J. HALCOMBE LANING

1920–2012

Elected in 1983

"Unique pioneering achievements in missile guidance and computer science—the 'Q-guidance system' for Thor and Polaris and George."

BY DONALD C. FRASER

Born in Kansas City, Missouri, J. HALCOMBE LANING (February 14, 1920–May 29, 2012) was educated at the Massachusetts Institute of Technology, where he received a BS in chemical engineering (1940) and PhD in applied mathematics (1947). He served in the US Army in World War II and in 1947 joined the MIT Instrumentation Laboratory (later the Draper Laboratory), where he spent his entire career.

Hal was one of the most brilliant people I have ever worked with, and simultaneously one of the most self-effacing—he avoided any publicity for his numerous major contributions. He possessed a quick, active, wry humor, and was always available to assist anyone with a problem. When I was a graduate student and writing programs in the language he had developed (MAC), he never refused or delayed helping me when I needed assistance.

He could read a hexadecimal dump of data as easily as I could read a novel. At any time if challenged, he could recite at least the first 30 digits of pi. Like most of us he made notes of things he needed to do and kept a calendar. Unlike the rest of us, however, his were on the back of unused punch cards that were originally used to load data and programs into computers. He must have stored an enormous number of these because he still was using them the last time I worked with him—long past when they were common. Of course this also meant he only wore shirts with appropriately sized pockets.

His accomplishments spanned a number of firsts. Among these were algorithms that are used to this day in guiding missiles, the first algebraic compiler, a computer operating system (OS) that enabled prioritized multiple simultaneous tasks, use of what is today termed "optimal control," and use of computers to design and analyze complex three-dimensional shapes. All of these firsts displayed his classic signature: providing simple solutions to very complex problems.

Inertial guidance systems in the 1950s had gimbals. The core accelerometers were on a platform stabilized by gyroscopes so that the input axes of the accelerometers were always in a stable known orientation. Needless to say, this was a complex set of hardware. The dream was to eliminate the gimbals and use computation to interpret the accelerometer output, and indeed this is true of all but the most precise of today's inertial guidance systems because computer technology advances have made it possible. Hal developed the algorithms to do this in 1953, 40–50 years before their use became commonplace.

In the 1950s he became interested in the guidance of ballistic missiles. Clearly, gravity affects the flight of any missile. Unless radio controlled, which was common on the first missiles, a means of measuring and accounting for the effect of gravity was necessary to guide a missile. Hal developed what at the time was a classified solution based on a very simple vector differential equation. It obviated the need for a device to measure gravity and was so simple that it could be implemented in analog electronics and later in the first digital devices, digital differential analyzers. Implemented in analog electronics it first flew on the Thor missile, then became the basis for the Polaris guidance system. Since then it has been used in virtually every missile or spacecraft guidance system. It was named "Q-guidance" after the symbol Hal chose to use in his differential equation.

After spectacular successes in military fire control systems during World War II and thereafter, "Doc" Draper's MIT Instrumentation Laboratory became "the place to go" for the country's most difficult guidance problems. During the 1950s one of these challenges was to develop a guidance system that would send a spacecraft to Mars, take photos, and return film (yes, film!) to Earth. Hal envisioned this mission being controlled by an onboard computer and went to work developing an operating system for such a computer.

The mission was never launched but the work (and the above-mentioned parallel successful work on Polaris missile guidance) led to the selection of the MIT Instrumentation Lab to develop all the guidance and navigation for the Apollo program. Hal took this early work and developed it to run the Apollo guidance computer that was in both the Command and Lunar modules.

For the Apollo program the operating system that Hal developed was a key differentiator between success and failure. The OS included an interpreter and was capable of managing multiple programs simultaneously. The interpreter contained a priority interrupt system that turned out to be invaluable during the first lunar landing, when a rendezvous radar wanted the computer's attention during the landing, not during rendezvous with the Command Module when it had higher priority. This saved the landing.

The Apollo operating system was not the only one Hal worked on. By the end of the 1950s the MIT Instrumentation Laboratory obtained the latest mainframe computer every few years. Hal was not satisfied with the operating system on a new Honeywell 1800 when it arrived so he developed his own and installed it. All of us using that computer used his OS from then on. And when Hal bought his first home computer, he deleted its OS and replaced it with his own.

His OS work was pioneering, indispensable for some of the nation's most important programs of that era, and led to the development of modern systems. But perhaps one of Hal's least recognized major breakthroughs was the development of the world's first algebraic compiler. He named it "George" (e.g., "let George do it") and it went into operation on MIT's Whirlwind computer in 1952. This precursor of Fortran and all other mathematical language software systems helped pave the way for what has become computer science today. IBM learned of this and sent a team to MIT to talk with Hal. They used what they learned in the development of Fortran.

Beginning around 1964 Hal developed an interest in manipulating complex geometric shapes with a computer to enable countless engineering design and manufacturing applications. By the 1970s there was limited software available for this purpose and most often it simply computerized two-dimensional engineering drawings. These packages lacked (or had severely limited) capacity to manipulate three-dimensional objects and could not do simple tasks like evaluating interference among objects.

Hal had developed software he called "SHAPES" and began collaborating with interested companies. The software could not only draw objects from any perspective but also calculate mass properties, thermal properties, radiation hardness, and so forth. Companies such as Fiat and Caterpillar were some of the early users both for their engineering developments and for flexible manufacturing systems where machines did not need to be specialized. An entire industry providing such software tools resulted from this early work and factories around the world now commonly use flexible manufacturing systems.

Hal was routinely decades ahead in anticipating needs and devising solutions for them. A few of these were the first use of the method of steepest descents, now a common tool in the development of optimal control algorithms; switching logic, which later led to algorithms to switch between cell phone towers; and algorithms for the control and routing of on-demand shuttles, decades before organizations like Uber were formed.

For all of Hal's achievements I am not aware of his ever publishing the results. He did not seek attention but let others spread his knowledge. The only exception was when his long-time colleague, Richard Battin, persuaded him to coauthor *Random Processes in Automatic Control* (McGraw-Hill, 1956), which became an essential text for decades in educating control engineers at MIT and around the world. Rumor has it that

Dr. Battin had to continuously cajole Dr. Laning to get him to write his part of the book.

I mentioned in my opening Hal's quick dry humor. One of my favorites is an anecdote from the Apollo program at the MIT Instrumentation Lab. Ralph Ragan, director of the project, became annoyed that people were arriving late for his early-morning weekly senior staff meetings. He announced that it would cost 25 cents for anyone arriving late and that the proceeds, when sufficient, would buy lunch for everyone. Hal instantly pulled out a dollar and stated that he was paid up for the month.

I have also been told that not only his humor but his skill in mathematics developed early. A self-described "forced Presbyterian," little Hal used to sit in church with his parents, oblivious to the prayers and sermon as he would "make math problems out of the hymn numbers on the sign board."

Hal Laning was married for 63 years to the former Betty Kolb, who passed away in 2005 after three years with Alzheimer's. They are survived by their children Chris, Jim and his wife Helen, Sue and her husband Jack, and Linda and her husband Jim; and grandchildren Alana, Jamie, Jessie, and Abby.