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## Finland and Nokia: Creating the World's Most Competitive Economy

*When an inventor in Silicon Valley opens his garage door to show off his latest idea, he has 50% of the world market in front of him. When an inventor in Finland opens his garage door, he faces three feet of snow.*

—J.O. Nieminen, CEO of Nokia Mobira, 1984

Until the 1990s, Finland was considered a remote and sleepy country in the northeastern corner of Europe, lying in the shadow of its large neighbor Russia. Finland had been part of Sweden for six centuries until 1809, when it was ceded to Russia. The Bolshevik revolution in 1917 and the collapse of the Romanov dynasty led Finland to unilaterally declare independence on December 6, 1917 (still the national day). After difficult years during World War II, Finland remained somewhat isolated, and its economy remained highly dependent on the Soviet Union. Following the model of its Nordic neighbors in the post-war years, Finland was characterized by heavy investments in social welfare and public infrastructure. There was a history of government involvement in the private sector. The government had large holdings in many top Finnish companies (see **Exhibit 1**) and, through its active involvement in mergers and other investments, influenced the ownership structures of key industries.

Finland's prosperity level caught up to the OECD average only slowly. With few exceptions, notably in pulp and paper and specialty shipbuilding, Finnish companies were absent from international business rankings.

By 2001, however, Finland had become one of the fastest growing and most competitive economies in the world. A member of the European Union, it was known for fiscal stability and was the only Nordic country introducing the Euro in the first wave. In the Competitiveness Rankings of the Global Competitiveness Report, Finland won the top spot from the United States in 2000. One Finnish company, Nokia, had outpaced others and cast a long shadow on the entire economy. Its emergence as the global market leader in mobile telecommunication equipment had made the company the leading contributor to Finnish exports, R&D expenditures, and market capitalization.

With the slowdown of the global telecommunication market, however, both Nokia and the Finnish economy were facing challenges. Some experts were raising questions about the sustainability of the company, and the country's, recent achievements.

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## Country Background

Finland was a sparsely populated European country, surrounded by the Baltic Sea in the South and the West, a 1,000-mile plus border with Russia in the East, and Sweden and Norway in the Northwest. The country's capital Helsinki was located at the same latitude as southern Alaska and Greenland. Finland's population of 5.3 million in 2001 was spread thinly across the country's 130,000 square miles. Only the region of the southern cities of Helsinki, Espoo, and Vantaa was more heavily populated, accounting for about 20% of the total population.

Finland was one of the world's most homogenous societies with a very low proportion of immigrants. Finns shared one culture, although about 6% of its population belonged to the Swedish minority. Finland had close cultural ties to its Nordic neighbors but had followed a separate path in many other respects. The Finnish language was part of the Finno-Ugrian language group and was related only to Estonian, Hungarian, and to the Inuit language spoken in the far north. Apart from Finnish and Swedish, the two official languages, most of the population also spoke English. With the establishment of the common Nordic labor market in 1954, large numbers of Finns moved to Sweden to work in the car and textile industries, making Finns the largest immigrant group in Sweden. Very few Swedes, however, had moved to Finland.

Beginning in 1919, the Finnish constitution had enshrined a so-called "semi-presidential" form of government. The president, directly elected by the people for a 6-year term, had some policy making powers, especially in foreign relations and the right to dissolve parliament and call elections. He or she (Tarja Halonen was elected the first female Finnish president in February 2000) also formally nominated government ministers that had to be confirmed by parliament. The Prime Minister is elected by Parliament, and proposes the Ministers who are formally appointed by the President. 200 members of the one-chamber parliament were elected for four years. Legislative proposals were usually initiated by the government, but could also come from any member of the parliament. On March 1, 2000, Finland adopted a new constitution that integrated four previously separate constitutional acts which had shifted more powers to parliamentary control.

The country's vulnerable geopolitical position vis-à-vis the Soviet Union, plus the constitution, had allowed President Urho Kekkonen to dominate the country's political agenda during his 26 years of office from 1956 to 1982. The parliament was controlled by coalitions often encompassing the whole spectrum of left- to right-wing parties. Kekkonen had forged these broad coalitions, which were accepted out of a desire to avoid discord on domestic policies that could destabilize Finland's external relations. This logic lived on in the government that had been elected in 1999. Only one party, the rural Center party, was not included in the government coalition.

## The Finnish Economy Prior to 1990

The Finnish economy was historically driven by the wealth of the country's natural resource endowment and its long coastline. The economy was dominated by manufacturing industries and had a service sector smaller than in many comparable European countries. The three largest clusters were pulp and paper, wood products, and engineered metal products. In 1970, pulp and paper accounted for 40% of exports, wood products for 16%, and engineered metal (including shipbuilding) for 23%.

The pulp and paper cluster had emerged based on the large forests covering 76% of the country's total land area. The cluster had achieved a leading role in the world despite slower growing forests than competing regions of the world as well as higher energy costs than other parts of Scandinavia. A shipbuilding cluster was focused on specialized ships such as icebreakers and ferries. Domestic

demand, for example from ferry lines connecting Finland to Sweden and continental Europe, was an important market for the cluster.

Finland's post-war economic performance was characterized by slow catch-up to the more advanced western economies from an initially low level. In 1950, Finland's GDP per hour worked was at 46% of the U.S. level, falling in between its Nordic neighbors and war-torn Germany and Austria. GDP per hour reached 69% of the United States level in 1970, closing some of the gap to its neighbors but falling behind Germany and Austria. From the 1960s through the 1980s, GDP growth rates stayed between 3 and 5% per year, investment rates were high, and total factor productivity growth outperformed many other European countries. Wage dispersion in the Finnish economy was low. Company profitability in Finland was also historically low compared to other OECD countries.

Finland's trade was heavily affected by the Soviet Union. Having joined forces with Germany during World War II, Finland lost some territory, requiring the relocation of 15% of its population, and was made to pay substantial war indemnities in the form of steel, ships, textiles and machinery sent to the Soviet Union. This created important business linkages in the east. Between the 1950s and the 1980s, some 20% of all Finnish exports were sent east and Finland became an important supplier of manufactured products to the Soviet Union. The Soviet trade was barter trade, with payments for industrial exports usually made in natural resources, often oil. Other important Finnish export markets were in Europe, primarily Sweden and Germany, with the United States accounting for 3% of Finnish exports in the early 1980s. The country joined the European Free Trade Association (EFTA) as an associate member in 1961.

Finland's economic policy in the 1970s and 80s followed Western European and Nordic patterns. Finland had traditionally been a country with a large public sector and strong welfare aspirations. Taxes were high after an era of active intervention by government in the 1960s and 1970s. Transfer payments and public spending on services were high. Macroeconomic policy featured a fixed nominal exchange rate, centralized wage bargaining, and increasing fiscal budget deficits through the 1980s. After World War II, Finland experienced at least one large devaluation every decade; 30.7% in 1949, 28.1% in 1957, 23.8% in 1967, and more than 20% in a series of devaluations in the 1970s.

Finland had a sophisticated public education and university system. Education between the ages of 7 and 16 was compulsory and most students stayed on for three to four more years in upper secondary or vocational schools. Public spending on education relative to GDP was traditionally above the level of many other European countries, and had increased at a steady rate. The quality of education was considered good, and Finnish students generally performed well in international school performance tests. Nearly 60% of the population had completed a secondary education or beyond.

Finland also was home to 20 universities and other institutions of higher education, with a student population of approximately 270,000. A number of universities had a long tradition; the University of Åbo was founded in 1640 but moved to Helsinki in 1828. A number of additional universities were created in outlying regions in the late 1950s and 1960s. For example, a university was founded in Oulu, a remote city in northern Finland with a population of about 50,000, in 1958. Nearly 13% of the population had a university degree or the equivalent.

Finland's financial markets were characterized by strong ties between companies and their banks, not unlike the system prevalent in the Germanic countries. Financial regulation was tight, making credit approval restrictive. Finnish competition policy, not unlike other Nordic countries, had a history of lax enforcement. Mergers and acquisitions were decided and negotiated by a small elite group of managers and owners (the so called "bergsråd"), together with the large banks and government officials.

The Finnish corporate sector had traditionally been dominated by large, diversified groups, such as Valmet, Nokia, and Ahlström, with roots back to the nineteenth century. Valmet was a world leader in sophisticated machinery for the pulp and paper industry with a long history. Nokia had historical roots all the way back to 1865, but was created in its modern form in 1967 when Suomen Kaapelitehdas (Finnish Cable Works, founded in 1917 and active in the telecommunications cable and electronics businesses) was merged with Suomen Gummi-tehdas (Finnish Rubber Works) and Nokia, a 100-year-old wood grinding mill. Other parts of the economy, such as the food retail sector, had a strong presence of small companies linked together in co-operatives.

**Developments in the 1980s** Economic growth in the 1980s was buoyed by rising government expenditure that led to increasing inflationary pressure. Growing government budgets were financed by public sector deficits and an increasing tax share of GDP. In October 1982 the Bank of Finland devalued the Finnish Markka, first by 3.8% and then by 5.7%.

Throughout the 1980s, a series of policy changes were made in reaction to a growing perception that Finland's economy was losing ground internationally. R&D expenditure as a share of GDP was increased continuously beginning in the early 1980s. Public R&D spending was increased at an annual rate of about 10%, soon making Finland one of the leading OECD countries in public R&D spending relative to GDP.

In 1983 the National Technology Agency (Tekes) was founded, which became the main implementer of technology policy. In March 1987, another research related body, the Science and Technology Policy Council, was founded. Headed by the Prime minister and including the Ministers of Finance, Trade and Industry, Education, four other Ministers, and representatives from the main research organizations and the private sector, the Council was to direct overall research policy and develop strategies in three-year cycles.

Rigid financial market regulations came under increasing pressure in the 1980s as Finland was increasingly uncompetitive. In the second half of the 1980s the financial markets were liberalized, as they were in Norway and Sweden, making lending much easier for banks. Access to international capital markets was also made easier, including Finland's accession to full EFTA membership in 1986.

### *Emergence of the Finnish Telecommunications Cluster*

Unlike in most other European countries, the Finnish telephone network was never monopolized by the state. The deliberately fragmented market structure reflected security concerns dating back to the late nineteenth century when Finland was a Russian Grand Duchy. At the time, the Finnish Senate had granted many licenses for telephone operations in order to complicate any effort by the Tsar to seize the telephone system.

After independence, a national public telecommunications operator (PTT), Telecom Finland, was established to operate the network left behind by Russia. The PTT was not only an operator but also the regulatory body for the industry. There were several attempts over the decades to nationalize poorly performing private operators in the name of harmonizing infrastructure, but these had met with political resistance and never materialized. The threat of nationalization, however, had stimulated private operators to upgrade their technology. In 1921, the private telephone operators founded the "Association of Telephone Companies" for administrative cooperation and joint actions. The Association became a powerful competitor to the PTT, dominating local telephone operations in major cities while the PTT had a monopoly in long distance and international calling. In the 1930s, there were no less than 815 private local telephone companies in Finland. Finnish operators, who were quite advanced technologically, engaged actively in R&D cooperation with equipment manufacturers.

The seeds of the Finnish radiophone and mobile phone industries dated back to three companies: Salora, established in 1928, was a regional manufacturer of TV and radio sets. It began the development of radiophones in 1964 in response to a Finnish Army invitation for tenders; the first in a series of tenders by government to meet demanding applications of radio technology. Valtion Sähköpaja (lit. State Electric Works), established in 1925 as the radio laboratory of the Ministry of Defense, was founded to strengthen national development and production of radio technology. Valtion Sähköpaja was later merged with the R&D unit of the PTT, renamed Televa. The third company, Suomen Kaapelitehdas (lit. Finnish Cable Works) founded in 1917, was a producer of telecommunications cables. It merged with Nokia in 1967. By the 1970s, Televa and Nokia, viewing the Finnish market as too small, combined their R&D and marketing efforts in digital exchange technology in a joint venture, Telefenno. Telefenno introduced the first digital telephone exchange in 1982, only shortly after Ericsson, Alcatel, ITT and Siemens. For years, the product was Nokia's most successful export.

**The first two decades of the Mobile Era** In 1969, the 'Nordic Telecom Conference', a body for formal and informal technical cooperation between the Nordic PTTs in Denmark, Finland, Norway and Sweden, initiated a project to develop an automatic Nordic Mobile Telephone (NMT) network. The analog NMT system, launched in 1981, was unique in several respects. Most importantly, it pioneered roaming technology (later used in other systems around the world) that made it possible for the system to know where a telephone was located, so that the user could travel across national borders using the same phone. NMT was also an open standard that could be implemented by any company. The introduction of the NMT made the Nordic region the world's largest single mobile market at the time.

Expanding at a rapid rate, the market began to attract private operators and manufacturers. In Finland, private license applications were rejected by the PTT in its role as regulator, arguing that competition would preclude economies of scale and that mobile communications was a natural monopoly. As a countermove, the Association of Telephone Companies formed a joint venture in 1988, Radiolinja, to operate a private network.

The introduction of the NMT marked the start of a fast-expanding new industry. The process of establishing the NMT standard brought the Nordic telecommunications administrators and providers into close cooperation. While active in the development of mobile phones, the Finnish industry had in the past not been competitive in network infrastructure. In 1981, however, demand from the Finnish PTT led the domestic equipment industry to develop a base station (see Appendix for an overview of the technologies involved). By 1985, the NMT standard held a leading position in a number of foreign markets, with an average annual growth rate of 50%. Several Nordic manufacturers of mobile phones and network infrastructure soon entered the market. In other countries, with closed standards, there was only one operator that also supplied the phones.

By the late 1980s there were some 15 competitors active in the Nordic mobile phone markets. The only other country with significant competition was the UK, which had a similar number of competitors. Other European markets had far fewer. Penetration in the Nordic region was the first to take off. It had 523,000 subscribers in June of 1988, while the U.K. had 366,000, Germany 70,000, France 69,000, Austria 34,000 and Switzerland 14,000 at the time.

With the NMT under way, Nokia and Salora created a 50-50 owned joint venture in 1979 named Mobira (later Nokia-Mobira) to market and develop radio technology, especially new NMT phones. Before 1980 Nokia had sold approximately half of its production in the domestic market, with the rest exported mostly to neighboring countries. During the 1980s, Mobira allied itself with distributors and mobile operators around the world, and the company began to build a global consumer brand.

Nokia began to expand its international operations by also acquiring several electronics companies including Luxor (a Swedish manufacturer of TV sets and personal computers) and Standard Elektrik Lorenz's consumer electronics businesses (a German manufacturer of TV sets and other electronics). Nokia also acquired the PC and office electronics business of Ericsson, Ericsson Information Systems. The acquired units operated mostly in the electronics industry and manufactured products such as TV sets, monitors and videos sold directly to consumers. Through these acquisitions Nokia became the largest consumer electronics company in the Nordic region during the 1980s. Nokia's mobile phone unit, Mobira, also expanded through global alliances. Together with Tandy Corporation, for example, Nokia established joint ventures in Korea and the United States. Mobile phones were sold under different brand names including the private label brands of dealers (e.g. Radio Shack in the U.S.) and service operators.

During this period, Nokia, still a large conglomerate, consolidated the Finnish telecommunication equipment industry. Through a series of mergers finalized in 1987, Salora, Telefenno, and Televa became parts of Nokia. Salora and units of Suomen Kaapelitehdas ultimately became Nokia Mobile Phones in 1989, and Telefenno and Televa became Nokia Telecommunications (the exchange equipment business) in 1992.

After rapid growth through acquisitions and alliances, however, Nokia ran into a financial crisis. With CEO Kari Kairamo's untimely death in 1988, a new CEO was brought in to try to establish some focus in the company as well as to cut costs. Company employment fell by around 15,000 between 1989 and 1992 (see **Exhibit 2**).

## Finnish Economic Policy in the 1990s

The 1990s began with the most severe crisis the Finnish economy had ever experienced. In 1991, real GDP fell by 6.2%. In 1992, it lost another 3.3%. Exports dropped by 13% in dollar terms in 1991. Unemployment rose from 3.5% in 1990 to 17.9% in 1993.

The Berlin wall had come down in 1989 and the Soviet Union was dissolving. Almost overnight, exports to what had been the most important market for Finnish exports dried up. German reunification and the economic integration of Germany led to an increase in real interest rates throughout Europe. Finland also experienced deteriorating terms-of-trade due to falling world pulp and paper prices, its main export industry. The problems were compounded by domestic economic conditions. In the late 1980s, the Finnish economy had taken on a huge increase in credit due to the liberalized banking sector. Property prices increased sharply and inflation rose. The savings rate fell to 12.1% in 1992, less than half of the 24.9% ten years earlier. As a result of the external shocks and internal overheating, the Finnish exchange rate came under pressure. In November 1991 the Marka was devalued by 12%, and in September 1992 Finland was forced to float its currency and fundamentally revisit its macroeconomic policies.

Tight macroeconomic policies were quickly adopted. The earlier creeping increase in the tax burden was halted, and tax rates stabilized. With wage growth and profits weak during the crisis, tax revenues on these two items as a share of GDP fell from 19.3% in 1990 to 18.1% in 1995. Government expenditures were cut by nearly 10% of GDP, with the aim of achieving budget surpluses by the end of the 1990s compared to a deficit of 7.3% of GDP in 1993. Monetary policy was changed to adopt an inflation target of 2% beginning in 1995. Interest rates were the main policy instrument, initially reaching levels above 13% on 10-year government bonds in 1992 implying an interest rate differential of up to 500 basis points relative to Germany.

Finland's economy began to rebound in 1993 with real GDP growth reaching 4% and staying between 3.8 and 6.3% throughout the rest of the 1990s. Inflation fell continuously from its peak of

almost 7% in 1990 to under 2% from 1993 onwards. Interest rates came down continuously to reach about 6% at the end of 1997, eliminating the differential with Germany. Finland was able to re-establish stable parity to European Union member currencies by 1996.

During the 1990s, the changes in the science and technology policies initiated in the preceding decade were accelerated. While some parts of the budget were severely cut in the 1992 crisis, the government decided to make additional resources available for research and development (see **Table 1**). In 1990, the Science and Technology Policy Council conducted a major review of Finland's economic position that resulted in two reform initiatives. The Center of Expertise Program focused on "strengthening regional competitiveness by increasing innovation, renewing the regional production structure, and creating new jobs in selected expertise areas." The Cluster Program focused on developing the innovative capacity of industrial clusters by supporting cluster-specific R&D efforts. In parallel, the government set up 15 incubators in proximity to regional clusters throughout Finland to make venture capital available for start-up companies.

The cluster approach was introduced in Finland in a study coordinated by the Research Institute of the Finnish Economy (ETLA) in the early 1990s, and outlined in 1993 in the White Paper "A National Industrial Strategy" by the Ministry of Trade and Industry. The central message for policy makers was that all government actions had implications for national competitiveness. Therefore, economic and industrial policies needed to be considered from an extended perspective, beyond the administrative boundaries of sectoral ministries. The cluster model stimulated new forums for interaction and coordination between ministries, public and private research units, and companies. The study further clarified the policy direction first begun in the 1980s in which the role of the government was to create favorable framework conditions, and which emphasized inter-organizational cooperation as well as the accumulation and transfer of know-how. Policies concerning technology, education and competition became center stage of the new Finnish industrial policy.

**Table 1** Finnish Research and Development Expenditure, 1989-1999 (€ millions)

	1989	1991	1993	1995	1997	1998	1999
Enterprises	€924.8	€975.1	€1,048.5	€1,373.4	€1,916.7	€2,252.8	€2,643.9
Public sector <sup>a</sup>	286.1	357.5	379.7	374.4	408.6	443.8	470.1
University sector <sup>b</sup>	290.2	378.0	367.5	424.6	579.5	657.9	764.8
Total	<b>1,501.2</b>	<b>1,710.6</b>	<b>1,795.8</b>	<b>2,172.4</b>	<b>2,904.9</b>	<b>3,354.5</b>	<b>3,878.8</b>
as % of GDP	1.8	2.0	2.2	2.3	2.7	2.9	3.2 <sup>c</sup>
Enterprises	61.6%	57.0%	58.4%	63.2%	66.0%	67.2%	68.2%
Public sector <sup>a</sup>	19.1	20.9	21.1	17.2	14.1	13.2	12.1
University sector <sup>b</sup>	19.3	22.1	20.5	19.6	20.0	19.6	19.7
Total	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>

Source: *Statistics Finland*, Science and technology statistics.

<sup>a</sup>Including private nonprofit sector.

<sup>b</sup>Including central university hospitals since 1997 and polytechnics since 1999.

<sup>c</sup>Preliminary data

The increasing focus on R&D and technology-intensive activities increased the demand for skilled employees. The government reacted by expanding the capacity of higher education. Between 1993-1998, the total intake of students in universities nearly doubled, and in polytechnics it nearly tripled. Despite growing enrollment, however, Finland ranked 14th—well below the OECD average—in expenditures per student at the tertiary level. In early 1998, the government adopted a program to expand education in the information and communication field.

The liberalization of the Finnish capital markets that had begun in the 1980s continued. In 1991, for example, households were allowed to borrow in foreign currency. Greater rivalry in the domestic banking market and easier access to foreign capital reshaped the traditionally tight relations between companies and their banks. In 1993, restrictions on foreign ownership of Finnish firms were removed. Venture capitalists emerged during the 1990s, stimulated in part by government-sponsored incubators. Successful business plans at the turn of the 21<sup>st</sup> century attracted increasing amounts of venture capital, which had emerged as the most common source of capital for start-ups. Investors were becoming more specialized due to the increased number of funds and investment companies. The availability of venture capital reshaped the role of public funding, traditionally the prime source of capital for risky enterprises. New kinds of investment syndicates were established where the public sector invested alongside venture capitalists.

In 1994, the policy-making powers of the regions within Finland were significantly strengthened through the Regional Development Act. Regions were encouraged to develop their own economic development activities and integrate the “Center’s of Excellence” concept developed as part of the new technology policy.

The attitude towards competition shifted in favor of more intense rivalry. However, mark-ups in many Finnish industries still remained above the levels of the United States and other European countries. The centralized wage setting mechanisms between unions and employer organizations also persisted.

In 1993, Finland joined the European Economic Area (EEA); a decision that eliminated many trade and investment barriers to other Nordic and European countries. Germany, Sweden, and the United Kingdom became Finland’s most important export markets. The United States doubled its share of Finnish exports, while the Russian share fell to 4.5%.

In 1995, Finland became a member of the European Union, entering together with its neighbor Sweden. Though this meant Finland had to leave EFTA, EU membership brought further integration into the European Common Market, and the harmonization of many laws and regulations with the other EU countries. With the opening towards the west, the Finnish economy attracted significant amounts of inward FDI. Large mergers between Swedish and Finnish firms in banking (Nordea), engineering (ABB), electronics (Nokia) and pulp and paper (Stora-Enso, UPM-Kymmene) created larger and more focused Finnish firms with global reach. In 1998, Swedish firms accounted for 50% of FDI in Finland, while 34% of Finnish FDI took place in Sweden. In 1985, the stock of Finnish inward and outward foreign direct investment had been 1.3% and 1.8% of GDP respectively. In 1998, these ratios had increased to 18.3% and 33.8%.

The transformation of Finnish industry could also be seen in the composition of the economy: In 1999, electronics and telecommunications equipment had become the leading sector, accounting for 21% of value added, followed by pulp and paper (15%), chemicals (10%), and machinery and equipment (9.5%). The pulp and paper cluster remained a leader in global markets together with a broad array of companies in specialized machinery manufacturers and services. In 1999, pulp and paper and electronics products each accounted for about 30% of exports. Engineered metal products accounted for another 20%.



In the second half of the 1990s, Finland's average GDP growth moved to about 5%, with Nokia's growth alone contributing close to 1% to the national growth rate. Unemployment rates came down but remained above 10% throughout the 1990s. In 1999, youth unemployment was above 20%, higher than in other European countries and still more than twice as high as ten years earlier.

### *Finnish Telecommunications Policy in the 1990s*

The Finnish telecommunications sector was subject to standard competition and consumer protection legislation. Telecommunications regulators pursued a policy of minimum interference, acting mainly in cases of insufficient competition, which was different from most other OECD countries. Some mandatory EU requirements had been enforced in Finland rather reluctantly, as they were considered to go against the liberal functioning of markets.

In 1987, a new Telecommunications Services Act had separated the regulatory and operator functions of the PTT, transferring regulatory authority from the PTT to an independent body under the Ministry of Transport and Communications. The Act also established the right of private companies to offer mobile communication network services. This legislation ended a long dispute over the PTTs monopoly rights that dated back to the 1960s.<sup>1</sup> In 1991, privately-owned Radiolinja was the first operator in the world to launch a commercial GSM network.

Liberalization had meant fundamental organizational changes for the PTT, which was turned into a private, publicly listed company. The PTT began to improve service and worked hard to launch its GSM service soon after Radiolinja, becoming one of the first PTTs in Europe to do so. The government started reducing its ownership in the PTT and indicated further privatization. In 1998, the name of the company was changed to Sonera to reflect a new strategic focus on fixed, mobile and media services.

At the end of the 1990s, government was mandated by parliament to withdraw from the telecommunications business. These intentions were later frustrated by Sonera's large expenditures on UMTS licenses in Europe which created large borrowings. In 2001, the Government decided to bail out the company by infusing new equity, which was inconsistent with the government's stated policy of limiting intervention. However, the Finnish government decided not to engage in direct, high-speed network capacity investments despite the political goal of providing leading infrastructure. This decision, different from neighboring Sweden and more in line with the United Kingdom and other continental European countries, was made to insure technology neutrality and the free functioning of the market. In line with the same liberal policy principles, Finland granted third-generation mobile network licenses without restricting the choice of standards.

## **The International Mobile Telecommunications Sector**

The mobile telecommunications sector grew out of the combination of radiophone technology with wired telephone systems. The basic technology of so-called cellular systems had been developed in the 1950s in the United States. With the exception of small city systems in some parts of the world, however, cellular or mobile telephony did not develop as a market until the early 1980s.

By 2001, over 500 million mobile phones were sold worldwide. Mobile telecom manufacturing was divided into two parts: mobile communication infrastructure and mobile handsets (often called cellular phones in the United States. See the **Appendix**). Each part had different competitive

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<sup>1</sup> The operative Imperial Telephone Decree of 1886 did not provide an unambiguous interpretation of the statutory rights to provide novel network services, such as data transfer, telefax and teletext.

characteristics, though the big three, Motorola, Ericsson (including Sony Ericsson) and Nokia were all active in both infrastructure and handsets in 2001.

The use of mobile phones was highest in the Nordic countries, with penetration rates of over 70% in 2000. Italy and Austria also had penetration rates above 70%, whereas most other European countries were around 60%. Japan had a penetration rate of about 50%, the United States 40%, and South East Asia around 10%.

### *Evolving Standards*

In 1986, there were mobile networks in 32 countries, most of which were incompatible across national borders. By 2001, mobile service had spread to over 150 countries and an emerging global standard had begun to be installed across the most advanced nations. This third generation system, referred to as UMTS, integrated voice and high-speed data communication (See Table 2).

First generation systems in the 1980s were analog and incompatible. In Europe alone, there were six systems: NMT, Comvik, TACS, Radiocom 2000, C-450, and RTMS. The leading system was the Nordic NMT system, the only one offering international compatibility (first throughout the Nordic region, and in 1988, in Switzerland and the Benelux region). Comvik was used in Sweden in parallel to the PTT-controlled NMT system. The TACS system from the United States was brought to Ireland and the U.K. in 1985. The Radiocom 2000 system was developed by Matra and used only in France. The C-450 system was developed by Siemens for the German market, and adopted by Portugal. The Italian RTMS system was introduced in Italy in 1985. In the United States, several competing systems and standards evolved that covered limited areas of the nation, and were also adopted in Latin America.

Second generation systems involved a shift to digital technology, and were introduced earlier in Europe than in the United States. Digital technology provided major benefits in terms of operating costs, system capacity and enhanced service offerings to customers. The Nordic Conference in 1982 played an active role in initiating the pan-European digital mobile network, or GSM system (an alternative standard proposed by German and French interests was later withdrawn). GSM was launched in 1990 and covered all of Europe, later spreading to Asia and the United States. A GSM group had been formed to secure Europe against Japanese competition and involved cooperation through alliances. For example, Nokia-Mobira developed systems and handsets together with AEG and Alcatel, and had an alliance for processor chip development together with AT&T. Motorola was also active in GSM technology, with a focus on Europe.

In the United States, two digital standards emerged, TDMA and CDMA. In the late 1990s, a number of GSM systems were established offering the ability to use a single phone in Europe and the United States. Qualcomm's Code Division Multiple Access (CDMA) followed a restrictive licensing strategy. Nokia decided not to license the technology and developed its own CDMA phone. In March of 1999, Qualcomm sold its manufacturing operations to Ericsson after a long patent fight. TDMA was championed by AT&T Wireless, Bell South, and Southwestern Bell Mobile. In 2000, GSM had 69% of digital subscribers worldwide, CDMA 13%, TDMA 10% and the Japanese system PDC 8%.

**Table 2** Mobile Telecommunication Standards

	First Generation	Second Generation	Third Generation
<b>Application</b>	National/local systems Portable phones Car phones	Regional systems Pocket phones Digital voice services Digital text: SMS (short message service) First-generation WAP	Global system Integrated high-quality audio and data Music and video Narrowband and broadband Multimedia services
<b>Type of System</b>	Analog cellular technology Macro-cellular systems	Digital cellular technology Micro-cellular and pico-cellular Enhanced cordless technology	Digital broadband Information compression Higher frequency spectrum IP packet switching
<b>Standards</b>	AMPS, ETACS, NMT 450, NMT 900, TACS, Radiocom 2000, C-450, RTMS, Comvik	GSM, CDMA, TDMA, PDC, GPRS	WCDMA, CDMA 2000, TDMA 136, UMTS

Source: Case writer.

There was fierce competition over third-generation standards. GPRS, sometimes referred to as the 2-1/2 generation system, had been developed in Europe to maintain momentum. The emerging leader in 3G systems was the European WCDMA. Together with Qualcomm's new CDMA 2000 and the leading Japanese companies, WCDMA formed a "global family" allowing phones to be used all over the world. American proponents of the TDMA system also introduced a third generation system under the name of TDMA 136. The transition to the third generation system was slow and in 2001/2002 investment plans were delayed in most countries with Japan and Korea being the first movers.

Mobile telecommunication systems had initially been separate from the Internet. The first standard allowing access to certain Internet services was the Wireless Application Protocol (WAP), introduced on high-end phones in the late 1990s. With increased bandwidth in third-generation systems, mobile Internet was emerging.

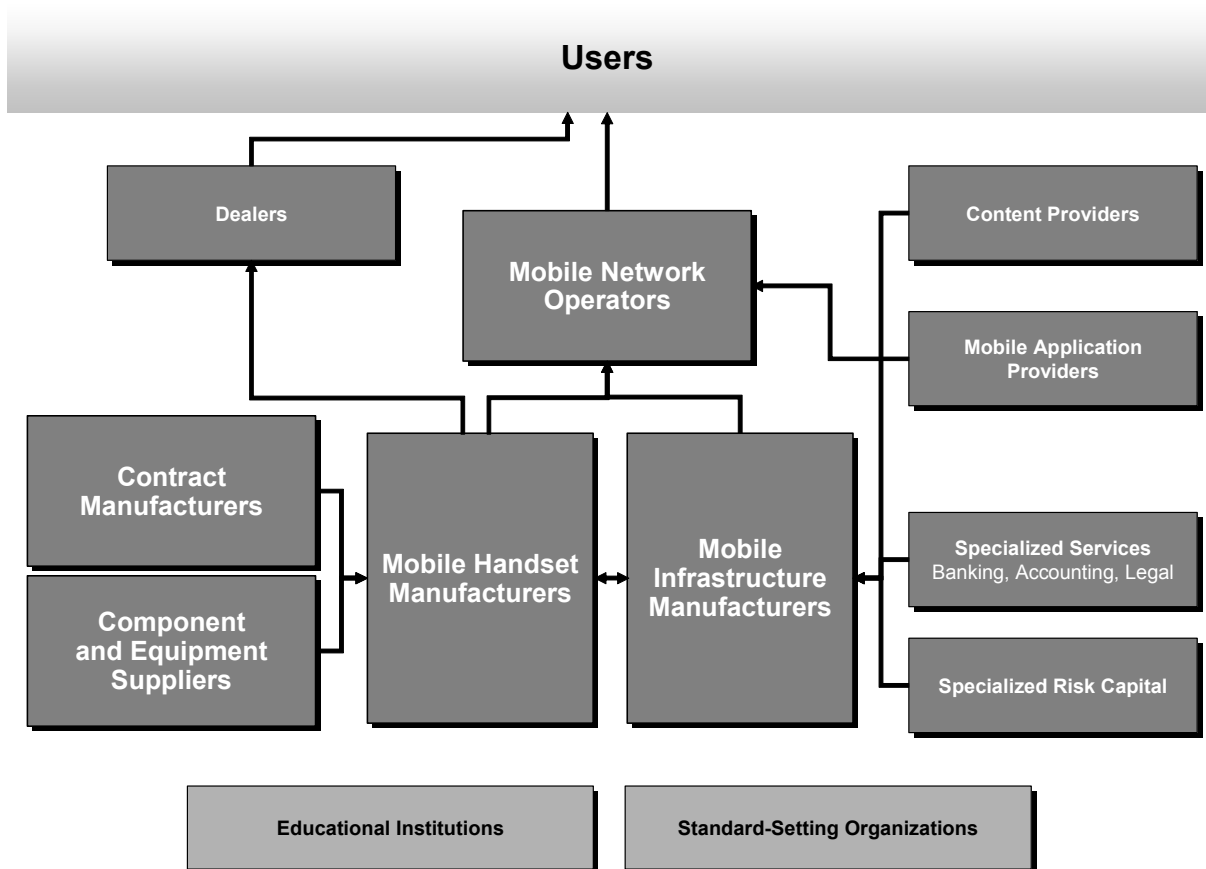
### *The Mobile Communications Value System*

Mobile service was provided by network operators (Figure 1). Once a monopoly in many countries, mobile service providers faced fierce competition in 2001. Three or more mobile operators typically competed in each local market. Verizon Wireless was the largest mobile operator in the United States in 2001 with some 30 million subscribers. Operators had internationalized, and a few global firms or "families" of firms had emerged.

Operators had begun to segment their services to cater to the differing usage needs of business and residential customers. Handset manufacturers had also begun developing handsets focused on segments.

The growth of fixed-line systems was slowing in advanced countries, and the paging market had recently begun to slow as well. Leading paging manufacturers such as Motorola and Glenayre in the United States were adding more functionality to paging with two-way paging and voice paging. Satellite phones were a long-term threat to mobile phones, but remained expensive and bulky in 2001.

**Figure 1** The Mobile Phone Value System



Source: Case writer.

Mobile telephone equipment could be divided into infrastructure and handsets; each accounting for about one half of the total manufacturing market. Infrastructure, consisting of base stations and switching equipment, was produced by major telecommunications manufacturers such as Ericsson, Motorola, and Nokia. Handsets, or mobile phones, were manufactured by many new companies, especially as standards became more established.

As the mobile communications industry emerged in the 1980s, two companies became leaders: Motorola from the United States and Nokia-Mobira from Finland (see **Table 3**). Suppliers of first generation analog infrastructure (such as Ericsson, Siemens, Philips, Alcatel, NEC) also developed proprietary phones for their own systems, and some also manufactured phones for open systems

such as NMT. Rapid industry growth attracted new handset competitors, many with a background in consumer electronics (such as Samsung, Panasonic, Mitsubishi, Sony). Ericsson and Samsung gained substantial market share in the 1990s, while NEC, Mitsubishi and Toshiba were the losers. In 2002 positions had shifted considerably with Sony-Ericsson (the two companies merged their handset businesses in 2000) far behind Nokia, Motorola, Samsung and Siemens.

Mobile handsets were sold through service operators as well as through independent dealers. Some operators sold phones directly to consumers (sometimes branding the phone themselves or jointly with the OEM), while others concentrated exclusively on subsidized sales of phones through independent dealers, with which they typically had exclusive relationships.

The components for mobile phones included the casing, LCD, circuits, battery, and antenna. Phone manufacturers made some parts themselves but contracted many components from outside suppliers. Some phone manufacturers such as Motorola, Nokia and Samsung had integrated backwards into semiconductors in an attempt to reduce costs and help shorten new product development cycles. In addition, software constituted an increasingly important part of the value of a phone.

**Table 3** World Market Shares of Leading Mobile Equipment Competitors

Company	Home Base	Mobile Phones		Infrastructure
		1988	2000	1999
Nokia	Finland	14%	31%	10%
Motorola	United States	13	15	13
Ericsson	Sweden	3	10	30
Samsung	Korea	--	6	--
Siemens	Germany	2	6	6
Panasonic	Japan	9	5	--
Alcatel	France	6	5	3
Philips	Netherlands	3	3	--
Sage	France	--	3	--
NEC	Japan	12	3	7
Mitsubishi	Japan	8	2	--
Qualcomm	United States	--	2	--
Toshiba	Japan	8	2	--
LG	Korea	--	1	--
Lucent	United States	--	--	11
Nortel	Canada	--	--	9
Fujitsu	Japan	--	--	2
OKI	Japan	6	--	--
Others		16	6	9

Source: "Nokia-Mobira OY," Harvard Business School case No. 589-112; Gardner Dataquest.

Note: -- = not active or less than 1% share.

### *Competition*

All mobile phone manufacturers were facing intense competition in 2001. Growth rates in major consumer markets were slowing, and incumbents together with new entrants from the consumer electronics industry had production capacity that outstripped market demand. Phone companies,

were also under financial pressure and less willing to subsidize phones in order to stimulate demand. The three leading competitors in 2001 were Nokia, Motorola, and SonyEricsson.

**Motorola** Based in the United States, Motorola had long been a leader in two-way radios, paging, mobile phone handsets and mobile infrastructure. Founded by Paul V. Galvin, Motorola successfully commercialized car radios under the brand name "Motorola" in the 1930s. In the 1960s, the company became a leader in military, space and commercial communications, as well as semiconductors and consumer electronics. It also began expanding into international markets.

After divesting its consumer electronics business, Motorola had, by the end of the 1980s, become the leading worldwide supplier of mobile phones and mobile infrastructure. In the 1990s Motorola invested several hundred million dollars in a new satellite phone system, the Iridium, which did not grow as expected.

Motorola's small and light mobile phones had garnered a strong following. In 1989, the MicroTAC phone was the smallest and lightest phone in the market. In 1996 the 3.1-ounce StarTAC was introduced. The company controlled almost 25% of the world market in the 1990s. However, Motorola was slow to shift from analog to digital phones, and lost its leadership position in the late 1990s. In 2001, Motorola held the number two spot in both mobile networks (13%) and phones (15%). The company was vertically integrated into semiconductors and other components.

**Ericsson** Founded as a telegraph repair shop in 1876 by Lars Magnus Ericsson, Ericsson copied the newly invented Bell telephone which had not been patented by Bell in Sweden. When Bell entered the Swedish market in 1880, a spirited rivalry began. Ericsson introduced the first half-automatic switch in 1883. Because the Swedish PTT began to manufacture its own telephone equipment, Ericsson turned to international markets in the late 19<sup>th</sup> century. Ericsson had manufacturing operations in Russia and sales subsidiaries in China and Mexico as early as the 1890s. Ericsson had entered the radio industry in 1919. By 2001, Ericsson served over 130 markets worldwide.

In 1977, when NMT specifications were issued, Ericsson developed a mobile phone and exchange infrastructure. The mobile handset business was seen as peripheral and Ericsson considered selling the division several times. Throughout the 1980s and 1990s, Ericsson became a world leader in network technologies, especially in digital switches, for both mobile and fixed-line telecommunication systems. Ericsson was known for its strong focus on technology, and invested 16% of revenues in R&D.

In 2000 and 2001, Ericsson sold off or closed a large number of units, concentrating on mobile telecom infrastructure where it was considered the world leader. In handsets, market share fell from 15% in 1998 to less than 10% a few years later. In 2000, Ericsson and Sony decided to join forces, establishing a 50/50-owned company, SonyEricsson, headquartered in London. As 3<sup>rd</sup> generation mobile systems were implemented beginning in the Japanese market, Ericsson had taken a lead with over 40% of the worldwide infrastructure market.

**Exhibit 3** presents comparative data sales, profitability, and employment for the major manufacturers throughout the 1990s.

### *The Finnish Telecommunications Cluster in 2001*

Finns had been early adopters of mobile phones. As Nokia became an international success story, Finns came to see the mobile phone as a "national symbol." Finland was among the world leaders in mobile penetration. By 1998 mobile subscribers outnumbered wired subscribers, and 20% of households had cancelled fixed line service and relied solely on mobile communications.

Finland had also been early to adopt the Internet in the late 1980s, led by students. The world's first graphic-based Internet browser was developed in an IT class at the Helsinki University of Technology in 1992, a year before Mosaic and Netscape. The students were not interested in commercializing the software, but other Finnish students, Tatu Ylönen (SSH encryption program) and Linus Torvalds (Linux operating system) went on to become legends in their own time. Finland ranked number one in the rate of Internet host penetration by 1999. A rapid increase in ISDN subscriptions, due to growing Internet penetration, was driving renewed demand for fixed line services in Finland.

From a modest base in the 1960s and 1970s, the Finnish telecommunications cluster began to emerge in earnest in the 1990s. By 2000, the cluster employed some 83,000 people (just under 4% of national employment) in over 4,000 firms, representing 6.9% of GDP (see **Table 4**). The total value of shipments was EUR 21.4 billion, with manufacturing of equipment and electronic components representing 70% of revenues. The cluster had grown at an average annual rate of 20% (manufacturing 32% and services 12%). See **Table 4**.

**Table 4** Key Economic Indicators of the Finnish Telecommunications Cluster (2000)

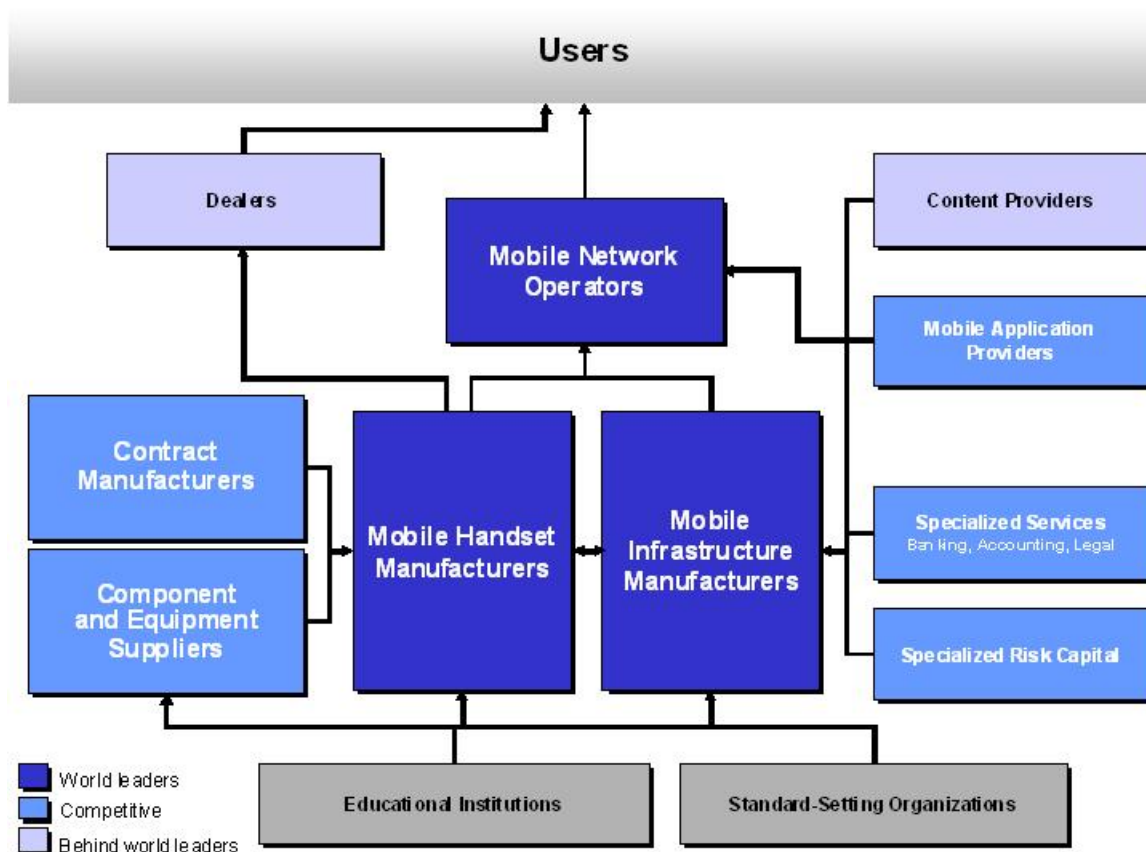
	Telecom Services							
	Telecom Manufacturing		Telecom Services				Cluster Total	
	EUR Million	Share of Production	EUR Million	Share of Production	EUR Million	Share of Production	EUR Million	Share of Production
Revenues	14,805		3,678		2,947		21,431	
Exports	12,125	82%	118	3%	1,009	34%	13,252	62%
Imports	4,185	28%	151	4%	605	21%	4,941	23%
No. of firms	414		216		3,463		4,093	
No. of employees	38,385		19,294		25,284		82,963	

Source: Adapted from L. Paija (ed), "Finnish ICT Cluster in the Digital Economy," Helsinki: ETLA—the Research Institute of the Finnish Economy).

Note: Small amounts of non-telecom IT software and services are included in the figures.

**Operators** In 2001, there were over 100 telecommunications operators in Finland, though most of them utilized leased network capacity. Sonera (formerly Telecom Finland) and the Finnet Group (the renamed Association of Telephone Companies) together held 95% of fixed line revenue. Sonera had restructured during the 1990s and upgraded employee skill levels. In mobile services, Sonera's main competitor was Radiolinja, owned by the largest private operator Elisa Communications. Swedish Telia had not succeeded in capturing any significant share of the Finnish market since its entry in 1997. The fourth mobile operator, DNA Finland, was launched in early 2001 by a group of private investors. Finland granted licenses for 3<sup>rd</sup> generation systems (called UMTS) to all four GSM operators on March 16, 1999, the first country in the world to do so.

**Content providers** There were over 300 Finnish companies engaged in the provision of digital content, including media, services (e.g., banks and travel agencies) and Internet portals. An expanding number of services were targeted at professional groups (e.g., in health care and education). Nokia offered tools and support for entertainment service providers in an open virtual forum. The National Technology Agency, Tekes, had assumed the role of a facilitator in the emerging digital media industry, and facilitated interaction between firms, venture capitalists, universities, and research institutes.

**Figure 2** The Finnish Mobile Telecommunications Cluster

Source: Case writer

**Equipment manufacturers** Nokia was the dominant equipment manufacturer in Finland, producing both handsets and infrastructure. There were also other manufacturers such as Benefon, a company founded by ex-Nokia managers. Much of Nokia's manufacturing was also outsourced to contract manufacturers such as Elcoteq.

**Suppliers** A large number of specialized suppliers and contract manufacturers had emerged in Finland, in part driven by the growth of Nokia. Finnish suppliers tended to produce highly customized inputs for mobile (e.g. ASIC, rf filters, customized circuit boards, hybrid circuits), while standard components were imported. Other Finnish companies specialized in process technologies such as surface mounting, robots, and precision moulding equipment for telecom use. Increased outsourcing was coupled with extensive cooperation and long-term commitments between manufacturers and suppliers. Increased technological complexity and shortening product life cycles had pushed firms to closer interaction and risk sharing. Finnish suppliers such as Perlos Ltd, Eimo Ltd and Elcoteq Networks Ltd followed Nokia by establishing or acquiring manufacturing units in such countries as China and the United States.

**Equity capital** A venture capital market had emerged as a new and important source of funding in the 1990s. In 1999, EUR 285 million of venture capital was invested in new Finnish companies. A Finnish Venture Capital Association had been formed, which included 36 members in 2001. Some 30% of all venture capital in Finland was directed towards telecommunications.



In part due to Nokia, investors and venture capitalists from around the world sought out other leading-edge technology companies in Finland. As a consequence, a number of small Finnish high-tech companies had obtained financing from abroad. The majority of the capital raised in recent private placements in companies such as Solid, Digia, Riot, AVS and LPG came from international venture capitalists. Most of the money went to first or second round investments, rather than seed stage financing. Since the early 1990s, a growing number of foreign portfolio investors had added Nokia to their portfolios. In 1993, Nokia's foreign ownership was 46%, and by July 2001 the foreign share had reached 90%. Nokia's share of the total market capitalization of the Helsinki Stock Exchange (HEX) peaked at 71% in November 2000. Although Nokia was listed in a number of markets, Helsinki had retained its position as the most important place to trade Nokia shares.

**Education and research** There were 12 colleges and universities in Finland providing education and conducting research in information technology and telecommunications. One of these, the University of Oulu in a remote area of northern Finland, had decided to concentrate on telecommunications and ICT as early as the 1960s. Nokia's main R&D center was located in Oulu, and there was close collaboration with university researchers. Overall, Finland was recognized as a location for highly skilled IT professionals.

Investment in IT and telecommunications-related R&D had risen substantially, mostly driven by a huge increase in private sector R&D. University and other public-sector R&D also increased substantially in absolute terms, but not as rapidly as investments by companies. Increased R&D led to an average annual growth rate in patenting in these fields of 42% between 1992 and 1998. Almost 30% of the United States patents granted to Finnish inventors were in IT and communications. During the 1990s, a number of international companies such as ICL, IBM, Siemens, Hewlett Packard and Ericsson had established R&D activities in Finland. Nokia conducted close to 60% of its research in Finland, and accounted for approximately 45% of all private R&D expenditure in the country.

## Nokia in 2001

Nokia's sales were EUR 30.4 billion in 2000, with an operating profit of EUR 5.8 billion, generating an above average margin for the industry. The company employed 60,289 people, 24,000 of whom were located in Finland. The company had production locations in 10 countries, R&D in 15 countries, and sales in over 130 countries.

Nokia had weathered a crisis in the late 1980s as the company tried to cope with growth and diversity. A new CEO had cut employment, but Nokia registered a large loss in 1992. The crisis was so severe that Nokia's owners considered selling the company to Ericsson. Jorma Olilla, 41, became CEO in 1992. New capital was raised through a private placement in the United States in 1993, and Nokia was listed on the New York Stock Exchange the following year. In 1994, Olilla got board approved to divest all of Nokia's businesses outside of telecommunications.

Olilla and his team also began to build a new culture. The four fundamental values of Nokia, the "Nokia Way", were introduced in 1992: customer satisfaction, respect for the individual, achievement, and continuous learning. Nokia's strong culture, shared especially among the Finnish management team, substituted for detailed systems when the company entered new geographies. Nokia was seen as mirroring the Finnish national character: pragmatic, honest, quiet, and serious. The business press often referred to Nokia as "non-political" and as an informal organization built on trust.

In 2001, Nokia was organized into three business groups: Nokia Networks (GSM and 3d generation mobile systems), Nokia Mobile Phones, and Nokia Ventures. Mobile phones accounted for

72% of revenues in 2000, and was the most profitable of the three groups. It sold phones for every standard and in just about every market in the world. Nokia Networks accounted for 25% of revenue in 2000. Nokia Ventures, founded in 1998 to search for new business opportunities, accounted for 3%.

In the early 1990s, Nokia controlled about 12% of the global market for handsets, with a goal of 25%. The new sleek Nokia 2100 phone was designed by Los Angeles freelance designer Frank Nuovo (who later became head designer for Nokia). The new phone offered a larger screen and a scrolling menu that later became the industry standard. The Nokia 2100 was Nokia's first consumer-targeted model and was launched in 1994, selling 20 million units compared to a goal of 400,000. Nokia would go on to define a mobile phone as a fashion item and consumer good, instead of a technology product. Nokia's strategy was to serve distinct customer segments with differing needs using technology compatible to whatever standard was utilized in a particular regional market.

In the 1990s Nokia became the world leader in digital phones with a market share of 31% in 2000. The company offered the widest line of phones, covering every segment of the market, and had the broadest geographical coverage. In 1998 Nokia announced that "mobile Internet" was to be the future guiding star of the company. Foreign sales accounted for 98% of revenue in 2000, up from 70% in 1990. In 2001, Nokia had a total of 19 manufacturing facilities in ten countries. Nokia Networks had five plants in Finland, five plants in China and one in Malaysia. Nokia Mobile Phones had production units in eight countries. See **Table 5**.

**Table 5** Nokia's Operations in Different Countries (2000)

R&D Units	Production Facilities	Listings on Stock Exchanges
Finland	Finland	Finland
Germany	Germany	Germany
United States	United States	United States
Hungary	Hungary	Sweden
China	China	U.K.
Malaysia	Malaysia	France
South Korea	South Korea	
Australia	Brazil	
United Kingdom	Mexico	
Japan		
Italy		
Canada		
Sweden		
Denmark		

Source: Case writer.

Nokia had R&D units located in 14 different countries, although somewhat over half of total R&D activities were located in Finland. R&D facilities were typically located close to leading universities and research centers. At the end of the 1990s, Nokia spent close to 9% of its revenues on R&D, up from 6% in the first half of the 1990s.

In the 1980s, Nokia had used subcontractors mainly as buffers to stabilize its manufacturing capacity. In the 1990s Nokia turned to outsourcing through long-term cooperation agreements. In the latter part of the 1990s, cooperation was gradually expanded from accessories to other components.

Nokia also reorganized its supply chain to include contract manufacturers. Furthermore, Nokia began to contract for some software development and R&D. Some of Nokia's partners and subcontractors began international operations, including exports and production abroad not only to Nokia's foreign units but also to other customers. The outsourcing activities of Nokia had created some public concerns that manufacturing operations would shift to low-cost countries in Eastern Europe and Asia.

One of the main challenges facing Nokia in 2001 was the evolution of standards. New standards for 3<sup>rd</sup> generation systems were being developed in mobile Internet services as well as software and hardware for phones and infrastructure. Personal digital assistants (PDA), electronic organizers, palmtops, and small-screen handsets were proliferating. A large number of firms and standards were competing, many of which sought enhanced mobility. For example, Microsoft had developed Stinger software and Palm had its own system. Nokia had licensed parts of its phone software and components to other handset manufacturers to encourage the adoption of its standard globally. In November 2001, Nokia announced it would license the source code for its mobile Internet browser and advanced text messaging technology to Samsung in Korea.

Together with Ericsson, Motorola and Phone.com (a small U.S. company), Nokia had established the WAP (Wireless Application Protocol) Forum. By 2000, there were over 200 members. Nokia introduced the first WAP phone in 1999, though the early products encountered some technical problems. In Japan, the i-mode system led by NTT had attracted large demand with millions of users.

Together with Sony, Ericsson (who invented the technology in 1994), Microsoft, IBM, Intel and others, Nokia had also developed Bluetooth, a standard used for short-range (under 30 feet) wireless connectivity. The main competing standard was called WiFi. Bluetooth chips used far less power than WiFi devices and were much cheaper, though WiFi offered a much higher bandwidth.

Research efforts were geared at developing "smart" mobile phones with multimedia messaging, connections to the Internet, and the possibility of downloading information from Web sites. Here Nokia was pushing the Symbian operating system used by more than 70% of the mobile phone market. Motorola, Sony Ericsson, Psion, (a U.K. based manufacturer of PDAs), and Japan's Matsushita were Nokia's partners in this effort.

## Finland in 2001

While Finland had maintained its ranking as a leading competitive nation in 2001, the nation was facing challenges. Overall growth rates were declining, and major export markets appeared weak. The telecommunications cluster especially was experiencing a severe downturn, and Nokia had seen its revenue and profits fall. Given the large role of Nokia and the cluster in Finland's economy, concerns about the level of exposure to one company and one cluster were becoming louder.

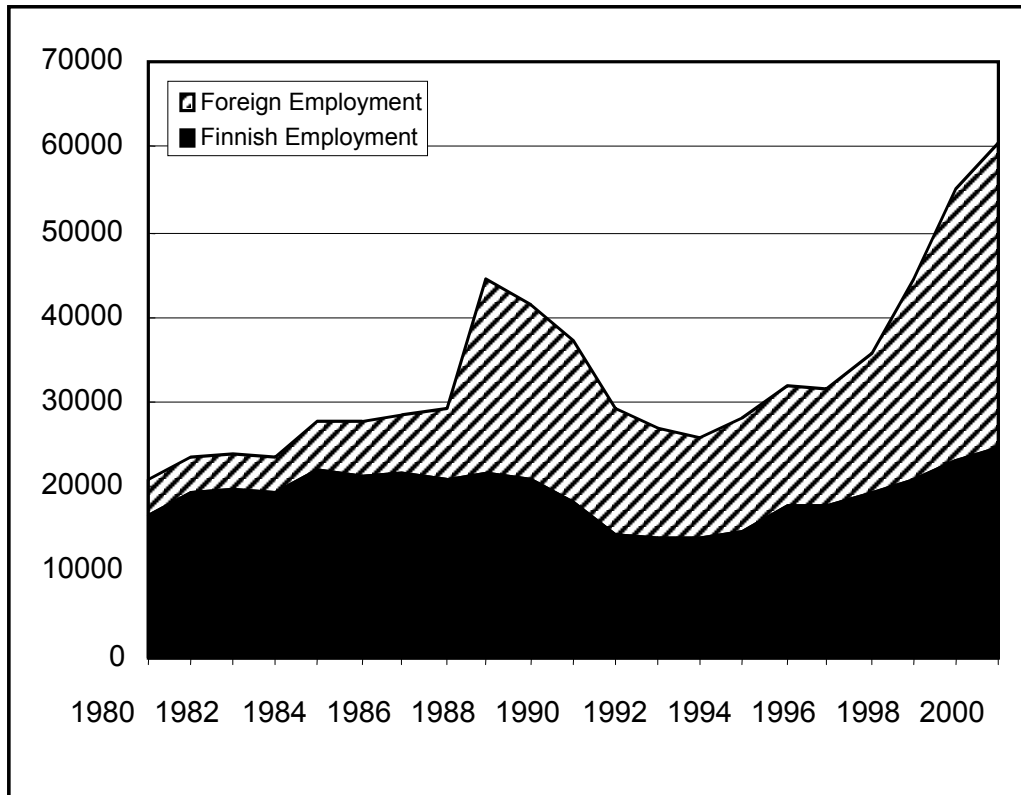
Finland was also facing shortages of skilled engineers and scientists. As demand for skilled labor was expected to increase, some universities had started offering programs tailored for foreign students to attract people to Finland. At the same time as IT jobs went begging, however, there was increasing unemployment, especially among the young and the low skilled. The differences in prosperity was creating strains on the traditionally egalitarian Finnish society.

**Exhibit 1** Government Ownership Stakes in the Top 25 Finnish Companies, 2000

<b>Sales Rank</b>	<b>Company</b>	<b>Industry</b>	<b>Government Share (%)</b>
1	Nokia	Electronics	--
2	Stora Enso*	Forestry	15.1
3	Fortum	Energy	70.7
4	UPM-Kymmene	Forestry	--
5	<u>Metsäliitto</u>	Forestry	--
6	Kesko	Wholesale trade	--
7	Sampo	Finance	40.2
8	Pohjola	Finance	--
9	Nordea*	Finance	--
10	Metso	Mining / Metals	11.6
11	Varma-Sampo	Finance	--
12	Outokumpu	Mining / Metals	40.0
13	Ilmarinen	Finance	--
14	Tamro	Pharmaceuticals trade	--
15	Huhtamäki	Food	--
16	SOK	Retail	--
17	Rautaruukki	Mining / Metals	40.1
18	Wärtsilä	Machinery / Shipyards	--
19	Kone	Machinery / Shipyards	--
20	Partek	Mining / Metals	30.2
21	Kemira	Chemicals/ Plastics	56.2
22	Elcoteq Network	Electronics	--
23	Merita Henkivakuutus	Finance	--
24	Ahlström	Forestry	--
25	Sonera	Telecommunication	52.8

Source: Talouselämä, Finland's Top500 Companies, 2000.

Note: \* indicates companies with broad Nordic Ownership. -- = 0% or not applicable.

**Exhibit 2** Nokia Employment, 1980-2001

Source: L. Paija (ed), "Finnish ICT Cluster in the Digital Economy," Helsinki: ETLA—the Research Institute of the Finnish Economy and Taloustieto Oy, 2001.

**Exhibit 3** Financial overview, major mobile telecommunication manufacturers

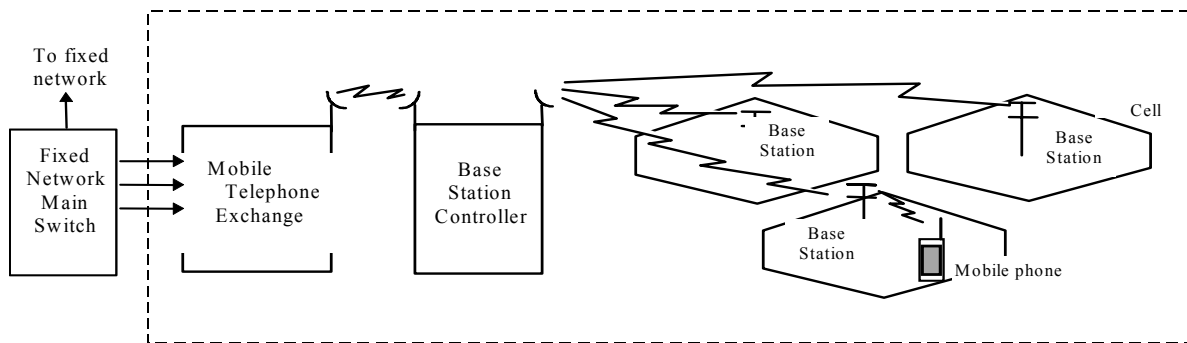
	1992	1993	1994	1995	1996	1997	1998	1999	2000
<b>Nokia</b>									
Sales (\$ mil)	3,451	4,079	6,368	8,400	8,446	9,702	15,553	19,954	28,608
Net Income (\$ mil)	(78)	132	632	509	745	1,154	2,043	2,601	3,709
Net Income (%)	(2.3)	3.2	9.9	6.1	8.8	11.9	13.1	13.0	13.0
Employees	26,700	25,800	28,600	31,948	31,723	36,647	44,543	51,777	60,000
<b>Ericsson</b>									
Sales (\$ mil)	6,644	7,622	11,342	14,902	18,291	21,219	22,760	25,267	29,026
Net Income (\$ mil)	68	340	531	813	1,033	1,511	1,609	1,423	2,230
Net Income (%)	1.0	4.5	4.7	5.5	5.6	7.1	7.1	5.6	7.7
Employees	66,232	69,597	76,144	84,513	93,949	100,774	103,667	103,290	105,129
<b>Motorola</b>									
Sales (\$ mil)	13,303	16,963	22,245	27,037	27,973	29,794	29,398	30,931	37,580
Net Income (\$ mil)	453	1,022	1,560	1,781	1,154	1,180	(962)	817	1,318
Net Income (%)	3.4	6.0	7.0	6.6	4.1	4.0	(3.3)	2.6	3.5
Employees	107,000	120,000	132,000	142,000	139,000	150,000	133,000	121,000	147,000

Source: Adapted from Hoover's, Inc.

Note: Motorola figures include a number of business units outside the mobile telecommunications sector.

## Appendix

### A Schematic View of a Mobile (Cellular) Network



The base station controller coordinates calls among the base stations; it controls and routes calls back to the main switch for routing to other base station controllers or the fixed line system depending on the call. The base station controller is also connected to the base station via fixed line or microwave. The base station covers a certain geographic area, which is called a cell. Base stations are strategically located so as to overlap and connect geographically to surrounding base stations. The combination of these base stations or cells is the overall coverage area of the cellular network. The base station connects to handsets, i.e. mobile phones, via radio signals. These radio signals have traditionally been transmitted using analog coding technology (e.g., AMPS, ETACS, NMT) but are now using digital technology (e.g. GSM, GPRS, TDMA, CDMA and WCDMA) for cost and capacity reasons.

The cellular network broadly consists of base stations (cells), a base station controller, and a mobile telephone exchange (MTX). The cellular concept was developed by Bell laboratories in the United States in the 1950s. The MTX is the central coordinator (similar to the CPU in a computer) in the cellular network and gateway to the fixed wire-line system. As the central coordinator, the main switch coordinates/routes calls within the cellular network and externally to the fixed line system. The cellular network customer database and call information reside in the main switch. The MTX connects to the base station controller either via fixed line or microwave. Traditional manufacturers of telephone exchanges for fixed networks, such as Ericsson, had developed the MTX technology based on their expertise in building large-scale switching systems.