Technical Paper

IISA AND CONVENTIONAL EQUIPMENT COST COMPARISON

16 January 1987

WEAPON SYSTEM COST ANALYSIS BRANCH

Prepared by

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Code 7023

Department of the Navy
Naval Air Development Center
Warminster, PA 18974

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19 ABSTRACT *(Continue on reverse if necessary and identify by block number)*
This report compares the cost aspects of a proposed new Integrated Inertial Sensor Assembly (IISA) system with conventional systems (ASW-44, LR-85, ASN-139 and USN-2) considered for use on the next generation aircraft. Cost estimates are based on technical analysis for both systems (IISA/Conventional) in the Production and Operating & Support (O&S) program phases. The Production/O&S cost estimates are presented.

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EXECUTIVE SUMMARY

The Weapon System Cost Analysis Branch (Code 7023) was tasked by the Air Navigation Systems Development Branch (Code 4011) to conduct a revised Production and O&S cost comparison of the proposed Integrated Inertial Sensor Assembly (IISA) with the conventional inertial systems planned for the next generation Navy aircraft. The initial comparison was conducted in May 1982 using the F-14 as the baseline aircraft.

The major assumptions in this analysis are:

- R&D costs are sunk costs.
- O&S period is 20 years.
- Combined (Organizational/Intermediate) and Depot Levels of maintenance are included.
- Warranties are not addressed.
- Software support costs are not addressed.
- Installation and Integration costs are not considered.

The results of the comparison of the IISA and the conventional systems are summarized in Table 1. Fleet sizes of 300, 500, and 1000 aircraft are shown.

TABLE 1. PRODUCTION AND O&S COST COMPARISON
CONVENTIONAL SYSTEM VS. IISA SYSTEM
(FY 86 $K)

COST ELEMENT	300 AIRCRAFT			500 AIRCRAFT			1000 AIRCRAFT		
	CONVENTIONAL	IISA	IISA SAVINGS	CONVENTIONAL	IISA	IISA SAVINGS	CONVENTIONAL	IISA	IISA SAVINGS
PRODUCTION	130,326	104,160	26,166	205,926	168,000	37,926	394,926	327,600	67,326
OPERATING AND SUPPORT	115,418	17,222	98,196	192,364	28,704	163,660	384,726	57,408	327,318
TOTAL LCC	245,744	121,382	124,362	398,290	196,704	201,586	779,652	385,008	394,644

1.0 INTRODUCTION

This study contains a hardware (avionics) cost comparison of the systems required to perform navigation, flight control, weapon delivery and sensor stabilization functions on modern naval aircraft.

1.1 Origin

The Air Navigation Systems Development Branch (Code 4011) of the Communication Navigation Technology Directorate (Code 40) at the Naval Air Development Center has tasked the Weapon System Cost Analysis Branch (Code 7023) to develop an independent cost study to compare conventional systems for navigation, flight control, weapon delivery and sensor stabilization currently targeted for conventional next generation Navy aircraft, with a potential replacement system, IISA.

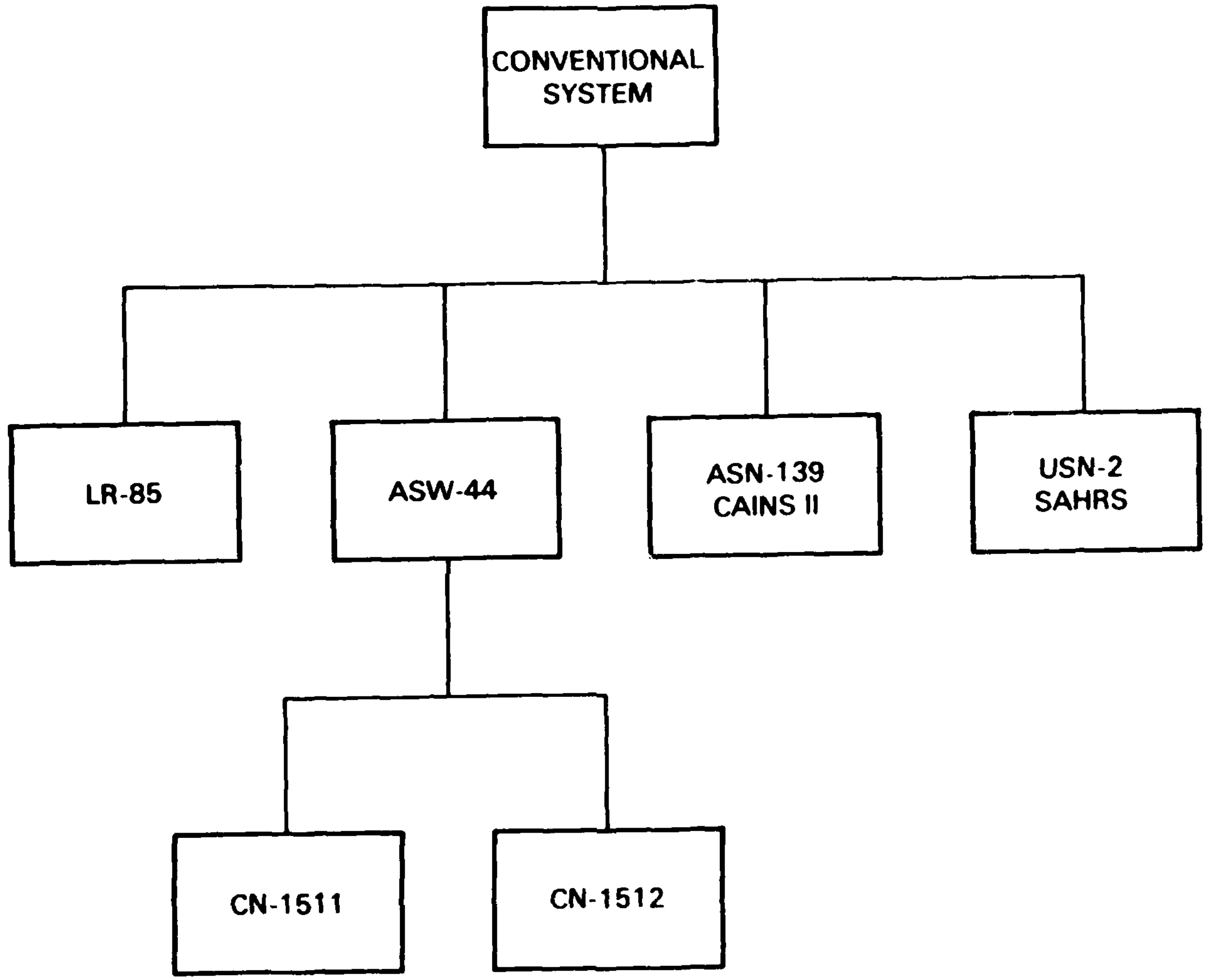
1.2 Purpose

This report compares a proposed new Integrated Inertial Sensor Assembly System (IISA) as a potential replacement for proposed conventional systems (ASW-44, LR-85, ASN-139 and USN-2) planned for use on the next generation aircraft. Contained in this report are cost estimates based on technical analysis for both systems (IISA/Conventional) in the Production and Operating & Support (O&S) phases of their programs. Aircraft lot quantities of 300, 500 & 1000 are assumed. The Production/O&S cost results are presented and documented.

1.3 System Description.

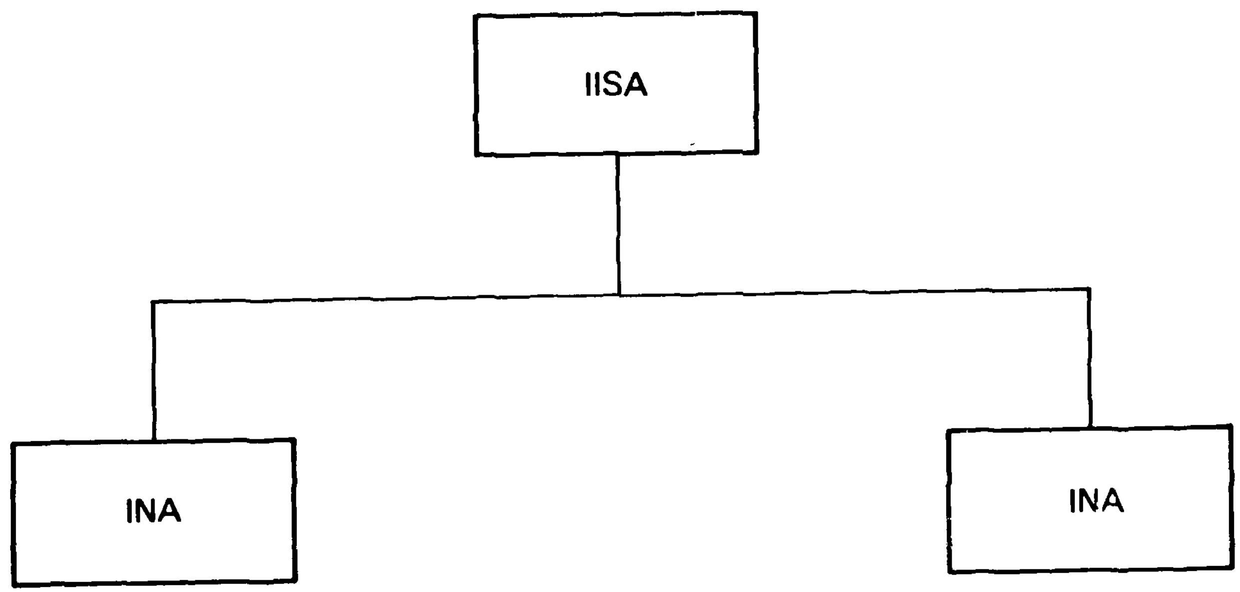
IISA is comprised of two identical inertial navigation assemblies (INAs). Each INA is an assembly of slightly less than 1 cubic foot in volume (.85) and contains 3 ring laser gyros and 3 accelerometers. Within an INA, sensor axes are orthogonal but skewed relative to the aircraft yaw axis. One accelerometer and one ring laser gyro in an INA are oriented along each skewed axis. No two axes are coincident, nor are three in the same plane. Thus, any three sensors may be used to derive three-axis outputs in aircraft axes after suitable computer transformation.

The IISA system provides two redundant inertial navigation system (INS) functions and is capable of performing additional functions such as altitude/flight reference, auto flight control/stable platform reference, & weapon control sensor stabilization. Currently this requires additional conventional avionics equipment (USN-2, ASW-44, LR-85).



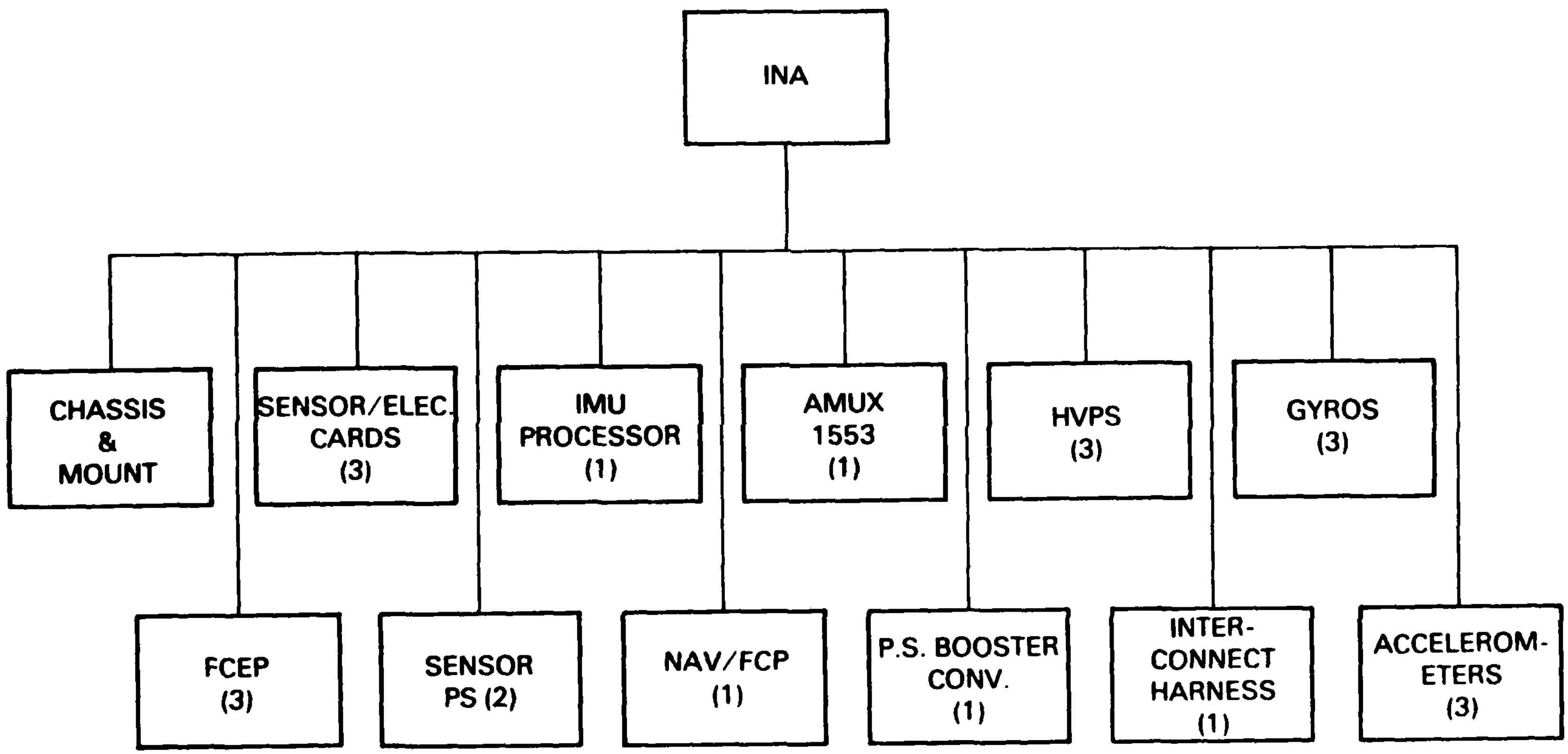
* These systems represent Flight Control, Navigation, Fire Control and Weapon Delivery Capabilities.

Figure 1. Conventional System Configuration



Proposed System to Potentially Replace the Conventional System

Figure 2. IISA System Configuration



IISA (INA) Configuration With Corresponding Quantities per INA Unit

Figure 3. INA Subsystem Configuration

2.0 CONCEPT

In order to perform their missions and maintain the highest possible level of readiness for navigation, flight control, weapon delivery and sensor stabilization, modern naval aircraft require inertial platforms. Conventionally, one or more inertial platforms are used for each function and are made up of numerous gyroscopes and accelerometers. Although the technology of these components is state-of-the-art, their reliability is such that redundancy is often required, along with backup capability by inter-system connectability. It is the duplication of function (effort) both within and betwen systems and equipments that drive cost upward in both production and O&S.

Historically, flight control gyros and accelerometers were not of sufficient accuracy for navigation. Likewise, inertial navigation system sensors, while of improved accuracy to satisfy weapons delivery requirements, were not suitable for flight control since they were gimballed and did not provide the body axis components of rate and acceleration. With the advent of laser gyro strapdown inertial technology and advanced microprocessors, it is feasible for the first time to cut across the traditional boundaries between these subsystems.

Ring laser gyro development has resulted in a system that has no moving parts, and is superior in accuracy and reliability. Additional advancements in technology, digital processing and management of the output data make practicable a single inertial system which will provide all the necessary capabilities for the specified missions. IISA is the practical implementation of the ring laser gyro in a system which can meet the performance and reliability needs of the next generation (conventional) Navy aircraft, with a minimum hardware configuration. The conventional system addressed in this report is represented by those equipments and components targeted for the next generation aircraft which utilize gyros, accelerometers and have overlapping functions.

Table 2 shows a functional comparison between IISA and conventional equipment.

TABLE 2. Conventional/IISA BASELINE EQUIPMENT COMPARISON

FUNCTION	CONVENTIONAL EQUIPMENT	IISA
Auto Flight Control: Stable Platform Reference	(1) ASW-44 (2) CN-1511 Rate Gyro (2) CN-1512 Accelerometer	(Performed by IISA)
Stabilize Antenna: Motion Compensation to Synthetic Aperture Radar (SAR)	(1) LR-85	(Performed by IISA)
Inertial Navigation	(1) ASN-139 CAINS II	Performed by IISA Dual Navigation Capability
Altitude/ Flight Reference	(1) USN-2 SAHRS	(Performed by IISA)

3.0 MAJOR GROUND RULES

This section provides major ground rules and assumptions used in this cost comparison. Specific assumptions for individual elements in the structure are addressed in the cost discussion of that element.

3.1 Ground Rules/Assumptions

- Research, Development, Test and Evaluation (RDT&E) costs for both IISA and the conventional system are sunk.
- All costs are in FY86 dollars.
- IISA system is comprised of two identical Inertial Navigation Assemblies (INAs).
- IISA is not designated for a specific aircraft, thus installation costs for either IISA or the conventional system were not considered. (Installation cost will vary by aircraft.)
- Unit production costs documented in this report are out-the-door/ flyaway costs.
- Production options for lots of 300, 500 and 1000 aircraft were analyzed and estimated.
- Learning will occur in a 90% slope from the 1st through the 300th unit. (Prices will stabilize at the 300th unit and no further learning will occur.)
- Two levels of maintenance are assumed, combined (organizational and intermediate) along with depot level maintenance.
- Warranty costs not addressed for either system.
- Service life of both systems is 20 years.
- IISA production will start in FY89.

3.2 Cost Element Breakdown Structure.

The following cost element breakdown structure was used in the analysis. RDT&E costs are considered sunk for both systems and is not listed.

- Production Costs
  - Hardware Procurement
    - IISA Equipment Cost
    - Conventional Equipment Cost
  - Integrated Logistic Support (ILS)
    - Training
    - Initial Spares
    - Support Equipment
    - Industrial Facilities
    - Operational Site Activation
    - Technical Orders
    - Packaging, Handling, Storage & Transportation (PHS&T)
    - Engineering Change Orders (ECO)
- Operations and Support (O&S) Costs
  - Organizational and Intermediate Maintenance Labor
  - Organizational and Intermediate Maintenance Consumables
  - Replenishment Spares
  - Depot/Component Rework Cost

4.0 GENERAL APPROACH

The general approach was to analyze the production and O&S costs of IISA and the equivalent conventional systems including those elements potentially replacable by IISA.

4.1 Methodology.

The procedure used to estimate costs for this study consisted of collecting technical and programmatic system descriptors, analyzing and extrapolating pertinent data and inputing the data into a cost model (RCA PRICE H) in order to obtain a structured output. Accurate system descriptors are required for realistic cost estimates; however in many programs such data is difficult to obtain. The descriptors used for the study are a result of the combined effort by NAVAIRDEVCEN, Litton, Singer, NAVAIR, MCAIR cognizant personnel and represent the best information available at the time of the analysis. All costs derived from these descriptors should be considered preliminary.

Production Costs were developed by using three primary methodologies, these are:

- Parametric Modeling
- Analogy
- Historical Data

These methodologies were combined to obtain total Production and Operating & Support costs.

4.2 Production Costs

Production cost elements are shown in the Cost Element Breakdown Structure. Production cost as defined in this report is identical to the Hardware Procurement Cost. The elements of production costs being addressed herein are:

Recurring/Nonrecurring

- Equipment

Integrated Logistic Support

- Training
- Initial Spares
- Support Equipment
- Industrial Facilities
- Operational Site Activation
- Technical Orders
- Packaging, Handling, Storage & Transportation (PHS&T)
- Engineering Change Orders (ECO)

4.2.1 Hardware Procurement

The hardware procurement costs were derived using the Wright learning curve method. This method states that the cost of an item will decrease by a given percent (rate) as the number of items produced is doubled. For this estimate, a 90% learning curve was used for the first 300 units. The production costs are assumed to stabilize at the 300th unit cost, and no further savings due to learning is assumed to take place. Therefore the procurement costs for n units is as follows:

Given: AUC_{300} = Average unit cost for first 300 units
UC_{300} = Unit cost for 300th unit
C_n = Procurement cost for n units

For $n < 300$ $\quad C_n = n \times AUC_{300}$

For $n > 300$ $\quad C_n = 300 \times AUC_{300} + (n-300) \times UC_{300}$

A summary of Equipment Production Costs is presented in Table 3 below. These costs are discussed more fully in Section 4.2.1.1 and Section 4.2.1.2.

TABLE 3. EQUIPMENT PRODUCTION COST COMPARISON

(FY 86 $K)

EQUIPMENT	AVERAGE UNIT COST- 1ST 300 UNITS	300TH UNIT COST	QUANTITY PER AIRCRAFT	TOTAL PRODUCTION COST FOR AIRCRAFT QUANITIES		
				300 A/C	500 A/C	1000 A/C
CONVENTIONAL						
ASW-44				26,640	42,960	83,760
CN-1511	33.9	28.8	2			
CN-1512	14.1	12.0	2			
LR-85	49.4	42.0	1	14,820	23,220	44,220
ASN-139	111.1	94.5	1	33,330	52,230	99,480
USN-2	61.0	51.9	1	18,300	28,680	54,630
TOTAL CONVENTIONAL				93,090	147,090	282,090
IISA						
INA	134.0	114.0	2	74,400	120,000	234,000
IISA SAVINGS				18,690	27,090	48,090

4.2.1.1 IISA Equipment Cost

Production costs include all costs for manufacturing the various subsystems which make up the complete IISA system. Costs were developed for production quantities of 600, 1000 and 2000 INAs or for aircraft quantities of 300, 500 and 1000 at two INAs per A/C. These costs include both non-recurring and recurring production. No costs were incurred against software for the production phase.

Prime Mission Equipment (PME) costs include all costs associated with hardware production including tooling and test equipment, and recurring costs composed of all direct labor and materials associated with manufacturing each unit. The recurring equipment cost is the sum of the individual subsystem unit production costs which are averaged over the quantity of subsystems to be manufactured.

The unit production cost was estimated by application of the "RCA PRICE Hardware" cost model. The PRICE model has the built-in capability of generating a first unit cost for production or "T_1" cost.

The parametric input data to the model includes not only equipment/programmatic characteristics, but also a qualitative evaluation of the difficulty of the project in comparison to similar previous projects. The cost output is also quite sensitive to the quantity of new design required to execute the program, noting the utilization of previous designs or purchased assemblies requiring no design effort or some modification of the design to adapt the unit to the current program.

Typical equipment characteristics include:

- Density of electronic packaging
- Weight of electronics
- Electronic equipment description as a function of engineering/ manufacturing difficulty
- State-of-the-Art of electronics (discretes, LSI's, etc.)
- Type and function of mechanical items and structure

In order to obtain the required input data, the technical volume of the Litton proposal was explored in detail. This volume was extremely useful since the design details were provided in depth. Most of the input data were directly derived from the descriptive material provided.

The approach taken for using the PRICE generated estimates to compute estimates of the total IISA hardware equipment cost for each fleet size was a two-step process. First, the cost of the first 300 units of each subassembly was calculated using PRICE data as the baseline. Then, the cost of the remaining quantity of each subassembly required was computed using its 300^{th} unit cost.

The 300^{th} unit cost of each subassembly was determined by using the log-linear unit theory learning curve with a 90% slope . The costs of test and integration, were included in the IISA UPC's.

Factors for management support and systems engineering, project management and data, were applied to the AUC_{300} and the UC_{300}. Based on these results, the CER in 3.2.1, and the quantity of INAs required for the three buy options, the IISA costs were estimated. These assumptions and the calculations of the IISA equipment costs are provided below.

- Assumptions and References:

a. T_1 for an INA = 198$K (FY86)(Equivalent 1/2 IISA system first 300 units only).
Reference: RCA PRICE-H Model

b. Manufacturing support and systems engineering costs are 20% of hardware costs.
Reference: Analogous program estimates (ASN-139,HFAJ,ASPJ) and communication with NAVAIR-524 personnel

c. Project Management Costs are 10% of hardware plus manufacturing support and systems engineering costs.
Reference: Analogous program estimates (ASN-139,HFAJ,ASPJ) and communication with NAVAIR-524 personnel

d. Cost of Data is 5% of hardware costs.
Reference: Analogous program estimates (ASN-139,HFAJ,ASPJ) and communication with NAVAIR-524 personnel

e. The technical inputs to the PRICE model were developed by Litton Guidance and Control Division and Air Navigation Systems Development Branch (Code 4011) NAVAIRDEVCEN.

f. One IISA is required for each aircraft. Since one IISA is composed of two INAs, two INAs are required for each aircraft.

- Calculations:

a. $AUC_{300} = T_1 \times .494013$

$= 198\$K \times .494013$

$= 97.8\$K$

AUC_{300} with adjustments is:

		FY86$K
Hardware	= 97.8	97.8
Mgmt. Support and Systems Engineering	= 97.8 x .20	19.6
Project Management	= 97.8 x 1.20 x .10	11.7
Data	= 97.8 x .05	4.9
		134.0

b. $UC_{300} = T_1 \times .420213$

$= 198\$K \times .420213$

$= 83.2\$K$

UC_{300} with adjustments is:

Hardware	= 83.2	83.2
Mgmt. Support and Systems Engineering	= 83.2 x .20	16.6
Project Management	= 83.2 x 1.20 x .10	10.0
Data	= 83.2 x .05	4.2
		114.0

c. Based on the CER in 4.2.1, assumption f. above, and calculations a. and b. above, the hardware procurement costs of the IISA systems for the three fleet size systems are as follows:

(1) Cost of IISA for 300 A/C = Cost of 600 INA

$= 300 \times AUC_{300} + 300 \times UC_{300}$

$= 300 \times 134\$K + 300 \times 114\$K$

$= 40{,}200\$K + 34{,}200\$K$

$= 74{,}400\$K$

(2) Cost of IISA for 500 A/C = cost of 1000 INA

$= 300 \times AUC_{300} + 700 \times UC_{300}$

$= 300 \times 134\$K + 700 \times 114\$K$

$= 40{,}200\$K + 79{,}800\$K$

$= 120{,}000\$K$

(3) Cost of IISA for 1000 A/C = cost of 2000 INA

$= 300 \times AUC_{300} + 1700 \times UC_{300}$

$= 300 \times 134\$K + 1700 \times 114\$K$

$= 40{,}200\$K + 193{,}800\$K$

$= 234{,}000\$K$

4.2.1.2 Conventional Equipment Cost

Projected average unit costs (AUC) for different lot buys of conventional equipment were vendor provided. Using these costs and the 90% unit learning curve tables, the first unit cost (T_1) was derived. The average unit cost for the 300th unit (AUC_{300}) was calculated, and the unit cost for the 300th unit (UC_{300}) was projected. Then, based on these results, the CER in 4.2.1, and the number of units required for the three buy options, the hardware procurement costs were calculated. These calculations for the four conventional systems are shown below:

ASW-44

- Definition: The ASW-44 Auto Flight Control System is composed of two CN-1511 Rate Gyros and two CN-1512 Accelerometers.
- Assumptions and References:

a. AUC_{200} of CN-1511 is 36$K (FY86)
Reference: MCAIR, St. Louis, MO and
NAVAIR Budget Data (Code 5242)

b. AUC_{200} of CN-1512 is 15\$K (FY86).
Reference: MCAIR, St. Louis, MO and
NAVAIR Budget Data (Code 5242)

c. An ASW-44 System is composed of two CN-1511 and two CN-1512 subsystems.

d. One ASW-44 system is required for each aircraft.

- Calculations:

a. T_1 of CN-1511 = 36\$K /.524820
= 68.595\$K

b. AUC_{300} of CN-1511 = 68.595\$K x .494013
= 33.9\$K

c. UC_{300} of CN-1511 = 68.595\$K x .420213
= 28.8\$K

d. T_1 of CN-1511 = 15\$K /.524820
= 28.581\$K

e. AUC_{300} of CN-1512 = 28.581\$K x .494013
= 14.1\$K

f. UC_{300} of CN-1512 = 28.581\$K x .420213
= 12.0\$K

g. Based on CER in Section 4.2.1, assumptions c. and d. above, and calculations b., c., e. and f.,the hardware procurment costs of the ASW-44 systems for the three fleet size options are as follows:

(1) Cost of ASW-44 for 300 A/C = cost of 600 CN-1511s plus cost of 600 CN-1512s

$= 300 \times AUC_{300}$ of CN-1511 and $300 \times UC_{300}$ of CN-1511 $+ 300 \times AUC_{300}$ of CN-1512 $+ 300 \times UC_{300}$ of CN-1512

= 300 x 33.9$K + 300 x 28.8$K + 300 x 14.1$K + 300 x 12.0$K

= 26,640$K

(2) Cost of ASW-44 for 500 A/C = cost of 1000 CN-1511s plus cost of 1000 CN-1512s

$= 300 \times AUC_{300}$ of CN-1511 $+ 700 \times UC_{300}$ of CN-1511 $+ 300 \times AUC_{300}$ of CN-1512 $+ 700 \times UC_{300}$ of CN-1512

= 300 x 33.9$K + 700 x 28.8$K + 300 x 14.1$K + 700 x 12.0$K

= 42,960$K

(3) Cost of ASW-44 for 1000 A/C = cost of 2000 CN-1511s plus cost of 2000 CN-1512s

= 300 x 33.9$K + 1700 x 28.8$K + 300 x 14.1$K + 1700 x 12.0$K

= 83,760$K

LR-85

- Definition: The LR-85 Inertial Measurement Unit is a two box system. It is composed of an Inertial Measurement Unit (IMU) and an Electronics Assembly.

- Assumptions and References:

a. AUC_{650} = $44K (FY86)
Reference: Litton Corp.
Guidance and Control Center
Woodland Hills, California

b. One LR-85 system is required per aircraft.

- Calculations:

a T_1 = 44\$K/.439851 = 100.034\$K

b. AUC_{300} = 100.034\$K x .494013 = 49.4\$K

c. UC_{300} = 100.034\$K x .420213 = 42.0\$K

d. Based on CER in 4.2.1, assumption b above, and calculated results b. and c., the procurement costs for the LR-85 system for the three fleet size options are as follows.

(1) Cost of LR-85 for 300 A/C = 300 x AUC_{300}
= 300 x 49.4\$K
= 14,820\$K

(2) Cost of LR-85 for 500 A/C = 300 x AUC_{300} + 200 x UC_{300}
= 300 x 49.4\$K + 200 x 42.0\$K
= 23,220\$K

(3) Cost of LR-85 for 1000 A/C = 300 x AUC_{300} + 700 x UC_{300}
= 300 x 49.4\$K + 700 x 42.0\$K
= 44,220\$K

ASN-139 CAINS II

- Definition: The ASN-139 CAINS II is an Inertial Navigation Unit

- Assumptions and References:

a. AUC_{100} = 130.8$K (FY86)
Reference: Litton Corp.
Guidance & Control Center
Woodland Hills, California

NAVAIR Budget Data (Code 5242)

b. One ASN-139 CAINS II System is required for each aircraft.

- Calculation:

a. T_1 = 130.8$K/.581410 = 224.970$K

b. AUC_{300} = 224.970$K x .494013 = 111.1$K

c. UC_{300} = 224.970$K x .420213 = 94.5$K

d. Based on CER in 4.2.1, assumption d. above, and calculations c. and e., the hardware procurement costs of the ASN-139 CAINS II systems for the three fleet size options are as follows:

(1)Cost of ASN-139 CAINS II for 300 A/C = 300 x AUC_{300}
= 300 x 111.1$K
= 33,330$K

(2)Cost of ASN-139 CAINS II for 500 A/C $= 300 \times AUC_{300}$

$+ 200 \times UC_{200}$

$= 300 \times 111.1\$K$

$+ 200 \times 94.5\$K$

$= 52{,}230\$K$

(3)Cost of ASN-139 CAINS II for 1000 A/C $= 300 \times AUC_{300}$

$+ 700 \times UC_{200}$

$= 300 \times 111.1\$K$

$+ 700 \times 94.5\$K$

$= 99{,}480\$K$

USN-2 SAHRS

- Definition: USN-2 SAHRS is a Standard Attitude Heading Reference System.

- Assumptions and References:

a. $AUC_{600} = 55\$K$ (FY86)
Reference: Projected Costs and Similar System Costs Air Navigation Systems Development Branch (Code 4011) NAVAIRDEVCEN

These costs were based on technical inputs received from the Singer Kearfott Div., Little Falls, New Jersey.

b. One USN-2 SAHRS per aircraft.

- Calculations:

a. T_1 = \$55K/.445186 = 123.544\$K

b. AUC_{300} = 123.544\$K x .494013 = 61.0\$K

c. UC_{300} = 123.544\$K x .420213 = 51.9\$K

d. Based on CER in 4.2.1, assumption b. above, and calculated results from b. and c., the hardware procurement cost for the USN-2 SAHRS systems for the three flight-size options are as follows:

(1)Cost of USN-2 SAHRS for 300 A/C

$$= 300 \times AUC_{300}$$
$$= 300 \times 61\$K$$
$$= 18{,}300\$K$$

(2)Cost of USN-2 SAHRS for 500 A/C

$$= 300 \times AUC_{300} + 200 \times UC_{300}$$
$$= 300 \times 61\$K + 200 \times 51.9\$K$$
$$= 28{,}680\$K$$

(3)Cost of USN-2 SAHRS for 1,000 A/C

$$= 300 \times AUC_{300} + 700 \times UC_{300}$$
$$= 300 \times 61\$K + 700 \times 51.9\$K$$
$$= 54{,}630\$K$$

4.2.2 Integrated Logistics Support (ILS)

ILS costs are delineated into the following elements:

- Training
- Initial Spares and Repair Parts
- Support Equipment
- Industrial Facilities
- Operational Site Activation
- Technical Orders
- Packaging, Handling, Storage and Transportation (PHS&T)
- Engineering Change Orders (ECO)

The costs for each of these elements within the ILS category were derived as percentages of total hardware equipment production costs and are applicable to both conventional and IISA equipments as shown in Table 4. These percentages are based on estimates prepared for other programs that have analogous manufacturing and production processes to inertial systems for modern naval aircraft. Examples of such program estimates are the Airborne Self Protection Jammer (ASPJ), High Frequency Anti-Jam System (HFAJ), and Ring Laser Gyro (ASN-140) program estimates.

Table 4 provides a summarization and comparison of conventional and IISA ILS costs for each assumed production quantity of 300, 500, and 1000 aircraft. The methodologies for costing each ILS element are discussed separately in the following sections.

TABLE 4. ILS COST COMPARISON

CONVENTIONAL VS IISA EQUIPMENTS (FY 86$K)

COST ELEMENT	ILS COST FACTORS (% of equip cost)	300 AIRCRAFT			500 AIRCRAFT			1000 AIRCRAFT		
		CONVENTIONAL	IISA	IISA SAVINGS	CONVENTIONAL	IISA	IISA SAVINGS	CONVENTIONAL	IISA	IISA SAVINGS
EQUIPMENT		93,090	74,400		147,090	120,000		282,090	234,000	
ILS										
TRAINING	7.0	6,516	5,200	1,308	10,296	8,400	1,896	19,746	16,380	3,366
SPARES	17.0	15,825	12,648	3,177	25,005	20,400	4,605	47,955	39,780	8,175
SUPT EQUIP	6.5	6,051	4,836	1,215	9,561	7,800	1,761	18,336	15,210	3.126
INDUST FAC	1.0	931	744	187	1,471	1,200	271	2,821	2,340	481
OPER SITE	1.0	931	744	187	1,471	1,200	271	2,821	2,340	481
TECH ORDERS	6.0	5,585	4,464	1,121	8,825	7,200	1,625	16,925	14,040	2,885
PHS &T	0.5	465	372	93	735	600	135	1,410	1,170	240
ECO	1.0	931	744	187	1,471	1,200	271	2,821	2,340	481
TOTAL ILS		37,236	29,760	7,476	58,836	48,000	10,836	112,836	93,600	19,236

4.2.2.1 Training

Definition: The training element refers to the training services, devices, accessories, aids, equipments and parts used to facilitate instruction through which personnel will acquire sufficient concepts, skills, and aptitudes to operate and maintain the system with maximum efficiency. This element includes all effort associated with the production of training equipment as well as the execution of training services. However, operator training is accomplished using simulators and actual operational aircraft. Since it is not known whether the simulation will be done by computer, or by dedicated equipment, equipment for training operators was not costed.

Calculations: The cost for training is 7% of the total cost of hardware equipment production.

Training Equipment Cost = Total Equipment Production Cost x 7%.

For the conventional and IISA systems, this cost is calculated for each of the assumed production quantities (300, 500, and 1000 A/C) in a, b, and c below, and is expressed in FY86 $K. Total production costs for conventional and IISA equipments were obtained from Table 3.

a. 300 A/C:

Conventional = 93,090 x .07 = 6,516$K
IISA = 74,400 x .07 = 5,208$K

b. 500 A/C:

Conventional = 147,090 x .07 = 10,296$K
IISA = 120,000 x .07 = 8,400$K

c. 1000 A/C:

Conventional = 282,090 x .07 = 19,746$K
IISA = 234,000 x .07 = 16,380$K

4.2.2.2 Initial Spares and Repair Parts

Definition: These items are required to support and maintain equipment during an initial period of service. They are generally procured during the production phase to initially fill the supply pipe-line.

Calculation: The ILS cost for initial spares and repair parts is 17% of the total cost of hardware equipment production.

Initial Spares & Repair Parts Cost = Total Equipment Production Cost x 17%.

For the conventional and IISA systems this cost is calculated for each of the assumed production quantities (300, 500, and 1000 A/C) in a, b, and c below, and is expressed in FY86 $K. Total production costs for conventional and IISA equipments were obtained from Table 3.

a. 300 A/C:

Conventional = 93,090 x .17 = 15,825$K
IISA = 74,400 x .17 = 12,648$K

b. 500 A/C:

Conventional = 147,090 x .17 = 25,005$K
IISA = 120,000 x .17 = 20,400$K

c. 1000 A/C:

Conventional = 282,090 x .17 = 47,955$K
IISA = 234,000 x .17 = 39,780$K

4.2.2.3 Support Equipment

Definition: This element includes all equipment required to perform the support and maintenance of the system including tools, test equipment, O-and I-level equipment, Depot level equipment and related computer programs and software.

Calculation: The cost for support equipment is 6.5% of the total cost of hardware equipment production. The 6.5% is a total percentage based on 5% for peculiar support equipment (PSE) and 1.5% for common support equipment (CSE)

Support Equipment Cost = Total Production Cost x 6.5%.

For the conventional and IISA systems this cost is calculated for each of the assumed production quantities (300, 500, and 1000 A/C) in a, b, and c below, and is expressed in FY86 $K. Total production costs for conventional and IISA equipments were obtained from Table 3.

a. 300 A/C:

Conventional = 93,090 x .065 = 6,051$K
IISA = 74,400 x .065 = 4,836$K

b. 500 A/C:

Conventional = 147,090 x .065 = 9,561$K
IISA = 120,000 x .065 = 7,800$K

c. 1000 A/C:

Conventional = 282,090 x .065 = 18,336$K
IISA = 234,000 x .065 = 15,210$K

4.2.2.4 Industrial Facilities

Definition:

These consist of real property assets required to support the equipment including space, capital equipment, environmental systems and utilities.

Calculation: The cost for industrial facilities is 1% of the total cost of hardware equipment production.

Industrial Facilities Cost: Total Equipment Production Cost x 1%.

For the conventional and IISA systems this cost is calculated for each of the assumed production quantities (300, 500, and 1000 A/C) in a, b, and c below, and is expressed in FY86 $K. Total production costs for conventional and IISA equipments were obtained from Table 3.

a. 300 A/C:

Conventional = 93,090 x .01 = 931$K
IISA = 74,400 x .01 = 744$K

b. 500 A/C:

Conventional = 147,090 x .01 = 1,471$K
IISA = 120,000 x .01 = 1,200$K

c. 1000 A/C:

Conventional = 282,090 x .01 = 2,821$K
IISA = 234,000 x .01 = 2,340$K

4.2.2.5 Operational Site Activation

Definition:

This element includes construction, conversion, utilities and equipment to provide facilities at the operating location to house, service and launch the IISA or conventional equipments. It also includes the cost of site surveys.

Calculation: The cost for operational site activation is 1% of the total cost of hardware equipment production.

Operational Site Activation cost = Total Equipment Production Cost x 1%.

For the conventional and IISA systems this cost is calculated for each of the assumed production quantities (300, 500, and 1000 A/C) in a, b, and c below, and is expressed in FY86 $K. Total production costs for conventional and IISA equipments were obtained from Table 3.

a. 300 A/C:

Conventional = 93,090 x .01 = 931$K
IISA = 74,400 x .01 = 744$K

b. 500 A/C:

Conventional = 147,090 x .01 = 1,471$K
IISA = 120,000 x .01 = 1,200$K

c. 1000 A/C:

Conventional = 282,090 x .01 = 2,821$K
IISA = 234,000 x .01 = 2,340$K

4.2.2.6 Technical Orders

Definition:

This is the cost of orders issued by the Government to the contractor to make technical changes to maintenance manuals, training manuals and other ILS data to reflect the results of engineering change orders.

Calculation: The cost for technical orders is 6% of the total cost of hardware equipment production.

Technical Orders Cost = Total Equipment Production Cost x 6%

For the conventional and IISA systems this cost is calculated for each of the assumed production quantities (300, 500, and 1000 A/C) in a, b, and c below, and is expressed in FY86 $K. Total production costs for conventional and IISA equipments were obtained from Table 3.

a. 300 A/C:

Conventional = 93,090 x .06 = 5,585$K
IISA = 74,400 x .06 = 4,464$K

b. 500 A/C:

Conventional = 147,090 x .06 = 8,825$K
IISA = 120,000 x .06 = 7,200$K

c. 1000 A/C:

Conventional = 282,090 x .06 = 16,925$K
IISA = 234,000 x .06 = 14,040$K

4.2.2.7 Packaging, Handling, Storage and Transportation (PHS&T)

Definition:

This element covers the cost for procedures used to protect material, to coordinate and move material for short distances, to store material and to transport material to and from operating locations.

Calculation: The cost for PHS&T is .5% of the total cost of hardware equipment production.

PHS&T Cost = Total Equipment Production Cost x .5%.

For the conventional and IISA systems this cost is calculated for each of the assumed production quantities (300, 500, and 1000 A/C) in a, b, and c below, and is expressed in FY86 $K. Total production costs for conventional and IISA equipments were obtained from Table 3.

a. 300 A/C:

Conventional = 93,090 x .005 = 465$K
IISA = 74,400 x .005 = 372$K

b. 500 A/C:

Conventional = 147,090 x .005 = 735$K
IISA = 120,000 x .005 = 600$K

c. 1000 A/C:

Conventional = 282,090 x .005 = 1,410$K
IISA = 234,000 x .005 = 1,170$K

4.2.2.8 Engineering Change Orders (ECO)

Definition:

This element covers the cost of making an engineering change to a design for equipment and to modify, add to, delete or supersede original parts after formal establishment of its configuration identification.

Calculation: The cost for ECO's is 1% of the total cost of hardware equipment production.

ECO Cost = Total Equipment Production Cost x 1%

For the conventional and IISA systems this cost is calculated for each of the assumed the production quantities (300, 500, and 1000 A/C) in a, b, and c below, and is expressed in FY86 $K. Total production costs for conventional and IISA equipments were obtained from Table 3.

a. 300 A/C:

Conventional = 93,090 x .01 = 931$K
IISA = 74,400 x .01 = 744$K

b. 500 A/C:

Conventional = 147,090 x .01 = 1,471$K
IISA = 120,000 x .01 = 1,200$K

1000 A/C:

c. Conventional = 282,090 x .01 = 2,821$K
IISA = 234,000 x .01 = 2,340$K

Total production cost (procurement plus ILS) for conventional and IISA aircraft is shown in Table 5.

TABLE 5. TOTAL PRODUCTION COST COMPARISON

CONVENTIONAL VS IISA (FY86$K)

COST ELEMENT	300 AIRCRAFT			500 AIRCRAFT			1000 AIRCRAFT		
	CONVENTIONAL	IISA	IISA SAVINGS	CONVENTIONAL	IISA	IISA SAVINGS	CONVENTIONAL	IISA	IISA SAVINGS
HARDWARE PROCUREMENT	93,090	74,400	18,690	147,090	120,000	27,090	282,090	234,000	48,090
ILS	37,236	29,760	7,476	58,836	48,000	10,836	112,836	93,600	19,236
TOTAL PRODUCTION COST	130,326	104,160	26,166	205,926	168,000	37,926	394,926	327,600	67,326

4.3 Operating and Support (O&S) Costs

Operating and Support Costs accrue from the day to day operation of the aircraft and its subsystems. Since, for avionics, there are no consumable fuels or oils used, the O&S costs result exclusively from maintenance performed on the individual equipments. O&S costs are broken into cost elements in Table 6. Each cost element is discussed below.

TABLE 6. CEBS, OPERATING AND SUPPORT

Operating and Support (O&S)
Organizational and Intermediate Maintenance Labor Organizational and Intermediate Maintenance Consumables Replenishment Spares Component Rework/Depot

4.3.1 Organizational and Intermediate Maintenance Labor Costs

This is the cost of the manhours expended in maintaining the equipments at the organizational level (O-level), and at the intermediate level (I-level)

4.3.1.1 Organizational & Intermediate Labor Costs for the Conventional Equipment

ASW-44, LR-85 and ASN-139 I-&O- Labor Costs

These I- and O- level labor costs are estimated as a function of the maintenance action rate (maintenance actions per flight hour (MA/FH), expended manhour rate (manhours per maintenance action (MH/MA) and labor rate ($/MH). The costs per flight hour are calculated using the following equation:

$$\$/FH = \frac{MH}{MA} \times \frac{MA}{FH} \times \frac{\$}{MH}$$

- Assumptions and References:

a. O- Level Labor Rate ($/MH) is $9.37 (FY85$).

I- Level Labor Rate ($/MH) is $11.25 (FY85$).

Reference: FY85 VAMOSC data

b. The FY86 → FY85 MPN Pay deflator rate is .9615

Source: Escalation Indices and Outlay Profile factors prepared by Naval Center for Cost Analysis, February 1986.

c. Table 7 below provides the maintenance action rates and the expended manhour rates for the above conventional equipment

TABLE 7. MAINTENANCE ACTION RATES

Equipment	MH/MA O-Level	MH/MA I-Level	MA/FH
ASW-44			
CN-1511	.41	1.64	.0046
CN-1512	.40	.74	.00041
LR-85	N/A	N/A	N/A
ASN-139*	.80	3.75	.0189

* Rates of the ASN-130 Inertial Navigation System, the predecessor of the ASN-139 were used.

Reference: The Logistics Support Analysis (LSA) prepared by McDonnell Douglas for the F/A-18.

Calculations:

a. Using assumptions a. and b. above, the FY86 labor rate is 10.72($/MH).

((9.37($/MH) + 11.26($/MH))/2) x (1/.9615) = 10.72($/MH)

b. Based on the equation for labor cost per flight hour the above assumptions, and the quantity of subsystem per system, the labor costs for each equipment is calculated below:

ASW-44:

Since an ASW-44 is made up of two CN-1511s and two CN-1512s, the labor cost is twice the sum of labor costs of the CN-1511 and the CN-1512.

$$\begin{aligned}\text{Labor Maintenance Cost} &= 2 \times ((.41 + 1.64) \times .0046 \times 10.72(\$/FH)) \\ &\quad + ((.40 + .74) \times .00041 \times 10.72(\$/FH)) \\ &= 2 \times (.101(\$/FH) + .005(\$/FH)) \\ &= .21(\$/FH)\end{aligned}$$

LR-85: Not Available.

ASN-139:

$$\begin{aligned}\text{Labor Maintenance Cost} &= (.80 + 3.75) \times .0189 \times 10.72(\$/FH) \\ &= .92(\$/FH)\end{aligned}$$

USN-2 Costs:

A maintenance action rate (MA/FH) and expended manhour rate (MH/MH) were not available from the LSA for the USN-2 equipment. However, for scaling purposes, FY84 maintenance labor costs were available and reported in VAMOSC Manuals. VAMOSC information, which is obtained from actual FY84 F-14 O&S data, provides the total O&I maintenance labor cost of 67,000$ for all F-14 aircraft. The labor costs (FY84$) per flight hour is calculated taking this cost and dividing it by 26,544, which is the number of flight hours per year in FY84 for all F-14 aircraft.

$$\frac{67{,}000\ \$\text{YR}}{26{,}544\ \text{FH/YR}} = 2.52\ \$/\text{FH}\ (\text{FY84\$})$$

Using an MPN Pay FY86 to FY84 deflator rate of .9246, this cost is converted to FY86$ as follows:

$$2.52\ \$/\text{FH} \times \frac{1}{.9246} = 2.73\ \$/\text{FH}\ (\text{FY86\$})$$

4.3.1.2 IISA Labor Costs

Since the O-level and I-level maintenance data were not available from the LSA and VAMOSC reports for the IISA, these costs were estimated by comparison and scaling with conventional equipment. The reliability of the conventional and IISA equipments determines the frequency of maintenance actions which, in turn, generates maintenance labor costs. Mean flight hours between failures (MFHBF), which measures the reliability of equipment, was predicted for both conventional and IISA equipments and used in the calculation of IISA maintenance labor costs. This was done by scaling the maintenance labor cost for conventional equipment by the ratio of the MFHBF of the conventional equipment to the MFHBF of the IISA.

Assumptions:

Several MFHBF rates were not available for conventional and IISA equipments because these equipments are either relatively new and still in their late stages of development or scheduled for production in FY87. In these cases, MFHBFs were based on either equivalent or previously used equipments from F-14, F-18, and EA-6B aircrafts. The following chart lists the conventional and IISA equipments, any equivalent equipments that were used as a basis for MFHBFs, the predicted MFHBFs, and the documents that were used to obtain this information.

Conventional Equipment	Equivalent Equipment/ Aircraft	MFHBF (HOURS)	Source Document
ASW-44	ASW-32/F-14	1140	VAMOSC
LR-85	N/A	5000(Projected)	Litton Data
ASN-139	ASN-92/ASN-130	3733(Projected)	Litton Data
USN-2	ASN-50/EA-6B	2061(Projected)	VAMOSC
IISA	N/A	20000(Projected)	Litton Data

Calculation:

The MFHBF used for conventional equipment is an average MFHBF and is calculated below.

$$\underset{\text{Conventional}}{\text{Average MTBF}} = (1140 + 5000 + 3733 + 2061)/4 = 2984 \text{ Hrs.}$$

The O-level and I-level maintenance labor cost per flight hour (FH) was determined by scaling the total maintenance labor cost/FH for the conventional equipment (Table 9) by the ratio of the average MFHBF of the conventional equipment to the MFHBF of the IISA.

$$\underset{\text{(IISA)}}{\text{Maintenance Labor Cost/FH}} = \underset{\text{(Conventional)}}{\text{Maint. Labor Cost/FH}} = \frac{\text{Avg. MFHBF (Conventional)}}{\text{MFHBF (IISA)}}$$

$$= 3.86(\$/\text{FH}) \times \frac{2984 \text{ Hrs}}{20000 \text{ Hrs}}$$

$$= .58(\$/\text{FH}) \ (\text{FY86\$})$$

4.3.2 Organizational and Intermediate Maintenance Consumables Cost

This is the cost of the individual piece parts and material used to repair the various assemblies and subassemblies. It is a function of material cost and the rate at which the material is used, which is a function of the MA/FH.

4.3.2.1 Conventional Equipment Consumables Costs

ASW-44, LR-85 and ASN-139 Consumables Costs

Since no data was available for the cost of consumables for the above equipments, it was necessary to scale from the equivalent F-14A and F-18 equipment data using the following relationship:

$$MC = MC_{14} \frac{MA/FH}{MA/FH_{14}} \times \frac{UPC}{UPC_{14}}$$

where:

MC = cost of consumables for conventional equipment ($/FH)

MC_{14} = cost of consumables for the equivalent F-14 equipment(s) (Table 8)

MA/FH = unscheduled maintenance action rate for the conventional equipment (Table 7)

MA/FH_{14} = unscheduled maintenance action rate for the equivalent F-14 equipment(s) (Table 8)

UPC = unit production cost for the conventional equipment (Table 3)

UPC_{14} = unit production cost for the equivalent F-14 equipment(s) (Table 8)

Table 8 lists the F-14 equipments with their MA/FH, UPC, and maintenance consumables cost ($/FH). Other O&S cost data discussed later are also shown in Table 8. All are aggregated by their equivalency to the conventional equipments. The F-14 UPC's were obtained from ASO records, while the remaining data were obtained from VAMOSC updated to FY86$.

TABLE 8. F-14 O&S SCALING DATA

(FY-86$)

F-14 EQUIVALENT EQUIPMENT	CONVENTIONAL COUNTERPART	MA/FH	UPC (K$)	CONSUMABLES O- & I-LEVEL ($/FH)	COMPONENT REWORK/DEPOT ($/FH)	REPLENISHMENT SPARES ($/FH)
DT-387/ASW-32	CN-1511/ ASW-44	.0011	4.440	.0256	.3577	.3780
DT-388/ASW-32		.0023	4.264	.1022	3.6800	1.1340
DT-389/ASW-32		.0018	6.327	.2555	3.0667	.7560
TOTAL		.0052	15.031	.3833	7.1044	2.2680
MX-8722/ ASW-32	CN-1512/ ASW-44	.0011	4.981	0	.2811	0
ASN-92	ASN-139	.0604	174.062	1.0222	30.0792	.0251
N/A	LR-85	N/A	N/A	N/A	N/A	N/A

- Calculations

ASW-44:

Cost of consumables for the CN-1511

= .3833($/FH) x (.0046/.0052) x (28.82$K/15.031$K)

= .6501 ($/FH)

Cost of consumables for the CN-1512

= 0($/FH) x (.00041/.0011) x (12.01$K/4.981$K)

= 0($/FH)

Cost of Consumables for the ASW-44

= Two times the cost of consumables for the CN-1511 plus two times the cost of consumables for the CN-1512

= 2 x .6501($/FH) + 2 x 0 ($/FH)

= 1.30 ($/FH)

LR-85:

Cost of consumables for the LR-85 is not available.

ASN-139:

Cost of consumables for the ASN-139

$$= 1.0222(\$/FH) \times (.0189/.0604) \times (94.5\$K/174.062\$K)$$
$$= .17(\$/FH)$$

USN-2 Consumable Costs

A Maintenance Action Rate (MA/FH) and expended manhour rate (MH/MA) were not available from the LSA for the USN-2 equipment. However, for scaling purposes, FY84 maintenance consumables costs were available and reported in VAMOSC Manuals. VAMOSC information, which is obtained from actual FY84 F-14 O&S data, provides the total annual O&I maintenance consumables cost of $9,000 for all F-14 aircraft. The consumables cost (FY84$) per flight hour is calculated taking this cost and dividing it by 26,544, which is the number of flight hours per year in FY84 for all F-14 aircraft.

$$\frac{9{,}000\ \$/YR}{26{,}544\ FH/YR} = .34\ \$/FH\ (FY84\$)$$

Using an O&MN purchases FY86 to FY84 deflator rate of .9353, this cost is converted to FY86$ as follows:

$$.34\ \$/FH \times \frac{1}{.9353} = .36\$/FH(FY86\$)$$

4.3.2.2 IISA Consumables Cost

Since the O-level and I-level maintenance data were not available from the LSA and VAMOSC reports for the IISA, these costs were estimated by comparison and scaling with conventional equipment. The reliability of the conventional and IISA equipments is used to determine the maintenance labor costs which, in turn, is directly related to the requirements for maintenance consumables. Mean flight hours between failures (MFHBF), which measures the reliability of equipment, was predicted for both conventional and IISA equipments and used in the calculation of IISA maintenance consumables costs. This was done by scaling the maintenance consumables cost for conventional equipment by the ratio of the MFHBF of the conventional equipment to the MFHBF of the IISA.

The O-level and I-level maintenance consumables cost per flight hour (FH) was determined by scaling the total maintenance consumables cost/FH for the conventional equipment (Table 9) by the ratio of the average MFHBF (Section 4.3.1.2) of the conventional equipment to the MFHBF of the IISA (Section 4.3.1.2).

$$\underset{\text{(IISA)}}{\text{Maint. Consum. Cost/FH}} = \underset{\text{(Conventional)}}{\text{Maint. Consum. Cost/FH}} \times \frac{\text{Avg. MFHBF (Conventional)}}{\text{MFHBF (IISA)}}$$

$$= 1.83(\$/\text{FH}) \times \frac{2984 \text{ Hrs}}{20000 \text{ Hrs}}$$

$$= .27(\$/\text{FH}) \text{ (FY86\$)}$$

4.3.3 Replenishment Spares Cost

This is the cost of replacing repairable equipments and assemblies which have been discarded after determination as being beyond repair. Their cost is a function of the rate at which the spares are used (a function of MA/FH) and the UPC.

4.3.3.1 Conventional Equipment Replenishment Spares Cost

ASW-44, LR-85 and ASN-139 Replenishment Spares Cost

Since replenishment spares costs are available for the F-14 equipments (See Table 8), but not for the conventional equipments, scaling was performed similarly to that for the consumables costs.

The equation used to calculate the cost of the element was the same as contained in Section 4.3.2.1 for O&I maintenance consumables. The terms RS_{14} (replenishment spares cost for F-14 equipment) was substituted for MC_{14}, thus resulting in RS (replenishment spares cost for the equivalent conventional equipment) ($/FH).

- Calculations

ASW-44:

Cost of replenishment spares for the CN-1511

= 2.268($/FH) x (.0046/.0052) x (28.82$K/15.031$K)
= 3.847 ($/FH)

Cost of replenishment spares for the CN-1512

= 0($/FH) x (.00041/.0011) x (12.01$K/4.981$K)
= 0($/FH)

Cost of replenishment spares for the ASW-44

= twice the cost of replenishment spares for the CN-1511 plus twice the cost of replenishment spares for the CN-1512.

= 2 x 3.847($/FH) + 2 x 0 ($/FH)

= 7.69 ($/FH)

LR-85:

Cost of replenishment spares for the LR-85 is not available.

ASN-139:

Cost of replenishment spares for the ASN-139

$$= .0251(\$/FH) \times (.0189/.0604) \times (94.5\$K/174.062\$K)$$
$$= .0043\ (\$/FH)$$

USN-2 Replenishment Spares Cost

A maintenance action rate (MA/FA) and expended manhour rate (MH/MA) were not available from the LSA for the USN-2 equipment. However, for scaling purposes FY84 O&S replenishment spares costs were available and reported in VAMOSC Manuals. VAMOSC information, which is obtained from actual FY-84 F-14 O&S data provides the total annual replenishment spares cost of $21,000 for F-14 aircraft. The replenishment spare (FY84$) per flight hour is calculated taking this cost and dividing it by 26,544, which is the number of flight hours per year in FY84 for all F-14 aircraft.

$$\frac{21{,}000\ \$/YR}{26{,}544\ FH/YR} = .79\ \$/FH\ (FY84\$)$$

Using an O&MN Purchases FY86 to FY84 deflator rate of .9353, this cost is converted to FY86$ as follows:

$$.79\ \$/FH \times \frac{1}{.9353} = .84\ \$/FH\ (FY86\$)$$

4.3.3.2 IISA Replenishment Spares Costs

Since O&S data were not available from the LSA and VAMOSC reports for the IISA, these costs were estimated by comparison and scaling with conventional equipment. The reliability of the conventional and IISA equipments is used to determine maintenance labor costs which, in turn, is directly related to the requirement for replenishment spares. Mean flight hours between failures (MFHBF), which measures the reliability of equipment, was predicted for both conventional and IISA equipments and used in the calculation of IISA replenishment spares costs. This was done by scaling the replenishment spares cost for conventional equipment by the ratio of the MFHBF of the conventional equipment to the MFHBF of the IISA.

The O-level and I-level replenishment spares cost per flight hour (FH) was determined by scaling the total replenishment spares cost/FH for the conventional equipment (Table 9) by the ratio of the average MFHBF of the conventional equipment (Section 4.3.1.2) to the MFHBF of the IISA (Section 4.3.1.2).

$$\underset{\text{(IISA)}}{\text{Repl. Spares Cost/FH}} = \underset{\text{(Conventional)}}{\text{Repl. Spares Cost/FH}} = \frac{\text{Avg. MFHBF (Conventional)}}{\text{MFHBF (IISA)}}$$

$$= 8.5343(\$/\text{FH}) \times \frac{2984 \text{ Hrs}}{20000 \text{ Hrs}}$$

$$= 1.27(\$/\text{FH}) \text{ (FY86\$)}$$

4.3.4 Depot/Component Rework Cost

This is the cost of repairing assemblies and subassemblies at either a Naval Air Rework Facility (NARF) or a commercial depot. This cost is a function of the rate at which items are sent to the depot for repair (a function of MA/FH), the cost of the repair parts and materials, and the depot direct and indirect labor rate.

4.3.4.1 Conventional Equipment Depot/Component Rework Cost

ASW-44, LR-85 and ASN-139 Depot/Component Rework Cost.

As in 4.3.2.1 and 4.3.3.1 above, these costs were available for the F-14 equipments (See Table 8). Here again, no data was available for the conventional equipments, and scaling from the F-14 equivalents was necessary. The scaling procedures and relationships used are the same as those in 4.3.2.1 and 4.3.3.1 above. The equation used to calculate the cost of this element was the same as contained in Section 4.3.2.1 for O&I maintenance consumables. The term CR_{14} (component rework/depot cost for F-14 equipment) was substituted for MC_{14},, thus resulting in CR (component rework/depot cost for conventional equivalent equipment) ($/FH).

- Calculations

ASW-44:

Component rework/depot cost for the CN-1511

= 7.1044($/FH) x (.0046/.0052) x (28.82$K/15.031$K)
= 12.05 ($/FH)

Component rework/depot cost for the CN-1512

=.2811($/FH) x (.00041/.0011) x (12.01$K/4.981$K)
=.25($/FH)

Component rework/depot cost for the ASW-44

= twice the component rework/depot cost for the CN-1511 plus twice the component rework/depot cost for the CN-1512.

= 2 x 12.05($/FH) + 2 x .25 ($/FH)

= 24.60 ($/FH)

LR-85:

Component rework/depot cost for the LR-85 is not available.

ASN-139:

Component rework/depot cost for the ASN-139

$$= 30.0792(\$/FH) \times (.0189/.0604) \times (94.5\$K/174.062\$K)$$
$$= 5.11\ (\$/FH)$$

USN-2 Depot/Component Rework Costs

A maintenance action rate (MA/FA) and expended manhours rate (MH/MA) were not available from the LSA for the USN-2 equipment. However, for scaling purposes, FY84-component rework and depot costs were available and reported in VAMOSC Manuals. VAMOSC information, which is obtained from actual FY84 F-14 O&S data, provides the total annual component rework and depot cost of 235,843$ for all F-14 aircraft. The cost (FY84$) per flight hour is calculated taking this cost and dividing it by 26,544, which is the number of flight hours per year in FY84 for all F-14 aircraft.

$$\frac{235{,}843\$YR}{26{,}544\ FH/YR} = 8.89\ \$/FH\ (FY84\$)$$

Using an O&MN purchases FY-86 to FY84 deflator rate of .9353, this cost is converted to FY86$ as follows

$$8.89(\$/FH) \times \frac{1}{.9353} = 9.50\ \$/FH\ (FY86\$)$$

4.3.4.2 IISA Depot/Component Rework Costs

Since O&S data were not available from the LSA and VAMOSC reports for the IISA, these costs were estimated by comparison and scaling with conventional equipment. The reliability of the conventional and IISA equipments is used to determine maintenance labor costs which, in turn, is directly related to the requirement for depot/component rework. Mean flight hours between failure (MFHBF), which measures the reliability of equipment, was predicted for both conventional and IISA equipments and used in the calculation of IISA depot/component rework costs. This was done by scaling the depot/component rework cost for conventional equipment by the ratio of the MFHBF of the conventional equipment to the MFHBF of the IISA.

The O-level and I-level replenishment spares cost per flight hour (FH) was determined by scaling the total replenishment spares cost/FH for the conventional equipment (Table 9) by the ratio of the average MFHBF of the conventional equipment (Section 4.3.1.2) to the MFHBF of the IISA (Section 4.3.1.2).

$$\underset{\text{(IISA)}}{\text{Depot/CR Cost/FH}} = \underset{\text{(Conventional)}}{\text{Depot/CR Cost/FH}} \times \frac{\text{Avg. MFHBF (Conventional)}}{\text{MFHBF (IISA)}}$$

$$= \$39.21/\text{FH} \times \frac{2984\text{Hrs.}}{20000\text{Hrs.}}$$

$$= \$5.85/\text{FH} \quad (\text{FY86\$K})$$

4.3.5 Summary of O&S Costs

A summary of O&S costs per flight hour for the conventional and IISA equipments are shown in Table 9 below for each individual equipment.

TABLE 9. O&S COST PER FLIGHT HOUR (FH)
FOR CONVENTIONAL AND IISA SYSTEMS
(FY 86 $)

EQUIPMENT	O&I LEVEL LABOR ($/FH)	CONSUMABLES O&I LEVEL ($/FH)	REPLENISHMENT SPARES ($/FH)	DEPOT/COMP. REWORK ($/FH)	TOTAL ($/FH)
CONVENTIONAL					
ASW-44	0.21	1.30	7.69	24.60	33.80
LR-85	N/A	N/A	N/A	N/A	0.00
ASN-139	0.92	0.17	0.0043	5.11	6.20
USN-2	2.73	0.36	0.84	9.50	13.43
TOTAL CONVENTIONAL	3.86	1.83	8.5343	39.21	53.43
IISA	0.58	0.27	1.2733	5.85	7.97

The total annual cost for O&S for the conventional and the IISA equipments are shown in Table 10 by the three production quantity options. The difference in cost between the conventional and IISA equipments are shown in IISA savings. These annual costs were calculated by multiplying the costs per flight hour from Table 9 by the total number of flight hours for each of the three production quantities. It was assumed that a typical aircraft could fly thirty hours a month, so that the total number of flight hours per production quantity option is as follows:

Total Flight Hours = Qty of A/C x 30 Hrs/Aircraft/Mo x 12 Mo/Year

300 A/C:	300 x 30 x 12 = 108,000 Hrs.Yr.
500 A/C:	500 x 30 x 12 = 180,000 Hrs/Yr.
1000 A/C:	1000 x 30 x 12 = 360,000 Hrs/Yr.

TABLE 10. COMPARISON OF TOTAL ANNUAL O&S COSTS
CONVENTIONAL SYSTEM VS. IISA SYSTEM
(FY 86 $K)

	O&I LEVEL LABOR	CONSUMABLES O&I LEVEL	REPLENISHMENT SPARES	DEPOT/COMP. REWORK	TOTAL
300 A/C (108,000 FH/YR)	$K/FY	$K/FY	$K/FY	$K/FY	$K/FY
CONVENTIONAL	416.9	197.6	921.7	4,234.7	5,770.9
IISA	62.6	29.2	137.5	631.8	861.1
IISA SAVINGS	354.3	168.4	784.2	3,602.9	4,909.8
500 A/C (180,000 FH/YR)	$K/FY	$K/FY	$K/FY	$K/FY	$K/FY
CONVENTIONAL	694.8	329.4	1,536.2	7,057.8	9,618.2
IISA	104.4	48.6	229.2	1,053.0	1,435.2
IISA SAVINGS	590.4	280.8	1,307.0	6,004.8	8,183.0
1000 A/C (360,000 FH/YR)	$K/FY	$K/FY	$K/FY	$K/FY	$K/FY
CONVENTIONAL	1,389.6	658.8	3,072.3	14,115.6	19,236.3
IISA	208.8	97.2	458.4	2,106.0	2,870.4
IISA SAVINGS	1,180.8	561.6	2,613.9	12,009.6	16,365.9

The annual costs shown in Table 10 were multiplied by 20 to provide a twenty year O&S cost by the assumed production quantity options and are shown in Table 11. Differences in cost between the conventional and IISA equipments are shown in IISA savings.

TABLE 11. TWENTY YEAR O&S COST COMPARISON
CONVENTIONAL SYSTEM VS. IISA SYSTEM
(FY 86 $K)

COST ELEMENT	300 AIRCRAFT			500 AIRCRAFT			1000 AIRCRAFT		
	CONVENTIONAL	IISA	IISA SAVINGS	CONVENTIONAL	IISA	IISA SAVINGS	CONVENTIONAL	IISA	IISA SAVINGS
O&I LEVEL MAINTENANCE LABOR	8,338	1,252	7,086	13,896	2,088	11,808	27,792	4,176	23,616
O&I LEVEL MAINTENANCE CONSUMABLES	3,952	584	3,368	6,588	972	5,616	13,176	1,944	11,232
REPLENISHMENT SPARES	18,434	2,750	15,684	30,724	4,584	26,140	61,446	9,168	52,278
COMPONENT REWORK/DEPOT	84,694	12,636	72,058	141,156	21,060	120,096	282,312	42,120	240,192
TOTAL O&S COST	115,418	17,222	98,196	192,364	28,704	163,660	384,726	57,408	327,318

4.4 Production Cost Comparison

The total Production Costs of the conventional system and IISA system which have been previously summarized and compared in Table 1 are repeated in Table 12. The IISA system shows significant savings over the 20 year service life. The savings are proportional to the fleet size and the number of equipments replaced. The greatest savings are realized in the O&S phase of the life cycle.

TABLE 12. PRODUCTION AND O&S COST COMPARISON
CONVENTIONAL SYSTEM VS. IISA SYSTEM
(FY 86 $K)

COST ELEMENT	300 AIRCRAFT			500 AIRCRAFT			1000 AIRCRAFT		
	CONVENTIONAL	IISA	IISA SAVINGS	CONVENTIONAL	IISA	IISA SAVINGS	CONVENTIONAL	IISA	IISA SAVINGS
PRODUCTION	130,326	104,160	26,166	205,926	168,000	37,926	394,926	327,600	67,326
OPERATING AND SUPPORT	115,418	17,222	98,196	192,364	28,704	163,660	384,726	57,400	327,318
TOTAL LCC	245,744	121,382	124,362	398,290	196,704	201,586	779,652	385,008	394,644

APPENDIX A

LIST OF ACRONYMS

A/C	Aircraft
AUC	Average Unit Cost
CEBS	Cost Element Breakdown Structure
COM	Cost of Money
D-Level	Depot level (re. maintenance)
ECO	Engineering Change Order
FH	Flight Hour
FY	Fiscal Year
G&A	General and Administrative
HR	Hour
IISA	Integrated Inertial Sensor Assembly
ILS	Integrated Logistics Support
INA	Inertial Navigation Assembly
I&T	Integration and Test
LSA	Logistics Support Analysis
LSI	Large Scale Integration (re. microchips)
MA	Maintenance Action
MCAIR	McDonnell Douglas Aircraft Corp.
MFHBF	Mean Flight Hours Between Failure
MH	Maintenance Hours
NARF	Naval Air Rework Facility
NAVAIRDEVCEN	Naval Air Development Center
NAVAIRSYSCOM	Naval Air Systems Command
O&M	Operations and Maintenance (funding appropriation)
O/I-Level	Organizational/Intermediate Level (re. maintenance)
O&S	Operations and Support
SE	Support Equipment
T_1	Theoretical First Unit Cost
UC	Unit Cost
UPC	Unit Production Cost
VAMOSC	Visability and Management of Operating Support Costs
WRA	Weapons Replaceable Assembly