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IFORS' Operational Research Hall of Fame: Ailsa Land

Pioneer of discrete optimization, co-inventor of the branch-and-bound method

Born: June 14, 1927, in West Bromwich, England, UK

Died: May 16, 2021, in Totnes, England, UK

Awards and recognition

Harold Larnder Prize of the Canadian Operational Research Society 1994 for achieving international distinction in operational research

Beale Medal of The Operational Research Society in 2020 in recognition of a sustained contribution to operational research in the United Kingdom

Posthumous award of the EURO Gold Medal, the highest distinction within operational research in Europe, at the EURO Conference in 2021

The annual Ailsa Land Prize, established in her honor in 2017, for the best MSc student in operational research and analytics in the London School of Economics Department of Mathematics

Ailsa Land, nee Dicken, was born and brought up in the West Midlands region of England. In 1939, she and her mother were stranded in Canada by the outbreak of war. After years of waiting, they both joined the Canadian Women's Army Corps in order to get passage back to Britain where her father was serving in the Royal Air Force. (Achieving this involved some creativity about her date of birth, as Ailsa was underage.)

Having enrolled at LSE in 1946 to study for the BSc Econ, she remained at LSE for the rest of her academic career. Gaining her PhD in 1957, she occupied in turn every academic rank from Research Assistant to Professor, after which she continued her association with LSE as an

Emeritus Professor. After taking early retirement Ailsa remained consistently active in research, always interested in novel formulations of practical problems.

Ailsa became interested in linear programming during her doctoral research at LSE. Her dissertation in 1957 developed and solved a transportation problem for optimizing the distribution of coking coal for Britain's publicly owned National Coal Board. She continued throughout her career to be stimulated by a wide range of practical problems, including transportation, pricing, machine scheduling, sports analytics, and auction theory.

Her most influential work was also inspired by an industrial context. With Alison Doig, she received a grant from British Petroleum to tackle a refinery planning problem that had the structure of a linear programming problem except that it included integrality constraints. They realized that to tackle this they would need to devise a systematic approach for solving integer linear programs. The approach they developed, subsequently known as the "branch-and-bound" method, became a cornerstone of integer programming. This ground-breaking work was published in their 1960 *Econometrica* paper "An Automatic Method of Solving Discrete Programming Problems."

In the 1950s, computers were still a rarity; although without access to one, Land and Doig nevertheless developed their method with the intention of efficient processing on a computer. It was indeed used in the first successful implementations of integer programming and remained a fundamental principle of the ever more powerful and sophisticated solvers in subsequent decades. Their paper stimulated research in mathematical programming all over the world. It has been said that the branch-and-bound method devised by Land and Doig "reshaped the landscape of mathematical programming." It is a fixture in courses in mathematics, computing, and statistics that have applications to real-world issues and continues to be deployed to tackle a wide range of practical problems.

Another strand in Ailsa Land's research interests was the traveling salesman problem. In fact, together with George Morton, she started thinking about this problem quite independently, calling it the "laundry van problem." Their 1955 paper contained important early contributions, including a variant of the 3-opt heuristic. In her 1979 report, re-published in 2021, she developed an efficient branch-and-cut-and-prize algorithm for the symmetric traveling salesman problem, using a variety of clever heuristics and technical ideas. This work was influential in the subsequent development of efficient cutting plane implementations for large-scale problems.

Ailsa was a pioneer in computational optimization. Once computers became available at the University of London, she started developing robust and efficient implementations of optimization code. In 1973, she published an impactful book on Fortran implementations with her former student and LSE colleague Susan Powell which included the theoretical background together with well-documented implementations and test instances. *Fortran Codes for Mathematical Programming* was one of the earliest examples of an open-source publication, a clear indication of the values that dictated her academic career.

When Ailsa became a Professor, there were only a handful of women holding chairs at LSE in any discipline. There were none holding a chair in operational research anywhere in the world. As the first female Professor of operational research, she has a place in social history as well as in the development of the field of operational research.

She resisted resolutely (and successfully) taking any committee posts within LSE. Operational research was throughout her career a group within the quite large Department of Statistical and Mathematical Sciences; and when it became impossible for her to resist any longer the obligation to take her turn in the rotation as Convener of the Department, she simply took early

retirement—and went on with her research. She took the same approach to any involvement with national and international professional organizations.

The London School of Economics which Ailsa entered post-war was by present standards a tiny institution, with an active social life among its annual intake of undergraduates of around 300. And, it was there in 1950 that she met her fellow research assistant Frank Land. They married in 1953, and their marriage lasted for 68 years. Their three children were born during Ailsa's PhD. Frank was a pioneer in information systems research and is Professor Emeritus at LSE. Indeed, Ailsa first became familiar with computers in the 1950s through Frank, one of the first computer programmers in the United Kingdom.

Ailsa's driving interest was always to find solutions to problems and to convey to her students the importance of this activity, along with her unstinting support and advice. She never sought public recognition or to use her achievements to advance her career in any conventional sense. Her reluctance to agree to taking on administrative roles was of a piece with this—she was happy to leave that to others who were more "career" oriented. When she became by default the head of Operational Research at the London School of Economics, she presided with a calm presence and straightforward but nondirective communication over a collaborative enterprise by the whole group. She created a research environment that allowed her, her colleagues, and her students to develop and pursue their intellectual interests. Her reassuring presence and friendly smile were always a source of encouragement.

Her many research students achieved influential positions in academic departments around the world. They constituted in effect an extended academic family, connected by the ties of friendship that developed so naturally under Ailsa Land's enabling personality.

Jonathan Rosenhead and László Végh

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