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QUANTIFICATION OF THE S-3 VIKING AIRCRAFT
SERVICE PERIOD ADJUSTMENT (ASPA) PROGRAM

by
Wayne Peter Borchers
and
Richard Michael Rowan

December 1986

Thesis Advisor: Alan W. McMasters
Co-Advisor : Casimir E. Lawler

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Quantification of the S-3 Viking Aircraft Service Period Adjustment (ASPA) Program

by

Wayne Peter Borchers
Lieutenant, United States Navy
B.S., United States Naval Academy, 1980

and

Richard Michael Rowan
Lieutenant, United States Navy
B.S., University of Arizona, 1979

Submitted in partial fulfillment of the requirements for the degree of

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December 1986

Authors:

Wayne Peter Borchers

Richard Michael Rowan

Approved by:

Alan W. McMasters, Thesis Advisor

Casimir E. Lawler, Co-Advisor

Willis R. Greer, Jr., Chairman
Department of Administrative Sciences

Kneale T. Marshall, Dean of Information
and Policy Sciences

ABSTRACT

The Aircraft Service Period Adjustment (ASPA) inspection/evaluation process for the Navy's S-3A Viking aircraft is presently a subjective assessment of the aircraft's general material condition. The purpose of this thesis is to quantify the ASPA inspection/evaluation process. The methodology used to quantify this process utilizes the Analytic Hierarchy Process (AHP) model. The AHP model is based upon three principles of logical analysis: (1) the principle of constructing hierarchies, (2) the principle of establishing priorities, and (3) the principle of logical consistency. This study presents a more efficient method of determining the aircraft induction decision than the current subjective ASPA procedures. Although the principle of logical consistency caused great concern amongst the authors, a methodology has been developed for quantifying the S-3A ASPA process that will assist NARF Alameda management in the control and documentation phase of the S-3A ASPA program.

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LIST OF ACRONYMS

AHP	Analytical Heirarchy Process
AIMD	Aircraft Intermediate Maintenance Department
ASPA	Aircraft Service Period Adjustment
CFA	Cognizant Field Authority
CI	Consistency Index
CR	Consistency Ratio
D/Cr	Depot Critical Defect
D/Ma	Depot Major Defect
D/Mi	Depot Minor Defect
DRP	Designated Rework Point
ESP	Effective Service Period
FS	Field Support
ISP	Initial Service Period
LES	Local Engineering Specification
NALC	Naval Aviation Logistics Center
NARF	Naval Air Rework Facility
O/Cr	Organizational Critical Defect
O/Ma	Organizational Major Defect
OSP	Operational Service Period
P&E	Planner and Estimator
PED	Period End Date
RI	Random Index
SDLM	Standard Depot Level Maintenance

LIST OF DEFINITIONS

1. Initial Service Period (ISP): The minimum time that aircraft in a reportable group (aircraft type) are expected to both safely and economically remain in service following fleet introduction or SDLM. This time period can be expressed in terms of months, flight hours or number of cycles and serves as the milestone for the initial ASPA evaluation. The ISP can be lengthened based on the ASPA evaluation results.

2. Local Engineering Specification (LES): Designed to assist depot level planners and estimators (P&E's) in the identification and correction of recurring, significant aircraft material maintenance conditions.

3. Naval Air Rework Facility (NARF): Organization responsible for coordinating and conducting Standard Depot Level Maintenance (SDLM) on fleet aircraft.

4. Operating Service Months (OSM): Applied to specific aircraft bureau numbers (i.e., serial number) and is the calendar months since acceptance/new or SDLM, whichever occurred last, less non-aging time (preserved and bagged).

5. Operating Service Period (OSP): The number of calendar months between SDLM inductions that an aircraft can safely and economically operate.

6. Period End Date (PED): The month and year in which the current Operating Service Period expires for a given aircraft and is subject to authorized adjustments (lengthening) resulting from ASPA evaluations or non-aging time.

7. Standard Depot Level Maintenance (SDLM): Series of tailored maintenance actions applied to specific aircraft bureau numbers; typically follows aircraft completion of an operating service period.

I. INTRODUCTION

A. BACKGROUND

The Aircraft Service Period Adjustment Program (ASPA) is now a reality for most aircraft in the U.S. Navy inventory. The primary goal of this program is the prevention of premature depot induction of fleet aircraft resulting in the unwarranted disassembly, inspection/evaluation and repair that Standard Depot Level Maintenance (SDLM) entails. The main feature of the ASPA program is an in-depth evaluation designed to reduce airframe maintenance budget costs and time spent overhauling airframe systems.

The focus of this study deals with the quantification of the ASPA inspection/evaluation for the S-3A Viking aircraft. Built by Lockheed California Company, the S-3A has been the Navy's premier carrier-based antisubmarine platform designed to counter the surface and subsurface threat to the carrier battle group since 1975. The Viking incorporates both acoustic and non-acoustic sensors to enhance its weapon system in support of its primary mission. As the Cognizant Field Authority (CFA)/Designated Rework Point (DRP) for the S-3A aircraft and related equipment the Naval Air Rework Facility (NARF), Alameda, California has managed the ASPA program for the aircraft since its inception in 1984.

B. OBJECTIVE

Present inspection/evaluation procedures entail the subjective assessment of an aircraft's material condition. Historically, this subjective non-quantitative approach appears to have some weaknesses.

For example, inspections performed on the same aircraft by different ASPA inspectors have revealed inconsistent results. The primary purpose of this thesis is to attempt to eliminate this weakness by introducing quantifiable measures into the ASPA inspection/evaluation procedures for the S-3A in an attempt to provide consistency and objectivity.

C. SCOPE

Specifically, this thesis attempts to eliminate the inherent problems associated with subjective evaluations through an application of the Analytic Hierarchy Process (AHP) model (developed by Thomas L. Saaty) to the ASPA inspection/evaluation. Aircraft general material condition is the primary criterion to be used in this approach. Consideration of cost factors was not possible due time constraints and lack of available data at the CFA/DRP level.

D. PREVIEW

Chapter II describes the evolution of the ASPA concept, and defines the process and key organizations involved. Chapter III presents an example utilizing the AHP methodology and its application to the S-3A ASPA program. Chapter IV discusses the relationship between the ASPA process and the principles of the AHP. Chapter V develops an observable scale which correlates ASPA inspection results to a weighted scale. Chapter VI presents conclusions and recommendations.

II. ASPA BACKGROUND

The Department of the Navy (DON) has entertained various approaches to aircraft maintenance in an effort to preserve and maintain fleet operational readiness. The DON's main objective has been to reduce total program maintenance costs by judiciously applying scarce depot rework assets as necessary without sacrificing fleet operational readiness.

In the early 1970's, for example, the DON implemented a program similar to the Aircraft Service Period Adjustment (ASPA) program entitled "Aircraft Condition Evaluation" (ACE). Unfortunately, introduction of the ACE program significantly increased organizational (O-level) maintenance man-hours which revealed less than optimal results; therefore, an unacceptable number of fleet aircraft were in a non-flight (disassembled) status for extended time periods. It was readily apparent to the DON that this maintenance philosophy (and others like it) resulted in poor budgeting practices and difficulty in quantifying depot level maintenance airframe requirements. Therefore, in 1982 the Naval Aviation Logistics Center (NAVAVNLOGCEN) proposed the ASPA program as a means of deferring SDLM for fleet aircraft by adjusting the Period End Date (PED). As a part of the Planning, Programming and Budgeting System (PPBS), the ASPA program is a significant departure from previous approaches. In contrast to the ACE program, ASPA provides a methodology for reducing maintenance costs in spite of ever-increasing material costs and wages. [Ref. 1:p. 5] The remainder of this chapter is devoted to a description and discussion of the significant aspects of the ASPA concept, process and key participants.

A. INTRODUCTION

The ASPA program philosophy focuses on the delicate, ever-changing balance between costs and readiness. The purpose of the program is two-fold. The primary purpose is to reduce maintenance costs of airframes (SDLM costs) by lengthening the aircraft's operational service period (OSP). An important aspect of the primary purpose is

> . . . to identify those aircraft that are in significantly better condition than that warranting depot induction for the detailed disassembly, inspection and repair that SDLM entails. Airframes which meet the ASPA criteria are proposed for a twelve-month deferral of SDLM induction and that amount of time is added to the individual aircraft's Period End Date (PED). Aircraft failing an ASPA inspection must be inducted for SDLM as soon as possible, but in no case more than 90 days beyond the PED, or be grounded. [Ref. 2:p. 1]

In direct support of the primary, a secondary purpose is

> . . . to define the airframe depot maintenance requirements based on actual assessment of the individual aircraft's material condition rather than a statistical prediction (i.e., rework on an as-needed basis) [Ref. 2:p. 1].

ASPA is based on the premise that fleet aircraft, regardless of community type, will have a wide distribution of observable material conditions (due to differing flight environments - shore, carrier based, climate, etc.) at any particular point during service life or following any given number of individual aircraft operating hours. The mean level of material degradation that is expected at the PED may very well be considered "fleet average" for that particular aircraft type. Recent evidence, however, has recorded degradation levels for a specific aircraft which are lower than expected at the PED thereby allowing such an aircraft to be safely kept in active service with no significant impact on readiness or costs. [Ref. 3:p. 17]

B. ASPA PROCESS

The ASPA process involves complex interaction and coordination between the cognizant field authority (CFA)/Designated Rework Point (DRP) and operational level activities (squadron). Historically, the end of the operating service period has been signalled by the PED, however, the implementation of the ASPA program revises this perspective. Typically, fleet aircraft material condition is evaluated within the "ASPA window" or time frame which is normally six months prior to the PED. For those aircraft being deferred, elapsed time between the ASPA evaluation and the adjusted PED normally does not exceed 18 months; therefore, the deferral is for a maximum 12-month period. Induction into field support (FS) custody no later than ninety calendar days following PED is mandatory for those aircraft not recommended for PED adjustment. Those recommended for adjustment may have an unlimited series of aircraft material condition evaluations. [Ref. 3:p. 17]

It is appropriate at this point to describe the ASPA program acceptance criteria and briefly discuss the responsibilities and functions of the key players involved in the ASPA process.

1. Program Acceptance Criteria

Aircraft under consideration for the ASPA program must meet the following conditions:

(a) Only aircraft approaching their first tour (initial fleet operational in-service period) extensions are eligible.

(b) For transition (to ASPA) purposes, aircraft can be inspected as early as six (6) months prior to their PED.

(c) Once an aircraft is on the ASPA schedule it will remain on the schedule.

(d) Subsequent ASPA inspections will be performed 90 days prior to or 30 days after the aircraft's PED. (SDLM normally commences at PED but due to operational requirements, a 30-day extension can be granted.)

(e) Aircraft currently on an extension program will remain on that program until the aircraft starts a new tour (normally starts following SDLM).

2. Responsibilities/Functions

a. Cognizant Field Authority (CFA) Involvement/Designated Rework Point (DRP) Involvement.

Establishment of ASPA examination and evaluation requirements, PED adjustment criteria, and program management as applied to operational aircraft custodians (squadron) is the direct responsibility of the CFA which is, for the purpose and scope of this thesis, the Naval Air Rework Facility (NARF) Alameda [Ref. 3:p. 17].

Effective and efficient execution of the ASPA process requires proper management and coordination at three levels within the NARF Alameda management framework.

ASPA Program Level. Coordination at this level involves the S-3A Engineering Branch (to include Branch Head, engineers, Planners and Evaluators, etc.). It establishes policies and procedures within the CFA/DRP structure.

Command Level. Responsible for establishing "consistency of purpose, timeliness and application of ASPA to the various aircraft programs assigned. An internal organization must be identified that consists of those major elements of the CFA/Prime DRP organization having functional and/or program assignments that support the attainment of the ASPA objectives" [Ref. 3:p. 20].

Aircraft Program Level. Coordination at this level is the responsibility of both the CFA/Prime DRP and a DRP ASPA participant (i.e, NARF Alameda/S-3 Division and fleet squadron). The prime objectives of this level, in terms of coordination, are to ensure effective execution and uniform interpretation of Local Engineering Specifications (LES) by properly trained and qualified ASPA evaluators. Also, it is necessary to minimize the effect on fleet operations of problems (aircraft down-time, inspection scheduling, man-hours required, etc.) associated with conducting ASPA conditional MRC's. The management effort should facilitate timely data generation, feedback analysis and analytical reporting as well as actions necessary to correct material impediments or defects uncovered as a by-product of the ASPA inspection (i.e., ensuring that all discrepancies are properly documented by the aircraft custodian maintenance activity). [Ref. 3:pp. 20-21]

b. Organization (Squadron) Level Involvement.

The requirement to meet all operational commitments and to request, schedule and prepare aircraft and their operational/maintenance records for the ASPA inspection and evaluation is the direct responsibility of the reporting custodian (squadron) of the aircraft as the on-site representative of the Aircraft Controlling Custodian (ACC). In preparation for the ASPA inspection, with direct assistance and support from the CFA/Prime DRP, the squadron maintenance department should ensure that ASPA Maintenance Requirement Cards (MRC's) be prepared and validated in order to restore the aircraft, if necessary, to meet the minimum material status (i.e., the aircraft is required to be in an "up" status) required for ASPA inspection eligibility. [Ref. 3: pp. 19-20]

C. EVALUATOR QUALIFICATION PROGRAM

In order to ensure that ASPA inspection and evaluation requirements are consistently applied, evaluator qualification standards are necessary. The need for consistent application of inspection procedures, with respect to the accuracy of inspection results, is quite critical since ASPA evaluations are presently subjective in nature.

1. ASPA Evaluator Requirements

Qualifications for an individual desiring designation as an ASPA examiner is established by the Maintenance Engineering Cognizant Field Activity (MECFA) for aircraft programs under its cognizance. Typically, the qualifications are expressed in terms of desired experience levels (avionics, structural or hydraulics technician), required training or a combination of both, and are coordinated within the production department of the respective CFA to ensure that consistent, relevant requirements are maintained.

2. ASPA Evaluator Selection

The selection of prospective ASPA evaluators is under the control of the CFA production department with a MECFA representative as a participating member of both the rating and selection panels [Ref. 3: pp. 34-35].

D. SUMMARY

This chapter has discussed the development and objectives of the ASPA concept and key organizations involved because the purpose of this thesis is to develop a methodology for quantifying the ASPA inspection and evaluation process for the S-3A aircraft. Chapter III will address and describe the Analytical Hierarchy Process (AHP) model selected by the authors to provide this quantification. The details of the ASPA procedure for evaluating an aircraft's material readiness and a discussion of the relationship between the ASPA process and the AHP will be addressed in Chapter IV. Chapter V discusses the development of an observable scale for correlating ASPA inspection results to a weighted scale providing the necessary link to completely quantify a previously subjective process. Chapter VI presents a summary, conclusions and recommendations.

III. THEORETICAL FRAMEWORK OF THE ANALYTICAL HIERARCHY PROCESS

A. INTRODUCTION

The major research question of our thesis was to quantify a previously subjective process in a manner which was consistent and logical. In our search for a model or methodology that would help answer this question, we decided to seek out a process which combined deductive and inductive approaches of the mind in an integrated and logical framework.

The human mind organizes decision making methodology into two broad categories. The first category is the deductive or logical approach, and the second category is the inductive or systems approach. The logical categorization entails the analysis of a system via a generic networking scheme whose structure consists of various interconnected chains and cycles. Once the human mind structures the network it is easier to explain the function of each individual component and, by synthesis, the network is defined. The most serious drawback of the logical approach is that the feedback concept is not utilized. To correct for this omission, the human mind must employ the inductive approach, which looks at the general or holistic perspective and ignores each individual component's function. Clearly, both the deductive and inductive approaches contribute to the human mind's ability to understand and analyze complex systems. [Ref. 4:p. 5]

B. THE ANALYTICAL HIERARCHY PROCESS

The model which seems to best satisfy our criterion is the Analytic Hierarchy Process (AHP) developed by Dr. Thomas L. Saaty. The Analytic

Hierarchy Process is based upon three fundamental principles of logical analysis [Ref. 4:p. 17]:

(1) The principle of constructing hierarchies.

(2) The principle of establishing priorities.

(3) The principle of logical consistency.

In the following sections of this chapter we will explain how the Analytical Hierarchy Process can be utilized to quantify the currently subjective S-3 Viking Aircraft Service Period Adjustment (ASPA) program.

Presently, the S-3 ASPA inspection is done by a Naval Air Rework Facility (NARF) Planner and Estimator (P&E). The P&E evaluator inspects the subject aircraft in accordance with the NARF Alameda S-3 ASPA Local Engineering Specification (LES) (Appendix A). A unique feature of the S-3 ASPA inspection is that zonal areas (i.e., the fuselage, rudder assembly, horizontal stabilizer, etc.) are inspected for deterioration instead of a leading indicator examination methodology (i.e., the hinges of the rudder assembly).

Since the zonal area inspection method could produce many discrepancies ranging in severity from organizational to depot level repair required, we attempted to quantify the ASPA evaluation by weighting the various discrepancy categories available for assignment by the P&E evaluator. The first step in accomplishing this objective utilizing AHP was to structure a hierarchy of the problem being studied.

1. Structuring Hierarchies

Saaty [Ref. 4:p. 17] expresses this view of the structuring of hierarchies:

> Humans have the ability to reduce a complex problem into various levels and sublevels as many times as necessary to simplify the

comprehension process. By the use of hierarchies one can show how changes in emphasis or priority on an upper level will effect the final outcome at the lower levels.

Since we are trying to quantify the S-3 ASPA process via logical, analytical thinking (the main characteristic of AHP) we must structure the ASPA process in a manner which allows us to study each decision level independent of the ASPA process as a whole. The use of a functional hierarchy helped to accomplish this goal.

The basic decision levels of the functional hierarchy are the focus, criteria, subcriteria and alternatives stage (Figure 1). The focus of the hierarchy is the broad, overall objective of the problem being studied. In the case of the ASPA evaluation process, the overall objective of the program is to identify aircraft for induction into Standard Depot Level Maintenance (SDLM) rework. The criteria of the hierarchy represents the forces which influence the focus. The major influential force in the determination of SDLM rework, according to the ASPA process, is the general material condition of the specific aircraft being inspected. The subcriteria of the functional hierarchy are the actors which determine the criteria. In our case, the subcriteria are the specific zonal areas the P&E evaluators inspect (Table 1 and Appendix B). These zonal areas are assigned a subjective grade, which is used by the P&E evaluator in his final determination of the general material condition of the aircraft. The final decision level of the functional hierarchy is the "possible alternatives" stage. This level of the hierarchy represents possible scenarios available within the ASPA process. Two courses of action are possible at this level: induct the aircraft or do not induct the aircraft into SDLM rework.

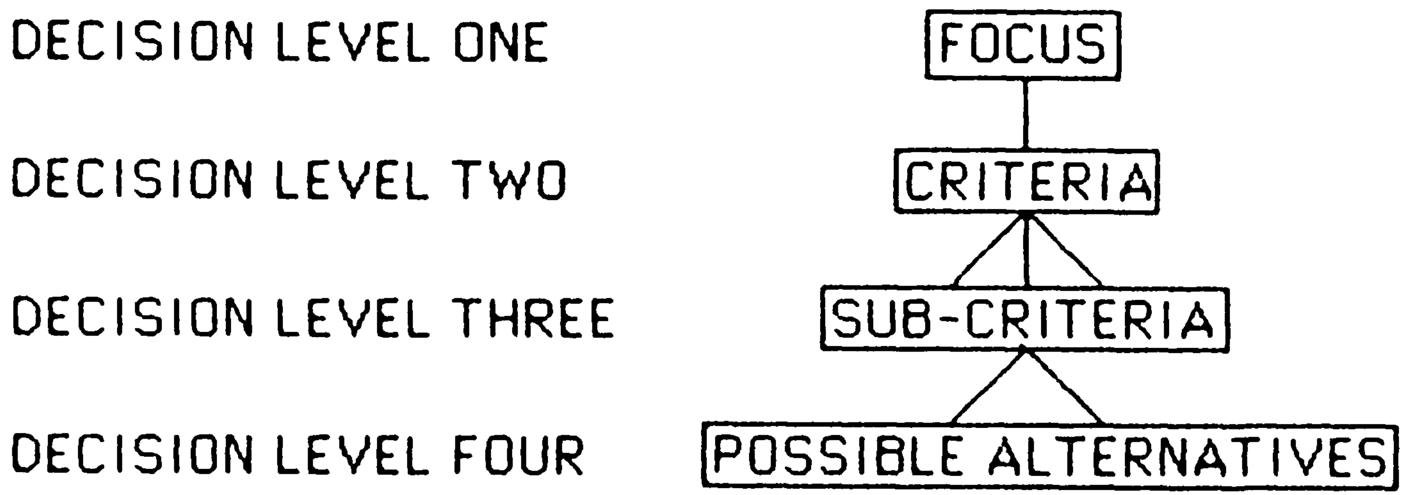


Figure 1. The Functional Hierarchy Structure

TABLE 1. S-3 VIKING ASPA INSPECTION ZONES

1. LEFT-HAND WING FOLD: OUTER WING PANEL
2. LEFT-HAND WING FOLD: INNER WING PANEL
3. RIGHT-HAND INNER WING PANEL SPAR AND FLAP WELL
4. RIGHT-HAND OUTER WING PANEL AFT SPAR AND FLAP WELL
5. RIGHT-HAND OUTER WING PANEL, TAB AND SPAR
6. RIGHT-HAND WING FOLD: OUTER WING PANEL
7. RIGHT-HAND WING FOLD: INNER WING PANEL
8. LEFT-HAND INNER WING PANEL SPAR AND FLAP WELL
9. LEFT-HAND OUTER WING PANEL AFT SPAR AND FLAP WELL
10. HORIZONTAL STABILIZER
11. LEFT-HAND ELEVATOR AND TAB
12. RIGHT-HAND ELEVATOR AND TAB
13. FIN FOLD
14. RUDDER
15. FUSELAGE
16. ENVIRONMENTAL CONTROL SYSTEM COMPARTMENT
17. LEFT-HAND MAIN LANDING GEAR AND WELL
18. RIGHT-HAND MAIN LANDING GEAR AND WELL
19. NOSE LANDING GEAR AND WELL
20. OVERALL PAINT CONDITION

Once the hierarchial structure of the ASPA process had been specified the next step is to determine the priorities between each decision level and every element within those levels.

2. Setting Priorities

The human mind has an innate ability to perceive relationships between items or facts we observe and assigns a relative importance to that event. By employing the Analytical Hierarchy Process in our study of the quantification of the S-3 ASPA program we have chosen a methodology that takes advantage of this thought process.

The level of the functional hierarchy that required prioritization was the subcriteria decision level. This level corresponds to the zonal area subjective judgments which are dominant in the ASPA evaluation process because the results of this level determine the induction decision. To answer our major research question we had to determine the relative priority, or percent contribution, each zonal area made to the criterion of general material condition and hence, the induction decision.

The first step in establishing the relative priorities of the subcriteria level was to construct a Pairwise Comparison Matrix. This matrix allowed the NARF Alameda P&E's to compare each element (zonal area) against the other zonal areas and judge their impact on general material condition [Ref. 4:p. 76]. The matrix structure is a mathematical tool that is well suited for this process (Figure 2).

To begin the pairwise comparison process, the Analytical Hierarchy Process takes the first zonal area of the left-hand column and compares it to each zonal area in the top row. This process continues

CRITERION GENERAL MATERIAL CONDITION		ZONAL AREAS 1	 2	 3
ZONAL AREAS	1	1	5	0.11
	2	0.2	1	3
	3	9	0.33	1
COLUMN SUMS		10.2	6.33	4.11

Figure 2. Pairwise Comparison Matrix Example

working down the left-hand column until the matrix is completed. An important point to consider during the pairwise comparison process is the phrasing of the comparison question. The left-hand column is always compared to the top row to maintain the proper relationship between zonal areas with respect to the criterion of general material condition [Ref. 4:p. 77].

To assign a relative importance to each comparison a numeric scale has been developed by Saaty [Ref. 4:p. 78]. Table 2 presents the values available for assignment during the pairwise comparison process. This graduated scale represents the degree of intensity of which the human mind is capable of distinguishing between.

As an example of how AHP works to this point, refer to Figure 2 again. When Zonal Area One of the left-hand column was compared to Zonal Area One of the top row an intensity of importance factor of one (1) was assigned. By consulting Table 2, the definition of this intensity of importance factor is "equal importance of both elements". This point will be true whenever a zonal area is compared to itself, thus the diagonal of the Pairwise Comparison Matrix will always contain unity.

Zonal Area One was then compared to Zonal Area Two and the example intensity of importance was determined to be five (5), which is defined as "essential or has a strong importance of one element over another". When Zonal Area One was compared to Zonal Area Three it was determined that area Three was more important by a factor of nine (9). This situation requires the use of reciprocal factors. When the top row area dominates, or is more important than the left-hand column area, the

TABLE 2. THE PAIRWISE COMPARISON SCALE

Intensity of Importance	Definition	Explanation
1	Equal importance of both elements	Two elements contribute equally to the property
3	Weak importance of one element over another	Experience and judgement slightly favor one element over another
5	Essential or there exists a a strong importance of one element over another	Experience and judgement strongly favor one element over another
7	Demonstrated importance of one element over another	An element is strongly favored and its dominance is demonstrated in practice
9	Absolute importance of one element over another	The evidence favoring one element over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between two adjacent judgements	Compromise is needed between two judgements

reciprocal intensity of importance factor is assigned. Therefore, the comparison in our example is assigned the factor 0.11.

The use of reciprocal factors also leads to a reduction in the work the evaluator must do when completing the matrix. Once the triangle above the diagonal is assigned the proper intensity of importance factors, the triangle below the diagonal can be completed through inference by entering the symmetrical reciprocal values as shown in Figure 3.

The final zonal comparison is made between Zonal Area Two and Zonal Area Three with the resulting assignment of an example intensity of importance factor of three (3). When the pairwise comparison process is finished, the next step of the AHP is to determine the relative importance of each zonal area with respect to the stated criterion of general material condition.

The first step in determining this value, termed the priority vector, is to sum each column of the matrix and divide each pairwise comparison factor by this sum to attain a normalized matrix (Figure 3). The normalized matrix permits a more meaningful comparison among zonal areas. [Ref. 4:p. 80]

Finally, the normalized zonal areas are summed by row and this summation is divided by the number of zonal areas in the row [Ref 4:p. 81]. The result of this normalized matrix row averaging is the percentage of overall relative priority for each zonal area with respect to the criterion of general material condition (Figure 3).

CRITERION: GENERAL MATERIAL CONDITION		ZONAL AREAS: 1	2	3	ROW SUM	RELATIVE PRIORITY
ZONAL AREAS:	1	0.09	0.78	0.02	0.913	0.304
	2	0.01	0.15	0.72	0.905	0.301
	3	0.88	0.05	0.24	1.777	0.392

Figure 3. Normalized Pairwise Comparison Matrix Example

3. Logical Consistency

Logical consistency is the third principle of the Analytical Hierarchy Process. Saaty [Ref. 4:p. 18] describes consistency as:

> . . .A trait that the human mind accomplishes in both the conscious and unconscious states. Humans have the ability to relate similar items, ideas and events in a harmonious manner for more efficient storage within the brain. Once the homogenous clumps have been filed, the intensity of the relationships are worked upon by the unconscious state of the mind by the application of a specific criterion with the result being either a strengthening or weakening of the individual's original classification scheme.

Since the pairwise comparison process was conducted by the S-3 Planning and Estimating (P&E) Branch of Naval Air Rework Facility (NARF) Alameda, a check for consistency of their subjective and experienced judgments was in order and is presented in Chapter IV.

The consistency check advocated by Saaty involves the generation of a random pairwise comparison matrix. The idea of generating a random matrix allows us to compare truly random judgments versus the experienced judgments of the P&E evaluators. The deviation from consistency that results from this comparison is termed the Consistency Index (CI), and is expressed mathematically as:

$$CI = \frac{\text{lambda max} - n}{n - 1}$$

where n equals the number of zonal areas (twenty in our problem) in the Pairwise Comparison Matrix.

Lambda max (the principle eigenvalue) of the CI equation is found by multiplying the zonal area priority vectors, as calculated in the pairwise comparison process, by each columnar element of the randomly generated matrix. The new row values are then summed and this summation is divided by the corresponding priority vectors of each zonal area. The mathematical average of these quotients is found and this numerical value represents lamda max. [Ref. 4:p. 84]

Once the Consistency Index of the Pairwise Comparison Matrix is found, a value termed the Random Index (RI) must be calculated. The RI is simply the consistency index of the random matrix. This value was calculated in the same manner as the CI and is presented in Chapter IV.

When the Consistency Index and Random Index have been calculated, the overall process consistency, or the Consistency Ratio (CR), can be found [Ref. 5:p. 21]. The Consistency Ratio is expressed as:

$$CR = \frac{CI}{RI}$$

The acid test for consistency via the Analytical Hierarchy Process is to obtain a CR less than ten percent [Ref. 5:p. 21].

C. SUMMARY

In this chapter we have presented the theoretical background necessary to understand how Saaty's Analytical Hierarchy Process works. We have emphasized that the AHP is based upon three fundamental principles of logical analysis:

(1) Constructing hierarchies

(2) Establishing priorities

(3) Maintaining logical consistency

These three principles set the framework upon which this chapter is structured. Within this framework we have outlined the procedures that must be accomplished when utilizing the Analytical Hierarchy Process to solve a complex problem.

D. PREVIEW

In Chapter IV we will apply the three principles of the AHP to the S-3 ASPA process in an attempt to quantify a previously subjective process. By generating priority values for each zonal area of the S-3A Viking we will be able to generate an ASPA score that can be utilized in the determination of the induction decision instead of using the subjective judgment of the P&E evaluator.

IV. AN EXAMPLE OF THE METHODOLOGY

A. AHP HIERARCHY STRUCTURE

According to the Naval Aviation Logistics Center (NALC), the purpose of the ASPA program is to determine whether the specific aircraft being evaluated should or should not be inducted into Standard Depot Level Maintenance (SDLM) rework. The most important criterion used in accomplishing this decision is the general material condition of the aircraft at the time of the ASPA evaluation. Thus, the first two levels of our AHP hierarchy are mandated by NALC. Level One, or the focus of the hierarchy, is the SDLM induction decision and Level Two, or the criterion of the hierarchy, is the general material condition of the aircraft being evaluated.

The third level of the AHP hierarchy is defined as the subcriteria level. The subcriteria level of the hierarchy contains the variables necessary for determining the general material condition of the aircraft. These variables are defined by the NARF Alameda S-3A Local Engineering Specification (LES) of 7 Aug 1985 (Appendix A).

The LES provides a detailed and comprehensive checklist of items to be inspected in the determination of an aircraft's general material condition. The P&E evaluator uses the LES during each ASPA evaluation and notes discrepancies in each zonal area by severity of defect (An example of a zonal area would be the fuselage of the aircraft and a common discrepancy would be chipped paint requiring an organizational level maintenance action to repair).

When the ASPA evaluation is complete the P&E evaluator totals the number of discrepancies and subjectively determines the overall general material condition of the aircraft. Based on this determination, the P&E evaluator either recommends that the aircraft be inducted into SDLM rework or remain on operational duty. This induction decision represents the fourth level of the AHP hierarchy, the possible alternatives stage. Figure 4 presents a diagrammatic view of the completed hierarchial structure as it applies to the ASPA evaluation process.

B. PRIORITY DETERMINATION

By incorporating the zonal areas of the S-3A LES into the sub-criteria of our hierarchy, we are proposing a method of reducing the subjectivity which currently exists within the ASPA evaluation process. Instead of a subjective input being used as the determining factor of an aircraft's material condition, we will employ the methodology of AHP to determine each zonal area's relative contribution (expressed as a percentage) to the criterion of general material condition.

The AHP methodology employs the use of a matrix to determine the relative contribution of each element (zonal area) being studied. Figure 5 presents the Pairwise Comparison Matrix structure for the S-3A aircraft. As can be seen from this figure, the matrix provides a tool for comparing each zonal area to all of the zonal areas.

The development of the Pairwise Comparison Matrix is the first step we will use to quantify a previously subjective process. The pairwise comparison process represents the P&E evaluator's decision regarding

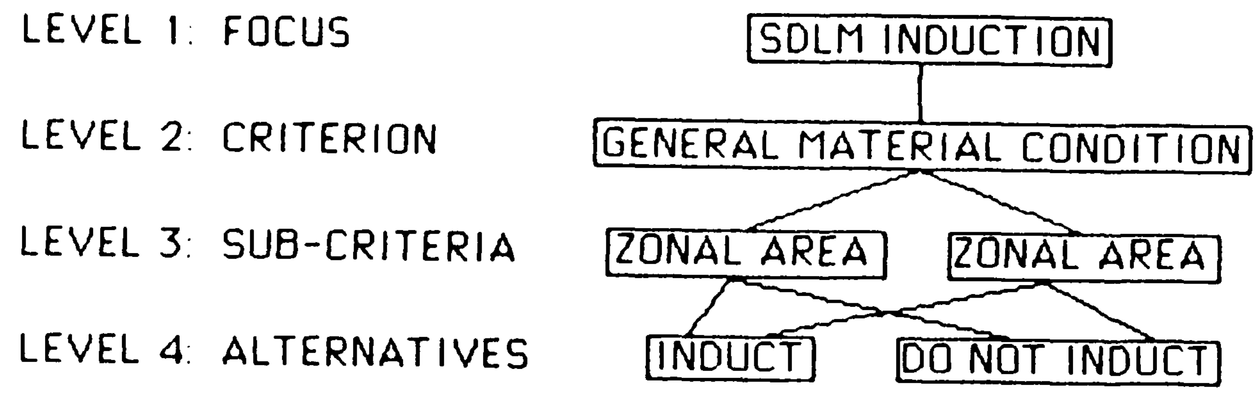


Figure 4. ASPA Process Hierarchial Structure

CRITERIA		ZONAL AREAS																			
	GENERAL MATERIAL CONDITION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	1																				
	2																				
	3																				
	4																				
	5																				
	6																				
	7																				
	8																				
	9																				
ZONAL AREAS	10																				
	11																				
	12																				
	13																				
	14																				
	15																				
	16																				
	17																				
	18																				
	19																				
	20																				

LIST OF ZONAL AREAS:

1. LH WING FOLD: OUTER WING PANEL
2. LH WING FOLD: INNER WING PANEL
3. RH INNER WING PANEL SPAR & FLAP WELL
4. RH OUTER WING PANEL AFT SPAR & FLAP WELL
5. RH OUTER WING PANEL, TAB & SPAR
6. RH WING FOLD: OUTER WING PANEL
7. RH WING FOLD: INNER WING PANEL
8. LH INNER WING PANEL SPAR & FLAP WELL
9. LH OUTER WING PANEL AFT SPAR & FLAP WELL
10. HORIZONTAL STABILIZER
11. LH ELEVATOR & TAB
12. RH ELEVATOR & TAB
13. FIN FOLD
14. RUDDER
15. FUSELAGE
16. ECS COMPARTMENT
17. LH MAIN LANDING GEAR & WELL
18. RH MAIN LANDING GEAR & WELL
19. NOSE LANDING GEAR & WELL
20. OVERALL PAINT CONDITION

Figure 5. Structure of ASPA Pairwise Comparison Matrix

which zonal area is most important/critical to the general material condition of the aircraft when matched against the other zonal areas.

The possible decisions the P&E evaluator could make within the pairwise comparison process were previously presented in Table 2 of Chapter III. The numerical scale ranges in intensity of importance from one (equal importance of both elements) to nine (absolute importance of one element over another). These values are assigned by comparing the zonal areas of the left-hand column to the zonal areas in the top row. The emphasis on order of comparison is necessary to produce a ranking which is relative to our stated criterion of aircraft general material condition.

As described in Chapter III, during the pairwise comparison process a zonal area which is considered more important than the zonal area it was being compared to was assigned a whole number. If the area is less important then the reciprocal intensity of importance is assigned. Figure 6 presents the Pairwise Comparison Matrix for the S-3A. This matrix was developed by a senior NARF Alameda P&E with the assistance of one member of the S-3A Engineering Branch. Consider, for example, Zonal Area 14, listed in the left-hand column of Figure 6. This area of the aircraft is the rudder assembly of the S-3A. When the rudder assembly was compared to the overall paint condition (Zonal Area 20) the P&E evaluator decided that the rudder was more important to the criterion of general material condition of the aircraft by an importance factor of three (3). The assignment of an intensity of importance factor of three means the P&E evaluator felt that the rudder assembly exhibited "a weak importance" over the paint condition in the

ZONAL AREAS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	0.2	0.33	0.5	2	1	3	0.33	5	0.14	0.2	0.2	5	0.17	0.11	3	0.14	0.14	0.14	0.2
2	5	1	0.5	2	0.5	0.5	1	3	0.5	0.14	0.2	0.2	4	0.33	0.14	3	0.11	0.11	0.11	0.2
3	3	2	1	3	4	0.33	2	1	1	0.13	0.14	0.13	4	0.14	0.11	4	0.13	0.13	0.13	0.2
4	2	0.5	0.33	1	0.5	0.5	2	0.5	1	0.13	0.14	0.14	4	0.33	0.17	3	0.13	0.13	0.13	0.2
5	0.5	2	0.25	2	1	0.33	3	2	0.5	0.14	0.17	0.17	3	0.2	0.14	3	0.14	0.14	0.14	0.2
6	1	2	3	2	3	1	0.33	0.5	2	0.2	0.25	0.25	3	0.25	0.17	6	0.2	0.2	0.2	0.25
7	0.33	1	0.5	0.5	0.33	3	1	2	2	0.2	0.25	0.25	2	0.2	0.14	2	0.14	0.14	0.14	0.2
8	3	0.33	1	2	0.5	2	0.5	1	2	0.2	0.25	0.25	3	0.33	0.17	3	0.17	0.17	0.17	0.2
9	0.2	2	1	1	2	0.5	0.5	0.5	1	0.17	0.2	0.2	3	0.33	0.17	4	0.17	0.17	0.17	0.2
10	7	7	8	8	7	5	5	5	6	1	2	2	5	4	0.33	8	2	2	2	6
11	5	5	7	7	6	4	4	4	5	0.5	1	1	5	2	0.5	5	2	2	2	5
12	5	5	8	7	6	4	4	4	5	0.5	1	1	5	2	0.25	4	2	2	2	5
13	0.2	0.25	0.25	0.25	0.33	0.33	0.5	0.33	0.33	0.2	0.2	0.2	1	0.2	0.14	0.5	0.11	0.11	0.11	0.14
14	6	3	7	3	5	4	5	3	3	0.25	0.5	0.5	5	1	0.25	0.5	0.5	0.5	0.5	3
15	9	7	9	6	7	6	7	6	6	3	2	4	7	4	1	5	3	3	3	3
16	0.33	0.33	0.25	0.33	0.33	0.17	0.5	0.33	0.25	0.13	0.2	0.25	2	2	0.2	1	0.17	0.17	0.17	0.33
17	7	9	8	8	7	5	7	6	6	0.5	0.5	0.5	9	2	0.33	6	1	1	1	4
18	7	9	8	8	7	5	7	6	6	0.5	0.5	0.5	9	2	0.33	6	1	1	1	4
19	7	9	8	8	7	5	7	6	6	0.5	0.5	0.5	9	2	0.33	6	1	1	1	4
20	5	5	5	5	5	4	5	5	5	0.17	0.2	0.2	7	0.33	0.33	3	0.25	0.25	0.25	1
COLUMN SUMS	74.56	70.61	76.41	74.58	71.49	51.66	65.33	56.49	63.68	8.7	10.4	12.44	95	23.81	5.31	76	14.36	14.36	14.36	37.32

Figure 6. The Pairwise Comparison Matrix for the S-3A Viking

determination of overall general material condition of the aircraft. When the rudder assembly was compared to the aircraft's fuselage (Zonal Area 15) the fuselage was adjudged to be more important with the resultant assignment of an importance factor of 0.25, or the reciprocal of four (4). The assignment of an intensity of importance factor of 0.25 indicates the P&E evaluator felt that this comparison ranked between "weak importance" and "essential or there exists strong importance" of the fuselage over the rudder assembly.

Once the matrix is filled, the procedure for determining the relative contribution (priority vectors) of the zonal areas can begin. First, all columns are totalled and the sum divided into all the elements within the respective column. The result of this calculation is a normalized matrix as presented in Figure 7. The row sums of the normalized matrix are calculated next and then divided by the number of elements in the row, which is twenty (20). The end result of these simple mathematical calculations is the relative priority vector, or the relative contribution each zonal area makes to the overall general material condition of the aircraft (Figure 8).

C. CONSISTENCY OF THE ANALYTICAL HIERARCHY PROCESS

As mentioned in Chapter III, the Analytical Hierarchy Process should provide consistent results. In this section we will present the methodology used to calculate a numerical value for consistency as it applies to our problem.

ZONAL AREAS	1	2	3	4	5	6	7	8	9	10
1	0.01341	0.00283	0.00432	0.00670	0.02798	0.01936	0.04592	0.00584	0.07864	0.01609
2	0.06706	0.01416	0.00654	0.02682	0.00699	0.00968	0.01531	0.05511	0.00786	0.01609
3	0.04024	0.02832	0.01309	0.04023	0.05595	0.00659	0.03061	0.01770	0.01573	0.01494
4	0.02682	0.00708	0.00432	0.01341	0.00699	0.00968	0.03061	0.00885	0.01573	0.01494
5	0.00671	0.02832	0.00327	0.02682	0.01399	0.00659	0.04592	0.03540	0.00786	0.01609
6	0.01341	0.02832	0.03926	0.02682	0.04196	0.01936	0.00606	0.00885	0.03146	0.02299
7	0.00443	0.01416	0.00654	0.00670	0.00462	0.05807	0.01531	0.03540	0.03146	0.02299
8	0.04024	0.00467	0.01309	0.02682	0.00699	0.03871	0.00765	0.01770	0.03146	0.02299
9	0.00268	0.02832	0.01309	0.01341	0.02798	0.00968	0.00766	0.00885	0.01573	0.01954
10	0.09388	0.09914	0.10470	0.10727	0.09792	0.09679	0.07653	0.08851	0.09437	0.11494
11	0.06706	0.07081	0.09161	0.09386	0.08395	0.07743	0.06125	0.07081	0.07864	0.05747
12	0.06706	0.07081	0.10470	0.09386	0.08398	0.07743	0.06128	0.07081	0.07864	0.06747
13	0.00268	0.00354	0.00327	0.00336	0.00462	0.00639	0.00765	0.00584	0.00519	0.02299
14	0.08047	0.04249	0.09161	0.04023	0.06994	0.07743	0.07653	0.05311	0.04718	0.02874
15	0.12071	0.09914	0.11779	0.08046	0.09792	0.11614	0.10715	0.10621	0.09437	0.34485
16	0.00443	0.00467	0.00327	0.00442	0.00462	0.00329	0.00765	0.00584	0.00393	0.01494
17	0.09388	0.12746	0.10470	0.10727	0.09792	0.09679	0.10715	0.10621	0.09437	0.05747
18	0.09388	0.12746	0.10470	0.10727	0.09792	0.09679	0.10715	0.10621	0.09437	0.05747
19	0.09388	0.12746	0.10470	0.10727	0.09792	0.09679	0.10715	0.10621	0.09437	0.06747
20	0.06706	0.07081	0.06544	0.06704	0.06994	0.07748	0.07658	0.08851	0.07864	0.01954

ZONAL AREAS	11	12	13	14	15	16	17	18	19	20
1	0.01923	0.01608	0.05263	0.00714	0.02072	0.03947	0.00975	0.00975	0.00975	0.00536
2	0.01923	0.01608	0.04211	0.01386	0.02637	0.03947	0.00766	0.00766	0.00766	0.00536
3	0.01346	0.01045	0.04211	0.00588	0.02072	0.05263	0.00905	0.00905	0.00905	0.00536
4	0.01346	0.01126	0.04211	0.01386	0.03202	0.03947	0.00906	0.00906	0.00905	0.00536
5	0.01635	0.01367	0.03158	0.00840	0.02637	0.03947	0.00975	0.00975	0.00975	0.00536
6	0.02404	0.02010	0.03158	0.01050	0.03202	0.07895	0.01393	0.01393	0.01393	0.00670
7	0.02404	0.02010	0.02105	0.00840	0.02637	0.02632	0.00975	0.00976	0.00975	0.00536
8	0.02404	0.02010	0.03158	0.01386	0.03202	0.03947	0.01184	0.01184	0.01164	0.00536
9	0.01925	0.01608	0.03158	0.01386	0.03202	0.05263	0.01184	0.01184	0.01184	0.00536
10	0.19231	0.16077	0.05263	0.16800	0.06215	0.10526	0.13928	0.13928	0.13928	0.16077
11	0.09615	0.08039	0.05265	0.08400	0.09416	0.06579	0.13928	0.13928	0.13928	0.13398
12	0.09616	0.08039	0.05268	0.08400	0.04708	0.05263	0.13928	0.13928	0.13928	0.13398
13	0.01923	0.01608	0.01053	0.00840	0.02637	0.00658	0.00766	0.00766	0.00766	0.00375
14	0.04808	0.04019	0.05263	0.04200	0.04708	0.00658	0.03482	0.03482	0.03482	0.08039
15	0.19231	0.32154	0.07368	0.16800	0.18032	0.06579	0.20891	0.20891	0.20891	0.06039
16	0.01923	0.02010	0.02106	0.08400	0.03766	0.01316	0.01184	0.01184	0.01184	0.00884
17	0.04808	0.04019	0.09474	0.08400	0.06215	0.07896	0.06964	0.06964	0.06964	0.10718
18	0.04808	0.04019	0.09474	0.08400	0.06215	0.07895	0.06964	0.06964	0.06964	0.10718
19	0.04808	0.04019	0.09474	0.08400	0.06215	0.07895	0.06964	0.06964	0.06964	0.10718
20	0.01923	0.01608	0.07368	0.01386	0.06216	0.03947	0.01741	0.01741	0.01741	0.02680

Figure 7. The Normalized Pairwise Comparison Matrix

ZONAL AREAS	ROW SUMS	PRIORITY ELEMENT
1	0.41097	0.02055
2	0.40908	0.02045
3	0.44096	0.02205
4	0.32313	0.01616
5	0.36121	0.01806
6	0.48314	0.02416
7	0.36056	0.01803
8	0.41226	0.02061
9	0.35320	0.01766
10	2.29376	0.11469
11	1.77777	0.08889
12	1.73062	0.08653
13	0.17944	0.00897
14	1.02913	0.05146
15	3.00147	0.15007
16	0.29663	0.01483
17	1.71741	0.08587
18	1.71741	0.08587
19	1.71741	0.08587
20	0.98444	0.04922

Figure 8. Row Sums and Priority Elements of the Pairwise Comparison Matrix

1. The Randomly Generated Consistent Matrix

To confirm that the judgments offered by the P&E evaluators were logical, and not merely random, we compared the Pairwise Comparison Matrix to a Randomly Generated Consistent Matrix. The intent of this comparison was to determine a value called the Consistency Ratio (CR), a numerical measure of AHP's consistency. The CR is derived by finding the Consistency Index (CI) of the Pairwise Comparison Matrix and dividing this value by a factor known as the Random Index (RI). The Randomly Generated Consistent Matrix is a matrix generated by a random number generator using the same intensity of importance scale as was used for the Pairwise Comparison Matrix (0.11, 0.13, 0.14, 0.17, 0.2, 0.25, 0.33, 0.5, 1 through 9). The matrix is termed consistent because the upper right triangle (above the diagonal) was generated, and the transpose positions (lower left triangle) were filled with the reciprocal values (Figure 9).

The calculation of the Consistency Index of the Pairwise Comparison Matrix begins with the multiplication of the elements of the priority vector by each corresponding column element of the Randomly Generated Consistent Matrix. For example, the priority vector element for Zonal Area 15 (fuselage) is 0.15007. When this value is multiplied by the first element, 0.17, of the fifteenth column of the Randomly Generated Consistent Matrix a value of 0.02551 is obtained, as can be seen in Figure 10 (row 1, column 15).

The next step in the process is to sum the rows of Figure 10 and divide this summation by the respective priority vector elements of the zonal areas. These quotients are then averaged to find a value termed

ZONAL AREAS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	0.5	0.33	0.25	7	0.25	8	1	4	5	2	0.5	0.5	0.25	0.17	3	1	0.5	1	1
2	2	1	0.5	3	5	0.25	1	0.5	1	0.25	4	0.33	1	6	9	0.25	1	0.17	0.2	0.33
3	3	2	1	5	0.25	0.17	1	1	2	8	1	8	5	4	0.17	0.25	7	0.2	1	6
4	4	0.33	0.2	1	1	1	8	0.17	2	0.5	2	0.25	0.33	4	3	6	6	1	0.33	1
5	0.14	0.2	4	1	1	4	0.5	3	0.25	0.5	6	2	1	7	1	4	5	0.25	2	3
6	4	4	6	1	0.25	1	1	4	0.5	0.13	0.2	4	3	0.17	0.33	1	1	5	1	2
7	0.13	1	1	0.13	2	1	1	2	5	0.5	1	2	2	0.14	0.11	1	6	0.5	3	0.2
8	1	2	1	6	0.33	0.25	0.5	1	0.33	0.25	4	1	3	8	0.5	6	0.11	8	0.14	6
9	0.25	1	0.5	0.5	4	2	0.2	3	1	0.14	1	0.17	0.25	1	0.17	1	4	0.5	0.33	1
10	0.2	4	0.13	2	2	8	2	4	7	1	0.2	2	3	3	1	0.5	0.33	7	0.33	1
11	0.5	0.25	1	0.5	0.17	5	1	0.25	1	5	1	5	0.5	0.25	5	1	5	3	1	4
12	2	3	0.13	4	0.5	0.25	0.5	1	6	0.5	0.2	1	6	9	8	0.2	0.33	0.14	0.5	0.33
13	2	1	0.2	3	1	0.33	0.5	0.33	4	0.33	2	0.17	1	5	1	0.5	2	0.11	1	1
14	4	0.17	0.25	0.25	0.14	6	7	0.13	1	0.33	4	0.11	0.2	1	0.2	1	7	0.25	3	0.17
15	6	0.11	6	0.33	1	3	9	2	6	1	0.2	0.13	1	5	1	0.5	8	4	0.2	0.5
16	0.33	4	4	0.17	0.25	1	1	0.17	1	2	1	5	2	1	2	1	2	9	8	3
17	1	1	0.14	0.17	0.2	1	0.17	9	0.25	3	0.2	3	0.5	0.14	0.13	0.5	1	0.33	1	0.5
18	2	6	5	1	4	0.2	2	0.13	2	0.14	0.33	7	9	4	0.25	0.11	3	1	0.17	4
19	1	5	1	3	0.5	1	0.33	7	3	3	1	2	1	0.33	5	0.13	1	6	1	1
20	1	3	0.17	1	0.33	0.5	5	0.17	1	1	0.25	3	1	6	2	0.33	2	0.25	1	1
COLUMN SUMS	35.55	39.56	32.55	33.3	30.92	36.2	49.7	39.85	48.33	32.57	31.58	46.66	41.28	65.28	40.03	28.27	62.77	47.2	26.2	37.03

Figure 9. The Randomly Generated Consistent Matrix

ZONAL AREAS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	0.02055	0.01023	0.00720	0.00404	0.12642	0.00604	0.14422	0.02061	0.07064	0.57344	0.17778	0.04327	0.00449	0.01286	0.02551	0.04449	0.08587	0.04294	0.08587	0.04922
2	0.04110	0.02045	0.01102	0.04847	0.09030	0.00604	0.01803	0.01031	0.01766	0.02867	0.35555	0.02856	0.00897	0.30874	1.35066	0.00371	0.08587	0.01460	0.01717	0.01624
3	0.06165	0.04091	0.02205	0.08078	0.00452	0.00411	0.01803	0.02061	0.03532	0.91751	0.00889	0.69225	0.04486	0.20583	0.02551	0.00371	0.60109	0.01717	0.08587	0.29535
4	0.08219	0.00675	0.00441	0.01616	0.01806	0.02416	0.14422	0.00350	0.03532	0.06734	0.17778	0.02163	0.00296	0.20583	0.45022	0.00899	0.51522	0.08587	0.02834	0.04922
5	0.00288	0.00409	0.08819	0.01616	0.01806	0.09663	0.00901	0.06184	0.00441	0.05734	0.53333	0.17306	0.00897	0.36020	0.15007	0.05933	0.42935	0.02147	0.17174	0.14767
6	0.08219	0.08182	0.15229	0.01616	0.00452	0.02416	0.01803	0.00245	0.00083	0.01491	0.01778	0.34612	0.02692	0.00875	0.04952	0.01483	0.08587	0.42935	0.08587	0.09844
7	0.00267	0.02045	0.02205	0.00210	0.03612	0.02416	0.01803	0.04123	0.00850	0.05734	0.00889	0.17306	0.01794	0.00720	0.01651	0.01483	0.51522	0.04294	0.25761	0.00984
8	0.02066	0.04091	0.02205	0.09694	0.00696	0.00604	0.00901	0.02061	0.00583	0.02867	0.36665	0.00653	0.02692	0.41165	0.07604	0.00899	0.00945	0.60696	0.01202	0.29533
9	0.00514	0.02045	0.01102	0.00808	0.07224	0.04831	0.00361	0.06184	0.01766	0.01606	0.00889	0.01471	0.00224	0.05146	0.02551	0.01483	0.34348	0.04294	0.02834	0.04922
10	0.00411	0.08182	0.00287	0.03231	0.03612	0.19326	0.03606	0.00245	0.12362	0.11469	0.01778	0.17306	0.02692	0.15437	0.15007	0.00742	0.02834	0.60109	0.02834	0.04922
11	0.01027	0.00511	0.02205	0.00808	0.00307	0.12079	0.01803	0.00515	0.01766	0.57344	0.00889	0.43266	0.00449	0.01286	0.75037	0.01483	0.42935	0.25761	0.08587	0.19689
12	0.04110	0.06136	0.00287	0.06463	0.00903	0.00604	0.00901	0.02061	0.10596	0.05734	0.01778	0.00653	0.05383	0.46311	1.20059	0.00297	0.02834	0.01202	0.04294	0.01624
13	0.04110	0.02045	0.00441	0.04847	0.01806	0.00797	0.00901	0.00680	0.07064	0.03785	0.17778	0.01471	0.00897	0.25726	0.15007	0.00742	0.17174	0.00945	0.08587	0.04922
14	0.08219	0.00348	0.00551	0.00404	0.00253	0.14494	0.12619	0.00260	0.01766	0.03785	0.55555	0.00952	0.00179	0.05146	0.03001	0.01483	0.60109	0.02147	0.25761	0.00837
15	0.12329	0.00225	0.13229	0.00555	0.01806	0.07247	0.16225	0.04125	0.10596	0.11469	0.01778	0.01125	0.00897	0.25720	0.15007	0.00742	0.68696	0.34348	0.01717	0.02461
16	0.00678	0.08182	0.08819	0.00276	0.00452	0.02416	0.01803	0.00350	0.01766	0.22930	0.00889	0.43266	0.01794	0.06146	0.30016	0.01483	0.17174	0.77283	0.68696	0.14767
17	0.02055	0.02045	0.00309	0.00275	0.00361	0.02416	0.00306	0.18552	0.00441	0.34406	0.01778	0.25959	0.00449	0.00720	0.01961	0.00742	0.08587	0.02834	0.08587	0.02461
18	0.04110	0.12272	0.11024	0.01616	0.07224	0.00483	0.03606	0.00260	0.03532	0.01606	0.02933	0.60572	0.00275	0.20583	0.03752	0.00163	0.25761	0.08587	0.01460	0.19689
19	0.02056	0.10227	0.02205	0.04847	0.00903	0.02416	0.00596	0.14429	0.06298	0.34406	0.00889	0.17306	0.00897	0.01696	0.75037	0.00193	0.08587	0.51522	0.08587	0.04922
20	0.02055	0.06136	0.00375	0.01616	0.00596	0.01208	0.09014	0.00350	0.01766	0.11469	0.02222	0.25959	0.00897	0.30874	0.30015	0.00489	0.17174	0.02147	0.08587	0.04922

Figure 10. Priority Elements of Pairwise Comparison Process Multiplied by Column Elements of Randomly Generated Consistent Matrix

"lambda max". Lambda max is a key variable in the mathematical equation for the Consistency Index:

$$CI = \frac{\text{lambda max} - n}{n - 1}$$

where n represents the number of elements in the sample, in this case, n equals 20.

The Consistency Index for the S-3A Pairwise Comparison Matrix was found to be 2.86555 as shown in Figure 11.

2. The Randomly Generated Matrix

To calculate the Random Index, or the random value of the Consistency Index, we must generate another random matrix (Figure 12). This matrix differs from the Randomly Generated Consistent Matrix in that all of the elements of this matrix were generated by the random number generator and not just the upper right triangle. To find the Random Index we first normalize the "consistent" matrix and determine the priority vector elements (Figure 13). Once the priority vector of the Randomly Generated Consistent Matrix is known we multiply these values by their respective column entries in the random matrix (Figure 14). The row sums are calculated and these values are divided by the applicable priority vector elements to obtain the values in Figure 15. Lambda max is found in the same manner as for the Consistency Index. The lambda max value is then inserted into the equation for the Random Index:

$$RI = \frac{\text{lambda max} - n}{n - 1}$$

and the Random Index is found to equal 3.72625 (Figure 15).

ZONAL AREAS	ROW SUMS	PRIORITY ELEMENT
1	1.55577	75.7117
2	2.48213	121.353
3	3.26598	148.130
4	2.01818	124.915
5	2.41381	133.650
6	1.62880	67.4255
7	1.45650	80.7919
8	2.30501	111.823
9	0.92603	52.4369
10	1.94390	16.9494
11	3.05747	34.3966
12	2.30229	26.6065
13	1.19728	133.449
14	1.77878	34.5687
15	2.30282	15.3446
16	3.16190	213.187
17	1.15234	13.4195
18	1.97314	22.9781
19	2.55019	29.6981
20	1.57871	32.0732

COLUMN SUM = 1488.91

LAMBDA MAX. = 74.4454

C. I. = 2.86555

Figure 11. Row Sums, Lambda Max and Consistency Index of the Pairwise Comparison Matrix

ZONAL AREAS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1	0.33	9	8	7	0.5	9	0.5	7	0.5	6	8	9	0.5	0.33	7	0.5	6	9	9
2	7	1	0.5	0.5	0.33	9	7	1	0.5	0.33	9	7	0.14	5	0.5	0.33	1	0.33	0.5	8
3	5	0.2	1	5	0.17	6	0.5	6	9	1	8	0.5	6	4	9	0.5	9	5	7	5
4	0.5	6	5	1	5	0.2	5	4	5	9	0.5	0.33	9	9	7	8	0.5	9	0.33	0.5
5	9	0.33	0.25	8	1	8	9	0.11	8	0.25	1	6	0.25	8	0.25	8	0.33	0.5	0.17	7
6	0.33	0.25	0.5	9	0.33	1	0.5	8	7	0.5	1	7	9	8	0.17	6	0.17	4	0.5	0.11
7	8	9	7	7	0.5	0.33	1	6	8	7	0.33	6	5	0.11	1	0.33	3	7	8	0.5
8	6	4	0.5	3	0.5	0.17	1	1	0.11	0.25	9	9	0.25	0.13	0.33	8	9	3	4	0.33
9	7	8	9	8	9	9	7	1	1	6	0.5	7	8	7	0.5	9	7	8	9	9
10	9	0.2	9	1	8	8	0.5	8	7	1	0.25	5	6	5	4	5	1	4	0.25	7
11	7	5	0.5	0.5	0.17	1	9	0.5	0.11	7	1	9	0.5	4	9	6	0.5	0.5	4	0.33
12	6	0.17	6	0.13	7	0.25	7	2	5	6	0.5	1	4	6	0.11	0.33	4	0.25	0.5	7
13	5	3	0.33	8	4	0.5	0.5	9	8	0.5	0.17	1	1	5	1	8	0.13	8	0.5	0.25
14	0.5	9	0.5	1	6	1	4	9	3	8	6	0.5	0.33	1	8	0.33	6	5	8	6
15	8	0.33	7	9	8	1	0.5	2	0.2	9	8	0.17	0.5	0.33	1	0.5	1	3	0.33	7
16	3	0.5	0.17	6	0.33	5	2	0.5	6	0.33	5	7	9	7	0.5	1	0.33	0.25	0.13	9
17	9	7	5	0.5	7	6	9	5	0.25	8	8	9	7	0.5	6	0.5	1	9	8	8
18	7	0.5	6	8	0.13	2	0.25	7	6	7	9	7	0.25	9	7	0.33	0.25	1	6	5
19	9	8	0.33	0.5	9	9	1	4	8	9	1	0.33	3	8	8	5	9	4	1	0.33
20	0.5	7	9	0.14	0.5	0.2	1	9	4	0.5	8	0.13	8	9	1	6	5	7	0.5	1
COLUMN SUMS	107.8	69.48	76.58	84.27	73.96	68.15	74.75	83.61	93.17	81.16	82.25	90.96	86.22	96.57	64.69	80.15	58.71	84.83	67.71	90.35

Figure 12. The Randomly Generated Matrix

ZONAL AREAS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	ROW SUMS	PRIORITY VECTORS
1	0.01827	0.00859	0.0000	0.00621	0.17668	0.00578	0.14070	0.01892	0.07165	0.15352	0.06333	0.01072	0.01211	0.00385	0.00425	0.10612	0.01593	0.01059	0.03817	0.02701	0.90037	0.04502
2	0.03655	0.01717	0.01212	0.07455	0.12620	0.00578	0.01759	0.00946	0.01791	0.00760	0.12666	0.00707	0.02422	0.09191	0.22485	0.00884	0.01593	0.00360	0.00765	0.00891	0.84462	0.04223
3	0.05482	0.03435	0.02424	0.12422	0.00631	0.00393	0.01759	0.01892	0.03582	0.24662	0.03167	0.17145	0.12112	0.04127	0.00425	0.00884	0.11152	0.00424	0.03817	0.16203	1.28040	0.06402
4	0.07310	0.00567	0.00485	0.02484	0.02524	0.02315	0.14070	0.00122	0.03582	0.01535	0.06333	0.00536	0.00799	0.06127	0.07494	0.21224	0.09559	0.02119	0.01260	0.02701	0.93345	0.04667
5	0.00256	0.00343	0.09697	0.02484	0.02524	0.09253	0.00879	0.05676	0.00448	0.01535	0.10999	0.04286	0.02422	0.10725	0.02498	0.14149	0.07966	0.00530	0.07634	0.00102	1.10405	0.05520
6	0.07310	0.06869	0.14545	0.02484	0.00631	0.02315	0.01759	0.07569	0.00896	0.00399	0.00633	0.00575	0.07267	0.00260	0.00824	0.03557	0.01593	0.10595	0.03817	0.05401	0.67275	0.03364
7	0.00238	0.01717	0.02424	0.00325	0.05048	0.02315	0.01759	0.03784	0.00956	0.01535	0.03167	0.04286	0.04845	0.00214	0.00275	0.03557	0.09559	0.01059	0.11450	0.00540	0.67030	0.0335
8	0.01827	0.03435	0.02424	0.14907	0.00835	0.00578	0.00879	0.01892	0.00591	0.00760	0.12666	0.02143	0.07267	0.12255	0.01249	0.21224	0.00175	0.16947	0.00534	0.16205	1.18801	0.05940
9	0.00457	0.01717	0.01212	0.01242	0.10096	0.04626	0.00352	0.05676	0.01791	0.00430	0.03167	0.00364	0.00606	0.01532	0.00425	0.03557	0.06372	0.01059	0.01260	0.02701	0.48622	0.02431
10	0.00365	0.06869	0.00315	0.04969	0.05048	0.10506	0.03517	0.07569	0.12538	0.03070	0.00633	0.04286	0.07267	0.04596	0.62496	0.01769	0.15951	0.14851	0.01260	0.02701	1.18556	0.05927
11	0.00914	0.00429	0.02424	0.01242	0.00429	0.11566	0.01759	0.00473	0.01791	0.15352	0.03167	0.10116	0.01211	0.00385	0.12491	0.03557	0.07966	0.06356	0.03817	0.10602	0.96824	0.04841
12	0.03655	0.05152	0.00315	0.09938	0.01262	0.00578	0.00879	0.01892	0.10747	0.01535	0.00633	0.02143	0.14535	0.13787	0.19985	0.00707	0.00526	0.00297	0.01906	0.00891	0.91366	0.04568
13	0.03655	0.01717	0.00485	0.07455	0.02524	0.00763	0.00879	0.00624	0.07165	0.01013	0.06333	0.00364	0.02422	0.07659	0.02498	0.01769	0.03186	0.00233	0.03817	0.02701	0.57262	0.02863
14	0.07310	0.00292	0.00606	0.00621	0.00355	0.13879	0.12311	0.00246	0.01791	0.01015	0.12666	0.00236	0.00484	0.01532	0.00500	0.03557	0.11152	0.00530	0.11450	0.00459	0.80966	0.04048
15	0.10965	0.00189	0.14545	0.00820	0.02524	0.06940	0.15828	0.03784	0.10747	0.03070	0.00633	0.00279	0.02422	0.07659	0.02498	0.01769	0.12745	0.08475	0.00763	0.01350	1.08006	0.05400
16	0.00605	0.06869	0.09697	0.00422	0.00631	0.02315	0.01759	0.00322	0.01791	0.06141	0.03167	0.10716	0.04845	0.01532	0.04996	0.03557	0.03186	0.19068	0.30534	0.00102	1.20231	0.06012
17	0.01827	0.01717	0.00339	0.00422	0.00505	0.02315	0.00299	0.17029	0.00448	0.09211	0.00633	0.06429	0.01211	0.00214	0.00325	0.01769	0.01593	0.00699	0.03817	0.01350	0.52155	0.02608
18	0.03655	0.10304	0.12121	0.02484	0.10096	0.00463	0.03517	0.00246	0.03582	0.00430	0.01045	0.15002	0.21802	0.06127	0.00625	0.00309	0.04779	0.02119	0.00649	0.10802	1.10238	0.05512
19	0.01827	0.00587	0.02424	0.07455	0.01262	0.02315	0.00580	0.13245	0.05375	0.09211	0.03167	0.04286	0.02422	0.00506	0.12491	0.00460	0.01593	0.12712	0.03817	0.02701	0.96436	0.04822
20	0.01827	0.05152	0.00412	0.02484	0.00835	0.01157	0.08794	0.00322	0.01791	0.03070	0.00792	0.06429	0.02422	0.09191	0.04996	0.01167	0.03186	0.00550	0.03817	0.02701	0.61074	0.03054

Figure 13. Normalized Randomly Generated Consistent Matrix

ZONAL AREAS		1	2	3	4	5	6	7	8	9	10
1		0.04402	0.01394	0.57709	0.37347	0.30659	0.02186	0.30195	0.02974	0.17023	0.02968
2		0.30014	0.04224	0.03206	0.02334	0.01822	0.39355	0.23405	0.05949	0.01216	0.01959
3		0.22010	0.00845	0.04412	0.28842	0.00939	0.26235	0.01678	0.35693	0.21006	0.05936
4		0.02201	0.26346	0.32061	0.04668	0.27614	0.00876	0.16776	0.28795	0.12159	0.53421
5		0.39610	0.01394	0.01603	0.37347	0.05523	0.34981	0.30195	0.00654	0.19454	0.01484
6		0.01453	0.01056	0.03206	0.42016	0.01822	0.04573	0.01678	0.47591	0.17023	0.02968
7		0.35216	0.30019	0.44005	0.32678	0.02761	0.01443	0.03355	0.35693	0.19454	0.41550
8		0.26412	0.16097	0.03206	0.14005	0.02761	0.00743	0.03355	0.05949	0.00267	0.01484
9		0.30814	0.33795	0.57709	0.37347	0.49704	0.39353	0.23485	0.05949	0.02432	0.35614
10		0.39610	0.00845	0.57709	0.04668	0.44182	0.34981	0.01678	0.47591	0.17023	0.05936
11		0.30014	0.21122	0.03206	0.02334	0.00939	0.04573	0.30195	0.02974	0.00267	0.41550
12		0.26412	0.00718	0.38473	0.00607	0.30659	0.01093	0.23406	0.11898	0.12159	0.36614
13		0.22010	0.12673	0.02116	0.37347	0.22091	0.02186	0.01678	0.53539	0.19454	0.02968
14		0.02201	0.38019	0.03206	0.04668	0.33136	0.04373	0.13420	0.53539	0.07295	0.47486
15		0.35216	0.01394	0.44005	0.42015	0.44182	0.04373	0.01678	0.11898	0.00486	0.53421
16		0.13206	0.02112	0.01090	0.28010	0.01822	0.21063	0.06710	0.02974	0.00486	0.01959
17		0.39610	0.29570	0.32061	0.02334	0.30659	0.26235	0.30195	0.29744	0.14591	0.47486
18		0.30014	0.02112	0.38473	0.37347	0.00718	0.08745	0.00839	0.41642	0.00608	0.41550
19		0.39610	0.33795	0.02116	0.02334	0.49704	0.39353	0.03355	0.23795	0.19454	0.53421
20		0.02201	0.29570	0.57709	0.00664	0.02761	0.00876	0.08166	0.63639	0.09727	0.02968

ZONAL AREAS	11	12	13	14	15	16	17	18	19	20
1	0.29083	0.36595	0.25778	0.02024	0.01783	0.42160	0.01305	0.33153	0.43451	0.27511
2	0.43624	0.32021	0.00401	0.20244	0.02702	0.01988	0.02610	0.01823	0.02414	0.24455
3	0.38777	0.02207	0.17185	0.16196	0.40636	0.03011	0.23494	0.27627	0.33795	0.18204
4	0.02424	0.01610	0.25778	0.36440	0.37828	0.48183	0.01305	0.49729	0.01598	0.01620
5	0.04847	0.27447	0.00716	0.32391	0.01351	0.48183	0.00061	0.02763	0.00821	0.21398
6	0.05466	0.32021	0.25778	0.32391	0.00919	0.36137	0.00444	0.22102	0.02414	0.00336
7	0.01600	0.27447	0.14321	0.00445	0.05404	0.01988	0.07831	0.38670	0.30623	0.01520
8	0.43624	0.41170	0.00716	0.00526	0.01783	0.48183	0.23494	0.16576	0.19311	0.01009
9	0.02424	0.32021	0.22913	0.28342	0.02702	0.54206	0.18273	0.44203	0.43451	0.27511
10	0.01212	0.22872	0.17185	0.20244	0.21616	0.30114	0.02610	0.22102	0.01207	0.21398
11	0.04847	0.41170	0.01432	0.16196	0.40636	0.36137	0.01305	0.02763	0.19511	0.01009
12	0.02424	0.04574	0.11467	0.24293	0.00594	0.01988	0.10442	0.01381	0.02414	0.21398
13	0.00824	0.04574	0.02864	0.20244	0.05404	0.48183	0.00339	0.44203	0.02414	0.00764
14	0.29083	0.02287	0.00945	0.04049	0.43232	0.01988	0.15662	0.27627	0.30623	0.18341
15	0.38777	0.00778	0.01432	0.01336	0.05404	0.03011	0.02610	0.16576	0.01593	0.21398
16	0.24236	0.32021	0.25778	0.28342	0.02702	0.06023	0.00861	0.01381	0.00628	0.27511
17	0.38777	0.41170	0.20049	0.02024	0.32424	0.03011	0.02610	0.49729	0.30623	0.24455
18	0.43624	0.32021	0.00716	0.36440	0.57828	0.01988	0.00653	0.05525	0.20967	0.15204
19	0.04847	0.01510	0.00595	0.32391	0.45232	0.30114	0.23494	0.22102	0.04820	0.01009
20	0.38777	0.00596	0.22913	0.36440	0.05404	0.36137	0.13062	0.38670	0.02414	0.08067

Figure 14. Priority Elements of Randomly Generated Consistent Matrix Multiplied by Column Elements of Randomly Generated Matrix

ZONAL AREAS	ROW SUMS	PRIORITY ELEMENT
1	1.55577	75.7117
2	2.48213	121.353
3	3.26598	148.130
4	2.01818	124.915
5	2.41381	133.650
6	1.62880	67.4255
7	1.45650	80.7919
8	2.30501	111.823
9	0.92603	52.4369
10	1.94390	16.9494
11	3.05747	34.3966
12	2.30229	26.6065
13	1.19728	133.449
14	1.77878	34.5687
15	2.30282	15.3446
16	3.16190	213.187
17	1.15234	13.4195
18	1.97314	22.9781
19	2.55019	29.6981
20	1.57871	32.0732

COLUMN SUM = 1488.91

LAMBDA MAX. = 74.4454

C. I. = 2.86555

Figure 15. Row Sums, Lambda Max, Random Index and Consistency Ratio of the Randomly Generated Consistent Matrix

3. Determination of the Consistency Ratio

Once the Consistency Index of the Pairwise Comparison Matrix and the Random Index of the Randomly Generated Consistent Matrix are known the Consistency Ratio can be calculated by the following formula:

$$CR = \frac{CI}{RI} = \frac{2.86555}{3.72625} = 0.76715$$

This value, in our opinion, is too far from the AHP goal of 0.10 to be considered a consistent result. Two factors that may have contributed to this unsatisfactory result are:

(1) The judgments of the P&E evaluator used in the Pairwise Comparison Matrix were randomly chosen.

(2) The Random Index of the Randomly Generated Consistent Matrix is not as accurate as it could be.

We feel that factor (2), the inaccuracy of the Random Index, deserves a more in-depth explanation at this time. Saaty and his colleagues have worked extensively at developing average Random Indexes for matrices of order 1 to 15. [Ref 5:p. 21]. They have generated hundreds of matrices at each order and then averaged the resulting Random Indexes. What we have done, due to resource constraints, is generate one Random Index for a 20 by 20 matrix. In effect, we have been unable to follow published guidelines for dealing with matrices of this magnitude under the Analytical Hierarchy Process. However, it is questionable whether expending the effort to generate 100 random matrices of size 20 by 20 will be worth it. The concern in AHP is having consistency in the Pairwise Comparison Matrix, not whether it can be quantified or not. A suggestion for ensuring consistency of the Pairwise Comparison Matrix would be to gather the entire NARF Alameda P&E staff and utilize the Delphi method [Ref. 6] to find the zonal area priority values. This methodology develops a consensus opinion of the entire group involved in the ranking task and thus eliminates the need to generate random matrices, or be concerned with monitoring consistency.

D. SUMMARY

In this chapter we have utilized the methodology of the Analytical Hierarchy Process to generate values which represent the contribution each zonal area makes to the criterion of general material condition of the S-3A aircraft. Unfortunately, we do not have an easy way to measure the consistency of opinion because of the difficulty of generating random matrices to obtain a comparison. This does not seem necessary anyway. The Delphi method [Ref. 6], developed by the Rand Corporation, can be used to aggregate the opinions of all involved P&E's and the results would, indeed, be consistent.

E. PREVIEW

In the next section we will develop an observable scale that can be used by the P&E evaluator when he conducts the S-3A ASPA inspection. This scale is necessary to reduce the P&E's evaluation of a specific aircraft to a single number, which is a step beyond the Analytical Hierarchy Process. The generation of a specific number to describe an aircraft's general material condition will make the SDLM induction decision much easier for NARF Alameda management.

V. DEVELOPMENT OF AN OBSERVABLE SCALE

A. INTRODUCTION

The Analytical Hierarchy Process provides us with the relative contribution each zonal area of the S-3 Viking makes to the general material condition of the aircraft. In the development of the observable scale we used the elements of the priority vector from the Pairwise Comparison Matrix to linearly weight the number and severity of the defects found by the P&E evaluator during the ASPA inspection. The decision to linearly weigh the number and severity of defects was reached by consulting the S-3A Engineering Branch of NARF Alameda. This procedure was deemed the most workable weighting scheme at this time.

The P&E evaluator, through knowledge and work experience, determines the lowest level of maintenance required to restore a discrepancy to its original condition. The levels of maintenance that are possible for assignment include the organization/squadron or O-level and the depot/NARF or D-level. The intermediate maintenance level is excluded as Aircraft Intermediate Maintenance Department(s) (AIMD) do very little, if any, structural corrosion repair work.

In addition to the assignment of the maintenance level capable of repairing the discrepancy, the P&E evaluator assigns a defect code of minor, major or critical designation. These defect codes are defined by NAVAVNLOGCENINST 4730.7A [Ref. 3] as:

> Minor (Mi) - a defect that does not materially reduce the useability of the unit or part for its intended purpose nor is deferral or correction likely to impose a disproportionate economic penalty.

Major (Ma) - a defect that materially reduces the useability of the unit or part for its intended purpose. Correction is subject to the operational/economic desires of the aircraft custodian but attention is recommended to regain essential operational capability.

Critical (Cr) - a defect that constitutes a hazardous or unsafe condition or, as determined by experience and judgment, could conceivably become so relative to its deleterious effect on the aircraft or its operating personnel.

An example of the P&E evaluator's worksheet is presented in Figure 16 with assigned rework codes and typical discrepancies found during the zonal inspection of the fuselage.

B. PROCESS

Based on the maintenance level/defect codes possible for assignment by the P&E (O/Mi, O/Ma, O/Cr, D/Mi, D/Ma, D/Cr) plus a category for "no defect", Figure 17 suggests a ranking of severity of defect from least severe (No Defect) to most severe (Depot/Critical). To quantify the ASPA process we have divided the priority vector elements of the Pairwise Comparison Matrix by six, the number of categories available for assignment by the P&E evaluator during an ASPA inspection, and multiplied this number by 10,000 to attain a linear weighting factor. For example, Zonal Area 15 (fuselage) has a priority value of 0.15007. This value divided by six and multiplied by 10,000 results in a point value equal to 250.12.

This number represents the difference in weighting between each of the assignable categories. The "No Defect" category is assigned a value of zero points and "Depot/Critical", the most severe category, is assigned the full point value. Using Zonal Area 15 as an example, the point assignment breakout would be as follows:

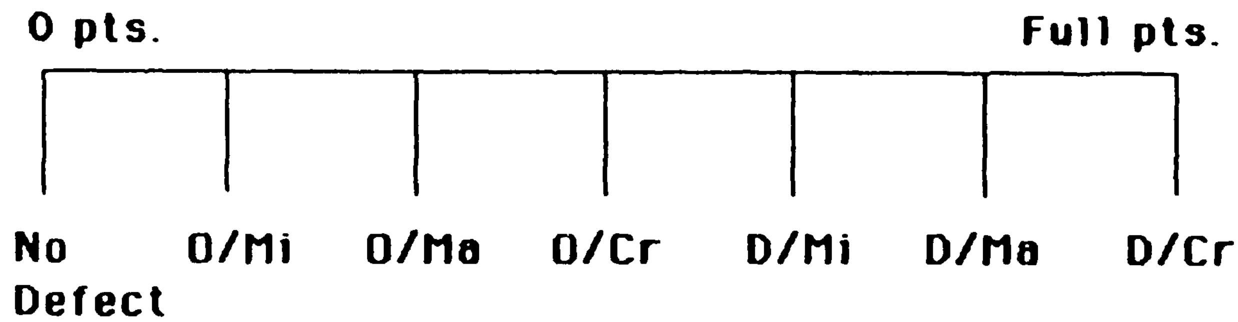
AIRCRAFT EXAMINATION AND EVALUATION REPORT

TYPE AIRCRAFT	BUREAU NUMBER	ESTIMATOR	DATE
S-3A	159419	R. SWANSON / A. MORGAN EYE NAVAIREWORKFAC ALAMEDA	3 Oct 85

O-ORGANIZATIONAL I-INTERMEDIATE D-DEPOT	DESCRIPTION	MI-MINOR MA-MAJOR CR-CRITICAL	REWORK LOCE
FUSELAGE: AREAS 1 THRU 14			
1. NOSE RADOME - DELAMINATION (BUBBLE) APPROX 10" x 14" 10 O'CLOCK POS			346/11124 O/CR *
2. AREA 4 - CRACKED STIFFENERS AT CAMERA BAY			190/11150 O/MA
3. AREA 4 - CORROSION UNDER BOND STRIPS			170/11150 O/MA
4. FLIR BAY - EXFOLIATED CORROSION AROUND BOND STRIPS			170/11150 O/MA
5. FLIR BAY - BROKEN SEAL RETAINER UPPER LOCATION AFT			O/MI
6. FLIR BAY - CORROSION AROUND FASTENERS UPPER FLIR AND FWD AVIONICS BAY			O/MI
7. AREA 4 - CORROSION ON SEAL RETAINER IN AVIONICS BAY LWR			O/MI
8. CRACKED BRACKET - EXTERNAL PWR RECEPT			190/11150 O/MA
9. CORROSION AROUND PLUG - LWR FS 272			O/MI
10. WATER ENTRAPMENT - RH FWD LWR AREA 14			O/MI
11. CORROSION AROUND BOND STRIPS & FRAMES LH AREA 14			O/MI
12. WORN HINGE - RH LWR GROUND SERVICE STEP			O/MI
ECS COMPARTMENT: AREA 12			
1. NUT LOOSE ON BOLT / NO COTTER PIN - AIL CONTROL POWER SERVO MECHANISM ROD END			108/1433100 O/CR *
2. L & R FWD STIFFENERS CRACKED - REF AFC 184			190/1131247 O/MA

NAVAIREWORKFAC ALAMEDA 4710/44A (OP) (REV 2-84)

Figure 16. Example Planner and Estimator (P&E) ASPA Worksheet



O/Mi Organizational Minor
O/Ma Organizational Major
O/Cr Organizational Critical
D/Mi Depot Minor
D/Ma Depot Major
D/Cr Depot Critical

Figure 17. Severity of Defect Ranking Structure

No Defect	0	points
Organizational Minor	250.12	points
Organizational Major	500.23	points
Organizational Critical	750.35	points
Depot Minor	1,000.47	points
Depot Major	1,250.58	points
Depot Critical	1,500.70	points

To apply these weighting factors to the ASPA process we propose that the P&E evaluator total the number of discrepancies in each severity of defect category for each zonal area, and multiply this number by the appropriate category weight. For example, using Zonal Area 15, if the P&E evaluator discovered three Organizational Minor (O/Mi) discrepancies and two Depot Major (D/Ma) discrepancies, the Zonal Area ASPA score would be:

$$= [(3)(250.12) + (2)(1,250.58)]$$

$$= 3,251.52$$

The overall ASPA score would then be determined by summing all the zonal area ASPA score inputs. Table 3 presents the Quantitative ASPA Evaluation Scoresheet we have developed from the zonal area priority values. This scoresheet is designed to be used by the P&E evaluator after the ASPA inspection is completed. The P&E simply annotates the number of discrepancies by severity category, and performs the appropriate calculations to find the specific aircraft's ASPA score.

Once the NARF Alameda S-3A Engineering Branch has collected a number of ASPA scores, a threshold score for determining the induction decision can be established. This threshold score could be found by comparing the ASPA scores of aircraft recommended for induction versus the ASPA

TABLE 3. QUANTITATIVE ASPA EVALUATION SCORESHEET

ASPA ZONAL INSPECTION AREAS:	O/MI FACTOR	O/MI NUMBER	O/Ms FACTOR	O/Ms NUMBER	O/Cr FACTOR	O/Cr NUMBER	D/MI FACTOR	D/MI NUMBER	D/Ms FACTOR	D/Ms NUMBER	D/Cr FACTOR	D/Cr NUMBER	ZONAL SCORES
1 LH WING FOLD: OUTER WING PANEL	34.25 x		68.50 x		102.75 x		137 x		171.25 x		205.50 x		
2 LH WING FOLD: INNER WING PANEL	34.08 x		68.17 x		102.25 x		136.33 x		170.42 x		204.50 x		
3 RH INNER WING PANEL SPAR & FLAP WELL	36.75 x		73.50 x		110.25 x		147 x		183.75 x		220.50 x		
4 RH OUTER WING PANEL AFT SPAR & FLAP WELL	26.93 x		53.87 x		80.80 x		107.73 x		134.67 x		161.60 x		
5 RH OUTER WING PANEL, TAB&SPAR	30.10 x		60.20 x		90.30 x		120.40 x		150.50 x		180.60 x		
6 RH WING FOLD: OUTER WING PANEL	40.27 x		80.53 x		120.80 x		161.07 x		201.33 x		241.60 x		
7 RH WING FOLD: INNER WING PANEL	30.05 x		60.10 x		90.15 x		120.20 x		150.25 x		180.30 x		
8 LH INNER WING PANEL SPAR & FLAP WELL	34.35 x		68.70 x		103.05 x		137.40 x		171.75 x		206.10 x		
9 LH OUTER WING PANEL AFT SPAR & FLAP WELL	29.43 x		58.87 x		88.30 x		117.73 x		147.17 x		176.60 x		
10 HORIZONTAL STABILIZER	191.15 x		382.3 x		573.45 x		764.60 x		955.75 x		1146.9 x		
11 LH ELEVATOR & TAB	148.15 x		296.3 x		444.45 x		592.60 x		740.75 x		888.90 x		
12 RH ELEVATOR & TAB	144.22 x		288.43 x		432.65 x		576.87 x		721.08 x		865.30 x		
13 FIN FOLD	14.95 x		29.90 x		44.85 x		59.80 x		74.75 x		89.70 x		
14 RUDDER	85.77 x		171.53 x		257.30 x		343.07 x		428.83 x		514.60 x		
15 FUSELAGE	250.12 x		500.23 x		750.35 x		1000.5 x		1250.6 x		1500.7 x		
16 ECS COMPARTMENT	24.72 x		49.43 x		74.15 x		98.87 x		123.58 x		148.30 x		
17 LH MAIN LANDING GEAR & WELL	143.12 x		286.23 x		429.35 x		572.47 x		715.58 x		858.70 x		
18 RH MAIN LANDING GEAR & WELL	143.12 x		286.23 x		429.35 x		572.47 x		715.58 x		858.70 x		
19 NOSE LANDING GEAR & WELL	143.12 x		286.23 x		429.35 x		572.47 x		715.58 x		858.70 x		
20 OVERALL PAINT CONDITION	82.03 x		164.07 x		246.10 x		328.13 x		410.17 x		492.20 x		

OVERALL ASPA SCORE (SUM TOTAL) =

scores of those aircraft that are extended on operational duty. The result of this comparison should be the generation of a maximum ASPA score or threshold value. Aircraft which fall under this value will be extended and those which exceed it will be inducted into SDLM rework.

C. SUMMARY

In this chapter we have proposed a methodology to consolidate the rankings developed through the AHP into a single value for each inspected aircraft. We have not removed all of the subjectivity from the S-3A ASPA process but we have accomplished our goal of proposing a methodology for quantifying the S-3A ASPA program. The subjectivity that remains at this point is the P&E evaluator's selection of the appropriate defect category. By the very nature of the ASPA process, this choice must remain under the control of the P&E evaluator.

VI. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

A. SUMMARY

This study has focused on the quantification of the previously subjective S-3A ASPA process. By first presenting a background and general overview of the ASPA concept, we have set the framework for analyzing the specific S-3A Viking ASPA process. We have discovered that the S-3A ASPA process is different than the ASPA process for all other Type/Model/Series aircraft in the Navy's inventory. The S-3A ASPA process evaluates zonal areas of the aircraft while the other Type/Model/Series aircraft use a leading indicator (i.e., specific component inspection) methodology during an ASPA evaluation.

Since the S-3A ASPA process employs a zonal area evaluation technique we were forced to search for a unique methodology that approached the quantification problem in a logical and analytical manner. The model we have chosen is the Analytical Hierarchy Process (AHP) developed by Dr. Thomas L. Saaty. The AHP is based upon three principles of logical analysis. The principle of structuring hierarchies was carried out by adapting the ASPA concept to the AHP hierarchial structure. The principle of setting priorities required developing a Pairwise Comparison Matrix for the zonal areas of the S-3A, the values of which were determined by consulting an experienced P&E evaluator. This matrix was then mathematically manipulated to produce a quantitative measure of the relative priority each zonal area contributes to the SDLM induction decision. Finally, we attempted to apply the principle of logical consistency. Unfortunately, the amount of effort required was considered beyong the time available.

Once the priority of each zonal area had been determined an observable scale was developed to reduce the P&E's rankings to a single number. In essence, this number described an aircraft's general material condition. After a suitable database has been collected, a threshold score should be able to be determined. Then, when a specific aircraft is inspected and its score assigned, the recommendation of induction/no induction can be determined by comparing the aircraft's ASPA score to the threshold value. A score above the threshold dictates the aircraft goes to rework and a score below the threshold indicates the aircraft can stay on operational duty (PED extension).

B. CONCLUSIONS

The quantified ASPA format that we have developed will eliminate most of the variation that now exists between the P&E's induction recommendations. By implementing our process the management staff of NARF Alameda will no longer have the problem of identifying the "hard" or "easy" grader. Even without being able to test for consistency, we feel that the process we have developed is workable and should be incorporated by NARF Alameda for quantifying the ASPA process for the S-3A Viking.

C. RECOMMENDATIONS

Specific recommendations to NARF Alameda include:

(1) Attempt to reduce any inconsistency in the Pairwise Comparison Matrix for the S-3A by forming a task group to develop a consensus of the proper weights for each pairwise comparison.

(2) Monitor the number of aircraft that pass/fail the quantitative ASPA inspection and ensure that the evaluation criteria are accurate and in conformance with the latest Navy directives.

(3) Analyze any future ASPA inspection data that will be generated and make certain that consistency is maintained.

The general material condition of the S-3A was the focus of this study. Although this factor was the only one evaluated in the ASPA process, we feel that other criteria should also be considered. These can easily be incorporated into the AHP by the development of separate matrices for each new criterion. Criteria such as cost, safety of flight and operational readiness are examples of areas that could be studied.

APPENDIX A

S-3A LOCAL ENGINEERING SPECIFICATION (LES)

This appendix presents the NARF Alameda LES for the S-3A Viking aircraft ASPA program.

DEPARTMENT OF THE NAVY
Naval Air Rework Facility
Naval Air Station
Alameda, California 94501

312:JKH
7 Aug. 1985

TITLE: S-3A Local Engineering Specification

IDENTIFICATION/CLASSFICATION GEN/AL 12-9-005B

SYSTEM: S-3A Aircraft

SUBJECT: S-3A Aircraft Service Period Adjustment (ASPA) Inspection; guidelines for

REFERENCE: (a) NAVAVNLOGCEN PATUXENT RIVER MD 011844Z NOV 82.
(b) NALC Patuxent River MD ltr 3138/13023/8166 of 15 Mar 83
(c) NALC Patuxent River MD ltr 405/4710/3118 of 25 Aug.83
(d) CNO Washington DC 3017132 Dec 83
(e) NAVAVNLOGCEN PATUXENT RIVER MD 201602Z Jan 84
(f) NAVAVNLOGCEN PATUXENT RIVER MD 151533Z Feb 84
(g) NAVAIR 01-S3AAA-6
(h) NAVAIR 01-S3AAA-6-3
(i) LES GEN/AL 02-2-0150

ENCLOSURE: (1) Aircraft E & E Report

1. PURPOSE: To define S-3A and derivative aircraft inspection procedures and requirements for a depot inspection team in the field to assess aircraft material condition and suitability for a 12 month increase to the present operating service period end date (PED).

2. CANCELLATION: None.

3. BACKGROUND: This directive was prepared as requested by reference (a), outlined in refs (b),(c), and (d), and modified by refs (e) and (f) to provide a disciplined procedure for maintaining positive control of aircraft material condition for aircraft required to be operated beyond the present PED.

4. APPLICATION: This directive applies to all S-3A and derivative aircraft requiring qualification for an increase to their current PED. The inspection specified in this directive shall be accomplished by a depot ASPA inspection team from a Depot Rework Point (DRP) as directed by the NAVAVNLOGCEN. The ASPA inspection must be conducted within the six months prior to PED of an aircraft as requested by the reporting custodian. The ASPA inspection shall result in either a recommendation that the aircraft be inducted in SDLM within 90 days of PED or that the aircraft's PED be adjusted twelve

months beyond the current PED. Aircraft not recommended for deferral and not inducted within 90 days of PED shall be grounded.

4.1 INSPECTION TEAM: A certified ASPA inspection team will be responsible for accomplishing the inspection requirements and reporting the aircraft suitability for a twelve month PED increase. The ASPA inspection team will consist of :

(a) One (1) Planner & Estimator
(b) Appropriate Trade Skills as required.

5. SPECIAL TOOLS AND TEST EQUIPMENT: a). Paint film thickness detector for Aluminum base foundation (Vector 121 NDI Instruments Inc. or equivalent).b). Articulating Borescope.

6. SPECIAL MATERIALS: None.

7. EFFECTIVE DATE: 1 SEPT 85.

8. INSTRUCTIONS: The following instructions are guidelines for an Aircraft Service Period Adjustment (ASPA) inspection of aircraft for possible tour extension (s) beyond the peacetime Operation Service Period (OSP) Period End Date (PED). The ASPA inspection shall be performed at a shore facility designated by the aircraft controlling custodian. The ASPA inspection shall be performed by a Field Team - delineated in paragraph 4.1 of this specification. Organizational and Intermediate Level maintenance personnel will assist with the inspection as required.

8.1 Aircraft Record Analysis.

8.1.1 Review Maintenance Action Forms OPNAV 4790/41) Naval Aircraft Flight Records (Yellow sheets, OPNAV 3760/2) and the aircraft log book for identification of repeat problem areas, unusual conditions,or significant maintenance actions (including structural repairs). This historical performance shall be analyzed to determine possible chronic system and component trouble areas for added emphasis during aircraft examination. The squadron maintenance personnel familiar with the aircraft being evaluated shall be interviewed , whenever possible, to gain additional information regarding potential problem areas or for other considerations to be used in determining if an extension will be recommended.

8.1.2 Review the Periodic Maintenance Information Conditional (PMICs) manuals, reference (g), scheduled removal components for high-time components.

8.1.3 Review the Technical Directives Section, (OPNAV 4790/24A), or List 2 of the Aircraft Log Book to determine incorporated technical directives which would be required if the aircraft were extended.

8.1.4 Examine Aircraft Log Book and available maintenance and historical records to determine and record items listed below. This information shall be submitted to the Naval Air Rework Facility , Alameda, California, Code 311/312 after the ASPA inspection has been performed.

8.1.4.1 Aircraft Bureau Number.

8.1.4.2 Tour Number and present extension number.

8.1.4.3 Total Operational service months and months-in-tour.

8.1.4.4 Last SDLM completion date.

8.1.4.5 Total flight hours and hours-in-tour.

8.1.4.6 Number and Type of Landings (total) , field, carrier, FCLP, and bolters.

8.1.4.7 Number and type of arrestments (carrier and field).

8.1.4.8 Number of catapults.

8.1.4.9 Non-aging time accumulated since last SDLM.

8.1.4.10 History of damage, overstress, hard/overweight landings, chronic or unusual, maintenance problems, special operaticonditions , and major component replacements.

8.1.4.11 Last phase inspection and date.

8.2 Detailed Inspection Requirements: Compliance with the following is required to determine aircraft suitability for tour extension.

8.2.1 Custodian wash aircraft in accordance with reference (h) to prepare aircraft for inspection.

a). Visually inspect entire paint system for evidence of :

(1) Paint lifting (poor adhesion).
(2) Blisters
(3) Checked coatings, erosion and corrosion (especially around fasteners.)
(4) Check the thickness of the paint film around areas that are listed below. (Using Vector 121 or equivalent) Use an average of three readings if there is wide discrepancy in the readings. 2 mils or less is cause for repainting.

a. L/H aileron, center underside, BL 365.
b. L/H wing top side, intersection of FS 338 and BL 94.
c. L/H fuselage, intersection of FS 326 and BL 38.8
d. R/H aileron, center, underside BL 365.
e. R/H flap, center, underside BL 320
f. R/H wing,top side intersection of FS 338 and BL 94
g. L/H fuselage,intersection of FS 519.4 and WL 200
h. L/H upper main landing gear , rear corner , FWD of and below of intersection of FS 496.6 and WL 200.

i. L/H fuselage,intersection of FS 333.8 and WL 180
j. R/H fuselage, intersection of FS 584.0 and WL 200.
k. R/H main landing gear door, upper aft corner, FWD of and below of the intersection of FS 496.5 and WL 200.
l. R/H fuselage,intersection of FS 333.8 and WL 180.
m. R/H fuselage,intersection of FS 279.7 and WL 180.

b). Perform wet and dry tape test as outlined in reference (i)

c). Cosmetic appearance should not be considered.

d). Repair capability is "O" level for touch-up and "D" level complete repainting.

8.2.2 Inspect nose radome using tap test technique.

a). Check each Radome for delamination and structural damage. Radomes found to have delamination flaws beyond three inches, but less than eight inches, in any direction must be repaired within 30 days. Radomes with delaminations in excess of eight inches in any direction must be replaced or repaired prior to the next flight. All the above applies except in the cap area, where any delamination flaws greater than three inches must be replaced or repaired prior to the next flight.

b). Repair requires Depot Level Capability.

8.2.3 Open all listed panels (and any other panels designated by the on-site P & E). Access panels are noted by numbers in parentheses. Inspect the following areas for cracks, corrosion, loose or missing fasteners, loss of paint, paint blisters cleaniness, obstructed drain holes, and water entrapment.

8.2.3.1 Internal Upper Fin (9111-1 and 9131-1)

8.2.3.2 Internal Engine Pylon (10112-2 and 10131-1)

8.2.3.3 Fin Stub Horizontal stabilizer cutout (7121-1,8121-1,6133-1,and 5132-1)

8.2.3.4 Internal rear fuselage (5133-1,5232-1, 5232-2)

8.2.3.5 Inspect inside the following wing panels and all flight control push rods, linkages, bearings, bushings, bellcranks, and fasteners.

1131-2	3213-4	3232-2	4213-1	4232-1	7231-1
3123-1	3213-5	4123-1	4123-2	4232-2	8211-1
3212-2	3231-1	4212-1	4213-4	4232-3	8211-2
3212-4	3231-3	4212-2	4213-5	5111-1	8221-1
3212-5	3231-6	4212-3	4231-3	6111-1	8231-1
3212-6	3231-7	4212-4	4231-5	7211-1	9113-2
3213-2	3231-9	4212-5	4231-6	7211-2	10121-1

3213-3 3232-1 4212-6 4231-7 7221-1 10122-1

8.2.3.6 With wings spread, check for binding in the following systems:

(a) Trailing edge flaps
(b) Leading edge flaps
(c) Spoilers
(d) Ailerons
(e) Elevators
(f) Rudder

8.2.3.6.1 Fold wings and inspect:

(a) Separable bellcranks
(b) Wing fold area.

8.2.4 Remove sonobuoy reference system antennas, P/N 673096 from the lower surface of the outer wing. Antennas are located at buttock lines 258 and 340 on port and starboard wings. Inspect interior-circumference of exposed hole for corrosion.

8.2.5 Inspect landing gear and wheel wells for corrosion, loose or missing fasteners and deformation. Pay particular attention to the nose landing gear launch bar assembly, trunnions, drag strutsupports,and nose jack fittings.

8.2.6 Inspect arresting gear hook well for cracks, corrosion, loose or missing fasteners, and deformation. Inspect left and right hand gear supports and fillet radii at the base of the supports for cracks and corrosion.

8.2.6.1 Inspect arresting gear drag link. Inspect apex radii at base of the supports for cracks and corrosion.

8.2.7 Remove panels 9123-2, and 9223-2. Inspect the structure about the Horizontal stabilizer support bracket, inspect for appearance of cracks in the fillet areas on the angle and lower beam structure aft of the horizontal stabilizer support hinge, pay particular attention to the right side.

8.3 Evaluation and Reporting.

8.3.1 Record requirements and inspection results on the Aircraft E & E Report, enclosure (1). The report shall identify all defects. Documentation shall include identification of the LES inspection which led to the defect discovery. The ASPA inspector and an authorized representative of the reporting custodian are to sign the Inspection Summary Report. A signed copy of the report shall be provided to the reporting custodian and to the Naval Air Rework Facility, Code 310 and 312, Naval Air Station, Alameda, California 94501. The CFA copy must include tje WUC applicable to each individual discrepancy,the malfunction code, and the when discovered code. The when discovered code shall indicate when the defect should have been discovered if the ASPA had not been performed. The WUC and these codes are only required for Critical and Major items.

8.3.2 Notify Weapons Systems Engineering Division, Code 310, of any unusal damage founded, that is not associated with aircraftageor service history. For example: indication of primary structure overstress. Code 311 will determine subsequent inspections and repairs.

8.3.3. The Planner-Estimator on the ASPA Inspection Team , will prepare a Naval Message Report on site. Neither Organization nor Intermediate Level defects are to be reported in this message. Included arethe following in the message text:

(a) TMS BUNO

(b) PED

(c) Tour

(d) Total operating service months.

(e) Total operating hours this period

(f) Total arresting landings this period

(g) ASPA inspection date

(h) Number of ASPA inspections in tour

(i)Number of man-hours expended in the ASPA inspection (Org/Intermediate/Dept)

(j)Description of critical and major defects which require depot resources for repair with an estimate of total man hours.

(k) Recommendation: A brief narrative as to the suitability of the aircraft for an ASPA change to the PED, based on the overall aircraft condition. Do not assume that any or all defects will be corrected.

(l) Distribution:

a). TYCOM
b). COMNAVAIRSYSCOM WASHINGTON
c). NAVAVNLOGCEN PATUXENT RIVER MD
d). NAVAIREWORKFAC ALAMEDA CA.
ATTN; CODE 0214, 311, 312, 521, 551, 553.

8.3.3.1 The ASPA decision will be made by the TYCOM based on the message report and in consultation with NAVAVNLOGCEN Depot Management. Disposition of any depot repair requirements will be in accordance with current emergency repair procedures.

8.4 Defects which require depot facilities/equipment to correct, shall be noted in the Aircraft Log Book "Miscellaneous History" section.

Prepared by

Jack K. Y. Hum
Aerospace Engineer

Reviewed by

Dave Groepler
Aerospace Engineer

Approved by

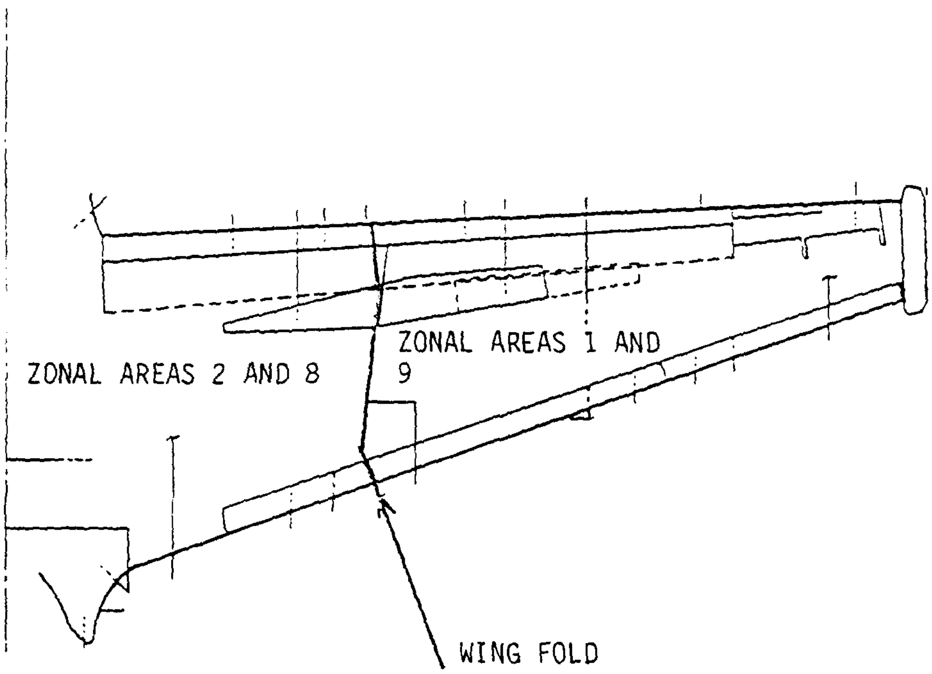
Nelson Woodford
S-3 Logistics Branch Head

Charles Maduell
S-3 Aircraft Branch Head

APPENDIX B

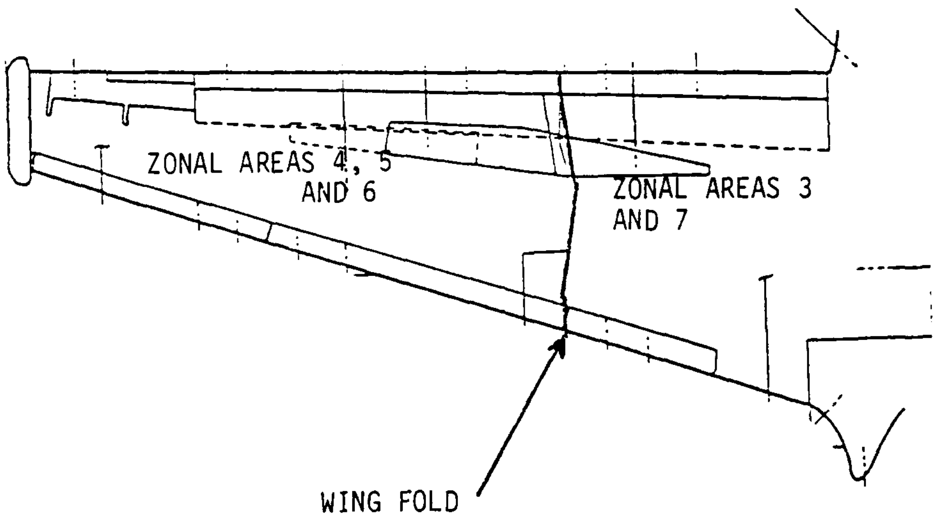
S-3A VIKING ZONAL AREAS

This appendix presents a pictorial view of the various zonal areas of the S-3A Viking aircraft.



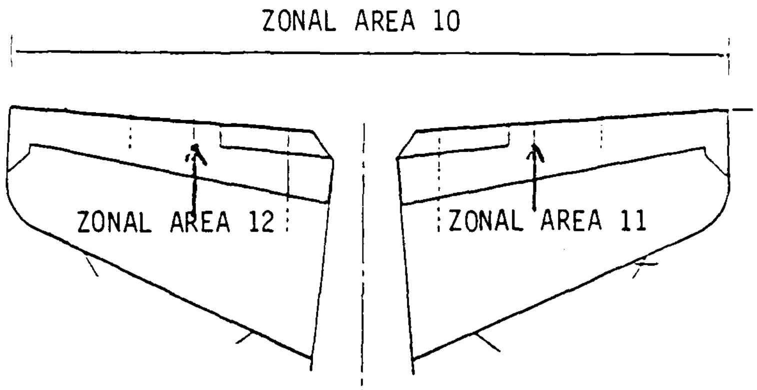
LEFT HAND WING

ZONAL AREA 1 LEFT HAND WING FOLD: OUTER WING PANEL
ZONAL AREA 2 LEFT HAND WING FOLD: INNER WING PANEL
ZONAL AREA 8 LEFT HAND INNER WING PANEL SPAR AND FLAP WELL
ZONAL AREA 9 LEFT HAND OUTER WING PANEL AFT SPAR AND FLAP WELL



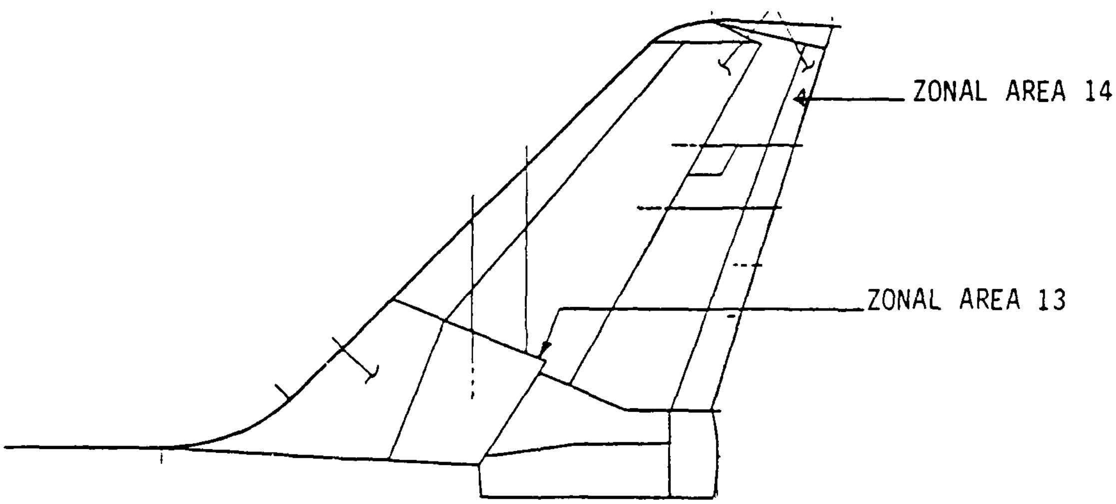
RIGHT HAND WING

ZONAL AREA 3 RIGHT HAND INNER WING PANEL SPAR AND FLAP WELL
ZONAL AREA 4 RIGHT HAND OUTER WING PANEL AFT SPAR AND FLAP WELL
ZONAL AREA 5 RIGHT HAND OUTER WING PANEL, TAB AND SPAR
ZONAL AREA 6 RIGHT HAND WING FOLD: OUTER WING PANEL
ZONAL AREA 7 RIGHT HAND WING FOLD: INNER WING PANEL



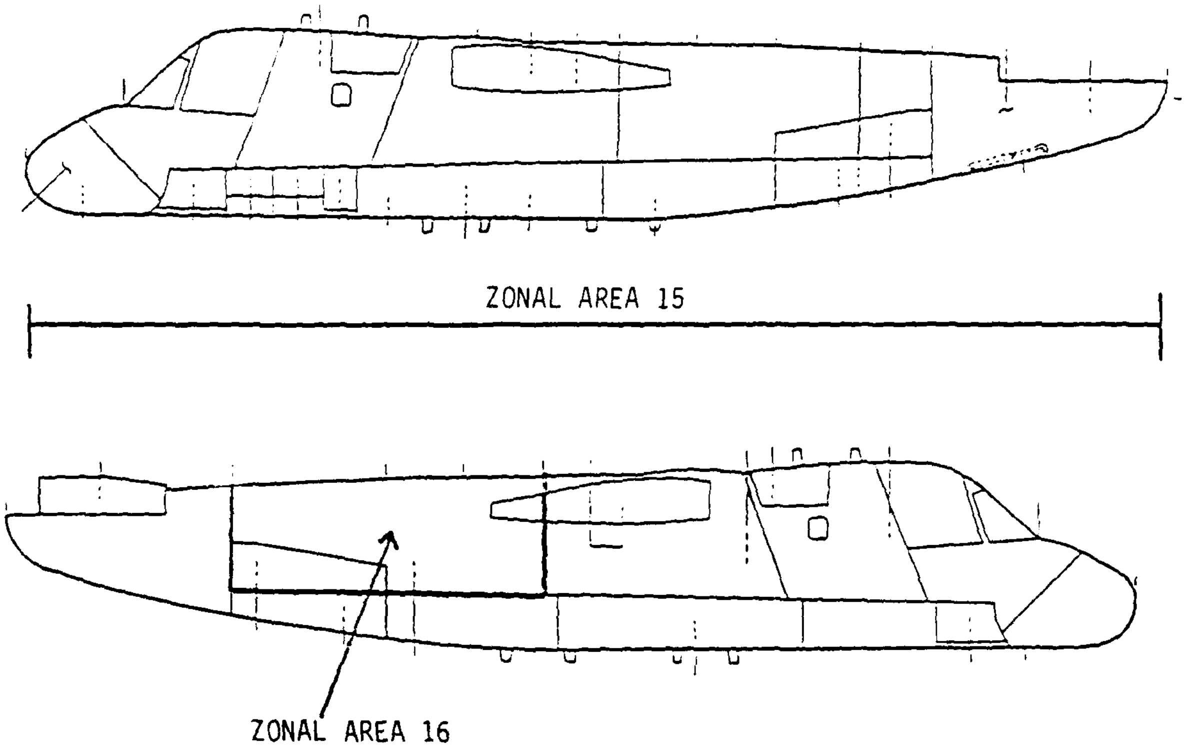
STABILIZER

ZONAL AREA 10 HORIZONTAL STABILIZER
ZONAL AREA 11 LEFT HAND ELEVATOR AND TAB
ZONAL AREA 12 RIGHT HAND ELEVATOR AND TAB



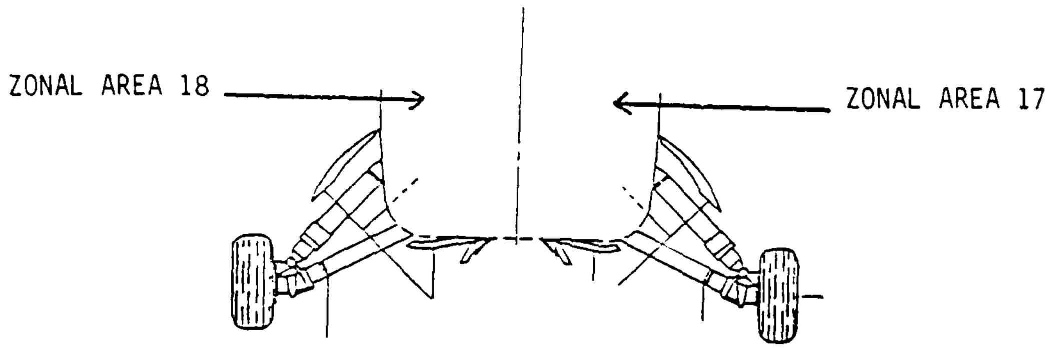
TAIL FIN

ZONAL AREA 13 FIN FOLD
ZONAL AREA 14 RUDDER



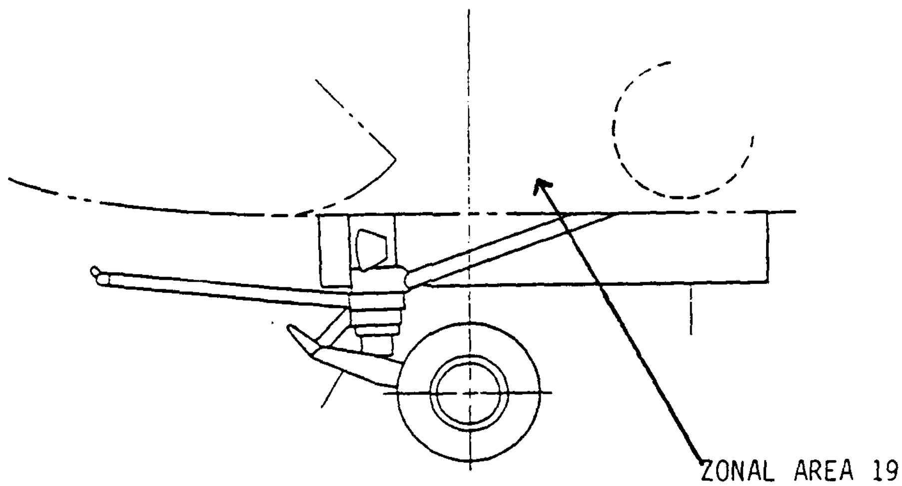
FUSELAGE

ZONAL AREA 15 FUSELAGE
ZONAL AREA 16 ECS COMPARTMENT



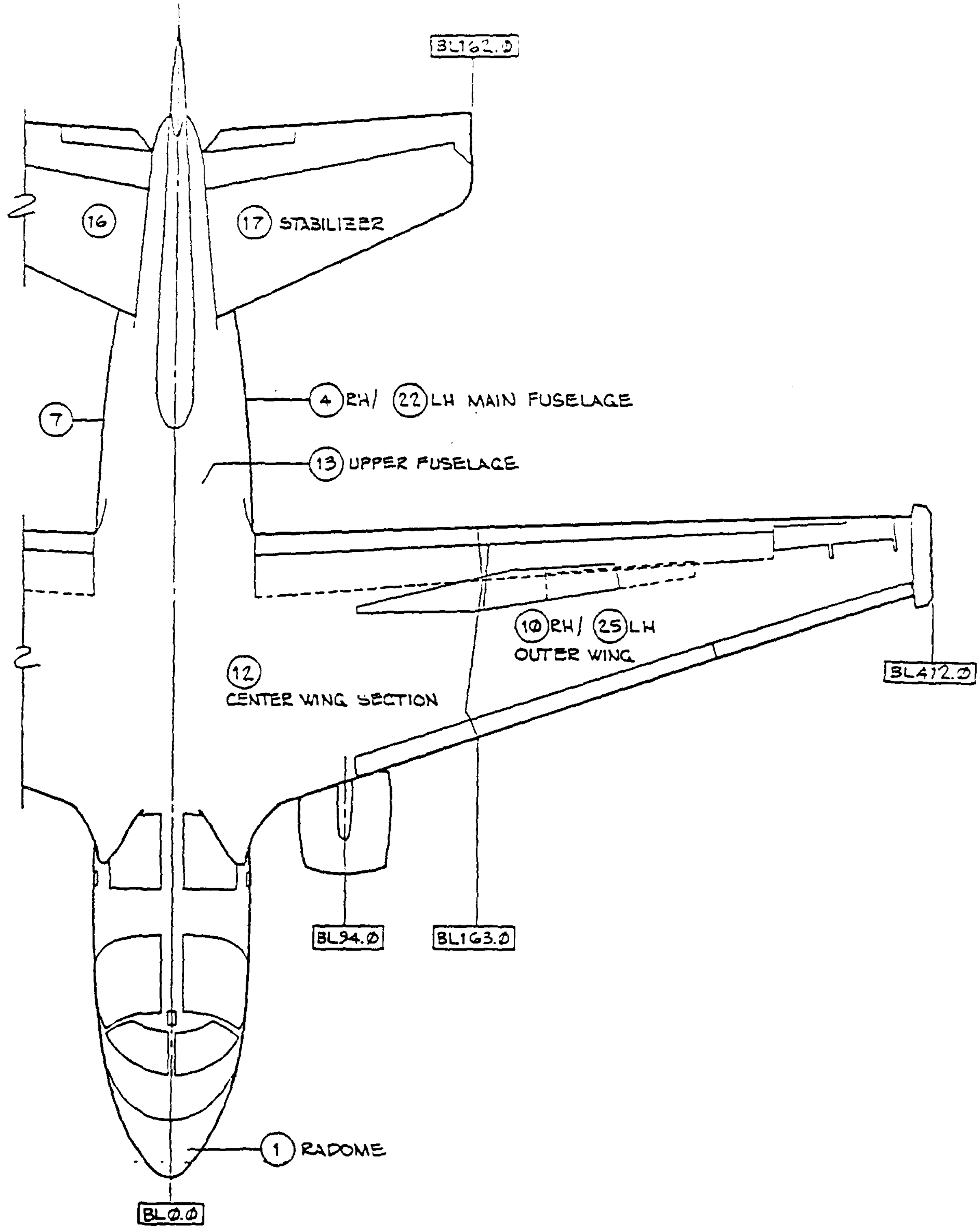
MAIN LANDING GEAR

ZONAL AREA 17 LEFT HAND MAIN LANDING GEAR AND WELL
ZONAL AREA 18 RIGHT HAND MAIN LANDING GEAR AND WELL



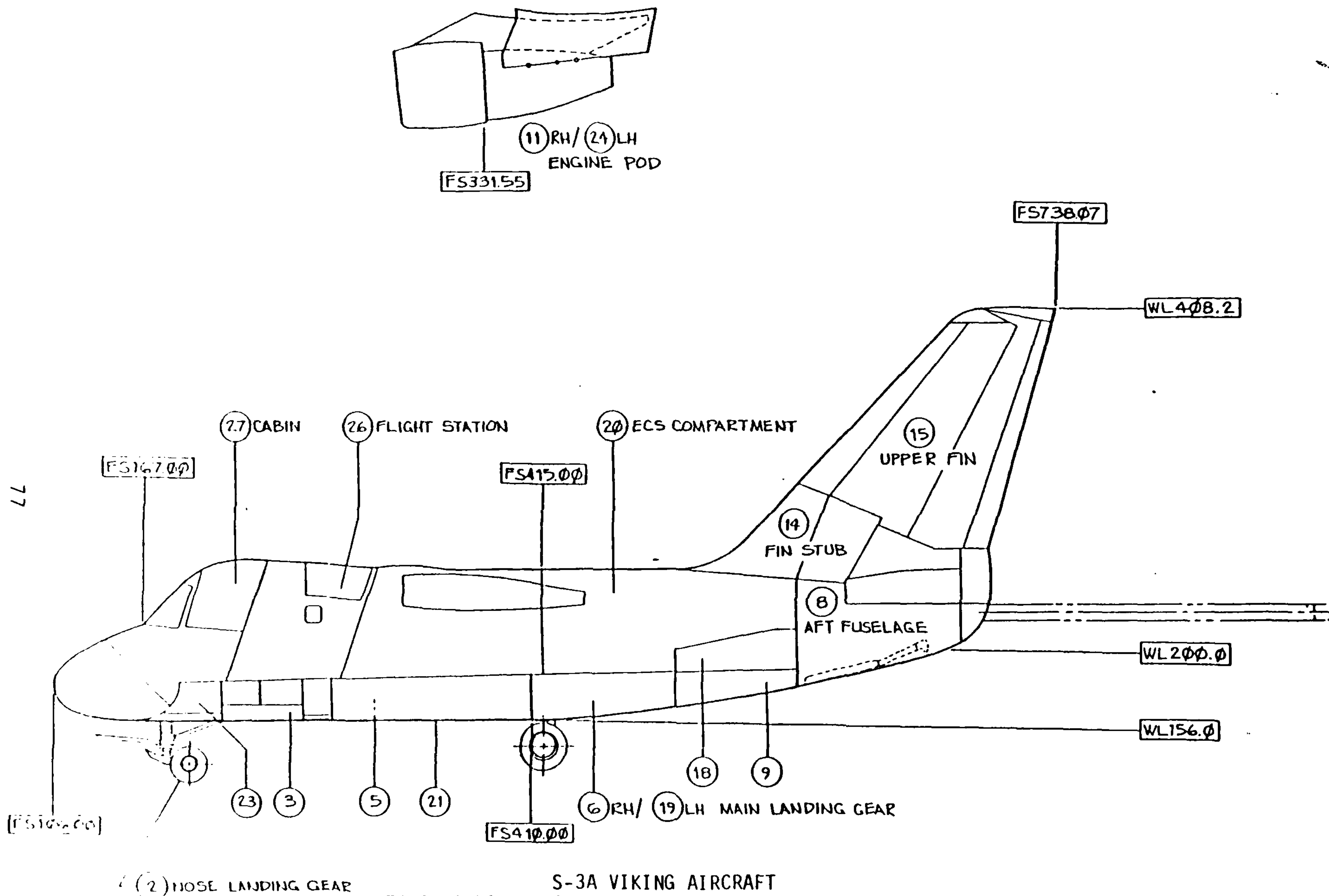
NOSE LANDING GEAR

ZONAL AREA 19 NOSE LANDING GEAR AND WELL



S-3A VIKING AIRCRAFT

ZONAL AREA 20 OVERALL AIRCRAFT PAINT CONDITION



S-3A VIKING AIRCRAFT
ZONAL AREA 20 OVERALL AIRCRAFT PAINT CONDITION

LIST OF REFERENCES

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