

Duane T. McRuer

Duane McRuer was born October 25, 1925 in Bakersfield, California and served in the Navy during World War II as a Lieutenant (j.g.) developing anti-submarine techniques. He attended the California Institute of Technology graduating with a Master of Science in Electrical Engineering in 1948. He was given a CalTech Distinguished Alumnus Award in 1983.

Rapid advancement in the design of aircraft following World War II called for major new developments in aircraft flight control system technology. After serving in the Navy and upon graduation from the California Institute of Technology, McRuer joined Northrop Aircraft and quickly became the Technical Chief of Flight Control. He spearheaded many flight control developments on such aircraft as the Northrop flying wings and the F-89 fighter, a mainstay of the Korean War.

Larger, higher performance aircraft required hydraulic powered control systems. Getting these to work right proved difficult, early versions would uncontrollably bang stop-to-stop. Understanding the phenomena, and its describing mathematics, and thereby making hydraulic aircraft control systems practical, was one of the early contributions of Duane McRuer. The theories he applied were well understood in academia, but McRuer's work was one of their first practical applications in the aerospace industry and are now a standard part of engineering school curricula. He was also among the first to introduce artificial stability to an aircraft whereby the control surface movement in response to a sensed motion was not felt by the pilot.

McRuer's early success was just the start of a career that spanned more than fifty years. He continued to make significant contributions to both the theory and practical application of aircraft flight control systems. For example, all aircraft in flight undergo a natural swaying motion, colorfully named "Dutch roll," like a Dutch skater on ice. This motion is exacerbated on aircraft such as commercial airliners with swept back wings, and is not only uncomfortable but leads to vomiting. McRuer recognized that reducing this motion puts an unreasonable workload on pilots, and so he developed an automatic control system to do so – the "sideslip stability augments". He holds four patents, including this device, related to flight control systems.

While at Northrop, McRuer also took an active role in disseminating his ideas through a series of reference books underwritten by the Navy Bureau of Aeronautics. This work later evolved to become the widely used graduate-level text *Aircraft Dynamics and Automatic Control* co-authored with Irving L. Ashkenas and Dunstan Graham. Along with the book *Analysis of Nonlinear Control Systems*, written by McRuer and Graham, evolving technology was disseminated to a generation of engineers working in these fields and, no doubt, influenced the design of control systems in a wide range of vehicles.

With Ashkenas and wife Betty, McRuer founded Systems Technology Inc. (STI) in 1957, located in Hawthorne California. At STI McRuer assembled the team that has continued research and development in aircraft dynamics and flight control. After the downturn in the aerospace industry, as the Apollo program ended, McRuer and his team broadened their interests to many vehicle types including submarines, airships, cars, trucks, trailers,

and tanks. The STI team specialized in the intersecting areas of dynamic systems and human behavior, known as manual control theory.

Duane McRuer, affectionally known as “Mac,” had a rare ability to transform practical problems into mathematics and thereby not only provide solutions to these problems but add to the research literature. A prominent contribution by McRuer circa 1970 was mathematical models of pilots and drivers, which he called “human operators.” The fundamental principle is the simple but powerful “Crossover Model,” also known as “McRuer’s Law.” This principle has led to the design of vehicles with improved performance while at the same time being safer and easier to operate. McRuer’s Law applies to all vehicles controlled by humans, undersea, on the sea, on the land, in the air, and outside the atmosphere. Application of these theories has led to improved understanding of how drivers control automobiles which has had great benefit in highway safety. This principle continues to be applied, and underlies contemporary efforts in the aerospace industry such as the redesign of control systems for military helicopters. McRuer’s Law, being fundamental, will always be applicable.

McRuer was a mentor for many engineers and researchers working on a variety of aircraft and manual control problems. These included his pioneering work in the phenomena of Pilot Induced Oscillations (PIO) in which a pilot's efforts to control an aircraft can drive the overall man-machine system unstable. The PIO phenomenon underlies the suspense in the Michael Crichton book *Airframe*. Many aircraft, including the Space Shuttle and commercial airliners, have encountered PIO phenomena in their development and in actual operation. McRuer was a major figure in PIO research throughout his career and led a recent National Research Council Committee study on this phenomena that provided recommendations to the aircraft manufacturers, airlines and regulatory agencies on improving aircraft safety.

McRuer served as an adviser to Government agencies and large corporations including advising NASA on the readiness of the flight control system of the Space Shuttle for its first flight. He was elected a Fellow of the Institute for Electrical and Electronic Engineers in 1967, a Fellow of the American Institute of Aeronautics and Astronautics in 1973 (Honorary Fellow 2002), a Fellow of the Society of Automotive Engineers in 1977, and also for several other professional societies. He served on the Aeronautics Advisory Committee of the NASA Advisory Council. Contributions by McRuer included recommendations for redesign of the space station. He was elected a member of the National Academy of Engineering in 1988 and headed a committee which studied the aircraft PIO problem.

McRuer retired as President of STI in 1995 but remained active in the industry and in education. He continued his long involvement with the Society of Automotive Engineers Aerospace Control and Guidance committee and also served as the Jerome Clarke Hunsaker Professor of Aeronautical Engineering at the Massachusetts Institute of Technology in 1992-3.

Besides his many engineering accomplishments, McRuer was an avid mountaineer and contributor to the Angeles Chapter of the Sierra Club, which he joined in 1962. He was instrumental in creating the Leadership Training Program that serves as the model for the entire Sierra Club and wrote and then edited several versions of the Leadership Reference

Book. McRuer met the demand from the Angeles Chapter for leadership standards, certifications, and training. Duane conceived the training system, wrote much of the LRB, organized and ran many of the snow, rock, and navigation practices and checkouts and, importantly, set the whole structure off on its own power, tapping various people on the shoulder, urging their involvement, encouraging their efforts. He served as the Chair of the Sierra Peaks Section of the Club in 1976 and continued to be an active climber and mentor. He climbed all of the 297 mountains contained on the Sierra Club Sierra Peaks List in 1985, and by 1997 had visited or climbed the high point in all fifty states, save one, Mount McKinley in Alaska. He also climbed all of the 97 mountains contained on the Sierra Club's Desert Peaks list twice. He was awarded the National Sierra Club's Oliver Kehrlein Award for Outings Leadership (1997) and the Sierra Club Angeles Chapter's Lifelong Service Award (1998) among many other honors. Mac continued to climb peaks well into his eightieth year. His energy, endurance, and knowledge of geology made him a favorite and inspirational companion to all who accompanied him on the many hiking trails and climbing routes here in California and across the U.S.

A tribute from Prof. A. E. Bryson, Professor of Engineering, Stanford University:

“Mac's outstanding work in flight mechanics and automatic control of aircraft and spacecraft was recognized world-wide through his books and technical papers and reports.

He was an Honorary Fellow of AIAA (their top honor) and received their top award in guidance and control, the Mechanics and Control of Flight Award. He was considered by many to be the world's leading authority in aircraft handling qualities and man-machine relations. He also made significant contributions to the handling qualities of automotive vehicles.

He was a mentor to many outstanding researchers in aerospace guidance and control through his work at Systems Technology Inc. which he co-founded with Irving Ashkenas.”

A tribute from the Central Aerohydrodynamic Institute, Russia

TsAGI's “dynamic” society perceives the news about the death of Duane McRuer with deep regret.

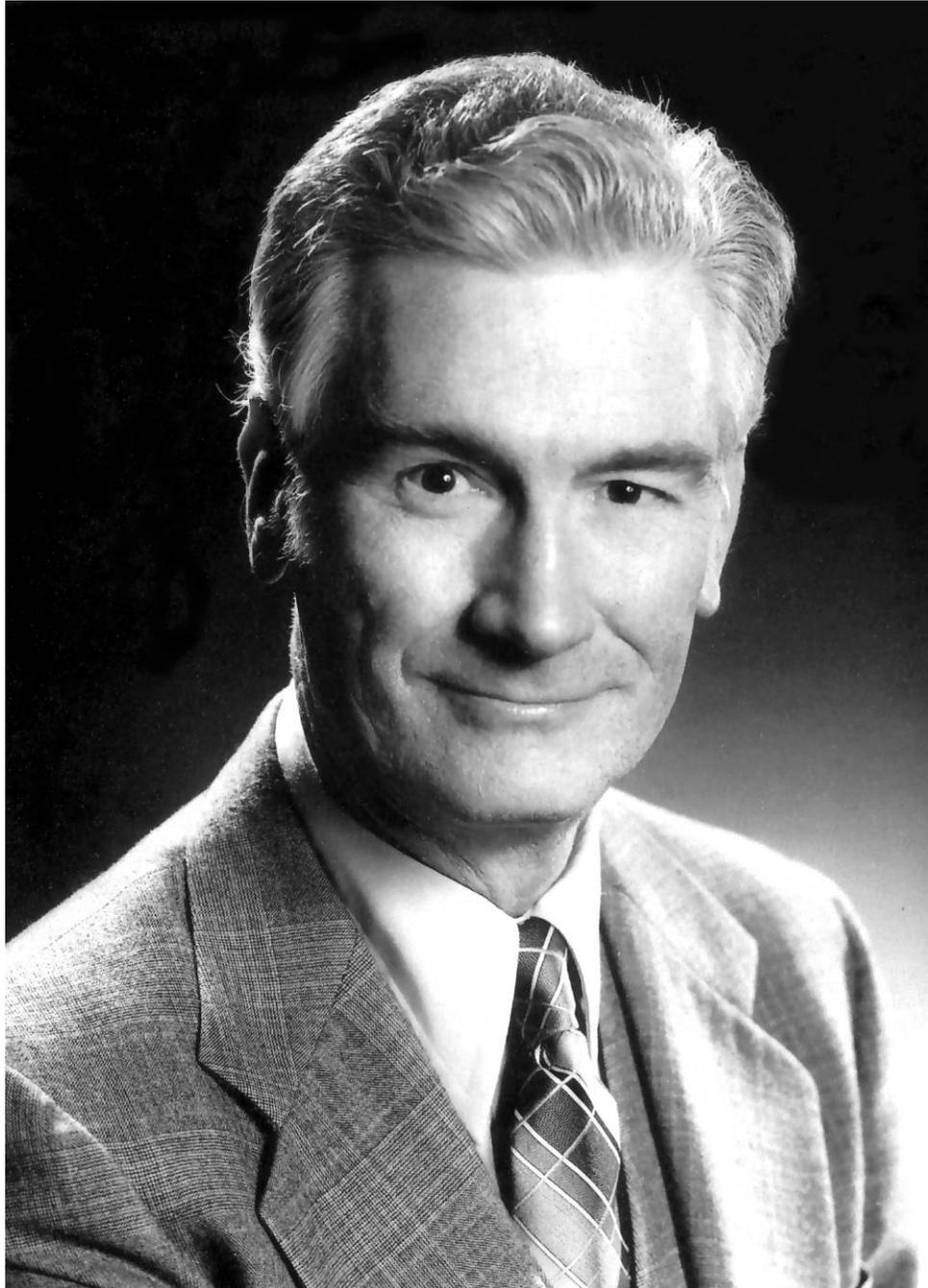
He was a scientist of world-wide reputation, the founder of manual control theory. Almost half a century he was a leader of scientific school of major importance, and all these years he had undisputable authority over scientific and industrial circles both inside the US and abroad. His ideas, thoughts, opinions on pilot-aircraft system problems were always perceived by his interlocutors, audience and readers with great gratitude.

Our science suffers the irreplaceable loss. We present our deep condolences to his relatives, friends and colleagues.

Dr. Valery L.Soukhanov, Deputy Director of TsAGI, dynamics15@tsagi.ru

Dr. Yury F.Schelukhin, Head of Flight Dynamics and Control System Department, TsAGI

Larisa E. Zaichik, Yury P.Yashin and other specialists of Flight Dynamics and Control System Department, TsAGI



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