PHILIP M. MORSE AND THE BEGINNINGS

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Morse was the many-sided founding father of operations research in the United States. Following his pioneering wartime effort, he vigorously promoted the nonmilitary development of the field. A glimpse into his activities and accomplishments helps explain the vitality and high intellectual standards of the field.

A 50th anniversary issue of *Operations Research* would be incomplete without a retrospective look at the remarkable contributions of Philip McCord Morse to the establishment of operations research as a field and the starting of the journal. Professor Morse (1903–1985) was a distinguished physicist, a World War II pioneer in operations research, and the first president of the Operations Research Society of America (ORSA), the latter a predecessor of today's INFORMS.

The importance attached to scientific publication by Morse and the scientists who founded ORSA is amply demonstrated by their actions. A scant five months elapsed between the Founding Meeting of the Society in May 1952 and the first issue of this journal in November 1952. We should have such turnaround today! Morse wrote the first paper in the first issue, albeit, a modest two-page introduction to ORSA (Morse 1952). After his inaugural year as president of the society, he published his retiring presidential address "Trends in Operations Research" (Morse 1953). In the first seven years of the journal he wrote seven articles and three notes and letters. Some of these were nontechnical discussions of aspects of the field, but not all, for example: "Stochastic Properties of Waiting Lines" (Morse 1955), "Solutions of a Class of Discrete-Time Inventory Problems" (Morse 1959), and "Dynamics of Two Classes of Continuous Review Inventory Systems" (Galliher et al. 1959). Morse published several other technical papers before his retirement in 1969 and, even after that, another one or two. The last paper in the journal with his byline (Morse 1986) was a compilation of his WWII experiences. It was pulled together posthumously by Hugh Miser from Morse's autobiography, *In at the Beginnings: A Physicist's Life* (Morse 1977). I recommend the paper (and the biography) to those of you interested in the origins of operations research. You will find exciting, high quality, high impact work.

Morse's books were even more influential than his papers. My copy of *Queues, Inventories and Maintenance* (Morse 1958) is worn and tattered. His *Library Effectiveness: A Systems Approach* (Morse 1968) won the Lanchester Prize that year. His effort to expand the boundaries of OR into the nonmilitary public arena led to his co-editing *Operations Research for Public Systems* (Morse and Bacon 1967) and *Analysis of Public Systems* (Drake et al. 1972).

But we should put Morse's contributions in context by looking more deeply at the man and the roots of operations research in the United States. Phil was born in Shreveport, Louisiana, and grew up in Cleveland, Ohio, where his father was a telephone engineer. Phil graduated from Lakewood High School in 1921 as a voracious reader, a violin player, and a prospective chemist. He then went off to the Case School of Applied Science (now Case Western Reserve University). After his freshman year, family finances were in such poor condition that he took a year off to earn money by working in a radio store that he and several friends had started. In his later *Who's Who in America* biography Morse describes his role as "salesman," but I'm sure he wrote this with a smile. First of all, the store's founders did everything; for example, they assembled many of the radios themselves. Some of the radio sets cost $500 in 1920's money and were sold after an in-home demonstration that surely required nontrivial selling skills. Morse must have looked back at this as excellent training for the many times in his long career that he found himself selling his ideas and vision to governments, military establishments, other scientists, and eager students.

Upon returning to Case as a sophomore, Morse fell under the aegis of the eminent American physicist, Dayton C. Miller, and proceeded to major in physics. Following graduation in 1926, Morse moved on to graduate school at Princeton, receiving a Ph.D. in 1929. While he was at Princeton, he published several theoretical papers with the late Karl T. Compton, who later became president of MIT. We have little idea today of how rare and precious was an academic job in physics during the Great Depression. Compton offered Morse a job as an assistant professor at MIT starting in 1931. In his autobiography Morse reports, "It was easy to say yes."

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By 1938 he was a full professor. Always a multiprocessor, his research ranged widely. Besides a steady stream of papers he wrote a seminal book modernizing the theory of acoustics and co-authored an early book on quantum mechanics. On the eve of World War II he was absorbed in astrophysics.

How did Morse move from physics into wartime OR? The answer is, in two quick steps, and he drove the process. He wanted to help the war effort and do so in a way that would maximize his contribution. He learned how to do this as he went along. In 1941, drawing on his expertise in acoustics, he directed a successful U.S. Navy project on sound measurement and control for defense against acoustically actuated mines. His team found devices that would explode the mines in advance, rendering them harmless. But Morse increasingly felt that the key to effectiveness lay not just in hardware but in understanding the Navy's operational problems and the interactions among hardware, people, and tactics. Therefore, in 1942, he quickly accepted a call to Washington to recruit and direct a team of civilian scientists who were to study and recommend actions on antisubmarine warfare. The Navy's hope was to duplicate in the United States the success of the "operational research" started in the U.K. under Professor P.M.S. Blackett. The Navy had the right person. Morse's team was called the Anti-Submarine Warfare Operations Research Group and later, after their role expanded, simply, the Operations Research Group (ORG).

This research on operations, in the hands of highly motivated, first-rank scientists recruited by Morse, produced striking improvements in short time frames under wartime pressures. Exciting examples appear in Morse's autobiography and in the compilation of Navy reports edited and expanded by himself and George Kimball (Morse and Kimball 1951). The resetting of the detonation depth for air-dropped depth charges, combined with better search tactics, increased the sinking of enemy submarines by a factor of five. ORG's plan for laying out search patterns between Brazil and Africa to catch German ships carrying rubber from the East Indies resulted in catching six of the seven ships that tried to run the blockade. Radar was an unfamiliar new technology. The civilian scientists worked with pilots and submariners to make effective use of it through analysis and scientific field experiments. As Morse points out, there simply wasn't time to learn by operator trial and error.

Throughout, one feels the strong push of the scientists to be permitted to observe field operations themselves, an almost unthinkable idea at the start. At the same time, they continuously sought to gain access to senior decision-makers by demonstrating outstanding results. After some persuasion, the Navy permitted the scientists to go out in the field, where, in rotating six-month assignments, they ensured the accuracy of data being gathered, learned more thoroughly the nature of antisubmarine operations, and saw firsthand the successes and failures of their implemented recommendations. The success of the group led to its growth and, by the end of the war in 1945, ORG contained nearly a hundred operations analysts. For his part in the effort Morse was awarded the Presidential Medal of Merit, the nation's highest civilian award, in 1946.

Following the war, Morse and a number of other scientists involved in the wartime effort were convinced that operations research could play an important role in nonmilitary as well as military organizations. While continuing an active role in physics and other fields, he devoted a major effort to the establishment and growth of OR.

At first Morse returned to his old job as professor of physics at MIT. He helped start the Acoustics Laboratory, but was soon pulled away to become the first director of Brookhaven National Laboratory, a civilian nuclear research facility. During that time he was also a member of the Emergency Committee of Atomic Scientists (popularly known as the Einstein Committee), which sought to educate the public about the potential benefits of nuclear energy as well as its dangers. In 1948 with Brookhaven firmly established, Morse found himself called to Washington to organize an operations research group for the Secretary of Defense and the Joint Chiefs of Staff. The result was the Weapons Systems Evaluation Group, which he served as deputy director and director of research until 1950. The organization's civilian side became the Institute for Defense Analysis (IDA) in 1956 and Morse served as a trustee. He was also a trustee for The RAND Corporation from 1948–1952.

Morse finally returned to MIT to stay in 1950, which is when I first met him as a physics graduate student. After I came to know more about him, I was amazed at his range of activities. As best I could tell, he had at least three separate careers going at the same time, each one at a level sufficient for most people's full-time energies. One of these obviously was physics. With Herman Feshbach, he was writing their famous two-volume work, *Methods of Theoretical Physics* (1953), as well as teaching the material in class. (I took his courses and helped proofread the galleys of the book.) He had long appreciated the increasing power of the digital computer and its importance to science and, as a result, he established the MIT Computation Center and secured funding for it, serving as director until 1967. Morse hired another physics student and myself as research assistants to compute a big book of tables for spheroidal wave functions (Stratton et al. 1956). We did not think it was going to be a best seller but Morse convinced us of its importance.

And, of course, Morse's operations research activities were everywhere. Besides his role in the founding of ORSA, he helped organize the first international OR conference and establish the International Federation of Operational Research Societies (IFORS). He started the OR Center at MIT, and began producing a stream of OR doctoral students, of which I was the first.

People have asked me what it was like to be Morse's student. I remember his office well. He had a totally inadequate blackboard. I recall it as about 2.5 feet by 3 feet and you couldn't write more than one and half equations

on it. (As a consequence, in every office I have occupied since then, I have insisted on a blackboard of at least 4 feet by 8 feet.) Morse's office also contained a couch opposite the blackboard. It was extraordinarily saggy and uncomfortable. Surely nobody overstayed their leave in his office if he had seated them on the couch. Morse, himself, sat at a desk, from which he could see both couch and blackboard, and, if he wished, look out the window. He was very friendly but business-like and extremely well organized. I have said he was a salesman, but he was not high pressure. Rather he was reasoned and flexible, but behind this demeanor was a very quick mind. At a critical juncture in my thesis (which was on the operation of hydroelectric systems), he suggested going in a certain direction. I explained the approach I had been developing. He said, "Is that the way you want to go?" I said, "Yes." He said, "OK," and that was it. I think he was pleased with the final results.

Morse had myriad honors. He was a fellow of the National Academy of Sciences, the National Academy of Engineering, the American Academy of Arts and Sciences, and the Acoustical Society of America. He was also a member of Sigma Si, Tau Beta Pi, and the Cosmos Club of Washington. The Operational Research Society in the United Kingdom awarded him its Silver Medal and the Acoustical Society of America its Gold Medal. His society presidencies included the Acoustical Society of America and the American Physical Society, as well as ORSA. He was a chairman of the Governing Board of the American Institute of Physics.

In closing, I would like to return to Morse and Kimball (1951) and note their definition of operations research:

"Operations research is a scientific method of providing executive departments with a quantitative basis for decisions regarding operations under their control." I have thought about this quite a lot. The wording clearly reflects the wartime experiences of Morse, Kimball, and others, yet generalizes the field beyond its military context. The definition leaves room for the tremendous development of methodology that we have witnessed in the past 50 years, but it keeps our feet on the ground with a requirement for data, models, and decisions. I like that, and I am sure it is what Morse intended.

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