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# An analysis of the concurrent certification program at Fleet Readiness Center Southwest

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Monterey, California. Naval Postgraduate School

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# NAVAL POSTGRADUATE SCHOOL

## MONTEREY, CALIFORNIA

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## MBA PROFESSIONAL REPORT

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**An Analysis of the Concurrent Certification Program at Fleet Readiness Center Southwest**

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**By: Stephen K. Gulick, Jayson C. Larsen, and Scott D. Stahl**


**December 2009**


**Advisors: Kenneth J. Euske and Becky Jones**


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Data from FRCSW E-2/C-2 production line was analyzed. The data included the number of Discrepancy Work Orders (DWO) created, number of Maintenance Action Forms (MAF) created, number of Functional Check Flights (FCF), and number of Aircraft Inspection Discrepancy Reports (AIDR) received from customers. Critical areas examined were the number of defects discovered in the hangar, the number of defects that were not discovered until the aircraft arrived on the test line, and the number of defects that made it to the customer. The analysis of the data revealed that ConCert appears to effectively perform the quality verification function. Furthermore, the data shows that quality has improved; however, the source of the improvement cannot be linked solely to ConCert.

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# AN ANALYSIS OF THE CONCURRENT CERTIFICATION PROGRAM AT FLEET READINESS CENTER SOUTHWEST

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Submitted in partial fulfillment of the requirements for the degree of

**MASTER OF BUSINESS ADMINISTRATION**

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# AN ANALYSIS OF THE CONCURRENT CERTIFICATION PROGRAM AT FLEET READINESS CENTER SOUTHWEST

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# LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AI | Aircraft Inspector |
| AIDR | Aircraft Inspection Discrepancy Report |
| ASI | Aircraft Systems Inspector |
| CA | Certification Acceptance |
| CBWE | Cell Based Work Environment |
| CDI | Collateral Duty Inspector |
| CI | Component Inspector |
| CI | Confidence Inspection |
| CSEC | Computerized Self Evaluation Checklist |
| CPI | Continual Process Improvement |
| CO | Commanding Officer |
| COMFRC | Commander, Fleet Readiness Command |
| COMNAVAIRSYSCOM | Commander, Naval Air Systems Command |
| CDQAR | Collateral Duty Quality Assurance Representative |
| D-Level | Depot Level |
| DLQP | Depot Level Quality Program |
| DoD | Department of Defense |
| DWO | Discrepancy Work Order |
| ECC | Executive ConCert Council |
| eIQR | Electronic Individual Qualification Record |
| FCF | Functional Check Flight |
| FHP | Flying Hour Program |
| FMS | Foreign Military Sales |
| FRCSW | Fleet Readiness Center Southwest |
| FRP | Fleet Response Plan |
| ISSC | In-Service Support Center |
| I-Level | Intermediate Level |

| | |
|---|---|
| IQR | Individual Qualification Record |
| JTD | Job Task Description |
| LCC | Local ConCert Council |
| MRC | Maintenance Requirement Card |
| NADEP | Naval Air Depot |
| NAMDRP | Naval Aviation Maintenance Discrepancy Reporting System |
| NAE | Naval Aviation Enterprise |
| NAMP | Naval Aviation Maintenance Program |
| NARF | Navel Air Rework Facility |
| NAVRIIP | Naval Aviation Readiness Integrated Improvement Program |
| NHA | Next Higher Assembly |
| NPSL | Navy Primary Standards Lab |
| OJT | On-the-job Training |
| O-Level | Organizational Level |
| ORM | Operational Risk Management |
| PM | Program Manager |
| PMI | Planned Maintenance Interval |
| QA | Quality Assurance |
| QAR | Quality Assurance Representative |
| QAS | Quality Assurance Specialist |
| QAWB | Quality Assurance Workbench |
| QCN | Quality Correction Notice |
| QMS | Quality Management System |
| QV | Quality Verification |
| SECDEF | Secretary of Defense |
| SLEP | Service Life Extension Life Program |
| SOP | Standard Operating Procedure |
| T/M/S | Type/Model/Series |

| | |
|---|---|
| TOC | Theory of Constraints |
| VIDS/MAF | Visual Information Display System/Maintenance Action Form |

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# I. INTRODUCTION

## A. PURPOSE OF THIS STUDY

The purpose of this study is to analyze the effect of Fleet Readiness Center Southwest's Concurrent Certification Program on the Quality Verification process after replacing the Quality Assurance Supervisors within the E-2/C-2 Production Line.

## B. BACKGROUND

Modern Naval aircraft and aircraft components are inherently complex. This complexity requires the individuals working on these products to have sufficient technical knowledge of aircraft systems to understand related interfaces and interdependencies. In 2007, FRCSW adopted a private sector business practice that capitalized on the expertise of its production personnel. This program is called Concurrent Certification (ConCert), and was designed to provide better product quality by ensuring quality at the source. The ConCert Program provides product verification by production personnel, allowing specially trained artisans designated as Aircraft/Component Inspectors (AIs/CIs) to perform "second set of eyes" verifications in lieu of Quality Assurance Specialists (QAS).[1] The ConCert Program was initially implemented in the E-2/C-2 Production Line.

ConCert is a change in the QA method of providing verification. ConCert shifts roles by having production assume total ownership of product verification and allowing QA to focus on Continuous Process Improvement (CPI) and ConCert program oversight. ConCert artisans are highly qualified and authorized to verify critical quality characteristics of work performed by other qualified artisans. Through ConCert, artisans should become more aware of process improvements, cognizant of customer requirements, task requirements, and enhance performance through positive peer pressure. Ideally, it promotes a cultural change of ownership of product quality to the

[1] Fleet Readiness Command Southwest Instruction. "FRCSWINST 4855.43 CH-1." 02 July 2009. San Diego, CA.

artisans, creating more quality at the source, and it allows Industrial Quality and AIRSpeed Department QASs to become process specialist independent of product type, allowing more focus on Airspeed, CPI, and prevention.[2]

This project examines the ConCert Program, which FRCSW relies on to provide the quality verification within the E-2/C-2 production lines. Data from FRCSW E-2/C-2 production lines was analyzed. The researchers looked at data including the number of DWOs created, number of MAFs created, number of FCFs, and number of AIDRs received from customers. The researchers interviewed managers in the Industrial Quality and AIRSpeed Department, the E-2/C-2 Production Line Manager, and AIs on the production line. The critical areas to examine were the number of defects discovered in the hangar, the number of defects that did not get discovered until the aircraft arrived on the test line, and the number of defects that made it to the customer. These areas help to determine if defects are being caught by AIs on the production lines and if the quality of the aircraft leaving the hangar has been improved since the implementation of the ConCert Program.

## C. RESEARCH QUESTIONS

### 1. Primary Question

- Is the Concurrent Certification program effectively meeting the quality verification requirements in the C-2/E-2 production line at FRCSW?

### 2. Secondary Questions

- Does Concurrent Certification improve quality at the source?
- If Concurrent Certification is effective, is it good enough to be exported to other FRCSW product lines?

[2] Fleet Readiness Command Southwest Instruction 4855.43.

# II. FLEET READINESS CENTER SOUTHWEST

## A. THE TRADITIONAL THREE LEVELS OF MAINTENANCE[3]

The organizational, intermediate, and depot levels of aviation maintenance are distinctive in organization, mission, and concept. Listed below is a brief synopsis of each level's responsibility to the Naval Aviation Maintenance Program (NAMP).

### 1. Organizational

Organizational level (O-level) is performed by an operating unit on a day-to-day basis in support of its own operations. The O-level's maintenance mission is to maintain assigned aircraft and aeronautical equipment in a Full Mission Capable (FMC) status while continually improving the local maintenance processes. While O-level maintenance may be done by intermediate (I-level) or depot level (D-level) activities, O-level maintenance is usually accomplished by maintenance personnel assigned to aircraft reporting custodians.[4] Aircraft-reporting custodians are responsible for the administrative reporting and maintenance of weapons systems in their custody. Squadrons, such as, VFA-34, VF-101, HM-14, HSC-26 are examples of O-level activities (or units). These O-level activities are assigned aircraft, equipment, and personnel that provide direct support to the warfighter. These maintenance functions generally are grouped under the categories of inspections, servicing, handling, on-equipment repairs, preventive maintenance, and upkeep.[5]

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[3] Section A with minor modification is drawn directly from, F. R. Clemmons and, H. M. Falconieri, "Analysis of Fleet Readiness Center Southwest Concept Integration: New-Employee Orientation and Communications Process" (MBA Project, Naval Postgraduate School, 2007), 3–4.

[4] Naval Air Systems Command, "COMNAVAIRFOR INSTRUCTION 4790.2A," Naval Aviation Maintenance Program (NAMP), vol. 1, Naval Air Systems Command, (February 15, 2009), http://www.navair.navy.mil/logistics/4790/library/basic2A-1.pdf (accessed June 10, 2009).

[5] Ibid.

### 2. Intermediate

The I-level's mission is to enhance and sustain the combat readiness and mission capability of supported activities by providing quality and timely material support at the nearest location with the lowest practical resource expenditure.[6] I-level maintenance consists of on-and off-equipment material support. On-equipment maintenance is conducted on the aircraft/end-item. On-equipment maintenance includes the repair of installed engines, calibration of systems, or repair of support equipment. Off-equipment maintenance is conducted when the component/item is removed from the aircraft/end-item and repaired at the facility. Off-equipment maintenance includes: the processing of aircraft components; incorporation of technical directives; provision of technical assistance; the manufacture of selected components, liquids, or gases; and performance of certain on-equipment repairs.[7]

### 3. Depot

The D-level's maintenance is performed at or by the Naval Aviation industrial establishment to ensure continued flying integrity of airframes and flight systems during subsequent operational service periods. D-level maintenance is also performed on material requiring major overhaul of parts, assemblies, sub-assemblies, and end-items beyond the capability of I-level. D-level maintenance includes manufacturing parts, modifying, testing, inspecting, sampling, and reclamation.[8] D-level maintenance supports O-level and I-level maintenance by providing engineering assistance and performing maintenance beyond O-level and I-level capabilities.

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[6] Naval Air Systems Command 4790.2A.

[7] Ibid.

[8] Ibid.

## B. UNITED STATES CODE TITLE 10[9]

Title 10 of the U.S. Code provides the legislative foundation for depot-level maintenance and the use of working capital funds for industrial type activities. The section of Subtitle A, Part IV from Chapter 148 sets the requirement for depot-level maintenance activities within DoD. Sections, 2460-2464, 2466-2467, 2469-2472 and 2474-2475, from Chapter 146, provide the majority of legislation for depot-level maintenance activities.

The sections from Chapter 146 are as follows:

- Define depot-level maintenance.
- Establish the scope of work.
- Establish the studies and reports requirements.
- Encourage public-private competition.
- Establish the requirements for converting to and from a contracting workforce.
- Establish the requirement to maintain core logistics capabilities.
- Limit the amount of depot maintenance that can be contracted to private industry.
- Set the standard for managing DoD civilian employees.
- Allow depot-level maintenance activities to compete for other Federal Agency work.
- Authorize the Secretary of Defense (SECDEF) to designate Centers of Industrial and Technical Excellence.

Section 2563, Chapter 152 allows depot maintenance activities to perform work for private industry. Section 2687, Chapter 159 discusses base closures and realignments and section 2208, Chapter 131 discusses working capital funds.

Title 10 provides legal justification, restrictions, opportunities, and requirements of the military depot-level maintenance industry. By providing the Armed Forces with a critical capacity to respond to the needs of the Armed Forces for depot-level maintenance

[9] Sections B and C with minor modifications is drawn directly from T. Curran and J. J. Schimpff, “An Analysis of Factors Generating the Variance between the Budgeted and Actual Operating Results of the Naval Aviation Depot at North Island, California” (MBA Project, Naval Postgraduate School, 2008), 5-9.

and repair of weapons systems and equipment, the depot-level maintenance and repair activities of the DoD play an essential role in maintaining the readiness of the Armed Forces.[10]

## C. NADEP NORTH ISLAND

The depot-level maintenance functions of FRC Southwest (FRCSW) are nearly as old as Naval Aviation itself. In 1919, nine years after the start of Naval Aviation, the FRC began work as an Assembly and Repair Department of the Naval Air Station at North Island. In 1969, the Assembly and Repair Department was renamed the Naval Air Rework Facility (NARF). By 1987, the NARF was renamed the Naval Aviation Depot (NADEP) North Island.[11] As a result of BRAC 2005, NADEP North Island was disestablished and realigned into FRCSW.[12]

Recognized as an innovator in depot-level maintenance by the Office of Naval Research's Best Manufacturing Practices program, FRCSW is the Navy's primary West Coast aircraft repair and modification facility for mission essential fighter and rotary wing aircraft for Navy and Marine Corps squadrons.[13] The mission of FRCSW is to provide top quality products and services at the best value in the fastest time.

FRCSW performs repair and modification work on F/A-18 Hornets and Super Hornets, EA-6B Prowlers, S-3 Vikings, E-2 Hawkeyes, C-2 Greyhounds, AV-8B 9 Harriers, SH-60 Seahawks and HH/MH-60s, AH-1 Cobras, UH/HH-1 Hueys, and CH-53 Sea Stallions. Additionally, FRCSW deploys Field Service Teams and Voyager Repair Teams to deployed aviation squadrons, ships, and installations worldwide. The Field Service and Voyager Repair Teams provide depot-level maintenance repair and

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[10] Title 10 United States Code (2007), http://frwebgate.access.gpo.gov/cgi-bin/usc.cgi?ACTION=BROWSE&title=10usc (accessed June 10, 2009).

[11] Best Manufacturing Practices, "Naval Aviation (NAVAIR) Depot, North Island – San Diego, CA: Best Practices," http://www/bmpcoe.org/bestpractices/internal/nadep/index.html (accessed June 10, 2009).

[12] Joe Moore, "BRAC 2005; The New Integrated I&D Level Maintenance," http://www.av8.org/brac-05 (accessed June 10, 2009).

[13] Ibid.

modification for aircraft, aviation structures, aircraft components, aircraft carrier catapult and arresting gear systems, and aviation equipment and facilities on other ships.[14]

### 1. FRCSW Programs[15]

FRCSW receives aircraft, engines, and a multitude of components from activities within the U.S., as well as forward deployed units, for maintenance, modification, and repair needed from normal operations or battle related damage. Requests to manufacture new replacement items for components that can no longer be repaired, refurbished, or are not commercially available are also received from fleet units as well as other Department of Defense (DoD) components. These demands are satisfied by the services provided through one or more of the following seven FRCSW programs.[16]

#### *a. Components Program*

The components program at FRCSW has the capabilities to repair and refurbish over 19,000 different types of Navy/Marine Corps aircraft components, supply systems, and DoD assets. The Components Department existed as a program within the depot prior to the merger. As a result of the FRC implementation, the AIMD repair capabilities and the Depot artisan (worker) skills are integrated into a single organization. The new organization has personnel, equipment, and facilities specialized in the repair and refurbishment of avionics, aircraft supports and surfaces, instruments and generators, landing gear, and hydraulics components for units ashore and afloat.

#### *b. E-2/C-2 Program*

The E-2/C-2 Program is comprised of five groups that include 1) Planned Maintenance Interval (PMI) One and Two for repair and refurbishing (PMI-1/2), 2) PMI-

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[14] Fleet Readiness Center Southwest, Homepage.

[15] Section 1 with minor modifications is drawn directly from J. F. Montes, “Organizational Design Analysis of Fleet Readiness Center Southwest Components Department” (MBA Project, Naval Postgraduate School, 2007), 7-10.

[16] Fleet Readiness Center Southwest, “Homepage.”

3/Service Life Extension Program (SLEP)/Rewire (C-2), 3) In-Service Repair (ISR), 4) Foreign Military Sales (FMS), and 5) E-2 Super Modules.

***c. F/A-18 Program***

The F/A-18 Program supports PMI-1/-2 Special Rework/Crash Damage Repair (SR/CD) and Center Barrel Replacement Plus (CBR+).

***d. Manufacturing Program***

The Manufacturing Program has machining, sheet metal fabrication, tube/hose/duct repair, foundry, welding, and heat treatment capabilities that support the aircraft and helicopter rework programs as well as the overhaul of the LM2500 marine gas turbine engine used on surface naval ships. This department also manufactures and repairs over 150 different configurations of mobile VANS (large steel containers with special equipment that support deployed Marine Corps Units).

***e. Engineering and Logistics Program***

The Engineering and Logistics Program is part of the In-Service Support Center (ISSC) and consists of a full Materials Laboratory and the Navy Primary Standards Laboratory (NPSL). This program is responsible for developing the safest, most reliable and cost-effective engineering solutions needed to meet or exceed the repair, refurbishment and modifications requirement for products.

***f. Multi-Line Program***

The Multi-Line Program supports PMI-1/-2 for UH-1/HH-1 Huey, CH-53 Super Stallion, AH-1W Super Cobra, and SH-60/MH-60/HH-60 Seahawk helicopters for the Navy and Marine Corps.

### *g. Field Service/Voyager Repair Program*

The field Service/Voyager Repair Program is comprised of Voyager Repair teams, Field Service teams, paint/finish, and surface/structural repair support for AV-8B Harrier aircraft in Yuma, Arizona.

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# III. NAVAL AVIATION QUALITY ASSURANCE AND QUALITY PROGRAMS

## A. CONCEPTS OF QUALITY ASSURANCE

The information in this chapter is taken from chapter seven of COMNAVAIRFOR INSTRUCTION 4790.2A (NAMP), which provides direction for quality assurance for Naval Aviation. This chapter is meant to provide an overall understanding of Quality Assurance (QA) and Quality Programs within Naval Aviation. The QA concept is fundamentally the prevention of the occurrence of defects. The concept embraces all events from the start of the maintenance operation to its completion and is the responsibility of all maintenance personnel. The achievement of QA depends on prevention, knowledge, and special skills.[17] The principle of prevention is that it is necessary to preclude maintenance failure. This principle extends to safety of personnel, maintenance of equipment, and virtually every aspect of the total maintenance effort. Knowledge is derived from factual information. Data collection and analysis are ways to acquire such knowledge. Special skills are required of a staff of trained personnel for the analysis of data and supervision of QA.[18]

The NAMP includes the terms inspection, QA, and audit as an integral part of the QA process. Each term has a separate and distinct meaning. Inspection is the examination/testing of supplies (including raw materials, documents, data, components, and assemblies) and services to determine if they conform to technical requirements. QA is a planned and systematic pattern of actions necessary to provide adequate confidence the product will perform satisfactorily in service and the monitoring and analyzing of data to verify the validity of these actions. Audit, as it applies to QA, is a periodic or special evaluation of details, plans, policies, procedures, products, directives, and/or records.[19]

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[17] Naval Air Systems Command 4790.2A.

[18] Ibid.

[19] Ibid.

QA provides a systematic and efficient method for gathering, analyzing, and maintaining information on the quality characteristics of products, the source and nature of defects, and their immediate impact on the current operation. It permits decisions to be based on facts rather than intuition or memory and provides comparative data, which is useful long after the details of the particular time or events have passed.[20] The objective of QA is to readily pinpoint problem areas in which management can:[21]

- Improve the quality, uniformity, and reliability of the total maintenance effort.
- Improve the work environment, tools, and equipment used in the maintenance effort.
- Eliminate unnecessary man-hour and dollar expenditures.
- Improve training, work habits, and procedures of maintenance personnel.
- Increase the excellence and value of reports and correspondence originated by maintenance personnel.
- Effectively disseminate technical information.
- Establish realistic material and equipment requirements in support of the maintenance effort.

## B. RESPONSIBILITY FOR QUALITY IN MAINTENANCE

The NAMP states Commanding Officers (CO) are responsible for the inspection and quality of material under their cognizance. Generating high standards of quality in a maintenance organization demands a sincere interest on the part of the CO, which must be evident to everyone in the command.[22]

Attaining quality in maintenance and the prevention of maintenance errors is an all hands task that can only be accomplished through positive leadership, proper

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[20] Naval Air Systems Command 4790.2A.

[21] Ibid.

[22] Ibid.

organization, and a complete understanding of responsibilities by each individual in the department. QA requirements, functions, and responsibilities provide a sound basis for attaining quality in maintenance.[23]

QA is a staff function that requires both authority and assumption of responsibility. Direct liaison between QA and production divisions is a necessity and must be energetically exercised. Although the QA Officer is responsible for the overall quality of maintenance within the department, division officers and work center supervisors are duly responsible for ensuring required inspections are conducted and high quality workmanship is attained.[24]

## C. QUALITY ASSURANCE PROGRAM RESPONSIBILITIES

### 1. Quality Assurance

The QA Officer ensures personnel assigned to perform QA functions receive continuous training in inspecting, testing, and quality control methods specifically applicable to their area of assignment.[25] Specific QA responsibilities are:

- Establish qualification requirements for Quality Assurance Representatives (QAR), Collateral Duty Quality Assurance Representatives (CDQAR), and Collateral Duty Inspectors (CDI) (discussed later in this section). FRC QA officers ensure that the upkeep of training, task and special process certification, and licensing requirements of artisans are maintained and accurate.
- Periodically (at a minimum annually), accompany CDIs during scheduled maintenance and unscheduled maintenance tasks to recheck their qualifications.
- Ensure all work guides, check-off lists, check sheets, and MRCs used to define and control maintenance are complete and current.
- Perform inspections of all maintenance equipment and facilities to ensure compliance with fire and safety regulations.
- Provide a continuous training program in techniques and procedures pertaining to the conduct of inspections.

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[23] Naval Air Systems Command 4790.2A.

[24] Ibid.

[25] Ibid.

- Establish and maintain liaison with other maintenance and rework activities to obtain information on ways for improving maintenance techniques, quality of workmanship, and QA procedures.
- Ensure check pilots and aircrews are briefed before post maintenance Functional Check Flights (FCF) so the purpose and objectives of the flight are clearly understood. After completion of the FCF, gather information to determine compliance with objectives outlined on the FCF checklist and clarify discrepancies noted.
- Ensure only personnel designated as QARs, CDQARs, and CDIs are authorized to sign as inspector for a QA inspection requirement. All specified QA inspections shall be conducted, witnessed, or verified by designated QA personnel.[26]

### 2. Quality Assurance Representatives

Quality Assurance Representatives (QARs) are assigned to the Quality Assurance Division and report to the QA Officer. Specific QAR responsibilities are:

- Assist in the certification of production personnel.
- Review the qualifications of personnel nominated to become CDIs and provide appropriate recommendations.
- Provide technical assistance to CDIs and production personnel who are required to make QA decisions. Periodically accompany CDIs on inspections to evaluate their performance.
- Conduct final inspections upon completion of tasks requiring certification by QARs.
- Coordinate with the analyst to develop discrepancy trends and applicable charts and graphs necessary to depict quality performance.[27]

### 3. Collateral Duty Quality Assurance Representatives

Collateral Duty Quality Assurance Representatives (CDQARs) function in the same capacity as QARs and must meet the same qualifications but are assigned to production work centers. CDQARs are not permitted to inspect their own work and sign as the inspector.

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[26] Naval Air Systems Command 4790.2A.

[27] Ibid.

### 4. Collateral Duty Inspectors

Collateral Duty Inspectors (CDI) assigned to production departments inspect all work and comply with the required QA inspections during all maintenance actions performed by their respective work centers. They are responsible to the QA Officer when performing such functions. CDIs spot check all work in progress and are familiar with the provisions and responsibilities of the various programs managed and audited by QA.[28]

## D. QUALITY PROGRAMS

Commander Naval Air Forces System Command (COMNAVAIRSYSCOM) and Commander Fleet Readiness Center (COMFRC) embrace the intent and spirit of command-wide responsibility for product quality and reliability.[29] COMFRC is ultimately responsible for the quality of products produced and services provided under their command. FRC Cos are required to identify a quality focal point to coordinate the Depot Level Quality Program (DLQP) and advise the COMFRC on all related matters. FRC Cos ensure all personnel performing QA functions have sufficient training and expertise, well-defined responsibility, authority, and organizational freedom to identify and evaluate quality problems and to initiate, recommend, or provide solutions.[30] All personnel are required to be familiar with Quality Certification and Quality Verification requirements and responsibilities within the DLQP.[31]

### 1. Quality Certification

According to the NAMP, quality certification is documented affirmation that all product characteristics affecting quality conform to applicable specifications and requirements. Qualified personnel are responsible for certifying the noted characteristics.

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[28] Naval Air Systems Command 4790.2A.

[29] Ibid.

[30] Ibid.

[31] Ibid.

This requirement results from the fundamental concept that skilled, qualified, and dedicated personnel shall be responsible for building quality and reliability into their own work.[32]

Personnel qualified to certify will certify only products, processes, systems, and areas for which they are specifically trained and qualified. The FRC Depot Level Quality Program (DLQP) ensures the adequacy of criteria for qualification using task or skill based qualification processes.[33] According to the NAMP, the artisan qualification process is administered as follows:

- Maintenance of aeronautical equipment shall be performed per technical manuals, engineering directives, and other COMNAVAIRSYSCOM approved technical references.
- Maintenance may be assigned on a variety of aeronautical equipment within the artisan's trade specialty based on their skill set developed from documented technical training, education, and experience.
- Technical skills have many general repair applications and can be competently exercised on multiple types of aeronautical equipment.
- Supervisors are required to use Operational Risk Management (ORM) principles to establish artisan training requirements for specific aeronautical equipment and maintenance processes that are determined to be highly complex, infrequently practiced, have no functional test available, single point failure, or required by higher authority or local policy.
- Supervisors are required to assess and continually monitor each artisan's ability and maintenance performance in order to exercise discretion in prescribing and documenting training in advance of low risk and common maintenance.[34]

Personnel granted certification authority must certify the work accomplished by others if they have accepted the responsibility. Certification by an artisan is that individual's personal guarantee that all work has been accomplished per specifications.[35]

[32] Naval Air Systems Command 4790.2A.

[33] Ibid.

[34] Ibid.

[35] Ibid.

Personnel accepting responsibility for certifying their own work and the work accomplished by others must be:

- Qualified in the same type of work operations as those they are certifying and for which they are accepting responsibility.
- Certifying the same type of work operation for another individual who is actually assisting the certifier in the work operation. If a work operation requires multiple trade skills, the work operation will be segregated in such a manner as to allow an electrician to certify for electrical and a hydraulic mechanic to certify for hydraulic.[36]

Personnel granted certification authority must certify that each product and quality characteristic identified on work documents has been satisfactorily completed and conforms to prescribed requirements.[37]

### 2. Quality Verification

According to the NAMP, quality verification is a method of objective evaluation employed to determine and measure the effectiveness of the Certification Program. The term verification refers to the determination of product conformance by actual examination, measurement, witnessing of tests, or review of documented objective evidence describing product or quality characteristics and comparison to prescribed quality requirements. Verification is accomplished by personnel who are trained and qualified to perform the QA function.[38]

All items produced by the FRCs may be subjected to quality verification. Verification may be applied to the artisan's completion, inspection, and certification of an assigned task and a thorough review of processing work documentation to ensure compliance with all specifications and control of the process. The verification method employed will depend on the point reached in the processing cycle, the type of product, the criticality of the characteristics or products being verified, quality history, and quality

[36] Naval Air Systems Command 4790.2A.

[37] Ibid.

[38] Ibid.

control techniques in use.[39] The verification methods used by personnel trained to perform the QA function shall consist of one or more of the following categories:

- Actual verification of the product and associated certified work documents. This method is mandatory for all safety of flight/flight critical/critical safety item characteristics and all tasks which require the aircraft to have a Functional Check Flight (FCF).
- Witness redundant or concurrent certification by a second qualified certifier.
- Verify certified work documents attesting to quality conformance and accepting certification that the characteristics or products conform to quality requirements.
- Use product or process surveillance based on an effective audit program and objective statistical history.[40]

According to the NAMP, products produced and processes used will be subject to verification consistent with the following guidelines:[41]

- **Type I (Mandatory).** This category is assigned to characteristics which would be classified as critical if found defective. Verification of this category is mandatory and shall be accomplished by evaluating the product and work documentation. Sampling of mandatory characteristics is not permissible.
- **Type II (Temporary Mandatory).** This category of verification temporarily imposes mandatory verification requirements and may be conducted on high failure rate items, items without objective evidence of good quality, or instances where the quality level is suspect or inadequate.

39 Naval Air Systems Command 4790.2A.

40 Ibid.

41 Ibid.

- **Type III.** Sampling and surveillance verifications are modes of verification that may be used independently or in combination to accomplish the verification function when Type I or Type II is not required.
    - Sampling verification is essentially a tool which permits reduced verification emphasis. It is important that the end use of the product, its relative complexity, and factors such as subsequent verification of the product as a system be considered.
    - Surveillance verification allows the use of reduced verification through the application of an effective audit program. Applicable products and processes are those that display objective quality evidence or a state of statistical quality control.[42]

[42] Naval Air Systems Command 4790.2A.

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# IV. QUALITY VERIFICATION AT FRCSW

## A. INTRODUCTION

The NAMP establishes the policy for the DLQP and defines responsibilities throughout all entities of FRCSW. As such, FRCSW's Commanding Officer is ultimately responsible for the overall quality of all products produced by FRCSW. The Industrial Quality and AIRSpeed Department is responsible for establishing DLQP procedures to ensure the products produced meet specific quality levels. Assurances are based on quality evidence derived through activities such as Quality Verification (QV) actions, audits, surveillance, and other process control techniques. QA personnel perform product verification following certification by Industrial Production Department personnel.[43] The previous chapter discussed the roles and responsibilities of personnel in the Navy QA program (QARs, CDQARs, and CDIs). Detailed responsibilities and procedures for performing verification by FRCSW personnel are outlined in this chapter. Figure 1 depicts the FRCSW equivalent functions to Navy QA program.

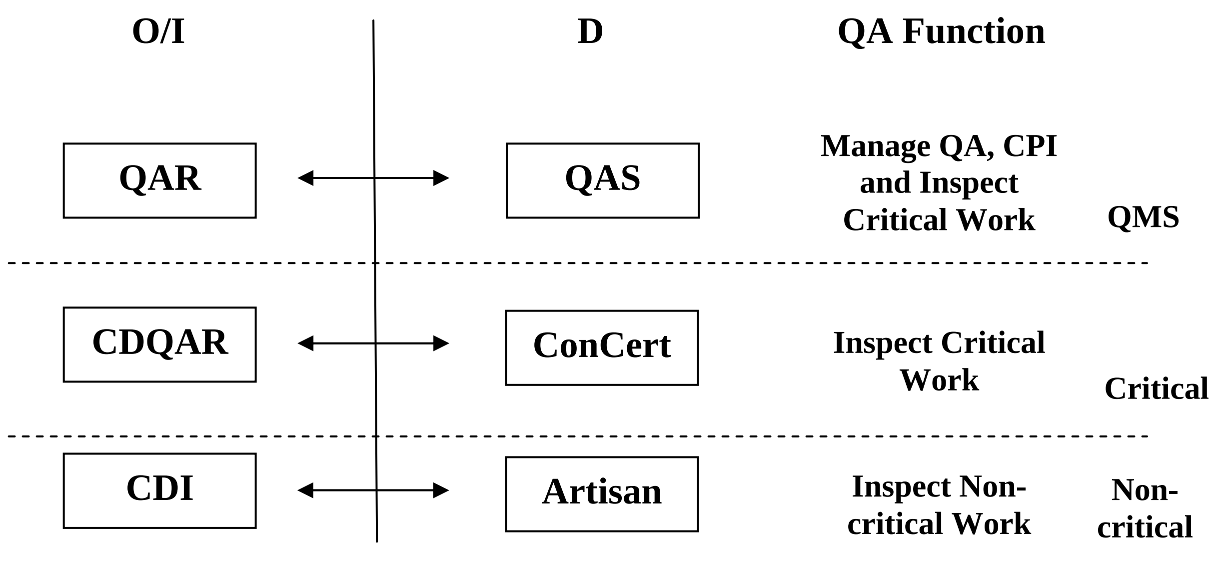


Figure 1. QA Function Comparison.

[43] Fleet Readiness Command Southwest Instruction 4855.43.

## B. RESPONSIBILITIES

### 1. FRCSW Certifiers

As discussed in the previous chapter, personnel granted certification authority must certify their own work and the work accomplished by others if they have accepted the responsibility. Certification by an artisan is that individual's personal guarantee that all work has been accomplished per specifications. According to Fleet Readiness Center Southwest Instruction 4855.43, all FRCSW certifiers shall.[44]

- Not accept or process products if accompanying processing documentation is missing the appropriate certification or verification stamp imprints for previous work tasks.
- Certify and date work documentation for each item produced or operation processed prior to presenting for Quality Verification.
- Notify QA/ConCert personnel when the processing cycle of an item has progressed to a point requiring verification.
- Sign up the product or item needing verification on a Quality Verification Request form (Call Sheet).
- Provide all applicable work documents and technical specifications upon request.
- Perform testing or measurement needed for accurate verification, when requested.
- Ensure all voiding actions have been recertified after correction of defects.

### 2. Industrial Quality and AIRSpeed Department Quality Assurance Personnel

Quality Assurance Supervisors (QAS) ensure verification is applied to the artisan's completion, inspection, and certification of an assigned task. They must review the processing of work documentation to ensure compliance with all specifications and control of the process. Specific QA tasks are**:**[45]

[44] Fleet Readiness Command Southwest Instruction 4855.43.

[45] Ibid.

- Provide Call Sheets for FRCSW personnel to sign up for verification of a product, item, or process. Completed Call Sheets must be retained by QA personnel as documentation of product processing and verification.
- Perform verification actions for items or operations presented for verification. Types of verification actions include:
  - <u>In-process verification</u> – verification on products as they are moving through the production cycle as a defect prevention action and for the purpose of verifying selected quality characteristics that cannot be observed after further processing.
  - <u>Reprocess verification</u> – verification actions during correction of work previously performed and subsequently found defective.
  - <u>Final acceptance verification</u> – verification actions on products that have been certified as completing processing, are ready for use by the Next Higher Assembly (NHA), or are ready to be delivered to our customer.
  - <u>Mandatory (Type I) verification</u> – discussed in previous chapter.
  - <u>Temporary Mandatory (Type II) verification</u> – discussed in previous chapter.
  - <u>Sampling and Surveillance (Type III) verification</u> – discussed in previous chapter.
- Establish methods of verification by determining quality levels of products, processes and operations, data collection and analysis, auditing, and other techniques.
- Document evidence of these actions by one of the following methods:
  - A Verification Acceptance Wing stamp indicates the product/item/process has been verified per Type I or Type II methods. The Wing stamp indicates the QAS has verified that the item meets applicable specifications. Certifiers and QASs are mutually responsible for tasks that have been certified and verified.
  - A Certification Acceptance (CA) stamp indicates a physical examination of the item or process was not performed, but work was accomplishment and artisan responsibility is reflected on properly certified work documents. The QAS is accountable only for the completeness of the paperwork.
  - Concurrent Certification (ConCert) indicates the aircraft/component inspector has verified that the item meets applicable specifications. Certifiers and Concurrent Certifiers are mutually responsible for tasks that have been certified and verified. This is discussed in detail in the next chapter.

- Verify aircraft have completed all required processing and inspections prior to check flights or delivery to the aircraft ferry pilot.
- Review all aircraft discrepancies written by the check flight pilot on Visual Information Display System/Maintenance Action Form (VIDS/MAF), OPNAV Form 4790/60(5C), following each check-flight and record each on the Inspection Discrepancy Sheet.
- Review work documentation for determination and insertion of needed verification points.

# V. CONCURRENT CERTIFICATION

## A. INTRODUCTION

Modern Naval aircraft and aircraft components are inherently complex. This complexity requires individuals working on these products to have sufficient technical knowledge of aircraft systems to understand related interfaces and interdependencies. In 2007, FRCSW adopted a private sector business practice in 2007 that capitalized on the pedigree of its people. This program was called Concurrent Certification (ConCert) and was designed to provide better product quality with cost savings and schedule reduction by ensuring quality at the source. The ConCert Program provides product verification by production personnel, allowing specially trained artisans designated as Aircraft/Component Inspectors (AIs/CIs) to perform "second set of eyes" verifications in lieu of Quality Assurance Specialists (QAS).[46] An AI/CI is expected to inspect the work of other artisans and document any variation from technical and quality requirements. The AI/CI performs the quality verifications in conjunction with normal artisan duties.[47]

ConCert is a change in the QA method of providing verification. ConCert shifts roles by having production assume total ownership of product verification and allowing QA to focus on Continuous Process Improvement (CPI) and ConCert program oversight. ConCert artisans are highly qualified and authorized to verify critical quality characteristics of work performed by other qualified artisans. Through ConCert, artisans should become more aware of process improvements, cognizant of customer requirements, task requirements, and enhance performance through positive peer pressure. Ideally, it promotes a cultural change of ownership of product quality by artisans, creating more quality at the source and it allows the Industrial Quality and

[46] Fleet Readiness Command Southwest Instruction 4855.43.

[47] Ibid.

AIRSpeed Department QASs to become process specialist independent of product type, allowing more focus on Airspeed, CPI, and prevention.[48]

## B. AIRSPEED

A key objective of the ConCert program is that it allows the Industrial Quality and AIRSpeed Department personnel to focus more effort and time on CPI initiatives along all product lines by enabling production personnel to perform the verification function. AIRSpeed is the CPI program for the Naval Aviation Enterprise (NAE). AIRSpeed provides the planning, training, integration, sustainment, and monitoring of business practices across the NAE. The program emphasizes CPI and integrates best business practices, which include the Theory of Constraints (TOC), Lean, and Six Sigma.[49] Details on the AIRSpeed program are available in Appendix A.

## C. CONCERT PROGRAM ELEMENTS

FRCSW AI/CIs carry a high degree of responsibility. Consequently, care is exercised in the selection of candidates for the ConCert Program to ensure they possess the mechanical aptitude, personal integrity, and motivation to accept this increased responsibility. The individual must possess the technical competence and sense of responsibility to ensure the aircraft or aircraft component he/she is inspecting is of the highest quality possible before release. A comprehensive formal and On-the-Job Training (OJT) program is necessary to ensure that only the most qualified individuals are designated as AIs/CIs.[50]

### 1. Training

The ConCert Program was established to ensure that AIs/CIs are fully trained and that they are provided every opportunity to succeed. All artisans selected as AIs/CIs are

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[48] Fleet Readiness Command Southwest Instruction 4855.43.

[49] "Naval Aviation Enterprise." Enterprise AIRSpeed. Http://www.cnaf.navy.mil/airspeed/main.asp?ItemID=363 (accessed June 10, 2009).

[50] Fleet Readiness Command Southwest Instruction 4855.43.

trained according to requirements outlined in this section. After successful completion of the training program, the AI/CI trainees continue to work under the guidance of an AI/CI OJT instructor to enhance their skills. When the AI/CI trainee has gained enough practical experience on the Type/Model/Series (T/M/S) aircraft or aircraft component, he/she demonstrates their knowledge to the Industrial Quality and AIRSpeed Department. After proper demonstration to QA, the AI/CI and QA certify the AI's/CI's AI/CI Training Sheet, FRCSW 12410/83.[51]

Artisans selected as AIs/CIs are required to complete two days of formal classroom training including dilemma/conflict resolution and eight weeks of OJT instruction with Quality Assurance Workbench (QAWB) training.[52] Other recommended training includes:

- Blueprint/schematic interpretation.
- Precision measuring tools.
- Computer basics (data entry).
- FRCSW intranet navigation.
- Basic root cause analysis.[53]

AI/CI qualification is retained provided that a good quality history is maintained, the shop supervisor re-qualifies his/her Job Tasks, and certification training is current, including special process and other applicable training.[54]

### 2. ConCert Program Risk

The ConCert Program has inherent risks that include (but are not limited to) the compromise of quality standards through peer pressure and supervisor pressure. To mitigate these risks, the Industrial Quality and AIRSpeed Department is charged with

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51 Fleet Readiness Command Southwest Instruction 4855.43.

52 Ibid.

53 Ibid.

54 Ibid.

program oversight.[55] According to FRCSWINST 4855.43, specific responsibilities of the Industrial Quality and AIRSpeed Department include:[56]

- Conducting Computerized Self Evaluation Checklist (CSEC) ConCert audits.
- Reviewing QAWB and Discrepancy Work Order (DWO) for defect data.
- Monitoring Individual Qualification Records (IQR) for proper/current qualification/certification.
- Reviewing product/work documents.
- Providing advice/direction on quality issues.
- Producing ConCert metrics on defect data for analysis in process improvement.

Other ConCert Program elements intended to mitigate risks and provide program oversight include a Local ConCert Council (LCC) and an Executive ConCert Council (ECC).

### 3. Local ConCert Council[57]

The LCC is comprised of at least one representative from the Industrial Quality and AIRSpeed Department, one AI/CI from each trade, and any other representatives as deemed necessary by the LCC Chairperson, the Council, or individual Council members. According to FRCSWINST 4855.43, LCC members should:

- Meet monthly to resolve problems with the ConCert Program. The Council Chairperson should schedule a meeting with all AIs/CIs and the Council at least once per quarter.
- Throughout the training period, interact with the trainees to gauge their progress.
- Interview AI/CI trainees and decide if more training is required. If the LCC decides no more training is necessary, their recommendation should be forwarded up the chain-of-command for Commanding Officer designation or disapproval.
- Review and approve standard training related to the ConCert Program.

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[55] Fleet Readiness Command Southwest Instruction 4855.43.

[56] Ibid.

[57] Ibid.

### 4. Executive ConCert Council[58]

The ECC is comprised of the Commanding Officer/Executive Officer, Production Officer, Quality Officer, one AI/CI from each program, and other representatives as deemed necessary by the council. According to FRCSWINST 4855.43, ECC members should:

- Meet monthly.
- Establish policy and procedures and provide direction for the ConCert Program.
- Review the progress of ConCert activities and issues affecting processes. Identify and address enhancements or inconsistencies.
- Interview all new AI/CI trainees before the AI/CI designation is signed by the Commanding Officer.
- Review and concur/not concur with revocation of certification authority actions.

### 5. Violation/Revocation of Certification Authority

According to FRCSWINST 4855.43, the primary concern of the FRCSW aviation facility is safety. If for any reason any member of the ECC considers that an AI/CI may not be able to fulfill his/her duties, the member should convene the ECC and review the situation. Safety of personnel and equipment will override personal considerations. When the ECC determines that it is unsafe to continue an artisan in the role of AI/CI, the Council will recommend that the Commanding Officer revoke the AI/CI designation. Where the Council determines that the inability to perform the duties is short-term, (thirty days or less), the AI/CI will be assigned to another AI/CI as a trainee. At the end of the determined time, the Council will meet and decide if reinstatement is appropriate. If reinstatement is not deemed appropriate, other actions may be necessary.[59]

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[58] Fleet Readiness Command Southwest Instruction 4855.43.

[59] Ibid.

## D. CONCERT PROGRAM RESPONSIBILITIES[60]

FRCSWINST 4855.43 directs the following personnel to carry out the specific responsibilities listed to ensure the highest chance of success for the ConCert Program.

### 1. The Cognizant Shop Supervisor[61]

- Establish Job Task Descriptions (JTDs) and assign task numbers for all ConCert tasks performed by AIs/CIs.
- Appoint a qualified and experienced AI/CI from each trade as the OJT instructor.
- Ensure AIs/CIs have the required computer programs and access to computers to perform required data inputs.
- Document AI's/CI's qualifications on an IQR or Electronic Individual Qualification Record (eIQR), and update as required.
- Upon qualification, request certification authority and a ConCert certification stamp from the Industrial Quality and AIRSpeed Department.
- Ensure corrective and preventive action entries for ConCert deficiencies are documented on Quality Correction Notices (QCNs) or DWOs.

### 2. The Industrial Quality and Airspeed Department[62]

- Develop and maintain for each workload program a Standard Operating Procedure (SOP) which provides the procedures and responsibilities pertaining to ConCert.
- Provide an AI/CI ConCert course consisting of two days of formal class room training and eight weeks On-the-Job Training (OJT).
- Provide QAWB training through OJT.
- Upon completion of OJT requirements, certify the AIs/CIs AI/CI Training Sheet, FRCSW 12410/83.
- Assign a QAS from the area to serve as the LCC Chairperson.
- Procure, store, and control all ConCert stamps, and process all AI/CI Certification Stamp Action Requests.

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[60] Fleet Readiness Command Southwest Instruction 4855.43.

[61] Ibid.

[62] Ibid.

- Perform monitoring, auditing, and surveillance of the ConCert Program and Certification Program (using the appropriate audit checklists) to ensure compliance. Elements discovered to be deficient during the any of these activities shall be documented on QCNs or DWOs as appropriate.
- Analyze and provide metrics of the ConCert Program performance to Program Managers (PMs) periodically or as requested.

### 3. Aircraft Inspector (AI)/Component Inspector (CI)[63]

- Not perform AI/CI inspections nor concurrent certification on their own work.
- Determine what trade the request for inspection involves.
- Perform inspections accurately and completely per applicable specifications and only on operations, task, or functions they are trained, qualified, and certified to perform.
- Log all calls/observations into QAWB and generate a DWO for any discrepancies found.
- Attend meetings as required when assigned to the LCC. Other AIs/CIs will attend as needed.
- Review their IQRs/eIQRs quarterly or when any changes occur.

## E. AIRCRAFT PROCESS FLOW

The E-2/C-2 product line processes aircraft in the accomplishment of Planned Maintenance Interval (PMI), Service Life Extension Program (SLEP), C-2 Airframe Change (AFC) 172, and the Rewire C-2 AFC 162. Figure 2 shows the process flow of aircraft through the E-2/C-2 production line. Aircraft are inducted at the test line through an aircraft acceptance inspection and then transferred to the hangar to start the production process (PMI, SLEP, AFC 172, and AFC 162). During the production process AI/CIs inspect critical work performed by other artisans and generate DWOs for all defects and discrepancies found. Once the defects and discrepancies are fixed, the aircraft are passed to the test line. At the test line, QASs are tasked to conduct a Confidence Inspection (CI) and generate Maintenance Action Forms (MAF) for all defects and discrepancies found. These defects and discrepancies are then fixed prior to any Functional Check Flights

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[63] Fleet Readiness Command Southwest Instruction 4855.43.

(FCF) (described later in this chapter). MAFs are also generated after FCFs. Once all defects and discrepancies are fixed at the test line, the aircraft are then turned over to the customer for the customer acceptance inspection. Aircraft Inspection Discrepancy Reports (AIDR) (discussed later this chapter) are generated for defects and discrepancies found by the customer.[64]

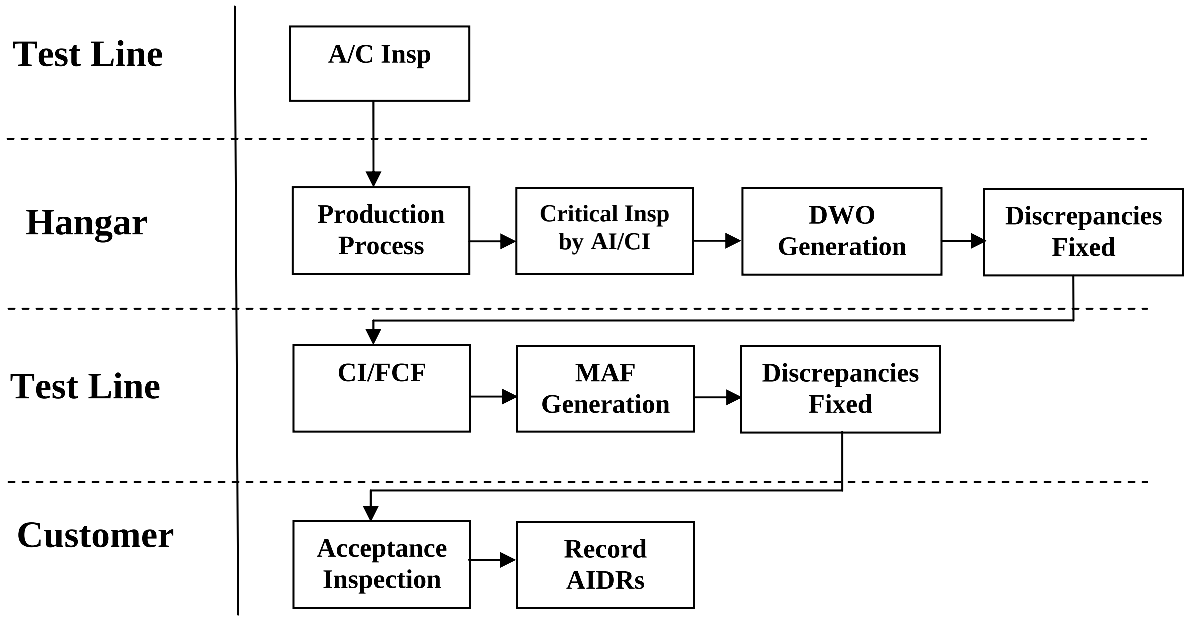


Figure 2. E-2/C-2 Product Line Process

## F. QUALITY DEFECTS AND DEFICIENCIES[65]

FRCSWINST 4855.43 directs prompt corrective and preventive action is required once defective work is detected. The Naval Aviation Maintenance Discrepancy Reporting Program (NAMDRP) establishes policy, responsibilities, and requirements for reporting substandard workmanship, improper QA procedures, and deficiencies in material. This program provides FRCSW with a method for reporting and responding to reported deficiencies and for taking corrective and preventive action when deficiencies are reported in a product, process, or system. This program applies to material or aircraft

64 Fleet Readiness Command Southwest SOP.

65 Fleet Readiness Command Southwest Instruction 4855.43.

deficiencies that may be attributed to nonconformance with contractual/specification requirements or substandard workmanship practices.[66]

Quality defects and deficiencies on reworked FRC products in the hanger are found by AI/CIs. Prior to making it to the end customer, there is another opportunity to find quality defects and deficiencies at the test line through a confidence inspection by a QAS. Where the QAS or AI/CI finds and reports the problem is what determines what the defect is classified under and which process is used.

### 1. Defects and Deficiencies Reported in the Hangar

#### *a. Discrepancy Work Order*

DWOs are used by AI/CI personnel to report quality defects found in reworked FRCSW products. A DWO is initiated and entered into QAWB whenever a certified product or process is found to be deficient with regard to specifications. The QAWB database collects and maintains all information generated from DWOs, and provides that information in a variety of formats for reporting purposes. Information provided is used to identify, detect and analyze internal trends (e.g., shops out of compliance, defective products, defective processes, substandard work). This information also helps to identify root causes of defects that can lead to continuous process improvements. The purpose of these reports is to identify quality defects for which FRCSW is responsible, and to facilitate analysis in determining what corrective and preventive actions are necessary.[67] The initiator of a DWO is responsible for ensuring the DWO is properly processed. Each DWO reports only one defect or deficiency on each DWO. Quality defects documented on a DWO are categorized as In-process or Reprocess as follows:

(1) In-process – Any certified task or operation found to be deficient in the certifying shop by AI/CI personnel during verification.

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[66] Fleet Readiness Command Southwest Instruction 4855.43.

[67] Ibid.

(2) Reprocess – A certified task or operation found to be deficient and not classified in-process.

## 2. Defects and Deficiencies Reported on the Test Line

### *a. Maintenance Action Form*

MAFs are generated on defects reported at the test line by Industrial Quality and AIRSpeed personnel and on defects reported during FCFs by aircrew.

(1) Confidence Inspection[68] – CIs are performed on any aircraft which has just completed rework. CI MAFs are generated during the confidence inspection when the aircraft arrives at the test line from the hanger after PMI rework is complete. CI MAFS can be either new-work or re-work. Re-work MAFs can be generated anytime throughout the test line process.

(2) Functional Check Flight[69] – FCFs are performed on any aircraft which has just completed rework after completion of CI. FCFs are required to determine if airframe, power plant, systems, accessories, and other items of equipment are functioning per predetermined standards while subjected to the intended operating environment.

## 3. Defects and Deficiencies Reported by the Customer

### *a. Acceptance Inspection Deficiency Reports*

AIDRs are used to report all aircraft related discrepancies found by the customer during aircraft acceptance inspections.[70] Reported deficiencies are classified as follows:

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[68] Fleet Readiness Command Southwest Instruction 4855.43.

[69] Naval Air Systems Command 4790.2A.

[70] Fleet Readiness Command Southwest Instruction 4855.43.

(1) Critical – A defect that judgment and experience indicate its detriment is likely to result in hazardous or unsafe conditions for individuals using, maintaining, or relying on the product, or may prevent functional performance of an aircraft, missile, space vehicle, or major component.

(2) Major – A defect that is likely to result in the failure or reduced material utility of a unit or product.

(3) Minor – A defect that is not likely to materially reduce the utility of a unit or product or is a departure from established standards having little bearing on the use or operation of a unit.

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# VI. DATA

## A. INTRODUCTION

This project examines the effect of the ConCert program at FRCSW on the E-2 and C-2 production lines. The methods of data collection were interviews with FRCSW employees and review of data from FRCSW databases. An analysis was performed by the researchers that examined the number of discrepancies (by aircraft sequence number) discovered in the hangar, on the test line, and after customer delivery for the E-2 and C-2 prior to the start of the ConCert program and after the start of the ConCert program. Aircraft are in order by the date that they are turned over to the customer. It is important for FRCSW to be able to recognize whether or not ConCert is having an effect on the number of discrepancies found during the production process.

## B. DATA GATHERING

FRCSW provided historical data for fiscal years 2005 to 2009. This data came from various excel spreadsheets, graphs, FRCSW Quality Assurance Work Bench, and other FRCSW databases. Data included information on DWOs, MAFs, FCFs, and AIDRs. ConCert was fully implemented in March 2007 with QASs completely turning over verifications within the hangar in August 2007. Data for the last four fiscal years provided information for two years before ConCert implementation and for two years afterwards. The researchers conducted interviews with QA personnel, AIs, and the E-2/C-2 Production Line Manager.

## C. DISCREPANCY WORK ORDERS

The DWO is used to report quality defects found in reworked FRCSW products. DWOs are only generated on discrepancies found before the aircraft leaves the hangar, and each DWO reports only one defect or deficiency on the aircraft.[71]

For both C-2s and E-2s, a regression of the data does not reveal any trends that the researchers can determine. For both aircraft, there is an increase in the number of DWOs immediately after ConCert implementation, then a decrease over the next year and a half before starting to increase again. The mean number of DWOs for both aircraft after ConCert implementation is lower than the mean number for the two years before ConCert.

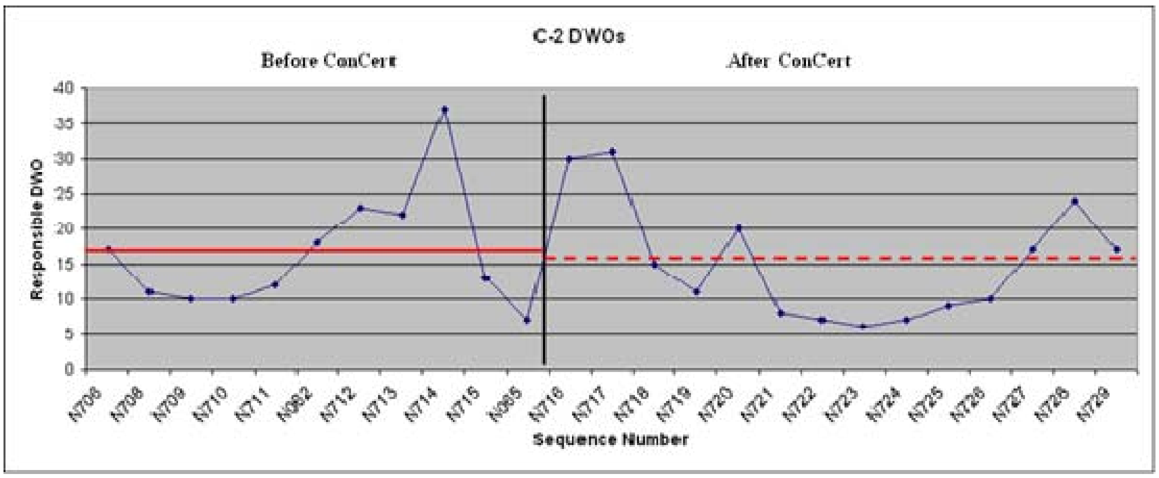


Figure 3. C-2 DWOs

Mean average before ConCert (solid line) = 16.36 DWOs

Mean average after ConCert (dashed line) = 15.14 DWOs

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[71] Fleet Readiness Command Southwest Instruction 4855.43.

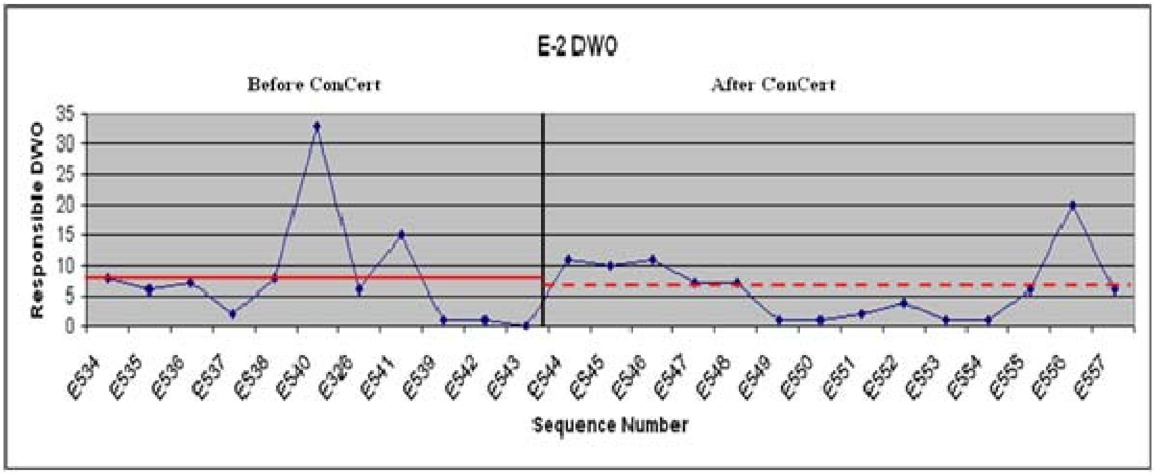


Figure 4. E-2 DWOs

Mean average before ConCert (solid line) = 7.91 DWOs

Mean average after ConCert (dashed line) = 6.29 DWOs

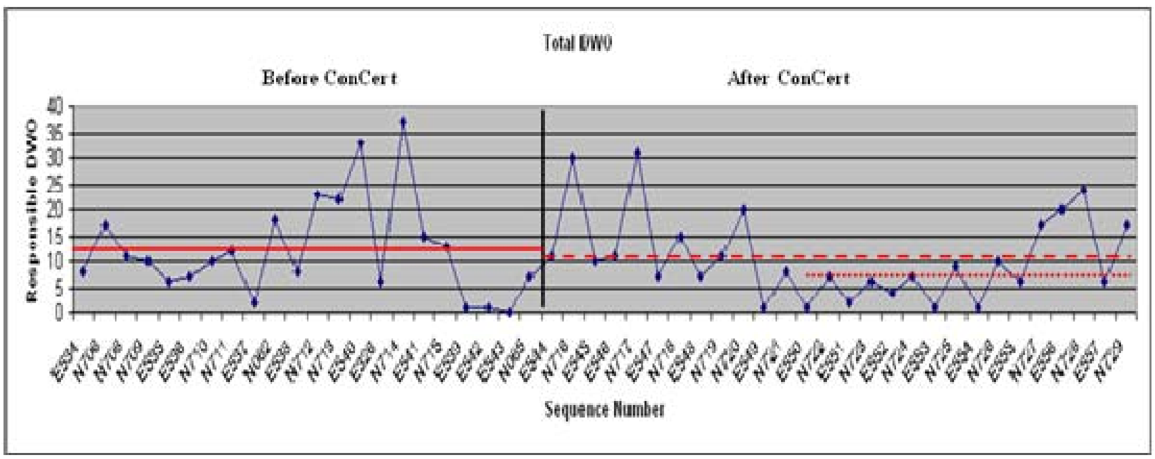


Figure 5. Total DWOs

Mean average before ConCert (solid line) = 12.14 DWOs

Mean average after ConCert (dashed line) = 10.71 DWOs

Mean average 12 months after ConCert (dotted line) = 8.63 DWOs

## D. MAINTENANCE ACTION FORMS

The MAF is used to report discrepancies after the aircraft has left the hangar. Confidence Inspection (CI) MAFs are generated during the confidence inspection when the aircraft arrives at the test line from the hanger after PMI rework is complete. CI MAFs can be either new work or rework. Rework MAFs can be generated anytime throughout the test line process. All MAFs are generated only on defects reported at the test line. [72]

For both C-2s and E-2s, a regression of the data indicates a downward trend following the implementation of ConCert. For both aircraft, there is an increase in the number of DWOs immediately after ConCert implementation, then a steady decrease over the next two years. The mean number of DWOs for both aircraft after ConCert implementation is lower than the mean number for the two years before ConCert.

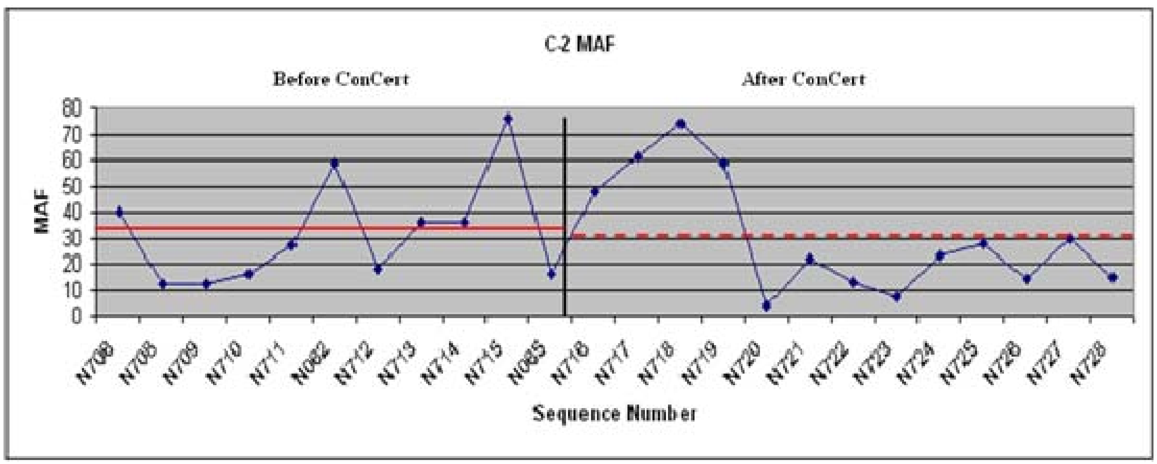


Figure 6. C-2 MAFs

Mean average before ConCert (solid line) = 31.64 MAFs

Mean average after ConCert (dashed line) = 30.62 MAFs

[72] Fleet Readiness Command Southwest Instruction 4855.43.

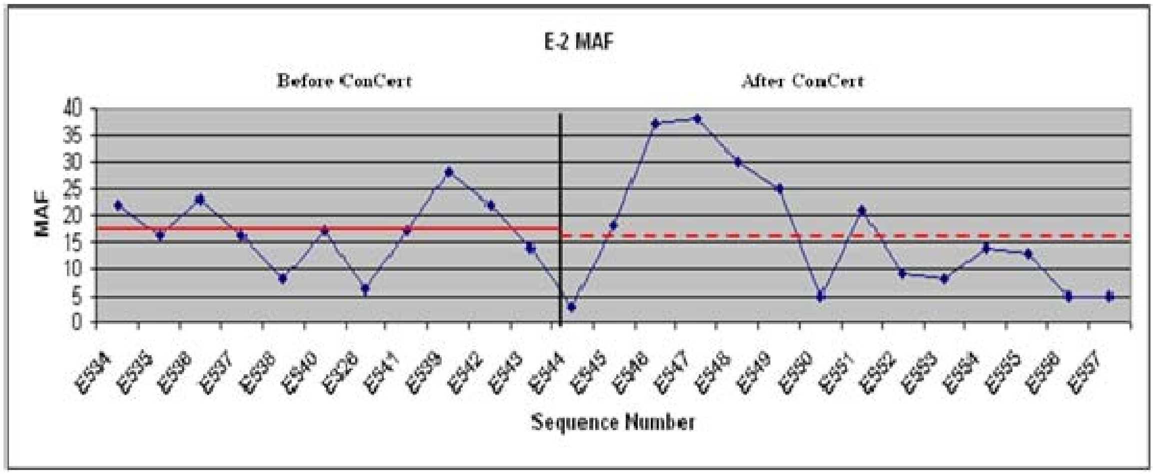


Figure 7. E-2 MAFs

Mean average before ConCert (solid line) = 17.18 MAFs

Mean average after ConCert (dashed line) = 16.50 MAFs

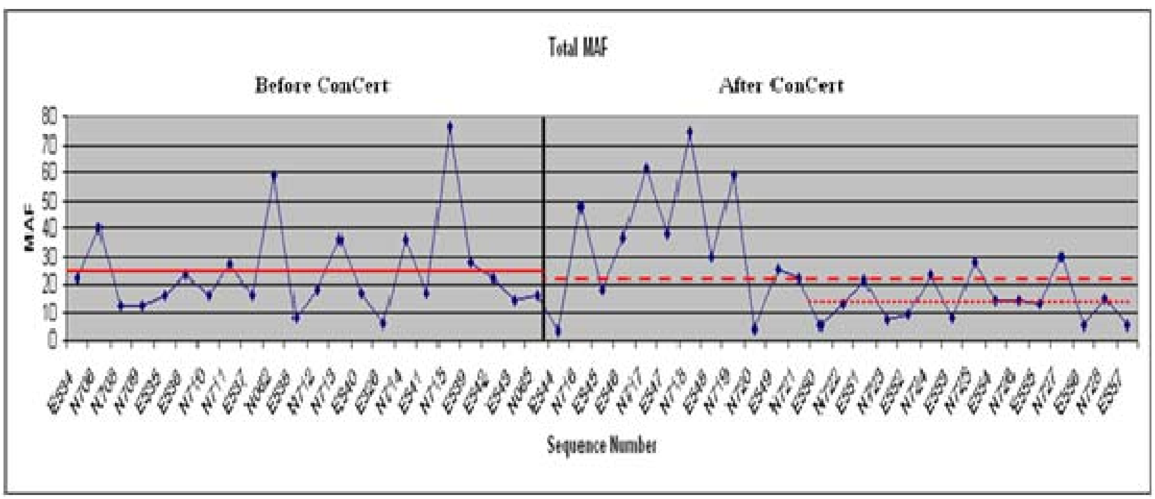


Figure 8. Total MAFs

Mean average before ConCert (solid line) = 24.41 MAFs

Mean average after ConCert (dashed line) = 23.30 MAFs

Mean average 12 months after ConCert (dotted line) = 14.00 MAFs

## E. FUNCTIONAL CHECK FLIGHTS

FCFs are performed on the test line on aircraft that have just completed rework. FCFs are required to determine if airframe, power plant, systems, accessories, and other items of equipment are functioning per predetermined standards while subjected to the intended operating environment. Repeated FCFs are required until the aircraft successfully meets all standards.[73]

For both C-2s and E-2s, there is a steady decrease in the number of FCFs from approximately a year prior to ConCert implementation and a steady decrease through the present. The mean number of FCFs for both aircraft after ConCert implementation is lower than the mean number for the two years before ConCert.

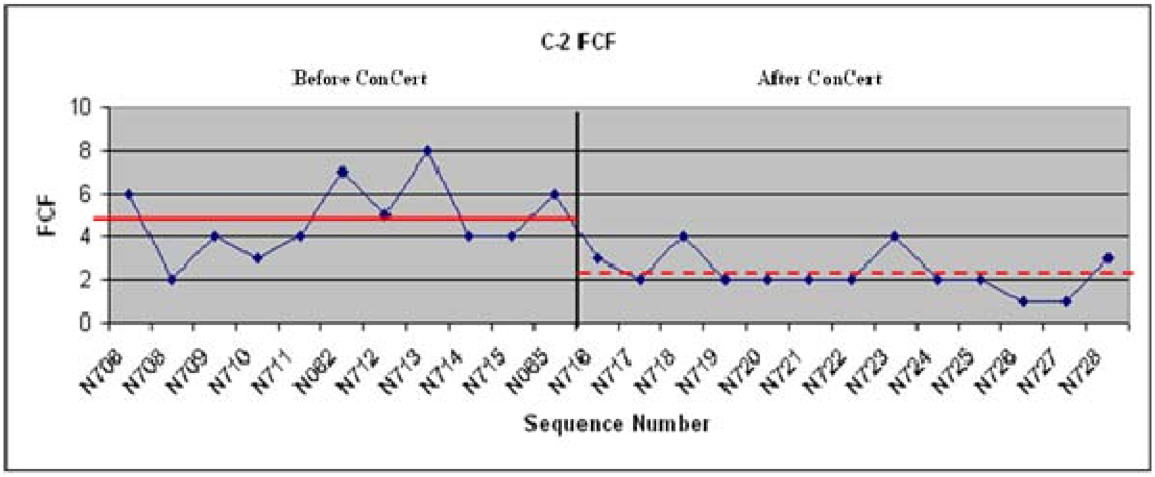


Figure 9. C-2 FCFs

Mean average before ConCert (solid line) = 4.82 FCFs

Mean average after ConCert (dashed line) = 2.31 FCFs

[73] Naval Air Systems Command 4790.2A.

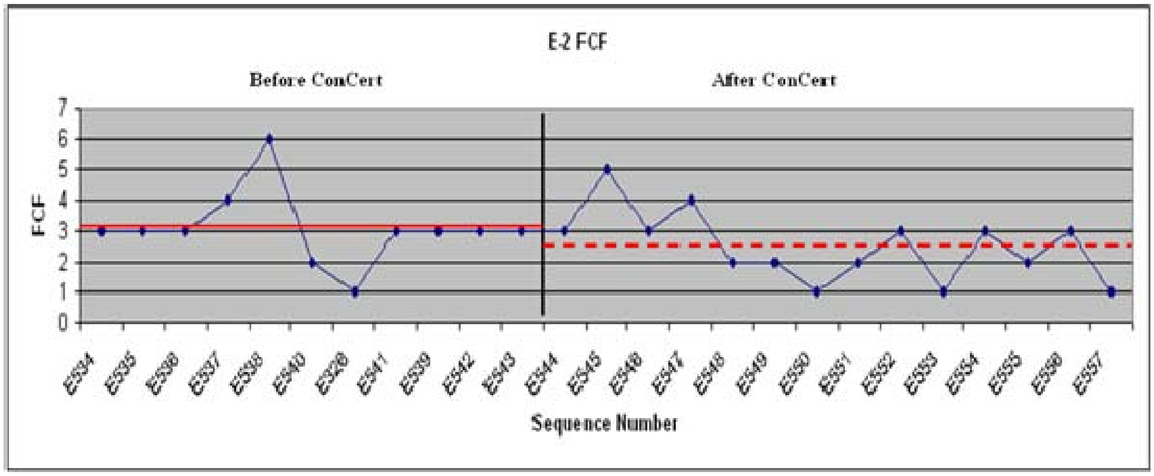


Figure 10. E-2 FCFs

Mean average before ConCert (solid line) = 3.09 FCFs

Mean average after ConCert (dashed line) = 2.50 FCFs

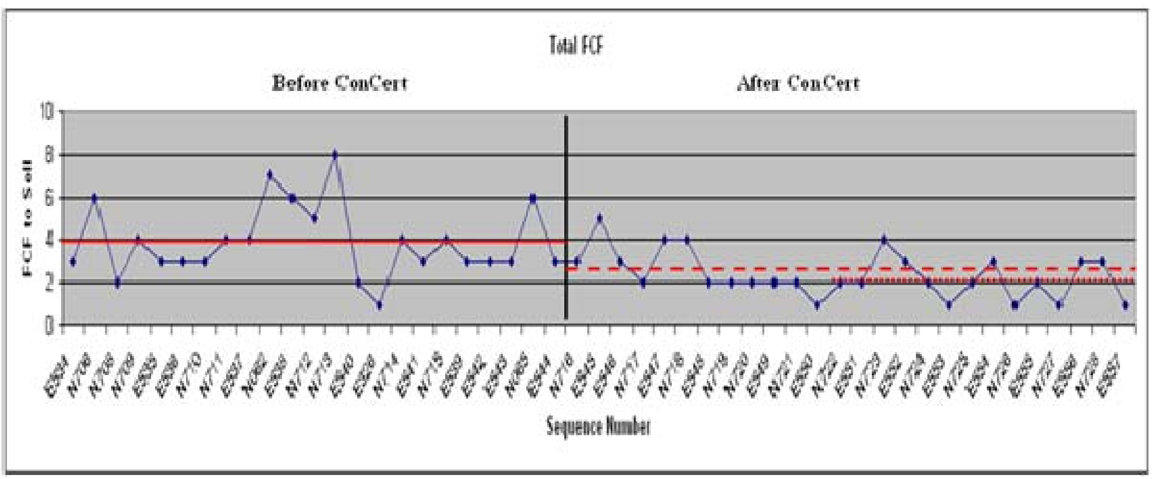


Figure 11. Total FCFs

Mean average before ConCert (solid line) = 3.95 FCFs

Mean average after ConCert (dashed line) = 2.41 FCFs

Mean average 12 months after ConCert implementation (dotted line) = 2.07 FCFs

## F. ACCEPTANCE INSPECTION DEFICIENCY REPORTS

AIDRs are used to report all aircraft related discrepancies found by the customer. The below graphs only include those faults which have been accepted by FRCSW. FRCSW accepts only those reported faults that they have a responsibility to repair. AIDRs are classified as minor, major, or critical.[74]

### 1. Minor AIDR

A minor AIDR is a defect that is not likely to materially reduce the utility of a unit or is a departure from established standards having little bearing on the use or operation of a unit.[75] Both E-2s and C-2s have experienced an increase in the mean number of minor AIDRs since the implementation of ConCert with large spikes at the beginning of 2009.

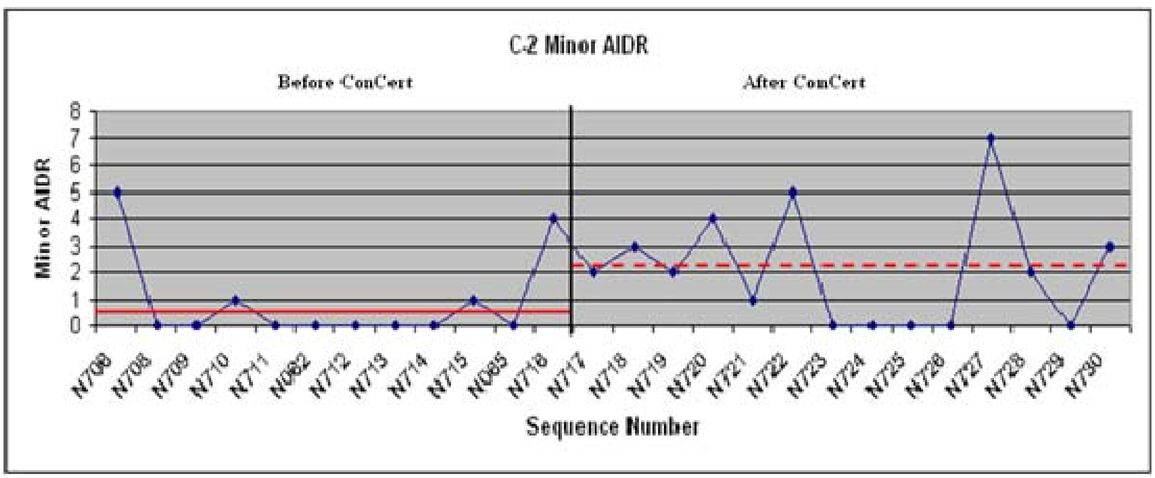


Figure 12. C-2 Minor AIDRs

Mean average before ConCert (solid line) = 0.64 Minor AIDRs

Mean average after ConCert (dashed line) = 2.20 Minor AIDRs

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[74] Fleet Readiness Command Southwest Instruction 4855.43.

[75] Ibid.

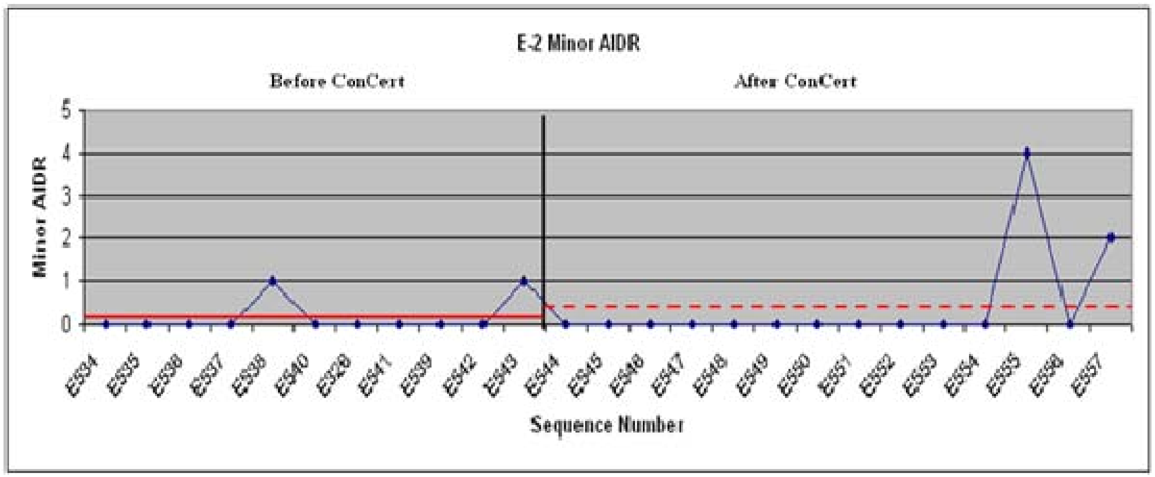


Figure 13. E-2 Minor AIDRs

Mean average before ConCert (solid line) = 0.18 Minor AIDRs

Mean average after ConCert (dashed line) = 0.43 Minor AIDRs

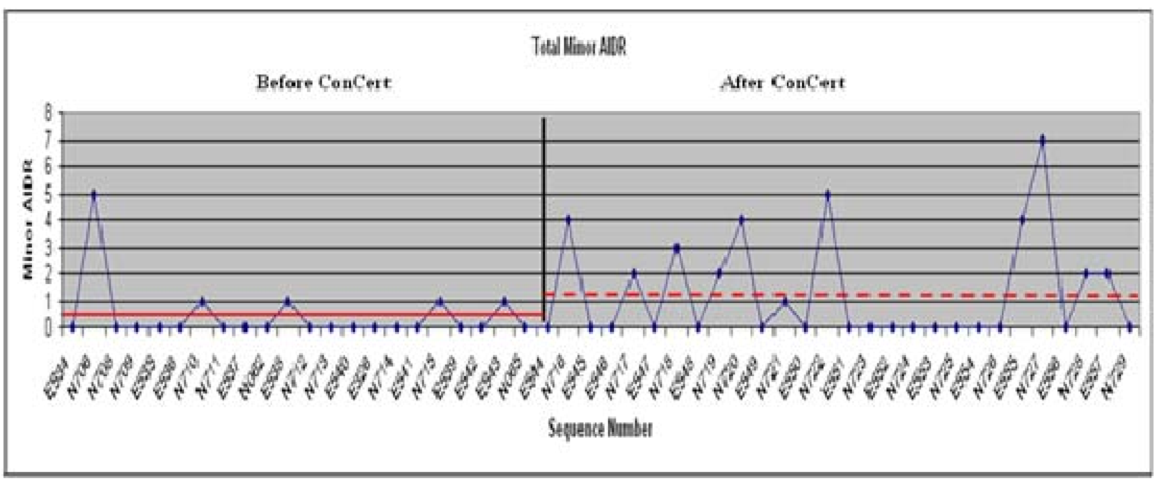


Figure 14. Total Minor AIDRs

Mean average before ConCert (solid line) = 0.41 Minor AIDRs

Mean average after ConCert (dashed line) = 1.29 Minor AIDRs

Mean average 12 months after ConCert (dotted line) = 1.25 Minor AIDRs

### 2. Major AIDR

A major AIDR is a defect that is likely to result in the failure or reduced material utility of a unit. Major AIDRs for C-2s have decreased since the implementation of ConCert.[76] Major AIDRs for E-2s have increased since the implementation of ConCert owing largely to aircraft E-555 having seven major AIDRs. Overall, the number of major AIDRs before and after ConCert has remained relatively constant.

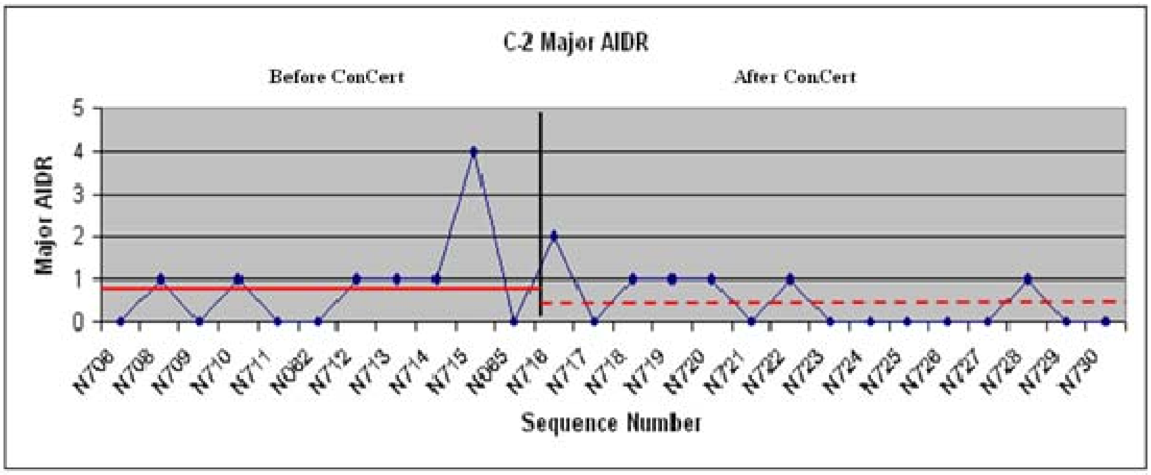


Figure 15. C-2 Major AIDRs

Mean average before ConCert (solid line) = 0.82 Major AIDRs

Mean average after ConCert (dashed line) = 0.47 Major AIDRs

76 Fleet Readiness Command Southwest Instruction 4855.43.

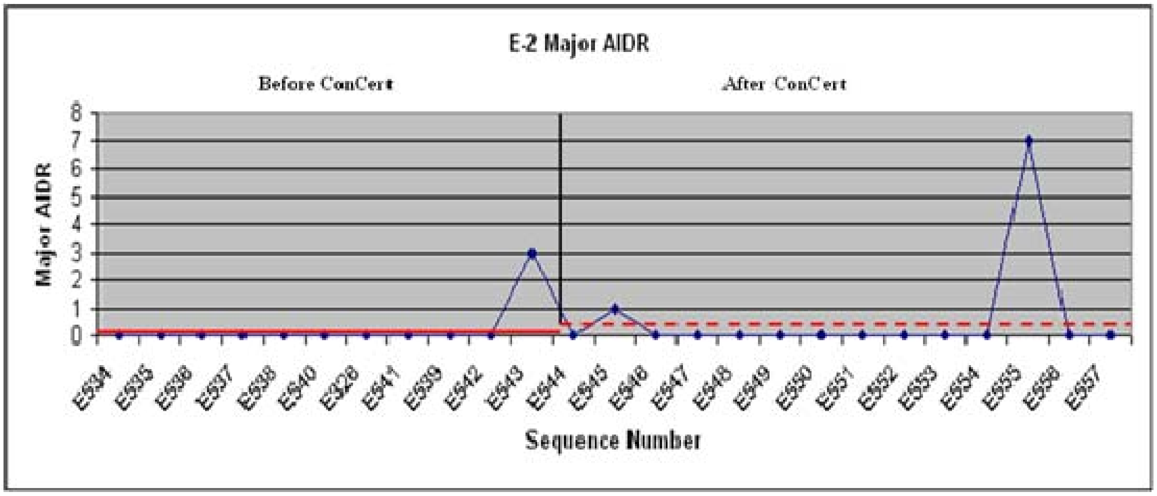


Figure 16. E-2 Major AIDRs

Mean average before ConCert (solid line) = 0.27 Major AIDRs

Mean average after ConCert (dashed line) = 0.57 Major AIDRs

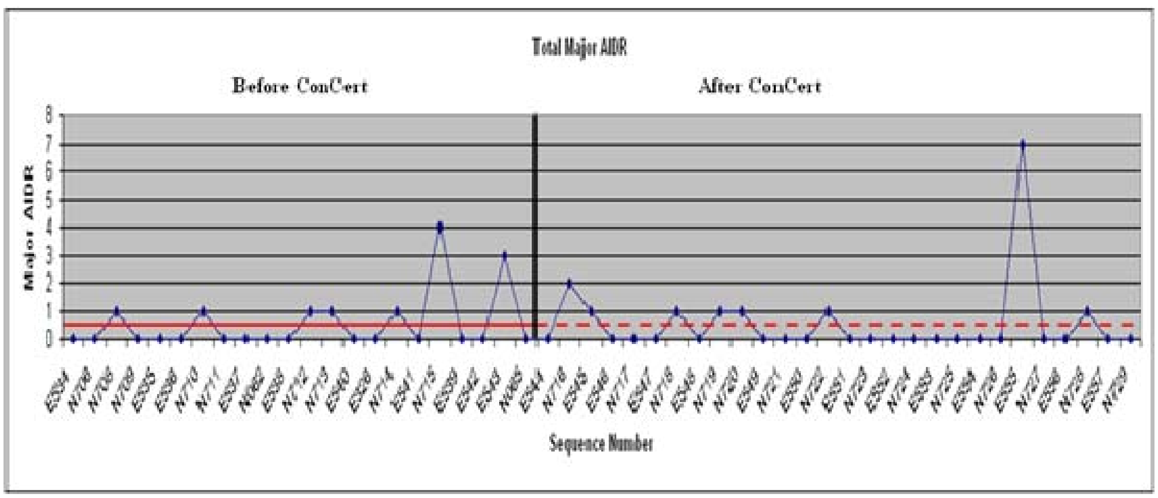


Figure 17. Total Major AIDRs

Mean average before ConCert (solid line) = 0.55 Major AIDRs

Mean average after ConCert (dashed line) = 0.54 Major AIDRs

Mean average 12 months after ConCert (dotted line) = 0.56 Major AIDRs

### 3. Critical AIDR

A critical AIDR is a defect that is likely to result in hazardous or unsafe conditions for individuals using, maintaining, or relying on the product, or may prevent functional performance of an aircraft, missile, space vehicle, or major component.[77] Within the reported data, the last critical AIDR was discovered two years prior to the implementation of ConCert.

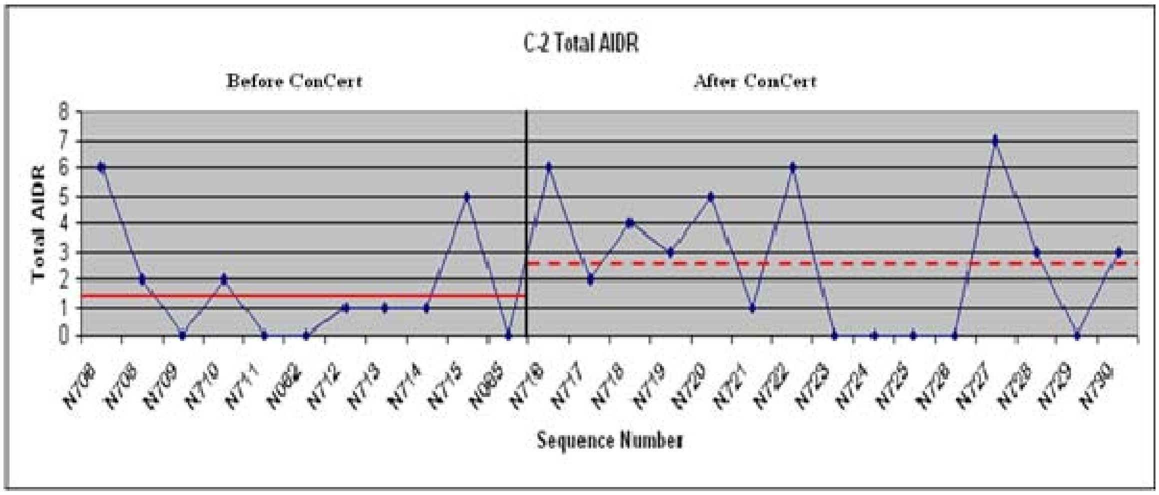


Figure 18. Total C-2 AIDRs

Mean average before ConCert (solid line) = 1.64 Total AIDRs

Mean average after ConCert (dashed line) = 2.67 Total AIDRs

[77] Fleet Readiness Command Southwest Instruction 4855.43.

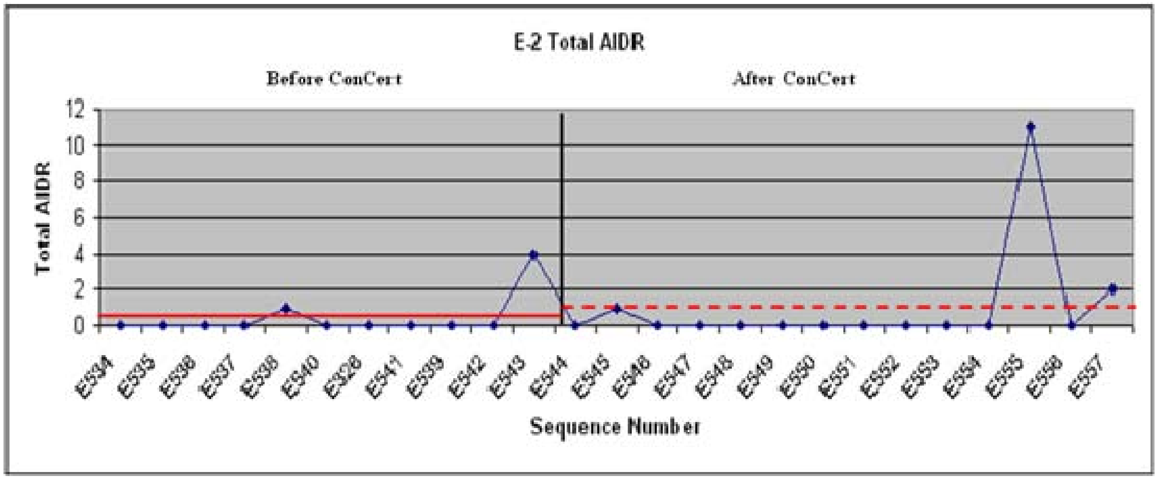


Figure 19. Total E-2 AIDRs

Mean average before ConCert (solid line) = 0.45 Total AIDRs

Mean average after ConCert (dashed line) = 1.00 Total AIDRs

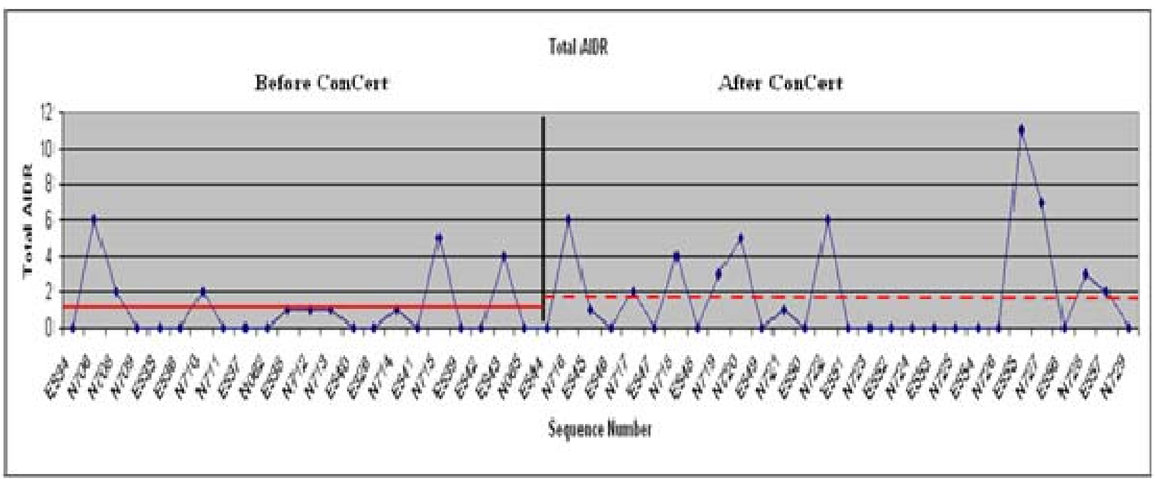


Figure 20. Total AIDRs

Mean average before ConCert (solid line) = 1.05 Total AIDRs

Mean average after ConCert (dashed line) = 1.82 Total AIDRs

Mean average 12 months after ConCert (dotted line) = 1.81 Total AIDRs

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# VII. CONCLUSIONS AND RECOMMENDATIONS

## A. INTRODUCTION

The primary purpose of this project is to answer the question of whether or not the ConCert program is working successfully on the E-2/C-2 aircraft production line. This study also determines if the ConCert program improves "quality at the source" and if ConCert should be rolled out to other product lines.

Data from FRCSW E-2/C-2 production lines was analyzed. We looked at data including the number of DWOs created, number of MAFs created, number of FCFs, and number of AIDRs received from customers. We also interviewed managers in the Industrial Quality and AIRSpeed Department, the E-2/C-2 Production Line Manager, and AIs on the production line. The critical areas examined were the number of defects discovered in the hangar, the number of defects that were not discovered until the aircraft arrived on the test line, and the number of defects detected by the customer. If a defect is found by an AI in the hangar, this is viewed as a success. Ideally, the number of MAFs (generated on the test line) and the number of AIDRs (generated by the customer) should go down if ConCert is effective.

## B. PRIMARY QUESTION

### 1. Is the Concurrent Certification Program Effectively Meeting the Quality Verification Requirements in the C-2/E-2 Production Line at FRCSW?

As mentioned above, the ideal situation consists of DWOs and MAFs both decreasing. This would indicate both that fewer faults are making it out of the hangar and that the quality of work being done in the hangar is improving. For both E-2s and C-2s, we see a similar trend in the DWO data (Figures 3 and 4). Both spike for the first two or three aircraft immediately after ConCert implementation. Then the number of DWOs decreases steadily over the next several aircraft before starting to gradually increase again at the end of the time period measured. Overall, the average number of DWOs from before ConCert to after ConCert dropped per aircraft. The average dropped even further one year after ConCert implementation as shown in Figure 5.

A key indicator to answer the question of whether or not ConCert is effectively meeting the quality verification requirements is the number of MAFs for both E-2s and C-2s. Figures 6 and 7 show that a similar increase in MAFs right after ConCert implementation exist but a steady decrease over the next two following years. After one year, the number of MAFs generated had been reduced almost in half. This decrease would seem to indicate a resounding success. It appears that defects are being found and corrected in the hangar and not making it to the test line.

The other data that is useful to answer the question of ConCert's effectiveness is the number of AIDRs received from the fleet (Figures 12 through 20). At first glance, it appears that the number of minor AIDRs has drastically increased after ConCert implementation while the number of major AIDRs has remained about constant. However, shortly after ConCert implementation, FRCSW instituted another policy regarding minor AIDRs. Minor discrepancies received on AIDR's do not fit the FRCSW criteria of useful time used communicating, investigating, composing responses, and processing through the internal review process.[78] FRCSW has developed a standard response to customer submission of minor AIDRs:

> The defect you noted is considered non-critical and is not likely to reduce the utility, the use, or the operation of the product. Therefore FRCSW has determined investigation and response of this defect would not be cost wise to the Naval Aviation Enterprise. This defect will be entered into our history database for trend analysis of future similar defects. FRCSW appreciates and encourages your continued feedback.[79]

This new policy shows that the increased number of minor AIDRs is likely due to the decision not to investigate and reject a portion of the submitted faults, but rather to accept all of them. That would cause the data to show an upward trend when there is

[78] Don Baca, e-mail message to LCDR Lucka, March 28, 2007.

[79] Ibid.

really little or no change. The AIDRs of concern, both major and critical, did not increase, on the whole, from before ConCert to after.

What we cannot see from the data analysis in this paper is how the AIRSpeed tools adopted by the E-2/C-2 Production Department have affected the production process and affected quality at the source. What we can say with certainty is that the ConCert program did not hurt the process and seems to be effective at performing the quality verification function.

## C. SECONDARY QUESTIONS

### 1. Does Concurrent Certification Improve Quality at the Source?

The ultimate goal of the ConCert program is to not only shift the quality verification process to the production line for total ownership, but to also create better quality at the source. Key indicators to answer this question are the number of DWOs, MAFs, FCFs, and AIDRs for both E-2s and C-2s. Analysis provided to answer the primary research question above suggests that quality has improved but what is not evident is how much ConCert has improved quality at the source because of the confounding influence of AIRSpeed initiatives. Analyses of FCFs indicate a decrease in the total number of FCFs required on each aircraft (Figures 9 and 10).

The researchers also considered the fact that the Industrial Quality and AIRSpeed Department and E-2/C-2 Production Lines have implemented several other programs to remove waste, implement improved flow, and to improve overall efficiency and quality. The following are AIRSpeed tools used to enhance product line productivity (details on the below are in Appendix C):

- Value Stream Mapping
- 5S Methodology
- Kanban
- Poka-yoke
- A3 Problem Solving
- Single Point Lesson Plans (SPLP)
- Total Productive Maintenance (TPM)

What the researchers cannot see from the data analysis in this paper is how the Airspeed tools adopted by the E-2/C-2 Production Department have affected the production process and affected quality at the source. The data seems to show that quality has improved but the source of the improvement cannot be linked solely to ConCert.

#### 2. If Concurrent Certification Is Effective, Is It Good Enough to Be Exported to Other FRCSW Product Lines?

The data indicates that the ConCert Program has been effective in replacing the QAS responsibilities in the E-2/C-2 Production Line. What is not evident is how much ConCert has improved quality at the source because of the confounding influence of AIRSpeed initiatives.

The results from the data analysis conducted for this project would indeed indicate that the ConCert Program would provide some benefits if implemented in other production lines. Furthermore, during the process of obtaining data, it became apparent that those associated with this program, from the E-2/C-2 Production Manager to the production line artisan argue that ConCert is an effective and successful program.

### D. RECOMMENDATIONS

#### 1. FRCSW Should Consider Implementing Concert in Another Production Line.

The data indicates that the ConCert Program has been effective in the E-2/C-2 Production Line. Other production lines should also follow the E-2/C-2 model of maintaining a QAS to perform quality verification at the test line. The additional verification done during the Confidence Inspection is the last chance to catch any defects before delivery to the customer. Additionally, maintaining a QAS on the test line helps contain the possible compromise of quality from any peer or supervisor pressures on the AI/CI.

## E. FURTHER ANALYSIS QUESTIONS

### 1. Is There a Compromise of Quality Standards Through Peer Pressure and Supervisor Pressure?

Although FRCSW has included policy within the ConCert Program to mitigate the risk of peer pressure and supervisor pressure compromising quality standards, the actual effectiveness of this policy is difficult to quantify. There are numerous organizational behavioral concepts that would need to be studied and applied to the ConCert program to analyze this question. Such an analysis is beyond the scope of this project.

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# APPENDIX A. AIRSPEED CONCEPT

## A. NAVAL AVIATION ENTERPRISE'S AIRSPEED CONCEPT

The Naval Aviation Enterprise (NAE) comprises all Naval Aviation stakeholders. It is a warfighting partnership in which interdependent issues affecting multiple commands (including all FRCs) are resolved on an enterprise-wide basis. The NAE supports the Fleet and Unified Commanders by providing combat-ready naval aviation forces which are fully trained, properly manned, interoperable, well maintained, and supported.[80]

Recognizing the need to reduce the cost of doing business, improve productivity, and increase customer satisfaction, the NAE implemented the AIRSpeed program. AIRSpeed is a current readiness (formally Naval Aviation Integrated Improvement Program—NAVRIIP) enabler for operationalizing cost-wise readiness across the NAE. AIRSpeed focuses on the total aviation solution within all levels of supply and maintenance. The program emphasizes Continuous Process Improvement (CPI) and integrates best business practices, which include the Theory of Constraints (TOC), Lean, and Six Sigma.[81] AIRSpeed is an initiative to achieve the following goals:

- Continued support of Fleet operations in the Global War on Terrorism by following the CNO's guidance for the new Fleet Readiness Program (FRP).
- Support by Naval Aviation of current levels of readiness despite a budget shortfall.
- Requirements growth in the flying hour program (FHP).
- To assist Navy and Marine Corps unit commanders in fighting in a cost-wise readiness environment.[82]

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80 "Naval Aviation Enterprise." *Enterprise AIRSpeed.* http://www.cnaf.navy.mil/airspeed/main.asp?ItemID=363 (accessed June 10, 2009).

81 Ibid.

82 Ibid.

AIRSpeed provides the NAE with the appropriate tools to help make the right decisions that deliver predetermined outcomes. It is revolutionary because changes are needed now to ensure cost-wise readiness now. It is evolutionary because the changes will be institutionalized throughout the NAE. AIRSpeed ensures the right material is delivered to the right place, at the right time, at the right cost.[83]


## B. THEORY OF CONSTRAINTS

In the mid-80s, Dr. Elijahu Goldratt, developed the Theory of Constraints (TOC). TOC is a management tool that focuses on reducing costs and improving productivity by identifying and removing constraints in a system.[84] The key elements of TOC are:

- TOC is goal oriented – the goal of the organization must be clearly defined.
- Increasing throughput is the dominant approach to achieving the goal.
- System throughput toward the goal can only be improved by improving/removing the constraint.
- Focus on the constraint will significantly impact throughput to the goal.
- TOC is an improvement process that uses five steps and aligns actions toward the goal.
- TOC is a continuous process. Once the constraint is eliminated, the process is reapplied to identify other constraints.[85]

83 Naval Aviation Enterprise.

84 Bryan T. McKernan, and Erik Herrman, "Analysis of Using Fleet Readiness Centers Vice Civilian Contractors for Aircraft Modification Work," (MBA Project, Naval Postgraduate School, 2007).

85 Naval Aviation Enterprise.

TOC uses the terms constraint, bottleneck, drum, rope, and buffer to explain the output of a plant. A constraint is a factor that limits an organization's ability to achieve its goal. The drum is essentially the bottleneck that paces the plant. Increase the drum and the bottleneck diminishes. Having a buffer, which is inventory that is in front of the bottleneck, reduces bottleneck idle time. The communication system within the plant is called the rope. Inventory requirements at the bottleneck need to be communicated back to the material release point in order to control production. Remove bottlenecks and production increases.[86]

The TOC Process can be broken down into five steps.

- **Step 1 – Identify**: Identify the system's constraint. For example: funding, parts, procedures, personnel.
- **Step 2 – Exploit**: Decide how to exploit the system's constraint. Example: How do you get more output without additional resources?
- **Step 3 – Subordinate**: Subordinate everything else to exploit a constraint. Relegate all parts of the system that are non-constraints to the role of supporters/background. Redefine the objectives of every process. Subordinating relieves conflicting priorities for resources and focuses the efforts of the system on things that maximize current performance.
- **Step 4 – Elevate**: Evaluate alternative ways to increase the capacity of a constraint.
- **Step 5 – RETURN to Step 1**. Counteract inertia. This ensures we know where the new system constraint is, and to ensure it has not migrated elsewhere. This part is critical to a learning organization.[87]

There are multiple benefits to applying the TOC to a DoD program. For instance, TOC can help reduce cost, cycle time, and it can help to improve quality, responsiveness, and performance.[88]

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86 McKernan, "Analysis of Using Fleet Readiness Centers Vice Civilian Contractors for Aircraft Modification Work."

87 Naval Aviation Enterprise.

88 McKernan, "Analysis of Using Fleet Readiness Centers Vice Civilian Contractors for Aircraft Modification Work."

## C. SIX SIGMA

Dave Nave of the Lean Enterprise Institute states Six Sigma is a process improvement strategy that uses quality improvement as the method for business improvement. Six Sigma is uniquely driven by close understanding of customer needs, disciplined use of data, statistical analysis, and diligent attention to managing, improving, and reinventing business processes. By using a set of statistical tools to understand the fluctuation of a process, management can begin to predict the expected outcome of that process. If the outcome is not satisfactory, associated tools can be used to further understand the elements influencing that process. Six Sigma focuses on variation reduction to produce highly repeatable processes that create customer satisfaction.[89] Six Sigma includes five steps: define, measure, analyze, improve, and control (commonly known as DMAIC).

- **Define.** Practitioners begin by defining the process. They ask who the customers are and what their problems are. They identify the key characteristics important to the customer along with the processes that support those key characteristics. They then identify existing output conditions along with the process elements.
- **Measure.** Next the focus is on measuring the process. Key characteristics are categorized, measurement systems are verified and data are collected.
- **Analyze.** Once data are collected, it is analyzed. The intent is to convert the raw data into information that provides insights into the process. These insights include identifying the fundamental and most important causes of the defects or problems.
- **Improve.** The fourth step is to improve the process. Solutions to the problem are developed, and changes are made to the process. Results of process changes are seen in the measurements. In this step, the company can judge whether the changes are beneficial, or if another set of changes is necessary.

[89] Naval Aviation Enterprise.

- **Control.** If the process is performing at a desired and predictable level, it is put under control. This last step is the sustaining portion of the Six Sigma methodology. The process is monitored to assure no unexpected changes occur. [90]

Nave argues focusing on the primary area of variation reduction produces secondary effects as well. Quality is improved. Process investigation produces the re-evaluation of the value added status of many elements. Some elements are modified, while others are discontinued. Elements are refined and improved while mistakes and opportunities for mistakes are reduced.[91]

Some elements discovered during the Six Sigma investigation constrain the flow of products or services through the system according to Nave. Flow is defined as the time from the input of raw material to the output of a finished item. Improvement of a process that was restricting flow results in reduced variation, better quality, and improvement in the volume of the process output. Thus the organization has less money tied up with in-process inventory. The time from paying for input material to seeing a profit is reduced and the organization can respond to customer needs more quickly.[92]

## D. THE LEAN PROCESS

Lean is a process improvement strategy that focuses on the ability to make everything, everyday, in the exact quantity required, with no defects. The goal is to achieve perfection through the total elimination of waste in the process. Lean uses incremental improvement to constantly expose waste to balance operational and standard workflows. Most notable examples are the supply chains established by Toyota and Honda.[93]

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90 Dave Nave. "How To Compare Six Sigma, Lean and the Theory of Constraints." *Lean Enterprise Institute* . March 2002. Http://www.lean.org/Community/Registered/ArticleDocuments/ASQStoryonQualitySigmaAndLean.pdf (accessed June 10, 2009).

91 Ibid.

92 Ibid.

93 Naval Aviation Enterprise.

One common measure of process improvement is touch time—the amount of time the product is actually being worked on, or touched, by the worker. Frequently, lean's focus is manifested in an emphasis on flow. There are five essential steps in lean:

- **Step 1:** Identify which features create value. The determination of which features create value in the product is made from the internal and external customer standpoints. Value is expressed in terms of how the specific product meets the customer's needs, at a specific price, at a specific time. Specific products or services are evaluated on which features add value. The value determination can be from the perspective of the ultimate customer or a subsequent process.
- **Step 2:** Identify the sequence of activities called the value stream. Once value is identified, activities that contribute value are identified. The entire sequence of activities is called the value stream. Then a determination is made as to whether activities that do not contribute value to the product or service are necessary. Necessary operations are defined as being a prerequisite to other value added activities or being an essential part of the business. Finally the impact necessary, non-value added activities have on the process is reduced to a minimum. All other non-value added activities are transitioned out of the process.
- **Step 3:** Make the activities flow. The assumption is the outcome of the entire process will be improved by reducing the variation of multiple elements. Once value added activities and necessary non-value activities are identified, improvement efforts are directed toward making the activities flow. Flow is the uninterrupted movement of product or service through the system to the customer. Major inhibitors of flow are work in queue, batch processing and transportation. These buffers slow the time from product or service initiation to delivery. Buffers also tie up money that can be used elsewhere in the organization and cover up the effects of system restraints and other wasted activities.
- **Step 4:** Let the customer pull product or service through the process. After waste is removed and flow established, efforts turn to letting the customer pull product or service through the process. The company must make the process responsive to providing the product or service only when the customer needs it—not before, not after.
- **Step 5:** Perfect the process. This effort is the repeated and constant attempt to remove non-value activity, improve flow and satisfy customer delivery needs. While lean focuses on removing waste and improving flow, it has some secondary effects. Quality is improved. The product spends less time in process, reducing the chances of damage or obsolescence. Simplification of processes results in reduction of variation. As the company looks at all the activities in the value stream, the system

constraint is removed, and performance is improved. The lean methodology also makes some assumptions:

- People value the visual effect of flow.
- Waste is the main restriction to profitability.
- Many small improvements in rapid succession are more beneficial than analytical study.
- Process interaction effects will be resolved through value stream refinement. [94]

Lean involves many people in process improvement. Transitioning to flow thinking causes vast changes in how people perceive their roles in the organization and their relationships to the product.[95]

## E. COMPARING THE THREE MODELS

Any number of techniques can be used to increase efficiency and effectiveness in the production process. There are some commonalities and general criticisms of all improvement models described above. In addition, these process improvement theories and methodologies make a few of the same assumptions. The main points of each methodology are summarized in Table 1.[96]

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94 Dave Nave, "How To Compare Six Sigma, Lean and the Theory of Constraints."

95 Ibid.

96 Ibid.

Table 1. Comparison of The Three Models

| **Program** | **Six Sigma** | **Lean Thinking** | **Theory of Constraints** |
|---|---|---|---|
| **Theory** | Reduce variation | Remove waste | Manage constraints |
| **Application Guidelines** | 1. Define<br>2. Measure<br>3. Analyze<br>4. Improve<br>5. Control | 1. Identify Value<br>2. ID Value Stream<br>3. Flow<br>4. Pull<br>5. Perfection | 1. Identify Constraint<br>2. Exploit Constraint<br>3. Subordinate Processes<br>4. Elevate Constraint<br>5. Repeat Cycle |
| **Focus** | System Constraints | Flow Focused | Problem Focused |
| **Assumptions** | A problem exists. Figures and numbers are valued. System output improves if variation in all processes is reduced. | Waste removal will improve business performance. Many small improvements are better than systems analysis. | Emphasis on speed and volume. Uses existing systems. Process interdependence. |
| **Primary Effects** | Uniform process output | Reduced flow time | Fast throughput |
| **Secondary Effects** | Less waste. Fast throughput. Less inventory. Fluctuation performance measures for managers improved quality. | Less variation. Uniform output. Less inventory. New accounting system. Flow-performance measure for managers. Improved quality. | Less inventory/waste. Throughput cost accounting. Throughput performance measurement system.<br>Improved quality. |
| **Criticisms** | System interaction not considered. Processes improved independently | Statistical or system analysis not valued. | Minimal worker input.<br>Data analysis not valued. |

**Source:** Nave, Dave

# APPENDIX B. RAW DATA

Table 2. Data By Aircraft Sequence Number

| Sequence Number | Log Sell Date | Responsible DWOs | Total MAFs | FCF to Sell | Critical AIDR | Major AIDR | Minor AIDR | Total AIDR |
|---|---|---|---|---|---|---|---|---|
| **E534** | 02/24/05 | 8 | 22 | 3 | 0 | 0 | 0 | 0 |
| **N706** | 03/07/05 | 17 | 40 | 6 | 1 | 0 | 5 | 6 |
| **N708** | 03/11/05 | 11 | 12 | 2 | 1 | 1 | 0 | 2 |
| **N709** | 03/29/05 | 10 | 12 | 4 | 0 | 0 | 0 | 0 |
| **E535** | 04/11/05 | 6 | 16 | 3 | 0 | 0 | 0 | 0 |
| **E536** | 05/21/05 | 7 | 23 | 3 | 0 | 0 | 0 | 0 |
| **N710** | 06/07/05 | 10 | 16 | 3 | 0 | 1 | 1 | 2 |
| **N711** | 07/20/05 | 12 | 27 | 4 | 0 | 0 | 0 | 0 |
| **E537** | 09/08/05 | 2 | 16 | 4 | 0 | 0 | 0 | 0 |
| **N062** | 09/14/05 | 18 | 59 | 7 | 0 | 0 | 0 | 0 |
| **E538** | 11/10/05 | 8 | 8 | 6 | 0 | 0 | 1 | 1 |
| **N712** | 11/29/05 | 23 | 18 | 5 | 0 | 1 | 0 | 1 |
| **N713** | 03/07/06 | 22 | 36 | 8 | 0 | 1 | 0 | 1 |
| **E540** | 03/30/06 | 33 | 17 | 2 | 0 | 0 | 0 | 0 |
| **E326** | 04/01/06 | 6 | 6 | 1 | 0 | 0 | 0 | 0 |
| **N714** | 06/06/06 | 37 | 36 | 4 | 0 | 1 | 0 | 1 |
| **E541** | 07/17/06 | 15 | 17 | 3 | 0 | 0 | 0 | 0 |
| **N715** | 09/07/06 | 13 | 76 | 4 | 0 | 4 | 1 | 5 |
| **E539** | 09/11/06 | 1 | 28 | 3 | 0 | 0 | 0 | 0 |
| **E542** | 09/21/06 | 1 | 22 | 3 | 0 | 0 | 0 | 0 |
| **E543** | 12/13/06 | 0 | 14 | 3 | 0 | 3 | 1 | 4 |
| **N065** | 12/18/06 | 7 | 16 | 6 | 0 | 0 | 0 | 0 |

Table 3. Data By Aircraft Sequence Number After Concert

| Sequence Number | Log Sell Date | Responsible DWOs | Total MAFs | FCF to Sell | Critical AIDR | Major AIDR | Minor AIDR | Total AIDR |
|---|---|---|---|---|---|---|---|---|
| **E544** | 03/17/07 | 11 | 3 | 3 | 0 | 0 | 0 | 0 |
| **N716** | 04/30/07 | 30 | 48 | 3 | 0 | 2 | 4 | 6 |
| **E545** | 05/07/07 | 10 | 18 | 5 | 0 | 1 | 0 | 1 |
| **E546** | 06/13/07 | 11 | 37 | 3 | 0 | 0 | 0 | 0 |
| **N717** | 07/18/07 | 31 | 61 | 2 | 0 | 0 | 2 | 2 |
| **E547** | 07/26/07 | 7 | 38 | 4 | 0 | 0 | 0 | 0 |
| **N718** | 09/11/07 | 15 | 74 | 4 | 0 | 1 | 3 | 4 |
| **E548** | 09/27/07 | 7 | 30 | 2 | 0 | 0 | 0 | 0 |
| **N719** | 10/29/07 | 11 | 59 | 2 | 0 | 1 | 2 | 3 |
| **N720** | 11/29/07 | 20 | 4 | 2 | 0 | 1 | 4 | 5 |
| **E549** | 12/21/07 | 1 | 25 | 2 | 0 | 0 | 0 | 0 |
| **N721** | 02/05/08 | 8 | 22 | 2 | 0 | 0 | 1 | 1 |
| **E550** | 03/01/08 | 1 | 5 | 1 | 0 | 0 | 0 | 0 |
| **N722** | 03/24/08 | 7 | 13 | 2 | 0 | 1 | 5 | 6 |
| **E551** | 04/23/08 | 2 | 21 | 2 | 0 | 0 | 0 | 0 |
| **N723** | 06/03/08 | 6 | 7 | 4 | 0 | 0 | 0 | 0 |
| **E552** | 06/30/08 | 4 | 9 | 3 | 0 | 0 | 0 | 0 |
| **N724** | 08/16/08 | 7 | 23 | 2 | 0 | 0 | 0 | 0 |
| **E553** | 09/08/08 | 1 | 8 | 1 | 0 | 0 | 0 | 0 |
| **N725** | 10/09/08 | 9 | 28 | 2 | 0 | 0 | 0 | 0 |
| **E554** | 12/06/08 | 1 | 14 | 3 | 0 | 0 | 0 | 0 |
| **N726** | 12/16/08 | 10 | 14 | 1 | 0 | 0 | 0 | 0 |
| **E555** | 01/27/09 | 6 | 13 | 2 | 0 | 7 | 4 | 11 |
| **N727** | 02/26/09 | 17 | 30 | 1 | 0 | 0 | 7 | 7 |
| **E556** | 03/19/09 | 20 | 5 | 3 | 0 | 0 | 0 | 0 |
| **N728** | 04/29/09 | 24 | 15 | 3 | 0 | 1 | 2 | 3 |
| **E557** | 05/13/09 | 6 | 5 | 1 | 0 | 0 | 2 | 2 |
| **N729** | 07/08/09 | 17 | | | 0 | 0 | 0 | 0 |

## Regression for C-2 DWOs:

| | | |
|---|---|---|
| **BEFORE CONCERT** | Mean = | 16.36364 |

SUMMARY OUTPUT

| *Regression Statistics* | | |
|---|---|---|
| Multiple R | 0.315348 | |
| R Square | 0.099444 | |
| Adjusted R Square | | -0.01313 |
| Standard Error | 3.047455 | |
| Observations | 10 | |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 8.204139 | 8.204139 | 0.883402 | 0.37478 |
| Residual | 8 | 74.29586 | 9.286983 | | |
| Total | 9 | 82.5 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 4.774484 | 2.073423 | 2.302706 | 0.050258 |
| 17 | 0.10586 | 0.112629 | 0.939895 | 0.37478 |

| | | |
|---|---|---|
| **AFTER CONCERT** | Mean = | 15.14286 |

SUMMARY OUTPUT

| *Regression Statistics* | | |
|---|---|---|
| Multiple R | 0.121166 | |
| R Square | 0.014681 | |
| Adjusted R Square | | -0.07489 |
| Standard Error | 4.037641 | |
| Observations | 13 | |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 2.671965 | 2.671965 | 0.163899 | 0.693354 |
| Residual | 11 | 179.328 | 16.30255 | | |
| Total | 12 | 182 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 19.86994 | 2.423123 | 8.200136 | 5.16E-06 |
| 6 | -0.06214 | 0.153488 | -0.40484 | 0.693354 |

## Regression for E-2 DWOs:

| | | |
|---|---|---|
| **BEFORE CONCERT** | Mean = | 7.909091 |
| SUMMARY OUTPUT | | |

| *Regression Statistics* | | |
|---|---|---|
| Multiple R | | 0.198455666 |
| R Square | 0.039384651 | |
| Adjusted R Square | -0.080692267 | |
| Standard Error | 3.147434794 | |
| Observations | 10 | |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 3.249234 | 3.249234 | 0.327995 | 0.582576 |
| Residual | 8 | 79.25077 | 9.906346 | | |
| Total | 9 | 82.5 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 6.979793393 | 1.300953 | 5.365138 | 0.000674 |
| 8 | -0.060733341 | 0.106046 | -0.57271 | 0.582576 |

| | | |
|---|---|---|
| **AFTER CONCERT** | Mean = | 6.285714 |
| SUMMARY OUTPUT | | |

| *Regression Statistics* | | |
|---|---|---|
| Multiple R | 0.239020851 | |
| R Square | 0.057130967 | |
| Adjusted R Square | -0.028584399 | |
| Standard Error | | 3.949708435 |
| Observations | 13 | |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 10.39784 | 10.39784 | 0.66652 | 0.431593 |
| Residual | 11 | 171.6022 | 15.6002 | | |
| Total | 12 | 182 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 18.13566375 | 1.523443 | 11.90439 | 1.26E-07 |
| 2 | 0.167707033 | 0.205421 | 0.816406 | 0.431593 |

## Regression for C-2 MAFs:

| **BEFORE CONCERT** SUMMARY OUTPUT | Mean = | 31.63636 |
|---|---|---|

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.483268 |
| R Square | 0.233548 |
| Adjusted R Square | 0.137742 |
| Standard Error | 2.811412 |
| Observations | 10 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 19.26772 | 19.26772 | 2.4377068 | 0.157073 |
| Residual | 8 | 63.23228 | 7.904035 | | |
| Total | 9 | 82.5 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 4.417734 | 1.602827 | 2.756214 | 0.024819512 |
| 40 | 0.067606 | 0.043301 | 1.561316 | 0.157072762 |

| **AFTER CONCERT** SUMMARY OUTPUT | Mean= | 30.61538 |
|---|---|---|

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.602797 |
| R Square | 0.363364 |
| Adjusted R Square | 0.2997 |
| Standard Error | 3.017266 |
| Observations | 12 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 51.96106 | 51.96106 | 5.707565118 | 0.03802 |
| Residual | 10 | 91.03894 | 9.103894 | | |
| Total | 11 | 143 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 21.25551 | 1.445327 | 14.70637 | 4.22717E-08 |
| 48 | -0.09447 | 0.039545 | -2.38905 | 0.038020176 |

## Regression for E-2 MAFs:

**BEFORE CONCERT** Mean = 17.18182
SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.141419725 |
| R Square | 0.019999539 |
| Adjusted R Square | -0.102500519 |
| Standard Error | 3.17903362 |
| Observations | 10 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 1.649962 | 1.649962 | 0.163261463 | 0.696757 |
| Residual | 8 | 80.85004 | 10.10625 | | |
| Total | 9 | 82.5 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 5.419436691 | 2.857 | 1.896898 | 0.094417914 |
| 22 | 0.06470439 | 0.160137 | 0.404056 | 0.696757433 |

**AFTER CONCERT** Mean = 16.5
SUMMARY OUTPUT

| *Regression Statistics* | |
|---|---|
| Multiple R | 0.750262336 |
| R Square | 0.562893573 |
| Adjusted R Square | 0.523156625 |
| Standard Error | 2.689260962 |
| Observations | 13 |

ANOVA

| | *df* | *SS* | *MS* | *F* | *Significance F* |
|---|---|---|---|---|---|
| Regression | 1 | 102.4466 | 102.4466 | 14.16549589 | 0.003134 |
| Residual | 11 | 79.55337 | 7.232125 | | |
| Total | 12 | 182 | | | |

| | *Coefficients* | *Standard Error* | *t Stat* | *P-value* |
|---|---|---|---|---|
| Intercept | 23.31912568 | 1.368663 | 17.03789 | 2.9611E-09 |
| 28 | -0.246265938 | 0.065432 | -3.76371 | 0.003134425 |

# APPENDIX C. E-2/C-2 AIRSPEED TOOLS

The QA Department and E-2/C-2 Production Lines have implemented several programs to remove waste, implement improved flow and overall efficiency and quality. As described in the E-2/C-2 Production Line Standard Operating Procedure (SOP), it is the E2/C2 management philosophy and Quality Objective to improve overall customer value by identifying the customers' needs to Cost, Quality and Delivery needs. The following are Airspeed/Lean Tools used to enhance the E-2/C-2 Product Line productivity:[97]

**A. VALUE STREAM MAPPING:** Value Stream Mapping is used to analyze the flow of materials and information currently required to bring a product or service to a consumer.

**B. 5S METHODOLOGY:** The 5Ss represent a philosophy and a way of organizing and managing the workspace and work flow with the intent to improve efficiency by eliminating *waste*, improving *flow*. The 5S items are:

1. **Sorting**: Going through all the tools and materials in the plant and work area and keeping only essential items. Non-essential items are stored or discarded.

2. **Straighten**: Arrange the tools, equipment and parts in a manner that promotes work flow.

3. **Sweeping**: Systematic cleaning or the need to keep the workplace clean as well as neat. At the end of each shift, the work area is cleaned up and everything is restored to its place, making it easy to know what goes where and to know when everything is where it should be are essential here.

4. **Standardizing**: Standardized work practices or operating in a consistent and standardized fashion. Everyone knows exactly what his or her responsibilities are to keep above 3S's.

[97] E-2/C-2 SOP.

5. **Sustaining**: Refers to maintaining and reviewing standards. Once the previous 4S's have been established they become the new way to operate. Maintain the focus on this new way of operating and do not allow a gradual decline back to the old ways of operating.

**C. KANBAN**: Part of a pull system that determines the supply, or production, according to the actual demand of the customers. Kanban is as a demand signal which immediately propagates through the supply chain.

**D. POKA-YOKE:** A Japanese term that means "fail-safing" or "mistake-proofing." Avoiding (*yokeru*) inadvertent errors (*poka*) is a behavior-shaping constraint, or a method of preventing errors by putting limits on how an operation can be performed in order to force the correct completion of the operation.

**E. A3 PROBLEM SOLVING**: A method of standardizing an approach to solving problems identified in higher-level value stream maps.

**F. SINGLE POINT LESSON PLANS (SPLP):** Provide the user with a single page, step-by-step training aid that is designed to clarify administrative procedures required by the Quality Management System.

**G. TOTAL PRODUCTIVE MAINTENANCE (TPM):** Continuous improvement strategy that is an equipment-focused, team-based activity aimed at dramatically improving quality, manufacturing cost, and delivery time involving everyone directly in equipment management issues

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