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THE ELECTRON TUBE INDUSTRY IN THE USSR

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Note: This report has not been coordinated with the intelligence organizations of the Departments of State, the Army, the Navy, and the Air Force. A preliminary working paper, it contains information available to CIA as of 1 January 1951

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a. Importance of the Industry.

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Starting with World War II, the need for an increased volume of rapid communications, plus the development and use of direct military weapons, have made military electronics material a leading article of war. During World War II, US production of military electronics totaled about $7.5 billion. From the beginning of the Korean war to June 1952, US military electronics contracts are to total about $8 billion. As an illustration of increased military applications for electronics, the factory value of electronic equipment requirements in several military aircraft schedules is greater than the total value of airframes.

Its great importance to present military operations, together with its past low output, makes the Soviet electronics industry a primary intelligence objective. Soviet intentions with respect to military electronics clearly indicate lesser quantities and simpler devices than are considered necessary in US planning. However, this field represents a major industrial effort for the Soviet economy. The obviously high priorities and tight security measures which the USSR has applied to this industry support such a conclusion.

The leading factor determining the productive capabilities in the industry is the production capacity for tubes and for critical components. In a complete basic intelligence study the production of electron tubes deserves first consideration, since this is the most important factor in determining industrial capabilities for electronics and represents the most apparent shortage in the Soviet electronics program.

Effort and time required for expansion of tube production is the greatest in the electronics industry. During World War II, for example, US tube facility expansion totaled $89 million, or 40 percent of all radio and radar expansions, the greatest sum for any segment of the industry. Postwar British and US evaluated intelligence has stated tubes to be the limiting factor in Soviet military electronics. A background of intelligence efforts exists, although production to date has been superficial.

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b. General Description of the Industry.

The electron tube is a device which provides the means for the conduction of electricity through gases or in vacuum and which is intended for use in the detection, amplification, generation, or control of electrical signals. Electron tubes comprise a wide variety of production categories and are required in large quantities for the operation of all electronic equipment. In the US, net prices range from 35 cents to $2,500 for each tube. Although tubes are usually described as a single product, there are three broad categories, for which the facilities and methods are not interchangeable: receiving tubes and allied types, produced in large numbers with automatic equipment; special purpose and transmitting tubes, produced in smaller numbers; and cathode ray tubes, requiring special facilities and methods. In order to measure exactly output and input, a further breakdown of categories would be necessary. During World War II, for example, production was based on 32 classifications, including 6 classifications of receiving tubes, 7 of cathode ray tubes, and 19 of special purpose tubes. In determining the output of the Soviet tube industry and the input factors involved, a knowledge of the distribution among product categories is important.

In a civilian economy like that of the US or Western Europe, the consumer product market provides an extremely large requirement for radio receiving tubes. By comparison, the requirements for transmitting and special purpose tubes are very small, although the value may be quite significant. In the case of a heavy military program with no production of consumer items, this distribution is shifted heavily in favor of greater quantities of special tubes. The following analysis of the US tube industry in millions of units and dollars is an illustration:

	Receiving Tubes		Special Purpose Tubes		CR Tubes	
	Units	$	Units	$	Units	$
1944	136	40	29	240	1.3	33
1947	204	84	5.3	0.25	0.27	7

Disregarding the effect of TV on CR tube levels, this analysis shows that the typical US distribution pattern was as follows:

	Civilian Economy		Military Economy	
	Units	Value	Units	Value
Total Tubes	100	100	100	100
Receiving-type Tubes	97	73	82	13
Trans. & Sp. Purpose Tubes	3	21	17	77
CR Tubes	0	6	1	10

The analysis also shows that the value, and therefore the relative amount of productive effort, for a given total quantity of tubes is different for a military economy as compared with a civilian economy. In the former the value per million tube is 2.7 times the value of the latter.

A review of reported production schedules at several Orbit tube plants indicates that the pattern of distribution more closely approaches the US wartime pattern than it does the civilian pattern. In addition to confirming the low proportion of Soviet effort devoted to civilian items, the review also indicates that the Soviet tube program is about twice as valuable as that of the US per unit of output.

The manufacture of electron tubes is complex and depends on the adequate supply of the following:

(1) Technical and supervisory manpower.
(2) Special technical plant machinery; in particular, special glass-working equipment and sealing machines, grid machines, exhaust machines, and test equipment.
(3) Specialized fabricated and raw materials, especially ductile refractory metals, strategic mica, borosilicate glasses, refractory insulation and special chemicals.
(4) Semi-skilled personnel in large numbers, especially with a high degree of manual dexterity.

The principal applications for electron tubes are as follows:

(1) Production of radio and television receivers.
(2) Replacements in existing services and receivers.
(3) Production of military communications equipment.
(4) Production of military radar and counter-measure equipment.
(5) Special military devices (missile controls and VT fuses).
(6) Professional broadcast, communications, and sound equipment.
(7) Industrial electronics equipment.
(8) Military depot stocks and strategic stockpiling.

2. Development of the Industry.

Radio communication was first employed in the USSR by Professor Popov in 1900 and more extensively in the next several years by the Russian Navy. Russian-produced radio equipment was employed in World War I. Under German sponsorship, some early tube work had been started before the revolution. The present industry was established in 1923. Electron tubes were produced in small quantities at Leningrad during the 20's and early 30's. Reports indicate that transmitting tube techniques were quite good, although work on the smaller receiving tubes was somewhat ineffective.

The foundation for the present Soviet tube industry as an effective manufacturing program was started in 1935 under the direction of the Glovesprom of the Ministry for Electrical Industry. This program was implemented by means of technical assistance, manufacturing equipment, and production supplies furnished under a contract with the US firm RCA. Facilities were delivered from the US and installed by 1938 in order to provide production capacity for receiving tubes, transmitting tubes, and a limited level of cathode ray tubes. The expansion program provided for a theoretical capacity of 30 million tubes per year, divided between the Svetlana plant No. 211 in Leningrad and the Radiolampa plant near Moscow. This output was never realized from the 14 production units supplied. By 1940, the maximum annual production rate attained was 8 million tubes.

Following the German attack, the Leningrad plant machinery and personnel were evacuated to Novosilbirsk and most of the Radiolampa facilities were evacuated to Tashkent with small departments elsewhere. It has been estimated that about 50 percent of the effective machine capacity was lost during the evacuation, mostly in crossing Lake Ladoga. The Soviet production of tubes in 1943 and 1944 was about 4 million tubes per year. During World War II, the US supplied under Lend-Lease more than two-thirds of the Soviet tube requirements, as well as considerable military communication equipment. Some shipments of tube machinery, especially grid lathes and stem machines, were made. However, most of a $16 million category for tube machinery included in the last Lend-Lease protocol was not shipped. During the war, the US also supplied nearly all of the tungsten and molybdenum metal products required in Soviet tube production.

The immediate postwar period was notable for the following four factors:

a. Many of the evacuated personnel returned to Leningrad and Moscow, where tube plant operations were reestablished. In addition, equipment and organizations were maintained at the major evacuation plants at Novosibirsk and Tashkent.

b. Extensive removal of technical plant equipment was effected at the AEG, Siemen-Halske, and Telefunken tube plants in Germany and Czechoslovakia, and at the Tungsram/UILCO plant in Budapest. Much of this equipment was reported as installed at the Svetlana plant, at the Radiolampa plant, at Gorki, and at Novosibirsk.

c. In October 1946, additional equipment, manufacturing data, and a group of 250 to 500 technicians, engineers, and scientists were evacuated from German companies to the USSR.

d. A program was carried out consolidating the equipment obtained from Germany and the US, assimilating the German technical personnel and technicians, and reorganizing facilities and production schedules. The Svetlana plant at Leningrad and the Moscow plants emerged again as the major Soviet producers.

From 1947 through 1950 many facilities were added and increased production scheduled. By the end of 1950 it was certain that the Soviet tube industry was operating at a scale larger than anything previously planned. Despite considerable increase in the output of tubes, 1950 production of civilian radios remained at a relatively low level and civilian stocks of replacement tubes were very scarce.

3. Technology.

With some reservations, the Soviet technology is not greatly different from that of the US. Receiving tubes, generally following US design, are produced by methods similar to those in the US, using the same basic types of automatic plant machines. Transmitting tubes appear to be a mixture of US, Soviet, and German designs, and in general are made in job lots, probably in facilities not heavily mechanized. Cathode ray tubes are produced in limited quantities, with methods and facilities not at all comparable to those in the US.

The following four major differences are indicated between the Soviet and US tube industries:

a. The labor input is greater in the USSR in similar tube categories as a result of the Soviet tendency to produce more of the parts in the tube plant, lower skill, inferior quality control, and inadequate supervision. In some cases, the more limited volume probably precludes the use of labor-saving automatic equipment.

b. On receiving tubes and allied types, the Soviet industry employs molybdenum grid wire instead of less critical and cheaper alloys.

c. The Soviet distribution between product categories results in a higher proportion of special tubes and transmitting tubes, more comparable to US experience in World War II. In terms of real factory value it is estimated that Soviet output is twice that of the US per million tubes of all kinds.

4. Organization.

The Soviet electron tube industry is administered by a Directorate of the Ministry for Communication Equipment Industry. This Directorate, whose headquarters is in Moscow, also controls the manufacture of electric lamps and related supplies. Plans and schedules are established by the Directorate, apparently with the assistance of stated requirements from other Ministries and Directorates. Sales and deliveries are arranged to enterprises and stock accounts of other Ministries, as well as to equipment manufacturers of the Ministry for Communication Industry. Military representatives are resident at tube plants, apparently performing functions of inspection, engineering, and expediting. Stringent security measures are observed.

5. Requirements.

a. Civilian.

Reasonably adequate information exists for providing an estimate of civilian tube requirements in the USSR. Domestic civilian demand for electron products has been maintained at a low level, approaching only a fraction of the industry's output.

Consumer demand for radios has been limited by high prices. The retail prices of Soviet radios range from 40 percent to 160 percent of the average industrial worker's monthly pay. This compares with the two popular price ranges in the US of 6 percent and 13 percent. It is noted that the 900-ruble Soviet table model sells in Egypt at $40.50 wholesale and $80.60 retail.

Effective systems for adequate coverage in the fields of broadcasting and telecommunications have been established in the USSR, utilizing the barest minimum investment in labor and materials. A major portion of the coverage is obtained through the use of wired radio outlets and community telephones. In addition to conserving materials, this system fits in with the need for tight Soviet control over the dissemination of information. There are no statutory controls or restrictions against the individual ownership of radios and no choice of stations.

In 1950, it is estimated that the USSR produced 750,000 radios averaging four tubes each and 25,000 TV receivers averaging 21 tubes. The tube requirements totaled 3.5 million tubes. Three million replacement tubes were required in 1950 to maintain existing civilian and commercial installations as follows:

(1) For 3.5 million radio receivers, 2.6 million tubes.
(2) For 9 million loud speaker outlets, no tubes.
(3) For an average of 15,000 TV receivers, 50,000 tubes.
(4) For 20,000 audio amplifiers at wired radio centers, 200,000 tubes.
(5) For 5,200 civilian and administrative communication stations, including 3,500 low-power transmitters and 160 broadcasting transmitters, 100,000 tubes.
(6) For industrial electronic equipment, 50,000 tubes.

An estimated additional 0.5 million tubes were required in 1950 for the production of audio amplifiers, telephone and telegraph equipment, and professional and industrial equipment.

As outlined above, total 1950 Soviet civilian tube requirements were:

Production of radio and TV receivers	3.5 million
Replacement tubes	3.0 "
Production of communications and industrial equipment	0.5 "
Total	7.0 million

The possible range in civilian tube requirements is believed to be from 5.5 million to 8 million.

b. Export.

The total Satellite civilian tube requirements are estimated at 10.5 million tubes, the Satellite 1950 tube production being estimated at 16.5 million tubes. Some of these 6 million surplus tubes were consumed in Czechoslovakia, Hungary, and East Germany for military equipment, and most of the balance was exported to the USSR. Although the USSR exports tubes to Poland and East Germany, as well as some to Rumania and Bulgaria, the USSR has received an estimated 2 to 4 million tubes per year more than it has exported to its Satellites. The export of electron tubes by the USSR is a negligible factor in economic warfare and in securing essential imports.

c. Military.

Military tube requirements may be divided into three categories: (1) operating and spare tubes required for military electronic equipment being produced; (2) operating tubes required for special large-scale projects for expendable equipment, such as proximity fuses and missile guidance controls, if such items are in quantity production; and (3) replacement tubes for military depot stocks and strategic stockpiling.

In this study, no consideration has been given to tubes required for expendable equipment, although it will be seen later that they could possibly be a factor of large magnitude.

No valid intelligence exists for determining the Soviet rates of production of military electronic equipment, from which military tube requirements could be estimated. However, there are three possible approaches for estimating military tube requirements. The first approach, based upon available Soviet statistics (subject to considerable error), is as follows:

(1) From a review of 37 major apparatus plants, it is estimated that 90,000 people are employed in Soviet electronic apparatus factories.

(2) At an estimated average output of 37,500 rubles per year per employee, the total apparatus output is calculated at 3.4 billion rubles.

(3) Subtracting a figure of 0.6 billion rubles to cover the civilian equipment outlined in paragraph a, above, the military equipment output is estimated at 2.8 billion rubles.

(4) Experience in the electronic industry indicates that tube requirements are valued at 7 percent of the equipment output value. Therefore, requirements for tubes are calculated at 290 million rubles. The net price of a Soviet-made receiving tube averages 7.5 rubles; the average net price for all classes of tubes is calculated at 20 rubles per tube. Therefore, 1950 tube requirements for military equipment may be calculated at 10 million tubes.

Second, an estimate of 1950 military equipment tube requirements may be made through comparison with the US industry:

(1) Since the US electronic apparatus industry in 1944 had 250,000 employees and the Soviet industry in 1950 had 90,000 workers, a labor productivity ratio of 40 percent would indicate that the 1950 Soviet production was 15 percent of that of the US industry in 1944.

(2) In 1944, the US electronic equipment industry required 100 million tubes per year, excluding proximity fuses.

(3) Assuming that the Soviet industry in 1950 devoted 75 percent of production to military purposes, military tube requirements can be calculated at .75 x .15 x 100 million, or 11.3 million tubes per year.

Third, some very approximate guesses on 1950 production rates for military equipment indicate requirements of at least 6 million tubes per year, as illustrated below:

Airborne communication	600,000
Airborne navigation sets	400,000
Airborne radar and IFF	600,000
Ground and ship radar	400,000
Marine communication	300,000
Ground communication sets	700,000
Control, radio waves, special	2,000,000
Military R & D	1,000,000
	6,000,000

Based on the above approaches, it is estimated that the 1950 requirements for electron tubes to meet Soviet production schedules on military electronic equipment are 11 million tubes. This estimate is subject to a wide range of error, possibly from a minimum of 6 million tubes per year to a maximum of 25 million tubes per year, the latter in the event that significant production programs for expendable items existed.

No information is available to justify an estimate of basic military needs for replacement and stockpiling tubes at this time. Certainly two million tubes per year, at the most, would cover maintenance requirements for Soviet equipment in Korea and for the Soviet and some of the US equipment in Communist China.

Therefore, since confirmed evidence indicates a shortage of civilian replacement tubes in 1950, it is assumed that the 1950 requirements for stockpiling were planned at the maximum availability less the civilian and military equipment requirements. This would permit a considerable increase in stocks.

In the event of a general war, production of civilian radio equipment would be halted, and non-military tube requirements would be limited to those essential to necessary maintenance. Although military requirements cannot be calculated from estimates of equipment and operational plans, it is believed that a reasonable prediction can be made based on a historical approach. For comparison, the following data represent slightly more than a four-fold increase in military tube requirements over the Soviet consumption in 1944; the rate for the armies and air forces of the Orbit countries is two-thirds that of the 1944 rate of consumption of the US Army and USAF; consumption for the Orbit navies is one-sixth that of the 1944 US Navy rate.

Annual requirements, Orbit navies	12 million
Annual requirements, armies and air forces	48 "
Essential civilian requirements	6 "
Total annual Orbit requirements in case of a general war	66 million

The method used in arriving at the above estimate is as follows:

(1) US tube requirements - monthly averages (1944) (in millions):

Class	Total	Army & USAF Eqt	Navy Eqt.	Depot	Int. Aid	USSR Portion of Int. Aid
Recg.	14.	3.9	3.4	2.1	2.0	0.8
Trans	2.70	0.75	0.80	0.55	0.30	0.10
CRT	0.123	.036	.045	.035	.003	-
	16.8	4.7	4.2	2.7	2.3	0.9

(2) Estimated UK monthly production (1944) 1.8
(3) Estimated USSR monthly production (1944) 0.4
(4) Average monthly requirements, USAF & Army 6.1
Average monthly requirements, US Navy 5.5
Average monthly requirements of UK 3.2
(of which 1.8 was UK production, 1.4 US production)
Average monthly requirements of USSR 1.3
(of which 0.4 was USSR production, 0.9 US production)

(5) An estimated breakdown of 1944 monthly requirements of the USSR:

Total	1.300
Civilian replacements	.100
Army and Air	1.000
Navy	.200

(6) Probable change in USSR Navy requirements:

(a) More units.
(b) Greater use of electronics.
(c) Comparison of 1951 USSR and 1944 US Navies:

	USSR	US
Major combatant vessels	543	2,000
Minor combatant vessels	2,500	10,000
Planes	4,000	25,000

In event of a general war, it would appear that the navies of the Soviet Orbit countries in 1951 would be about one-quarter of the maximum size of the US Navy. The tube requirements per unit would be less in view of the simpler electronics equipment on Soviet vessels and less dispersion of supply bases. Therefore requirements are estimated at 1.0 million tubes per month.

(7) Probable change in USSR Army and Air Force requirements:

(a) A larger military force (in general war).
(b) Increased use of electronics:

1. All tanks and SP guns have radios - instead of 20 percent.
2. Military planes equipped with communication sets, ADF, navigational-aid receivers; bombers and some fighters have radar.
3. Vast net of EW ground radar.
4. Increasing numbers of FC radar.

(c) Suggested factor for tube requirements (equipment plus stocks) 4 x 1944 = 4.0 million.

(8) Soviet Orbit monthly tube requirements, estimated from the historical approach, would be, in case of general war, as follows:

Navy	1.0	
Army & AF	4.0	
Total Mil	5.0	
Essential Civ	0.5	(2/3 of current replacement rate)
	5.5 million	

Estimates of military tube requirements are subject to wide error and varying interpretation. It is believed that current Soviet tube production is adequate for civilian requirements plus current military requirements and will permit a sizable increment in stocks. In the event of a general war, Soviet military requirements would increase greatly, perhaps as much as six-fold. Therefore, a large stockpile is needed, and expansion of tube-producing facilities must be continued if Soviet intentions are to prepare for a general war, rather than to prepare for limited military operations and national defense.

d. Substitutes.

No substitutes as such are possible. The only way in which requirements might be reduced is through a curtailment in plans or in uses. This would mean less electronics and less tubes per basic function; both of these principles are observed in Soviet military equipment and civilian radios.

(Continued on next page)

6. Production.

a. 1950 Tube Production.

Somewhat well-confirmed information of a general nature is available on the six major tube plants in the USSR, permitting the pin-pointing of locations and approximate estimates as to size and general production programs. These plants are as follows:

Plant	Location	1950 Production	
Svetlana No. 211	Leningrad	8	million
Elektrolampy No. 632	Moscow	3.5	"
Radiolampa No. 191	Fryazino (Shchelkovo)	6	"
Tube Factory No. 617 (& 509)	Novosibirsk	5	"
Tube Factory No. 191	Tashkent	3.5	"
Svirl Radiozavod No. 326	Gorki	1.0	"

All of the above plants produce transmitting and special tubes, in addition to standard receiving types. The proportion of special tubes is higher at Novosibirsk, Svirl, and Radiolampa than at the others.

Other tube or lamp facilities of lesser magnitude than the above plants have been reported at perhaps 12 locations: Leningrad, Riga, Lvov, Kirovabad, Rybinsk, Sverdlovsk, Ufa, Tbilisi, Mytishchi, Ryazany, Tirga/Prokopyevsk, and Tomsk. Their combined output is estimated to be about two million tubes. Total Soviet 1950 output is estimated at 29 million tubes, although a range of from 25 million to 50 million tubes is considered possible.

In this report the estimate of theoretical production capacity will not be used because it is a misleading factor in the tube industry. Given the condition of heavy and increasing demand, the actual production is normally considered the effective capacity, even though certain machines or sections of plants could in time increase production without additions. A discussion of Soviet tube and lamp plants follows.

(1) Svetlana No. 211, Engels Prospekt and V. Murinskogo Prospekt, Leningrad. The factory, believed to be the largest Soviet tube plant and an important lamp producer, is located 5.5 kilometers north of the Neva River, just to the right of the main Leningrad to Viborg highway. It includes seven old and four postwar shops, plus storehouses and an administration building. Total floor space is about 850,000 sq. feet. The plant director is Gal'din; employees total about 5,000, including a number of German engineers and scientists.

The original plant, built in 1908, was equipped as a modern tube factory in 1937 and 1938 by RCA. All important equipment, together with about 1,000 key personnel, were evacuated to Novosibirsk (No. 617) in 1941; about half of the major machines were lost. Starting in 1945, Svetlana was reequipped with plant facilities from Germany and the US. Prewar equipment remained at Novosibirsk, although many of the personnel returned to Leningrad. After 1947, some Soviet-made tube and lamp machinery also was installed.

Various reports provide a good general knowledge of the installed machinery, although no detailed information is available relative to the numbers and types of basic tube and lamp machines. The principal product lines are general service incandescent lamps, airport and high-power lamps, fluorescent lamps, receiving tubes and allied types, medium-power transmitting tubes, high-power transmitting tubes, and X-ray tubes. It would appear that about one-third of the plant production was devoted to lamps and two-thirds to tubes. Most of the tube parts are produced in the plant, but part or all of certain items are shipped into the plant, as listed below:

(a) Svetlana produces tungsten and molybdenum wire; a major fraction of the production requirement is received from Moscow — partly from Elektrolampyzavod No. 632, partly from Soviet imports.

(b) Technical glass is produced and bulbs are blown at Svetlana, but a significant amount is shipped in, both as bulbs and as glass rod and tubing, from the Kalashnikovo glass plant.

(c) Mica tube spacers are supplied by the Mica Trust Plant at Petrozavodsk and by mica fabricating plants Nos. 1 and 2 in Leningrad.

Lamp production was estimated at 8 to 10 million in 1946 and 15 million in 1947. 1950 output is estimated at 20 million electric lamps of all types and 8 million tubes of all types, including 800,000 special-purpose and transmitting tubes.

(2) Radiolampa No. 191, Fryazino, Moscow Oblast. This plant, believed to be the second largest tube-producing facility as well as the major design and development center (with its associated Design Bureau), is a complex comprised of three main multistory factory buildings, an administration building, and smaller shops, located 4 miles north northeast of the center of Shchelkovo or about 23 miles northeast of the center of Moscow. The original factory, founded as a tube works in 1934 and equipped with some RCA equipment in 1937 and 1938, was dismantled in 1941. Equipment and some personnel were evacuated to Tashkent; some smaller departments were moved to other locations, including Ufa.

The number of personnel engaged in producing lamps and tubes was reported as 5,000 in 1941 and as 2,000 in 1946. As full effort has been indicated since 1948 on tubes only, current employment is estimated at 4,000. From May 1945 through 1947, tube manufacturing machinery, test equipment, and optical equipment were installed and put into operation at Radiolampa. Equipment was received from German tube and television plants, Zeiss-Jena; from

AEG-Bodenbach in Czechoslovakia; from Siemens tube works in Vienna; from Tungsram/UILCO in Budapest; and from US Lend-Lease. Rather good reports indicate that all of the evacuated Tungsram/UILCO machinery and all of the 40 to 50 US Lend-Lease grid lathes were brought to Radiolampa. The effective capacity of the UILCO and US machinery combined would be 6 to 8 million tubes per year. Production in 1950 is estimated at 6 million tubes of all types. If these units, plus equipment from German plants as well, were installed and in operation at Radiolampa, the production capacity would be considerably larger than this estimate. The possibility must be considered that Radiolampa may have been used from 1945 to 1947 as a "staging area" for special tube machinery, and that some of this vast group of equipment may have been sent to other Soviet tube plants. No lamp manufacture is indicated since the war.

From 1946 to 1948, the associated Design Bureau operated as a gathering point for German electronics personnel, including top-flight tube men. Very little useful information effective after 1948 has been seen. It is quite certain that the Design Bureau is engaged in electron optics work and military television and guidance control development, as well as on general tube research. Radiolampa No. 191 is believed to be producing cathode-ray, transmitting, and special-purpose tubes, in addition to standard receiving tubes.

(3) <u>IM Lenin Elektrolampovy Zavod No. 632, 21 Elektrozavodskaya, Stalinskiy Rayon, Moscow.</u> This plant, the major Soviet lamp producer and one of the four divisions of the former Kuibyshev combine, covers an area of 30 acres and includes a number of four- and five-story brick buildings. It is located slightly less than four miles northeast of the center of Moscow.

Unlike other plants now engaged in electronics, Elektrolampovy 632 was not greatly dislocated during World War II and has been an efficient manufacturing enterprise since 1946. In 1945, this plant established a receiving tube department with personnel and equipment diverted from lamp production. Transmitting tube production was begun in 1947 and cathode-ray tube production in late 1948.

Factory No. 632 has been the major Soviet supplier of refractory metals for a number of years. The Soviet capacity to produce ductile hard metals (tungsten, molybdenum, and tantalum) has been quite inadequate; imports in 1950 were heavy. A new metals expansion was added to Elektrolampovy No. 632 in late 1949; tantalum production was started in early 1948. Wire and metal products are shipped to other lamp and tube producers.

The plant director is G.M. Tsvetkov. Employees totaled 6,000 to 7,000 in 1941. In 1950, employees were estimated at 8,000, with 5,000 working on lamps and related products, 2,000 on tubes, and 1,000 on metals, special machines, and other products.

1950 output at Elektrolampovy Zavod 632 is estimated at 85 million electric lamps of all types and 3.5 million tubes of all types, primarily standard receiving tubes but also standard transmitting types and some CR tubes.

(4) Novosibirsk Elektrolampovy Zavod No. 617, Krasny Prospekt ul., Novosibirsk. This plant was established in late 1941 as an evacuations plant in the buildings of an agricultural college by the transfer of machinery and 1,000 key personnel from the Leningrad Svetlana plant. By 1944, the plant employed several thousand people, producing three to four million tubes per year, including all major categories. Although many of the key personnel returned to Leningrad at the end of the war, this facility was maintained and expanded. In 1944, the buildings used were considered temporary, but one 1948 report mentioned new construction. As recent information is scarce, further study is needed to pinpoint the present location and structure.

There is evidence to indicate the production program is predominantly military, including special-purpose types. German specialists were sent to Novosibirsk, as were the German manufacturing data for centimeter-frequency metal-ceramic and klystron tubes. Little information exists to permit a firm analysis of detailed production programs.

The plant director is reported as Dzhuk, who had RCA training in the US in the late 30's. Total personnel is estimated at 4,000 to 5,000. 1950 production is estimated at 5 million tubes, including a high proportion (in value) of special-purpose types.

(5) Tashkent Electric Lamp Factory No. 191, 10 Uzbekistanska ul., Tashkent. This factory was established in a number of miscellaneous existing buildings in 1942-43, with lamp and tube equipment evacuated from Moscow — presumably, mostly from Radiolampa. Wartime personnel were reported to be about 2,500, and products were primarily lamps and transmitting tubes. The plant was reorganized in 1946-47 and automatic machinery added. There probably also was some consolidation of floor space. Recent details on facilities are not available. The total number of employees is now estimated at 2,400.

Lamp production increased in 1947. Production of glass receiving tubes was initiated in 1947, with a considerable increase reported in 1949. Production of transmitting tubes, possibly including tubes for Soviet early-warning radars, has been continued. There are indications that lamp production has become of secondary importance.

For production materials, refractory metals and parts are obtained from No. 632, Moscow, and mica from the Mica Trust fabricating plant at Irkutsk. The source of glass has not been determined.

The 1950 output is estimated at 3 million lamps and 3.5 million tubes, primarily glass receiving tubes and medium and large transmitting tubes.

(6) Svirl Radiozavod No. 326, Gorki. The location of this plant, believed to be affiliated with but not a part of Lenin Radiozavod 197, has been pinpointed. It was reported as producing radios, components, meters, and tubes during World War II, with 2,000 employees.

Current information is scant. There are quantities of tubes labeled Gorki, which are presumed to be made at this plant. German tube specialists were sent to the Gorki area. Unconfirmed reports state that German equipment for special tubes, small resistors, and capacitors was sent to this plant.

Radiozavod No. 326, possibly in conjunction with sections of No. 197, is believed to be a potential source of important military tubes and components. Further extensive intelligence effort is required, both in research and in collection, to unearth more information about this plant. Tube output in 1950 is estimated at one million, a figure subject to wide error.

(7) Other Possible Soviet Tube Producers. In addition to the six major plants listed, various reports have indicated tube operations at other locations. In general, the information, although superficial, indicates that the total contribution to the supply of tubes is not great from such sources. The 1950 output is estimated at 2 million tubes.

The following list outlines the probable status of such suppliers:

(a) Vaists Elektrotechnika Fabrikn (VEF), 19 Brivibas Gotve, Riga, a fairly large producer of civilian radio equipment, telephones, and military communications equipment, is located in two factories in Riga. The total company personnel is about 5,000. The Brivibas Gotve factory includes a department producing lamps and tubes, largely for local consumption.

(b) Sverdlovsk Tube Plant, Sverdlovsk (or Kamensk). Two references indicate the possibility of a small production of tubes, using some equipment evacuated from Germany. Confirmation is required.

(c) Electric Lamp Plants, Lvov. Two associated factories, started after World War II, are engaged in producing lamps at an estimated rate of one million per year. There is no evidence of tube work as yet.

(d) Elektrik Zavod A.S. Skorokhodov, Leningrad, is a large manufacturer of electric welding and industrial apparatus; it reportedly produces a small number of welding tubes.

(e) Elektrostanze Radio Factory No. 325, Kirovobad Armenian SSR. The source of one report believes that the plant makes radio tubes; this needs confirmation.

(f) Radio Tube Factory, Rybinsk, Yaroslave Oblast. There are brief references in German World War II intelligence reports to a plant at that time, but present operation is doubtful.

(g) Solch Lamp Plant, Tirga/Prokopyevsk. This plant has 1,500 employees and produces special lamps for mines. No tube work.

(h) Ryazan Electric Lamp Factory No. 33, ul. Yamskaya, Ryazan, Ryazan Oblast. This plant was completed just prior to World War II. Since the war it has been producing bulbs, lamps, and glass ampules. Miniature radio (panel) lamps were in production in 1949. The plant area was prohibited to prisoners of war. Indications are that this is a sizable operation, possibly up to 2,000 employees. The size and type of work indicates possible conversion to small tubes.

(i) Tube Plant, Ufa. Some of Radiolampa 191 equipment was evacuated here during World War II. Very little current information exists on this plant, other than indications that operations are continuing, probably on special tubes and not in large quantities. It may have received German technical personnel and equipment after the war. Further intelligence effort is required.

(j) Tube Plant, Tbilisi. Several references indicate that post-war activity does not include lamps or tubes but is probably centered on communications equipment. German specialists may be conducting some experimental work on special tubes.

(k) NIIISS (Military Research Institute) Mytishchi, Moscow Oblast, is engaged on circuit work, field testing, and development of microwave radar. Some experimental model-shop work on special tubes possibly is being conducted.

(l) Radio Tube Factory, Tomsk. Confirmed information fragmentary in nature indicates the existence of a plant at Tomsk. It is not believed to be a large producer. In view of known plans for postwar rearrangement at Novosibirsk Plant No. 617, it is considered likely that sections of No. 617 formed the base for the Tomsk plant. Further intelligence study is required.

(8) Important Supporting Plants. Although the Soviet tube industry, as is generally true of the larger European tube manufacturing complexes, tends to establish each major plant as a self-sufficient entity, certain production parts are purchased from other plants.

Glass and envelopes are produced at several tube plants. Other important sources of glass and glass parts include the Elektrokolby Zavod in Stalinskiy Rayon, near Plant No. 632; the Zapruduya Glass Factory; and the October Glass Plant, Kalacknikovo, Kalinin Oblast.

In addition to the major refractory metal plant at Elektrolampovy Zavod 632, and minor shops at one or two tube plants, the Ogrednevo plant (northeast Moscow) is reported as a tungsten wire supplier.

Clear mica sheet and block are processed and fabricated for the entire tube industry at two principal plants: the Mica Plant, Irkutsk, and the Klima Mica Plant, Petrozavodsk. There are two smaller factories in Leningrad.

b. Regional Production.

The leading tube-producing area now appears to be the Moscow-Gorki region, where nearly 40 percent of the Soviet capacity is located. Second in magnitude is the Leningrad area, with over 30 percent; before World War II, most of the tube capacity was situated in Leningrad. The remaining 30 percent of installed capacity is spread throughout the Urals, the Tashkent, and the Novosibirsk areas.

c. Trends.

(1) Soviet tube production has increased six-fold from the estimated 1945 rate of 5 million. Expansions of facilities reported as being started or in process in the 1947-1949 period at Svetlana, Radiolampa, Moscow Plant No. 632, and Novosibirsk No. 617, will permit a continuing increase beyond the 1950 figure. There has been no current information on more recent expansions, but brief notes in the Soviet press relative to the recent production of special factory equipment (specifically, automatic grid lathes and automatic tube and lamp processing machines) indicate that the expansion of productive facilities is still underway.

(2) Potential additional capacity for tube manufacture exists in the diversion of facilities and staffs from the production of lamps. This was done extensively in the US during World War II. In the USSR, this has been illustrated by the postwar changes at Elektrolampovy Zavod 632 and at Tashkent 191.

(3) It is believed that the USSR is capable of doubling its tube capacity from the 1950 figure within 2 years by these two methods if necessary.

d. Stocks.

No data are available regarding total working conditions or stockpiles. However, a comparison (necessarily approximate) of past production, imports, and consumption indicates that total stock (strategic and depot) was about 30 to 40 million tubes at the end of 1950. In 1951, stocks can be expected to increase by 15 to 20 million tubes.

e. External Sources.

(1) The following tube production in the Satellites is significant:

(a) Hungary - 10 million in 1950
(b) Czechoslovakia - 3 million in 1950
(c) East Germany - 2.5 million in 1950
(d) All others - 1 million in 1950

Of the 6.5 million tubes in excess of the Satellites' military and civilian consumption, it is estimated that over 70 percent is exported to the USSR.

Production is continuing to increase in the Satellites.

(2) Before 1950, total exports of tubes by non-Orbit countries to the Orbit was estimated at 5 million; some of these were shipped directly to the USSR, but most went to Satellites and to China. It is believed that this trade was curtailed appreciably in 1950, primarily due to increased local demand in the non-Orbit countries.

(a) Principal suppliers of tubes to the Orbit and China have been the US, UK, Netherlands, Germany, Italy, France, and Austria. Currently this trade is probably limited to the Netherlands, Austria, Germany, and Italy.

(b) The tube industries of Germany, Netherlands, Austria, France, Sweden, and Italy, which are potentially available to the USSR in case Western Europe is overrun, are currently producing between 45 and 50 million tubes per year. Some expansion is planned in view of the combined NATO and civilian television demand. Subject to some reduction in Western European capabilities resulting from materials cut-off, the Soviet Orbit would almost double its tube capacity through the acquisition of European facilities.

(c) Western export control measures have been fairly effective in stopping the quantity shipment of special military and ultra-high frequency tubes to the Orbit. Except for recent US action, no restrictions have been placed on standard tubes. This accounts for the rather large numerical figures relating to tube transactions. Currency problems and a heavy Western Europe demand for tubes since mid-1950 have probably been more effective than administrative controls in curbing exports to the Orbit.

7. Input Use and Requirements.

a. Principal Raw Materials.

Principal raw materials required in tube manufacture are divided into two categories. Major items, for which the tube industry share is a negligible fraction of total industry consumption, are as follows: cold-rolled steel strip, electrolytic copper, synthetic resins, and nickel sheet and wire. There is a longer list of specialized forms of materials, for which the tube industry is a major or sole user or which entail a difficult technology in preparation. These items are tungsten rod and wire; molybdenum rod, wire, and sheet; zirconium metal and compounds; tantalum; technical glass; nickel tubing and cathode sleeves; high-quality muscovite mica block and sheet; diamond dies; tube getters; oxygen-free copper; refractory insulation (38-900 alumina and block talc); special glass-to-metal sealing alloys; emission-coating chemicals; fluorescent-coating chemicals; mercury; rare gases; and rare-earth metals. A number of the items in the above list are potential supply bottlenecks in the Orbit, as well as good indicators of tube manufacturing levels. Four have been selected for study to date:

(1) Metallic tungsten, including its fabricated forms of wire, rod, and ribbon, is in very short supply in the USSR. Essentially, this is not a raw material (ore) problem but one of difficult technology and expensive plant equipment.

Four Soviet producing plants are known to date, and possibly there are others of small size. One plant is in Leningrad, and three are in Moscow. Although two of these have been expanded since 1947, total output is entirely inadequate. In 1950, Orbit imports, principally from Sweden and (through Switzerland) from Austria and possibly the Netherlands, may have exceeded total annual requirements.

Estimated input factors for tungsten (the data being per 1,000 tubes or lamps) are:

Category	Small Tubes	Large Tubes	Lamps
Wire, under .010"	1,200 meters	800 meters	1,500 meters
Heavy wire and rod	—	33 lbs.	—

Total 1950 tungsten requirements for this industry would be 60,000 pounds, 30,000 for tubes and 30,000 for lamps, or about 190 million meters.

(2) Metallic molybdenum, including its fabricated forms of wire, rod, and sheet, is produced in the same facilities and is subject to the same comments.

Input factors (the data being per 1,000 tubes) are:

Category	Small Tubes	Large Tubes	Lamps
Wire, under .010"	5,000 meters	—	(not
Heavy wire, rod, and sheet	—	45 lbs.	used)

Total 1950 metallic molybdenum requirements would be 40,000 pounds, or 150 million meters, virtually all for tubes.

(3) Strategic block and sheet mica (muscovite, better than good-stain quality, in sizes of No. 6½ and larger) is required for tubes in the amount of 10 pounds per 1,000 tubes. At 1950 production rates, 300,000 pounds per year are required for tubes.

An ample supply of raw material is indicated in the long-developed workings of Siberia and the northwestern part of the USSR. As in the rest of the world, the splitting, handling, sorting, and punching of this material is a bottleneck. Only two major fabricating facilities exist — one at Irkutsk and one at Petrozavodsk — although two lesser factories are located in Leningrad. A further study of the two major plants is planned as a measure of Soviet electronics programs and with respect to vulnerability. There are no indications of significant imports of mica by the Orbit.

(4) Suitable diamond dies are essential to the manufacture of wires used in tubes and lamps, as well as for fine nickel wire (atomic energy) and electronic resistance wire. Die-stones, and especially diamond dies, are imported on a large scale. Further study is suggested in connection with economic warfare possibilities.

b. Fuel and Power Requirements.

No analysis of fuel and power input factors or requirements has been conducted, although the means for this are available, both from US and from USSR data. Further study is recommended on the consumption of electric power; gas, manufactured or bottled; and hydrogen, oxygen, carbon dioxide, and nitrogen.

c. Transport.

No basic consideration of transport is important in this industry with the exception of its qualifying effect upon the production and shipping methods relating to blown glass bulbs. Further study of transport is planned in connection with technical glass supplies.

d. Manpower.

(1) As indicated from an analysis of individual plants, total employment in 1950 in the Soviet tube and lamp industry is estimated at 31,000, with 20,000 working on tubes and related parts and 11,000 on lamps. This total of 20,000 is consistent with the estimated figure of 90,000 employed in the electronic apparatus industry; it is also consistent with the production figure of 29 million tubes when related to US data and considering relative productivity.

Most reports on Soviet tube plants indicate 6-day, 8-hour shifts, with plant operation usually on two or three shifts. As is normal in this industry, the third shift is generally small.

(2) For the large proportion of plant labor, little or no initial skill is required. The best source is a plentiful supply of younger women. Manual dexterity and routine skill are attained on the job, and productivity is low for the first several months; so it is important to maintain the same labor force, once it is trained. A small nucleus of highly skilled key labor is required, especially as assembly leaders, exhaust operators, and glass operators. This latter factor is important, since it precludes the establishment of manufacturing units in a number of widely separated locations.

(3) Managerial, engineering, and scientific personnel are required in about the highest proportion of any industry. Lack of experienced factory engineers and supervisors, in particular, has limited Soviet capabilities in tubes. There are indications that both the supply and the competence of such personnel have improved since the war.

In the field of electronics, Soviet scientific personnel have rated high for many years. As far as research and advanced development are concerned (as opposed to actual production and operation), the USSR must be considered well qualified.

German technical personnel have been used extensively since the war. The number of German tube technicians, engineers, and scientists evacuated to the USSR to work on tube projects and related programs were estimated at from 250 to 500.

(4) Labor input requirements for the tube industry have been estimated for various countries at:

Industry	Labor	Machine Time
US	1.0	1.0
UK	1.9	1.4
France	2.5	1.6
USSR	4.0	1.8

Since the direct labor input in the US for 1,000 tubes of a Soviet mix would be about 250 man-hours, the input per 1,000 tubes in the USSR is estimated at 1,000 man-hours. For the 29 million tubes produced in 1950, this indicates a direct labor requirement of 12,000 workers. Adding 60 percent for all nondirect labor, the calculated requirement checks closely with the 20,000 estimated count.

As new automatic equipment is installed and higher production levels are reached, it is anticipated that the Soviet labor input ratio will decrease appreciably.

8. Conclusions.

a. Capabilities.

The annual Soviet production of electron tubes (estimated at 29 million for 1950, with expansion in output continuing) is adequate to meet Soviet requirements for civilian consumption plus current military requirements and will permit a large increase in strategic stockpiles. In the event of general hostilities, it is believed that the USSR tube production, supplemented by Satellite capabilities, can be expanded adequately before stocks are dissipated in order to meet essential civilian plus military requirements based upon an adequate use of conventional Soviet electronics items.

If the Soviet armed forces were to plan extensive application of a wide scope of more complex military electronics items, were to compete with the US in a variety of such tactical uses, or were to plan large operational use of proximity fuses, the Soviet Orbit tube industry would not meet requirements. Such courses of action would be limited at an early stage. It must be noted at this point, however, that there does not appear to be any firm indication that the Soviet armed forces do contemplate the use of complex electronics systems on a scale comparable to that of the US.

Key factors limiting future expansion of supply in the USSR include (1) the availability of key technical factory personnel, which would limit the effective rate of expansion; (2) the inadequate domestic supply of a few specialized materials, such as tungsten and molybdenum metal products, and diamond dies; and (3) to a degree only, the rate at which new special machinery can be constructed.

b. Vulnerabilities.

Under conditions of cold war, the steps (if possible) to be taken to restrict Soviet tube supplies would be as follows:

(1) Effectively prevent the shipment into the Soviet Orbit of tungsten and molybdenum metal products (preclusive buying and export controls), of diamond dies (embargo), and of electronic test equipment (embargo). At present, this is not done effectively by certain nations.

(2) Embargo shipments to the Orbit of all classes of tubes and lamps.

(3) As a hampering step, restrict the export to the Orbit of technical data.

Under conditions of general war, the steps would be to prevent the acquisition of effective tube facilities in Western Europe and to destroy a number of selected industrial targets in the Orbit. No analysis has been made to date of the time before a pinch would be felt.

c. Intentions.

A reasonably accurate knowledge of actual and potential supplies could be used as a good indicator of probable intentions and courses of action. A firm estimate on the extent of stocks would be an indication of timing in preparing for general hostilities, in that large tube stocks are not otherwise needed. A more exact knowledge of the type distribution in supplies would indicate tactical kinds of military equipment and probable courses of action. A knowledge of the magnitude of supply would indicate the relative dependence of Soviet armed forces on electronic warfare and would indicate probable strategic courses of action.

(Continued on next page)

9. Gaps in Intelligence Material.

a. In CIA.

As indicated by this preliminary research report, three major faults exist in the intelligence effort on tubes at the present time:

(1) A considerable volume of undigested available information exists, requiring more research effort in both depth and scope. In particular, further effort is required to review information in IR, BR, and Graphics; to analyze PW reports, Wringer reports, and special sources; to develop better input factors; to study Soviet tube designs and methods; and to review related data on Satellite plants. For cross-checking, analysis of a large volume of related intelligence material is necessary, including special materials, plant constructions, and manpower data. It is believed, for example, that the estimated production at the three major Soviet plants of Svetlana, Elektrolampovy, and Radiolampa can be established within adequate limits by using available information.

Extreme lack of recent (postwar) detailed data and firm figures place the major dependence upon the extrapolation from fragmentary indications and upon technical evaluation of a variety of dependent and partially related factors. A large volume of such materials exists now, especially as related to plants, supplies, civilian uses, and organization. The most immediate return can be realized by authoritative research — namely, the applications of extensive evaluating and analytical effort to currently available material.

(2) No realistic appraisal of Soviet military requirements has been found, without which no conclusion of value can be made in a basic study on electronics. This particular intelligence does not depend primarily upon complete or new collection, but rather should be a product of competent US military judgment. This gap is most striking.

(3) The bulk of available information dates prior to the end of 1949. Collection of more recent economic data is necessary if any reasonable industry-wide estimate is to be made. The coordinated interrogation of leading German technical personnel should be the most fruitful channel. A selected list of a few key Soviet enterprises should be established as collection targets by covert means. One result of the lack of recent collection is the scarcity of information on newer plants. It is possible that the combined errors caused by the inadequacy of available material on newer operations could double the total output factor now accepted as the best estimate. There are at least four important Soviet tube plants on which information is scanty and on which there is no information except for existence and location.

Much of the work of the Soviet tube industry obviously is conducted under conditions of military security that further aggravate the normal lack of information on Soviet industrial data. No report from any source has provided a single factual figure on the tube output of any Soviet tube plant since the war. Therefore over-all figures must be estimated, using fragmentary data on a few input factors and on general production programs as pertaining to individual plants. The 1950 output for the USSR is estimated at 29 million tubes of all types, as derived from studies of individual plants. It is believed that the maximum possible range of total production of tubes would be from a minimum of 25 million to a maximum of 50 million.

In order to produce a better analysis of the Soviet tube industry, a workable plan for coordinated collection should be carried out, especially since potential sources do exist. The following steps should be taken:

(1) Further research — perhaps 2 man-months — should be done on Soviet input factors, on the consumption of materials and manpower, on biographic and plant equipment data, using information already collected but unselected.

(2) Properly guided collection should be initiated to obtain recent (1950) information from a number of German tube specialists reported to have returned from the USSR.

(3) A search of all available but unselected information from all sources must be concentrated on the following important facilities, which presently are analyzed superficially:

Novosibirsk Elektrolampovy Zavod 617.
Svirl Radiozavod 326, Gorki.
Sverdlovsk Tube Plant, Sverdlovsk (or Kamensk).
Ryazan Lamp Plant 33, Ryazan.
Tube Plant, Ufa.
Tube Plant, Tomsk.

It is noted that the CIA Library's machine-run for information on electron tubes, including both economic and scientific categories, was most ineffective in producing documents pertinent to tube plant operations.

b. Outside CIA.

Based upon available documents and productions and upon incomplete discussions, important intelligence work relative to Soviet electron tubes is conducted by G-2; by Technical Institute, AMC; and by Signal Corps Institute Agency. Most of this effort is directed toward technical and scientific intelligence rather than economic intelligence. A further review of intelligence work outside CIA is required to provide a complete picture.

c. Research Effort Required to Complete Intelligence Gaps.

The research effort required to complete the intelligence gaps in this report total 15 man-weeks. A breakdown of the research effort required for each phase of the study is as follows:

General description and use of electron tubes.	Reasonably adequate.
Development of the industry in the USSR.	Reasonably adequate.
Description and analysis of current technology.	Some collection and much analysis needed; estimate: 1 man-week in O/RR and O/SI.
Organization of the industry in the USSR.	More analysis required; estimate: ½ man-week in O/RR.
Importance of the industry.	Adequate.
Civilian requirements including export.	Reasonably adequate; further factual confirmation desirable; estimate: ½ man-week in O/RR.
Military requirements.	Extensive effort required; estimate: 2 man-weeks in O/RR and O/SI, plus adequate outside support.
Productive capacity.	Extensive research and collection effort required; estimate: 8 man-weeks in O/RR, exclusive of external collection effort.
Trends.	Refinement required; estimate: 1/4 man-week.
Stocks.	No data found; conclusions are rationalized. Confirmatory search needed; estimate: 1/4 man-week.
Sources of supply outside the USSR.	Reasonably adequate. Further research required as a by-product of other area studies.

Raw material input requirements.	Present figures based on US practices are not too far off.
Manpower input requirements.	Additional research required on Soviet material analysis, on reported shortages, and on economic warfare; estimate: possibly 2 man-weeks.
Conclusions (capabilities, vulnerabilities, and intentions).	Additional research needed to refine conclusion; estimate: ½ man-week.