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AVIONICS COST DEVELOPMENT FOR USE OF LORAN-C NAVIGATION SYSTEMS--ETC(U)

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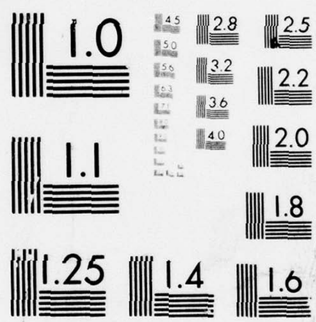

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Publication 1326-01-8-1906

FINAL REPORT

AVIONICS COST DEVELOPMENT FOR USE OF LORAN-C NAVIGATION SYSTEMS BY LOW-PERFORMANCE GENERAL-AVIATION AIRCRAFT

April 1979

Prepared for
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
OFFICE OF SYSTEMS ENGINEERING MANAGEMENT
WASHINGTON, D.C. 20591
under Contract DOT-FA76WA-3788

ARINC RESEARCH CORPORATION

This Avionics cost study of the Long-Range Navigation (LORAN-C) system used by low-preformance general aviation aircraft, performed for the Federal Aviation Administration (FAA) Office of Systems Engineering Management (OSEM), was based on a uniform approach to cost estimating with the assistance of a pricing model.

The system evaluated is the Teledyne TDL-711 LORAN Micro-Navigator, with approporiate design and packaging modifications to meet the less stringent environmental and packaging requirements of general aviation.

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by

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SUMMARY

This avionics cost study of the Long-Range Navigation (LORAN-C) system used by low-performance general-aviation aircraft, performed for the Federal Aviation Administration (FAA) Office of Systems Engineering Management (OSEM), was based on a uniform approach to cost estimating with the assistance of a pricing model.

The system evaluated is the Teledyne TDL-711 LORAN Micro-Navigator, with appropriate design and packaging modifications to meet the less stringent environmental and packaging requirements of general aviation.

The LORAN-C system in its airborne configuration requires a receiver, a control and display unit, and an antenna with a built-in coupler. The expected costs of the avionics required by single- and light-twin-engine aircraft were developed by using a parametric cost-estimating model. These costs, shown in Table S-1, are in 1977 dollars, without inflation, and are based on annual production quantities of 1,000 units. Development costs were amortized over a 3,000-unit production quantity. The 1977 dollars were used to facilitate comparison with other cost results of alternative navigation systems previously evaluated by ARINC Research for the FAA.

Table S-1. ACQUISITION COST OF LORAN-C AVIONICS FOR LOW-PERFORMANCE GENERAL-AVIATION AIRCRAFT

Equipment	Cost (Dollars)
Receiver Unit	1,408
Control and Display Unit	628
Antenna with Coupler	150
Total System Cost	2,186

CONTENTS

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

Long-range navigation capability has been enhanced through the development and installation of Long-Range Navigation (LORAN) systems in many parts of the world. Recent improvements to the system through the introduction of LORAN-C have provided position-determining accuracies that appear suitable for use by the low-performance general-aviation class of aircraft navigating in the National Air Space (NAS).

As part of a Federal Aviation Administration (FAA) program to review new candidates for navigation, the Office of Systems Engineering Management (OSEM) is examining the LORAN-C concept and has tasked ARINC Research Corporation, under Contract DOT-FA76WA-3788, to develop probable acquisition costs of low-performance aircraft LORAN-C avionics.

This study addresses only issues relating to the economic feasibility of a LORAN-C-based navigation concept, developing expected acquisition costs of the required avionics.

1.2 PROJECT OVERVIEW

The objective of the analysis is to develop an independent assessment of the cost of avionics required to implement a LORAN-C navigation concept in the low-performance civilian aircraft on the basis of designs being developed for the high-performance aircraft. To meet this objective it has been necessary to review the LORAN-C avionic equipments being developed and adapt one of the designs to the typical general-aviation practices of manufacturing avionics for use by low-performance aircraft.

ARINC Research is developing the cost of LORAN-C avionics by applying a commercially available pricing model. This report describes the methodology and constraints applied to ensure uniformity in the cost development and presents the results of the application of the pricing model.

1.3 ORGANIZATION OF THE REPORT

Chapter Two describes the pricing model used in the study, together with the parametric data required to execute the model.

Chapter Three is an evaluation of the system and the costs of the avionics required for implementing the system.

Chapter Four presents the results of the evaluation and the expected cost of avionics required for system operation in low-performance aircraft.

The Appendix lists the input parameters used by the pricing model.

CHAPTER TWO

COST-ESTIMATING METHODOLOGY

The equipment costs developed in this study will provide the basis for comparing various concepts intended to improve navigation accuracy in the next generation of Air Traffic Control (ATC) systems. Careful development of these data is an essential step in the overall analysis of the alternatives. This chapter addresses the method used in the study and describes the model chosen for cost estimating and evaluation.

2.1 PARAMETRIC METHOD

The model chosen for equipment pricing, the RCA Programmed Review of Information for Costing and Evaluation (PRICE), requires a set of parametric data inputs that properly define the module, or system, to be priced. The model was chosen because of its wide acceptance by military branches of the Federal Government as a computer-based pricing model. Of the many input parameters required, the most critical cost-driving ones are the weight, volume, and structural-electronic division; manufacturing complexities; and markups for overhead, G&A, and profit. Since manufacturing complexities vary among manufacturers in different fields (e.g., avionics for ARINC class or general-aviation class equipments), a detailed characterization is necessary for each manufacturer expected to produce avionic equipment.

ARINC Research has studied the manufacturing complexities of several key manufacturers of avionics by thoroughly reviewing existing avionics, collecting data at various avionics plants, and frequently exercising the PRICE model to establish the typical values for manufacturing complexities. To ensure accuracy in characterizations of existing equipment, all modules of a specific item of avionics were measured and weighed. The process was repeated on numerous types of avionics to enhance the accuracy of the parametric analyses.

The results were compiled and stored in ARINC Research data files, and they were used in estimating the cost of the avionics considered in this study.

2.2 THE PRICE MODEL

PRICE is a computerized parametric cost-modeling technique developed by RCA. It estimates development and production costs on the basis of physical and economic descriptors of the systems evaluated and compares new requirements with industry-wide data bases on analogous systems. PRICE efficiently stores, retrieves, and uses the historical information. Effective use of such empirical data allows classifying new designs by relating them to past similar design efforts. The method provides the means of reducing great quantities of empirical data to a relatively small number of principal variables that can be adjusted to match the economic and technological characteristics of the specific system.

2.3 MODEL INPUT DATA

The model requires up to 40 parametric data inputs describing the physical and economic characteristics of the system or subassembly to be evaluated. When operated in the subassembly mode, the model requires similar inputs for all subassemblies and provides the means for final test and integration of the system. In general, the latter mode was employed for the cost estimates in this study.

The physical descriptors included such key features as weight of structure and electronics, packaging densities, volumes, quantities to be produced, manufacturing complexities, and degree of new design. Since the model is structured to provide a cost-per-pound based on densities and complexities, an accurate determination of the probable weight and volume of the subassembly being evaluated is essential.

The economic descriptors include such features as year of production, escalation rates, engineering schedules, production schedules, and management activities required during development and production. Schedules must be carefully selected because the final costs developed by the model are affected by the complexity of a product and the time allowed for its development and production. Other costs, such as those for management, tooling, or test equipment, have been normalized to the RCA data bank and are altered through sensitivity analyses and adaptation to specific manufacturers.

The key input parameters are listed in Table 2-1 in the format used throughout the study. Abbreviations and acronyms used are defined to provide an insight into the parametric data employed by the model. The Appendix provides a complete list of input parameters used by the model.

2.4 MODEL OUTPUT DATA

The RCA PRICE model performs a series of evaluations based on the input parametric data and provides costs as a function of the elements associated with engineering and manufacturing for both development and

Table 2-1. KEY PRICE PHYSICAL AND ECONOMIC DESCRIPTORS	
Descriptor Acronym or Abbreviation	Description
QTY	Total quantity to be produced
WT	Weight of assembly (subassembly) in pounds
VOL	Volume of assembly (subassembly) in cubic feet
WS	Weight of structure (nonelectronic) of assembly in pounds
MCPLXS	Manufacturing complexity for structure
NEWST	Percent of new design required for structure
MCPLXE	Manufacturing complexity for electronics
NEWEL	Percent of new design required for electronics
CMPNTS	Number of electronic components
ECMPLX	Engineering complexity of assembly (subassembly)
PRMTH	Production period in months
LCURVE	Production learning curve
ECNE	Engineering change orders for electronics, in percent
ECNS	Engineering change orders for structure, in percent
YEAR	Year of technology (usual start of design/production)
ESC	Escalation rate in percent
PROJCT	Degree of project management support during engineering
DATA	Degree of data requirements
TLGTST	Degree of special tools and test equipment required for development
PLTFM	Factor for reliability testing, specification severity
SYSTEM	Degree of system engineering required
PPROJ	Degree of project management support during production
PDATA	Degree of data required during production
PTLGTS	Degree of special tools and test equipment required for production

production of a system or subassembly. Engineering costs include the cost of drafting, design, system management, project management, and data documentation required during system development and production. The costs are presented for the entire production quantity for the development and production period on the basis of the data input parameter set; they include the effect of learning. Manufacturing is concerned primarily with the production of a system, but it also includes costs for prototype development and special tools or test equipment that might be required during development. As in the case of engineering, the output costs are for the entire production quantity with no escalation.

During program execution, the model frequently compares schedules, packaging densities, and other key input parameters with historical data in the RCA data banks. Abnormal inputs, such as too short development periods, are flagged and brought to the attention of the operator.

The output data sheet contains in the header all the information used as the parametric input to the model; it also provides the key parameters used in the derivation of the costs as a means to check the reason ableness of the results. Finally, the output data sheet provides the expected cost estimated by the program, bounded by approximately two-sigma level-of-confidence costs. The confidence intervals, although available from the model results, are omitted from this study to keep it similar to other economic analysis reports used in the evaluation of future ATC alternatives. A copy of a typical model output data sheet is provided in the Appendix.

CHAPTER THREE

LONG-RANGE NAVIGATION (LORAN)

Long-range navigation is a concept developed in the 1940s to allow position determination by reception of radio signals transmitted from two ground stations separated in space but synchronized in time. The transmission of pulses from each station is omnidirectional, but the intersection of the propagated waves from two stations generates a loci of points that form hyperbolic arcs which are related by time or distance from the stations. With the assistance of charts prepared for areas of coverage, a vessel is able to determine its line of position by measuring the time differences of the two synchronized pulses as received by the vessel. By using an additional station, the point of position can also be determined.

The introduction of LORAN-C, an enhancement of the standard LORAN (or LORAN-A), has allowed continuous and simultaneous reception of both transmitted signals, resulting in greater accuracy but still requiring use of standard charts. Microprocessor development has permitted storage of chart information on memory chips, with the resultant comparison of signals and position determination being performed electronically. The continuous display of latitude-longitude information, updated at reasonable intervals, has eliminated the need for a dedicated navigator with accompanying charts and has allowed introduction of the system into aircraft with single operators.

The system considered in this analysis is based on the LORAN-C concept with automatic display of either latitude-longitude or time difference. Up to nine waypoints can be manually entered with Area Navigation (RNAV) type displays, which have distance, bearing, ground speed, etc., available to the pilot from the control indicator panel. Two LORAN-C preprogrammed area coverage chips are included in the set with provisions for customizing to other areas by replacement of the chips. The system is designed to meet RTCA* DO-159 Type III requirements for minimum LORAN-C performance standards, and RTCA DO-160 environmental standards for the low-performance aircraft class of avionics.

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*RTCA Radio Technical Commission for Aeronautics.

3.1 AVIONICS COST DEVELOPMENT

The avionics required by the low-performance aircraft using LORAN-C as the navigation system consist of an antenna, receiver unit, and control and indicator panel (as shown in Figure 3-1). The antenna is a standard dipole or rod antenna with an integral antenna coupler unit intended for external mounting on the fuselage of an aircraft. The cost of this antenna was not developed but is assumed to be $150 per unit on the basis of the advertised costs of similar antennae. The costs of the remaining avionics of the LORAN-C system were estimated by the pricing model with parametric data inputs to the model obtained from details of the Teledyne TDL-711 LORAN Micro-Navigator and information furnished by the engineering staff of Teledyne Systems Company.

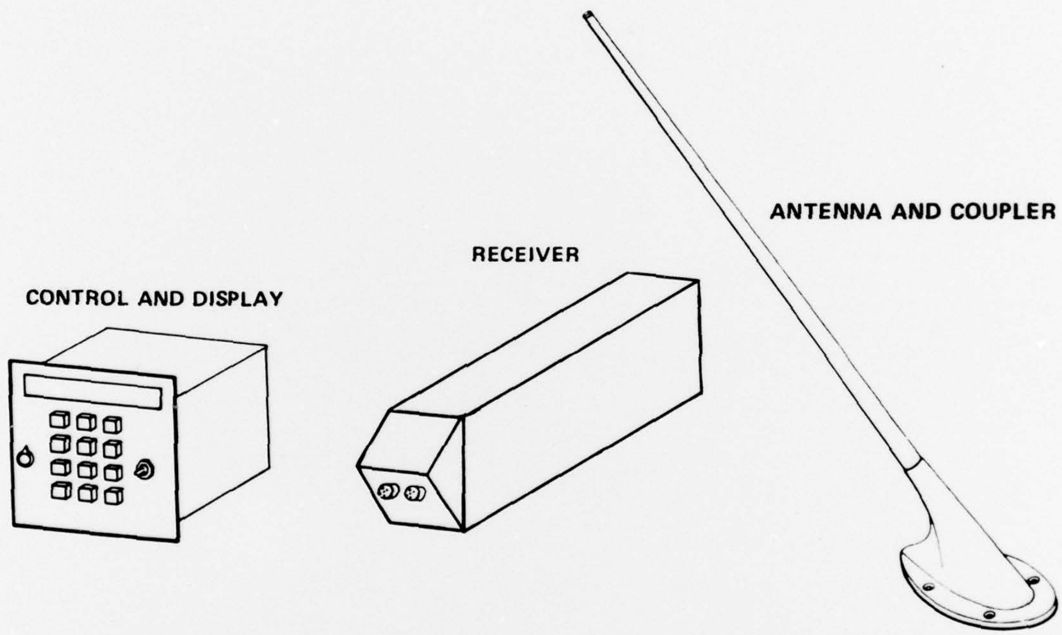

Figure 3-1. GPS AVIONICS FOR LOW-PERFORMANCE AIRCRAFT

All costs developed in this study are based on the 1977 dollar without inflation, to allow direct comparison with cost analyses of alternative-navigation systems previously conducted by ARINC Research for the FAA.

3.1.1 Receiver Unit

The receiver unit contains all the electronics required for signal acquisition, frequency conversion, data processing, internal power supply, and information generation to drive the display unit. The electronics will be mounted on four printed-circuit cards for plugging into the chassis; an additional card enclosed in an RF module will serve as the antenna coupler control and RF/IF module. The packaging of the receiver unit is unrestricted, as is typical of the enclosures and the practice of general-aviation manufacturers. The enclosure will be designed for remote mounting in the aircraft.

Table 3-1 gives the physical and economic descriptors of the LORAN-C receiver required by the PRICE model. Critical parameters, such as electronic and structural complexity data, were developed in comparison with RCA empirical data and with our data files for typical general-aviation avionics. The economic descriptors used in the analysis are those that have been developed in past applications of the PRICE model for this class of avionics manufacturing.

The results of the PRICE analysis are shown in Table 3-2. The development costs are shown for each module and have been amortized over a production quantity of 3,000 units. Test and integration costs reflect the expense of final assembly and factory testing of the completed LORAN-C receiver. The factory sell price is the cost to distributors handling the product. A typical distributor markup of 100 percent has been applied to the sell price to estimate the list price, which private aircraft owners would pay for a LORAN-C receiver.

3.1.2 Control and Display Unit

The control and display unit recommended for low-performance aircraft applications is a panel-mounted unit containing all indicators, switches, and a keyboard for data entry. The unit consists of five printed-circuit boards, a mother board for interconnects, and a display board mounted in the front panel of the enclosure. The printed-circuit boards contain all the converters and drivers necessary to process and display the position information generated by the receiver-navigation computer. The displays are light-emitting diode (LED) type with two sets of six digits showing degrees, minutes, and tenths of minutes for latitude-longitude, or various other data as selected by the function switch. Although a course-deviation indicator (CDI) is not part of the system, electrical connections are provided for driving a standard CDI unit.

Table 3-3 presents the physical and economic descriptors required by the PRICE model for evaluation of the control and display unit. The same procedure as used for the LORAN-C receiver has been followed in developing critical parametric data for the unit. Enclosure and chassis data were developed from information for similar control units documented in our data files.

Table 3-4 gives the results of the PRICE evaluation. Production quantities are consistent with the assumption that only one unit will be required with each receiver. The list price shown includes the normal markup for distribution and is the expected cost to single-aircraft owners.

Table 3-1. LORAN-C RECEIVER UNIT, LOW-PERFORMANCE AIRCRAFT

Descriptor Acronym or Abbreviation	Navigation Computer	Interface Board	Digital Processor	RF Module	Power Supply	Enclosure and Chassis	
QTY	3,000	3,000	3,000	3,000	3,000	3,000	
WT	0.532	0.5	0.485	0.438	0.4	3.0	
VOL	0.016	0.016	0.016	0.01	0.007	0.203	
WS	-	-	-	0.063	-	3.0	
MCPLYS	-	-	-	4.0	-	4.68	
NEWST	-	-	-	0.1	-	0.3	
MCPLXE	6.299	6.299	6.299	6.037	5.714	-	
NEWEL	1.0	1.0	1.0	1.0	0.4	-	
CMPNTS	47	84	40	219	31	-	
ECMPLX	1	1	1	1	0.4	0.4	
PRMTH	36	36	36	36	36	36	
LCURVE	0.865	0.865	0.865	0.865	0.865	0.865	
ECNE	0.05	0.05	0.05	0.05	0.05	-	
ECNS	-	-	-	0.05	-	0.05	
YEAR	1977	1977	1977	1977	1977	1977	
ESC	0	0	0	0	0	0	
PROJCT	0.3	0.3	0.3	0.3	0.3	0.3	
DATA	0.3	0.3	0.3	0.3	0.3	0.3	
TLGTST	0.2	0.2	0.2	0.2	0.2	0.2	
PLTFM	1.6	1.6	1.6	1.6	1.6	1.6	
SYSTEM	0.3	0.3	0.3	0.3	0.3	0.3	
PPROJ	0.3	0.3	0.3	0.3	0.3	0.3	
PDATA	0.3	0.3	0.3	0.3	0.3	0.3	
PTLGTS	0.2	0.2	0.2	0.2	0.2	0.2	

Table 3-2. LORAN-C RECEIVER UNIT, LOW-PERFORMANCE AIRCRAFT (1977 DOLLARS)

Function	Cost Factors		
	Development (Dollars/ Unit)	Production (Dollars/ Unit)	Total (Dollars/ Unit)
Navigation Computer	22.02	112.63	134.65
Interface Board	20.94	107.08	128.02
Digital Processor	20.38	104.19	124.57
RF Module	18.54	71.45	89.99
Power Supply	4.27	53.40	57.67
Enclosure and Chassis	1.51	106.63	108.14
Test and Integration	3.72	57.36	61.08
Total	91.38	612.74	704.12
Factory Sell Price			704.12
Distributor Markup			704.12
List Price			1,408.24

3.2 COST SUMMARY

The cost of avionics required by low-performance aircraft for implementation of the LORAN-C navigation system is presented in Table 3-5. Total development costs, unit production costs, and factory selling prices with development costs amortized over the 3,000-unit production quantity are shown for the three subsystems that make up the LORAN-C avionics. The list price of $2,186 per aircraft is the expected acquisition cost to single- and light-twin-engine aircraft owners to obtain the navigational capability defined by the LORAN-C system.

Table 3-3. LORAN-C CONTROL AND DISPLAY, LOW-PERFORMANCE AIRCRAFT

Descriptor Acronym or Abbreviation	Card A1	Card A2 and A3	Card A4	Card A5	Mother Board	Enclosure and Chassis*
QTY	3,000	6,000	3,000	3,000	3,000	3,000
WT	0.157	0.095	0.095	0.11	0.047	2.08
VOL	0.003	0.002	0.002	0.002	0.002	0.097
WS	-	-	-	-	0.047	2.078
MCPLXS	-	-	-	-	4.0	4.833
NEWST	-	-	-	-	1.0	0.5
MCPLXE	6.299	6.299	6.299	6.299	-	-
NEWEL	1.0	1.0	1.0	1.0	-	-
CMPNTS	26	19	23	20	-	-
ECMPLX	1	1	1	1	0.4	0.9
PRMTH	36	36	36	36	36	36
LCURVE	0.865	0.865	0.865	0.865	0.865	0.865
ECNE	0.05	0.05	0.05	0.05	-	-
ECNS	-	-	-	-	0.05	0.05
YEAR	1977	1977	1977	1977	1977	1977
ESC	0	0	0	0	0	0
PROJCT	0.3	0.3	0.3	0.3	0.3	0.3
DATA	0.3	0.3	0.3	0.3	0.3	0.3
TLGTST	0.2	0.2	0.2	0.2	0.2	0.2
PLTFM	1.6	1.6	1.6	1.6	1.6	1.6
SYSTEM	0.3	0.3	0.3	0.3	0.3	0.3
PPROJ	0.3	0.3	0.3	0.3	0.3	0.3
PDATA	0.3	0.3	0.3	0.3	0.3	0.3
PTLGTS	0.2	0.2	0.2	0.2	0.2	0.2

*Includes Display Board.

Table 3-4. LORAN-C CONTROL AND DISPLAY, LOW-PERFORMANCE AIRCRAFT (1977 DOLLARS)			
Function	Cost Factors		
	Development (Dollars/ Unit)	Production (Dollars/ Unit)	Total (Dollars/ Unit)
Card A1	13.35	40.46	53.81
Card A2	4.97	23.06	28.03
Card A3	4.97	23.06	28.03
Card A4	9.93	26.51	36.44
Card A5	11.24	30.00	41.24
Mother Board	0.35	4.02	4.37
Enclosure and Chassis	3.35	92.57	95.92
Test and Integration	1.96	23.90	25.86
Total	50.12	263.58	313.70
Factory Sell Price			313.70
Distributor Markup			313.70
List Price			627.40

Table 3-5. LORAN-C AVIONICS, LOW-PERFORMANCE AIRCRAFT, SINGLE SYSTEM (1977 DOLLARS)			
Function	Cost Factors		
	Development* (Dollars/ Unit)	Production (Dollars/ Unit)	Total (Dollars/ Unit)
Receiver	274,173	613	704
Control and Display	150,096	264	314
Antenna with Coupler	15,000	70	75
Totals	439,269	947	1,093
Factory Sell Price			1,093
Distributor Markup			1,093
List Price			2,186

*Development costs assumed amortized over 3,000-unit production quantity.

CHAPTER FOUR

RESULTS OF EVALUATION

The study has developed costs of avionics on the basis of a uniform approach to estimating costs with the assistance of a pricing model. The data used in exercising the model were developed through detailed analyses of systems of several leading avionics manufacturers producing low-performance aircraft equipment. This chapter summarizes the results of the evaluation of the LORAN-C concept for civil-aviation users of low-performance aircraft.

4.1 CONCEPT EVALUATED

The introduction of the LORAN-C concept to the general-aviation community has resulted in a navigation system that will provide positioning information to aircraft in flight as well as the functional capability equivalent to an area navigation (RNAV) system. The basis for the cost evaluation of low-performance aircraft avionics was the Teledyne TDL-711 LORAN Micro-Navigator designed for more sophisticated aircraft. All operational and functional features and capabilities of the TDL-711 were retained, but the packaging was modified to reflect general-aviation manufacturing practices with volume production. The results developed in this analysis provide insight into the probable cost of low-performance-aircraft civil avionics when LORAN-C is used as the navigation system in the National Air Space (NAS).

4.2 COST OF CONCEPT EVALUATED

The avionics costs developed by application of the pricing model are summarized in Table 4-1. The values indicate the probable selling price per item of avionics to the owners of low-performance general-aviation aircraft. Appropriate markups for distribution have been included on the basis of known or expected practices of the avionics manufacturers. All costs are based on the 1977 dollar without inflation. Potential variability in costs exists as a function of the production volume dictated by user demand. However, the costs of alternatives can be compared because the cost of LORAN-C avionics was evaluated with a uniform production quantity used in other studies performed by ARINC Research for the FAA.

Table 4-1. ACQUISITION COST OF LORAN-C AVIONICS FOR LOW-PERFORMANCE GENERAL-AVIATION AIRCRAFT	
Equipment	Cost (Dollars)
Receiver Unit	1,408
Control and Display Unit	628
Antenna with Coupler	150
Total System Cost	2,186

APPENDIX

RCA PRICE MODEL INPUT PARAMETERS

The appendix presents a listing of the input parameters used by the RCA PRICE model. Figure A-1 shows a typical input worksheet; Figure A-2 shows an example of a typical model output data sheet.

PRICE System
Input Worksheet

RCA Government and Commercial Systems

Item: Loran-C Receiver

Date:

General	QTY: 3000	PROTOS: 1	WT: .438	VOL: .01	MODE: 1
	QTYSYS: 1	INTEGE: .3	INTEGS: .5	AMULTE (%): 167000	AMULTM (%): 167000
Mechanical/ Structural	WS: .063	MCPLXS: 4.0	PRODS: 0	NEWST: .1	DESRPS: 2
Electronics	USEVOL: .9	MCPLXE: 6.037	PRODE: 0	NEWEL: 1.0	DESRPE: 2
	PWR: 0	CMPNTS: 219	CMPID: 0	PWRFAC: 2.9	CMPEFF: 0
Engineering	ENMTHS: 1	ENMTHP: 12	ENMTHT: 12	ECMPLX: 1.0	PRNF: 1
Production	PRMTHS: 12	PRMTHF: 48	LCURVE: .865	ECNE: .05	ECNS: .05
Purchased Item (Mode 3)	WS:	BVCOST:	LCURVE:		
GFE (Mode 4)	WS:	MCPLXE:	MCPLXS:		
Additional Data (Modes 9 & 10)	MCONST:	MEXP:	WECF:	TARCST (Mode 10 only):	
Global	YEAR: 1977	ESC: 0	PROJCT: .3	DATA: .3	TLGTST: .2
	PLTFM: 1.6	SYSTEM: .3	PPROJ: .3	PDATA: .3	PTLGTS: .2

MODES

0 PRINT TOTALS	6 MODIFIED PURCH ITEM
1 E/M ITEM	7 MODIFIED GFE ITEM
2 MECH ITEM	8 PARASYN
3 PURCH ITEM	9 E/M ITEM CALC WT & VOL
4 GFE ITEM	10 GEOSYN
5 INTEG & TEST	

Notes:

GC 1595 2/75

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LORAN-C RECEIVER

INPUT DATA                             PRICE  83B  1-FEB-79   08:51 (    78291)
QTY      3000. PROTOS     1.0 WT      0.438 VOL      0.010 MODE      1.
QTYSYS      1. INTEGE   0.300 INTEGS  0.500 AMULTD********% AMULTP********%

MECH/STRUCT
WS       0.063 MCPLXS   4.000 PRODS   0.000 NEWST    0.100 DESRPS   2.000

ELECTRONICS
USEVOL   0.900 MCPLXE   6.037 PRODE   0.000 NEWEL    1.000 DESRPE   2.000
PWR      0.000 CMPNTS    219. CMPID   0.000 PWRFAC   2.900 CMPEFF   0.000

ENGINEERING
ENMTHS     1.0 ENMTHP    12.0 ENMTHT   12.0 ECMPLX   1.000 PRNF     1.000

PRODUCTION
PRMTHS    12.0 PRMTHF    48.0 LCURVE  0.865 ECNE     0.050 ECNS     0.050

GLOBAL
YEAR     1977. ESC      0.00% PROJCT  0.300 DATA     0.300 TLGTST   0.200
PLTFM    1.600 SYSTEM   0.300 PPROJ   0.300 PDATA    0.300 PTLGTS    0.20

PROGRAM COST             DEVELOPMENT       PRODUCTION       TOTAL COST
ENGINEERING
 DRAFTING                     13552.             609.           14161.
 DESIGN                       37618.            1411.           39029.
 SYSTEMS                       1977.               0.            1977.
 PROJ MGMT                     1330.            3456.            4786.
 DATA                           524.             137.             661.
  SUBTOTAL(ENG)               55002.            5612.           60614.

MANUFACTURING
 PRODUCTION                       0.          202511.          202511.
 PROTOTYPE                      572.               0.             572.
 TOOL-TEST EQ                    54.            6213.            6267.
  SUBTOTAL(MFG)                 626.          208724.          209351.

  TOTAL COST                  55628.          214336.          269964.

AVCOST              67.50            TOTAL AV PROD COST           71.45
WT       0.438 VOL         0.010 ECNS     0.050 NEWST    0.100 DESRPS 0.000
LCURVE   0.865                   ECNE     0.050 NEWEL    1.000 DESPPE 0.000

MECH/STRUCT
WS       0.063 WSCF        6.300 MECID    0.000 PRODS  3.141 MCPLXS  4.000
ELECTRONICS
WE       0.375 WECF       41.667 CMPID    0.000 PRODE  3.324 MCPLXE  6.037
PWR      2.007 CMPNTS       219.                PWRFAC 2.900 CMPEFF 23.365

SCHEDULES
ENMTHS   1.000 ENMTHP   12.000 ENMTHT 12.000 ECMPLX 1.000 PRNF     1.000
PRMTHS  12.000 PRMTHF   48.000 AVER. PROD RATE PER MONTH         83.333

COST RANGES              DEVELOPMENT       PRODUCTION       TOTAL COST
      FROM                    48936.          189352.          238288.
      CENTER                  55628.          214336.          269964.
      TO                      67253.          258419.          325672.
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