mild exercise. While the latter had no beneficial effects (perhaps the exercise was too mild), napping had some positive consequences. However, the napping also induced "sleep interia" in some subjects, i.e., a period of grogginess for a while after waking. An appropriate waiting time between waking and working remains to be determined. From the study with FAA controllers, subjective reports indicated that controllers were the most sleepy during the drive home following the midnight shift. Lab and field data indicated that the least sleep occurred prior to the midnight shift.

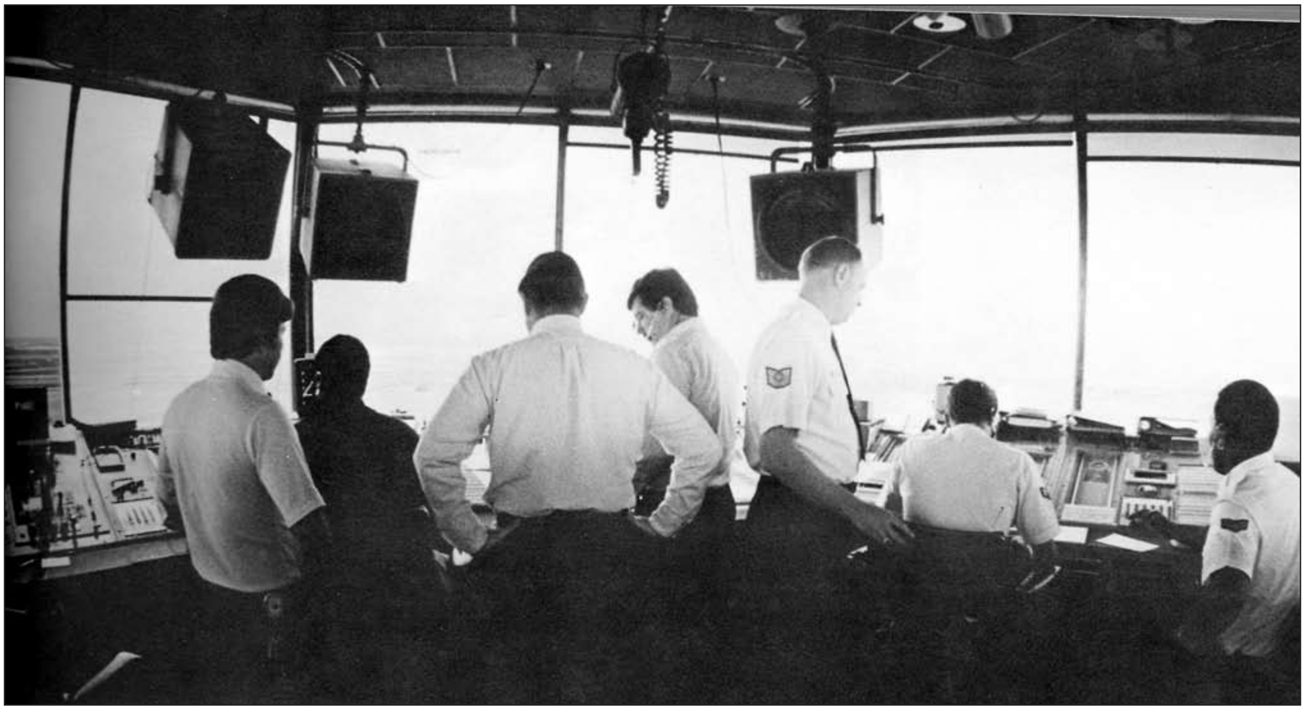
Congressional interest in controller fatigue led to special funding for the conduct of a shift work and fatigue survey of the controller workforce plus a laboratory study and field research. With input from a scientific panel and an FAA/NATCA (National Air Traffic Controllers Association) work group, CAMI researchers developed an extensive shift work and fatigue survey that was distributed to all controllers in 1999.

The survey effort used a modified version of the Standard Shiftwork Index, an established, comprehensive survey that encompassed shift work history, sleep and fatigue, health and well-being, social and domestic situation, coping strategies, circadian type, and demographics. The Index was modified by CAMI to incorporate current ATC shift-scheduling practices and to facilitate distribution to the entire ATCS workforce. Feedback to each controller included summary results and a multimedia CD ROM, entitled Shiftwork Coping Strategies (10), developed under the guidance of Della Rocco, along with Thomas E. Nesthus, Ph.D., and Crystal Cruz. The CD provided information concerning the effects on fatigue and performance of working a rotating shift schedule and identified ways to improve adaptation and reduce the amount of fatigue associated with working such schedules.

The field study, dubbed the Air Traffic Shiftwork and Fatigue Evaluation (AT-SAFE), was designed to provide empirical data regarding the effects of shift work and shift scheduling on ATCSs and to corroborate the results of the Shiftwork Survey. Data from a Tower/TRACON and an Air Route Traffic Control Center (ARTCC) included: entries into the daily logbooks by the volunteers throughout the 21-day study period (sleep duration, quality of sleep, subjective mood, and sleepiness); measures from wrist activity monitors worn by the volunteers 24 hrs a day to provide corroborative data of sleep duration; and cognitive performance (via CogScreen – Aeromedical Edition).

The laboratory study, headed by Cruz and Nesthus, evaluated clockwise and counter-clockwise rapidly rotating (2-2-1) shift schedules. A direct comparison of the 2 different rotations resulted in reports indicating that the direction of rotation did not affect performance when it came to working the last shift of the week (i.e., the midnight shift). Thus, CAMI's circadian studies have contributed information from both laboratory and field studies, clockwise vs. counter clockwise shift rotations, and effects of scheduled napping and other countermeasures on subjective alertness and measured performance…and provided controllers with coping strategies. ❒

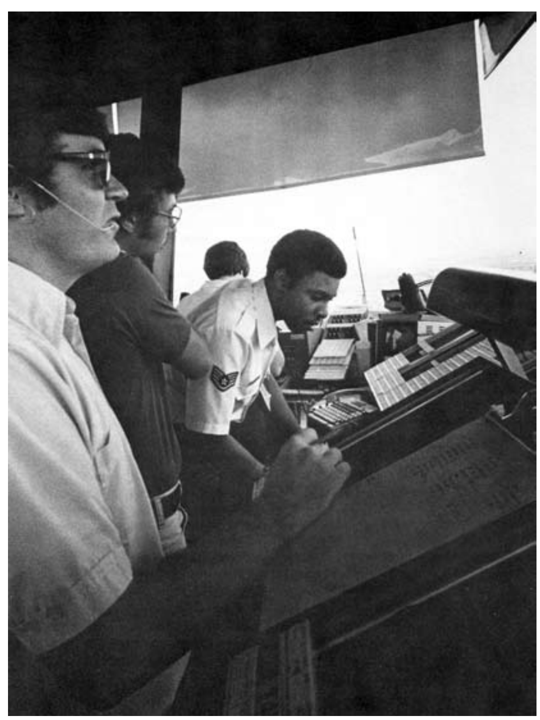
An Agency Crisis: Recovery … And CAMI Shines



The Strike

In 1981, an historic labor-management and labor law crisis hit the agency – the illegal strike by more than 11,000 air traffic controllers, who were subsequently fired by U.S. President Ronald Reagan. "Strike recovery" imposed immediate, severe, operational requirements (despite curtailment in the amount of traffic) that included the very demanding daily handling of air traffic by a much smaller than needed contingent of controllers supplemented with supervisory and managerial air traffic personnel who went back to the "boards" … and by some military controllers. It also required major infrastructure changes under intensive time pressures – viz., selecting, training, and hiring thousands of new controllers at a significantly faster pace than ever before while maintaining aviation safety. And CAMI played a key role by increasing its existing partnership with the FAA Academy via the selection and training research psychologists who had succeeded Bart Cobb. One of those researchers, James O. Boone, Ed.D., was recognized as pre-eminent by the FAA Administrator, was assigned to his staff (as FAA-1B), and moved to Washington, D.C., where he participated in the hiring plans and provided statistical projections for decision-making regarding ATC applicants and their training; he later became involved in new agency approaches to management training and ultimately participated in a variety of other high level agency policy groups.

Into the Breach. Only hours after the air traffic controller strike began, military controllers joined with FAA supervisors, non-striking controllers, and retired controllers who volunteered to return to duty, at air traffic facilities including JFK International (top) and Chicago O'Hare Tower (lower). Ultimately, 850 military controllers participated in maintaining air traffic safety in 13 major cities (46).



Contributing. Boone (l) leading a strategy session and VanDeventer (r) providing data-based direction to Washington staffers.

During early 1981, ATCS student loads at the Academy were low. Following the strike, both the Academy – and CAMI – were pressed to respond to greatly increased student inputs and, ultimately for the Academy, a 3/shifts/day training schedule to meet a goal of providing 7,000 Academy graduates to the field by December 1983. Outstanding direct local support on a daily basis was provided by CAMI to the Academy, first by Alan D. VanDeventer, Ph.D., and subsequently by Carol A. Manning, Ph.D. That support included close monitoring of the subjective ratings of Academy laboratory performance, predicting the proportions of ATC applicants who would pass selection tests at various score cut-offs, the proportions that would subsequently pass the Academy pass-fail training, and predicting pass-fail consequences of modifying the curriculum. CAMI quickly established itself as a major contributor by predicting almost exactly the failure rate for the first post-strike classes (for which the immediate need required selecting many candidates from old hiring registers that held a reduced range of qualifying scores).

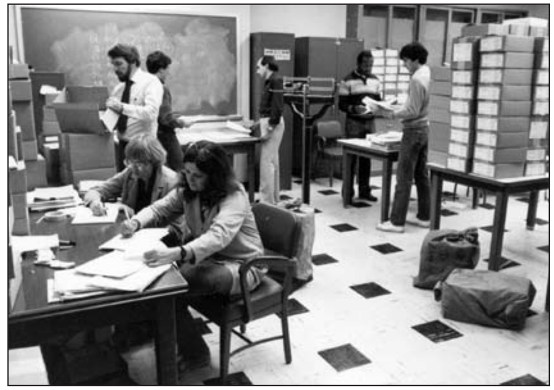
Another area of psychological contribution by CAMI was related to congressional, other governmental, and press concerns about the potential impact of the new "stress problem" in air traffic control (in the late '60s and early '70s, the problem was the well-publicized notion of a uniquely stressful nature of the occupation itself and its alleged psychiatric implications – a concern that CAMI's psychological and physiological research findings helped to dispel). In the context of the extended work hours and work weeks required of controllers for strike recovery, concerns for safety were expressed about fatigue and "burnout." As a partial response to these concerns, CAMI introduced and conducted stress management lectures at the FAA Academy for all incoming developmental ATCSs from mid-1982 to mid-1986. The lectures were also video taped by the Air Traffic Service for use at field facilities around the country.

The safety issues and governmental significance of the recovery process, along with concerns for gender and racial fairness, led the Academy to be subjected to additional considerable pressures and scrutiny by congressional as well as agency groups and the media – and the CAMI researchers provided many of the statistical, data-based briefings to those groups. The strike recovery effort was eminently successful and CAMI's significant contributions received notable recognition.

Telling It Like It Is

But that effort was only part of the impact CAMI's work would have on the FAA and its organization. Investigative groups that looked into the causes of the strike recommended strongly that the agency have better information about its employees, their needs, and their views. In a contracted study of the air traffic control occupation conducted prior to the strike recovery period, the so-called Rose Report had concluded, among other findings, that the ATCS job was not "uniquely stressful" and that what was significant was not so much the job (i.e., controlling traffic) but, rather, the context in which the job was done. Some related findings by the "Jones Committee" (an out-of-agency panel of consulting experts appointed subsequent to the strike) led agency management to look more closely at how management was interacting with its employees.

Thus, in the early spring of 1984, FAA Associate Administrator Charles Weithoner approached William E. Collins, Ph.D., then head of CAMI's psychology laboratory, for help in developing, administering, and reporting results of an Employee Attitude Survey under conditions of significant time pressure, funding limitations, and organizational tension. The entire agency workforce – then



An FAA Turning Point. *CAMI's start-to-finish role in the first in-depth Employee Attitude Survey of the entire FAA work force began (above) with developmental consultation with Saul B. Sells, Ph.D., (a noted survey specialist) and the sending and receiving of survey forms; scoring and collating (l), reading and coding comments (r); and (below) analyses of data, report preparation, and presentations at Washington Headquarters. The success of that effort was regarded as an "organizational turning point" for the agency.*

47,097 employees - was to be surveyed. The laboratory focus was redirected in support of that goal.

Under David J. Schroeder, Ph.D., a CAMI team (and, on some occasions, the entire laboratory) responded by not only developing, refining, and pre-testing an extensive questionnaire, but also arranging for its printing and mailing through Aeronautical Center services, receiving completed forms, scoring them, analyzing results across a variety of groupings and categories, and preparing final printed reports for the overall agency and for each FAA region independently – with complete confidentiality of respondents and in what the agency lauded as record time. The survey included a comments section and 66 direct ratings of satisfaction with various aspects of the job, the agency and its policies, and various levels of management … as well as "burnout" – a contentious issue at that time.

In November of 1984, Collins was designated as the scientist to report and interpret the findings to the Administrator and his management team and (during two sessions on the next day) to FAA Washington employees (26). Because of the extraordinary tensions within the agency, those were the first occasions that anyone outside of the CAMI survey team was made aware of any survey result. Later, invited presentations were made to regions (comparing regional and national results) and at national meetings (e.g., of air traffic managers). Also, every employee received a copy of the survey results. While the employee ratings and comments were not all that agency managers had hoped they would be – and some had initial difficulty in accepting the data – the agency developed plans (and updated them with each subsequent survey) to improve aspects of the organization and of work environments based on the results. That included steps to improve "the context" in which the air traffic control and other jobs were done in the agency by establishing an office for an activist associate administrator for human resource management, encouraging employee participation groups, taking other actions designed to improve the work environment and the management of employees (e.g., revamped management training – to which Boone, and later VanDeventer, contributed), and effectively institutionalizing the employee attitude survey.

The confidence of agency management in this CAMI survey product and its interpretation is reflected in the continuation of the survey process approximately bi-annually to date (e.g., 27) - and the continuation of CAMI as the focal point for survey development and analysis. Although made available to all employees in numerous reports, survey data were not published in the OAM series until 2004; Carla Hackworth, Ph.D., now heads that work. For the past decade or more, survey results have been used as one of the agency's prime indicators of its degree of success in meeting its organizational goals within the Department of Transportation. And that confidence in the performance of CAMI psychologists, from the strike through the recovery, helped lead to the selection of VanDeventer and Deborah Clough, Ph.D., (in addition to Boone) to positions in Washington Headquarters. Moreover, it was a major factor in the encouragement from the agency's associate administrator level that contributed to making the psychology laboratory a separate research branch (now the Human Factors Research Division) in the Institute. It also stimulated the subsequent recruitment of additional Ph.D. psychologists by Washington offices, most prominently in the area of human resources.

Skyjacking and Terrorism

Significant contributions to other national aviation crises were also made by CAMI and Office of Aviation Medicine psychologists. During the late 1970s, when a worldwide rash of aircraft "skyjackings" occurred, John T. Dailey, Ph.D., at Washington headquarters, was primary in the development of a behavioral profile to assist the airlines in identifying potential hijackers. CAMI's contribution to the skyjacking issue came when Roger C. Smith, Ph.D., a clinical psychologist, was tapped to provide some of the initial screening, at Fort Dix, New Jersey, for the newly organized Federal Air Marshal Service. Subsequent to the 2001 terrorist attack in New York City, CAMI's current clinical psychologist, Raymond King, Ph.D., along with Schroeder and Edna Fiedler, Ph.D., were involved during 2002 in the psychological screening of the post-9/11 air marshal applicants, at facilities near Atlantic City, New Jersey. ❐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Forensics: Fatal Accidents ... Their Toxicology and Biochemistry

Making a Living. Based on their exposure to pesticides, aerial application (crop duster) pilots were a major CARI interest .

An initial focus of CARI's aviation toxicology laboratory centered on exposure to pesticides and safety concerns for crop duster pilots. Strong support was provided by the aviation physiology laboratory through a number of studies documenting the bodily effects of exposure to those pesticides in major use. Paul W. Smith, Ph.D., original head of the toxicology laboratory, took the lead in defining the hazards of various substances used by such pilots and in promoting guidelines and providing lectures to groups of agricultural pilots.

A later, more enduring research focus was a shift to an emphasis on assessing aircraft cabin and cockpit materials (e.g., panel or seat coverings), for the potential toxic effects of thermal degradation of the materials due to fire. The inhalation toxicity of flame-retardant materials when subjected to fire and heat was an early research thrust led by Charles R. Crane, Ph.D.; with new materials being generated quite regularly, that line of research has continued to date. The subsequent work by Arvind K. Chaturvedi, Ph.D., and Donald Sanders has involved experiments with recently developed, unique sets of combustion assemblies and exposure chambers to determine the combustion toxicity of the newer polymeric materials now used in some aircraft and of other materials proposed for such use.

Accident Research

When the small accident research team that went on-site to general aviation accidents from the Protection and Survival Laboratory was moved to the Aviation Toxicology Laboratory, a more direct, wider-scope involvement with fatal accidents began. That involvement came to include participation by William R. Kirkham, M.D., who succeeded Smith as head of the toxicology laboratory and earned from the local media a nickname of "Quincy" (the title character in a popular TV series on medical forensics). At first, accident research teams made trips to general aviation accident sites. Later, the NTSB invited CAMI researchers, such as Stephen J.H. Veronneau, M.D., to participate in some on-site investigations of commercial accidents. CAMI scientists, led by Charles A. DeJohn, M.D., now maintain full records and accounting of major fatal accidents and explore the data to define medical and toxicological areas of potential concern.

CARI/CAMI's toxicology laboratory has long conducted analyses of blood and tissue samples from fatal general aviation accidents; the major early interest was with respect to the involvement of alcohol. Samples were provided from around the country via the well-known

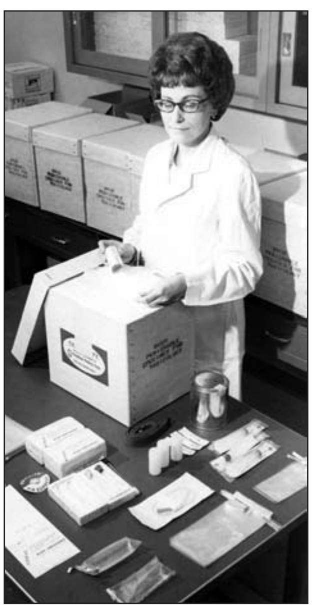
Fire and Smoke. Crane determined inhalation toxicity of various aircraft cabin materials.

GA Accidents. Early CARI on-site accident research teams participated only in general aviation aircraft accidents.

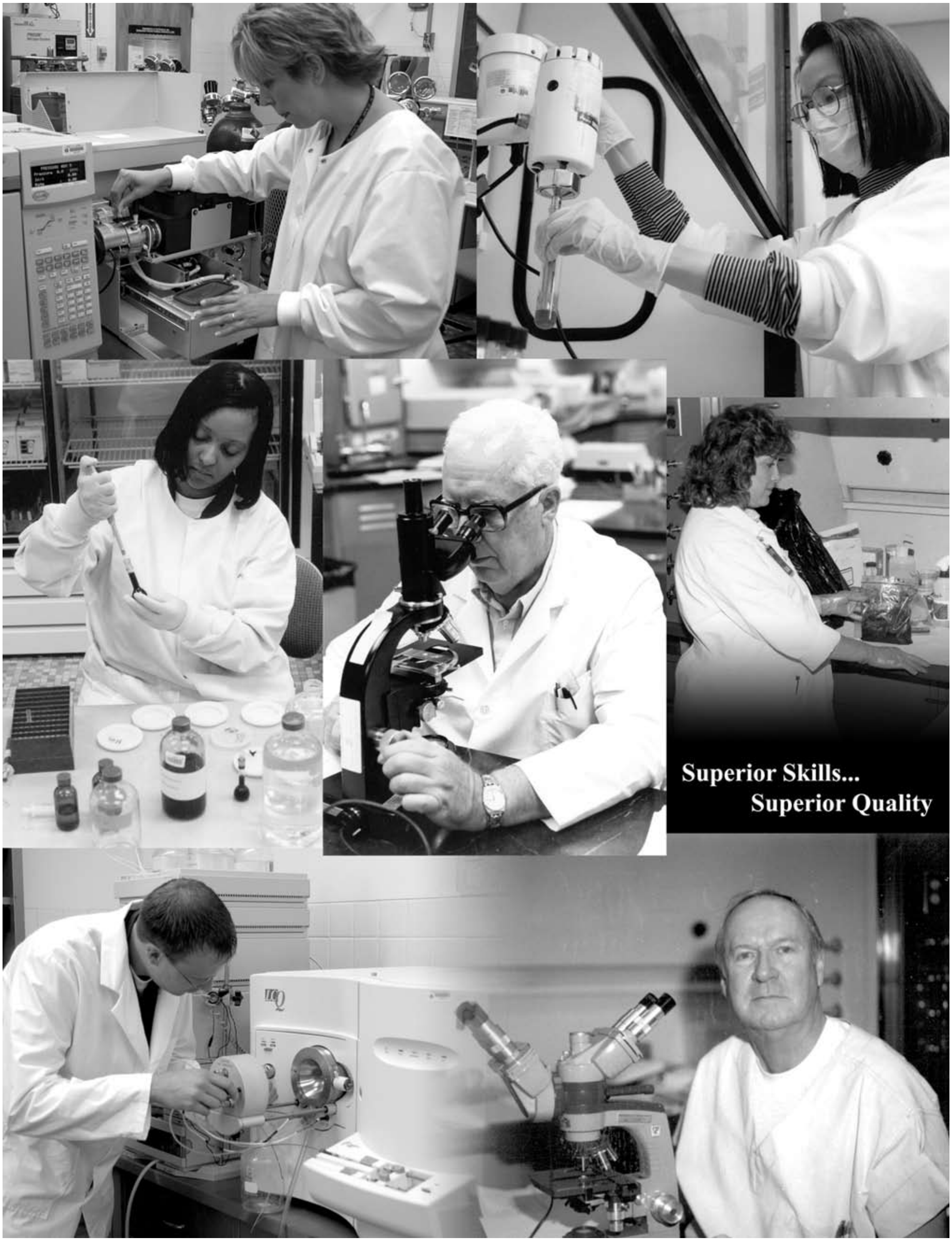
CARI/CAMI "tox boxes" provided by the Institute to all Flight Standards District Offices (FSDOs). The FSDO, in addition to a variety of responsibilities including pilot and aircraft certification issues, investigates general aviation accidents and is sometimes assisted by FAA-designated aviation medical examiners (all of whom perform pilot physical examinations and some of whom voluntarily go to local accidents to help obtain data).

Forensic Quality

CAMI's current aeromedical research in forensic toxicology runs the gamut from highly technical but pragmatic work under Russell T. Lewis, Ph.D., on analyzing human blood and tissue samples from fatal aviation accidents for the National Transportation Safety Board (NTSB), to the development of DNA techniques to differentiate ingested alcohol from alcohol that naturally develops from the putrefaction of human tissues, to methodologies for detecting a variety of drugs. CAMI's continued contracted designation by the NTSB as its primary laboratory for performing state-of-the-art toxicological analyses of fatal aviation accidents (dating from 1986) and of fatal surface accidents (dating from 1998) attests to the quality of the laboratory. That quality is further validated by the laboratory's successful renewals of accreditations by the American Board of Forensic Toxicology and by the College



Accidents and the "Tox Box". CARI/CAMI's famous "tox box" kits at Flight Standards District Offices contain instructions and materials to obtain samples from a fatal aircraft accident to be packed and shipped to CAMI for analyses. Precise documentation of all evidence received by CAMI is carried out in a modern accessioning laboratory.


Superior Skills...
Superior Quality

NTSB CALLS. During the 1990s CAMI scientists were invited by the NTSB to participate in their accident investigations. Three CAMI employees (Gale Braden in 1976, Mark George, above, in 1998, and Jeffrey Marcus in 1999) have moved from the Institute to positions with the NTSB.

QUALITY ASSURANCE. Chaturvedi prepares proficiency testing specimens for use both in CAMI's quality assurance programs and for the national program he manages. In 1995, he organized a successful International Colloquium on Advances in Combustion Toxicology hosted at CAMI. The proceedings were published in the journal Toxicology.

of American Pathologists – the only laboratory in the world accredited by both organizations. The accreditation program is managed by John W. Soper, Ph.D.

As another means of assuring excellence in quality control, CAMI houses the nation's only proficiency testing program in the field of postmortem forensic toxicology. More than 30 forensic toxicology laboratories around the country regularly participate in this unique CAMI program (initiated and managed by Chaturvedi) that checks the proficiency of analyses of postmortem biological samples.

World Class Capability

The toxicology laboratory was redesigned beginning in 1989 and updated to its present state-of-the-art level by Dennis V. Canfield, Ph.D., culminating in the present major forensic thrust of the (renamed) Bioaeronautical Sciences Research Laboratory. Its world-renowned capabilities in blood and tissue analysis for the NTSB include precision tests for a myriad of drugs as well as alcohol. Blood tests at CAMI can help determine whether aircraft occupants died from an exhaust leak producing carbon monoxide or whether the plane had an in-flight fire prior to crashing. Basic research to improve drug detection and to distinguish, via DNA, ingested alcohol vs. postmortem alcohol has been led by Chaturvedi.

And a more recent investigative initiative involved the formation of a functional genomics team that conducts gene expression research. This team combines analyses of genetic information with computational methods to assess networks of environmentally responsive genes that signal physiological fatigue and performance impairment following exposure to aeromedically significant stressors. Such stressors include hypoxia, alcohol, drugs, and jet-lag fatigue. Research applications include aeromedical certification as well as post-crash accident investigations.

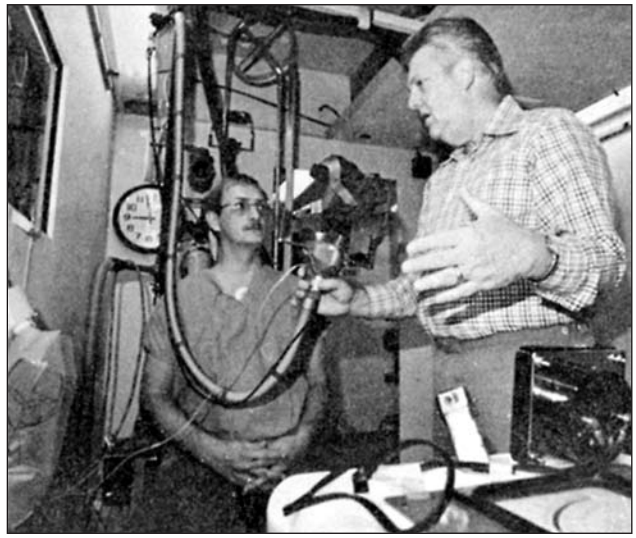
The laboratory's work not only contributes significantly to NTSB determinations of the causes of (or factors associated with) fatal accidents, but also has sometimes absolved an accused, deceased pilot and, on other occasions, has reduced or eliminated the liability of the agency in complex legal cases. Moreover, CAMI's toxicological analyses also serve as a partial test of the integrity of the aeromedical certification system, specifically with respect to drugs and medical conditions. ❑

BUILDING EXCELLENCE. Canfield, architect and head of the Bioaeronautical Sciences Research Laboratory.

The Flight Environment: Altitude, Temperature, Ozone ... and Radiation

Altitude

Studies on altitude and oxygen masks were undertaken by John Swearingen and his small team prior to the opening of CARI. They were continued by Ernest McFadden and, later, by E. Arnold Higgins, Ph.D. The continuation of that important line of work resides in the periodic development of new oxygen masks and types of delivery systems. The work comprises evaluating any safety issues in accessing and using those devices, assessing the effects of their use on emergency evacuation times, and testing the integrity of the masks in the aviation environment. The latter includes research regarding the fit of masks on bearded men and on the smaller face structure of women and children.



Chamber Flight. Higgins preparing for an altitude run and oxygen mask testing.

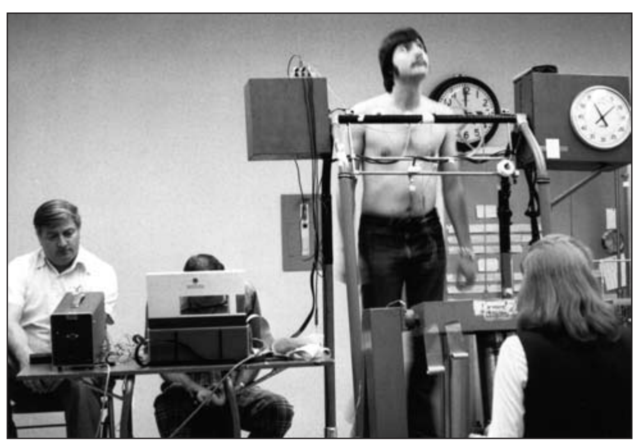
Temperature

Research on temperature as an aviation stressor was conducted primarily by P. F. Iampietro, Ph.D., (original head of the physiology laboratory) and by Carlton E. Melton, Ph.D., (who later succeeded Iampietro), in the '60s and early '70s. Melton's work was closely associated with his studies on assessing stress issues in the training of general aviation pilots. In those studies, the effects of high cockpit temperatures on flight simulator performance and pilot physiology were studied for their training implications and for application to crop duster pilots. In 1968, during the developmental stages of the supersonic transport (SST), Higgins examined complex performance in temperatures up to 140° F over a time period required to get an SST down from cruising flight altitudes in the event of an in-flight air compressor failure. (Other CAMI studies assessed emergency passenger evacuation in an SST model.)

High Temperature. Some early temperature research involved performance in a Link trainer.

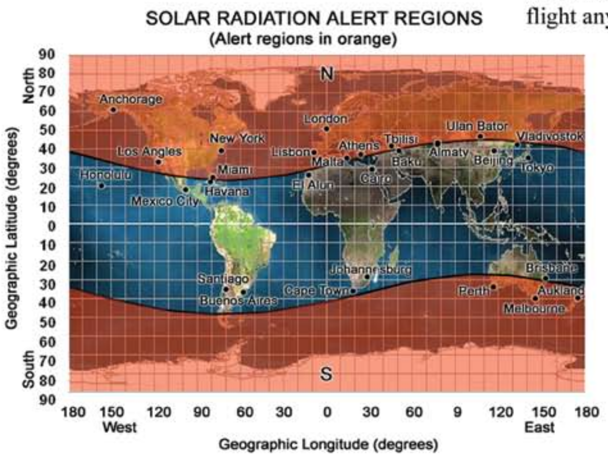
Ozone

Higgins and Melton, along with Michael T. Lategola, Ph.D., also led the work on ozone assessments. Ozone level exposures had been raised as a subject of concern by aviation industry employees in the late '70s (and again in the late '80s, stimulated as an off-shoot of concerns over urban environments). CAMI's research was conducted with an emphasis on pulmonary function. That work assured that no harmful ozone effects were present in the aviation environment. An updated review of ozone findings was provided in a 1989 CAMI report by Melton.



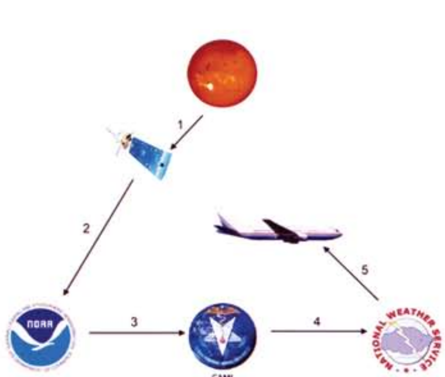
Ozone Concerns. Treadmill, spirometer, visual, and short-term memory tests, along with symptom questionnaires, were used to assess potential effects of exposure to ozone in the laboratory.

Radiation Exposure. Friedberg periodically reviews a map of altitude and aircraft routes across the United States with updated information to gauge exposures of aircrew and passengers to normal galactic radiation for individual flights.Those exposure levels can be calculated for any flight anywhere in the world via the CARI program on the Internet.



Radiation Alert. Friedberg's and Kyle Copeland's description of the radiation alert system; the map of alert regions is regularly updated.

Solar Radiation Alert System



1. Occasionally, a disturbance in the sun (solar flare, coronal mass ejection) leads to a large flux of high-energy particles in the vicinity of the earth.

2. Instruments on a GOES satellite continuously measure the radiation and the information is transmitted to NOAA. From there it is sent to the Civil Aerospace Medical Institute (CAMI).

3. A computer at CAMI analyzes the measurements.

4. If the measurements indicate the likelihood of a substantial elevation of ionizing-radiation levels at aircraft flight altitudes, a Solar Radiation Alert (SRA) is issued to the NOAA Weather Wire Service within 10 min.

5. NOAA Weather Wire Service subscribers are provided effective dose rates at 30,000, 40,000, 50,000, 60,000, and 70,000 ft. This information is updated at 5-min intervals for the duration of the SRA.

Radiation

One of the less well-known areas of research contribution by CAMI may be that of radiation levels and their effects on aircraft crew members, passengers, and fetuses. Studies by Wallace Friedberg, Ph.D., have included the levels of radioactive materials sometimes transported by civilian aircraft with regard to meeting safety criteria. A series of reports by his radiobiology research team provided recommendations for placement of packages of radioactive material in cargo areas of passenger-carrying aircraft so that radiation exposure of passengers would not exceed limits specified by the U.S. Department of Transportation.

Other radiobiological studies have focused on cosmic radiation exposure at various altitudes (it increases with altitude), latitudes, and during periods of solar particle events (solar flares or coronal mass ejections). Air travelers are constantly exposed to ionizing radiation at higher dose rates than normally received by the general population at ground level; the principal ionizing radiation is galactic cosmic radiation. With regard to altitude issues, Friedberg's work has led to advisories and to airline company guidelines limiting exposure of crewmembers based upon the altitudes, duration, and frequency of various flight schedules. Risk ratios for potential development of radiation-induced cancers continue to be calculated to assure travelers and flight crews of the safety of air travel; guidelines for pregnant crewmembers have been established to assure protection of developing fetuses.

Radiation levels are calculated based on the date of the flight (to tap the effects on galactic radiation levels in the atmosphere due to changes both in solar activity and in the earth's magnetic field) and the variation in altitude and geographic location during the course of a given flight. Exposure levels are determined and plotted in Friedberg's laboratory for every U.S. airline flight profile by a regularly updated, proprietary computer program called "CARI" (as a purely historical whim). That program has been made freely available, can be run (with MS-DOS) on most personal computers, is used by countries around the world, and has been the model for those countries that have developed their own programs.

A second CAMI radiation program deals with solar flares. These occasional disturbances in the sun lead to a large flux of solar protons with sufficient energy to penetrate the earth's magnetic field, enter the atmosphere, and increase ionizing radiation levels at aircraft flight altitudes. A solar radiation alert system has been developed by CAMI's Friedberg and Kyle Copeland in a collaborative effort with CIRES-University of Colorado and National Geophysical Data Center of the National Oceanic and Atmospheric Administration (NOAA) located in Boulder, Colorado. Radiation measurements from instruments on a GOES geosynchronous satellite are collected and provided by NOAA's Space Environment Service Center facility from where they are accessed by CAMI. The CAMI system provides for the continuous evaluation of proton measurements and the issuing of timely alerts to the aviation community through NOAA's Weather Wire Service if the measurements indicate the likelihood of a substantial elevation of ionizing radiation levels at aircraft flight altitudes. In the case of an issued alert, the entire process takes only a few minutes...another unique and ongoing aviation contribution by CAMI. ❒

HIGH FLIERS. Friedberg addressed a joint meeting of the Air Transport Association's medical panel and cabin operations panel held at CAMI in 1991. He provided descriptions of the cosmic radiation environments at air carrier flight altitudes and addressed concerns related to possible associated health risks. Demonstrations were provided of his early CARI computer program (then called CARRIER) for estimating the amount of radiation received on individual flights. Friedberg also organized a successful international scientific symposium entitled "Cosmic Radiation Exposure of Air Carrier Crewmembers," held at CAMI in 1990.

Human Factors: Performance ... Doing It Right

Many of the CAMI research projects on human performance in aviation-related tasks have involved the effects of various stressors on complex performance (more recently referred to as time sharing performance or multi-tasking). The range of types of performance studies extends from laboratory task consoles (e.g., the Multiple Task Performance Battery) to flight (or radar) simulators, to in-flight (or on-site) observations. Stressors evaluated for their effects on performance—and often on physiological responses — have included simulated altitude exposure, alcohol, sleep loss, various drugs and medications, temperature, startle, smoking, motion vs. static environments, and others, singly and in combination.

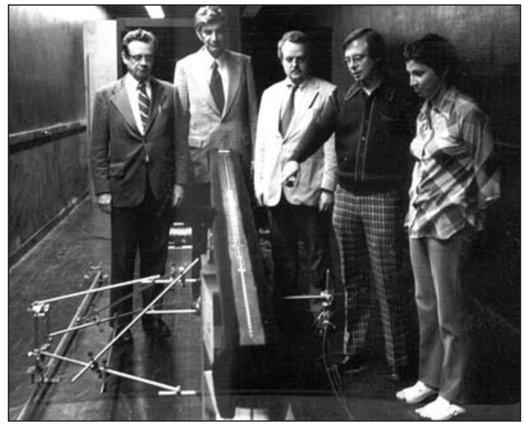
Other research has investigated the effects on performance of color-coded targets, flash rates for target detection, peripheral visual cues, various visual approach slope indicators, communication methods, situational awareness, and other conditions affecting safe performance.

Sensing It

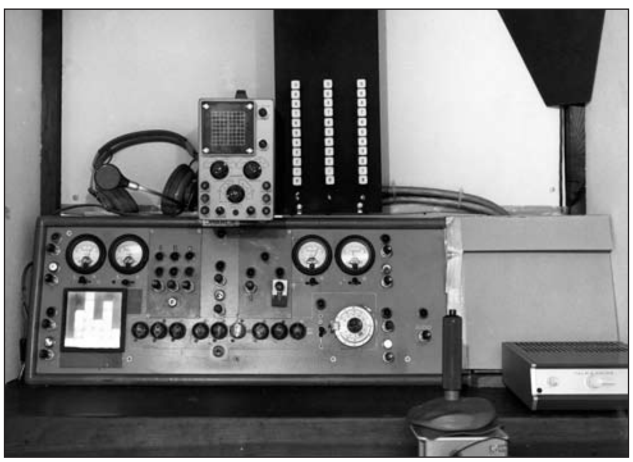
Some research during the '60s used both simulators and the CARI single-engine aircraft. A highly experienced pilot and former aircraft accident investigator, A. Howard Hasbrook, in addition to exploring the potential safety increments of using cockpit systems he devised for instrument approaches, also assessed ways to enhance peripheral vision cues. Other vision research involved a series of studies on depth perception issues by Walter C. Gogel, Ph.D., and the extension of those concepts by Henry W. Mertens, Ph.D., and Mark F. Lewis, Ph.D., to the influence on glide slope angle of perceived depth, distance, and size and on the effectiveness of various models of visual approach slope indicators (VASI systems).

Indeed, with the exception of the air traffic controller selection and training research program, the psychologically based research during the decade of the '60s was largely sensory-based. In addition to the vision work, auditory research by Jerry V. Tobias, Ph.D., who also edited two books on auditory theory (57), and vestibular research by William E. Collins, Ph.D., were prominent and included such foci as cockpit noise and speech intelligibility and studies of adaptation to vestibular stimulation (stimulation associated with spatial disorientation or pilot's vertigo). With respect to the latter, considerable scientific attention was generated by studies of professional figure skaters

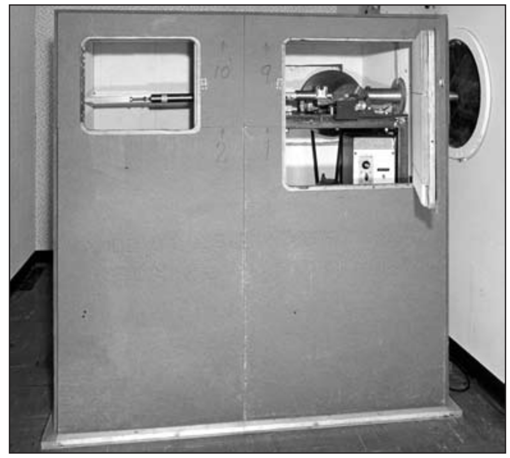
In the Air and on the Ground. (l) Stanley R. Mohler, M.D., CARI director (top) and Hasbrook (lower) used the CARI single-engine aircraft to collect performance data. (above) Hasbrook also engaged in laboratory research on piloting skills.



Sound, Sight, and Position. (clockwise) Tobias researched cockpit noise levels and hearing loss; Mertens (2nd from r) in "The Alley" described laboratory procedures on glideslope/depth perception laboratory research to the executive secretary and 2 members of the National Academy of Sciences/National Research Council Committee on Vision; vestibular research by Collins involved motion and position sensing, performance measures, and eye movement recordings to define motion effects.



Workload and Performance. (l) The original Multiple Task Performance Battery (MTPB) used by Chiles in studies of pilot workload; (lower l) the updated MTPB assessed both individual and group performance as a function of workload demands; (below) air traffic control laboratory tasks provided information regarding vigilance, distraction, and various potential aids to maintaining performance levels.



Booms. International interest in supersonic aircraft in the 1960s led to CAMI research on the effects of sonic booms on performance and sleep. Thackray (above l) engaged in several laboratory studies of physiological and performance effects using CAMI's sonic boom simulator developed by the Stanford Research Institute. The "boomer" was also used in sleep studies conducted by Collins and P.F. Iampietro, Ph.D.

who appear to have trained themselves to be impervious to vertigo and disorientation (13, 14). Results showed the importance of the visual system and visual reference to objects (e.g., the audience) fixed relative to the earth. The set of studies on figure skaters was partially documented by film of their laboratory and on-ice responses to vestibular stimulation, including telemetered eye movements during their spins – the first such use in vestibular research; the film was widely shown (and purchased) on an international basis (including the BBC) and came to be regarded as a scientific classic.

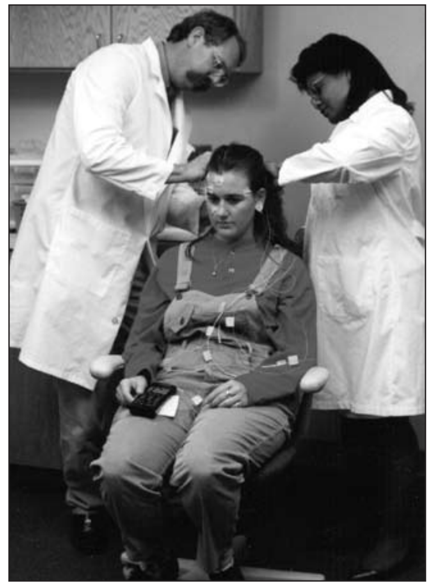
The differential effects of motion (dynamic vs. static environments) on glide slope tracking performance was assessed for a variety of conditions that included alcohol and hangover effects, sleep loss effects, use of anti-motion sickness drugs, and others. The addition of motion exacerbates any performance decrements produced by these conditions in a non-motion (static) environment.

Complex Performance

CAMI's programmatic laboratory research in complex human performance initially used a testing device developed by the Lockheed-Marietta Corporation for assessing time-sharing skills of importance to piloting aircraft. It was brought from a U.S. Air Force laboratory in 1968 by W. Dean Chiles, Ph.D., when he joined CAMI. The equipment was upgraded over the years with advances in technology to provide improved control of informational stimuli and recording of responses, along with the capability of obtaining team-based as well as individual performance measures. This unique device — the Multiple Task Performance Battery — was used in a variety of settings to assess stressor effects on the kinds of performance required of aircraft pilots. Moreover, its so-called "synthetic" tasks tap such basic skills that, by arraying the tasks differently, they can provide tests of performance that relate to the demands on air traffic controllers.

Perceptual-motor responses, physiological effects, and performance recovery on tasks requiring sustained attention such as in radar monitoring, were assessed by Richard I. Thackray, Ph.D., under conditions in which distracting auditory stimuli or startle occurred; boredom and monotony effects were evaluated and described as were the presence or absence of a sweep line or of computer aiding, the use of bifocals, gender and age differences, and other factors. Subsequent work on blink rates and saccades during monitoring was conducted in a joint project with Russian scientists, university researchers, and CAMI's David J. Schroeder, Ph.D., (now head of the Aerospace Human Factors Research Division). Such complex visual monitoring is basic to work in both the cockpit and air traffic control.

Visual monitoring tasks involving tracking behavior were also used in a series of laboratory studies of the performance effects of simulated sonic booms. (Those



Non-Smoking and Non-Sleeping. (above) Nesthus assessed smoking/non-smoking effects on complex performance at simulated altitude and (pictured right assisting with electrode placement) measured effects of extended sleep loss.

studies led to the invited participation of Thackray in field studies of sonic booms conducted in Sweden). One issue was the potential startle effect of a boom that might result in a decline in visual-motor efficiency. Instead, the booms produced an alerting (or orienting) response and performance efficiency was improved for about one minute along with a decrease (rather than a startle-produced increase) in heart rate. (The boom simulation was also used to assess effects on sleep using electroencephalographic and other physiological recordings.)

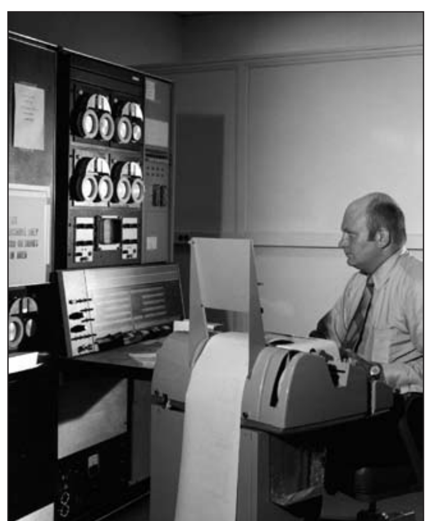
Other more recent studies by Thomas E. Nesthus, Ph.D., have used complex performance measures to determine effects of mild hypoxia, up to 34 hours of sleep loss, and smoking vs. non-smoking effects on subsequent performance at simulated altitude.

Computer Capability: State-of-the-Art

Basic to a world class research facility is a state-of-the-art computer capability. From the late ‘60s throughout the ‘70s, Lewis, in addition to his vision research, provided the depth of knowledge and ingenuity necessary for the early development of what quickly became, and continues to be, an outstanding computer resource that serves not only research and rapid complex data analysis but also the administrative needs of the Institute. Parenthetically, in 1972, Lewis also organized the world’s first symposium on the aeromedical aspects of marijuana when use of the illegal drug had become widespread. The CAMI symposium included major researchers and authorities in drug behavior and stimulated some university research projects relevant to aeromedical issues. A book on the proceedings was published by Academic Press in 1972 (33).

Advanced Aviation Systems: New Research Approaches

The Systematic Air Traffic Operations Research Initiative (SATORI) developed by Mark D. Rodgers, Ph.D., was designed to permit an analysis of the dynamics associated with ATC operational errors and incidents. (In fact, before its expanded utility was recognized, it was called Situation Assessment Through Re-creation of Incidents.) Data from air route traffic control centers’ magnetic and audio tapes are integrated on a sophisticated graphics display to re-create ATC incidents. Its success was attested to by its almost immediate installation in Washington Headquarters as well as at the Atlanta En Route Center where it was first tested. Since then, SATORI has been incorporated in all enroute centers in the country, not



Computer Excellence. Lewis’ knowledge and skills established a foundation of computer excellence for CAMI.

Technology Applied. Rodgers created SATORI in the CAMI laboratories; it was field-tested (and kept) in the Atlanta Center. All Centers and Washington Headquarters now have the technology.

only to investigate operational errors and accidents but also to present operational error briefings and improve simulation training and training management. Other potential uses of SATORI have been proposed to help assess system designs and traffic management. CAMI's POWER project, initiated by Carol A. Manning, Ph.D., is one such application, evaluating objective indices of air traffic (such as aircraft mix) and their association with subjective workload assessments.

Human factors problems specific to general aviation received increased attention with the development by Dennis B. Beringer, Ph.D., of a sophisticated PC-based Basic General Aviation Research Simulator (BGARS) that permits rapid, low-cost performance assessments using various types of instrument enhancements. Almost simultaneously, more complex studies became feasible using the unique capabilities of CAMI's elegant Advanced General Aviation Research Simulator (AGARS), a device that is reconfigurable into four different aircraft types, the development of which was expertly guided by Robert E. Blanchard, Ph.D. AGARS reconfigurability extends to the capability of testing innovative display concepts and has also been used by Beringer to study effects on pilot behavior of loss of some instrument capability and to assess the decision-making of pilots using the NEXRAD weather display. The latest addition to this array of general aviation research simulators is VGARS – a vertical-flight simulator developed by Beringer that can represent a variety of helicopters. VGARS can be configured with various kinds of head-down instrumentation as well as being interfaced with other types of cutting-edge displays (e.g., Electronic Flight Instrumentation System, head-mounted displays). Its out-the-window view depicts features of the "outside world" (buildings, terrain, weather) with realism. And, most recently, an Air Traffic Control Advanced Research Simulator (ATCARS) has been developed under the guidance of Dennis Rester to permit laboratory testing of the effects of new ATC equipment and programs on controller workload, situation awareness, and performance.

AGARS. The high fidelity, realistic 150° field-of-view simulator and Beringer (seated) at its communication and control center.

BY GAR. The BGARS "cockpit" shown here as used in the CAPSTONE project faces a large display screen with programmable flight scenarios.

VGARS – a vertical flight simulator - is a very recent Beringer-developed addition to CAMI's general aviation flight research capability.

Kevin W. Williams, Ph.D., has employed BGARS to assess ground position systems, to conduct part of the Capstone Project (an Alaska Region safety office project to assess new displays outfitted in 200 aircraft to increase awareness in Alaskan pilots of terrain, traffic, and weather in an effort to reduce the high accident rates in Alaska). Currently, he has begun to assess the requirements (medical as well as skill and training) for ground "pilots" of unmanned aircraft; some applications of these unmanned vehicles include crop dusting, fire fighting, and border patrol.

Still other work, by O. Veronica Prinzo, Ph.D., has focused on pilot/controller communications and has provided evaluations and recommendations regarding the Cockpit Display of Traffic Information (CDTI) and the controller-pilot data link communication (CPDLC) systems in studies conducted both in the laboratory and using data from the Dallas-Fort Worth Tracon. Meanwhile, Lawrence L. Bailey, Ph.D., has explored communication between controllers (e.g., ground and local control at low-volume airports) and team work

ATCARS. This innovative capability developed by Dennis Rester provides a means of testing new air traffic control equipment and procedures and their effects on workload, performance, and situation awareness.

Communicating. Prinzo's laboratory (l) and field studies (above) of communication between pilots and air traffic controllers included the effects of data-link communication on operational communication. The Dallas-Fort Worth Tracon was the site of the field monitoring of audio and video transmissions during system assessment.

The Flight Strips Issue. Manning's studies of the changing role of flight strips in advanced air traffic control systems included field observations at Payne Tower (WA) (above), Atlanta Center (top r), and the Minneapolis Center (lower r) (note the reduced size of flight strips in the Minneapolis study).

among controllers in general. Carol Manning's ATC work extends to researching situation awareness issues and exploring the role of flight progress strips in advanced system air traffic control. The latter work has included on-site data collection at 10 towers, the Atlanta Center, and the Minneapolis Center.

An innovative approach by Scott A. Shappell, Ph.D., to aircraft accident investigation — the Human Factors Analysis and Classification System (HFACS) —is leading to new, more complete ways of examining potential causation issues in civil aircraft accidents. The HFACS provides a comprehensive four-level analysis (with subdivisions): human error or conscious rule violation, preconditions (operators and practices) for unsafe acts, unsafe or inadequate supervision, and organizational factors.

That approach is being extended to air traffic control by CAMI's Julia Pounds, Ph.D., in a joint effort with Eurocontrol where it is being used as part of an operational incident investigation process called JANUS. Pilots, air traffic controllers, and, more recently, aviation maintenance groups (with whom more than a decade of human factors work was also conducted and reported by William T. Shepherd, Ph.D., and Jean Watson in the Office of Aviation Medicine in Washington, D.C.) have been the main focus of these HFACS studies. Moreover, HFACS has also been applied to the computer-based re-creation of flight situations (the SATORI approach) to help assess the causes of incidents or operational errors. ❑

HFACS → JANUS. A controller is interviewed for the JANUS project.

Aeromedical Education: Spatial Disorientation … and Technology Transfer

R&E Interactions

Interactions between CAMI's research and educational activities have been considerable. They include joint efforts with the hypobaric (altitude) and environmental chambers and with the ditching tank, use of researchers in the presentation of specialty lectures during the training of aviation medical examiners, and use of research findings in physiological and other safety training of pilots by the education staff. But perhaps the most visible and most widely applicable interaction is that related to familiarizing general aviation pilots with spatial disorientation.

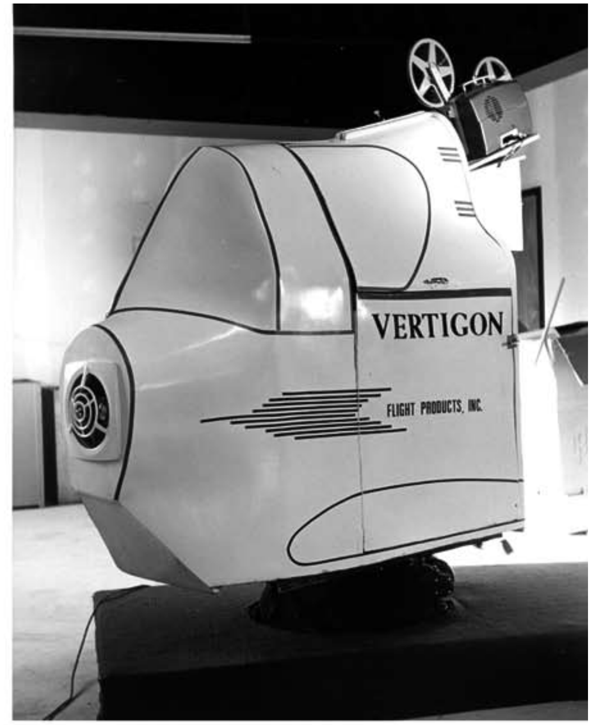
Medic Updates. CAMI researchers regularly provide the latest data in their fields to new aviation medical examiners during their week of basic training.

Spatial Disorientation

Throughout the '60s, spatial disorientation (SD) – sometimes called "pilot's vertigo" – was a significant factor in fatal general aviation accidents – a persistent 16% annually. The physical locus for SD – that is, an incorrect perception of one's position, attitude, and motion relative to the earth – is in the vestibular (motion and gravity sensing) system of the inner ear. To provide a demonstration of false-motion sensing, CAMI's aeromedical education staff used a manually rotatable stool and equipped the student with blinder goggles (which presented two stationary points of light) and a "joystick" (which was used to signal direction of motion). Strong sensations of false motion could be elicited in this manner.

To improve this educational experience, CAMI scientists developed a stimulus profile in the early 1960s using a precision angular accelerator — an elegant Stille-Werner RS-3 rotation device that was primarily used for motion research — to enhance practical demonstrations of SD to aviation medical examiners and groups of visiting pilots. Initially, the chair was fitted with a partial metal surround, the interior of which was coated with luminescent paint so that observers could watch the motion in otherwise total darkness and the "rider" could see only the interior of the surround that, like the cockpit of an aircraft, moved with him and eliminated breeze cues to motion. By the mid '60s, CAMI's engineering support branch had fabricated a sleek cockpit-like enclosure for the rotator that had eye appeal as well as providing capability for expanded motion research.

Developing an Application. Stages in the development of CAMI's angular accelerator for vestibular research and laboratory demonstrations of spatial disorientation.



Research and Education. (Above) The 1969 Vertigon and a replica of the stickers issued to "pilot" riders at safety education events. Harry L. Gibbons, M.D., then-head of the aeromedical research branch, Dr. William E. Collins, scientist and then-head of the psychology laboratory (seated), and Lou Zigler, engineer/president of Flight Products, Inc., are pictured during delivery of the first Vertigon.

(Below) An advanced design of the Vertigon, a Gyro I, and a more recent GAT II spatial disorientation demonstrators.

The Vertigon

The laboratory demonstrations were designed to show how powerful the SD experiences could be in the absence of visual references fixed to the earth and as a result of simple head movements during angular motion. That protocol was designed to induce incorrect but vivid sensations of pitching, climbing, rolling, the absence of experienced movement during real motion, movement in a direction opposite that of real motion, and angular movement in the absence of real motion. The stated lesson was the powerful misperceptions of position and of direction of motion that could occur in flight, and the need to obtain an instrument rating and maintain instrument proficiency.

That compelling demonstration, made one day to a visiting aviation engineering group, led to the joint commercial development of the Vertigon – a portable, enclosed, programmed SD demonstrator. CAMI's technical and procedural specifications and fidelity testing were freely provided in the interest of enhancing aviation safety education. Flight Products, Inc., engineers developed a programmable rotating base that was capable of smoothly accelerating at a predetermined rate to a desired constant velocity and, when decelerated, smoothly coming to a stop. An enclosure was constructed with a rudimentary cockpit interior (including a screen) attached to the base. Projection onto the interior (windscreen) of a motion picture of a flight sequence was added along with sound track directions to the rotating "flyer" to scan the windscreen, search for a map or notebook, or jot down "air traffic" guidance resulting in head movements that would induce compelling vestibular stimulation (including so-called coriolis effects) during the various depicted "flight" maneuvers from take-off to landing. The critical lesson of this experience – the importance of an instrument rating and instrument proficiency - was always a concluding statement.

The first Vertigon was completed in 1969, and its portability and ease of operation resulted its regular use by CAMI's James L. Harris and his aeromedical education staff at numerous airshows and training courses around the country. The Vertigon provided an excellent familiarization for pilots and others regarding the power and degree of misleading information that can characterize spatial disorientation. In fact, CAMI's education staff developed circular red stickers that announced "Wow! I flew the Vertigon" – "riders" at air shows and related safety events wore them proudly.

Advanced Models

A later version of the Vertigon (Vista) in the 80s, two versions (I and II) of the Gyro demonstrators in the 90s, and the GAT II in the 2000s were sleeker in appearance and kept pace with technology advances in electromechanics and the presentation of the "flight," but the basic simulation and procedural paradigms have remained (12).

Virtual Reality. The latest concept in spatial disorientation familiarization was the direct result of ideas from Antuñano when he headed aeromedical education.

However, just before the start of the new century, a novel approach was suggested to the manufacturer by Melchor J. Antuñano, M.D., then-head of CAMI's aeromedical education staff. That approach incorporated virtual reality technology and an external computer screen to monitor the "flight." The device – the Virtual Reality Spatial Disorientation Demonstrator – was manufactured and CAMI immediately put it into use – the first of its kind.

A Useful Tool Internationally

CAMI's aeromedical education specialists have used the Vertigon and its successors at air shows and seminars around the country with great success, as have numerous other aviation safety programs around the world. Tens of thousands of U.S. pilots have "flown" the device over the years. The proportion of private pilots with an instrument rating has climbed slowly, but regularly, along with a small but steady reduction in the proportion of fatal general aviation accidents ascribed to SD – outcomes that appear at least partly attributable to this unique form of educational experience. ❑

Sharing Knowledge...and Resources

CAMI's research outcomes and their by-products have immediate conduits to the FAA, the National Transportation Safety Board, NASA, the National Highway Traffic Safety Administration, the military, and the aviation and aerospace industries. And there are regularly scheduled exchanges with scientific and professional groups. All of these conduits tend to involve regular, intensive, and largely formal interactions…many of which are evident in the preceding sections of this report. But CAMI's contributions and free sharing of knowledge and resources extend to other entities and involve the development and modification of formats at CAMI for providing special opportunities for special groups. For example, many local junior college, college, and university students have gained research experience as summer aides or part-time aides through special student programs or via the participation of CAMI researchers on university faculties. Some other types of opportunities are depicted in this section. They comprise important elements in the conduct, scope, and meaningfulness of CAMI's scientific enterprise…all in support of improving aviation and aerospace safety.

Sharing the Knowledge...Kids Count


Taiwan
China
Norway
Russia
Sharing Knowledge...
International Visitors
...A Few of the Many
England
Canada
Japan
Hungary


Sharing Expertise and Resources...
Some of the Formal Training
Accident Investigation for
Medical Support
Oklahoma City, OK
3-15-2000
Dynamic Impact Test Procedures in
Australia
Dynamic Impact Test Procedures
Training Class
SWAT Team
FBI Course
Military Teams
Cabin Safety Workshop
CIVIL AEROMEDICAL INSTITUTE

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Appendix

Historical Vignettes

These historical vignettes capture different aspects of the CARI/OAM research story. They have been published previously in the OAM series as prefaces to some of the periodically issued cumulative indexes of OAM research reports as a means of preserving historical perspectives. Because that context tends not to highlight their presence, the vignettes are reproduced here in the interest of incorporating in a single document the additional history they provide. The vignettes are presented in the order in which they appeared in the Index issues, viz., in OAM Reports No. AM 87-1, 97-1, 98-1, 01-1 (2 vignettes), 03-1 (2 vignettes), and 05-1.

BACKGROUND OF FAA AEROMEDICAL RESEARCH
Forty Years in Oklahoma City
By J.R. Dille, M.D., and Marcia Grimm

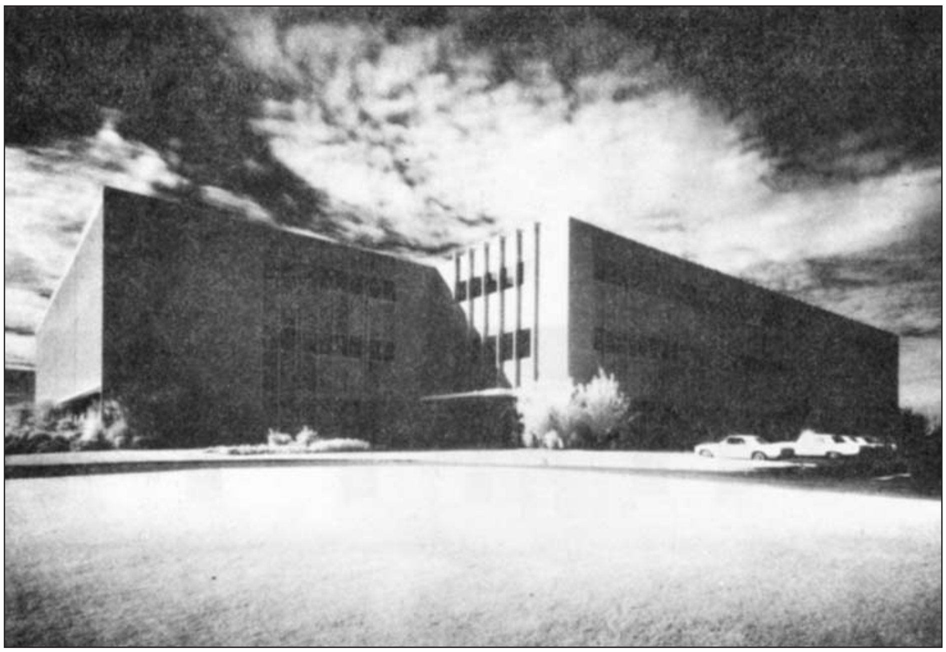
Dormant medical research plans at the Civil Aeronautics Administration (CAA) Standardization Center in Houston were transferred to the new Aeronautical Center at Will Rogers Field, Oklahoma City, in 1946. Dr. W.R. Stovall, Director, Aviation Medical Service, planned to name the program the Aviation Medical Development Center to be headed by a deputy to him. When the medical facility actually opened in late 1947--40 years ago--it was the Aviation Medical Branch of the Aeronautical Center. John J. Swearingen joined the staff as a senior scientist in October 1947; Ernest B. McFadden and J.D. Garner followed soon after. In 1948, research reports started to appear from the, by then, Civil Aeronautics Medical Research Laboratory (CAMRL).

CAMRL, CAA Aeronautical Center, Oklahoma City, OK

"The lack of enthusiasm within the CAA and the Department of Commerce hierarchy to pursue research projects which could prove costly to the aviation industry appears to have been a source of constant friction between Dr. Stovall and federal officials having flight operations and regulating duties." This problem, plus a perceived need to have the resources of a large university nearby, resulted in the transfer of CAMRL to the campus of the Ohio State University School of Medicine effective July 1, 1953. CAA Administrator James T. Pyle ordered CAMRL moved back to the Aeronautical Center on June 30, 1958, where it became the Protection and Survival Branch of the new Civil Aeromedical Research Institute (CARI) in late 1959.

Twenty-fifth Anniversary of CARI Building

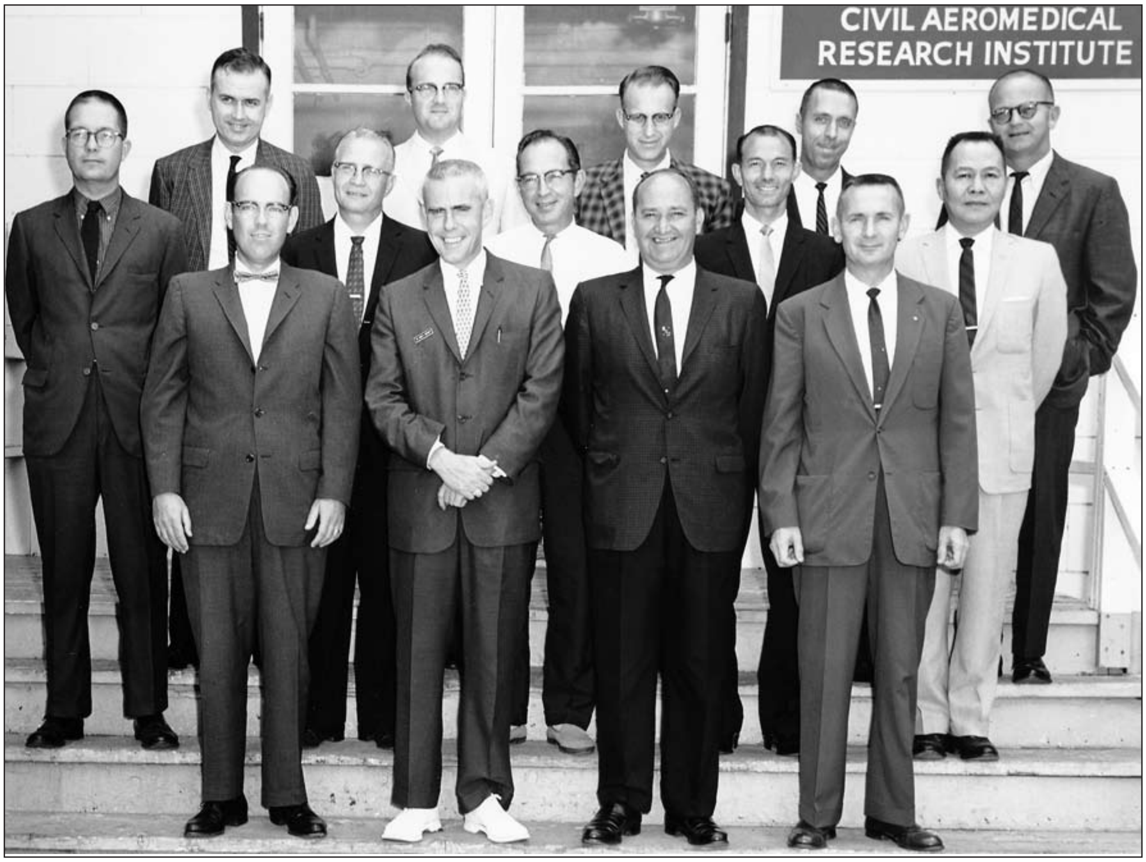
On August 8, 1961, Dr. Stanley R. Mohler became director of CARI. He guided the final staff design, dedication, and occupancy of a new building and fostered development of the research program. A few classic CAMRL reports were reprinted as CARI Reports 62-1, 62-14, and 63-9.



CARI, FAA Aeronautical Center, Oklahoma City

At the dedication of the CARI building, on October 21, 1962, FAA Administrator Najeeb E. Halaby distinguished between CARI as a concept and CARI as a building. Initially, the building contained the Aeromedical Standards Division and the Aeromedical Certification Division, both national operational medical responsibilities of the FAA, in addition to civil aeromedical research.

In December 1965, CARI became the Aeromedical Research Branch of the Civil Aeromedical Institute (CAMI). Also included in CAMI were the medical certification program; the aeromedical education program; positions from the Georgetown Clinical Research Institute, which was closed in 1966; and clinical and industrial hygiene responsibilities. Dr. J. Robert Dille was named chief of CAMI in 1965 and has continued to serve as manager of the institute, which now has five branches: the Aeromedical Certification Branch, the Aeromedical Education Branch, the Aeromedical Research Branch, the Human Resources Research Branch, and the Aeromedical Clinical Branch.



Key personnel in the FAA medical program in the early 1960's, left to right,

First row: Stanley R. Mohler, M.D., Director, CARI, 1961-65, and later, Chief, Aeromedical Applications Division, in FAA Headquarters
James L. Goddard, M.D., Civil Air Surgeon, 1959-62;
George R. Steinkamp, M.D., Deputy Civil Air Surgeon for Research and Operations, 1962-63;
Peter V. Siegel, M.D., Chief, Aeromedical Certification Division, 1962-65, and later, Federal Air Surgeon

Second row: Herbert C. Haynes, M.D., Staff Psychiatrist
Paul W. Smith, Ph.D., Chief, Pharmacology-Biochemistry Branch, CARI
John J. Swearingen, Chief, Protection and Survival Branch, CARI
P.F. Iampietro, Ph.D., Chief, Physiology Branch, CARI
P.C. Tang, Ph.D., Chief, Neurophysiology Branch, CARI

Third row: William R. Albers, M.D., Chief, Aeromedical Standards Division, 1962-64;
J. Robert Dille, M.D., Program Advisory Officer, CARI, and later, Chief, CAMI
Vaughan E. Choate, CARI Executive Officer
Michael T. Lategola, Ph.D., standing in for Bruno Balke, M.D., Chief, Biodynamics Branch, CARI
George T. Hauty, Ph.D., Chief, Psychology Branch, CARI

THE CIVIL AEROMEDICAL INSTITUTE FACILITY IN ITS 35TH YEAR

BY STANLELY R. MOHLER, M.D., AND WILLIAM E. COLLINS, PH.D.*

The CARI Building and Its Mural

The building that houses the Civil Aeromedical Institute was dedicated and formally opened on a sunny, pleasant Sunday in October 1962. The facility was constructed as a research building and was initially named the Civil Aeromedical Research Institute (CARI). In 1965, its mission expanded: CARI became the Aeromedical Research Branch of the Civil Aeromedical Institute (CAMI), and the building was accordingly renamed. Aeromedical certification and education, along with clinical and industrial hygiene responsibilities were and remain, the other components of CAMI.

Prelude

The first Civil Air Surgeon of the newly established Federal Aviation Agency (1958), was James L. Goddard, M.D., a Public Health Service officer. He reported directly to the first FAA administrator, General Elwood Quesada (USAF, Ret.), and was "seconded" to the FAA as an active duty Public Health Service officer. General Quesada had authorized the establishment of the Civil Aeromedical Research Institute (CARI - now the Civil Aeromedical Institute, or CAMI) and Dr. Goddard set about implementing its staffing and the construction of a new building for it. Detailed documentation of the measures that led to the establishment of the FAA, the

The CARI Building during construction in 1961. The barracks buildings in the background are remnants of the Will Rogers Army Air Base, built during World War II.

***Stanley R. Mohler, M.D., served as the first CARI director. He is now dean of the Aerospace Medicine program at Wright State University School of Medicine. William E. Collins, Ph.D., is the current director of the FAA Civil Aeromedical Institute. He was also present at the dedication of the new building in 1962.**

Civil Air Surgeon position, and the Institute (CARI) are contained in the book Civil Aviation Medicine in the Bureaucracy (1), by Heber A. Holbrook. Some additional historical background by J.R. Dille, M.D. appears in the Preface of Office of Aviation Medicine Report DOT/FAA/AM/87-1 (2).

The original facility was a product of the Oklahoma City Airport Trust, which had started an innovative building program after World War II, aimed to entice government agencies, especially the FAA, to place organizational entitles at the Aeronautical Center (now the Mike Monroney Aeronautical Center), located at Will Rogers World Airport in Oklahoma City. The Trust program issued bonds that provided money to build structures necessary to house various FAA components at the Aeronautical Center. The FAA leased from the Trust the various individual facilities that were tailor-made to the needs of various offices and services.

The CARI Building

In 1960, while occupying temporary quarters in wooden barracks (built to house sailors at the now-closed U.S. Navy base) at Westheimer Field in Norman, Oklahoma, on the North Campus of the University of Oklahoma, the scientists at CARI set to work laying out their individual laboratory plans in a customized approach. This was probably one of the few times in history that a group of scientists — psychologists, physiologists, anthropologists, crash-worthiness engineers, and other specialists —actually designed and, within three years, moved into, a large technical bio-medical research space they had planned.

The CARI building was initially to be located directly to the west and across the street from the Aeronautical Center manager's building. The manager, Mr. Lewis Bayne, decided to relocate the CARI site to the south about a city block in distance. He felt that, since some animal research was projected at that time, a more remote location would be desirable. The change was accomplished without the knowledge of the medical personnel or of newly-appointed CARI director, Stanley R. Mohler, M.D., until ground breaking started. In the long-run, the more distant location proved ideal. However, in the "short" run, it led to pulling some non-research components (including medical certification) out of the building and locating them in the Airman Records Building (near the Center's consolidated records computer facilities).

The CARI Dedication Program

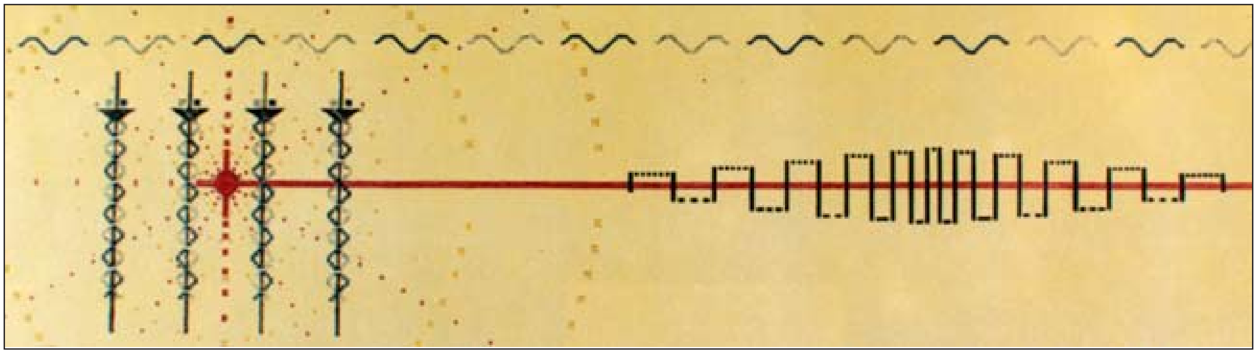
On October 21,1962, an outdoor ceremony was held at 3 p.m. to dedicate the new Civil Aeromedical Research Institute. On the previous day, a scientific seminar had been held in the auditorium of the Aeronautical Center manager's building, and that night, the immortal Jimmy

FAA Administrator Najeeb Halaby speaking at the dedication ceremony.

Doolittle gave a banquet talk in downtown Oklahoma City in honor of the Institute; the text of that talk appeared in the column "Aviation Medicine Heritage" by J.R. Dille, M.D., published in Aviation, Space and Environmental Medicine (3).

The outdoor dedication ceremony was conducted on the north side of the Institute and was attended by FAA Administrator Halaby and Acting Civil Air Surgeon, Don Estes, M.D. (Dr. Goddard had departed the FAA on September 1, 1962). Speakers included Oklahoma Senator Mike Monroney and Congressmen Tom Steed and Jon Jarman. Texan Albert Thomas, the powerful Chairman of the House Independent Agencies Appropriation Subcommittee covering the FAA, also attended. Local Oklahoma business leaders and other officials participated, including one of the most famous military and civilian flight surgeons, Randolph Lovelace, II, M.D. Mr. Delos Rentzel, former head of the Civil Aviation Administration (predecessor of the FAA), served as Master of Ceremony and Mr. Halaby delivered the keynote dedicatory address. A 45-minute movie was made of the ceremony (and is available at the Institute).

The CARI mural (reproduced from the original drawing).



The CARI Mural

A spacious entrance to CARI was designed by Hudgins, Thompson, and Ball, (the "HTB" architectural firm for the Aeronautical Center). A highlight of the entrance was to be a large, multi-colored tile mural that, following the architectural designers' rendition, would be prepared through a computer program by a subcontractor. The mural was delivered in sub-assembled tile blocks, with the proper colored tiles in the proper places (the individual tiles are about one inch on each side) to be glued in strips to the wall. The mural design covered the west wall of the entrance lobby.

The mural that went into the rapidly evolving CARI building was computer designed (perhaps the first to be so done for a federal building) by an employee of the architectural firm and was of a somewhat abstract nature. The design had a symbolic supersonic transport with a shock wave and a symbolic biomedical electrical signal as obtained in research data collection. The four main aeromedical areas — research, standards, certification, and education/preventive medicine — were abstractly portrayed by caduceus renditions. Above the mural, a series of head-on bird silhouettes denoted airmen.

By October 1962, the entire mural was in place. It drew many favorable comments. Dr. Mohler had clocks put around the upper margins of the lobby walls to show the various world time zones. Visitors were brought through for tours of the new building prior to the its dedication. The visitors uniformly went away with a very positive feeling about the Institute, and they were impressed with the total effect of the structure and interior as being very modern (and they liked the mural).

The Airman With a Waiver

There was an accidental misplacement of a single tile (it is located one tile space lower than its proper position) on the wing tip of one of the symbolic airmen (a bird) near the ceiling of the erected mural (the second bird from the left). While leading a dedication-day tour through the building, a guest in a crowd of visitors teased Dr. Mohler, pointing out the error, proclaiming loudly, "There's an error in your mural." Dr. Mohler's immediate response was, "That's no error! That's an airman flying on a waiver!"

The visitors loved it.

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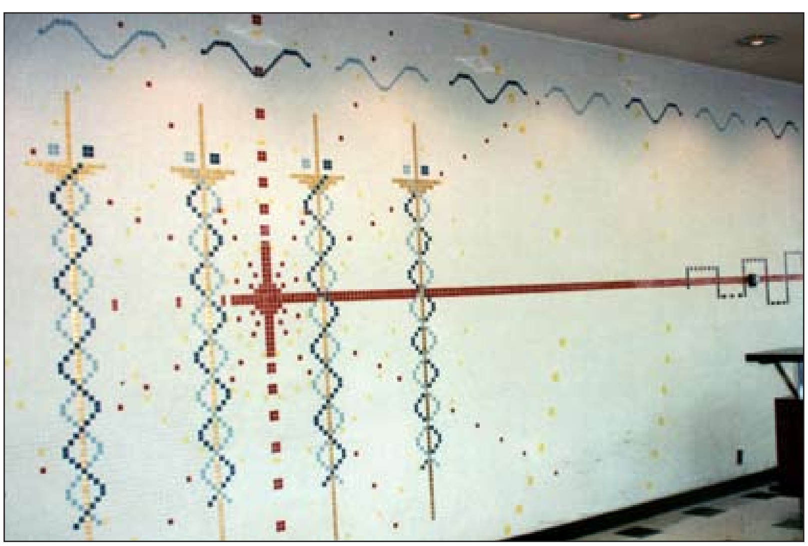

A portion of the CAMI lobby with the tile mural. (The "airman on a waiver" is in the upper left corner.)

ORIGIN OF THE JET PASSENGER DROP-OUT OXYGEN SYSTEM AND THE DOUBLE PANE PROTECTIVE DECOMPRESSION WINDOWS

By Stanley R. Mohler, M.D.
and William E. Collins, Ph.D.

JOHN J. SWEARINGEN retired from the Civil Aeromedical Institute (CAMI) as Chief of the Protection and Survival research program in 1971. His many accomplishments in the areas of crash injury protection, human tolerances to abrupt acceleration forces, and proper restraint system design are widely known in the aerospace safety field.

Somewhat less well known is his earlier work (1950s) that anticipated the need in the evolving generation of jet passenger aircraft for passenger drop-out emergency oxygen equipment and his passenger window designs that afforded protection should a window under pressurization forces be lost.

On October 15, 1957, John Swearingen and colleague Ernest B. McFadden patented an "adhesive-type oxygen mask" and an automatic drop-out mechanism, both of these for airline passenger protection in the event of a decompression at altitudes where passenger oxygen is desirable (U.S. Patent 2,809,633). Both Swearingen and McFadden were researchers at the Civil Aeronautics Medical Research Laboratory, a forerunner of the Civil Aeromedical Institute, located at various times in Columbus, Ohio, and Oklahoma City, Oklahoma. The mask and automatic drop-out apparatus were first described in a presentation on April 15, 1956, at the 27th annual meeting of the Aeromedical Association (now the Aerospace Medical Association) held in Chicago. The presentation was published (1) in the February 1957 issue of the *Journal of Aviation Medicine* (now *Aviation, Space, and Environmental Medicine*).

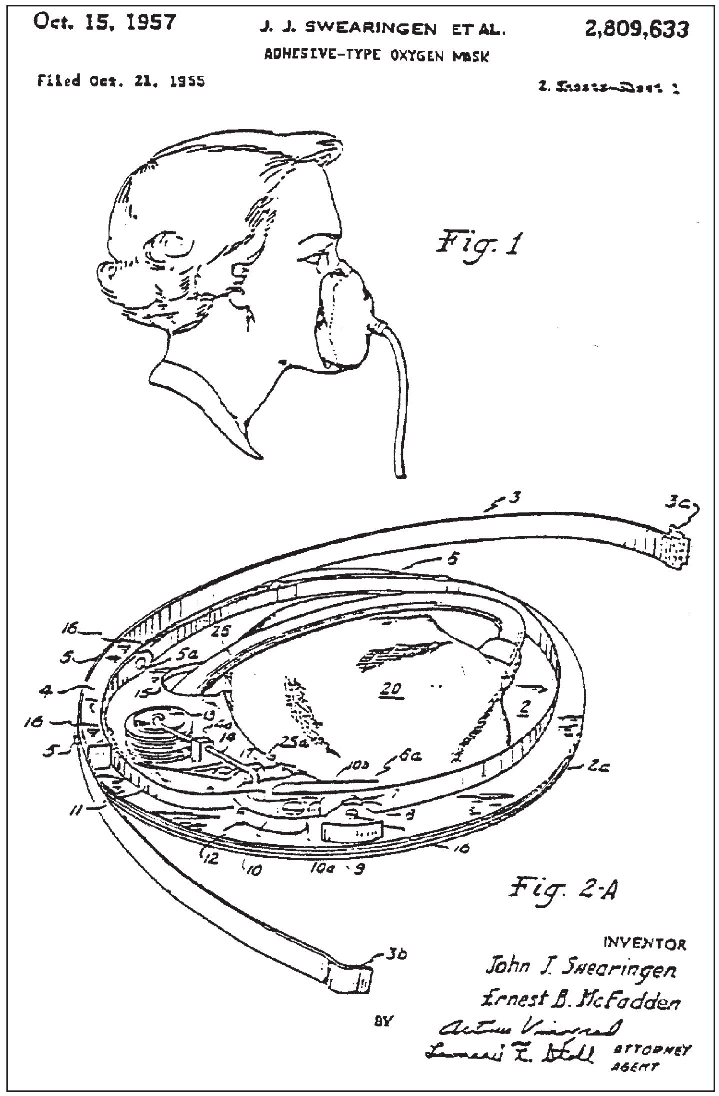

Figure 1. A replica of part of the Swearingen-McFadden original patent. The patent covers the total passenger emergency oxygen system, including the automatic drop-down mechanism triggered by altitude and the associated adhesive oxygen mask. The descriptive emphasis was on improving protection of the passenger, rather than on the release mechanism.

The accomplishments by Swearingen and McFadden in developing the oxygen drop-out mechanism with a proposed new passenger mask were reflected in the equipment carried by the first generation of passenger jets, the Boeing 707, the Douglas DC-8, and the Convair 880. Although the adhesive mask proposed by Swearingen and McFadden provided a superior seal to the passenger masks actually installed in those early flights, industry concern with the shelf life of the then-available adhesive material precluded introduction of the adhesive mask. However, the presentation aspects they developed, with automatic deployment of the mask should the cabin of an airliner exceed a given altitude (12,000 - 14,000 foot range), are in use today.

With respect to high altitude pressurized cabin flight, instances of occupant ejection through a failed window of a pressurized aircraft began to occur with the World War II era. Large pressurized piston engine aircraft retained the large, single pane window design of unpressurized aircraft. As altitudes increased, window failures occurred for one or another reason. The rapid outflow of the air from within would at times bring objects in the airflow path through the window to the outside, including any hapless human who was nearby and unrestrained.

Figure 2. A typical work-setting photo of John Swearingen in CAMI's "high bay" area during 1963. Long-time associate J.D. Garner stands in the background.

Swearingen began his airflow studies in the 1950s and conducted further studies through the transition of the Civil Aeronautics Medical Research Laboratory to the Civil Aeromedical Research Institute to CAMI. His early work revealed the utility of utilizing double pane windows so that, should the outer pressure-bearing window fail, orifices at the perimeter of the inner window would allow the airflow to escape, leaving the inner window pane intact. This double pane safety concept was introduced in the first generation of jet passenger aircraft. Swearingen worked out a series of profiles that illustrated the safe distance of a passenger from a lost single pane window of various diameters. These profiles are published in the 1963 report, "Studies of Airloads on Man" (2). The report provided data for design engineers of aircraft with respect to specifications for windows that enhance air safety should an airliner decompress during its flight profile.

This historical summary is prepared in recognition of the pioneering work accomplished by personnel of the Civil Aeromedical Institute and its predecessor organizations. Other brief historical summaries regarding the Institute are available elsewhere (3, 4, 5).

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Historical Vignette

Some Historical Observations of CARI/CAMI 1960-1984

By S.R. Mohler, M.D., K.A. Hayes, and W.E. Collins, Ph.D.

Completed in 1962, the Civil Aeromedical Institute is the home of aeromedical research, certification, education, and occupational health programs (photo circa 1985).

The Civil Aeromedical Research Center, later called the Civil Aeromedical Research Institute (CARI), was established in August 1960 to develop medical data to meet the problems of civil air operations as civil aviation moved into higher altitudes and supersonic speeds. CARI was placed under the executive and technical direction of the Research Requirements Division, Bureau of Aviation Medicine. Hilliard D. Estes, M.D., a physician in the U.S. Public Health Service, was appointed the first Medical Director of CARI, and Robert P. Clark, Ph.D., was appointed the first Research Director. This dual-directors situation resulted in some confusion regarding primacy of roles, but was resolved when, on August 7, 1961, S.R Mohler, was appointed Director of the Civil Aeromedical Research Institute, and William E. Collins, Ph.D., was already recently onboard instituting vestibular and visual research. There were approximately 20 full-time scientists and research support personnel at the new institute plus additional administrative and secretarial staff.

CARI consisted of an Office of the Director, Audio Visuals Service and Research Engineering, and six branches specializing in the areas of biochemistry, biodynamics, environmental physiology, psychology, protection and survival, and neurophysiology. A total of 21 positions was authorized in the operations appropriation for CARI at that time. Researchers concentrated on the following types of projects: (1) man's aging process and the relation to chronological age and pilot proficiency; (2) selection criteria for an environmental stress factors experienced by air traffic controllers; and (3) inflight fatigue affecting flight engineering on jet aircraft. Researchers were housed in several temporary wooden buildings and a gymnasium that were owned by the University of Oklahoma and located at Westheimer Field (a former World War II naval aviation training base) in Norman, Oklahoma, until the CARI Building was completed in October 1962.

The scientists noted above had drawn up their respective aeromedical research projects and had planned and designed the layout for their individual laboratory space in the emerging new 220,000 square foot, four level (one level underground) medical research building at the Aeronautical Center, Will Rogers Field, Oklahoma City. This was said to be the first time that an enthusiastic cadre of scientists had a major role in the design and preparation of their future institute's laboratories.

The scientists were drawn from the US Air Force at Randolph Field, the US Army, the University of Oklahoma Medical School, Ohio State University (the group of protection and survival research personnel led by John J. Swearingen who had previously been moved from the Aeronautical Center to Ohio State University by the Civil Aviation Administration and were now being returned by the FAA to Oklahoma), and other organizations.

In June 1962, the Office of the Deputy Civil Air Surgeon for Research and Operations and the Certification, Research, and Standards Divisions under the Civil Air Surgeon in FAA Headquarters were all moved to Oklahoma City. Also, as a part of this move, the Washington Office Clinic became a part of a new medical Clinical Services Division. The Deputy Civil Air Surgeon was established to provide centralized medical standards, certification, research, and clinic activities for the agency. The only medical operation retained at FAA Headquarters at that time was program planning and management in the immediate Office of the Civil Air Surgeon. The Deputy Civil Air Surgeon's charge consisted of a Medical Research Division (which included CARI and FAA's Clinical Research Institute in Georgetown), Medical Clinical Services division, Medical Certification Division, and Medical Standards Division. A total of 112 positions was allocated to this organization. This included 50 positions in the operations appropriation and 62 in the facilities, engineering, and development (FE&D) appropriation.

As the scientists settled into the new CARI facility during the fall of 1962, and began their respective aeromedical research studies, a troubling cloud appeared in the form of a Congressional House of Representatives mandated budget ceiling on personnel and funding for the new institute, imposed by Mr. Albert Thomas, then congressman from Houston, Texas, and a powerful appropriations committee chairman. There was, at that time, some tension between Mr. Thomas and Oklahoma Senator Robert S. Kerr regarding the establishment of several FAA and NASA sites.

The planned institute staffing of 212 persons was formally cut back to 100. Recruiting activities for scientists and research support personnel were slowed and the number of planned projects was reduced. The time of the Institute's scientists was concentrated on regrouping and reformulating their research plans, and the new Director and the branch chiefs spent much time juggling priorities. When the new institute building was dedicated in October 1962, Mr. Najeeb Halaby, FAA Administrator, invited Mr. Thomas to participate in the proceedings. Senator Kerr had passed away by this time, but Mr. Thomas' concerns did not seem to have been relieved. Senator Mike Monroney of Oklahoma participated in the dedication and the discussions at that time between Mr. Thomas and Senator Monroney may actually have been primarily responsible for saving the Institute from a support perspective. At the evening dedication banquet, the featured speaker was Jimmy Doolittle who told of the important role flight surgeons had performed during his illustrious aviation career.

A peculiar development had occurred in 1960-61 in that the FAA instituted the Georgetown Clinical Research Facility (approximately 20 persons in 1961), later renamed the Georgetown Clinical Research Institute (GCRI). The purpose of the GCRI was to study "longitudinal" pilot aging and look for ways to make individual exceptions to the 1961 FAA "age 60" mandatory retirement regulation for airline pilots. It developed that a similar longitudinal research program on airline pilots was established in 1960 by the National Institutes of Health (NIH) at the Lovelace Foundation, Albuquerque, New Mexico, with the help of S.R. Mohler, M.D., a Public Health Service officer in the Center for Aging Research at NIH, who was about to be offered the Directorship of CARI. It also developed that certain FAA headquarters personnel proposed closing CARI and enlarging the GCRI as they felt it more convenient to administer a medical research program in the same town as FAA headquarters rather than one in Oklahoma. These Washington personnel had to take propeller airline aircraft on their periodic trips to Oklahoma City, a circumstance requiring a full day and multiple stops at the time.

As assessment of the FAA Headquarters/Aeronautical Center medical structure in December 1962, resulted in the abolishment of the Office of the Deputy Civil Air Surgeon and the transfer of the Standards Division back to FAA Headquarters to augment the Civil Air Surgeon in a major realignment of the Aviation Medical Service.

The other existing medical divisions at the Aeronautical Center were retained and reported directly to the Civil Air Surgeon.

In January 1964, CARI was placed under the executive and technical direction of the new Washington-based Aeromedical Education and Research Division in the Aviation Medicine Service. At that time, under Federal Air Surgeon M.S. White, M.D., the Georgetown Clinical Research Institute became a branch of this new division which was established to plan and direct research activities at a national level. However, this was later changed in July 1965, when Administrator Halaby directed that the medical research program be managed directly by the Federal Air Surgeon.

The CARI medical certification, research, and clinic activities were reorganized into one division in October 1965. At that time, the Institute was renamed the Civil Aeromedical Institute (CAMI) and was placed under the executive direction of the new Aeronautical Center Director, Mr. Lloyd Lane. Technical direction continued to be provided by the Federal Air Surgeon. CAMI consisted of four branches – Administrative and Technical Branch, Aeromedical Certification Branch, Aeromedical Research Branch, and Aeromedical Services Branch. J. Robert Dille, MD, was named chief of CAMI in December 1965. A total of 172 positions (93 operations and 79 RE&D) were authorized to CAMI at that time, representing what proved to be a one-year reduction of 21 RE&D positions.

The issue of CARI versus GCRI was settled by the Government Accounting Office in a report that recommended closing GCRI due in part to its duplication of the NIH supported Lovelace longitudinal aging study of pilots. The new Federal Air Surgeon, Peter Siegal, M.D., also had received an Ad Hoc Advisory Committee report to the effect that the GCRI was not following a clear statistical design relative to its study population and, accordingly, had made no notable progress toward achieving the goal for which it had been established. Moreover, the cost of maintaining two medical research facilities – one overcrowded (GCRI) and one underutilized due to the Congressional ceiling situations – was more than difficult to defend. The GCRI positions and dollars were moved to CAMI in 1966 restoring the CAMI level to 100 positions.

At that time, newly appointed FAA Administrator, William McKee, gave a speech to an Aerospace Medical Association annual meeting and stated that CARI would contract for a large moveable hydraulic lift platform that had capabilities of tilting and would raise the fuselage of an airline-type aircraft for passenger emergency evacuation studies. The money from GCRI was used for this platform and, as only one GCRI person elected to move to Oklahoma, the position authorizations began to be melded into the Institute in Oklahoma. By this time, S.R. Mohler, M.D., had moved to Washington and had assisted in preparing the Administrator's speech. The evacuation simulator proposal seemed very timely as several airline accidents involving passenger evacuation problems had occurred in the relatively recent past.

In 1966, a Clinical Research Laboratory was established in the Aeromedical Research Branch in which to place the scientists from the FAA's closed out Georgetown Clinical Research Institute. In August 1968, the aeromedical education function was moved from the Aviation Medical Service in FAA Headquarters to CAMI so that existing CAMI facilities (altitude chambers, etc.) could be utilized. At that time, the Aeromedical Education Branch was established. With this came the responsibility of aeromedical education and information programs supporting safety and promotion of civil aviation; and development of standards and procedures governing the selection, designation, training, and management of physicians appointed to conduct aviation medical examinations of civil airmen in the U.S. and abroad. Also in 1968, a Technical Staff and Administrative Staff were established to assume functions of the former Administrative and Technical Branch; however, these functions were later moved to the Aeromedical Research Branch and the division office in July 1979. A biostatistical staff was established in June 1968 but was later moved to the Aeromedical Research Branch in April 1975. The Aeromedical Services Branch was retitled Aeromedical Clinical Branch in June 1968. Based on the Federal Air Surgeon's decision that it was his office's lowest priority, the Aeromedical Clinical Branch was abolished in May 1981 during a financial crunch. However, the Aeronautical Center Director reestablished and staffed it in October 1981, under CAMI direction, in order to support the training aspects of the air traffic recovery program (not surprisingly, CAMI eventually negotiated successfully to re-own the clinic in the early 1990's). CAMI was thus structured with an Aeromedical Research Branch, Aeromedical Certification Branch, Aeromedical Education Branch, and Aeromedical Clinical Branch.

In the late 1960's and into the early 1970's, a series of events arose in aviation that led to the vitiation of the earlier mentioned resource ceiling on FAA medical research resources. Serious labor problems with the FAA air traffic controllers and FAA management at the facility, area, regional, and Washington headquarters levels, began to develop throughout the National Aerospace System.

The "vacuum tube" air traffic control hardware and the problems with the new software along with the necessary shift work rotations began to escalate air traffic controller stress concerns. The contributions by researchers at CAMI and the need to properly support CAMI scientists with respect to air traffic controller psychological, physiological, and medical aspects were becoming apparent. Mr. Albert Thomas had passed away in 1966, but the funding ceiling for CAMI persisted through 1983 (although by 1972 overall RE&D funding for OAM began to increase). Moreover, in 1973 the number of authorized research positions dropped from 100 to 97, a loss that was later attributed to an error on the part of the FAA budget office. When the loss was called to the attention of the budget office, a decision was allegedly made to leave it at 97 on the grounds that the budget document was too far along in the process to seek a correction. The correction was never made. In addition to the in-house research at CAMI, the FAA made available to OAM an additional $700,000 for a longitudinal study by Boston University's Dr. Robert Rose on controller stress and illness. The FAA designated a Headquarters medical officer to help Dr. Rose to develop the contract for the proposed landmark study during the subsequent four-year period (1974-78) and the physician who was assigned to help develop this contract and to help Dr. Rose during the four-year period it was in force and monitored by the Office of Aviation Medicine was S.R. Mohler, M.D. That influx of those contract funds established a higher dollar base for the Office of Aviation Medicine's overall research programs. It also established the use of those types of funds by the Washington office so that some research projects came to be funded and monitored outside of CAMI.

The Rose study reflected one of the agency's thrusts to evaluate scientifically issues related to air traffic controller stress. Other research was being conducted at CAMI on related stress topics. Specifically, field studies of controller shift schedules and air traffic workload along with psychological assessments of anxiety, job attitudes, and interest patterns were completed.

In the late 1970's, an interesting option began to be considered by the FAA and the Department of Transportation, specifically there was a proposal to convert CAMI to a departmental function as the Transportation Biomedical Research Institute (TBRI). That proposal received considerable attention over a number of months and appeared to be favorably viewed at the highest levels of DOT. However, interest waned and the proposal was never acted upon.

In 1979, the FAA conducted an "early out" program to reduce staffing levels. A number of research staff took advantage of the opportunity to retire early and, as a result, the authorized position levels were subsequently reduced from 97 to 90 (although actual staffing levels never approached these numbers, due, in major part, to the insufficiency of funding).

In the summer of 1981, a major event occurred in the history of the FAA and of U.S. labor law. The Professional Air Traffic Controllers Organization (PATCO) went on strike and refused to return to work at the order of U.S. President Ronald Reagan. President Reagan fired the striking controllers and the FAA undertook a strike recovery program which included the unprecedented hiring and basic training of over 8,000 air traffic controller applicants in a 2-year period. CAMI played a key role in the recovery program.

As the need for an FAA recovery plan developed, the significant skills of CAMI scientists and their considerable knowledge about air traffic controller selection and training were recognized by then FAA Administrator J. Lyn Helms. A CAMI scientist , Dr. James O. Boone, was appointed to the Administrator's staff and moved to Washington Headquarters to assist in the strategic and operational recovery planning. Other scientists, led by Allan D. VanDeventer, took full charge of CAMI's controller selection research program and provided the local research leadership for the FAA Academy to help make strike recovery work; that included changing the ATC Screen program to make it more efficient with respect to success in Academy training. The importance of CAMI's contributions to strike recovery was underscored by Administrator Helms when he provided certificates of commendation and appreciation from Pan American World Airways dated May 6, 1982, to regional and center headquarters offices, air route traffic control centers, level IV and V terminals; level III flight service stations, the FAA Academy—and to CAMI. The certificate recognized the "outstanding performance of FAA employees in maintaining a high level of safety and operations following the controller strike." Helms also noted in his August 2, 1982, memorandum that he believed that "this is the first time in the history of Pan American World Airways that the Board of Directors has authorized a commendation for a total organization."

As part of the strike recovery effort, following outcomes from contract studies of air traffic controllers (the "Jones Committee Report") and with support from CAMI psychologists, Administrator Helms requested that CAMI scientists develop a questionnaire to assess the FAA's organizational culture as a means of establishing a baseline to determine the effects of organizational interventions. That effort was designed to provide a base of information that could help to prevent the types of impasse that led to the air traffic controller strike and firings. The first FAA Employee Survey was conducted in 1984 as a census of all FAA employees. It was a major undertaking. All aspects of the survey from development of the items, to printing, mailing, scoring, statistical analyses, and preparation of reports were conducted at CAMI under the direction of David J. Schroeder, PhD. The scannable survey form comprised 66 substantive items, was distributed to about 47,000 employees at their home addresses (a considered decision by agency management, reflecting some of the continuing concerns of that period), and yielded a 55% return rate. Although there had been considerable managerial anxiety about the conduct of this first agency-wide survey, and although the results showed a number of areas in need of improvement, the survey project was a highly successful one – it led to consideration by management of plans to improve aspects of the work environment, and identified successful policies. In support of the perceived value of the survey approach, the Administrator decided to continue use of the survey on a biennial basis.

A confluence of events during this time led to some later organizational changes involving both the research branch and the Institute as a whole. Specifically, in 1984, the FAA Associate Administrator for Aviation Standards, Mr. Walter S. Luffsey, assigned a study of CAMI research to a staff member, William Smith, Ph.D., who had a background in physics. The so-called "Smith Report," released in 1984, presented a plan for modifying the CAMI research structure (removing some aeromedical areas from a research to an operations category), introduced the rather cumbersome term "workplace performance optimization" – to cover selection, training, and survey studies - as an area of acceptable research along with "protection and survival" and "workload and performance", emphasized the need for research sponsorship by an operational agency element, and recommended that the Institute report to the Assistant Administrator for Development and Logistics. The "workplace performance optimization" category survived for about a decade while the enhanced sponsorship recommendation was addressed and developed in future years. However, CAMI's basic research structure stayed intact, and the Institute continued to report to Aviation Standards into the 1990's. Moreover, the strike, the successful recovery efforts, and the successful survey project emphasized the need by the agency to direct more attention to its human resources. In that regard, CAMI psychologists had provided leadership and accomplishments significant enough by 1984 to lead agency executives, particularly the highly respected Associate Administrator for Administration, Mr. Gene Weithoner, to seek actively to assure a more prominent role for that group in the organization. The Aeronautical Center Director, Mr. Benjamin Demps, strongly supported the enhancement of human resources research (he had had very positive first-hand experience with CAMI psychologists when he had served as Superintendent of the FAA Academy). Mr. Demps developed a position paper in 1984, drafted by K.A. Hayes, to establish a Human Resources Research Institute at the Aeronautical Center by converting the Aviation Psychology Laboratory to that role. (A similar, less formalized attempt to effect the same type of result was generated among the human resources offices in Washington Headquarters in late 1988). However, the near-term major outcome of these suggestions was the 1986 decision and the January 1987 conversion of the Aviation Psychology Laboratory within the Aeromedical Research Branch to its own branch status as the Human Resources Research Branch. In December 1988, all of the CAMI branches were elevated to division status with the Aeromedical Clinical Branch renamed the Occupational Health Division. These organizational changes remained effective through the year 2000.

Historical Vignette

A Brief History of OAM Research Funding, Staffing, and Technical Report Production

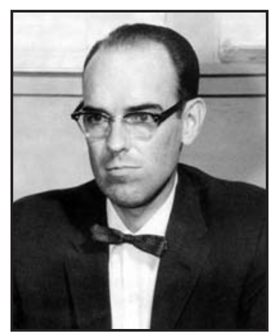
By W.E. Collins, Ph.D. and Gale G. Dills

With the establishment of the Civil Aeromedical Research Institute (CARI) in 1960, research staffing, funding, and the production of technical reports by the Office of Aviation Medicine (OAM) were initially centered in CARI. Indeed, the first two years of research publications (1961-62) were termed CARI reports. The use of the OAM logo and the like change in the designation of those reports began in 1963. Research funding also was tied to CARI/CAMI during the 1960s; later, Washington Headquarters retained funds designated as contract dollars and issued and monitored contracts in such areas as air traffic controller (ATC) selection, aspects of air piracy research, ATC color vision, aspects of aircraft maintenance, and others over the years. The discrepancies between CARI/CAMI funding and overall Office of Aviation Medicine research funding is largely accounted for by the allocation and use of contract dollars from Washington Headquarters. CAMI has always been primarily a hands-on conductor of research and had relatively little or no annually contracted research until the 1990s. During that decade, an expansion of the vision for CAMI research and a concomitant increase in resources – both personnel and dollars – led to an enhanced approach to contracting and, for the first time in 1993, to awarding research grants in support of internal programmatic goals.

Nevertheless, the first two contracted studies by CARI/CAMI were initiated early in its history, at about the same time, and resulted in final reports in October and November 1964. One of these, not surprisingly, dealt with air traffic controllers (Investigation of the Training-Performance Criteria for Several Federal Aviation Agency Occupational Specialties by M. Clinton Miller III, Department of Preventive Medicine and Public Health, University of Oklahoma Medical Center); the other (Vestibular Investigations in Mammals by R.D. Burns, Ph.D., University of Oklahoma, University of Oklahoma Research Institute, June 1962-July 1964) had the added benefit of providing CARI/CAMI with a model RS-2 Stille-LKB rotating chair for vestibular stimulation. The Stille device was employed extensively for decades as a research tool and to demonstrate aspects of spatial disorientation; it later became the basis for commercially produced disorientation trainers, and, to date, is still operable and used as needed.

Figures 1 and 2 show the history of appropriations and authorized positions for the OAM and for CARI/CAMI, respectively. Because the Institute always received the major share of the appropriations, the time course of dollar support in both graphs is similar and, during the 1960s, was veridical.

A similar situation obtains for the position allocation data in both curves with the exception of 1965 and 1986-88. The former case represented a peculiar drop from 100 to 79 as part of the agency order that changed CARI to CAMI; the level reverted back to 100 the following year. Except for 1965 and the 1986-88 period, during which 3 positions were moved from CAMI to the Washington office, all the research positions were nominally located in Oklahoma City. The displacement of those 3 positions was effected by Federal Air Surgeon Frank Austin, M.D., who used them to support the Headquarters OAM staff that was monitoring contract research. The positions were returned to CAMI in 1990.



Dr. S.R. Mohler (c. 1962)

Aeromedical research positions moved up from 62 in 1962 to a 100-level ceiling beginning in 1963, shortly after Stanley R. Mohler, M.D., had become CARI Director. The ceiling of 100 had been set initially by Mr. Albert Thomas' Congressional appropriations committee and was never exceeded. In 1965, the level dropped to 79 as part of the order when CARI was reorganized as CAMI, but rose back to 100 in 1966 when positions at the defunct Georgetown Clinical Research Institute were transferred to CAMI. In 1974, the level dropped to 97 – allegedly on the basis of an error by the agency budget office at Washington Headquarters that was never corrected. Somewhat ironically, OAM research funding increased at about the same time due, in part, to agency support of the so-called "Rose Study" of air traffic controllers.

Overall OAM funding showed a modest linear increase from 1970-1978 and then leveled off for 5 years, but CAMI research dollars remained level over the same

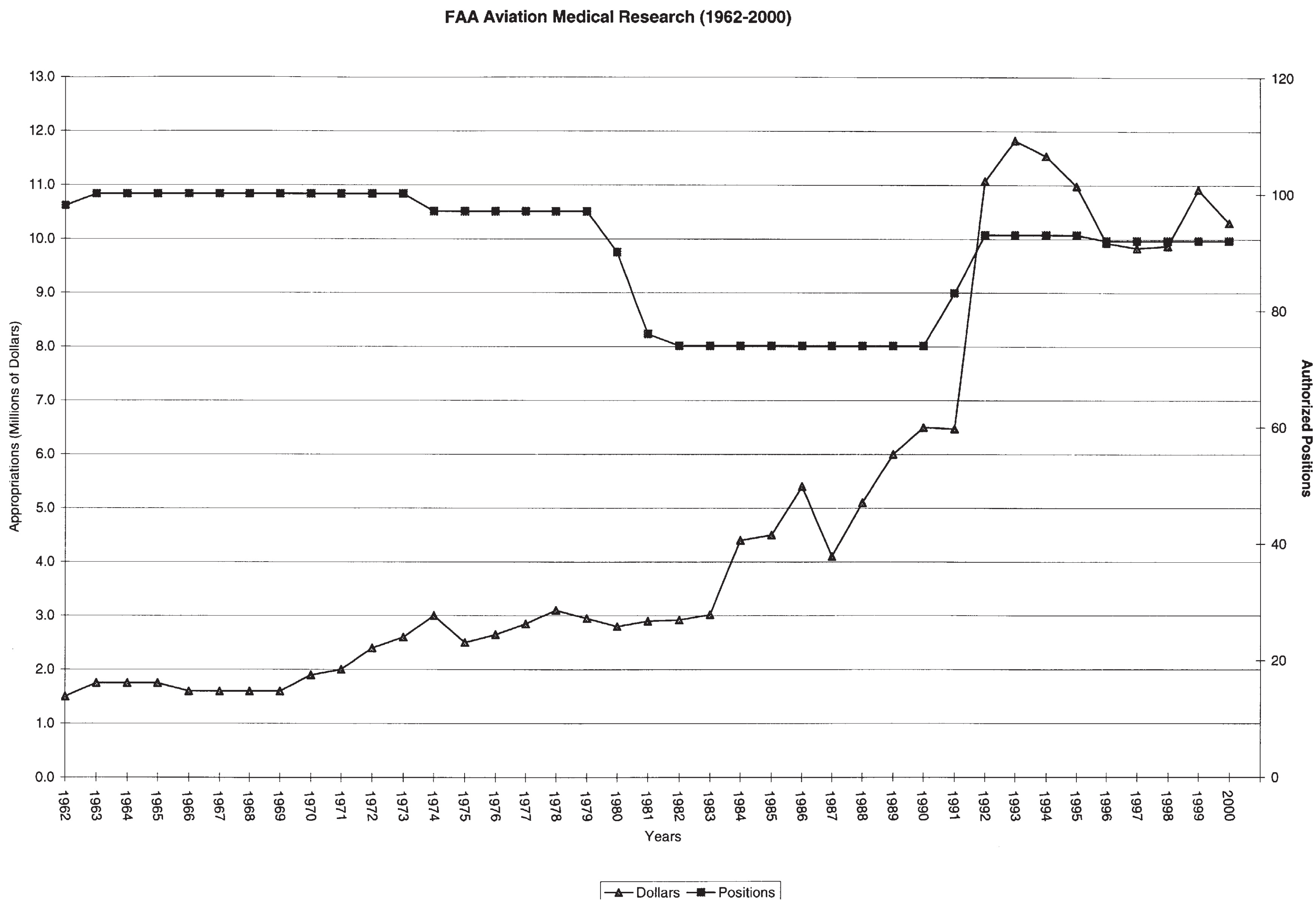


Figure 1. History of appropriations for the Office of Aviation Medicine: 1961–2000.

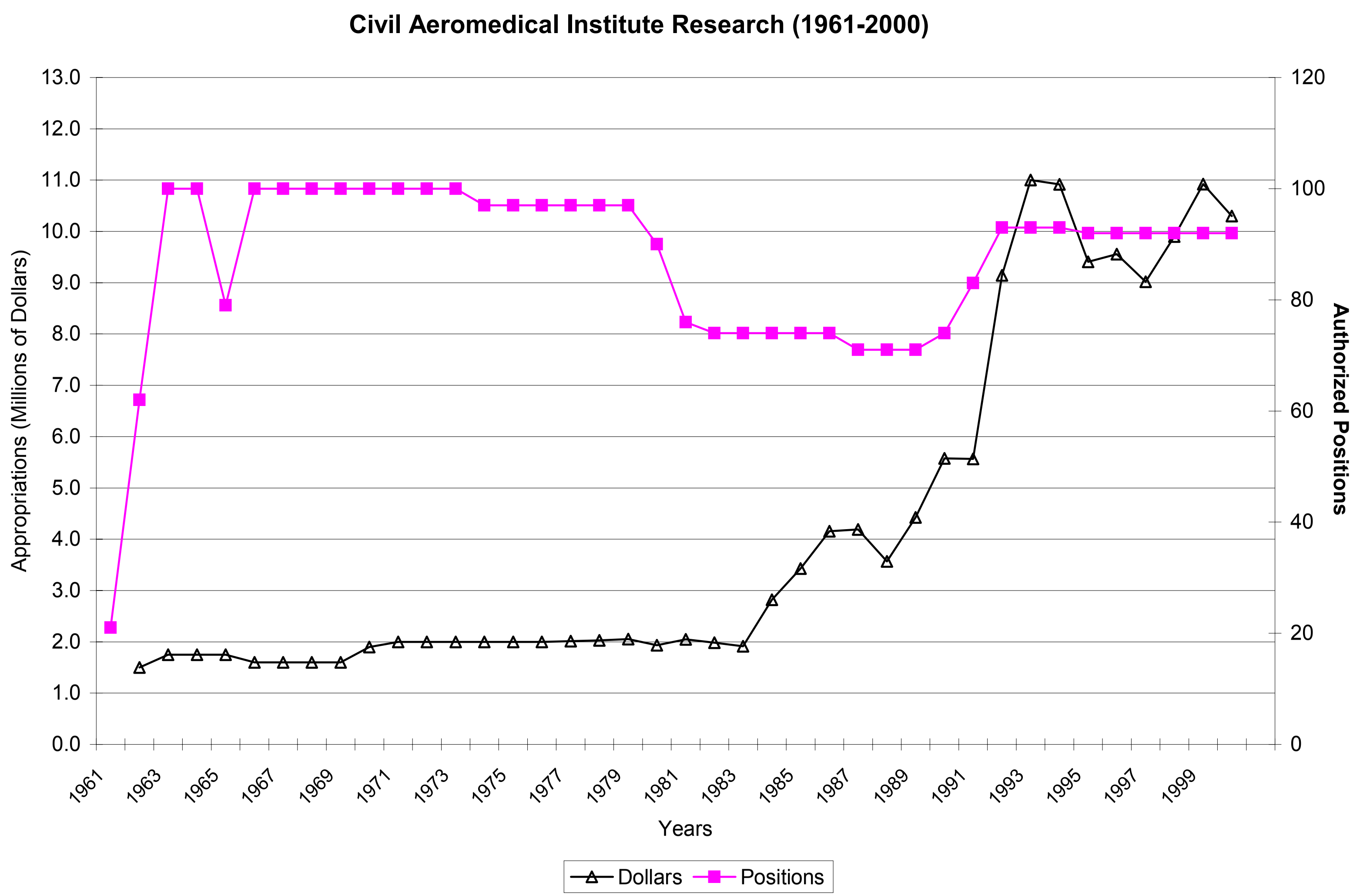


Figure 2. History of appropriations for the Civil Aeromedical Institute: 1961–2000.

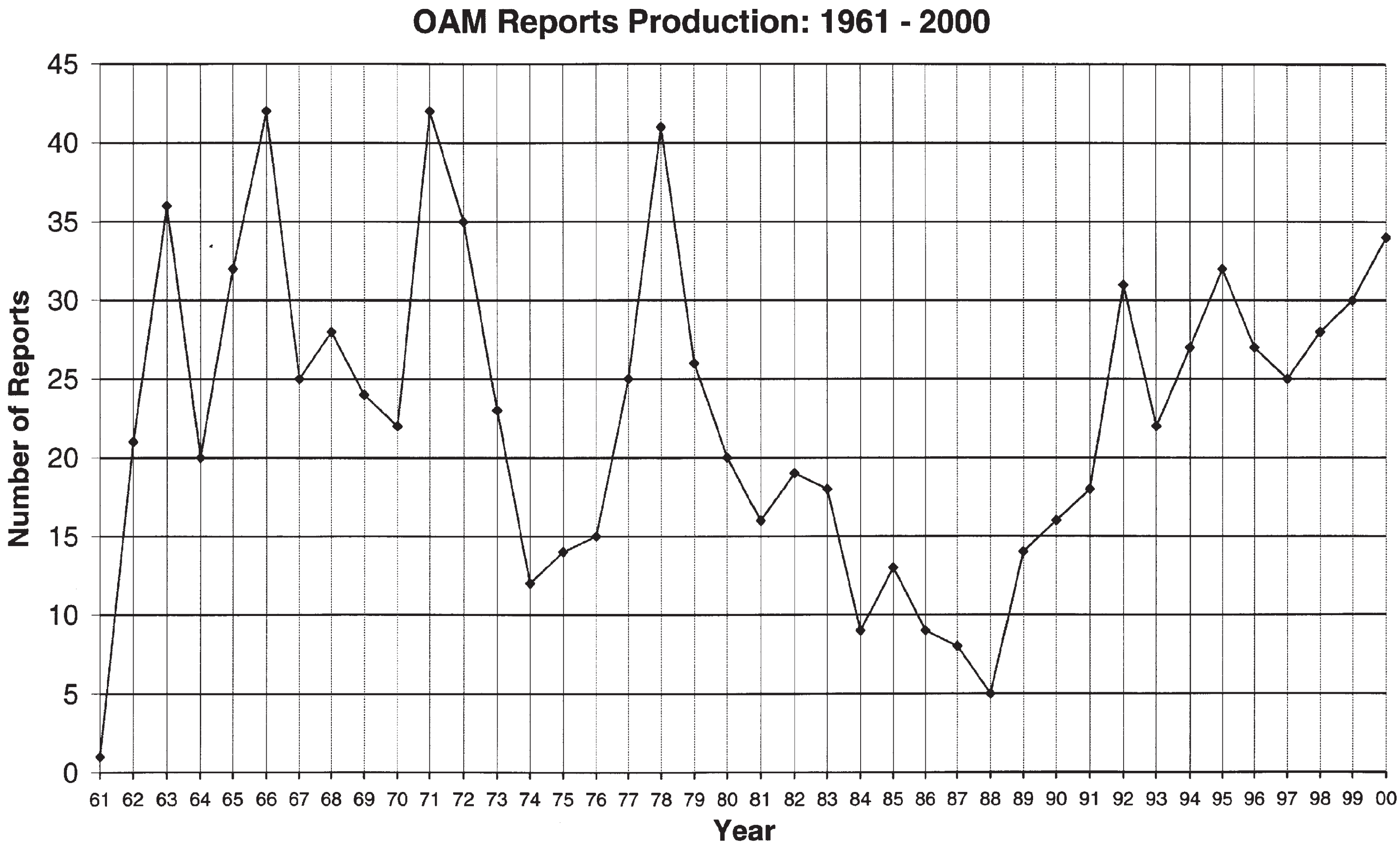


Figure 3. Office of Aviation Medicine Technical Reports: By Year, 1961–2000.

time period. During the 1978-83 period, the number of authorized positions fell on 3 occasions. The first (1980) was related to an "early out" program conducted by the agency and reduced the authorized number to 90 positions. Subsequent reductions occurred in 1981 (to 76 positions) and 1982, leveling off at 74 positions. Also, during this period, a change occurred in the allocation of positions. While previously (and subsequently) all positions were RE&D (i.e., Research, Engineering, and Development), during 1975-1983 from 58 to 77 of the positions were FE&D (Facilities, Equipment, and Development) slots; the remaining 16-20 positions were designated as RE&D. Those variations reflected Washington budget office decisions related to much larger FE&D and RE&D issues. Partly as a result of the increased emphases related to the controller strike, strike recovery, the Employee Attitude Survey, and a new look at selecting and training controllers (along with the diminishing amounts of research resources after CAMI personnel costs were deducted), some increase in OAM funding occurred from 1984-1986, a major part of which was assigned to the Institute.

J. Robert Dille, M.D., who had served as CAMI Director since 1965, retired at the end of 1987. Following several months of rotating acting CAMI managers, William E. Collins, Ph.D., was appointed deputy manager (the term "Director" was temporarily not used because agency officials had come to feel it conflicted with the titles of FAA regional and center directors – it was later restored) in 1988 and CAMI Director in 1989. During that time negotiations to return the 3 CAMI research positions that had been relocated to the Washington office in 1987 were successful; the positions were reallocated to CAMI in 1990. Although the Institute had 74 authorized research positions, by 1988 only 57 full-time permanent personnel were on board and CAMI's research funding was not adequate for a larger base of personnel. Given the approximate 2-year lag in the normal budget process, an immediate concerted effort to negotiate an improvement in resources was needed at every level (Agency, Department, Office of Management and Budget (OMB), and the Congress). Those efforts were successfully undertaken and resulted in significant increases in both positions and dollars. Positions jumped from 74 to 83 in 1991 and then to 93 in 1992. Funding went from less than $4 million in 1987-88 to over $5 million in 1990 to more than $11 million in 1993.

Dr. J. Robert Dille (c. 1963)

Dr. W.E. Collins (c. 1965)

It is perhaps of some interest that these staffing increases were almost topped during the 1993 budget process. At that time CAMI had successfully requested 5 more positions - uniquely the Agency was requesting no others - and had seen them retained during the first FAA-DOT-OMB pass through of the budget (although no new funding was being requested). The positions survived the final FAA cut but were dropped during the final DOT pass through by Admiral James B. Busey who had served as the FAA Administrator from 1989 - 1991 and had moved from there to a DOT position. The grounds reported for removing the 5 positions at that stage were that no new air traffic control or safety positions were being requested in the budget, and no funding for the 5 CAMI positions was in the budget. The OAM-CAMI position level stayed at 93.

Throughout the first three decades of CARI/CAMI research, budgets were submitted through the Office of the Federal (nee Civil) Air Surgeon, and funding was provided to that office and distributed to the Institute. Aviation Medicine was a research budget line. By 1989, however, as part of a response to industry/professional organization/advisory group recommendations, the agency initiated a "human factors" research emphasis that included the hiring of a scientific and technical advisor for human factors. The appointee, Clay Foushee, Ph.D., began to develop a human factors research plan and to work with the agency budget officials. The agency research budget was divided into chapters and the new human factors thrust was assigned to Chapter 8. There was considerable interaction in the budget meetings regarding the title for Chapter 8 – Dr. Foushee and some others preferred "Human Factors" as the title to subsume aviation medicine, aspects of research at the FAA Technical Center (particularly with respect to air traffic controllers), and Washington-based research contracts in various human factors areas. However, perseverance by aviation medicine in these budget meetings led finally to titling Chapter 8 as "Human Factors and Aviation Medicine" – an accomplishment largely attributable to the on-site work of William T. Shepherd, Ph.D., an OAM-based psychologist. The importance of maintaining the identity of aviation medicine research in this instance, and in a later instance regarding logos, transcends any purely nominal issues. Because the agency is largely geared to, and staffed in, regulatory, engineering, and development areas, the unique person-oriented research approach that typifies the OAM research programs needs to be imbedded in a similarly oriented office if it is to maintain its human-centered thrust.

The funding mechanisms subsequently changed. Dr. Foushee developed an office and a staff within the agency's aviation research organization and by 1992 CAMI was being funded directly from the research budget office while the contract research being conducted from the office of Aviation Medicine was given separate funds. In 1995, the latter transfer of funds ceased and, while aviation medicine's contract research from the Washington office continued with the small staff there, funding was drawn from the Office of Aviation Research (AAR) and not allocated to OAM. In 1997, a similar change was attempted for CAMI funding but a case was vigorously and successfully made to allocate immediately to CAMI each year's funding for all "in-house" costs (i.e., everything except contracts and grants for research by outside organizations) and to follow-up during the first quarter of the year (beginning in FY-98) with CAMI's contract research/grants funding. In 1996, the Congressional appropriation for all of FAA's RE&D funding changed, without notice, from a "no-year appropriation" to a "3-year appropriation."

CAMI's research productivity is largely defined by its output of technical reports. Indeed, it is probably the best indicator of its published (or public) research results. Such a measure, while of singular importance, represents only part of the value derived from its research program. CAMI researchers also publish in scientific journals, make scientific presentations at national and international meetings, give safety lectures, provide data and knowledge for educational purposes, and serve as agency, department, national, and international consultants in their areas of expertise. However, as is evident from Figure 3, productivity as measured by technical reports was highly variable irrespective of funding levels during the first two decades. The peak in 1978 is partly attributable to some extra efforts to complete projects before a 1979 "early out" program by the agency to reduce overall staffing levels. From that peak, however, two clear trends emerged. Productivity dropped steadily from 1978 to 1988 to a low of 5 reports; it then increased steadily to an average of about 28 per year during the later half of the 1990's. It is perhaps of some interest that in 1995, AAR developed a logo and initiated an undertaking to use that logo on OAM reports - first in place of the OAM logo, later along with it. Pursuit of both alternatives was discontinued after several months of intermittent discussions to insure the integrity of the medical programs.

The position gains (to 93) were later tempered when the agency introduced a "buy out" program in 1994 (along with a required change in the ratio of employees to supervisors/managers – to reduce the size of the supervisory staff) as part of U.S. Vice President Gore's goal to reduce the size of government. As a result, the agency's overall research program was required to reduce its number of authorized positions and restrict filling the remaining positions by 7 positions per year for the following 3 years. CAMI was able to retain 92 authorized positions (an initial determination to set the level at 88, based on prior-year vacancies, was successfully changed), and the allowed employment level (staffing ceiling) settled at 89 in meeting these agency goals. Those levels were maintained through the year 2000.

Similarly, the peak funding levels achieved by CAMI in 1993 and 1994 were affected following the 1994 "buyout" by reductions in 1995 - 1997; a return to those peak levels began in 1998 and was sustained in years 1999 and 2000.

The data in this report were derived from analyses and resolution of budgetary documents and memoranda initiated at the Aeronautical Center, OAM, and CARI/CAMI.

Some Observations on the Origins of The Civil Aerospace Medical Institute (CAMI): Its First Predecessor, The Civil Aeromedical Research Institute (CARI)

By William E. Collins, Ph.D., and Stanley R. Mohler, M.D.

The following vignette was created by Myrna Johnson during 1966. On October 3, 1960, Ms. Johnson joined CAMI (then CARI) as a receptionist and later served as a budget analyst for Mr. Vaughan E. Choate; the Institute's Administrative Officer. On her own initiative and based on her own sense of history ("all organizations have a history and it should be recorded"), Ms. Johnson undertook the writing of this piece during her last few months at the Institute.

The special section on the Institute's library has some roots in the fact that her husband, who had twice been a part-time employee of the Institute as an editorial clerk/writer (June 1961-September 1962; June-September 1963) while he attended graduate school at the University of Oklahoma, helped set up the library prior to the hiring of the first official librarian.

Ms. Johnson completed the manuscript in July 1966, just prior to her leaving the Institute (August 26, 1966) for Texas where her husband had secured a teaching position following completion of his Ph.D. degree. The text of the article, which is referenced as a "mimeograph" under a slightly different title ("Civil Aeromedical Research Institute – A Brief History, 1959-1966") in Heber Holbrook's 1974 *Civil Aviation Medicine in the Bureaucracy*, is presented below exactly as written. What is not presented is a listing appended by Ms. Johnson, of every federal research employee of the Institute during the period covered along with their job titles, grades, dates they joined the Institute, and for those who left, a date and a one-word description of the reason for leaving. All of the latter data are now available in the CAMI Library.

Ms. Johnson's focus is on the original function of the Institute – research – and, as such, there is no detailing of personnel who came to occupy non-research positions (e.g., in aeromedical certification) as organizational changes (which she notes) took place. Also, when the name (and functions) of the Institute changed to the Civil Aeromedical Institute in late 1965, she uses the acronym CAI for the organization's new title; the acronym became CAMI shortly after she left in 1966 and has been preserved to identify the Institute with its new name – The Civil Aerospace Medical Institute – authorized in 2001 to reflect the FAA's responsibilities associated with the commercial space transportation program.

With Ms. Johnson's permission, we have taken one liberty with her article, i.e., we have added archival photographs that supplement the text.

A rare grouping of key figures in the CARI story. *Pictured in the northeast corner of the CARI lobby in 1963 are (l to r) Heber Holbrook (Administrative Officer in Aeromedical Certification and later author of "Civil Aviation Medicine in the Bureaucracy"), J. Robert Dille, M.D. (CARI Program Advisory Officer – next CARI Director), Peter V. Siegel, M.D. (Chief of Aeromedical Certification – the next Federal Air Surgeon), M.S. White, M.D. (Federal Air Surgeon, September 1963-September 1965 and the first to hold that title – it had previously been "Civil Air Surgeon"), Stanley R. Mohler, M.D. (CARI Director), and Vaughan E. Choate (CARI Administrative Officer).*

Historical Vignette

Civil Aeromedical Research Institute, 1959 – 1966

By Myrna Johnson
July 1966


Ms. Johnson

From its beginning in 1959 until in October 1965, the research facility in Oklahoma City has been called the Civil Aeromedical Research Institute, CARI, for short. To those who were CARI employees during this period of time, the Institute will be remembered as CARI. The purpose of this history is to sketch the growth of this institution.

The Federal Aviation Agency announced on October 31, 1959, plans for the Civil Aeromedical Research Center, later called Civil Aeromedical Research Institute (CARI), to be established at the Aeronautical Center in Oklahoma City, Oklahoma. The purpose of the new medical research center was to develop medical data to meet the problems of civil air operations as civil aviation moved into higher altitudes and supersonic speeds (1).

Late in December 1959, the first CARI personnel arrived in Oklahoma City. John Swearingen, J.D. Garner, Ernest B. McFadden, and John Blethrow had been with the Civil Aeronautics Medical Research Laboratory (CAMRL) in Columbus, Ohio. Dr. Robert T. Clark arrived from the School of Aviation Medicine (SAM) in San Antonio, Texas, to become CARI's Director of Research. The first home of CARI was the second floor, Hanger 8 at the Aeronautical Center. In February 1960, a group of researchers and other staff members arrived at CARI from SAM. This group was comprised of Dr. Jess McKenzie, physiologist; J.D. Allred, audio visual specialist; Dr. Bruno Balke, biodynamics; Dr. James Green, biochemist; Dr. P.C. Tang, neurophysiologist; Aline "Corky" Koch, secretary; M.C. Oviatt, engineering technician; and Claude Jones, administrative officer. During the spring and summer, staff members continued to arrive.

Dr. George Hauty, Rollo Beebe, and Bart Cobb, all in psychology, came from SAM.

In April, Dr. Michael T. Lategola, physiologist, arrived. Dr. Don H. Estes joined the staff in July as the Director of CARI. Vaughan E. Choate became the executive officer in July. Drs. P.F. Iampietro and L.J. O'Brien, physiologists, joined the staff in August. Howard Hasbrook, crash injury specialist, arrived in September. In the last four months of the first year, Dr. Wallace Friedberg, physiologist; Dr. William Stavinoha, pharmacologist; Dr. Richard Snyder, anthropologist; and Dr. E.E. Phillips, physiologist, joined the staff.

The main efforts during the first year were spent in setting up the laboratories and recruiting researchers and technicians. Several moves were accomplished during the first six or seven months. In May 1960, the small group moved form Oklahoma City to Building 604, North Campus, Norman. This building was part of the University of Oklahoma Research Institute. In August, the group moved again into Building 803, Building 805,


The "gym" on the North Campus of the University of Oklahoma in Norman, Okla., housed biodynamics and related research by CARI scientists in 1960-1962. The several buildings occupied by CARI personnel had been temporary U.S. Navy buildings during World War II.

and a gymnasium, which were leased from the University of Oklahoma. Three more buildings were acquired later. The institute remained in these quarters until it moved into new facilities at the Aeronautical Center in October 1962.

The Bureau of Aviation Medicine in Washington, D.C., was established on March 14, 1960 – an indication of the growing significance of the medical program in aviation safety. CARI researchers concentrated on the following projects during the next three months:

1. Man's aging process and the relation to chronological age and pilot proficiency;
2. Selection criteria for and environmental stress factors experienced by air traffic controllers; and
3. Inflight fatigue affecting flight engineers on jet aircraft (2).

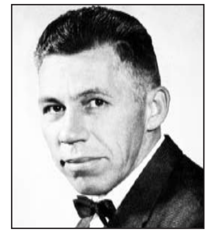
At the end of the first year, the staff consisted of a Director, Director of Research, 18 researchers, 4 secretaries, a receptionist, an executive officer, an administrative officer, a supply specialist, and 20 technicians and scientific aides. Each branch had several members, and the audio visual and engineering services were functioning.

During FY 1961 the accomplishments were threefold: design of the new facility, recruitment of key staff; and initiation of long-range research programs.

The second year was marked by several significant developments and continued growth. The first major change occurred in April 1961, when Drs. Estes, Clark, and Green and several technicians resigned or transferred.

Dr. Hauty served as Acting Director of CARI until the appointment of Dr. Stanley R. Mohler as Director in August 1961. On September 20, 1961, the staff consisted of 89 members, including temporary and part-time workers. The authorized permanent staffing was 64, authorized temporary 18, and authorized part-time 20. Listed below is the staffing by branches and services:

10: Director's Office
8: Biochemistry Branch
6: Branch Chiefs
17: Psychology Branch
2: Clinical Examination
4: Environmental Physiology Branch
6: Employee Health
11: Protection & Survival Branch
1: Library
2: Animal Care
5: Research Engineering
6: Biodynamics Branch
6: Audio Visual
3: Neurophysiology Branch
2: Biometrics


Dr. Estes

Branch secretaries were added in October and November 1961.

Plans originally called for a staff of several hundred in five years or less. However, growth was limited by a congressional ceiling on staffing. The budget prepared in June 1960 for 1961 and 1962 requested 61 positions for 1961, which were within the limit, and requested 150 additional positions over the ceiling. For 1962, 320 positions were requested. Seventy-five positions were authorized for 1962, and this authorization still holds for Research and Development (FY 1966).

At the end of 1961, 18 professional researchers, 7 secretaries and clerks, and 21 technicians and scientific aides had joined the staff in its second year. Part-time employees are included in these numbers.

During FY 1962, 13 CARI reports and 45 scientific articles were published. Research developed methods of predicting success of air traffic controllers in training. The investigations of air crashes furnished information for improvements in air safety. Preliminary work was completed on toxic hazards in aerial application of insecticides.

In June 1962, decentralization of the Washington office occurred, and Certification and Standards Divisions moved to Oklahoma City. The new organization was headed by Dr. George Steinkamp, Deputy Civil Air Surgeon for Research and Operations. CARI, Georgetown Clinical Research Institute, and Research Direction became a part of the Aeromedical Research Division, one of the four divisions, and the Clinic became Aeromedical Clinical Services Division. The remaining two divisions were Aeromedical Certification Division and Aeromedical Standards Division. In December, the Office of the Deputy Civil Air Surgeon was abolished, and the 15 positions given to CARI and Certification. Standards Division moved back to Washington in November 1963.


Mr. Halaby

The major event in FY 1963 was the move in October 1962 into the new $8.5 million research facility at the Aeronautical Center. On October 21, the building was dedicated by FAA Administrator N.E. Halaby (3).

In FY 1963, the staff reached full strength with 35 professional research scientists, 25 research scientists, 15 scientific aides, and 20 part-time aides. In Research Direction, 11 were in the

Office of the Director, and there were six branch chiefs and six branch secretaries. During this year, CARI participated in the supersonic program and Project "Little Guy," in addition to the approved projects. Thirty-five CARI reports and one Technical Publication were issued.

With the move into the new building completed and the labs set up and working, the new facility allowed new projects to be undertaken in FY 1964. Experiments were conducted in the altitude, pressure, and environmental chambers. Ditching, evacuation, and rescue experiments were conducted in the pool. Drug, alcohol, and decompression studies were made at high altitudes. Tests of oxygen masks were conducted. Twenty OAM reports (13 from Georgetown and seven from CARI) were published during this year.

The major projects were retitled in FY 1965 to more clearly describe the medical research program at CARI. Thirty-three professional research scientists, 30 research scientists, 12 scientific aides, and 20 part-time positions were abolished. Thirty-two OAM reports were issued during this year.

During FY 1966, the first major turnover of personnel occurred. Sixteen members of the scientific staff left during this year. Their vacancies were filled with scientific aides. Highlights of FY 1966 included 24 OAM reports, 23 presentations by staff members at various meetings, and 14 papers published in open scientific literature. Late in FY 1966, the Federal Air Surgeon announced the move of [the] Georgetown [facility] to Oklahoma City. This added 25 more researchers and aides to the research program in Oklahoma.

During CARI's existence, CARI has maintained a good relationship with the University of Oklahoma, the OU Medical School, and the communities of Norman and Oklahoma City. Students at OU and the medical schools have worked with CARI scientists, and many of CARI's researchers have had faculty status at OU and the medical school.

Organization

When CARI was established, there were six branches and the Office of the Director, Audio Visual Service, and Research Engineering. Animal Care was added later. The branches and branch chiefs were

- Biochemistry – Dr. James Green;
- Biodynamics – Dr. Bruno Balke;
- Environmental Physiology – Dr. P. F. Iampietro;
- Psychology – Dr. George T. Hauty;
- Protection & Survival – Mr. John Swearingen; and
- Neurophysiology - Dr. Pei Chin Tang.

As mentioned previously, the first change occurred in April 1961 when Dr. Estes transferred to Washington, and Dr. Clark and Dr. Green resigned to take academic appointments. The Director of Research position was abolished. Biochemistry Branch became Pharmacology-Biochemistry, and Dr. Paul Smith became its new chief. In August, Dr. Mohler became CARI's second director and remained in that position until December 1965, when he transferred to the Office of Aviation Medicine in Washington, D.C.

In September 1964, Dr. Balke took an academic position, and Dr. Lategola became the Acting Chief of Biodynamics. In FY 1964, the six branches were changed to laboratories, and in January 1965, the Neurophysiology and Biodynamics Laboratories were dissolved and the personnel absorbed by the remaining four laboratories.

In September 1965, Dr. Hauty resigned to become a department head at an Eastern university [and] Dr. William E. Collins became the new Psychology Laboratory chief.

From CARI's beginning in 1959 to the present time, the Washington organization has changed from time to time, and consequently affected CARI's operation and organization. From 1960 to 1962, CARI was under the Research Requirements Division in Washington. In June 1962, the Office of the Deputy Civil Air Surgeon for Research and Operations was moved to Oklahoma City, and CARI and Georgetown came under the Aeromedical Research Division in this new organization. Dr. Mohler, in addition to continuing as Director of CARI, was the Division Chief of the Aeromedical Research Division from July 8, 1962, until January 2, 1964. In January 1964, CARI came under the Aeromedical Education and Research Division in Washington. Dr. Romney Lowry was the new division's chief. In October 1965, the medical activities at the Aeronautical Center (Certification, CARI, and the Clinic) were reorganized into one division entitled the Civil Aeromedical Institute (CAI). In December, Dr. J. Robert Dille became the new division chief. Dr. Dille had been Program Advisory Officer for CARI from June 1961 until February 1965, when he was transferred to the Western Region as Flight Surgeon. CAI no longer has direct contact with Washington but is under the Director of the Aeronautical Center. There are four branches and the Office of the Division Chief in the new organization.


Dr. Mohler

Dr. Dille

The branches are Administrative and Technical Branch, Aeromedical Certification Branch, Aeromedical Research Branch (formerly CARI), and Aeromedical Services Branch.

The latest reorganization or change is the move by Georgetown to Oklahoma City, to be accomplished by September 30, 1966. In August, Dr. Harry L. Gibbons will become chief of the Aeromedical Research Branch.

CARI Library

A research facility needs a library and CARI was no exception. Early in CARI's history, beginning steps were taken to obtain a library. A library committee was established, and Dr. Jess McKenzie became its first chairman. The original purpose of the committee was established to oversee the entire library functions. Dr. Larry J. O'Brien arrived at CARI in August 1960 and was appointed the committee chairman.

With the establishment of the library committee, the first step was taken. At first, the incoming subscriptions were passed from desk to desk. The receptionist checked in the journals and books as they arrived in the mail. In June 1961, Bobby H. Johnson, a part-time editorial clerk, handled the library materials and set up an efficient operating library. Two rooms of Building 803 became the first library.

Miss Heck

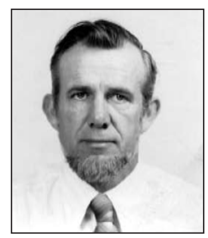
In March 1962, Miss Lilah B. Heck, medical librarian at the University of Oklahoma Medical School, became the first CARI librarian. At this time, the library moved into Building 802 and occupied four rooms (1,175 sq. ft.). With the additional space, there was a library office, a current journals and general reference room, a room for bound periodicals and book stacks, and a photo duplication room. New shelving, reading tables, reading carrels, and duplicating equipment were added.

In FY 1962, the funding responsibility for the librarian, furnishings, and physical appointments was given to the Aeronautical Center library, but the books, subscriptions, and other needs came from medical funds. The function of the committee was changed because of this policy. Instead of overseeing all functions of the library, the committee became representatives of the staff to decide how the budget would be spent for books and journals. In August 1962, Dr. O'Brien accepted an academic appointment and left CARI, and Dr. Carlton Melton became the new chairman.

In October 1962, the library moved into its spacious new home. At first, it occupied rooms 256 and 379. Bound periodical stacks, current periodicals, reference books, patron's work space, and charge desks were on [the] second floor. The book stacks, card catalog, and the library staff's workroom were on [the] third. This move was not final by any means. Office space was required on [the] third floor, so the book stacks were moved to the basement. Later, partitions were removed form the back part of the second floor library, and the stacks were moved to second floor. Finally, all the library was on a single floor.

In June 1965, Miss Heck retired because of poor health, and Mrs. Alfreda Hanna became the new librarian. Mrs. Hanna resigned in February 1966 because of the lack of library help, and Ted Goulden became the third librarian.

Ms. Hanna



Mr. Goulden

The present library committee is comprised of Drs. Melton, Crane, Tobias, McKenzie, Fiorica, Davis, John Ice, and Ted Goulden.

The main problem of the library at the present time is to stay within the assigned library space. The library is growing at the rate of 30 shelf-inches a week. The library budget is another problem. An equipment ceiling in the past couple of years has held the purchase of books and back issue journals to a minimum.

Footnotes

1. "Federal Aviation Agency Historical Fact Book: A Chronology, 1926-1963," P. 45, 1966.
2. *Ibid.*, p. 47.
3. *Ibid.*, p. 60.

A 1960 Prelude to New FAA Medical Leadership at Washington Headquarters and CAMI: Some Personal Recollections

By Stanley R. Mohler, M.D.

Preludes

General Dwight D. Eisenhower was elected the 34th President of the United States in November 1956. On August 23, 1958, he signed the Federal Aviation Act that included the creation of the Federal Aviation Agency (FAA). On November 1, 1958, he selected Elwood "Pete" Quesada, Lt. Gen. USAF (Ret.) to become the first Administrator of the newly established Federal Aviation Agency. General Quesada arranged for James L. Goddard, M.D., a career U.S. Public Health Service officer, to become on July 12, 1959, the FAA's initial Civil Air Surgeon (Holbrook, 1974), a new title for the enhanced top FAA medical position that was elevated to report directly to the Administrator (who reported to the President).

In collaboration with William F. Ashe, M.D., Chair of the Department of Preventive Medicine, Ohio State University School of Medicine, Dr. Goddard convened on September 15, 1960, his first FAA formal assemblage of aviation medical examiners (AMEs). This was in conjunction with the 7th Annual Postgraduate Course in Aviation Medicine that Dr. Ashe had been conducting for several years. A group of selected interested physicians and aviation professionals comprised speakers for this prototypical AME seminar, held in the fall of 1960, that has grown to become today's outstanding seminar presentations by the Civil Aerospace Medical Institute (CAMI). At the conclusion of the course, Dr. Goddard announced that he intended to initiate FAA seminars of this type for AMEs before the end of the year. And he did so. Mr. James L. Harris organized the first one in December of 1960. CAMI AME seminars are now provided nationally and internationally and continue to achieve Dr. Goddard's objective to upgrade the aviation medical certification practice of AMEs.

Those attending the historic 1960 gathering included the following:

- Charles I. Barron, M.D., Medical Director of the Lockheed Aircraft Company, speaker
- George P. Kidera, M.D., Medical Director, United Airlines, speaker
- Peter V. Siegel, M.D., Smithton, Missouri, AME
- Stanley R. Mohler, M.D., Medical Officer, Center for Aging Research, NIH, speaker
- Philip B. Phillips, M.D., Psychiatrist, U.S. Navy, speaker
- Richard G. Snyder, Ph.D., Crash Injury Researcher, Phoenix, Arizona, speaker
- Ralph F. Nelson, Aircraft Owners and Pilots Association, Bethesda, Maryland, speaker
- Duane A. Catterson, M.D., Student/resident, aerospace medicine, OSU
- Charles E. Billings, M.D., Student/resident, aerospace medicine, OSU
- Richard L. Wick, M.D., Student/resident, aerospace medicine, OSU
- Luis A. Amezcua, M.D., International AME
- Bert D. Dinman, M.D., Occupational medicine facility, OSU

In addition to Dr. Goddard, other attending FAA medical personnel included:

- William R. Albers, M.D., Assistant Eastern Region Flight Surgeon, New York
- James L. Harris, M.Ed., tasked to organize the first AME seminar, Washington, DC
- John E. Smith, M.D., Chief, FAA Research Requirements Division, Washington, DC
- Arthur E. Wentz, M.D., Head, FAA Georgetown Clinical Research Branch, Washington, DC
- Carl E. Wilbur, M.D., USN, Assigned to FAA, Accident Investigation, Washington, DC

Developments

By the summer of 1961, Dr. Goddard had asked Dr. Siegel to join the Headquarters Certification Division and Dr. Mohler to become the Director of the emerging Civil Aeromedical Research Institute (CARI) at the FAA Aeronautical Center, Will Rogers Airport, Oklahoma City, Oklahoma. Both accepted. In 1962, Dr. Goddard moved the Headquarters Certification Division plus the Standards Division to facilities in the new Institute. Dr. Albers was asked to be the new Standards Division Chief and he quickly accepted. Dr. Siegel was asked to be the

Participants in Dr. Ashe's 7th Annual Postgraduate Course in Aviation Medicine, Ohio State University, 1960.

1. Dr. Mohler, 2. Dr. Siegel, 3. Dr. Dinman, 4. Dr. Smith, 5. Mr. Nelson, 6. Dr. Amezcua, 7. Dr. Goddard, 8. Dr. Kidera, 9. Dr. Ashe, 10. Dr. Catterson, 11. Dr. Wick, 12. Dr. Billings, 13. Dr. Barron, 14. Dr. Wentz, 15. Dr. Albers, 16. Mr. Harris, 17. Dr. Snyder, 18. Dr. Phillips, 19. Dr. Wilbur. Others are primarily AMEs.

Chief of the Certification Division and he accepted. Mr. Harris transitioned to the Institute to manage aviation medical examiner and airman education programs.

The Research Requirements Division remained in Washington, DC. When Dr. Smith retired, Dr. Mohler was appointed to head the Washington-located Division, giving him both an Oklahoma base and a Washington Headquarters base. He could write a memo to Washington as CARI head and send himself an answer as Washington Division head. This was a very efficient arrangement. Support for a soon-to-be-famous and widely quoted decompression study (Barron and Cook, 1965) by Dr. Charles Barron of Lockheed (Barron and Mohler had become acquainted at the 1960 OSU meeting) was requested by "the CARI Dr. Mohler" and subsequently approved by "the Division Chief Dr. Mohler."

Drs. Albers, Siegel, and Mohler obtained homes in Norman, Oklahoma, and often rode back and forth to the Institute together, providing useful opportunities for program coordination. Their "triad" formed an interlocking, synergistic, and functional exchange mechanism that benefited their periodic briefings for national and international aviation executives. A new FAA "National Aviation System Course," monthly five-day seminars for aviation industry executives, and engineering and operational professionals (including airline pilots), was introduced in 1963 by General Quesada's successor, Mr. Najeeb E. Halaby. The course made heavy use of the three physicians for several years as regular presenters. A guided tour through the Institute was a highlight for the "student" visitors and gave the three medical programs considerable visibility throughout the aviation industry.

The Aviation Medical Service programs became increasingly known and consulted. Dr. Siegel oversaw the computerization of the FAA medical records certification process for airmen. He moved the Class One airman ECG reception point address from Georgetown University to his Division in Oklahoma where the responsibility for assessment and action lay. Dr. Albers, with Charles R. Harper, M.D., made the first definitive study of the number of fatal alcohol-associated general aviation accidents. Dr. Mohler assisted the researchers to expeditiously prepare, communicate, and publish their aeromedical safety findings for use by the aviation community, including manufacturers, airmen, and FAA flight standards and air traffic personnel.

In September 1965, Dr. Siegel was asked by the new FAA Administrator, General William F. McKee, USAF, to be the Federal Air Surgeon (the position that was originally entitled Civil Air Surgeon). Dr. Siegel asked


CERTIFICATE OF PARTICIPATION

This is to certify that

STANLEY R. MOHLER, M. D.

was a participant in the Seventh Annual

POSTGRADUATE COURSE IN AVIATION MEDICINE

given at Columbus, Ohio, September 12 to 16, 1960
under the auspices of the

Department of Preventive Medicine of
The Ohio State University
and the
Bureau of Aviation Medicine
Federal Aviation Agency

Chairman, Department of Preventive Medicine
The Ohio State University

Civil Air Surgeon, Bureau of Aviation Medicine
Federal Aviation Agency

Replica of a certificate, signed by Drs. Ashe and Goddard, documenting participation in the 7th Annual Postgraduate Course in Aviation Medicine, 1960.

Dr. Mohler to accompany him to headquarters as Chief of the new Aeromedical Applications Division (research planning branch, accident investigation branch, and bioengineering branch). Both moved to Washington. Dr. Albers was now with United Airlines, Washington, DC, and subsequently became Medical Director of the Atomic Energy Commission.

In order to consolidate and more efficiently conduct the FAA medical research, Dr. Mohler suggested, Dr. Siegel concurred, and General McKee agreed, that the FAA Georgetown clinical research activity (set up to study pilot aging) be amalgamated with the now Civil Aeromedical Institute (CAMI) in Oklahoma City. The move was facilitated by a Government Accounting Office (GAO) report suggesting that similar research was being accomplished at the Lovelace Foundation, Albuquerque, New Mexico. Some of the Georgetown resources were applied to construct a large-scale emergency evacuation research facility adjacent to CAMI (Mohler, Hays, and Collins, 2001). Longitudinal pilot aging studies at the Lovelace Foundation continued to provide the FAA with data on the topic after the FAA Georgetown activity ended. While at the Center for Aging Research, National Institutes of Health (NIH), prior to joining the FAA, Dr. Mohler had assisted Lovelace scientists to obtain large-scale support to study airline pilot aging. In fact, the invitation by Dr. Goddard to Dr. Mohler to attend the 1960 OSU seminar was for the latter to give a presentation on the latest developments from the NIH perspective in the field of research in aging (Mohler, 1961).

Dr. Siegel retired from the FAA in 1976. Dr. Mohler retired in 1978, becoming Professor and Director of the new Aerospace Medicine Residency Program being established by National Aeronautics and Space Administration (NASA) at the new School of Medicine, Wright State University, Dayton, Ohio. With the departure of its key faculty, Ohio State University had just closed out its aerospace medicine residency program.

CARI/CAMI

With regard to CARI, in October 1965, just prior to Dr. Mohler's December move to Washington, DC, Administrator McKee gave the Aeronautical Center Director, Mr. W. Lloyd Lane, managerial authority over all Center activities. As part of the general reorganization of the Aeronautical Center, CARI, the Medical Certification Division, and an Aeromedical Services Branch that included a medical clinic were combined into one new division and CARI became CAMI – the Civil Aeromedical Institute. Succeeding Dr. Mohler was J.R. Dille, M.D., who had served as Program Advisory Officer to Dr. Mohler from 1961-1964 before spending a year as Regional Flight Surgeon, Western Region, Los Angeles, California. Dr. Dille directed CAMI from December 1965 until his retirement in December 1987. He was succeeded by William E. Collins, Ph.D., a psychologist who had been jointly selected in December 1965 by Dr. Mohler, Dr. Dille, and Mr. Lane to head CAMI's Aviation Psychology Laboratory. Dr. Collins was acting CAMI Director during 1988 and served as Director from 1989 until his retirement in 2001. Melchor J. Antuñano, M.D., who had been hired by Dr. Collins in 1992 to head the Aeromedical Education Division, was appointed the new Director of CAMI in 2001.

In the continuation of historical linkages, Dr. Antuñano was a former aerospace medicine resident with Dr. Mohler at Wright State University, graduating in 1987. Dr. Antuñano, a native of Mexico, had been recommended to Dr. Mohler for the residency program by none other than Dr. Luis Amezcua, who had risen to the top in Mexico's civil aviation medicine programs. It will be recalled that at the 1960 meeting at Ohio State University, Dr. Mohler and Dr. Amezcua had become acquainted and evolved a lasting professional friendship! Dr. Amezcua's recommendation of Dr. Antuñano thus received a high weighting, a fully justified decision as subsequent events have so well demonstrated.

After Word

In late 2001, CAMI was given "commercial space flight" responsibilities and enters the 21st century with the same acronym but an updated name: the Civil Aerospace Medical Institute. Under Dr. Antuñano's guidance, the personnel at the Institute are looking forward to the completion of a large-scale renovation of the Institute building, currently in progress, as they continue their national and international aerospace medical and human factors research, medical certification, aeromedical education, and medical standards safety work and contributions.

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