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LEO ARTICLE

The Legacy of LEO: Lessons Learned from an English Tea and Cake Company's Pioneering Efforts in Information Systems*

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"The Leo team can certainly teach us a thing or two."
Computing magazine[1]

Modern Lessons from LEO

Introduction

At the 1999 International Conference on Information Systems (ICIS) held in Charlotte, North Carolina, the Association for Information Systems made its first LEO awards for outstanding contributions to the Information Systems community.[2] Appendix A notes the recipients as of December 2003.

LEO is the acronym for the Lyons Electronic Office, a business-oriented computer system created by J. Lyons & Co. Ltd. Founded in 1887, the company's teashops had become a British institution. It was a family owned and run organization in the catering, tea-and-cake shop, bakery, ice-cream and restaurant businesses. As such it was an unlikely enterprise to undertake such a far-reaching innovation. The company was better known for its Red and Green Label tea, foil-wrapped Kup Kakes, Lyons Maid ice cream and, of course, its exceedingly popular "nippies," those speedy, efficient waitresses adorned in black blouses and starched white aprons who provided stellar service in its over 250 teashops. Lyons' restaurants set standards of "service to customers" and "sumptuousness of surroundings that astonished and delighted

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* Kalle Lyytinen was the accepting senior editor of this paper.
• Dedicated to LEO Award recipient Frank Land who lived the LEO saga and provided innumerable useful comments on earlier versions of the manuscript. The editor and anonymous reviewers also provided valuable guidance and corrections. Any errors that remain are mine.

[1] Quoted from the back cover of the dust jacket of Caminer et.al., 1998.
[2] For more information on the LEO award see aisnet.org/award/leorecip.shtml

clientele" (Ferry, 2003, p. 10). Nevertheless, being in a low margin business, the company's leaders recognized an ever pressing business need to improve the efficiency of its operations. Consequently, in the late 1940s the company decided to make a computer, subsequently dubbed LEO. It became the world's first office computer.

The legacy of LEO for the IS community is at once profound and bittersweet. In the first place, the LEO project was a pacesetter, building the first computer and implementing the first systems specifically designed for business operations. On Thursday, November 29, 1951, at its Cadby Hall facility in West London, Lyons ran the world's first routine office job on a stored-program electronic computer (Caminer et. al., 1998, p. 1)[3]. Unfortunately, the company's pioneering effort had a limited reach. The considerable accomplishments of the LEO team did not extend very far beyond the UK and, consequently, many of their innovations had to be re-invented by others. In the end there was a more tragic loss as well. Lyons' systems design philosophy of "get-the-whole-system-right-the-first-time" and attention to detail, one that in large measure remains the espoused yet seldom practiced ideal today, was not widely adopted. In the end, it actually served to contribute to the company's demise. In competition, IBM and other hardware movers' sales strategy of providing "good enough systems" beat out the emphasis on perfection toward which the LEO team strove. Oxford science writer Georgina Ferry summarizes:

> "The LEO experiment, quixotic as it may have been in the context of a large catering company, is worth remembering for much more than being first. It is worth remembering because its architects never forgot what the computer was for: it was a tool for business, and so it was their responsibility to make sure it worked for business" (Ferry, 2003, p. 199).

During the last 50 plus years, many rather dramatic changes in management practices have occured. As it turns out, a goodly number of these were pioneered or anticipated or at least refined by a gutsy group of Lyons personnel whose overriding goal was to discover improved methods for conducting their tea-and-cake and catering businesses. We cannot claim that the management approaches initiated in that off-the-beaten-path facility near London found their way directly to North America. There is no direct evidence that their accomplishments influenced developments in the U.S., although transoceanic communications were well established between Lyons and American firms. Nor can we conclusively argue that British industry as a whole was materially affected by Lyons' innovations. Yet, many UK companies and government offices were directly affected, and several early participants in LEO projects went on to have distinguished and influential careers in business and academia.[4]

What can be claimed, however, is that many once loosely formed ideas about information and management coalesced and were operationalized by Lyons personnel

[3] Remington Rand's claim to have the first business computer is discussed in Section II c below.

[4] However, there was likely some modest cross-fertilization with North America. Two senior LEO personnel, John Gosden and Paul Dixon, emigrated to Canada and the USA. Both worked in consultancy and industry, Gosden was at Auerbach, the Mitre Corporation and Equitable Life. Dixon was at the Mitre Corporation and Massey Ferguson, where he became head of global IS. Both were active with ACM and IFIP and acknowledged for their contribution to the development of business computing, which they themselves attributed to their LEO training. John Gosden died December 2003. The ACM published an obituary in their newsletter with some very complimentary words from Peter Denning. (Source: Personal Communication with Frank Land)

during the postwar 1940s and the 1950s. Lyons was an innovator. Table 1 is a timeline that demonstrates that the LEO project produced several computer-based business applications prior to the key North American manufactures and users, specifically UNIVAC, IBM, and Bank of America, the U.S. innovator in bank automation whose decision processes were similar to those used at Lyons.

Table1. Time Line for the Legacy of Leo

Date	LEO and Lyons	Other Significant Events
1887	J. Lyons & Co. founded	
1890		IBM – Herman Hollerith's 80 column punch card tabulator used for U.S. census
1896 (Dec.)		IBM - Hollerith incorporates as Tabulating Machine Company (TMC)
1911 (July)		IBM – Hollerith's TMC sold to the company that would become IBM. Thomas J. Watson appointed general manager
1923	John Simmons joins Lyons	
1930		IBM – IBM and Powers Accounting Machine Corporate (later part of Remington Rand) compete for processing the 1930 U.S. Census.
1931	Simmons establishes Systems Research Office	
1932		IBM – the IBM 405 alphabetic tabulating machine released. Becomes the dominate design for punch card processing
1943 (April)		UNIVAC – US Ballistics Research Lab contracts with the Moore School and Eckert and Mauchly to build ENIAC. Loring Crosman approaches James Rand, Chairman and President of Remington Rand, to build an electronic computer for processing the company's 90-column punch cards
1944 (Aug.)		IBM – Howard Aiken's Mark I inaugurated at Harvard
1945 (June)		UNIVAC – Von Neumann's EDVAC concept paper introduces stored program idea
(Dec.)		UNIVAC – ENIAC operational
1946 (March)		UNIVAC – Eckert and Mauchly establish Electronic Control Company (EEC) to commercialize computers
		IBM – IBM 602 Calculating Punch incorporating plugboard programming released
(Aug.)	Maurice Wilkes attends Moore School conference on ENIAC/EDVAC. Conceives of EDSAC during his return	
(Oct.)		UNIVAC – US Census Bureau signs contract with ECC for UNIVAC
1947 (May)	Two Lyons executives visit leading computer organizations in the US to learn about the state-of-the-art of business computing	UNIVAC – Prudential Insurance Co. says it intends to order a UNIVAC for policy processing. The Pru's order is subsequently canceled
(Nov.)	Simmons recommends that Lyons build a machine but first support Wilkes' EDSAC effort. Board approves grant to EDSAC and seconds a technician to Cambridge	
1948	Max Newman's Manchester	IBM – IBM 602-A an upgraded version of the IBM 602

(June)	University, "the Baby," computer executes first stored program	plugboard calculator released
1949 (May)	EDSAC completes first job on May 6 **Work on LEO begins**	IBM – Thomas J. Watson Sr. purportedly decides that the market for computers is less than a dozen
(late)		UNIVAC – a prototype Remington Rand 409 plugboard programmed punch card calculator demonstrated
1950 (Jan.)		Bank of America – SRI meets with BofA senior executive Clark Beise
(March)		UNIVAC – Remington Rand acquires Eckert and Mauchly's Electronic Control Company
(Dec.)		Bank of America – Beise asks Al Zipf to join innovation team
1951 (March)		UNIVAC – EDVAC finally operational at Aberdeen Proving Grounds performing ballistics calculations. UNIVAC I operational, delivered to US Census Bureau
(July)		UNIVAC – 409 is commercially available
(Nov.)	Leo runs bakery evaluation job. **First commercial computer job**	
1952 (Jan.)		Bank of America – BofA contracts with SRI to build ERM (ERMA) UNIVAC – second, third, and fourth Model 409's delivered to IRS
(April)	Ballistic calculation for Ordance Board performed on LEO I The first recorded service bureau job seen on any UK computer. Spawns outsourcing industry.	
(Dec.)		UNIVAC – Three UNIVAC I's installed
1953 (March)		UNIVAC – upgraded design of Model 409 renamed UNIVAC 60 and UNIVAC 120
(April)		IBM – IBM 701, (Defense Calculator), a scientific computer is dedicated
(July)	Payroll pilot run on LEO I	
(Oct.)		Bank of America – Zipf sets up Systems and Equipment Research unit. (similar to Lyons' Systems Research Office.) Orders IBM 702
1954 (Feb.)	Lyons payroll fully operational, L1	
(Oct.)	Teashops Distribution, L2, and Tea Blending, L4, jobs operational	
(Dec.)		UNIVAC – First UNIVAC for business applications sold to General Electric Appliance Division to do payroll IBM – First IBM 650 delivered to John Hancock Mutual Life
1955 (Feb.)		IBM – First IBM 702 installed.
(Sept.)		Bank of America – "ERMA Day" First bank check processing computer operational BofA's first IBM 702 installed
1956 (Jan.)	Bakery Sales Invoicing, L3, operational	Bank of America – Zipf appoints bank's first automation advisory council
1957 (May)	LEO II operational	UNIVAC – Forty-six UNIVAC I's installed in total
1961	LEO III operational	

(May)		
1962		UNIVAC – Installations begin for Sperry Rand UNIVAC 1100 designed with tightly coupled multiprocessors and 1 to 6 identical instruction processors
(June)		UNIVAC – UNIVAC 1004 extension of UNIVAC 60/120 RELEASED. This was the last plugboard calculator produced by UNIVAC
1963 (Feb.)	Lyons' computer business – LEO Computers Ltd. – merged with English Electric Company	
1964 (April)	LEO 326 operational	IBM – IBM 360 range announced
1968 (July)	English Electric LEO Marconi merges with ICT to form ECL. The old LEO company is effectively dead	
(Nov.)	Post Office orders five LEO 326s. Largest order for any vendor in UK to date.	
1981	Post Office 326s taken out of service, ending LEO's life.	

The management approaches perfected by the LEO project can be related directly to what has evolved into a contemporary philosophy of information systems. The information systems community can deepen its understanding of modern information systems by examining Lyons' experience with LEO in light of contemporary IS thinking and practice – our current "received wisdom" - while at the same time paying homage to our heritage.

In order to place the LEO team's contributions into perspective, it is useful to propose a mission statement for the field of information systems. This mission statement will serve as a backdrop for understanding the field, its evolving set of increasingly powerful ideas, and the role the LEO team played in forming and applying those ideas.

A Proposed IS Mission Statement

The mission of the IS discipline is *to secure improvement in organizational performance by managing the flow of data, information and knowledge provided, inter alia, by information and communications technology (ICT).*

The mid-20th century innovators of LEO would likely be congenial with this mission statement. As their story shows, they took many actions that were consistent with this sense of direction, although to my knowledge the Lyons executives never explicitly made statements to this effect. These were executives who were "learning by doing." According to LEO award winner Frank Land, an early Lyons participant, the company's pre-computer approach was first to realize major improvements in performance by establishing an organizational architecture[5] that encouraged the best possible flow of crucial information to relevant managers. That is, they got the information flows right first. Then, Lyons' systems personnel sought to apply the most appropriate technology

[5] Drawing on the management theorist John Kay, Frank Land explains this use of the word "architecture": "By architecture Kay means the set of formal and informal relations that exist in the enterprise. Kay describes architecture as ' . . .a network of relational contracts within, or around, the firm'" (Land, 2000, p. 24; Kay, 1993.)

to improve the efficiency and effectiveness of these flows (Land, 1998). This approach served them well when the company designed the LEO computer to meet its needs. For the most part, these executives used common sense to plan for, build, and put into operation a business-oriented computer that would solve their business' problems. Their story, however, is also a model of systems thinking, although at the time there were few formal theories of business systems available to guide them in their task.

Drawing on this mission statement as a backdrop, the paper proceeds as follows. Section IIa explains how and why was LEO conceived and built in terms of a theory of the necessary roles for technological innovation: top level executive champion, maestro, supertechs and systems translators. Section IIb,recounts maestro John Simmon's masterful orchestrating of the project.. Section III describes several new business applications that were implemented on LEO. The paper ends with an Epilogue in Section IV.

How and why LEO was conceived and built[6]

Finding a Maestro and Creating a Systems Organization: Laying the Groundwork for Success

Historical research concludes that three conditions must be met for a technological innovation to be organizationally successful. First, the organization's top-level executives must include a champion for the technological project who has sufficient vision, power, and prestige to initiate it and drive it to fruition. Second, a "maestro of technology" must lead the effort. Maestros combine superior business acumen with great insight into the technology and how it can be applied. They recruit and assemble a strong team of technologists – the third necessary condition – and guide their activities to completion (McKinney, Copeland and Mason, 1995, pp. 4-6, passim). Frank Land insightfully suggests a fourth condition: that of a "systems translator" who interprets the maestro's vision in terms that facilitate systems design, programming and hardware specifications and provides guidance for the supertechs.[7] For the sake of brevity these three roles are referred to respectively as executive, maestro, and supertechs, and the fourth as systems translators.

John Richardson Mainwaring Simmons played the crucial role of maestro for the LEO project. Simmons joined J. Lyons & Co. as a management trainee and statistician in 1923 fresh from Cambridge University. He graduated as a "wrangler," a student with the highest-class honors in mathematics. When he arrived at Lyons, Great Britain was just recovering from severe economic and social losses the country suffered as a result of World War I. Now, however, Lyons' business was expanding again as people returned to desiring teas and cakes and lunches served in convenient locations. Like most retail

[6] Recent publications provide considerable detail about Lyons and LEO. See Aris, 2000; Bird, 1994, 2000, Caminer, 2003; Caminer, Aris, Hermon and Land, 1998; Ferry, 2003; Land, 1985, 1998; and 2000. See also Simmons 1962. This recounting stresses management and systems thinking innovations.

[7] Personal communication: Land also deplores the use of the awkward term "supertech" but this term, which was coined by James O'Neill in the early 1970's at American Airlines and used broadly there, is the most descriptive we have come up with (see McKenney, Copeland and Mason, 1995). Richard Mason is a LEO Award Recipient. See also Mason 1969, 2000, and 2003.

operations, the demands of Lyons' business were quite exacting. The business was characterized by the handling of high volumes of low-ticket items, razor thin margins, and considerable geographic scope within which to produce, store, and transport or dispatch goods and services.[8] Simmons realized that if the company was to be economically successful, Lyons' needed a way to process a higher volume of transactions at higher speed and with greater precision. He was also keenly aware of the company's need for better management control data.[9] Management's previous answer to this challenge had been simply to add more back office clerks and have them track and record the ever-growing movement of goods and money. LEO pioneer David Caminer describes the scene at the time:

> "Back in the 1920s, when Simmons arrived, the ambience was still Dickensian, with clerks standing at tall tables, and occasionally resting themselves on high stools. Vestiges of this still remained 25 years later in the demeanor and dress on some of the older clerks who still remained. There were residual Bob Cratchits, happy in the few specialized tasks that had not been susceptible to mechanization." (Caminer et. al, 1998, p. 14-15)

MIT's JoAnne Yates provides a similar glimpse into the pre-computer business information world – 1880 to 1920 – in "Business Use of Information and Technology during the Industrial Age." (Chandler and Cortada, 2000, pp. 107-135) and in her more comprehensive work *Control through Communication: The Rise of System in American Management* (Yates, 1989).

Simmons was recruited by and reported to the highly respected company secretary, George William Booth, the only nonfamily member on the Board of Directors. J. Lyons & Co. was owned and controlled by the Salmon and Gluckstein families, who had conducted a highly successful tobacco retailing firm. In large part to avoid confusion among the public about its other businesses, the family picked a entrepreneur and distant relative Joseph Nathaniel Lyons to form the new catering business and provide his name for it. Booth, who joined the company in 1891, was the confidant and most trusted advisor for the family during this period.[10] Booth would play the crucial role of the "executive" as the LEO saga unfolded. He recognized something special in Simmons and soon gave him his unwavering support. Simmons' ability to communicate clearly with "the family" and with Booth and to earn their trust and confidence would subsequently prove to be vital to LEO's success.

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[8] Ferry observes "A typical teashop customer bought no more than a bun and a cup of tea, costing a few pence. The profit to the company on that transaction might be as little as a farthing (barely a tenth of a penny in today's decimal currency, and even allowing for inflation worth only about 4p)." (Ferry, 2003, p. 15)

[9] Simmon's requirement that managers must identify the factors that are critical to the business operation's success and marshal information with respect to them is consistent with a line of thinking that eventually resulted in Rockart's Critical Success Factor methodology (Rockart, 1979). John F. (Jack) Rockart is a LEO Award recipient. This line of thinking eventually led to the development of decision support systems (DSS), executive support systems (ESS), and group decision support systems (GDSS). LEO award recipients Paul Gray, Jay Nunamaker, and Jack Rockart have been leaders in this endeavor.

[10] "'He [Booth] wasn't family,' says Anthony Salmon, former Lyons board member and grandson of Montague Gluckstein, 'but the family would never move without consulting him. He acted as a public conscience'" (Ferry, 2003, p. 15).

The first assignment Booth gave Simmons in the 1920s was to rationalize back office operations and bring them under control. The situation had reached a point that James Beniger would later call a "crisis of control" – events were occurring more rapidly and in greater volume than the organization's capacity to direct them toward its goals (Beniger, 1986, p. 9-16). One of Simmons' first steps was to take a study trip to North America to visit various leading organizations including IBM, Powers, and the American Machine and Foundry Company. Drawing on what he had learned by studying Lyons' operations, and integrating this knowledge with lessons gleaned from his trip, Simmons crafted a four pronged managerial approach for coping with the crisis very similar to what today is called "systems analysis."

1. Analyze each office job into its functional parts and then identify appropriate methods and machinery for handling each sub-task.[11]
2. Establish cost standards and expectations for each product and task. Collect data on actual performance and feed it back for comparison purposes.[12]
3. Create a systems research department to design systems, evaluate technology, and establish information needs.
4. Implement a management structure and organizational architecture capable of passing information rapidly from its sources in the field to decision makers and to enable decision makers to ask "what if" questions.

As a result of Simmons' efforts, by the late 1930s "in the British office management world," Caminer observes, "Lyons came to be recognized as a center of excellence in everything that concerned office systems and management" (Caminer, et. al. 1998, p. 15). In retrospect, Simmons' four-pronged program is similar to many "best practices" approaches that had evolved around the same time and later in the United States.

Systems were defined and analyzed into their component parts. Information requirements were specified and methods devised to collect and distribute the requisite information. Negative feedback loops were constructed by establishing standards (or forecasts or expectations) and collecting data on actual performance to be compared with these standards. Deviations were calculated and fed back to managers so that corrective action could be taken.[13]

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[11] This application of systems thinking was introduced in the U.S. in the late 19th century by Frederick Winslow Taylor who called it "scientific management." Chicagoian William Henry Leffingwell applied the notions to office work early in the 20th century (Leffingwell, 1917). Forms printers such as the Moore Business Forms, Inc. and Standard Register Company commericalized some of these authors' ideas for achieving efficiency in the office.

[12] Management control in organizations involves three primary phases: planning, coordination and control. The development of standard costs for central work activities using, among other methods, time and motion studies takes place during the planning phase and collecting actual costs for comparison comprises control. An important element of the control phase is performance feedback and evaluation of the cost variances. Costing methods date back at least to 1830 with Charles Babbage's study and were developed further around 1890, in Great Britain by the economist Alfred Marshall and in the in U.S. by Taylor about 1903. Simmons was drawing on this tradition. See Billy Goetz 1949 and *The Encyclopaedia Britannica*, Volume 6, 1970 pp. 588-599.

[13] Ferry describes "Each [factory] was laid out to handle the particular kind of cake, pie, bun, loaf or bread roll in which it specialized. Under the direction of a Planning Office, every operation was time-and-motion studied to arrive at a fair, efficient time. These times were used both to calculate the number of staff required, and to compute the standard cost of the labor entailed in making the product, which in turn partly determined its selling price." (Ferry, 2003, p.21)

Alfred P. Sloan and F. Donaldson Brown had brought this kind of systems thinking to General Motors beginning in 1920. Brown had pioneered this approach previously while Treasurer at du Pont. As a result, by 1926 Albert Bradley, an economist with experience as a treasurer and comptroller, could report enthusiastically on GM's techniques at a meeting of the American Management Association:

> "The first and controlling principle in the establishment of General Motor's production schedules is that they shall be based absolutely upon the ability of its distributors and dealers to sell cars to the public. Each car division now receives from its dealers every ten days the actual number of cars delivered to consumers, the number of new orders taken, the total orders on hand, and the number of new and used cars on hand. Each ten-day period the actual results are compared with the month's forecast, and each month, as these figures are received, the entire situation is carefully analyzed to see whether the original estimate was too high or too low. If it is decided that the estimate is too high, the production schedule is immediately reduced. If, on the other hand, it is found that the retail demand is greater than had been estimated, the production program is increased, provided the plant capacity permits. . . . . the Corporation now follows the policy of keeping production at all times under control and in correct alignment with the indicated annual retail demand, with the minimum accumulation of finished products in the hands of dealers for seasonal requirements, which the flexibility of the production schedule permits. (Bradley, 1926, P. 181.)

This is classic management control as Robert Anthony (1965) later described it. Simmons did not visit GM or du Pont, but it is likely that in his quest for improved management methods he learned about the massive changes Sloan, Brown, and Bradley were bringing about at the emerging automobile firm. At any rate, his approach was similar. As computers later came upon the scene, this approach to management control would assume fundamental importance. For example, in their quite early computer information systems textbook, Gregory and Van Horn (1960) explain that exceptional reporting feedback control systems, such as developed at GM and Lyons, were essential for selecting the information to be reported to managers as part of a "management information system." The authors identify two methods for selecting the information to be communicated to management: (1) to scan reports to find significant differences and (2) to "report only those items that vary significantly from the planned results" (Gregory and Van Horn, 1960, p. 340). By adopting his four pronged information management approach at Lyons, Simmons was anticipating one of the cornerstone concepts of computer-based management information systems.

Simmons was a quintessential "maestro of technology." Arthur Squires coined the term to describe the leaders of many successful large technology projects such as the Manhattan Project (Squires, 1986). As stated earlier, research on North American innovators of "dominant design" information systems, such as the Bank of America's ERMA (circa 1960) and American Airlines' SABRE (circa 1964), reveals that each organization had at least one exceptional senior executive who played the crucial role of "maestro." This executive is positioned between the top executives and the board on one side, and a strong technical team on the other. He (in the early days they were almost always "his men") communicates well with each side, translating differing languages and view points between the two parties. Importantly, a maestro understands deeply how the technology can be aligned with the business' needs and goals. He plans and implements new technological infrastructures; recruits, organizes, and leads a team of talented technologists; and insures that organizational processes are changed to take full advantage of the technology's potential (McKenney, Copeland and Mason, 1995, p 1-11). Al Zipf at the Bank of America, who spearheaded the ERMA system and business applications of IBM's 702, is the prototype North American computer era maestro. Charles Ammann, Fred Plugge, and Max Hopper, successive leading technology officers at American Airlines, also were exceptional maestros.

In the late 1940s, as LEO was being conceived, Lyons had in place, or soon would acquire, the three major ingredients for success: (1) visionary leadership on the part of G. W. Booth and members of the founding Gluckstein and Salmon families who comprised the company's board, especially Director Anthony Salmon,[14] (2) a maestro in the person of Simmons to orchestrate the technical team toward a successful completion of their innovative project, and (3) a talented group of managerial systems and technical people or "supertechs." Major contributors to the technical initiatives were Thomas Raymond Thompson,[15] (also a "wrangler" and a close associate of Simmons), Oliver Standingford, David Caminer, John Aris, Peter Hermon, John Gosden, Derek Hemy, Ernest Lenaerts, Leo Fantl, Ralph Land, Frank Land, and Dr. David Wheeler, whose Ph.D. dissertation at Cambridge under Maurice Wilkes was the first ever written on programming an electronic computer. The LEO computer itself was built under the direction of Dr. John Pinkerton, a Cambridge physicist who Wilkes described as the "most able of all the industrial computing engineers at that time." (Ferry, 2003, p. 89) As it turns out, this collection of extraordinary people fulfilled all of the roles necessary to complete a successful technological innovation (See Table 2).

Well before the development of LEO, however, Simmons was responsible for at least two other managerial innovations that were crucial to the company's computer initiative's success. One was to rationalize Lyons' existing basic business processes to get them under control prior to automation. The popular – and all too appropriate – phrase "garbage in, garbage out" was coined to describe the many instances in which organizations failed to get their house in order before attempting to computerize it. David Caminer recalls:

> "My own role as Programming Manager [for LEO] sprang directly from my previous post as Manager manager of the Systems Research Office. The aim from the time Simmons had established the function, as far back as 1931, had been to build totally integrated systems from the ground up. . . . it was a cardinal principle that they [office technologies and later computer applications] should not be introduced without the system as a whole being reexamined. There was no question of leaving the system as it stood and merely mechanizing those aspects that most readily presented themselves. The computer was to be considered in the same way" (Caminer, 2003, p. 25). Thus, no process was simply automated. Rather, in Shoshana Zuboff's instructive term, it was "informated" (Zuboff, 1988) or, to draw on a more popular

[14] Bird observes "The project was not without influential supporters, and one of the family champions was Anthony Salmon, Director. He had been given responsibility for the LEO project in 1953 and his active interest in all matters associated with it helped secure management commitments and the necessary flow of funds" (Bird, 1994, pp. 84-85).

[15] Peter Bird says of Thompson, who started at Lyons on June 1, 1931, and Simmons "During the next thirty-five years these two brilliant mathematicians together transformed Lyons' office procedures; in doing so they placed Lyons at the forefront of expertise in clerical methods" (Bird, 2000, p. 306).

recent notion, the business process was "reengineered" (Hammer and Champy, 1993). Thus, the first two prongs of Simmons' four-pronged approach were applied to avoid the pitfall of providing bad information more quickly.

Table 2. Key Innovation Roles for LEO*		
I. **Visionary Leadership**:		
	Board Members:	G. W. Booth, Company Secretary Anthony Salmon, Managing Director of LEO computers Members of Gluckstein and Salmon families
II. **Maestro**:		
	Maestro:	John R. M. Simmons
III. **Management Systems and Technical People (Supertechs)**		
	Steering the Project:	
	Project Executive	T. R. Thompson (member of the Board of LEO computers)
	Systems Translators:	
	Engineering:	John Pinkerton
	Systems and Programming:	David Caminer
	Operating:	Anthony Barnes
	Project Leaders	
	Engineers:	Ernest Lenaerts, Ernest Kaye
	Systems and Programming:	Derek Hemy, Leo Fantl, John Grover, Mary Blood, Frank Land, John Gosden
	Operating:	Peter Wood
	Cambridge University Collaboration	
		David Wheeler, influential Cambridge research student
*Based on a classification suggested by Frank Land. See also Bird (1994) pp. 40-52.		

Related to his insistence on optimizing information flows before automating them was Simmons' emphasis on getting economies from "write-it-once" designs. Lyons historian Peter Bird recalls: "Simmons had realized that the most efficient method of processing business data was to have it recorded at the outset in a form that could be understood by a machine. These ideas were radical and far-reaching, but it was not until the Second World War, which created acute staff shortages, that he was able to take them further" (Bird, 2000, p.307).

The second key innovation at Lyons was to set up a special organization and methods unit within the company called the Systems Research Office (after World War II renamed Organization and Methods or "O&M"). Systems Research was dedicated to analyzing the business' systems and fitting suitable technologies to them.[16] Importantly, this organization also served as the political base for instituting change. Applying appropriate, business specific technology to its problems sometimes meant, as it did in the case of LEO, that Lyons took the lead in creating new technology rather than accepting "off-the-shelf" technology from existing manufactures. In the early days of computer applications in the U.S., the Bank of America and American Airlines accepted the same responsibility. Just as war is too important to be left to the generals, applying

[16] Establishing a unit with this mission was consistent with a trend begun by U.S. railroads during the mid-19th century to establish control over operations and continued by insurance and other data intensive companies. (See Beniger, 1986; Chandler, 1962, 2000; Yates, 1989) Lyons was a leader in this respect in the U.K. and likely on a par with leading U.S. firms such as Prudential Life Insurance, du Pont and GM.

technology to a company's specific business problems and opportunities is often too important to be left solely to hardware and software manufacturers.

In the late 1920s, Simmons and his colleagues recognized that a deep chasm might emerge between the company's operating managers and its technologists and information systems specialists unless some mediating organization was created. Systems design always requires generating several alternative approaches and selecting the best one for achieving the organization's overall strategic goals. In his classic 1967 article, "Management Misinformation Systems," Russell Ackoff points out how the different interests of different units of an organization's division of labor often come into conflict with one another, resulting in these units having different preferences for information and technology (Ackoff, 1967). Thus, tradeoffs must be made between the competing interests of the various parties who are – and must be – involved. At Lyons, Systems Research undertook this crucial mediating task.

Over two decades after Simmons created Systems Research, Harvard Business School Professor F. Warren McFarlan, in an unpublished memorandum dated January 14, 1963, a white paper intended as a background document for developing a new curriculum at the school, described the function of and challenge facing such a department:

> "The information handling specialists [an early term for information systems professionals] have a dynamic responsibility to utilize new techniques for the improvement of information available for management control and operational control processes. The proper interaction between operating people and information handling specialists in implementing this responsibility is essential.
>
> "Operating people bring to a problem their practical experience and a conception of what their needs are. They also bring a bias, which favors preservation of the status quo. [And, according to Russell Ackoff, a bias toward satisfying the interests of their individual organizational units.] The information handling analyst brings with him his broad experience in tackling a number of systems problems. Often he has a broader conception of these problems than does the operating manager. He also has analytical and technological tools that the operating manager is unfamiliar with. His bias is towards the introduction of too much change. The information handling analyst performs the function of an innovator and catalyst. He must educate the operating manager concerning the available sources of information and urge him to take appropriate action. While it is not his responsibility to decide what information the manager *should* have, it is his responsibility to show the manager what information he *can* have. For his part, the operating manager must actively contribute his time and experience to the design of a system to assure that he will get the information most useful to his needs. It is only through his sustained interest that meaningful information, which he is predisposed to use, will be developed. Successful implementation of an improvement in information handling requires coordinated efforts by both information handling specialists and operating personnel." (Quoted in Anthony, 1965, page 96-97)

What McFarlan was proposing to the field at large in 1963 the Bank of America had already been doing for about a decade and Lyons for much longer. The maestro negotiates among the interests of senior management, business operating personal representing various units, information specialists, and technologists and leads them to a common solution, one aimed at achieving the organization's overall goals. The systems department, therefore, is the organizational vehicle used to accomplish this. Al Zipf assumed responsibility for the newly created Systems and Equipment Research Department (S&ER) in October 1953 when he was appointed assistant vice president at the Bank of America. S&ER would ultimately become to the bank what Systems Research was to Lyons: an organization set up "to ensure that the most suitable machines were installed and that they were incorporated into comprehensive systems aimed at producing, in a secure and timely way, the information needed by management at all levels to run the business" (Caminer, 2003 p 15). Virtually all organizations that have succeeded in applying information and communication technology to their business problems have created a department with a similar mission. Today, this department generally reports to the Chief Information Officer (CIO) or Chief Technology Officer (CTO), the contemporary institutional labels for the maestro's role. Simmons, who ultimately joined Lyons' board, was a forerunner of the modern CIO.

Conceiving LEO

World War II severely interrupted Lyons' business. Demand slackened, raw materials were in short supply, what was available was needed for the war effort, key personnel joined the military or defense operations, shops were closed. When the war was over and people had returned to peacetime activities, consumer interest in tea-and-cake shops peaked once more. As a result, by 1947 a new and more severe crisis of control had emerged at Lyons. The company once again needed to rationalize its business operations and find more economical ways to cope with the volume, pace and complexity of the business environment it was facing.

McKinsey consultant Ronald Daniel described the difficulty U.S. companies were having in maintaining control and profitability in the expanded post war economy.

> "In each company the origin of the problem lay in the gap between a static information system and a changing organizational structure. This difficulty is not new or uncommon. There is hardly a major company in the United States whose plan of organization has not been changed and rechanged since World War II. And with revised structures have come new jobs, new responsibilities, new decision-making authorities, and reshaped reporting relationships. All of these factors combine to create new demands for information – information that is usually missing in existing systems. As a result, many leading companies are suffering a major information crisis – often without fully realizing it" (Daniel, 1961, p. 111).

By 1947, however, Simmons was "fully" aware of Lyons' impending information crisis and the company's crisis of control. News of an "Electronic Brain" had reached England. Captivated by the imagined possibilities of such a marvel, Assistant Controller Oliver Standingford believed that what war-time computers had done for making complex ballistics calculations, some version of an electronic brain could do for solving business office problems. He took his idea to Simmons. After short deliberation it was proposed that Standingford accompany Thomas Raymond Thompson, chief assistant comptroller and Simmons' key lieutenant, on a trip to the United States to visit key parties in the newly emerging computer-business world. Their assignment was to learn what was being done in business information processing, to see what new business processes had been developed during World War II, and, incidentally to learn about developments in computers. Arrangements were made through Dr. Herman H. Goldstine of the

Electronic Computer Project at the Institute for Advanced Study at Princeton University. Thompson and Standingford's report of their visit during May and June of 1947 is a vital historical document. It serves as a snapshot of the state-of-the-art in computers in the U.S. at the time. Moreover, it places in perspective the conditions under which Lyons conceived of and created LEO. While in the U.S., the two visitors made 10 major contacts.

1. Dr. Goldstine. As a captain in the Army, Goldstine had worked with John W. Mauchly and J. Presper Eckert of the University of Pennsylvania's Moore School of Electrical Engineering to begin planning the ENIAC – Electronic Numerical Integrator And Computer – in 1943. ENIAC is, arguably, the most important machine of the era. It was completed in 1945. Goldstine had worked with mathematician John von Neumann and was quite familiar with one of the key documents of the information age: von Neumann's 1945 *First Draft of a Report on the EDVAC* (Electronic Discrete Variable Automatic Computer). The EDVAC idea (now better known as the von Neumann architecture) became the dominant design blueprint for the modern computer (See, for example, Eames, and Eames 1973). Goldstine acknowledged that little was being done in the U.S. at the time with respect to applying computers to business problems, but he was intrigued with the possibilities. Thompson and Standingford visited him a second time just before returning to England. During this second visit, Goldstine outlined for them his thoughts about a general technical approach for a business oriented computer. Importantly, Goldstine provided introductions to Cambridge University Professors Douglas Hartree and Dr. Maurice Wilkes (recently honored as Sir Maurice Wilkes). Goldstine had met Hartree during Hartree's trip to the U.S.
2. The Moore School of Electrical Engineering at the University of Pennsylvania. Thompson and Standingford saw new developments on a post-ENIAC machine. The visit was informative; but, in general, they were disappointed, noting that morale was low since the original team had disbanded.
3. John Presper Eckert, Electronic Control Company in Philadelphia. While at the University of Pennsylvania, electrical engineer John Presper Eckert and physicist John William Mauchly developed ENIAC following Mauchly's visit with University of Iowa scientist John Vincent Atanasoff. Atanasoff arguably invented the basic concepts of computer technology. Eckert and Mauchly left the Moore School in March of 1946 to pursue commercial interests. Before the end of the war they had visited the Bureau of the Census proposing the idea that an electronic computer might help with census data processing and in October of 1946 they signed a contract to build an EDVAC (von Neumann) type machine for the Bureau. The following spring EDVAC was renamed UNIVAC – UNIVersal Automatic Computer. In 1951 Remington Rand Corporation, which had acquired the Electronic Control Company, delivered the first American commercial computer, UNIVAC I, to the Census Bureau and announced that it was available to the commercial market. During their meeting, Eckert described his plans for building a general purpose commercial machine. Eckert also discussed the company's negotiations with the Prudential Insurance Company of America to do routine premium billing and actuarial calculations.
4. Radio Corporation of America Laboratories. Research engineers at RCA were working on memory technology utilizing a cathode ray tube that was capable of storing about 4,000 impulses accessible by photo-electronic means. Thompson

and Standingford included this technology as a candidate for their computer's storage device.

5. IBM. Thompson and Standingford witnessed a demonstration of a punch card multiplier (likely the 602A or its predecessor). They concluded that "as far as we were able to see the aim of this company is to use electronic calculation purely as an adjunct to punched cards" (Caminer et. al., 1998, P. 351). This was a reflection of Thomas Watson Sr.'s view that selling electronic computers would cut into the company's lucrative punch card business. IBM later, in 1951, built a computer for the Defense Department that was subsequently renamed the IBM 701. Still primarily a scientific computer with limited input and output capability, nineteen IBM 701's were eventually sold, eight to aerospace companies, four to other corporations, four to government agencies, and three to universities. The company developed the IBM 702 with greater I/O capacity in 1952 to meet business data processing needs. Al Zipf ordered an IBM 702 for the Bank of America in October of 1953 to perform management reporting and other high-volume, repetitive clerical tasks. In late 1958, the bank added exception reporting, trend analysis, and notice of time-dependent actions. The first computer to reach a large-scale business market was the IBM 650 announced in 1953. At the time of Thompson and Standingford's 1947 visit, however, IBM was not aggressively pursuing electronic computing. (Although, as discussed below, the company did participate in Howard Aiken's Mark I project and, thus, had some experience in automatic, general-purpose, digital calculation.)

6. National Cash Register Company. NCR had an electronic research section and, due to the company's extensive cash register and accounting machine business, had considerable interest in trends affecting their business. Thompson and Standingford were unable to learn much from their visit.

7. Burroughs Adding Machine Company. Thompson and Standingford's experience at Burroughs was much the same as at NCR. They were unable to learn much. Burroughs also would enter the general purpose computer market a few years later.

8. U.S. Army at Aberdeen Proving Grounds. The Lyons executives had obtained permission through the British Embassy to see a demonstration on the new version of ENIAC; but, at the last moment the permit was withdrawn.

9. Prudential Life Insurance Company of America. The Prudential had a long history of rationalizing its business processes in order to handle large volumes of transactions and actuarial calculations. The company installed Hollerith punch cards in 1891 and subsequently switched to a specially made mechanical card-perforating machine and sorter devised by John Gore, an actuary qua inventor who believed the company needed to continue to innovate in office systems if it intended to become more efficient and stay competitive. The Prudential continued to appreciate the value of information processing after Gore left, and by the time of Thompson and Standingford's visit the company's rather extensive Methods Division was managed by a leading thinker with wartime experience in computers: Dr. Edmund C. Berkeley. Dr. Berkeley believed at the time that "Prudential was the only commercial concern [in the U.S.] actively interested in the application of electronic machinery in its offices" (Caminer et. al., 1998, p. 352.). The visit report describes some of Berkeley's plans:

"Their project is to build a machine that will carry out the premium billing of their millions of policy holders, a job that at present occupies a staff of some 300 clerks. They anticipate that this work can be done with less than 20 percent of the staff in about two days per month. The remainder of the machine's time will be given up to actuarial calculations. They are proceeding with detailed plans, and Dr. Berkeley is confident that they will have a machine installed within about two years. When they have established premium billing, they propose to continue their investigation with a view to putting other routine work on the machine, including the writing of contracts for which they have some 200 standard clauses from which to select" (Caminer et. al., 1998, p. 351).

In May 1947 Prudential received a proposal from Eckert and Mauchly to computerize premium billing, mortality tables, and group insurance by converting "information into punched cards with IBM or Remington Rand punch machines" for later conversion to magnetic tape (Yates, 1997, p. 68). Augarten reports that when Eckert and Mauchly's Electronic Control Company announced the release of the UNIVAC in 1948 the company had five contracts: two from the U.S. government, two from the market research firm A. C. Nielson, and one from the Prudential (Augarten, 1984, p.161). Had this contract proceeded according to Berkeley's plans, Prudential would likely have run a commercial application before Lyons ran one on LEO. But, in a dispute with Remington Rand, after its acquisition of Eckert and Mauchly's company, both Neilson and Prudential cancelled their orders. Prudential bought its first computer from IBM several years later. In 1949, Berkeley published the first popular book on computers *Giant Brains, or Machines That Think.*

10. <u>Howard H. Aiken's Computational Laboratory at Harvard University</u>. In 1937 Howard Aiken, a former Westinghouse engineer who was working as an instructor in applied mathematics at Harvard, developed a proposal for an electromechanical calculator. There "exist problems," he wrote, "beyond our ability to solve, not because of theoretical difficulties, but because of insufficient means of mechanical computation" (Eames, 1973, p. 122). Thomas Watson Sr. was impressed with his ideas and in 1938 assigned an engineer to work on the project at Harvard. Originally called the "Automatic Sequence Controlled Calculator" the machine was manufactured at IBM's Endicott plant and delivered to Harvard in February 1944. Renamed the Mark I, Aiken's machine began running ballistics problems for the Navy in April. In addition to ballistics, the Mark I was used for scientific type calculations in ship design, physics, lens design, insurance, economics (such as Wassily Leontief's input-output models), and linguistics. Mark I contained 760,000 electrical components, 500 miles of wire and could read two 23-digit numbers from paper tape inputs, process them and punch the result out in three seconds. The machine, however, was designed for performing mathematical calculations, not logic. It did not have the logic capacity to execute conditional jumps. Thompson and Standingford saw the Mark I demonstrated and quickly recognized that it was not strictly an electronic computer. Nevertheless, they were struck by its reliability. It was slower than ENIAC, but Mark I had an up time of about 80 percent – versus closer to 20 percent for ENIAC. The increased down-time on ENIAC was due largely to need to service or replace its some 18,000 undependable valves. Mark II, the Lyons visitors observed, was 12 times faster than Mark I; but it was gigantic, filling a large room. Mark III, 20 times faster than Mark II and utilizing a high-speed magnetic drum for its memory, was still under construction at the time of their

> visit. Importantly, Thompson and Standingford were impressed with three things: (1) Aiken's management style (his "faith, enthusiasm, and drive are reflected in everyone in the laboratory" (Caminer et. al., 1998, p. 352), (2) his pragmatic approach (focusing first on reliability and accuracy), and (3) his vision that eventually computers would automatically control factories, unleashing a second industrial revolution. This made them aware of the taxing requirements of managing a computer – i.e. the need for operating systems – and the emerging importance of what today is called "software." Aiken's technology had little influence on the Lyons personnel but his philosophy had a substantial impact on their thinking.[17]

In the summer of 1947 Thompson and Standingford were able to witness and evaluate the early stages of the development of the U.S. computer industry and to meet face-to-face with several of its leading lights. Looking back from the perspective of the passage of more than 50 years, it is remarkable how much of the state-of-the-art at the time they were able to tap into. The two visitors learned a great deal about the technical requirements of computers and the emerging notions of programming. Based on the evidence they collected, they also determined that, with respect to business information processing, none of these sources were working on technologies that would satisfy Lyons' needs.

Upon their return to England, Thompson and Standingford visited the Mathematical Laboratory at Cambridge headed by Dr. Maurice Wilkes. They had been referred to Professor Douglas Hartree, a mathematical physicist interested in computing, by both Goldstine and Aiken. Hartree had visited the U.S. and seen the Moore School's progress on ENIAC as part of his wartime work for the Ministry of Supply. He had then proposed to Cambridge that the university form a committee to consider building its own computer. Wilkes was selected to head that effort. As mathematicians, neither Hartree nor Wilkes had previously considered business applications for computers. But, they were intrigued by the prospect, and they told the Lyons' executives that "they are interested in applying their machine to any clerical job we may suggest, and they are ready to assist in translating clerical procedure into terms of coded instructions" (Caminer et. al. 1998, p. 354). Thus, Lyons had found a much needed partner for developing its own computer.

The computer concept that Wilkes was working on became known as EDSAC – Electronic Delay Storage Automatic Calculator. He worked on its design while attending the Moore School lectures during the summer of 1946 where he learned about von Neumann's *First Draft* of the EDVAC stored program concept. Visits to Aiken's laboratory to see Mark I and to MIT to see Jay Forrester's Whirlwind, convinced him that the use of massive arrays of relays and tubes was not a viable long term solution.

[17] It is interesting to note that during World War II Grace Hopper was assigned to the Navy's project at Harvard. In 1943 she was a programmer for Mark I and developed the original operating system. Later, working on UNIVAC she wrote the first practical compiler and was instrumental in developing and promoting COBOL -- Common Business Oriented Language. John Gosden joined Lyons as a trainee programmer in 1953 and met Hopper in 1958. They remained in correspondence until she retired. In February 1959, Gosden sketched out a new higher level language, CLEO, for a new, faster, microprogramming; multiprogramming generation of LEO called LEO III. CLEO's development coincided with the development of COBOL and was a similar yet less comprehensive problem oriented programming language.

Stored programming, he concluded, was the answer. Sailing back on the *Queen Mary,* he sketched out the design of a "computer of modest dimensions very much along the lines of the EDVAC proposal." (Campbell-Kelly and Aspray, 1996, p. 102) Wilkes wanted to produce a workable machine as quickly as possible. So, like Aiken, he stressed reliability and simplicity in design. His goal was to "try out real programs instead of dreaming them up for an imaginary machine" (Campbell-Kelly and Aspray, 1996, p. 103). As a result of his dedicated efforts to adhere to this engineering philosophy, EDSAC was completed in just over two years. It performed its first automatic computation on May 6, 1949. Goldstine claims that EDSAC was the first machine in the world to execute a stored program (Goldstine, 1972, p. 197). That distinction, however, more likely goes to Max Newman's Manchester University computer – "the Baby" – that was demonstrated in June 1948 (Ceruzzi, 1999, p. 23, Ferry, 2003, p. 76). The control and computing units of Wilkes' EDSAC used short acoustic delay line tubes to store bits for short periods of time rather than the faster, but more difficult to control and definitely less reliable, cathode ray tube (CRT) based storage. CRT's were pioneered by F. C. "Freddie" Williams at Manchester University and later adopted by Jay Forrester for Whirlwind and by IBM for its early computers (Bashe et. al, 1986). Implementation of the stored program von Neumann is fundamental to the modern concept of a computer.

Wilkes had to overcome one significant barrier in getting EDSAC completed in time to meet his schedule and turn his attention to the Lyons project: money. During their meeting in 1947, Wilkes told Thompson and Standingford that detailed plans for the machine were complete, and they left believing that he had a staff of only one draftsman and two temporary vacation students working with him. Wilkes later told Frank Land (personal communication with the author) that he also had several PhD students and more than one member of the academic department working on EDSAC to develop a program to calculate prime numbers. Any additional funds, however, would definitely speed up his progress. Thompson and Standingford concluded that 2000 to 3000 British pounds (about $6000) would be enough to bring Wilkes' prime number demonstration program to completion. David Wheeler programmed it. These funds allowed the Cambridge group to turn more of their attention to Lyons' needs. An era of cooperation was begun.

Simmons Takes Action

Upon reviewing Thompson and Standingford's report, Simmons weighed several alternative strategies for the company to take to develop a computer to the company's business needs: (1) try to persuade Wilkes and Hartree to help Lyons take the basic EDSAC design and modify it to become a business-oriented machine, (2) work with Eckert and Mauchley in the U.S., (3) cooperate with other British electrical companies, (4) form a research alliance with the British government, or (5) "build a machine in our own workshops, drawing information and advice from Cambridge and Harvard Universities" (Caminer et. al., 1998, p. 21). After due deliberation Simmons decided on the fifth option. He then submitted Thompson and Standingford's report to the board of directors with a cover letter concluding:

> "We feel, therefore, that the company might well wish to take a lead in the development of the machine . . ." (Caminer et. al., 1998, page 21).

For the Lyons' machine to succeed, Cambridge first had to succeed. Simmons requested immediate support for Wilkes in order to expedite the university's efforts. In November 1947 the Lyons board agreed to provide aid to Cambridge University to encourage the completion of EDSAC.

> "This was seen as providing a basis for a Lyons system once EDSAC had proven itself. Three weeks later a delegation, led by Booth, the veteran Company Secretary, then in sight of his 80th birthday, visited Cambridge and made an offer of $8400 and the services of an electrical assistant in return for guidance in constructing a computer for Lyon's own purposes" (Caminer et. al., 1998, p. 22).

As part of the deal, Lyons was allowed to second one of its own technicians, Ernest (Len) Lenaerts, to work on the EDSAC before returning to Lyons and joining the LEO team (Caminer, 2003). Lenaerts' experience at Cambridge proved to be invaluable. Thereafter, Wilkes' Mathematical Laboratory at Cambridge and J. Lyons & Co. formed what today would be called a cooperative alliance to help each other produce computers and programs. As a result, in late 1947 Lyons played an instrumental part in speeding up the completion of EDSAC, which was demonstrated in May 1949. After, EDSAC proved itself, Lyons decided to proceed with building LEO. For their part, the Cambridge team provided valuable technical advice on components and programming approaches to help Lyons produce LEO. A prototype of LEO, the world's first business computer, was demonstrated to Her Royal Highness Princess Elizabeth in February 1951. Subsequently, on Thursday, November 29, 1951, the first production model of LEO ran what is by most accounts the world's first regular routine office computer job.

LEO's claim as the first computer designed specifically for business application has been contested. But the validity of this claim depends on the definition of a "computer." In 1949, a prototype of the Remington Rand 409 plugboard programmed punch card calculator was demonstrated. The machine was made commercially available in July, 1951. After Remington Rand's acquisition of Eckert and Mauchly's Electronic Control Company, it was renamed the Univac 60 or Univac 120 depending on the unit's memory size. The Univac 60/120 was indeed used for business applications such as tax and payroll calculations.[18] This gives some credence to William B. Wenning, an early participant's claim that the "Barn," Remington Rand's laboratory located at a Carriage House for Rockledge Estate on Highland Avenue in Rowayton, Connecticut, was the "Birth place of the First Business Computer." Theirs was a remarkable and often overlooked achievement. Nevertheless, since the 409 and the Univac 60/120 were *not* stored program computers (nor was the successor, the Univac 1004, released in June 1962). They qualify as plugboard programmed "calculators" – more like IBM 602A – than as "computers."[19] LEO I was a full-fledged stored program computer.

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[18] The author had the privilege of designing systems and helping program a Univac 120 at Fort Lewis, Washington, while on active duty in 1957 to implement the Army's Command Management System. I learned a great deal about designing business systems from that experience which proved useful when I returned to the Burroughs Corporation and worked with the Burroughs (Electro Data) B205, B220 and B5000 series machines.

[19] See W. B. Wenning "Remington Rand's First Computer," www.rowayton.org/rhs/Computers/hstrandsfirst.htm; and Fay, Frances X. www.rowayton.org/rhs/Computers/hstbirthhour.htm

The technical characteristics of LEO I are summarized in Appendix A.

What new business applications did LEO develop?

Thinking About Business Applications

Thompson and Standingford outlined three possible applications for a business-oriented computer in their 1947 report: sales invoicing and inventory, letter writing (similar to today's word processing), and payroll. For each application they identified both the static and dynamic information required. They then proceeded to specify the components necessary for the machine to carry out the applications: multiple input sources (in their case magnetic wire), printed and electronic outputs, instruction storage, and processing capabilities. It is clear from their report that a machine designed for business had discernibly different requirements from a machine intended to perform purely scientific tasks, such as ballistics calculations.

This idea of envisioning a machine from a business applications perspective was quite visionary for the time and anticipated future developments. In his 1956 book, for example, Canning discusses two leading edge applications of systems analysis and computer application: inventory control in a department store and production control in job shop manufacturing. Gregory and Van Horn's 1960 text illustrates the newly emerging field of electronic business-data processing with a sales analysis problem, an application that involves accumulating, analyzing, summarizing, and reporting sales and inventory data to managers in marketing. They model their example on *The General Electric Company Sales Analysis Applications* report published in 1957. GE was an early installer of UNIVAC I and subsequently used it for production control, logistics planning, and payroll. Basic approachs to applications like these, however, were identified in the 1947 report and developed at Lyons early in the game.

The Cadby Hall Bakery Valuations Job

The customer or business user for the Lyon's first business application was Geoffrey Salmon, the director in charge of Cadby Hall Bakeries. Mr. Geoffrey was a descendent of the founding family and a close relative of the chairman of the company, Harry Salmon. In June of 1951 Simmons wrote Mr. Geoffrey requesting an opportunity to use LEO to value the Cadby Hall Bakeries' output and sales, an application that provided key decision information for Mr. Geoffrey. Simmons stressed the need for the department to submit raw data on quantities and products accurately and according to an agreed upon timetable. "A main board director would never normally have been approached about details such as this," Caminer recalls, "but it was felt imperative that there should be the fullest awareness at the highest level of this first excursion into live office work" (Caminer et. al., 1998, p. 31). Significantly, Simmons was shrewd enough to know that with satisfaction and "buy-in" on the part of high level executives, the LEO project had a better chance of success.

Lyons operated a dozen or more bakeries that shipped baked goods to more than 150 London teashops and other outlets that, in turn, sold the goods to customers.[20] Mr. Geoffrey monitored this business by means of a trading analysis report. This report was

[20] Before WWII there were about 250 Lyons teashops. About 70 were destroyed during the war.

prepared by Simmons' office each week. It required that three related calculations, previously done separately, be performed in one pass:

1. Value the output of goods – breads, cakes, pies, etc. – from each of the different bakeries at standard material, labor, indirect cost, and total factory cost.
2. Value the goods issued to each different channel of sale at standard factory cost, distribution cost, sales price, and profit margin.
3. Calculate and value at standard factory cost the dispatch stock balances ("dispatch" was the logistical unit that distributed goods) for each item arising from differences between the quantity of goods received from the bakeries and the quantity of goods actually sold through several different channels of sale. This yielded a valuation of the inventory or stock balance in the field.

In effect Lyons treated each unit as a profit center and calculated transfer prices to manage the system. Mr. Geoffrey controlled the system by knowing exactly how costs were flowing among the units. The use of this kind of management technique became commonplace in the U.S. during the mid-1950s following the publication of Joel Dean's influential *Harvard Business Review* article "Decentralization and Intracompany Pricing," but it was rather revolutionary at the time (Dean, 1955).

The LEO Cadby Hall Bakery valuations job combined the three calculations described above into one integrated executive-oriented report. Producing similar information before had required 50 hours per week of clerical labor. The LEO application cut the time required to 8 hours of computer data preparation time per week and 4½ hours per week computer run time. Run time was eventually lowered to 30 minutes. This initial installed application was not an especially challenging application for an electronic computer. Indeed, in an interview for the Science Museum in the 1970s Simmons observes that since this job could have been accomplished on EDSAC, it might be considered more scientific than business. Nevertheless, running this pioneering job proved to be important for developing relations with users, especially high level executive users, gaining their confidence and getting some practical live action experience under the team's belt (Caminer et. al., 1998, p. 372-3). Lyons continued to run this application for over a decade. "Though small," Caminer states, "the job opened the way for the larger and more exacting mainstream jobs that constitute an office workload. Payroll, sales invoicing, stock control, and replenishment all swiftly followed on LEO" (Caminer et. al., 1998, p. 8).

Although the calculations for the bakery valuation job were straightforward and did not require the extensive business systems development that Payroll and other applications later required, it set an extremely valuable precedent: information is valuable for higher level management decision making as well as for streamlining operations. This and the subsequent applications summarized below constitute an early incursion into management information systems (MIS). Davis and Olson define MIS as "an integrated, user-machine system for providing information to support operations, management, analysis and decision making functions in an organization" (Davis and Olson, 1985, p. 6).[21] With this application of LEO at Lyons, a new approach to management thinking was being born.

[21] Gordon B. Davis is a LEO Award recipient.

Between 1954 and 1957, Lyons implemented four major innovative business-oriented programs. In the company's lexicon, L1 referred to the company's payroll, L2 to its teashop distribution job, L3 to the Lyons bakery sales invoicing job, and L4 to the tea blending job.

Payroll (L1)

The first major applications challenge that the LEO team took on was payroll, L1. Thompson and Standingford's report had identified payroll as one of three applications for business-oriented technology and sketched out the basic logic for automating it. Payroll is a prototypical business application since it requires multiple inputs and outputs, has a relatively high volume of transactions, and must be accomplished to meet scheduled due dates. In addition to timeliness, payroll also requires accuracy. If the payee does not receive the correct amount, he or she will complain immediately and begin to lose confidence in the company.

During the 1950s, more than 30,000 employees worked for Lyons. Many of them were causal or part time workers like wash-up staff or kitchen porters. Annual staff turnover in some areas approximated 100 percent. Heretofore, the company's payroll had been prepared using time tickets, ledger cards, calculators, and accounting machines. However, upon Simmons' insistence this manual payroll system was quite efficient despite its technological limitations. As numerous companies would subsequently find out, the basic logic of a payroll application is straightforward, but coping with all of its details can be devilish. Among the variations the LEO programmers had to deal with were holiday and sick pay, National Insurance Stamps, club and society subscriptions, loan repayments, taxes, and other deductions that had to be applied against gross pay. Net pay had to comply with the provisions of the Catering Wage Act's minimal wage requirements, although the first payroll was run for factory workers who were not subject to this act. Pay sheets had to be routed to the "pay at" location at which each employee was to receive his or her pay envelope. Since many employees were paid in cash, bill and coin denominations had to be determined and a denomination inventory calculated for each paying location so that the right amounts of coins and currency were delivered to the right place by payday.

In the early days of computer applications, just a few firms such as GE and Bank of America completed a thorough going analysis and "re-engineering" of a business process before computerizing it. However, Lyons used an even more encompassing approach, as was its leader's predilection. Its systems analysts first specified the entire job in systems terms, including detailed diagrams of all data flows and relationships.[22]

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[22] This appears to be an early use of flow charts for this purpose. Churchman, Ackoff and Arnoff show applications of flow charting in their 1957 *Introduction to Operations Research* (Churchman, et. a., 1957) The underlying systems theory is developed more completely in Ackoff and Emery, 1972; Churchman 1968, 1971; Churchman and Verhulst, 1960. Optner details a method in his 1960 *Systems Analysis for Business Management* (Optner, 1960). These are among the first books applying systems theory to computer-based systems design.
Few if any innovations, however, emerge without precedent. During the early 1920's several office equipment companies, notably Burroughs, National Cash Register (NCR), Underwood Elliott Fisher, Remington Rand (which acquired the Powers Accounting Machine Corporation's punch card line), and IBM began proposing information flow systems to make better use of their technologies including adding machines, cash registers, mechanical calculators and punch card equipment. (Sobel, 1981, p. 66-88) Business Forms printers such as Moore Business Forms,

Then, the LEO team implemented the entire payroll program all at once, except for premium bonuses. Bonus calculations were excluded at that time because the mathematical computation that was required exceeded available space in the machine's working memory. "It was then, and remained, a LEO systems and programming maxim," Caminer recalls in drawing a lesson for the future, "that a project, although as fully embracing as possible, should never be put at risk by trying to cross a bridge too far" (Caminer et. al., 1998, p. 36).

Although common place today, in the early 1950s the LEO team was undertaking a task that a rare number of people had addressed and few had even contemplated. Employees devote their time, energy, and talent to an organization under terms of agreement, often stated in formal contracts or laws, specifying what work they will do and how they will be compensated. From the beginning of the age of organizations, some method had to be devised to record what the employee actually did, arrive at pay amount, and issue the pay in an acceptable form. Automating the real world process required systems thinking. All elements of the process had to be identified and their relationships determined. Payroll, like all applications, is the product of what the philosopher Ludwig Wittgenstein called a "language game." Designers must interact with the reality of the situation – a socially constructed reality – and represent it by means of signs and symbols. In doing this, the LEO team had no precedents to follow. So, they first studied the process as carefully as they could, wrote down the details in non-technical terms, and sketched out pro forma reports. Periodically they reviewed their results with Wages Office management. When the team felt they had captured the essence of the application, they prepared a hierarchical system of flow charts, the highest level being the master diagram, the lowest level detailing "the 20 or 30 instruction stages into which the runs were divided" (Caminer et. al., 1998, p. 37). The analysts strove for simplicity – focusing primarily on branching routes and not displaying all of the most intricate details of the calculations within a box. Their initial intent was that any chart "could be understood and commented upon by any intelligent lay person associated with the job" (Caminer et. al., 1998, p. 37). Executive and user understanding and buy-in were essential. A comprehensive set of accounting and completeness checks was implemented to insure accuracy. Caminer, it turns out, was a stickler for accuracy. He demanded that every routine have some form of check and on occasion developed some clever and not obvious checking procedures. These precautions added to the reliability and credibility of LEO's systems.

Inc. and Standard Register also promoted methods for flow charting information flows. Most of this development was predicated on the process flow diagramming developed at the beginning of the 20th century for industrial work by Frederich W. Taylor (1911), and Frank and Lillian Gilbreath. As Couger has observed during the period between 1920 and 1950 process flow charts were modified to incorporate forms flows, tabulating procedures and board wiring diagrams. (Couger, 1974, p. 170, see also Couger et, al., 1996, Couger et. al, 1980, and Cougar et. al. 1982). During the period 1951 to 1960 information process charts were introduced (Grad and Canning, 1969; see also Canning, 1956). The information algebra developed by the CODASYL Development Committee and published by ACM in 1962 applied concepts of modern algebra and point set theory to the task of representing data flows in systems. (CODASYL Development Committee, 1962). Börje Langefors proposed the first comprehensive approach to a theory of information in 1963 and expanded on it in 1966 (Langefors 1963, 1966; 1973; and Bubenko et. al., 1971). Teichroew and Nunamaker operationalized the theory by developing problem statement language (PSL), problem statement analyzer (PSA), and Systems Optimization and Design Algorithm (SODA) (Teichroew 1970, 1971, Nunamaker 1971). (C. West Churchman, Börje Langefors, Daniel Couger, and Jay Nunamaker have each received the LEO Award.)

The LEO team was venturing into virgin territory when it ran its first payroll in 1953. No one in the U.K. had previously developed a payroll program. Few had applied systems thinking to any real world business phenomena or tried to represent it so that their associates could understand it and so that a machine could execute it precisely. Likely not many in the U.S. had done so either. Computers that were even capable of running a comprehensive payroll application were just becoming available. A few UNIVACs were installed in 1953. In fact, the first UNIVAC for business applications was installed at the General Electric Appliance Division to do payroll in 1954 (Lubar, 1993, p. 316). (According to a 1958 publication, payroll would later be one of the first uses of Grace Hopper's FLOW-MATIC compiler running on UNIVAC (Remington Rand, 1958). Computers that were even capable of running a comprehensive payroll application were just becoming available. The IBM 650 was released 1953, as was the 701.[23] The IBM 702, a more business-oriented machine, was not available until February 1955.[24] When Lyons' T. R. Thompson and Anthony Barnes visited the U.S. in the summer of 1955, they witnessed UNIVACs running payroll at U.S. Steel in Pittsburgh. Even at this late date, IBM executives were skeptical of the applications' benefits. Although some IBM customers were developing payroll applications for the IBM 702 and 650 computers, a company vice president told them that the application had not paid off for the IBM Poughkeepsie plant. "His view was that payroll could not be done economically on computers," they reported (Caminer et. al., 1998, p. 53).

Lyons' pilot payroll was run for a limited set of bakeries in July 1953, and within a year, a payroll for 10,000 employees was being processed. Processing payroll for ten thousand employees was the threshold set until a backup computer was available. (Lyons had about 30,000 employees at the time.) Ultimately the payroll for the entire organization and other companies such as Ford Motor Co. U.K. was run successfully on LEO I and its successors. The LEO computers never failed to produce a payroll on time. "Because of the care that had been employed in constructing the programs," Caminer remarks with respect to the system's efficiency, "the computer time was 1½ seconds per employee as compared to 8 minutes of human time [a factor of 320] that it had taken using one of the most efficient precomputer systems anywhere" (Caminer et. al., 1998, p 39).

Fifty years later it is difficult for us, with so much off the shelf software available, to appreciate fully what the LEO team accomplished. They were literally making it up as they were going. A crucial component of their efforts was fitting their grand systems

[23] The IBM 650 was a magnetic drum computer with either a 1,000 or 2,000-word drum. It had 60 words of magnetic core memory for registers and adders. The earliest version received input from punched cards but soon thereafter magnetic tape units were added. Its time to multiply two numbers was 2 milliseconds. By December 1955,32 120 were in operation and 750 on order. The IBM 701 was a scientific computer dedicated on April 7, 1953. It used electrostatic storage tubes, a magnetic drum and magnetic tapes. Nineteen were produced and installed. (Source: Goldstine, 1972, pp. 330-1)

[24] A key feature of the IBM 702 was that it used binary coded decimal and alphabetic symbols making it more applicable to commercial problems. Thompson and Barnes saw several IBM 702s doing rather "small-scale office work" at General Electric during their 1955 trip to the U.S. and observed customers checking out programs on one at IBM's Madison Avenue showroom. About 14 were produced until it was replaced by the IBM 705. It was the company's first major foray into business computing. An article "The IBM Type 702, An Electronic Data Processing Machine for Business" in Volume I of the *Journal of ACM* published in 1954 lays out the plan for the machine. (Bashe et al., 1954)

logic for the application into the severe restrictions placed on programming by the limitations of the first LEO machine. Laying out file designs, coordinating inputs, streamlining initial code in order to reduce memory requirements and enhance speed and efficiency, and managing storage space – all 2048 17-bit words (see Appendix B): all of these tasks had to be accomplished without the aid of tools or experienced sources to fall back on. Consequently, the LEO team, consistent with Simmons' edicts, carefully documented their work and detailed the procedures they used. This intellectual capital proved very useful as Lyons ventured into the service bureau business and ran jobs for a variety of different companies and government agencies (See, for example, Aris, 2000).

The Teashops Distribution Job (L2)

The next application the LEO team undertook was L2, the comprehensive teashops distribution application. It was, in effect, an extensive elaboration of the initial bakery valuations program and a first attempt by an organization at implementing a total management information system.[25] During the early 1960s in the U.S. a spate of articles was published - many heralding but some debunking, or at least, demystifying, the promise of a "total information system" for business made possible by the computer.[26] Then, in 1969, Sherman Blumenthal brought several streams of thought together and put a more realistic spin on the possibilities in *Management Information Systems: A Framework for Planning and Development* (Blumenthal, 1969). From the very beginning, Simmons and the LEO team believed that to improve the company's operations and to justify building a computer on their own they had to take a total systems approach. In 1954, however, they did not have the benefit of subsequent thinking on the topic and, consequently, had to go it alone.

Running teashops was at the very heart of the business. Consequently, "teashop distribution" – managing the flow of goods to the shops – was what today would be called a "mission critical" or "core" business application.

Prior to WWII Lyons operated about 250 teashops. The war brought many changes to the company. Due to labor shortages as a result of war, self-service replaced the popular waitresses called "nippies". Instead of preparing meals on the premises, most dishes were prepared in a centralized kitchen and quick frozen to be distributed to the shops each morning. Further, about 70 shops were destroyed by German bombers, leaving about 180 operating at the time LEO was conceived. This was a high volume, low margin business even in the 1920s. "It was calculated that only a farthing [about one fourth of a penny] profit was made on each of 150 million meals sold annually from all teashops," Bird explains, "and that only a decimal of a penny profit was made on the 75,000 tons per week of other goods sold through the shops. As management wished to control costs to fractions of a penny, the volume of paperwork and the consequent flood of dull routine processing of business transactions was becoming an accounting nightmare. More worrying was that a small error in cost accounting could have

[25] According to historian Thomas Haigh the first person to define "management information systems" was Charles Stein in 1959. He described MIS as a computerized tool that meets all information needs at all levels of management in a "timely, accurate and useful manner." (Haigh, 2001, p. 36) The LEO team was working with this notion about five years earlier. Davis and Olson carry the concept future in 1974 and 1985. (Davis and Olson, 1985)

[26] Haigh (2001) recounts much of the excitement, controversy and disappointment of this era.

disastrous effect on profits" (Bird, 2000, p. 304). As the business was rebuilt after WW II, the pressure on profitability became increasingly intense. Moreover, this was a notably complex business. The demands associated with operating 180 stores on a daily basis - producing, distributing, and selling some 250 different products, most perishable within 24 hours and some, like bread rolls, delivered more than once a day; and collecting and handling cash -- created significant management control problems.

The organizational structure for this part of the business was fairly rigid and hierarchical. At the lowest level, each teashop was run by a teashop manageres. (Nearly all of the managers were female). Six or seven manageresses reported to a section supervisor, each of whom reported to one of eight divisional superintendents, who, in turn, reported to the head office, directed by Felix Salmon, a member of the owning family.

Prior to computerization, Systems Research had devised a rather efficient paper-based system for dealing with the distribution problem. Each manageress was provided with a carbon paper inter-leafed order book with sheets for each day of the week. Each wrote down her requirements for a given day and forwarded the original copy to the central office at Cadby Hall two or three days before the expected delivery. Information on the sheets included requirements for different types of food items, different packing sites, and different delivery schedules. The managers kept a carbon copy for reference. The originals were collected and analyzed in the central office. Total requirements were calculated, picking and packing lists produced, delivery instructions generated, and the management accounting and statistical data necessary to charge each shop with the goods delivered was prepared. "Dispatch" was the name given to the organizational unit that picked and delivered the items. At about 6:00 a.m. each morning the vans departed Cadby Hall delivering the goods for the day. This system, though adequate, generated large masses of paper to be handled. And it was clumsy. Moreover, by requiring almost all orders to be placed several days ahead of time, last minute adjustments were difficult to accommodate. As the business grew, it became increasingly difficult and costly to add the clerical staff needed to process the mounds of paper generated by this system. Consequently, maintaining these overhead activities was cutting severely into margins. The LEO team sought to further rationalize and economize this crucial management process using a total systems approach.

In developing the LEO application, Systems Research first developed and documented a systems description of the entire process. Then the remarkable and indefatigable David Caminer personally analyzed batches of order forms to determine patterns. He discovered that the greatest variation in volume per item was between days of the week. A Monday's order generally looked more like a previous Monday's order than a Tuesday's order, and so forth. Hence, adopting the concept of exception reporting, he decided to have LEO print out a standard Monday order sheet for each teashop, and similarly for each day of the week. The manageresses would review the standard order and forward permanent changes to it a week or so prior to when they wanted them put into effect. By taking this strategy, Caminer was employing a systems concept called "preprocessing." Control can be improved in a system in one of two ways: by increasing the controller's capability to process information – sometimes called the "brute force" approach, or by decreasing the amount of data to be processed (Beniger, 1986, p.15). Lyons took the second approach. By assuming a standard baseline order, the volume of data to be processed by the application was reduced significantly. But, as would be expected, shops frequently needed to change some component of their order away from the standard as late as the evening before in order to respond to unusual events such as changes in the weather, a parade or a street closing, or a special order. To accommodate this need for dynamic change, Caminer came up with a clever solution. At a predetermined time each day, telephone operators would phone each shop and ask for any late adjustments to the manager's order. Wearing headsets, the operators would take the order changes and simultaneously keypunch them directly into punched cards to be read into LEO at L2 run time. This provided the basic input to the application. (In 1956 CEO Foster McGraw would authorize a similar system be installed at American Hospital Supply to control the company's far-flung inventory. In 1973, this application would evolve into ASAP – Analytic Systems Automatic Purchasing. ASAP is an historic exemplar of the strategic use of information systems (McKenney et.al., 1995, pp. 164-175).

Accessing its tape files, the L2 program read in the pre-determined standard order, updated it with any permanent changes submitted, and then applied the daily punch card changes to determine the order quantity for each product for each shop. Next, the program compared the total quantity with the production schedule provided by the kitchens. In the event that orders for an item exceeded production or availability, substitutes were specified or shortfalls allocated among the shops. Packing notes were then prepared in predetermined groups for each of the kitchen locations so that the order could be picked and put up for each teashop. This included calculating the packing material required for each delivery, including carton dimensions. Grand totals for each item provided each productive department with an overall figure of demand for its items. Dispatch received totals of the amounts of each item to be loaded on each van. Throughout the processing, items were maintained in at least two different sequences: (1) the sequence that best facilitated the manager's ordering and (2) the sequence that best facilitated picking and dispatch. Thus, by translating back and forth as needed between the manager's order item numbers and the dispatcher's routing item numbers, changes could be made on either side without having to get the agreement of the other party or having to disturb either party's natural way of doing their jobs. Thereby, interdepartmental conflict was reduced. That is, both the teashop managers and the dispatchers had an information system tailor-made to their specific needs.

Composite dishes – e.g. boiled beef, carrots and dumplings – were ordered by a single code number and a "goes into" decomposition routine was applied to generate the pounds of boiled beef, pounds of carrots and quantity of dumplings that dispatch needed to have packed and delivered to each ordering shop. The program collected numerous statistics throughout this processing. Since Lyons treated each shop as a profit center, all deliveries to each teashop were valued at selling price. Monthly, or weekly if needed, beginning inventory at sales value, plus deliveries, minus sales (as determined from cash receipts) was compared with ending inventory for each item for control purposes. Standard costs were applied to arrive at item and unit profit figures.[27] In accordance with the Lyons' organizational structure, profitability and other forms of information were reported for each shop, each section, each division, and for the operation as a whole. Integrating data from L2 and labor statistics from payroll (L1) with data from other sources, performance metrics were calculated for each item and each organizational unit. The program prepared exception reports in sequence showing lowest to best unit performance so that appropriate managerial action could be taken. It also searched for excessive upward and downward daily adjustments that had been telephoned in so as to

[27] "Everything was specified," according to Ferry, "from the value of the energy needed to bake a loaf of bread to the thickness of the jam spread on the Swiss rolls" (Ferry, 2003, p. 31).

uncover suspected "gaming" on the part of managers who wanted to disguise their poor planning.

The Teashop Distribution program, L2, went live on October 20, 1954, and with modifications was in continual use throughout the life of the LEOs. Among the advantages realized by Lyons early on were net savings of about $560 per shop per week, reduced ordering workload for teashop managers, reduced work load for dispatch and simpler packing instructions, and the elimination of several paper forms such as delivery notes. Meanwhile, the overall work load was distributed more evenly throughout the week, reducing "crunches." Importantly, sales and marketing improved as well. Utilizing the additional management information, the teashops managers could more easily promote sales, and were more aware of lines that did not pay and of teashops, sections, or divisions that lagged behind the remainder. L2 also served to prevent teashop managers from making trivial changes to their orders (Caminer et. al.,1998, p. 383).

By implementing the teashop distribution program in 1954, Lyons put in place one of the first integrated "total information systems" in the world. The company had applied advanced techniques of management control, such as preprocessing, feedback, and exception reporting. It had dealt with many of the pitfalls Ackoff later identified in his classic "Management Misinformation Systems" (Ackoff, 1967). The company reduced the overall quantity of information managers received (The fallacy of "Give Them More"), while providing them with better targeted, decision-oriented information. Analysis was undertaken to determine what information was required to manage each unit effectively ("The Manager Needs the Information He Wants"), and the requisite information was provided. Potential conflicts between shop managers and dispatch managers, each of whom had different interests and goals, were reduced by the social buffering provided by an item code translator. The company delivered education and training programs to help managers and others understand how the L2 system worked ("A Manager Does Not Have To Understand How an Information System Works, Only How to Use It").

The LEO applications also conformed to the systems theories of Stafford Beer, UK cybernetics and operational research pioneer, whose books Decision and Control (1966), Brain of the Firm (1972), and Platform for Change (1975) build on British cybernetician Ross Ashby's (1956) profound insights into systems. Business complexity is handled by applying Ashby's law of requisite variety. As Enid Mumford explains, a "viable system" for Beer operates at five levels: Level 1, Operational, performing day-to-day tasks; Level 2, anti-Oscillation, preventing and solving problems; Level 3, Optimization, adding new value; Level 4, Development, thinking creatively about solutions; and, Level 5, Control, meeting targets and standards (Mumford, 2003 pp. 66-69). Without the benefit of these formal theories, the LEO group intuitively designed a system that incorporated many of their concepts.[28]

But all was not perfect. The training program was only partially successful. Many of Lyons' employees had been with the company since before the war and had been schooled in traditional ways. Because the basic hierarchical organizational structure was left unchanged, it was like "modern technology grafted to a prewar, almost 19th century management structure" (Caminer et. al., 1998, p. 225). Some improvements in the overall implementation were made when a new champion was assigned. Alec Kirby, "a

[28] Enid Mumford is a LEO Award recipient See Mumford 1979, 1983, 1995, and 2003.

high-flying young manager from the Statistical office who was familiar with both LEO and the Simmons' management requirements, was brought in and promoted to become effectively chief executive of the Teashops Division" and to serve as a proponent of the L2 system (Caminer et. al., 1998, p. 224). Unfortunately, due to the failure to fully change the mind-sets of all of the managers and employees, L2 never lived up to its fullest potential. So, the project fell victim to Ackoff's (1967) fifth pitfall: the myth "Give a Manager the Information He Needs and His Decision Making Will Improve." Many traditional managers at Lyons were not persuaded to change their behavior. Despite this shortcoming, however, most observers conclude that the L2 teashop distribution program solved many pressing management problems and clearly justified the investment made in it. It improved people's working lives. "The head staff at this shop would like to give thanks for LEO. This is a wonderful time saver, work saver and we are grateful for it," John Aris quotes from a daily report of the Wembley teashop a few days after L2 went on stream. "As the Manageresses were a notoriously crusty group this was a most satisfying achievement" (Aris, 2000, p. 13).

Bakery Sales Invoicing Job (L3)

Sales invoicing was one of the applications identified by Thompson and Standingford in their 1947 report, and L3 was the follow through on that idea. It was designed to handle all of the paperwork for Lyon's largest sales and distribution organization, the Wholesale Bakeries Rails Department. This department sold and delivered cake and pie supplies to shopkeepers located all over Britain. During the 1930s, Simmons had pushed to have a system implemented to reduce the heavy volumes of paper involved in sales invoicing, and had come up with a novel answer. As Caminer explains, a "special feature of the system was that [consistent with Simmons' "write-it-once" objective] only one piece of paper served as order, packing note, delivery note, and invoice. No paper copy was retained either in the dispatch or in the offices. Instead, a [micro]film copy, was retained that could be referred to if any query arose.[29] The orders were taken by a salesman, who and also collected the cash on a one week's credit basis, so that there was little in the way of an accounting system" (Caminer et. al., 1998, p56). Thus, by eliminating paper and reducing the amount of information processed, substantial economies were realized. Consequently, it was initially difficult to make a business case for applying LEO to this application because so much of the cost had already been wrung out of the system. Nevertheless, a team lead by John Grover was able to design a system that incorporated more of the related tasks and reduced the key-punching input required. Caminer describes the result. "As by-products of the invoice calculations, LEO automatically produced instructions as to which of a range of cartons was to be used for each order, calculated the assembly for packers and loaders, and checked the carriage-free-of-charge thresholds. It also provided each salesman with a cash collection list, incorporating amounts not yet paid for previous weeks' deliveries, checked and made the now standard provision for rapid restarts." L3 went live in January 1956, and served as a model program design for other sales invoicing jobs.

[29] The earliest use of photography to reduce greatly the size of documents copied by capturing them on narrow rolls of film began with the introduction of the Recordak system by Eastman Kodak in 1928. 16-mm, and then 35-mm, film was used in continuous, automatic cameras to photograph documents. Special projection equipment was required to wind rapidly through the film, find pertinent frames, and enlarge them. An effective microfilming system required detailed analysis of paperwork flows. By applying this technology in the early 1930's Lyons was an early adopter.

Tea Blending (L4)

L4 was developed by Frank Land to value the many varieties of tea that Lyons included in its various tea blends such as Red Label and Green Label. Tea was a major staple in the Lyons product line, and managing the company's stock of thousands of chests of tea, classified by flavor, color, strength, aroma and other characteristics, was an enormous yet crucial job. The raw tea came from a variety of sources: either purchased at auctions held in the London center of the tea trade, Mincing Lane, imported from the company's tea gardens in the African colonies, or acquired by direct purchase from growers in India, China, and Ceylon. Each week different strains of tea were mixed in prescribed proportions to produce the company's famous blends, which, in turn, were packaged for distribution and sale. A further complication was that tea coming from overseas was stored in bonded warehouses and was only released when appropriate duties were paid. L4 had to deal with these inventories separately. In Land's program, the various basic teas were allocated to each blend and valued at standard raw material prices. Mixture proportions were then used to calculate a standard product price for each blend. When the blending was completed, checks were made to insure that the permissible total cost for each blend was adhered to. Valuation totals were calculated for each product and the total production output. As with all of the Lyon's applications, the program prepared accounting, statistical, and management control data for all levels of management. The tea blending application went live on October 18, 1954, and according to Land, it continued in service with modifications for another 25 years[30] (Land, 1998). Lyons Tea and Lyons Coffee brands still exist.

A Growing Array of Applications

From these beginnings, the LEO team fanned out into almost all parts of the Lyons & Co.'s and other firms' businesses: accounting and valuation, reconciliation accounting, actuarial and insurance-related applications, clerical and office, statistical analysis, financial and banking, tax tables, inventory, telephone billing, invoicing, utility billing, weather forecasting, simulations, mail order, railway distancing, and word processing. Among the organizations the LEO team provided support for were the British Meteorological Office, the Ordnance Board, Ford Motor Co. U.K., Stewards and Lloyds, Greenwich London Boroughs, W. D. & H. O. Wills, Army and Airforce Officers payroll, Ministry of Pensions, Standard Motors, Durlachers Stock Jobbers, HM Customs and Excise, Rand Mines of Johannesburg, Dunlop, Shell-Mex and British Petroleum, Freemans Mail Order, VLD of Prague, HM Dockyards, and the British Post Office.

As computer design and components improved, new versions of LEO were released: LEO I in February 1951; LEO II in May 1957; LEO III in May 1961; LEO 326 in April 1963; LEO 360 in January 1965. Reg Cann, the leader of the Royal Dockyards information systems group, reports that in 1963 his team evaluated 11 different manufactures' computers: English Electric, EMI, ICT, Honeywell, NCR, Burroughs, Remington Rand, De La Rue Bull, AEI, IBM, and LEO Computers, Ltd. The LEO 360 came out on top. " . . . it became clear to us that, while they [the other manufacturers]

[30] Land's blending program did not use linear programming to determine the optimal mix although his blend solutions had to meet cost constraints. His work, nevertheless, involved leading edge thinking. In April 1952 Charnes, Cooper and Mellon had published the first Operations Research application to blending problems in *Econometrica* (Charnes, et. al, 1952).

were trying to sell us hardware of which they well knew the technical capabilities, not all of them were knowledgeable in the ways in which the machines could be used to process business data, or indeed had the software to do so. LEO Computers were well equipped here. They had the practical experience of business processing, proven software, a high-level language (CLEO), a proven compiler, and a proven operating system. None of the other manufactures could match this" (Caminer, et al, (1998) p. 275).

That was in 1963. At that time Lyons and the LEO team had been in the forefront of business information processing for over a decade. Having been a prime innovator in the field, they remained among the leaders until the mid 1960s. But, the world changed for LEO and its people on April 7, 1964. On that date IBM announced its 360 range of computers. LEO had been competing with IBM for several years since IBM entered the UK market after its long standing market division agreement with ICT ended. The 360 drove the nail into the coffin. IBM's System/360 purportedly allowed users to begin with a low range system and migrate upward as their needs grew without rewriting their applications programs.[31] It was directed to meet users' needs for orderly growth from mechanized accounting machines to several consecutive tiers of sophisticated, high speed computers. At the time, IBM had some 8,000 low level 1401 punch card "walloper" computers installed in the field. This provided the company with the marketing advantage of a large installed base to augment its still extensive base of non-computer punch card EAM (electronic accounting machine) equipment.

Nevertheless, the LEO Group, which had been reformed in February, 1963 after the merger with the computer department to form English Electric LEO, kept innovating for several years until it reached the peak of its installations in 1965. LEO continued to produce excellent machines and trustworthy business systems. A large scale LEO III was released in May of 1961 that incorporated early designs for real-time and multi-access. Among its technological advances were early applications of diode and transistor technology, magnetic core storage, and transistor registers. The LEO III design also featured two major innovations: microprogramming and multiprogramming, or time-sharing. Many of the most prestigious computer orders placed during this period in the U.K. went to this system. But the writing, nevertheless, was on the wall. IBM was simply too forceful as a sales and marketing organization. Moreover, it produced

[31] Business historian Robert Sobel refers to the IBM System/360 as "The Incomparable 360" because it remade the industry (Sobel, 1981). The company committed virtually all of its $5 billion of assets behind it and succeeded. The 360 and its upward compatible successor, System/370, were so widely used during the 1960's and 1970's that it became almost essential for everyone in the computer field to be aware of the major aspects of the lines' hardware and software. This series of machines established the standard for the era. The basic unit of information in the 360/370 was an eight-bit byte. Four bytes comprised a word. By today's standards the magnetic core memories of the early 360's were severely limited in size, ranging from 64K bytes to 1M bytes on the largest machine. Upon its release the 360 was intended to obsolete virtually every other existing computer. According to Campbell-Kelly and Aspray this "'most crucial and portentous – as well as perhaps the riskiest – business judgments of recent times' paid off handsomely. Literally thousands of orders for System/360 flooded in, far exceeding IBM's ability to deliver; in the first two years of production, it was able to satisfy less than half of the 9,000 orders on its books" (Campbell-Kelly and Aspray, 1996, p. 144). The LEO organization simply could not compete with this enormous marketing power. IBM's success came despite the fact that its operating system OS/360 was initially faulty, late and over budget (See Brooks, 1975).

hardware that for the most part worked well enough. In July 1968 the LEO group, as part of the Government's industrial rationalization program, merged with ICT to form ICL. The group was absorbed by the larger ICT component and essentially lost its identity. The government offered a multimillion pound loan as an inducement to be repaid only if ICT became profitable. Neither party was enthusiastic. The new company did not survive, and the loan was never repaid. Finally, in 1981 the British Post Office took the last LEO 326s out of service. The saga was finished.

Epilogue

Hubris is described as "exaggerated pride, self-confidence, or arrogance, frequently resulting in retribution" (Kroll, et al., 2000, p. 117). It derives in part from a series of successes and an uncritical acceptance of accolades received following those successes. Hubris often leads to an excessive emphasis on perfection and a belief that one's ideas and capabilities are superior to all others. Toward the end of its life the LEO team succumbed to hubris and became dismissive of others in the field, especially IBM.

Caminer cites as an epitaph a quote from a paper by Dr. John Hendry entitled "The Teashop Computer Manufacture: J. Lyons":

> "In the end, they [the LEO team] were perhaps too strong on the applications side. Carried away by their own sophistication and obsessed by the pioneering spirit, they failed to understand the social and psychological needs of ordinary customers with ordinary muddled systems and ordinary resistance to change" (Caminer et.al., 1998, p. 140).

An addictive application of whole systems thinking, inordinate attention to detail, and a dedication to professionalism as a code of honor, traits that had resulted in so many successes - in the end contributed to LEO's bitter demise. It was not because they were inept, but because they were too good at insuring profitability in the face of IBM's more cost effective approach.

Importantly, however, this special group of people who conceived, built, programmed, and applied a succession of LEOs did leave an abiding legacy. They showed us how to secure improvements in an organization's performance by means of adroit systems analysis and design. And they provided the early incursions into ICT hardware and software necessary to implement these designs. Many of their number went on to influence the practice and teaching of information systems elsewhere.[32] It is a legacy of which to be proud.

[32] The demise of LEO led to the dispersion of key LEO people who propagated the LEO methodology widely in the UK and also the USA. For example Frank Land became chairman of the National Computing Councils' Systems Analysis Examination Board and chaired the British Computer Societies working party on setting up curricula in information systems. Gosden and Dixon in the US and Hermon, Aris, Gifford, Hornstein, Feeney, Holley, Ralph Land, Josephs, Jackson, John Smith and others in the UK: all had influential careers with many ending up in very senior positions in major corporations. Moreover, the LEO service bureau pioneered serious outsourcing.

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Appendix A

LEO Award for Lifetime Exceptional Achievement in Information Systems

	Recipients
1999	C. West Churchman J. Daniel Couger Börje Langefors Enid Mumford
2000	Gordon B. Davis
2001	Richard O. Mason

2002	Paul Gray Jay F. Nunamaker, Jr.
2003	Frank Land John F. Rockart

Appendix B

LEO I Technological Characteristics

Logic circuitry:	Thermionic and Ge diodes. Hard valve amplifiers Wholly serial
Storage type:	Mercury delay tubes
Storage size:	2,048, 17-bit words.
Store access time:	500μsecs
Backing store:	None
Word size:	17 or 35, 4-bit character.
Add time:	1,300μsecs.
Channels:	Four input and output.
Peripherals:	Paper tape read, card read/punch, line printers.
Innovative features:	Automatic clock pulse frequency control. Convert and reconvert instructions. Analytical marginal testing. Data preparation and checking equipment.

Source: Bird, 1994, p. 257.

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