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KULICKE AND SOFFA INDUSTRIES, INC.: DESIGNING A SUPPLY CHAIN NETWORK

Accustomed to effectively conducting business on a global scale, Shay Torton, a general manager with Kulicke and Soffa Industries, Inc. (K&S), was excited yet guarded about the scope and speed of the firm's plans to expand its capillary production facilities. The company designed, manufactured, marketed, serviced, and upgraded wire bonding equipment and consumable tools used to assemble semiconductors. Torton was deeply familiar with all the processes involving capillaries; he started as a planner with the company in 1991, became a capillaries manufacturing manager, and relocated to Alabama and then to Singapore. Working in the semiconductor equipment industry required adapting quickly to evolving conditions, and Torton was sure that significant growth opportunities existed now—in spring 2000. Several K&S competitors had begun to set up shop in China and the Asia-Pacific region, customers were moving to Asia, and markets were opening up. Another K&S plant would reduce the supply risk associated with holding the largest worldwide market share of wire bonding tools.

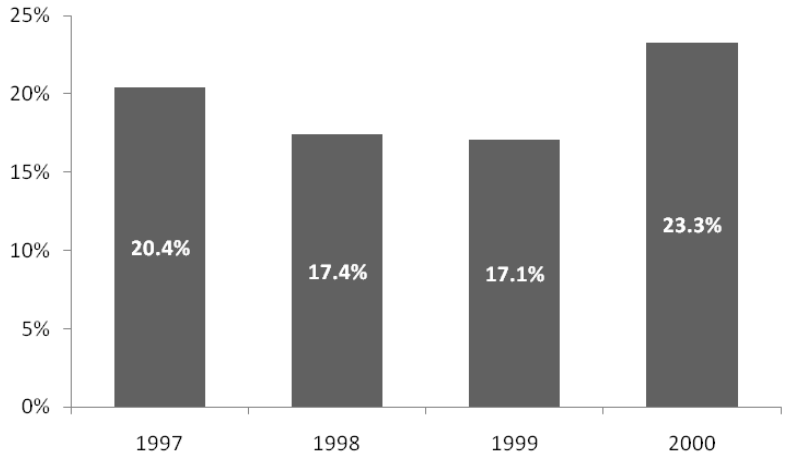
Although the decision had been made to expand the company's tool bonding capacity, the question became one of either growing current operations or seeking alternative sites. Torton was heading a committee that would make facility decisions. Other team members were Ilan Gilboa and Shlomit Drori from K&S Israel. The key questions they had to answer were whether the current Yokneam, Israel facility should be expanded or a new plant should be built in another location. And if it was decided to seek a location outside of Israel, where exactly should the company go?

Industry Background

Although making steady money in the semiconductor equipment industry was never easy, the sector, tied to the needs of semiconductor manufacturers, was generally profitable. (See **Figure 1** for global semiconductor equipment sales as a percentage of semiconductor sales between 1997 and 2000.)

This case was prepared by Senior Researcher Gerry Yemen, Associate Professor Gal Raz, and Associate Professor Martin N. Davidson. It was written as a basis for class discussion rather than to illustrate effective or ineffective handling of an administrative situation.

Figure 1. Semiconductor equipment sales as a percentage of semiconductor sales.



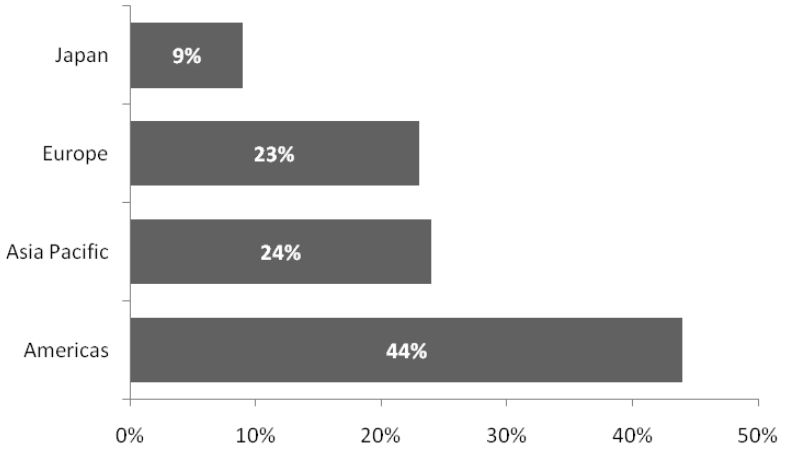
Data source: Angelo Zino, "Semiconductor Equipment," *Standard & Poor's Industry Surveys*, May 14, 2009, 3.

Profits were influenced by the price of raw materials and small components. Globally, sales across the semiconductor equipment industry grew from $7.5 billion in 1992 to $47.7 billion in 2000.[1] Key sales drivers included global GDP, global chip demand, and chipmaker capacity and utilization. The rapid change in technology affected the financial health of companies in the industry. New markets for semiconductors (especially in wired and wireless appliances) were driving up manufacturers' capacity utilization rates in 2000.[2] New plants were being built in Singapore, Taiwan, the Philippines, and South Korea.[3] All that translated into increasing demand for semiconductor equipment makers and the need for more capacity in the sector.[4]

The geographical shift in the electronics manufacturing industry to Asia and other Pacific Rim countries affected supply chain businesses.[5] Some semiconductor firms followed suit to be more closely connected to their customers and take advantage of reduced labor, operating, property, and raw material costs.[6] As **Figure 2** indicates, Asia-Pacific spending outpaced Europe's slightly in the year 2000, and it was expected to grow more in the next few years.

[1] Thomas W. Smith, "Semiconductor Equipment," *Standard & Poor's Industry Surveys*, August 23, 2001, 15.
[2] Smith, 4.
[3] Smith.
[4] Smith, 6.
[5] Angelo Zino, "Semiconductor Equipment," *Standard & Poor's Industry Surveys*, May 14, 2009, 15.
[6] Zino, 15.

Figure 2. Semiconductor equipment spending by geographic region.



Data source: Zino, 15.

K&S

An American company, K&S was founded by Fred Kulicke and Al Soffa in Fort Washington, Pennsylvania, in 1951. The founders incorporated it in 1956, publicly offered its stock on the NASDAQ in 1961, and first expanded it globally to Switzerland in 1972. The company designed, manufactured, marketed, repaired, serviced, maintained, and upgraded equipment used to assemble semiconductors. The firm quickly became a global player with facilities in North America, Europe, and Asia. By 2000, K&S employed more than 3,000 people. With a healthy financial situation (see **Exhibit 1** for financials), the company held 50% global market share in the semiconductor wire bonding equipment segment—indeed, the Israeli site itself held 50% of the worldwide market share of bonding tools.

Customers and competition

Primary markets for K&S products and services included Asia, the United States, and Europe. Customers in K&S's markets were firms that performed contract assembly of semiconductor devices as well as merchant and captive manufacturers. The majority of sales were denominated in U.S. dollars. In 2000, 91% of net sales were to customers outside the United States (83% in 1999 and 80% in 1998).[7] **Figure 3** shows the geographical breakdown of sales in FY2000.

[7] 2000 K&S Form 10-K, 6.

Figure 3. Sales by region.

Country	Percent of total sales
United States	9%
Taiwan	31%
Malaysia	9%
The Philippines	11%
Singapore	10%
Korea, China, and other Asia Pacific	22%
Other International	8%

Data source: K&S Form 10-K 2000, 18.

Even with the firm's healthy market position, competition within K&S's primary markets was often intense. Several factors influenced the nature of the multicountry competitive interaction: performance, quality, customer support, price, and delivery. According to K&S executives, major competitors included ASM International and Shinkawa (bonders), Disco Corporation (blades), and CoorsTek, PECO, and Small Precision Tools, Inc. (capillaries).

- *Wire bonders*: ASM Pacific Technology, Shinkawa, Kaijo, and ESEC
- *Die bonders*: ESEC, Nichiden, ASM Pacific Technology, and Alphasem
- *Dicing saws*: Disco Corporation
- *Expandable tools*: Gaiser Tool Co. and Small Precision Tools, Inc.
- *Blades*: Disco Corporation
- *Bonding wire*: Tanaka Electronic Industries and Sumitomo Metal Mining

The semiconductor business

Building semiconductors meant acquiring parts from various suppliers to complete two stages—the *front end* and *back end*—of the process (**Figure 4**).

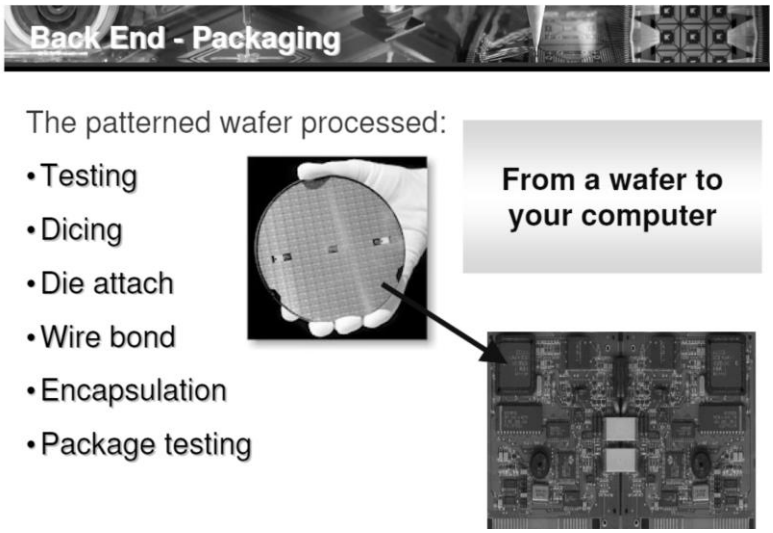
Figure 4. Semiconductor industry process.

Source: Company documents. Used with permission.

Manufacturing semiconductors was tremendously complex and comprised approximately 500 individual process steps.[8] Most chipmakers outsourced some functions (back in the day, large firms such as IBM built their own equipment). The front end was where materials were prepared and *wafers* (the basic component made of crystalline silicon) were made, cleaned, and tested.

The back-end manufacture of semiconductors included wafer dicing, die bonding, and wire bonding and was referred to as *assembly*. The back-end process started after a finished wafer was tested and cut into individual devices (**Figure 5**). It was then bonded to the lead frame (pictured in bottom corner of **Figure 6**), encapsulated into molded plastic packages, and subjected to a final test process.

Figure 5. Back-end process.



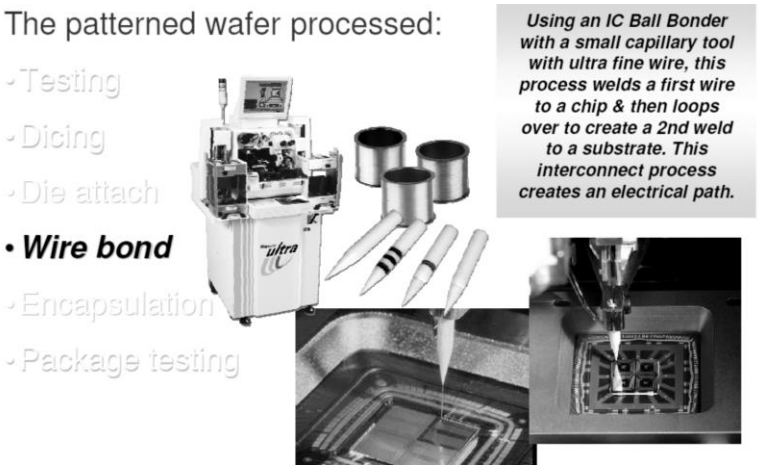
Source: Company documents. Used with permission.

K&S's crown jewel was its wire bonders, which connected fine gold or aluminum wires between the bond pads of a die and the leads on the integrated circuit (IC) package.[9] K&S manufactured two different kinds, ball and wedge bonders, which came in both automatic and manual designs. (**Figure 6** shows a ball bonder.) In a cost-reduction effort, K&S transferred the manufacturing of its automatic ball bonders to Singapore in 2000.

[8] Zino, 22.

[9] An *IC* was a tiny, complex device able to implement several electronic functions. It consisted of two pieces, the silicon chip, called the *die*, and the package that protected the chip.

Figure 6. Wire bonding with an IC ball bonder.



Source: Company documents. Used with permission.

Wire bonding was K&S's main market space (see **Figure 7** for K&S facility locations and products). The company also manufactured several semiconductor device assemblers that included bonding wire and expendable tools. *Bonding wire*, 0.001 inches in diameter and made from copper, aluminum, or gold, was used extensively. K&S *expendable tools* included capillaries, wedges, die collets, and saw blades. *Capillaries* and *wedges* were similar to needles and functioned in much the same way: They were to feed out, attach, and, as needed, cut wires used in wire bonding. *Die collets* picked up and placed dies into packages, and *saw blades* cut wafers and other hard materials.

Figure 7. Major manufacturing facilities, 2000.

Facility	Size (sq. ft.)	Products
Yokneam, Israel	60,400	Capillaries, wedges, die collets, hard material blades
Thalwil, Switzerland	15,100	Bonding wire
Singapore	108,800	Bonding wire, wire bonders
Selma, Alabama	25,600	Bonding wire
Santa Clara, California	13,600	Dicing saw blades
Kaohsiung, Taiwan	28,406	Bonding wire

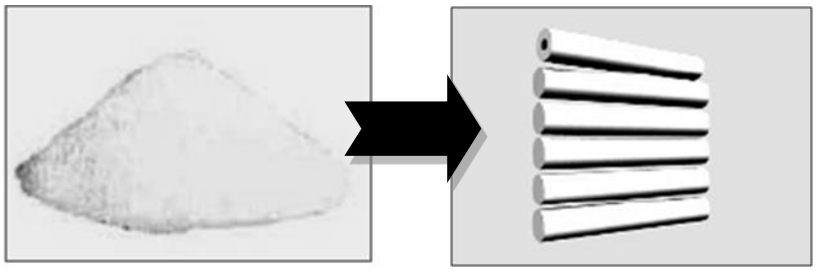
Data source: 2000 K&S Form 10-K, 10.

The capillary production process

K&S produced approximately six million units of capillaries a year. There were two stages to capillary production: (1) the *semifinished* stage, which took the powder substance and created a blank (**Figure 8**); and (2) the *finished goods* stage, where the grinding, cleaning, and

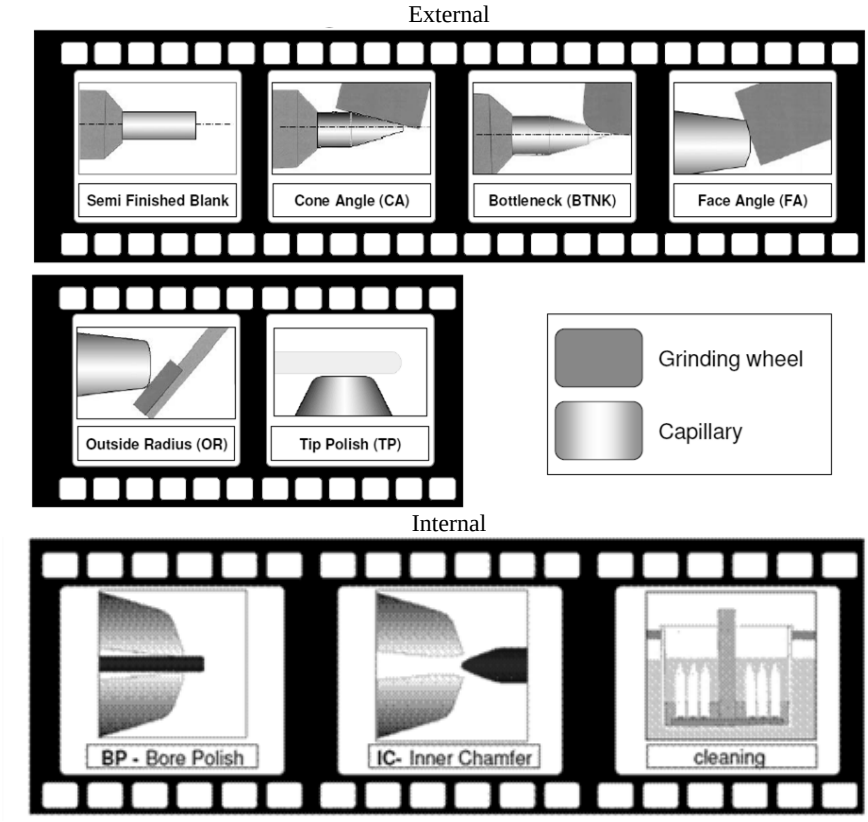
inspection of each capillary—a very labor-intensive job—took place (**Figure 9**). Finished goods production took eight to ten times more labor than did the semifinished stage.[10]

Figure 8. The semifinished stage: from powder to blank.



Source: Company documents. Used with permission.

Figure 9. The finished goods stage: external (above) and internal (below) grinding finish.



Source: Company documents. Used with permission.

[10] Based on case writer interview with protagonists.

Expansion Plans

FY2000–01 was among one of the firm's best years; K&S reported record-high sales. And with that success, capacity-expansion discussions followed. K&S was selling 6 million units of capillaries per year (and had enough capacity in Israel to produce it), but expected demand to grow to approximately 8 million per year. With manufacturing capabilities in North America, Europe, Singapore, and Taiwan, executives searched for another site option. At the time, the Israeli site held 50% of the worldwide market share supplying bonding tools. In the event of a forced shutdown, no competitor had the capacity or scale to fill the gap—which was both a good and bad thing. The upside was that competitors were unable to steal away customers; the downside was that K&S had no capability to step up production to include large new markets opening up—particularly in China.

Competitive pressure and the erosion of the application server provider market also played a role in the motivation to expand. The company could expand the capacity of the Israel site to 8.5 million units per year with an estimated investment of $2 million. It was also possible to expand production elsewhere complementing the existing capacity in Israel. Given the company's significant position in the tool bonding market, a dual source would be advantageous, in which case a key question for the company's growth strategy would focus on where exactly the optimal location to establish it would be.

As discussions continued, so did conversations about what the optimal location would be. "Our customer base was moving to Asia," Torton said, "so we decided to look at China, Jordan, and Singapore as well [as expanding capacity in Israel]." (See **Exhibit 2** for country maps.) Within China, two cities—Suzhou and Wuxi—were considered possibilities. While conducting due diligence, a picture of the advantages and disadvantages of each geographic area began to appear. **Figure 10** provides economic indicators for each geographical area the team examined. **Figure 11** includes projected investment costs, capacities, shipping costs, and manufacturing efficiencies for each location discussed.

Figure 10. Economic indicator comparison (amounts in U.S. dollars).

	GDP (in billions)	GDP per capita	Exchange rates	Average hourly manufacturing wages
China	1,099.0	870	8.28 yuan/dollar	0.50
Israel	110.4	17,591	4.084 new shekels/dollar	10.78
Jordan	7.8	1,172	0.71 Jordanian dinars/dollar	1.05
Singapore	91.0	24,288	1.72 Singapore dollars/dollar	9.19
United States	9,765	34,599	-	14.38

Data sources: China and U.S. Import Administration Index.

Figure 11. Project comparison data.

	Investment cost (in millions of U.S. dollars)	Efficiencies (units/ worker/ hour)	Capacity (in millions of units)[11]	Shipping cost to Asia	Shipping cost to United States and other int'l.
Israel	2	10	2.5	$1.00	$0.75
Jordan	4.5	8	3.5	$1.00	$0.75
Singapore	6	8	3	$0.50	$1.50
China	6.5	7	4	$0.50	$1.50

Data source: Disguised company-provided data.

Facility Location and Capacity Allocation Options

Yokneam, Israel, manufacturing facility

K&S had had a presence in Israel for over 30 years and been a part of the country's development to a diversified and sophisticated economy. Both money and markets had gradually been deregulated, and a lift of controls on foreign-exchange flows had started in 1987.[12] Perhaps one of the biggest detractors of being located in Israel was the tax burden (approximately 43% of GDP in 2000). The Israel new shekel was nearly fully convertible. (The exchange rate in 2000 averaged ILS = USD0.24).

The ongoing political and economic upheaval in the Middle East caused anxiety for some. Despite the turmoil, Israel's infrastructure was solid, and companies such as Cisco Systems and Intel Corporation opened their first non-U.S. R&D operation there. Indeed, the K&S Israeli factory had a long history and took great pride in serving reliably for many years with only one shutdown during a significant fire in 2000.

The Yokneam factory specialized in expendable tools production and was the firm's sole manufacturing site of those products. It also focused on R&D. "Operators at the Yokneam plant were mostly female and over 30 years old," Torton said. "Turnover was low as there were fewer options for workers to find jobs elsewhere."

As the company looked toward capability allocation, it looked as though expanding the current location in Israel made sense in some regards. "From an overhead prospective, really one site is more effective," Torton said. "With two factories, you have to double everything, like finance, etc., so having one site would provide the flexibility to share overhead." In addition, having production near R&D made sense; there was little discussion about moving intellectual

[11] For Israel, the 2.5 million units is the increase in capacity from the current 6 million units to 8.5 million units
[12] Economist Intelligence Unit, *Country Profile: Israel*, 2000 (London: EIU, 2000), 22.

property associated with Israel's R&D to another location. Having the lab and plant on the same site meant utilities and other services were combined, reducing operating cost. It also allowed for R&D and factory personnel to seek each other's advice should operating problems arise. Drori and Gilboa believed the efficiencies gained by expanding K&S Israel might mitigate the higher relative cost.

Jordan

Sharing its longest border with Israel and only a few hours' drive away, Jordan held a strategic location for K&S. Jordan joined the World Trade Organization in 2000, and King Abdullah II pushed an aggressive economic development agenda.[13] The Ministry of Industry and Trade was responsible for the country's trade policy formation and implementation. Although Arabic was the official language, many people understood English. The Jordanian dinar (JOD) was fully convertible and had been pegged to the U.S. dollar since 1995. (JOD = USD1.41 average in 2000).

There were several attractive features of opening a plant in Jordan. For one, it would be close to the Israeli site and labor costs would be much lower. In addition, as part of a plan to encourage peace, the U.S. Congress had authorized the creation of Qualified Industrial Zones (QIZs) in 1996, which allowed goods produced through partnerships between Israel and either Jordan or Egypt to enter the United States duty-free. There were five QIZs in Jordan that employed more than 5,000 Jordanians. With high unemployment (14%), there were plenty of opportunities to find workers. And the government was pushing to attract computer software and Internet-related businesses to Jordan.

Uncertain diplomatic relationships, however, had some executives concerned about opening up businesses in Jordan. The on-again, off-again Arab–Israeli peace agreements affected Jordan because more than 50% of its citizens were of Palestinian origin.[14] Any unrest could impede the training of Jordanian employees due to security concerns of sending Israeli employees there.

Other issues that worried Torton and his team were related to infrastructure: Would Jordan be able to offer advanced communication channels, computerization, manufacturing capabilities, and adequate access to local suppliers?

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[13] The CIA World Factbook, https://www.cia.gov/library/publications/the-world-factbook/geos/jo.html (accessed January 20, 2010).

[14] WEFA, *Jordan Country Monitor*, November 2000.

Singapore

Singapore is an island located almost 5,000 miles from Israel in the Pacific Ocean. For the most part, Singapore engaged in a free-market economy and became a member of the World Trade Organization in 1995. Despite the government's hands-on approach to economic policy, a well-trained work force, excellent infrastructure (telecommunications was a key growth engine), and political, economic, and social stability made Singapore an attractive location to establish a manufacturing facility. Manufacturing was an important part of Singapore's highly industrialized economy. The government introduced a program called "Industry 21" (I-21) to build up its knowledge-based economy.[15] That initiative exempted foreign investors from required joint ventures or relinquishing management to local interests.

In 2000, the exchange rate averaged SGD = USD0.59. The country's public transportation was famously efficient, and the government was highly active in developing a "wired" Singapore economy.[16] Perhaps one of the biggest drawbacks to the location was the high cost of living.

Already having a production site in Singapore that had machines and a logistics center made this option appealing to Torton's team. It was also closer to customers than the Israeli facility was. "And for some, it seemed almost clear that going to Singapore made the most sense," one senior manager said.

China

Impressive natural barriers—the Himalayas, the Gobi Desert, the Pacific Ocean—have always isolated China from the rest of the world, as did imperial rule until 1912, when the Qing dynasty collapsed. Since 1980, the year Zhao Ziyang was named premier, the economy had shifted from a centrally planned financial system to a market orientation. Although strictly controlled by the centralized political framework, non-state managers and businesses had gained economic influence as old-style collectivism had been slowly replaced by increased authority of local officials and industrial plant managers. Starting with four Special Economic Zones (SEZs) in the south, foreign investors were offered tax incentives and other privileges to make the country an attractive spot. A busy private sector began to take shape, and a market economy, with highly competitive industries and bustling international trade activities, had been established by 2000—although government still played a significant role in how business was conducted in the China. With numerous computer-chip makers launching businesses in China, Torton and the establishing committee had to explore the country's offerings.

[15] Icon Group International, *Executive Report on Strategies in Singapore*, 2000, 35.
[16]Economist Intelligence Unit, *Country Profile: Singapore*, 2000 (London: EIU, 2000), 15.

The language of business in China was Chinese; Mandarin was the official and most common dialect. Although not fully convertible, the Chinese yuan's average exchange rate was CNY = USD0.12 in 2000. Low production costs made China an attractive option for outsiders. "We understood costs to be quite cheap," Drori said, "but it would be a big investment in infrastructure."

According to Torton, it made sense to look at two major cities in China: Suzhou and Wuxi, both located in Jiangsu province. Suzhou was a developed area with an attractively low cost of living, conveniently located close to several K&S customers. With a well-established infrastructure (communications, technology, etc.), Suzhou was considered quite developed as well as being located reasonably close to Shanghai, an international city. A partnership between China and Singapore created an industrial park, the China-Singapore Suzhou Industrial Park (CS-SIP), in 1994. The 80 square km at CS-SIP offered reliable infrastructure, plentiful public transportation, and easy, one-stop government approval service; some called the area "the new Silicon Valley."[17]

In contrast, the city of Wuxi was farther away from Shanghai, considered a less-prestigious location, and offered a lower cost of living. Wuxi also provided an excellent growth potential. "One of our biggest competitors was located there," Drori said. Despite its distance from Shanghai and lagging infrastructure, Wuxi was considered a strong option.

The one constant variable in both cities would be the readily available supply of labor. Torton was told there was no shortage of manufacturing operators who would work at a plant in the city for two or three years and then go back to their hometown in the country. He wondered what that would mean in terms of employee turnover.

The Expansion Team Had Choices

Given that predicting future demand for semiconductors was infamously difficult and completing a new fabrication plant would take one to two years, Torton knew the company had to decide whether to add capacity long before it would be needed. The issue at hand was exactly what the increased capacity would look like. Would it be an expansion of the already established facility in Israel? Perhaps a move to another location made more sense? As the clock ticked, Torton was eager to get the facility decision moving along.

[17] China-Singapore Suzhou Industrial Park, "Comments from the Authorities," http://www.sipac.gov.cn /ENGLISH /sipprofile/200901/t20090116_36704.htm (accessed January 9, 2010).

Exhibit 1

KULICKE AND SOFFA INDUSTRIES, INC.:
DESIGNING A SUPPLY CHAIN NETWORK

Selected Financial Data, 1998–2000

Statement of Operations Data (in thousands except share amounts)

	1998	**1999**	**2000**
Total net sales	411,040	398,917	899,273
Total cost of goods sold	274,207	285,382	573,177
Total operating expenses	140,989	133,267	187,637
Total income from operations	(4,156)	(19,732)	138,459
Interest, net	5,514	3,547	4,719
Equity in loss of joint ventures	(8,715)	(10,000)	(1,221)
Income before taxes	(7,357)	(26,185)	141,957
Provision for income taxes	(1,917)	(8,221)	40,149
Minority interest	—	1,018	1,437
Net income per common share	($5,440	($16,946)	$103,245
Diluted net income (loss) per common share	($0.12)	($0.36)	$2.15
Shares used per common share calculations	($0.12)	($0.36)	$1.90
Basic	46,602	46,846	47,932
Diluted	46,602	46,846	56,496
Balance Sheet Data			
Cash, cash equivalents, and short-term investments	$106,900	$39,345	$316,619
Working capital	182,181	167,131	462,688
Total assets	342,584	378,145	722,852
Long-term debt	—	—	175,000
Shareholders' equity	287,910	274,776	405,342

Data source: 2000 K&S Form 10-K, 12.

Exhibit 2

KULICKE AND SOFFA INDUSTRIES, INC.:
DESIGNING A SUPPLY CHAIN NETWORK

Maps

Israel

Jordan

Singapore

China

Source: CIA World Factbook, https://www.cia.gov/library/publications/the-world-factbook /index.html (accessed January 20, 2010).