Project B-209

ELECTRONICS

A MANUFACTURING OPPORTUNITY IN GEORGIA

Prepared for
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Foreword

This is the first major revision of any of the approximately 40 special product and industry studies completed by the Industrial Development Division during the past six and one half years. The rapid changes which have taken place, not only in the scientific and technological aspects of the industry but also in important location factors such as air transportation have made revision essential.

Revisions of other reports are in process or planned, particularly where there have been significant changes in the market situation. Other revisions will be prepared on the basis of indicated interest by industrial firms as well as on the basis of the other factors noted above.

Companies interested in Georgia locations are invited to request data they may require to adapt any of the studies under discussion to their individual location needs.

Kenneth C. Wagner, Chief
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Summary

Georgia as a site for new electronics plants offers manufacturers the following advantages:

1. High value added per dollar of wages paid (Table 6, page 21).
2. The availability of trained engineers and technicians.
3. A supply of semi-skilled and unskilled production workers.
4. Proximity to a large number of aerospace installations.
5. A transportation network which will allow close liaison between manufacturer and customer and which will provide more than adequate facilities to transport the finished goods to the national market.
6. Educational facilities which will provide a continuous supply of electronics engineers and technicians.
7. Independent research capabilities.

Because of increasing demand, new plants will be needed in the near future in all fields of the electronics industry. Additional production facilities will be most urgently needed to manufacture the growth items indicated in the following fields:

1. Components: Power and special purpose tubes, semiconductor devices, resistors, connectors and relays.
2. Consumer Products: High fidelity components and miscellaneous items (electronic ovens, garage door openers, toys, etc.).
3. Industrial and Commercial Products: Communication equipment, data processing equipment, testing and measuring instruments, industrial controls, and medical equipment.
4. Military Products: Communication equipment; navigation, guidance and control equipment, and miscellaneous equipment (reconnaissance and surveillance, countermeasure, check-out, detection, tracking, data reduction, etc.).

The following factors are the most significant in locating new plants in the indicated fields of the electronics industry:

1. The availability of an adequate supply of low-cost production labor (components, consumer products).
2. Availability of trained electronics engineers and technicians or the ability to attract these people from other regions (commercial and industrial products, military products).
3. Availability of an adequate transportation network to transport the finished goods to the national market (commercial and industrial products, consumer products).
4. Proximity to military and defense installations to allow close liaison between the producer and the customer (military products).

INTRODUCTION

For purposes of analysis the electronics industry has been divided into four categories of manufacture -- components, consumer products, industrial and commercial products, and military products.

The first section of this study presents an analysis of the market growth of the various segments of the electronics industry and particularly pinpoints those areas where the expansion has been concentrated and is expected to be concentrated through 1965. Since little, if any, electronics manufacture is oriented toward regional markets, those products which promise the greatest national market growth for the future are the ones for which new plants will most likely be constructed. Therefore, an attempt has been made in the first section to analyze the need for new plants caused by the expansion of the national market.

The second section identifies the principal location considerations involved in the selection of an area in which a new plant is to be constructed.

The last section of the report indicates to a manufacturer contemplating a new plant the advantages of locating the facility in Georgia. These advantages indicate the extent to which Georgia measures up to the location criteria established in the previous section.

Even though the report is oriented primarily toward existing electronics manufacturing firms, opportunities nevertheless exist for new firms in the industry. However, the opportunities for new firms to manufacture standard components or mass-produced consumer products such as television receivers are very remote because of the high capital investment required and because of the keen competition they would encounter from the large established firms in the industry.

Components

The U. S. market for electronic components from 1954 through 1959 is shown in Table 1. Of all electronic components the following have experienced the greatest market growth over the six-year period:

Component	Growth in Sales, 1954-1959
Power and Special Purpose Tubes	67%
Semiconductors	148%
Connectors	190%
Relays	100%
Resistors	81%

The market for receiving tubes has not been growing, primarily because of the development of semiconductors. Since electronic equipment manufacturers have begun to use semiconductors instead of tubes on original equipment, it is very likely that the market for receiving tubes will experience a steady decline. Also, the market for television picture tubes has been relatively steady and is not expected to increase substantially in the near future. However, manufacturers' sales of power and special purpose tubes (SIC 3673) increased substantially from 1954 through 1959, as indicated in the above tabulation. Microwave tubes accounted for 48% of 1959 sales of power tubes, while high vacuum tubes accounted for 25% of the total. Sales of power tubes are expected to reach $396 million in 1965.

As indicated in the above tabulation, sales of semiconductors (transistors, diodes and rectifiers) increased immensely from 1954 through 1959. The greatest increase was in the sale of transistors. The market for these products is expected to diminish only slightly in the near future. Sales in 1965 are expected to exceed $600 million.

Table 1

MANUFACTURERS' SALES OF ELECTRONIC COMPONENTS, 1954-1959
(Millions of Dollars)

	1954	1955	1956	1957	1958	1959
Tubes						
Receiving	300	380	390	400	355	375
TV Picture	240	235	240	230	215	240
Power and Special Purpose	150	150	160	185	215	250
Total	690	765	790	815	785	865
Semiconductor Devices						
Transistors	10	15	40	70	110	230
Diodes and Rectifiers	15	25	50	85	100	165
Total	25	40	90	155	210	395
Capacitors	200	220	210	215	190	235
Connectors	50	55	65	80	115	145
Relays	85	110	110	155	135	170
Resistors	130	150	170	190	175	235
Transformers	150	140	135	135	120	145
Other	660	690	670	675	610	780
GRAND TOTAL	1,990	2,170	2,240	2,420	2,340	2,970

Source: U. S. Department of Commerce,
Business and Defense Services Administration

The market for connectors, relays and resistors has increased significantly since 1954. Sales of connectors increased from $50 million in 1954 to $145 million in 1959 (190%), while relays increased from $85 million to $170 million (100%), and resistors increased from $130 million to $235 million (81%) during the same period. These three products combined accounted for 18.5% of all component sales in 1959. Sales of connectors, relays and other components are expected to reach $1,309 million in 1965, while resistor sales should reach $324 million in the same year.

On the other hand, the market for capacitors, transformers and reactors has shown practically no growth from 1954 through 1959. Transformer sales actually showed a slight decline from 1954 through 1959. These products combined accounted for 12.8% of total component sales in 1959.

The following tabulation compares the anticipated growth in sales for 1965 over 1959 with the yearly shipments of an average size plant for selected components:

	Anticipated Sales Growth 1959-1965 (Millions of Dollars)	Yearly Shipments of an Average Size Plant
Power and Special Purpose Tubes	146.0	5.4
Semiconductor Devices	205.0+	5.6
Resistors	89.0	2.1
Connectors) Relays) Others)	214.0	.9

Obviously, there is a need for additional production facilities in the above categories of products between 1959 and 1965.

Consumer Products

The U. S. market for electronic consumer products from 1956 through 1960 is shown in Table 2.

Table 2

FACTORY SALES OF ELECTRONIC CONSUMER PRODUCTS, 1956-1960
(Millions of Dollars)

Product	1956	1957	1958	1959	1960
Television Sets	930	831	686	886	825
Radios	290	350	320	328	345
Phonographs	146	248	263	373	395
Phonograph Records	155	180	198	220	250
High Fidelity Components	27	34	36	38	40
Miscellaneous	52	57	97	155	245
TOTAL	1,600	1,700	1,600	2,000	2,100

The demand for television sets and radios has remained relatively stable over the five-year period, and a sharp increase in sales is not anticipated in the immediate future. Technological improvements which would lower the price of color television sets could cause an increase in demand for this product, but this condition is not likely to come about shortly.

The market for high fidelity components has increased steadily from 1956 through 1960. However, the trend of phonograph manufacturers to incorporate the units in new sets may curtail the growth of this group of products.

The consumer products which have shown the largest market growth in dollar value from 1956 through 1960 are phonographs (170%), high fidelity components (48%), and miscellaneous products such as electronic ovens, garage door openers, toys and hearing aids (370%). Unit sales of phonographs, however, have been fairly stable, and the 170% increase in value over the five-year period is attributable to increased costs of producing the more complex phonographs.

The consumer products for which new plants will need to be established because of market expansion in the near future are high fidelity components and the miscellaneous items.

The following tabulation compares the anticipated growth in sales for 1965 over 1960 with the yearly shipments of an average size plant for "growth" consumer products:

	Anticipated Sales Growth 1960-1965 (Millions of Dollars)	Yearly Shipments of an Average Size Plant
High Fidelity Components	16.0	1.5
Miscellaneous Consumer Products	100.0+	5.0 (est.)

Industrial and Commercial Products

The market for industrial and commercial electronic items is shown in Table 3.

Table 3

SALES OF INDUSTRIAL AND COMMERCIAL ELECTRONIC PRODUCTS, 1954-1965
(Millions of Dollars)

Equipment	1954	1955	1956	1957 (Projected)	1958 (Projected)	1959 (Projected)	1960 (Projected)	1965 (Projected)
Communication								
Land Mobile Radio, Broadcast Equipment, Microwave Communication Equipment	90	95	120	150	155	175	190	330
Aviation/Marine Communication and Navigation Equipment	-	-	100	130	140	175	200	370
Commercial Sound Equipment	-	-	110	135	140	150	160	200
Total Communication	250	270	330	415	435	500	550	900
Data Processing[1/]	50	70	125	265	290	350	400	800
Testing and Measuring	110	145	170	210	220	250	290	500
Industrial Controls	80	90	115	150	160	180	210	400
Medical	80	90	110	140	145	170	190	350
Other	80	85	100	120	130	150	160	250
GRAND TOTAL	650	750	950	1,300	1,380	1,600	1,800	3,200

Source: A Study of Small Business in the Electronics Industry, Stanford Research Institute, 1962.

1/ The sales figures used here are not in agreement with those in earlier Industrial Development Division reports because of a difference in definition of data processing equipment.

Manufacturers' sales of land mobile radios, broadcast equipment and microwave communication equipment increased 110% from 1954 through 1960. The market for land mobile radios and microwave equipment has experienced the most growth during the period and is expected to grow substantially in the immediate future. Current (1962) sales of land mobile radios are estimated at $100 million and are expected to increase at least 10% per year through 1965. Sales of microwave equipment have doubled in the last five years to a current level of approximately $50 million and are expected to grow substantially in the future. Sales of broadcast equipment have been relatively stable and are not expected to grow significantly in the future because of the stability of the using industry.

Factory sales of aviation/marine communication and navigation equipment increased 100% from 1956 through 1960. Navigation equipment accounts for approximately 70% of the total at the present time, with the major customer being the Federal Aeronautics Administration. Sales of both aviation/marine communication and navigation equipment should increase substantially in the future because of the anticipated increase in the number of boats and commercial aircraft that will be in operation. Sales in 1965 are estimated at $370 million for this category of products (an 85% increase over 1960).

Manufacturers' sales of commercial sound equipment increased 45% from 1956 to a 1960 level of $160 million. The rate of growth of this category of products has been the slowest of all communication equipment primarily because of the slow rate of technological improvements in the field. The products include public address equipment, intercommunication, paging, and music distribution systems, theatre sound equipment and coin-operated phonographs. The 1965 sales are estimated at $200 million (a 25% increase over 1960).

Manufacturers' sales of electronic computers and data processing equipment have increased over 700% from 1954 to a 1960 level of $400 million. The projected need for new plants for this type of equipment is covered in detail in a separate report by the Industrial Development Division.[1/]

1/ Morris, G. W., Jr., Calculators and Computers, A Manufacturing Opportunity in Atlanta, Industrial Development Division, Engineering Experiment Station, Georgia Institute of Technology, August, 1962.

Factory sales of electronic testing and measuring equipment have increased 164% from 1954 to a 1960 total of $290 million. Projected sales for 1965 are $500 million (a 72% increase over 1960). A detailed analysis of this category of products is published in a separate report by the Industrial Development Division.[1/]

Sales of industrial controls have increased 162% from 1954 to a 1960 level of $210 million. They are expected to increase another 90% to $400 million by 1965. The products include manufacturing process control equipment used in the chemical, petroleum and other industries. Also included in the group are machine tool controls, vehicle traffic controls, electric motor controls and others. The rate of sales growth of both process controls and other industrial controls is expected to be approximately the same.

Sales of medical electronic equipment have increased approximately 137% from 1954 to a 1960 level of $190 million and are expected to increase another 84% by 1965 to $350 million. X-ray apparatus is the major sales item in this category. Other products include electrocardiographs, encephalographs, diathermic apparatus and anesthesia equipment.

The market for other industrial and commercial electronic equipment increased 100% from 1954 to a 1960 total of $160 million and is expected to increase another 56% by 1965 to a total of $250 million. One of the major subgroups in this category is nuclear electronic equipment including the following products with estimated sales:

	1957 Sales (Millions of Dollars)	1958 Sales (Millions of Dollars)
Radiation Detection and Monitoring Devices	17.5	24.2
Instrumentation for Reactor Control	10.0	15.3
Measuring Devices Containing Radioactive Isotopes	6.0	4.9

The other major subgroup of products include laboratory instruments such as refractometers, calorimeters, spectrometers, chromatographs, leak detectors,

1/ Eisenhauer, W. C., Electronic Testing and Measuring Instruments, A Manufacturing Opportunity in Atlanta, Industrial Development Division, Engineering Experiment Station, Georgia Institute of Technology, September, 1962.

vacuum gauges and vibration measuring equipment. Present annual sales are estimated at $40 million. The growth rate for this group of products should be very high because of the emphasis placed on research and development in the using industries.

Electronic heating equipment is another subgroup of the category with annual sales now estimated at approximately $25 million.

A concept of the need for additional production facilities by 1965 in the industrial and commercial electronics field can be gained by a comparison of the projected growth in value of sales between 1960 and 1965 with the average value of shipments per manufacturing establishment for each product group. The following tabulation presents this comparison:

	Anticipated Increase in 1965 Sales over 1960 (Millions of Dollars)	Yearly Shipments of an Average Size Plant
Communication Equipment		
Land Mobile Radio and Microwave	140	8.5
Aviation/Marine Communication and Navigation Equipment	170	8.9
Commercial Sound Equipment	40	8.5
Data Processing Equipment	400	Not available
Testing and Measuring Instruments	210	1.4
Industrial Controls	190	1.9
Medical Equipment	160	.8
Other	90	Not available

It is apparent that there will be a need for new manufacturing facilities in each of the above categories of products.

Military Products

Electronic equipment produced primarily for military purposes may be classified by its functions as (1) communication, (2) navigation, guidance or control, or (3) miscellaneous items. Stanford University estimates the 1961 and 1965 market for each of these categories as follows:[1/]

1/ A Study of Small Business in the Electronics Industry, Stanford Research Institute, 1962.

	Manufacturers' Sales Fiscal Year 1961 (Billions of Dollars)	1965	Increase
Communication	1.5	2.0	33%
Navigation, Guidance, Control	2.1	3.2	53%
Miscellaneous	.6	.9	50%
TOTAL	4.2	6.1	45%

Communication equipment includes airborne equipment in manned aircraft and missiles, simple ground-based equipment, complex early-warning systems and shipboard communication equipment. The navigation, guidance and control category includes both airborne and ground-based equipment for use with manned aircraft, missiles and ships. The miscellaneous category includes reconnaissance and surveillance equipment, countermeasures, check-out, detection, tracking, data reduction equipment and other equipment.

The above estimates were derived from the following Department of Defense figures on expenditures for electronic equipment (by DOD classification):[1/]

	Manufacturers' Sales 1961 (Billions of Dollars)	1965
Aircraft	1.3	1.1
Missiles and Astronautics	1.7	3.4
Electronics and Communications	1.1	1.4
Ships	.1	.2
TOTAL	4.2	6.1

It is apparent that the markets for communication, navigation, guidance and control, and miscellaneous military electronic equipment are expected to expand significantly from 1961 to 1965. However, the greatest expansion is expected for navigation, guidance and control equipment (53%) and the miscellaneous equipment category (50%). The above tabulation also indicates that the portion of military expenditures for missiles and astronautics electronics equipment will increase from 40% to 56% of total military expenditures for electronic equipment from 1961 to 1965, whereas the portion of

1/ These totals include expenditures by The National Aeronautics and Space Administration.

expenditures for aircraft electronic equipment will decrease from 31% to 18% of the total over the same period.

The following tabulation provides a concept as to the magnitude of the projected need for additional facilities to produce military electronic equipment by 1965:

	Anticipated Sales Growth 1961-1965 (Millions of Dollars)	Yearly Shipments of an Average Size Plant
Communication Equipment (SIC 36621)	500	8
Navigation, Guidance, Control (SIC 36624 and 36625)	1,100	14
Miscellaneous Military Equipment	300	6 (Est.)[1/]

It would be inaccurate, of course, to imply from the above figures that there will be a need by 1965 for 50 new average size plants to produce miscellaneous military electronic equipment or 62 more plants to produce military communications equipment. However, the figures do indicate a significant need for more production facilities in all three categories of equipment by 1965 because of the large expansion of their markets.

1/ Estimated from 1958 Census of Manufactures, SIC 36626, Electronic Military, Industrial and Commercial Equipment, not elsewhere classified.

LOCATION FACTORS

Components

For most electronic component manufacturers the most important consideration in locating a new plant is the availability of an adequate supply of low cost production labor. Production labor costs amount to a significant portion of the value of manufacturers' shipments as indicated below:[1/]

	Percent of Value Added by Manufacture	
	Production Labor	Other Labor
Electron Tubes (SIC 3671)	38.7	13.6
TV Picture Tubes (SIC 3672)	40.9	15.6
Power and Special Purpose Tubes (SIC 3673)	39.3	22.3
Electronic Components, n.e.c. (SIC 3679)	40.2	21.5

Since production labor costs are large, a producer can significantly lower his production costs in a new plant by locating the new facility in a geographic region which offers relatively low production wage rates, high productivity, and an adequate supply of the type labor required.

Although most component manufacturers have tended to locate near original equipment manufacturers (customers for their products), there are no compelling reasons why they should do so. Freight costs on shipments of components are a negligible percentage of their value. In the case of certain specialty (non-standard) components, however, location near the user will allow the desirable closer liaison between producer and user.

Consumer Products

Generally, consumer products are not manufactured for a regional market. Even though freight costs for shipments of the high volume items, such as television sets, radios and phonographs, add a significant amount to the cost of the products, the manufacture strictly for a regional market is not

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1/ Unless otherwise noted, data for all calculations in this section were taken from 1958 Census of Manufactures.

economical because the local market is usually not large enough to consume the products of a single plant. Average shipments of television sets per plant in 1958 were $47.0 million, while average shipments of radios, phonographs, and radio-phonographs per plant were $8.5 million.

Because of the keen price competition that now exists in the industry and the importance of production labor costs as a percentage of the value added by manufacture, one of the prime location factors to be considered in constructing new plants is the availability of an adequate supply of low cost production labor. The following tabulation indicates the importance of production labor costs in the manufacture of various items in the consumer products industry.

	Percent of Value Added by Manufacture	
	Production Labor	Other Labor
Household radios, phonographs and radio-phonographs (SIC 36511)	35.9	15.8
Household television receivers, including television combinations (SIC 36512)	29.1	14.5
Recorders, audio amplifiers, tuners and other audio equipment (SIC 36513)	38.0	21.0

The average number of workers per plant for each consumer product category in 1958 was as follows:

	Number of Workers	
	Production	Other
Household radio, phonographs and radio-phonographs (SIC 36511)	309	79
Household television receivers, including television combinations (SIC 36512)	1,220	339
Recorders, audio amplifiers, tuners and other audio equipment (SIC 36513)	83	26

From the above figures it is apparent that production labor costs are a significant portion of total manufacturing costs. Also, it can be seen that a sizable labor force is required for the manufacture of radios, phonographs and television sets. The latter requirement is not as great for the high fidelity components (recorders, audio amplifiers, etc.) because they are

produced on a much smaller scale.

Other factors to be considered in locating a consumer products plant are the size of the market immediately surrounding the plant and the transportation facilities available to ship the products to the national market.

Commercial and Industrial Products

Most producers of commercial and industrial electronic equipment have tended to locate in or adjacent to large metropolitan areas. Plants in Baltimore, Chicago, Cleveland, Dallas, Los Angeles, Milwaukee and New York account for a substantial portion of the total employment in these industries. Undoubtedly, the primary attraction of the large metropolitan areas is the availability of trained electronics engineers and technicians or the ability of the area to attract these people from other regions.

The requirements for trained technical personnel are still of paramount importance in the selection of a site for a new plant. An indication of the higher percentage of employment of "other" employees (including engineers) for this segment of the electronics industry is given by the comparison in Table 4 of commercial and industrial electronics employees with employees in other segments of the electronics industry.

A questionnaire survey of the entire electronics industry by Stanford Research Institute indicates that 14% of all workers in the industry are engaged in engineering work, whereas 44% are in production.[1/] Undoubtedly the percentage of employment of engineers in the industrial and commercial products segment of the industry is much greater than 14%.

The factors affecting the ability of an area to attract engineers and technicians are the attractiveness of the area as a place to live and the available educational facilities.

Another location factor is the availability of an adequate transportation network to transport the finished goods to the national market.

Production wage costs are not generally considered a prime plant location factor for this segment of the electronics industry, because variations

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1/ A Study of Small Business in the Electronics Industry, Stanford Research Institute, 1962.

Table 4

RATIO OF PRODUCTION EMPLOYEES TO OTHER EMPLOYEES
IN SELECTED SEGMENTS OF THE ELECTRONICS INDUSTRY

Components	Employees		Wages and Salaries	
	Production (%)	Other (%)	Production (%)	Other (%)
Electron Tubes - Receiving	74.0	26.0	83.7	16.3
Cathode Ray Picture Tubes	72.4	27.6	81.3	18.7
Electron Tubes - Transmitting	63.8	36.2	71.9	28.1
Other Components	65.1	34.9	77.8	22.2
Radio and TV Receiving Sets	67.2	32.8	78.3	21.7
Commercial and Industrial				
Communication Equipment	50.8	49.2	60.3	39.7
Data Processing Equipment	56.8	43.2	62.5	37.5
Testing and Measuring	57.8	42.2	67.6	32.4
Industrial Controls	56.3	43.7	63.8	36.2
Medical Equipment	46.6	53.4	57.3	42.7

Source: Data for calculations taken from 1958 Census of Manufactures.

in cost can usually be passed on to the customer. However, they do account for a considerable portion of total manufacturing costs as indicated below:

	Percent of Value Added by Manufacture	
	Production Labor	Other Labor
Communication Equipment (SIC 3662)	29.1	28.2
Data Processing	Not Available	
Testing and Measuring Equipment (SIC 3611)	35.1	25.7
Industrial Controls	29.0	22.5
Medical	24.5	28.0

Because production wage costs are a significant portion of total manufacturing costs, they are considered at least a secondary location factor.

Military Products

The principal factors to be considered in locating a new plant to produce military electronic equipment are (1) proximity to the using or installation facility to allow close liaison between the producer and the customer, and (2) the availability of trained electronics engineers and technicians in the area (or the ability of the area to attract these trained personnel).

Most military electronic equipment is custom made to the customer's specifications. In many instances, particularly in the production of electronic systems for use in missiles, the products will undergo many changes in design before the first system is turned out. This means that there must be a very close liaison between the producer and the customer so that the finished products will be within the allowable functional tolerances specified by the customer. Also, the need for very high reliability of military electronic products, especially those to be used in missiles, greatly increases the need for close liaison.

Because of the relative shortage of trained electronics engineers and technicians, the location of a new plant either in an area where they are in abundance or in an area which can attract them in quantity is very important. This factor is probably just as important to this segment of the electronics industry as it is to the commercial and industrial products segment. The tabulation on page 15 indicates the importance of this factor for commercial and industrial producers.

Although labor costs are not a prime consideration in plant location decisions for military electronics, they do represent a sizable portion of the value added by manufacture as indicated below:

	Percent of Value Added by Manufacture	
	Production Labor	Other Labor
Communication Equipment (SIC 36621)	29.1	28.2
Navigation, Guidance, Control (SIC 36624 and 36625)	32.1	25.3
Miscellaneous Military Electronics	20.0	34.5

Production wage costs would, therefore, be considered a secondary location factor.

GEORGIA AS A LOCATION

The principal assets which Georgia has to offer potential manufacturing plants in the electronics industry are:

1. the availability of trained electronics engineers and technicians,
2. a supply of semi-skilled and unskilled production workers,
3. low production wage rates,
4. a transportation network which will allow close liaison between manufacturer and customer and which will provide more than adequate facilities to transport the finished goods to the national market,
5. educational facilities which will provide a continuous supply of electronics engineers and technicians, and
6. independent research capabilities.

Manpower Resources

Mechanization of farming has released large numbers of workers so that labor surpluses exist in 122 of the state's 159 counties.[1/] In addition to workers available in the immediate area of a plant, data indicate that a potential labor supply may exist up to a radius of 60 miles or more from the plant. The experience of plants such as Lockheed-Georgia Company and Southern States Equipment Company has proven the adaptability and trainability of these workers for production jobs. In particular, the large number of women workers engaged in textile mills (Georgia's largest manufacturing industry) should be of interest to electronics producers since a great portion of electronics production is performed by women. The high degree of manual and finger dexterity required in textile manufacturing workers is also required in electronics production workers.

Southern Technical Institute, a unit of Georgia Tech's Engineering Extension Division, assures a continuing supply of trained electronics technicians.

1/ Fulmer, John L., Population Estimates in Georgia Counties for 1956-1957, with Analysis of Reasons for Changes from 1950, Special Report No. 33, Engineering Experiment Station, Georgia Institute of Technology, December, 1957.

Southern Tech now graduates 60 to 70 electrical and electronics technicians yearly. The breakdown of degrees awarded by this institution in 1962 was as follows:

Course	Number of Degrees
Building Construction Technology	42
Civil Technology	49
Electrical Technology (including electronics)	62
Gas Fuel Technology	17
Heating and Air Conditioning Technology	21
Industrial Technology	38
Mechanical Technology	36
Textile Technology	8

The Georgia Institute of Technology in Atlanta provides an excellent source for a continuous supply of electronics engineers, physicists and mathematicians. Table 5 indicates the graduates by degree from 1955 through 1961. In addition to current graduates, a 1957 survey by the Industrial Development Division of 237 electrical engineering graduates[1/] indicated that almost 70% were interested in relocating in Atlanta or the surrounding area if suitable jobs became available.

Further evidence of the existence of a sizable supply of electronics engineers in the state (particularly in Atlanta) is given by the experience of one of the largest manufacturers of electronic equipment in the country in recently locating a major facility in the Atlanta area. One of the vice presidents of the firm stated that the company had received far more applications for the Atlanta facility than it had required or expected. Noteworthy is the fact that many of these applications were requests from within the company for transfers to Atlanta.

1/ The year of graduation of these engineers varied from 1946 through 1957.

Table 5

GRADUATES BY DEGREE,
GEORGIA INSTITUTE OF TECHNOLOGY, 1956-1961

	1956	1957	1958	1959	1960	1961
Bachelor of Science in Applied Mathematics	4	11	7	7	16	18
Bachelor of Architecture	16	18	20	24	15	19
Bachelor of Aeronautical Engineering	26	46	56	58	42	55
Bachelor of Ceramic Engineering	7	19	14	22	9	14
Bachelor of Chemical Engineering	46	55	59	55	61	25
Bachelor of Science in Chemistry	4	4	13	15	6	11
Bachelor of Civil Engineering	73	42	68	70	79	61
Bachelor of Electrical Engineering	116	102	104	102	127	125
Bachelor of Science	43	44	56	27	25	18
Bachelor of Industrial Engineering	123	178	211	162	157	132
Bachelor of Science in Industrial Management	186	216	263	297	286	299
Bachelor of Mechanical Engineering	100	142	142	153	97	111
Bachelor of Science in Physics	12	24	25	22	30	23
Bachelor of Textile Engineering	3	9	4	8	6	6
Bachelor of Science in Textiles	34	37	34	39	22	17
Master of Science	107	97	110	111	135	140
Doctor of Philosophy	7	9	4	12	12	20

Production Labor Savings

As indicated in a previous section, production labor costs are primary location considerations both for firms manufacturing electronic components and for those producing consumer products. The ratio of value added by manufacture to dollar of production wages paid for the major producing areas is compared with the Georgia ratio below:

	Value Added Per Dollar of Production Wages	
	Components (SIC 367)	Consumer Products (SIC 365)
Wisconsin	$2.11	
Illinois	2.45	$3.09
New Jersey	2.56	2.71
Ohio	2.57	
Pennsylvania	2.59	
New York	2.61	3.27
California	2.64	
GEORGIA	3.08	3.54[1/]

For component and consumer product manufacturers the labor costs of average size plants in various locations are indicated in Table 6.

Table 6 indicates that production labor savings of a Georgia producer of electron receiving tubes range from 4.2% of sales (compared to a California plant) to 11.8% (compared to a plant in Wisconsin). For a producer of cathode ray picture tubes the savings would range from 2.4% to 6.7% of sales, and for electron power tubes producers and producers of other electronic components the savings ranges would be 3.5% to 9.8% and 3.1% to 9.2%, respectively. These savings in production labor costs are significant when compared to the net profit before taxes figure for the electronics industry -- approximately 8.5% of sales.

1/ Since there are presently no Georgia firms in SIC 365, it was necessary to estimate the Georgia rate for this industry. The Georgia rate for SIC 361, Electrical Distribution Products, was used for SIC 365. This should be a very conservative estimate since a comparison of rates for the two industries in major producing areas revealed that the rate for SIC 361 is well below SIC 365 in each area.

Table 6

COMPARISON OF PRODUCTION LABOR COSTS FOR AVERAGE SIZE PLANTS MANUFACTURING COMPONENTS AND CONSUMER PRODUCTS IN VARIOUS LOCATIONS
(Millions of Dollars)

	Wisconsin	Illinois	New Jersey	Ohio	Pennsylvania	New York	California	Georgia
Electron Tubes-Receiving								
Shipments *	$4.5	$4.5	$4.5	$4.5	$4.5	$4.5	$4.5	$4.5
Material Cost	.98	.98	.98	.98	.98	.98	.98	.98
Value Added by Manufacture	$3.52	$3.52	$3.52	$3.52	$3.52	$3.52	$3.52	$3.52
Value Added per Dollar Wages	$2.11	$2.45	$2.45	$2.57	$2.59	$2.61	$2.64	$3.08
Production Wages	$1.67	$1.44	$1.44	$1.37	$1.36	$1.35	$1.33	$1.14
Savings of Georgia Plant (as % of sales) over:	11.8%	6.7%	6.7%	5.1%	4.9%	4.7%	4.2%	
Cathode Ray Tubes								
Shipments *	$2.1	$2.1	$2.1	$2.1	$2.1	$2.1	$2.1	$2.1
Material Cost	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Value Added by Manufacture	$ .90	$ .90	$ .90	$ .90	$ .90	$ .90	$ .90	$ .90
Value Added per Dollar Wages	$2.11	$2.45	$2.45	$2.57	$2.59	$2.61	$2.64	$3.08
Production Wages	$ .43	$ .37	$ .37	$ .35	$ .35	$ .34	$ .34	$ .29
Savings of Georgia Plant (as % of sales) over:	6.7%	3.8%	3.8%	2.9%	2.9%	2.4%	2.4%	
Electron Tubes-Power								
Shipments *	$5.4	$5.4	$5.4	$5.4	$5.4	$5.4	$5.4	$5.4
Material Cost	1.83	1.83	1.83	1.83	1.83	1.83	1.83	1.83
Value Added by Manufacture	$3.57	$3.57	$3.57	$3.57	$3.57	$3.57	$3.57	$3.57
Value Added per Dollar Wages	$2.11	$2.45	$2.45	$2.57	$2.59	$2.61	$2.64	$3.08
Production Wages	$1.69	$1.46	$1.46	$1.39	$1.38	$1.37	$1.35	$1.16
Savings of Georgia Plant (as % of sales) over:	9.8%	5.6%	5.6%	4.3%	4.1%	3.9%	3.5%	
Electronic Components, n.e.c.								
Shipments *	$ .98	$ .98	$ .98	$ .98	$ .98	$ .98	$ .98	$ .98
Material Cost	.36	.36	.36	.36	.36	.36	.36	.36
Value Added by Manufacture	$ .62	$ .62	$ .62	$ .62	$ .62	$ .62	$ .62	$ .62
Value Added per Dollar Wages	$2.11	$2.45	$2.45	$2.57	$2.59	$2.61	$2.64	$3.08
Production Wages	$ .29	$ .25	$ .25	$ .24	$ .24	$ .23	$ .23	$ .20
Savings of Georgia Plant (as % of sales) over:	9.2%	5.1%	5.1%	4.1%	4.1%	2.1%	3.1%	
Radio, TV Receiving Sets								
Shipments *		$6.6	$6.6			$6.6		$6.6
Material Cost		3.95	3.95			3.95		3.95
Value Added by Manufacture		$2.65	$2.65			$2.65		$2.65
Value Added per Dollar Wages		$3.09	$2.71			$3.27		$3.54
Production Wages		$ .86	$ .98			$ .81		$ .75
Savings of Georgia Plant (as % of sales) over:		1.7%	3.5%			.9%		

* Average Size Plant

Table 6 also indicates that producers of radio, television and phonograph sets could expect savings in production labor cost ranging from .9% to 3.5% of sales by producing the items in Georgia. Although the savings for these producers are smaller than for producers of components, they would represent a significant increase in net profits.

Potential savings in production labor costs were not computed for producers of commercial, industrial and military electronic products, since production labor costs are not considered a prime location factor for these industries. However, savings are available to these producers also. They would be an additional benefit of producing in Georgia.

Proximity to Missile Production and Test Facilities

Georgia is located in the center of the missile production and test facilities in the Southeast. (See Map 1.) This geographical advantage is important to producers of missile products because it provides a manufacturer in Georgia the opportunity for close liaison between the production and using facility. The short airline travel time between Atlanta and Cape Canaveral, Florida, and between Atlanta and Huntsville, Alabama, is a distinct advantage to a producer located near the Atlanta area. As pointed out earlier, close liaison between the producing and using facility is a prime location factor for producers of military electronic products. Table 7 indicates typical airline flight time between Atlanta and major cities in the U. S.

Transportation Facilities

Since most electronic products are distributed nationally, transportation facilities are an important consideration in plant location decisions. Although most electronic products are not bulky enough to cause handling problems, it is necessary to have a good transportation network to ship the products to the national market.

Atlanta is the distribution center of the Southeast, and the transportation network which radiates from Atlanta, unsurpassed anywhere in the South, would give a Georgia producer easy access to markets, materials and components. In addition, company officials would have excellent service to any city in the U. S. for necessary business trips.

MAP 1
LOCATIONS OF MAJOR MILITARY, NASA, AND AEC INSTALLATIONS AND AIRFRAME MANUFACTURERS IN THE SOUTHEAST

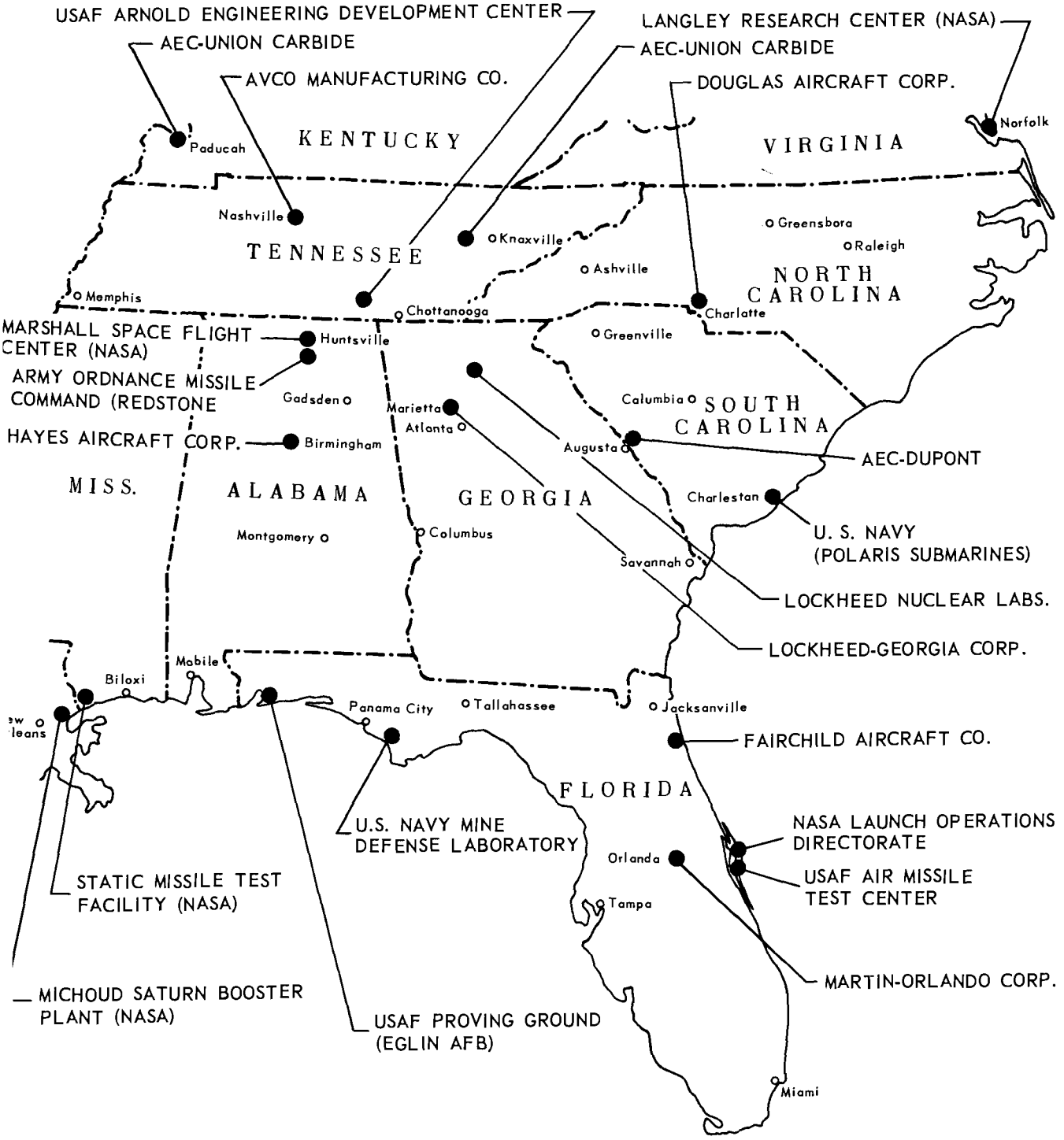

Table 7

TYPICAL AIRLINE TIME BETWEEN ATLANTA AND SELECTED POINTS

Washington, D. C.	1 hour	36 minutes
New York, New York	1 hour	44 minutes
Chicago, Illinois	1 hour	35 minutes
St. Louis, Missouri	2 hours	17 minutes
Denver, Colorado	4 hours	7 minutes
Seattle, Washington	6 hours	55 minutes
San Francisco, California	6 hours	35 minutes
Los Angeles, California	4 hours	17 minutes
Dallas, Texas	1 hour	45 minutes
Miami, Florida	1 hour	27 minutes
Orlando, Florida	1 hour	4 minutes
Huntsville, Alabama	--	49 minutes
Pittsburgh, Pennsylvania	1 hour	37 minutes
Cleveland, Ohio	1 hour	45 minutes

Georgia has 32 rail carriers, including 15 Class 1 railroads. It has approximately 100 motor freight carriers and six air freight carriers. In addition, ports at Savannah and Brunswick provide facilities for export trade.

Electronics Research in Atlanta

The Georgia Tech Engineering Experiment Station performs $4 million worth of research annually -- almost a million dollars of that total in electronics. Several private companies, an aircraft plant and a major medical research complex in Atlanta also conduct research programs relative to electric and electronic measuring devices.

The research staff of 650 employees at the Engineering Experiment Station is built around 300 experienced scientists and engineers. Two thirds of these devote full time to research, and the remaining 100 divide their time between teaching and research. They are supported by qualified technical assistants, machinists and technicians, all under centralized administrative direction. Facilities are available for research in most phases of science and engineering. The services of these personnel and facilities are available on a consultation or contract basis through the Georgia Tech Research Institute.

Research in electrical engineering at Georgia Tech includes such diverse areas as network theory, automatic controls, electromagnetic theory, communication circuits and instrumentation. Facilities and qualified personnel are available in most of the other important areas of electrical machinery and systems, particularly electronics.

Major electronics research capabilities are in the areas of radar, microwaves and communications. Facilities include two field sites for propagation links, HF and VHF antenna ground plane and vehicular laboratories, a microwave test range, and well-equipped frequency control, electronic, microwave and interference measurements laboratories.

Programs in radar, encompassing the fields of information theory, ultra-narrow-beam antennas and millimicrosecond pulse techniques, have produced designs for several new types of radar systems. Some of these systems have been completely developed and evaluated under field conditions by Georgia Tech personnel.

Microwave research efforts have included work with devices for high resolution radar and radiometer systems and research directed toward increasing the sensitivity of microwave spectrometers. Some of the major subareas have been the fields of shaped-beam antennas, geodesic lenses, ring switches, millimeter wave techniques and ferrite devices.

In the area of communications, advanced techniques for both FM and AM modulation and detection have been developed. They include suppressed-carrier systems which are insensitive to the Doppler Effect and can consequently provide power-conserving voice communications for high-velocity aircraft. Extensive research activities in frequency control have resulted in improved techniques for fabrication and utilization of quartz crystals and have produced crystal controlled oscillations with frequencies up to 600 megacycles.

Representative of work on RF interference is a comprehensive research program to develop electronic computer techniques for assigning frequencies and equipments to army field communication systems on a non-mutual interference basis. This program includes studies to determine the interference susceptibility and emanation characteristics of transmitting and receiving equipment, as well as methods for computing optimum allocations of this equipment and its frequencies within an arbitrary communications system.

Following the pattern set at Massachusetts Institute of Technology, Stanford University, California Institute of Technology and many other campuses, new research-based companies have been established by former personnel of the Georgia Tech Engineering Experiment Station. Most are based upon instrumentation technology. The foremost example of this is Scientific-Atlanta. This company, created in 1952, now has about 225 employees and over $3 million annually in sales. It claims to be the leading specialist in the antenna instrumentation field, furnishing well over half the instruments used in this activity. It also develops other new products, such as a B-H meter for testing magnetic tape, which is now used by most major tape manufacturers.

Emory University spends approximately $2.5 million per year on research, primarily in the medical field. This effort is closely meshed with that of the Communicable Disease Center, which has an estimated research budget of $6 million per year. The Center is consolidating its national operations in

Atlanta and is building extensive research facilities adjacent to the Emory campus. The relatively new field of medical electronics is an important element of the research being done in the CDC-Emory complex. The Special Problems Branch of Georgia Tech's Engineering Experiment Station also works in medical electronics. For example, the Branch has designed and built analogue computing devices for continuous processing and data reduction of blood pressure, heart rate and electro-encephalographic signals.

Private companies performing in related fields include RMS Engineering, Inc. (formed by Engineering Experiment Station personnel), which specializes in the development of precision radio receivers; Lockheed-Georgia Company at Marietta, which is concerned with aircraft instrumentation and airframe testing equipment; Radiation Technology, Inc., which produces transistorized instruments for the measurement of radiation; and Aeroscience Electronics, Inc., which specializes in telemetry systems.

Perhaps most important, the recently announced location of a major electronics facility in DeKalb County by Litton Industries, not far from the new plant built by Scientific-Atlanta and a plant announced by Theta Electronics of Georgia, Inc., gives promise of a new technology-oriented center in this area.