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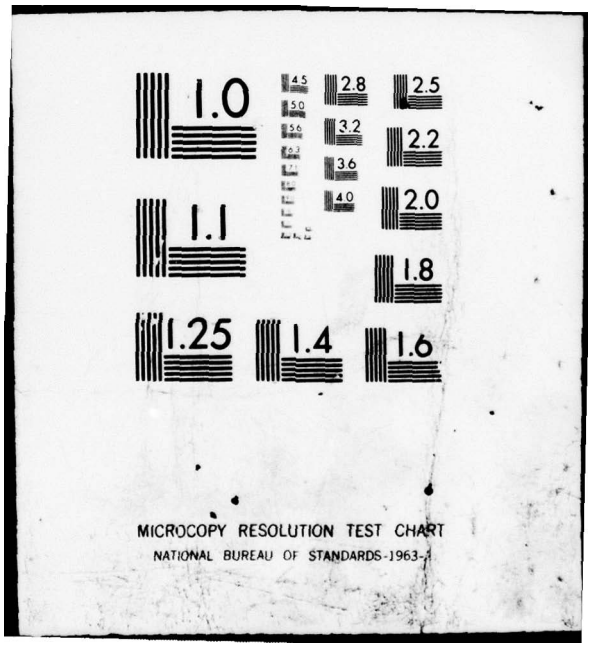
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. Summary Report: LCC/DTC TASKS CONDUCTED FOR GPS ARMY USER EQUIPMENT

June 1979

Prepared for

U.S. ARMY DEPUTY PROGRAM MANAGER, SATCOMA
GPS JOINT PROGRAM OFFICE
SPACE AND MISSILE SYSTEMS ORGANIZATION
El Segundo, California

Under Contract F04701-76-C-0028

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1
INTRODUCTION

1.1 SCOPE

Under Contract F04701-76-C-0028 with the USAF Space and Missile Systems Organization (SAMSO), ARINC Research Corporation performed tasks in the life cycle cost/design-to-cost (LCC/DTC) area to support development of Army user equipment (UE) for the Global Positioning System (GPS). The contract time period was from October 1975 to 30 June 1979. The effort was conducted under the technical direction of the Army GPS Deputy Program Manager (SAMSO/YEA) and the Contracting Officer's Representative in the GPS Logistics Directorate (SAMSO/YEL). This report summarizes the tasks performed and documents delivered during the contract period.

1.2 BACKGROUND

1.2.1 GPS Program

The NAVSTAR Global Positioning System is a satellite-based, worldwide positioning and navigation system being developed as a joint service effort. The U.S. Air Force is the executive service for the system, and the Joint Program Office (JPO) is located at the Air Force Space and Missile Systems Organization facility in El Segundo, California.

During the contract period the GPS was in the concept validation phase, proceeding toward a Defense System Acquisition Review Council (DSARC) Milestone II in May 1979. In preparation for this review, the Army SARC (ASARC II) review was completed in April 1979. At the DSARC II review, the JPO received approval to proceed into the full scale development (FSD) phase of the GPS program.

During concept validation, the JPO has awarded multiple development contracts for GPS UE. The multiple contracts serve to maintain industry competition, reduce program risk, and promote development of specialized UE for unique applications.

Emphasis has been on the evaluation of alternative design and operational concepts, promotion of joint-service equipment commonality, and reduction of system life cycle cost.

Each development contractor has been performing cost estimating and LCC/DTC tradeoff tasks as a part of his concept validation effort. In addition, a separate set of four study contracts has been awarded by the JPO. Those four studies, being performed by hardware developers, are preparatory to the FSD phase and constitute the first step in a series of competitive activities leading to the first UE production contract following DSARC III.

The JPO has been conducting LCC/DTC trades internally, in addition to those performed by the UE contractors. Early in the concept validation phase, many of those cost analyses were performed using an LCC model created by ARINC Research under a previous contract with SAMSO (F09603-73-A-0933-TB01). The Army, however, in preparing for its own in-service reviews and analyses, desired an LCC model tailored more specifically toward Army cost structure and support concepts. Such a model was developed and updated as appropriate during the course of the current contract. The JPO, to update its joint-service cost modeling capability, has adapted the Army model to treat joint service factors in more detail. That adapted model was also provided to the four pre-FSD study contractors for use in their LCC/DTC analyses.

1.2.2 Contract Activities

Basic tasks under this contract included the following:

a. Developing the Army LCC model

b. Developing Army UE data files to feed the model and conduct tradeoff analyses

c. Monitoring UE development contractor activities in the LCC/DTC area

d. Analyzing Army UE development program cost/schedule risks

e. Updating and expanding the original LCC model to include additional cost categories, revise the cost breakdown structure, and modify output formats and options

f. Preparing cost estimates to support the Army Positioning/Navigation Cost and Operational Effectiveness Assessment (COEA)

g. Supporting preparation of the Army GPS UE Baseline Cost Estimate (BCE) for ASARC II and DSARC II presentation.

Results of these efforts have been documented in various formats, including formal reports, LCC model user's guides, technical notes, and informal briefings or summaries for working sessions. Specific documents delivered are identified in the following section.

2
IMPLEMENTATION OF TASKS

2.1 ARMY LCC MODEL

This contracted effort began with the development by ARINC Research of a new life cycle cost model for Army use in conducting tradeoffs and generating LCC estimates. The first step in that task was a thorough review of existing models, including those from Army, Air Force, and JPO sources. Features of existing models which seemed applicable to the equipment or support concepts for Army GPS UE were identified as candidates for use in the new model. Extensive consultation with Army and Logistics Directorate personnel at JPO and Cost Analysis Office personnel at the Army Satellite Communications Agency (SATCOMA) also provided guidance and requirements definition for the model.

The LCC model was then defined in terms of cost categories to be included, assumptions and ground rules to be built into the algorithms, and the execution options to be provided. After a review of that definition with the JPO, the model was refined and implemented in FORTRAN IV for timesharing, interactive use on Control Data Corporation computers. The program was then modified and installed by ARINC Research on the Burrough 5700 computer at Ft. Monmouth for use by SATCOMA personnel. The model and both implementations are documented in ARINC Research publication 1172-02-1-1528, Life Cycle Cost Model for Army User Equipment of NAVSTAR Global Positioning System, August 1976.

Several modifications and corrections to the model were made subsequent to the above publication, and are described in a May 1977 revision to the report. The revised model forms the basis for the current JPO LCC model used in the pre-DSARC II studies. The JPO form of the model was prepared, documented, and installed at the JPO by Logistics Directorate personnel.

During the past year, the Army decided that the model should be expanded to include all cost elements defined in Army Pamphlets 11-2 through 11-5, even though some of those elements are not required for GPS UE LCC calculations. It also

appeared desirable to restructure the output of the model to conform directly to the cost breakdowns and reporting formats required by those pamphlets. Those revisions were accomplished, with the implementation again being in FORTRAN IV for time-sharing use on CDC systems. A copy of the source deck was provided to SATCOMA for installation on timesharing services available at Ft. Monmouth. The user's manual for the upgraded version of the model has been prepared by ARINC Research and documented in ARINC Research publication 1172-02-5-1913, Life Cycle Cost Model for Army User Equipment of NAVSTAR Global Positioning System, April 1979. The upgraded LCC model was used to generate the Baseline Cost Estimate for Army GPS UE in late 1978 and early 1979.

2.2 DATA FILES AND CONTRACTOR MONITORING

The LCC model, in all versions, uses several input data files to define the UE, its procurement and operational concept, and a variety of cost factors. In general, these input data fall into two categories: those independent of and those dependent on UE type. Both categories of files have been developed and maintained by ARINC Research throughout the study effort.

Data elements independent of UE type tend to represent economic factors (e.g., pay rates for personnel), GPS program planning factors (e.g., identification of base year dollars), or support factors common to all UE types (e.g., number of depots, cost of entering a new item into the inventory, etc.). ARINC Research identified the necessary factors for inclusion in these files and gathered the data to define their values. The data were collected during visits and interviews at Army support facilities and organizations, and from official Army and DoD documentation; and then compiled by mutual agreement with JPO and SATCOMA personnel to represent the Army UE support and operational concepts. These factors have been updated during the contract period as impacted by inflation, changes in the Army support structure, changing user requirements, etc.

Data elements dependent upon UE type, and therefore descriptive of some aspect of the UE, have been established through use of development contractor inputs, UE specification parameters, and statements of user requirements; as well as from mutual analysis efforts of JPO and ARINC Research. A number of such UE-dependent files have been established and maintained during the course of the contract as UE

concepts changed and alternatives were considered. The files were also updated as required to account for inflation, specification changes, user requirement changes, etc.

Data gathered from the UE development contractors were obtained through interviews, questionnaires, documentation review, and attendance at design reviews. Separate files were established and maintained for the different contractors, to define independently their respective design concepts and to protect any proprietary information obtained.

In addition to being applied in cost analyses in support of the JPO, the information obtained from the UE contractors was also used to monitor their progress in the LCC/DTC area in general. The data were assessed in terms of how thoroughly and adequately LCC was being addressed during the development. Parametric and sensitivity trades were also performed for each manufacturer's concepts to identify cost-risk areas and factors for design tradeoffs with significant cost-saving potential. Development contractor concepts were also compared on an inter-contractor basis, standardizing cost factors not dependent on the individual concepts, in order to provide impartial comparison of their approaches and to highlight the benefits and disadvantages of each.

To support the cost estimates generated in these studies, the contents of the data files have been documented as appropriate at various points in time. The contractor monitoring tradeoff activities, having extended over a long period of time, have been reported primarily in working notes and informal briefings presented to JPO personnel throughout the contract period.

2.3 RISK ANALYSIS

A statistical analysis was conducted to assess the risk or uncertainty associated with the FSD program planned for Army UE. The analysis was conducted in early 1977 and was reported in ARINC Research publication W77-1172-TN01, Cost/Schedule Risk Analysis of Engineering Development Phase for Army User Equipment of GPS, April, 1977. The analysis was based upon the latest available Army planning information for FSD.

The statistical analyses were conducted utilizing the Army's "Advanced SOLVNET" computer program, modified slightly to run on CDC timesharing systems available to ARINC Research. That model represents a program plan in terms of a PERT-type network diagram, accepting input data for each branch and node of the network to define program activities and events, respectively. The inputs define the anticipated best, worst, and median cases for duration and costs of activities as well as the logical relationships between events and task initiation or completion. SOLVNET then exercises the program network as modeled, applying Monte Carlo techniques to generate a statistical distribution of completion times and costs, together with tabular data regarding event or activity criticality.

ARINC Research developed a complete set of input data, exercised the model, and documented the results. The input data, supporting rationale, and results are all reported in the above-referenced document.

2.4 COEA INPUTS

As a part of the GPS UE development process, the Army conducted a COEA comparing many alternative positioning/navigation concepts including GPS. The COEA determined the relative cost effectiveness of each of the alternative's ability to satisfy stated Army user requirements. The life cycle cost data for each alternative were provided by various program offices and Army analysis organizations as inputs to the COEA process.

ARINC Research supported the GPS Army Deputy Program Manager and the SATCOMA Cost Analysis office in preparing the LCC inputs for GPS UE. The cost model developed under this contract was used extensively to generate LCC estimates. Costing ground rules and user requirements for the initial effort were provided by the Army and reflected in the data files prepared for model runs. Results of the costing were documented, in Army Pamphlet 11-5 format, in ARINC Research publication 1172-02-3-1712, Global Positioning System Life Cycle Cost Estimates to Support Positioning and Navigation Cost and Operational Effectiveness Analysis, February 1978. ARINC Research also supported a series of briefings and working sessions at other Army commands to validate and explain the cost estimates.

The first iteration of the COEA revealed some incompatibilities in the ground rules and assumptions used in preparing LCC estimates for various systems. In

response to an Army decision to refine the COEA and eliminate those incompatibilities, ARINC Research modified the input data file contents to conform to newly defined assumptions and scenarios and then generated updated UE LCC estimates. Those updated estimates are reported in a September 1978 revision to the above-cited COEA input document. The new estimates were again supported by ARINC Research through briefings and working sessions.

2.5 BCE INPUTS

In preparation for the ASARC II and DSARC II reviews, the JPO and SATCOMA updated the Army GPS UE Baseline Cost Estimate, which is the official Army budgetary estimate for UE LCC. This estimate was generated using the latest version of the LCC model developed under this contract. ARINC Research prepared and maintained all data files for this process and exercised the model to generate the LCC estimates. Data for the files was drawn from a variety of sources, including UE specifications, UE development contractor analyses, JPO analyses, official government documentation, and best engineering judgment by various program participants. The data files, alternative scenarios, and cost analyses were all generated under close coordination with cognizant JPO and SATCOMA personnel, particularly in the Research and Development cost area.

The initial version of the BCE was prepared and submitted as ARINC Research publication 1172-02-4-1834, Global Positioning System Baseline Cost Estimate, December 1978. The validation review at CORADCOM generated a number of corrections, revisions, and clarifications required for the BCE documentation. Consequently, the report was revised and the final two-volume document was prepared and submitted as ARINC Research publication 1172-02-4-1834R, Global Positioning System Baseline Cost Estimate, April 1979 (Second Revision).