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LINCOLN LABORATORY  
MEMORANDUM VI - L-84

TRANSITION SYSTEM FOR AIR DEFENSE  
ESTIMATE OF COST AND DELIVERY FOR THE INITIAL SECTOR

18 February 1953

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY  
CAMBRIDGE, MASSACHUSETTS

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Prepared by Division 2 and Division 6

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TRANSITION SYSTEM

## Estimated Cost for Initial Sector

1. INTRODUCTION

In Lincoln Laboratory Technical Memorandum No. 20 (second draft dated 2 January 1953) which describes the proposed Transition System for Air Defense, Section VIII indicates that a study is being made regarding the cost and time factors for an initial sector. This memorandum summarizes this information for a proposal which we believe to represent the best way to provide the maximum amount of coverage at the earliest practical date. The information here represents the professional judgment and opinion of members of the MIT Lincoln Laboratory staff; however, at this early stage of development it is necessarily general in nature. The figures express the order of magnitude of the job, but may not be regarded as numbers to which any industrial manufacturer, such as IBM Corporation, should be expected to conform without having opportunity to evaluate the matter in the light of their particular circumstances.

The costs referred to herein are over and above those of the research and development program which will lead to the design of the basic equipment and the construction of two prototype models for test and trial purposes.

2. CONDITIONS ON WHICH ESTIMATE IS BASED

In order to develop an estimated cost for the initial sector of the Transition System, it is necessary that certain variables and alternatives that are mentioned in Technical Memorandum No. 20 be resolved into definite conditions. The assumptions on which this estimate is based are enumerated below. These assumptions must be verified or altered to lead ultimately to the decisions which are needed prior to actual construction of equipment, buildings, etc.

- A. The sector selected for the first installation is the one portrayed in Figure 2 of the second draft of TM-20. It is the sector which includes Boston, New York and Philadelphia.
- B. The general organization of the Air Defense System visualized for this sector is one having three sub-sectors, each of which will contain a Center where data will be received and processed. For the purpose of the estimate, these three Centers are assumed to be located in the approximate vicinity of Westover, Stewart and Maguire Air Force Bases. At one of these Centers the Sector Command Post will be situated.

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2. CONDITIONS ON WHICH ESTIMATE IS BASED (Continued)

To achieve the maximum coverage at the earliest time and to minimize the effect of probable engineering difficulties with this early equipment, it is felt that the first of these three Centers to be installed in the first sector only should be set up with two digital computers as insurance of equipment performance reliability. Further, at no time prior to equipping the initial sector will opportunity exist for full scale engineering trial of the problem of automatic communication between two computers geographically separated from each other. With proper engineering, the need to relocate equipment or reroute communication circuits at the time of installation of the second and third Centers can be avoided. Thus we believe that this procedure offers, at a relatively small increase in cost, a significant advance in the time when a high degree of coverage can be available.

Once the initial sector has permitted solution of the engineering questions, we assume that other sectors will not require Centers with more than one computer at each location if communication circuits for transferring data between Centers are provided.

- C. Our estimate contemplates that the Center will comprise two major elements:
1. An underground building as protection against bomb damage to house the computer and associated input, output, display and communications equipment.
  2. Conventional above-ground administrative buildings for headquarters, mess, barracks, etc. for the officers and troops stationed at the location.
- D. The type and amount of input equipment at each Center, and the number of telephone circuits for communication between Centers included in the estimate will provide for data from each radar set to be available at all times at two of the three Centers in the sector. Thus, if one Center should become inoperative through malfunctioning, sabotage, bomb damage, etc., the second location will be in position to immediately continue generating guidance and command instructions for the weapons that the inoperative Center had been controlling.

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2. CONDITIONS ON WHICH ESTIMATE IS BASED (Continued)

- E. Within the initial sector it is assumed that radar data will be available from the five presently installed G.C.I. stations, and from a network of gap-filler radars (average five in number) surrounding each of these long-range radars.

Note: Figure 1 attached shows a proposed network of radars which was used in connection with the preparation of this estimate.

3. ESTIMATED COST

In line with the conditions cited above, we estimate the cost of the initial sector having three Centers, one of which will contain a duplex computer installation, to be

	<u>Center with duplex computer</u>	<u>Center with single computer</u>
I EQUIPMENT	\$ 8,167,900	\$ 5,875,900
II INSTALLATION	525,100	433,900
III REAL ESTATE & BUILDINGS	3,457,600	3,082,600
	<u>\$12,150,600</u>	<u>\$ 9,392,400</u>

Refer to Table A attached for details regarding these figures.

Note: Since future sectors beyond the first do not contemplate a Center having a duplex computer installation, a cost of \$9,400,000 per Center may be regarded as a typical figure for subsequent sectors having Centers each with a single computer.

In addition to the above, to set up for the manufacture of the electronic equipment, i.e., digital computer, input and output systems, it has been assumed that the manufacturer will require a plant facility and other items of expense indicated on Table B attached, which will total \$8,515,000. We estimate that this will provide capacity to permit the manufacture of equipment for one Center per month on a single shift basis. Since this may be regarded as a set-up expense and will not recur, it is a necessary cost of the initial sector but not of subsequent sectors.

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3. ESTIMATED COST (Continued)

Thus, the total expense may be summarized as follows:

	Estimate for the first Sector	Estimate for sub- sequent Sectors (assuming three Centers)
	_____	_____
Buildings, Equipment and Installation for Center having a duplex computer	\$ 12,150,600	
Buildings, Equipment and Installation for Centers having a single computer at \$9,392,400 each	18,784,800	\$ 28,177,200
Set-up expense for manufac- turing facility, etc.	<u>8,515,000</u>	_____
Total	\$ 39,450,400	\$ 28,177,200

To set up for facilities and manufacture the required equipment several years will be required, and therefore provision of the funds may be spread over this period. The approximate amount required for the first Sector in each fiscal year is estimated at

FY 54	\$ 14,000,000
FY 55	15,500,000
FY 56	10,000,000

4. ESTIMATED DELIVERY OF EQUIPMENT

Provision of the funds in the amount and manner indicated above, and authorization to proceed with all phases of the project by 1 July 1953 envisions the equipment for the initial Center becoming available about mid-1955, with the balance of the equipment required for the initial sector being available about the end of 1955. With installation carried out as rapidly as the equipment is delivered by the manufacturer, we believe that the complete sector could be set up and placed in operation by the latter part of 1956. The time estimates are those the Lincoln Laboratory believes possible, and have not yet been studied in detail by a contractor who would execute the contract.

Provision of equipment for additional sectors on a continuing basis will depend on authorization being made at the time deemed necessary by the manufacturer.

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5. ESTIMATED OPERATING COST FOR INITIAL SECTOR TRANSITION SYSTEM

The Transition Air Defense System contemplated herein represents a major installation of equipment which entails certain annual operating costs. Table C attached itemizes our estimate of these costs which total \$1,504,000 per year for the Center having the duplex computer installation, and \$1,085,900 per year for each Center having a single computer. The total annual operating cost for the initial sector therefore will be \$3,676,700. (See the next section for items not included.)

Note: Since additional sectors are assumed to contain Centers having a single computer at each location, the estimated yearly operating cost for these is \$3,257,700.

6. ITEMS NOT INCLUDED IN THE ESTIMATE

The estimate of the cost of the sector does not provide for the expense of

- (a) troops (estimated at 700 men) stationed at each of the Information & Direction Centers;
- (b) supporting equipment for troops;
- (c) radar sets - data will be taken from the sets which comprise the radar net which will exist at the time the Centers are installed (SDV equipment to accept radar data and transmit it to Center is included in cost figures);
- (d) ground-to-air automatic digital data link - this equipment with associated radio transmitters must be provided in connection with future weapons regardless of the system that generates command instructions;
- (e) depreciation on the capital investment the equipment represents;
- (f) continued work in connection with operational studies and analyses, development of programs to suit new weapons and tactics, improvement in equipment performance, etc.

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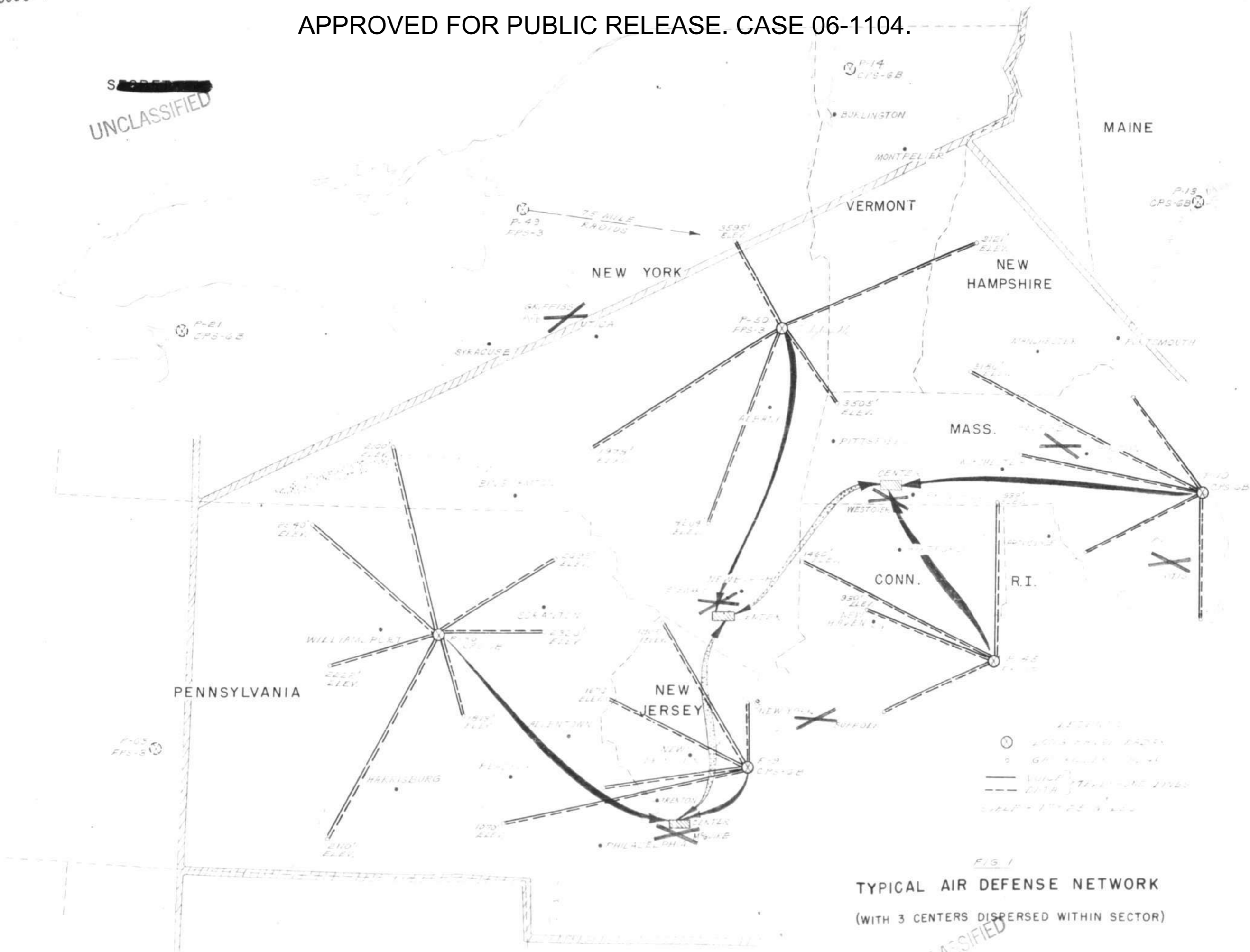


FIG. 1  
TYPICAL AIR DEFENSE NETWORK  
(WITH 3 CENTERS DISPERSED WITHIN SECTOR)

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TABLE A  
TRANSITION SYSTEM

<u>Estimated Cost for Equipment, Installation &amp; Buildings</u>	<u>Center with Duplex Computer</u>	<u>Center with Single Computer</u>
<u>I EQUIPMENT</u>		
A. Computer & associated equipment at center	\$ 3,800,000	\$ 2,280,000
(1) Peculiar test equipment & tools	200,000	100,000
B. Radar data input systems (SDV)	500,000	500,000
C. Output data & display systems	478,000	478,000
D. System installation & application engineering	400,000	400,000
E. Telephone system equipment	100,000	90,000
F. Teletype system equipment	22,600	22,600
G. Spare parts for installation and first year operation	735,000	525,000
H. Standby power generating equipment	171,000	126,000
J. Standard test equipment and tools	350,000	350,000
K. Standard furniture and fixtures for center	50,000	25,000
L. Miscellaneous undesignated items and contingencies (20%)	1,361,300	979,300
SUB-TOTAL	\$ 8,167,900	\$ 5,875,900
<u>II. INSTALLATION</u>		
A. Computer and associated equipment at center	200,000	150,000
B. Radar data input systems (SDV)	18,600	18,600
C. Data output and display systems	23,000	23,000
D. Telephone and teletype equipment	11,000	10,000
E. Standby power generating equipment	45,000	35,000
F. Commercial power substation (Installation plus provision of equipment)	140,000	125,000
G. Miscellaneous undesignated items and contingencies (20%)	87,500	72,300
SUB-TOTAL	\$ 525,100	\$ 433,900

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TABLE A (Continued)

<u>III REAL ESTATE &amp; BUILDINGS</u>	<u>Center with Duplex Computer</u>	<u>Center with Single Computer</u>
A. Lease for site of center	\$ 100	\$ 100
B. Leased right of easement for power and phone lines	2,000	2,000
C. Operations center building (underground)	2,000,000	1,625,000
D. Administrative buildings at site	1,000,000	1,000,000
E. Security protection provisions	47,500	47,500
F. Acquisition of land for access road	8,000	8,000
G. Access road construction	100,000	100,000
H. Water and sewerage system	300,000	300,000
SUB-TOTAL	\$ 3,457,600	\$ 3,082,600
TOTAL	\$12,150,600	\$ 9,392,400

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DESCRIPTION OF ITEMS FOR WHICH ESTIMATED COST IS SHOWN ON TABLE AI Equipment

- A. A high speed parallel digital computer with associated equipment to accept radar and other input data and to provide output information for display and command purposes. The complement of equipment at each Center is sufficient to suit the number of operating personnel for emergency conditions as indicated in Col.(b) p. 110 of TM-20, second draft.
- B. The amount of radar input (SDV) equipment provided will permit each Center to accept data not only from the radars regularly assigned to that location, but also the full complement of data normally received at an adjacent Center.
- C. Equipment is provided to permit output data transmission to voice radio and G/A digital link transmitter locations, and to transmit and display data on tote boards at AAOC, EADF and ADC.
- D. This cost provides for engineering effort involved with arrangement and layout of equipment in Center, including power installation and distribution, air conditioning and ventilation system, as well as installation and interconnection of equipment to Radars, telephone circuits, teletype circuits, G/A link equipment, etc. Also engineering on problem of automatic communication between geographically separated Centers.
- E. A telephone system covering both the operations (underground) building and administrative buildings above ground, to provide for circuits which handle input and output data and voice links as well as normal internal and external telephone communications for the Base.
- F. Teletype equipment to receive and transmit input and output data and to confirm information initially transmitted by voice communication. Also provides for Facsimile equipment for receiving weather information.
- G. A figure equal to 15% of the value of the electronic equipment has been included for spare parts that will be required for installation and first year's operation supply. Since the system is one where crosstopping between Centers provides spare and emergency capacity, it is not contemplated that major elements of the computer will be considered as spare parts and therefore the percentage figure usually applied to electronic equipment has been reduced to 15% in this instance.

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I Equipment (Continued)

- H. Diesel operated generators to provide emergency standby power are contemplated. Capacity is provided to handle the operations at the Center as well as the normal requirements for administrative functions.
- J. Approximately 15% of the cost of equipment is provided for test equipment and tools. This amount has been reduced by the value of Peculiar Test Equipment and tools indicated under IA.
- K. This figure provides for items such as office, conference room and briefing room furniture, map boards, slide and movie projection equipment, intercom page system, etc. in the underground operations building. It does not provide for equipment required in barracks, mess, etc. for use by troops stationed at base.
- L. In view of fact that the estimate is prepared at an early stage of the evolution of the system and equipment development is similarly just getting under way, allowance for undesignated items has been included.

II Installation

- A. Installation and debugging of the equipment described in IA above.
- B. Installation and debugging of equipment under IB above.
- C. Installation and debugging of equipment under IC above.
- D. Installation of telephone and teletype equipment described in IE and IF above.
- E. Installation of standby diesel generator equipment described in IH above.
- F. Provision and installation of a sub-station to provide sufficient primary power to operate the equipment in the underground building and the administrative buildings situated above ground.
- G. Allowance for the installation of undesignated items mentioned in IL above.

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III Real Estate and Buildings

- A. Provides for long-term lease of site (in line with past practice of leasing sites for G.C.I. Stations).

NOTE: If outright acquisition of land is desired, approximately 100 acres will be required for each site. It is estimated that suitable land may be acquired at a cost of \$200.00 per acre.

- B. Leased right of easement for power and phone lines required for communication network. The estimate envisions that approaching the Center (the last few miles) where large numbers of circuits are grouped there will be two alternate routes, with lines preferably underground as protection against weather damage, sabotage, etc.
- C. Underground operations building for the Center with space provided for all operations equipment and functions:

Communications input and output equipment;  
Standby power equipment building;  
Heating and ventilation equipment;  
Maintenance laboratory.

For a Center having a single computer it is estimated that 25,000 square feet of floor area on two levels is needed. (For a Center having a duplex computer installation, it is estimated that 31,000 square feet on two levels is required.)

- D. Conventional above-ground administrative and supply buildings to accomodate approximately 700 people.
- E. Provides for enclosing the area using approved type security fencing.
- F. Acquisition of right of way for access roads to site of Center.
- G. Construction costs are estimated for an average of two miles of road at each location, (for approach access roadways within Center).
- H. The estimate covers systems to accommodate 700 to 900 people at each location.

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TABLE B

## TRANSITION SYSTEM

<u>Estimate of Non-recurring Set-up Expense</u>	<u>Amount</u>
A. Manufacturing plant facility to produce electronics	\$2,500,000
B. Production tools, test equipment, methods and process engineering expense	3,440,000
C. Overall management and coordination of project planning and installation	500,000
D. Preparation of operation and maintenance manuals	650,000
E. Miscellaneous other items and contingencies (20%)	1,425,000
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TOTAL	\$8,515,000

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DESCRIPTION OF ITEMS FOR WHICH ESTIMATED COST IS SHOWN ON TABLE B

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- A. In view of the magnitude of the project, it has been assumed that any industrial organization who would undertake manufacture of the equipment would require additional plant facility to keep manufacture of all portions of the equipment housed together in order to permit close engineering coordination and control of quality. Based on subcontracting of parts, a manufacturing plant of 100,000 square feet is estimated for assembly and testing of equipment to be delivered at a rate to permit installation of one Center per month. (Plant operations on a 5-day week, single shift basis.)
  - B. Provides for tools, jigs and fixtures; test equipment for control of performance of components, assemblies and systems; manufacturing engineering of methods processes, plant layout and material handling, and inspection and quality control for the manufacture of equipment covered by items IA, IB and IC of Table A.
  - C. Provides for contractor management in planning and coordination of schedules and follow-up work in connection with construction and installation of equipment at the Center. Liaison will be required with many organizations such as Air Force, Corps of Engineers, Signal Corps, telephone company, power company, outside vendors and subcontractors, etc.
  - D. Provides for preparation of an operating manual per military specifications, and a maintenance manual of the type that would be suitable for use under arrangements of contractor-supplied maintenance; (this latter manual may not conform to all military specifications).
  - E. Contingency factor for undesignated items of setup expense that may be encountered but cannot be detailed at this early date.

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## TRANSITION SYSTEM

<u>Estimate of Sustained Operating Costs (Yearly Basis)</u>	<u>Center with Duplex Computer</u>	<u>Center with Single Computer</u>
A. Telephone circuit rental	\$327,600	\$327,600
B. Teletype circuit rental	15,300	15,300
C. Standard IBM machine rental	18,000	18,000
D. Contractor-supplied maintenance service	570,000	310,000
E. Purchased electric power	78,000	60,000
F. Fuel for heating and diesel- generators	6,000	5,000
G. Spare parts replacement (2nd year and on)	490,000	350,000
SUB-TOTAL	\$1,504,900	\$1,085,900

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DESCRIPTION OF ITEMS FOR WHICH ESTIMATED COST IS SHOWN ON TABLE C

- A. Provides for rental of telephone circuits for an average length of voice communication and data transmission lines that will be required with each Center (based on typical network shown in Fig. 1). A figure of \$3.00 per month per mile was used for telephone circuit rental.
- B. Provides for rental of estimated average length of teletype circuits required per Center at cost of \$1.50 per month per mile.
- C. Operation of the Center will require a number of standard IBM card machines which will be obtained on a rental basis in accord with their established business practice.
- D. The system envisions contractor-supplied maintenance service on a three-shift basis. The estimated cost provides for both engineering and technicians as indicated in TM-20, p. 111.
- E. Provides for the cost of purchased commercial electric power which will be the supply under normal operating conditions.
- F. Self-explanatory.
- G. Replacement spare parts for second year and future service periods are estimated at 10% of the value of the electronic equipment.

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