

Systems Engineering Integrative Project

Part Marking, Serialization, & Traceability

Loyola Marymount University – Graduate School of Engineering

Systems Engineering Integrative Project

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Presentation Outline

- Foreword
- Introduction
- Project Topic – Criticality Traceability
- Issues Encountered
 - Data Analysis
- Systems Engineering Principles
- Requirements Development & Allocation
- Integration, Verification, & Validation
- Risk Management
- Conclusion
- Reference

Foreword

- Academic Background
- Work Experience
- Current Position
- Integrative Project Concept

Acronyms

• ASNR	Accessory Serial Number Record
• ALOO	Assembly Line Order Operation
• DADT	Durability and Damage Tolerance
• BTP	Build-to-Package
• NL	Notes List
• FC	Fracture Critical
• FCS	Flight Science Critical
• MC	Maintenance Critical
• DC	Durability Critical
• SC	Safety Critical
• MAC	Mission Abort Critical
• ME	Manufacturing Engineer
• MRB	Material Review Board
• IMPCA	Integrated Management Planning and Control for Assembly
• MES	Manufacturing Execution System
• CPIOS	Contract/Production and Inventory Optimization System
• PDM	Product Data Manager
• OASIS	Online Automated Supplier Information System
• SQUID	Store and Query Unique Identification
• Livelink	System used to review manufacturing plans

No UTP

Integrative Project Experience

- Purpose: To use systems engineering to develop a system that would allow NGC to have 100% traceability on all critical and UID mandated parts.
- Research was conducted using the SE principles most applicable to software integration
- The report demonstrates how these recommendations would allow NGIS to meet current DoD mandate MIL-STD-130L and assist in meeting program schedules and budgets throughout the program lifecycles.

Integrative Project Concept

- The original project envisioned was one that looked at manufacturing's role within the current system used to identify critical parts and reducing the non-value added work associated with it. Manufacturing is required to log on to IMPCA and record the serial numbers of all the traceable parts. At a production interval of one air vehicle per day this would put a non-value added cost and negative cycle time impact on the program. But, after looking at the system it was apparent that the entire system, not just the manufacturing portion was in need of repair.

Aircraft Serial Number Report Log Issue

Issue: Aircraft Serial Number Report log (ASNR) is still unusable. Currently the only numbers tracked via the Engineering critical list are fracture critical traceable. This list has changed many times. No hydro, fuel or electronic components are listed as requiring serial numbers verification.

Currently: Inspection has been keeping an Excel spread sheet of serialized parts installed on units at PMC. Form 27-835 is also filled out only if the plan has this requirement. This form is then sent to closed records. At delivery the forms will need to be pulled and checked to the Excel list to ensure parts have not been removed and replaced for some recall or MRB action.

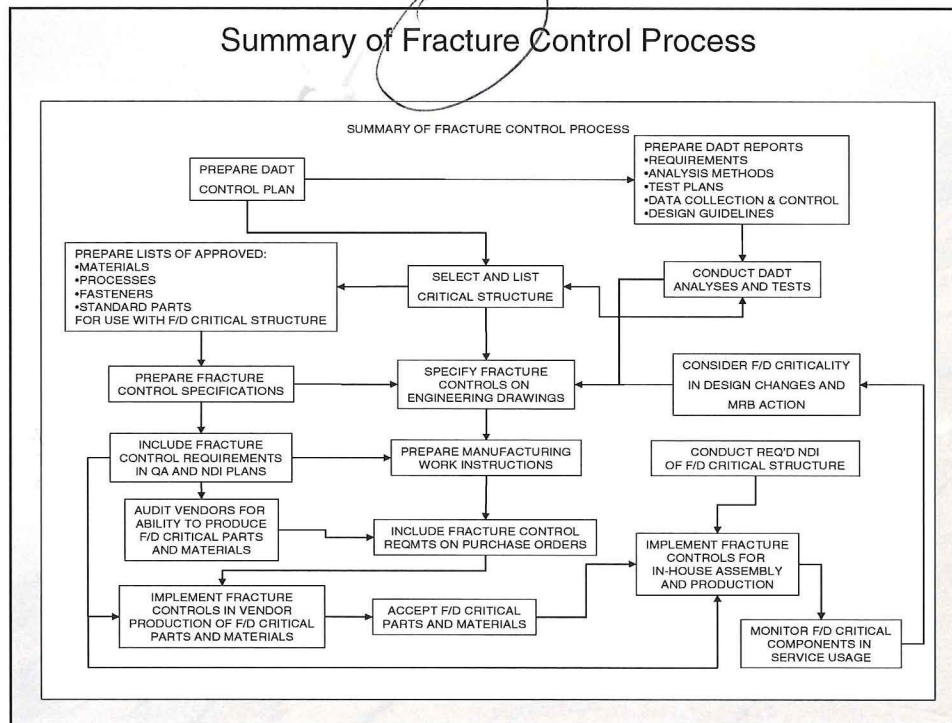
Impact: If parts were to be placed on recalled NGC would not know what unit the part was installed on. This could possibly ground the fleet or require hours of maintainer investigation.

Current System - Risk

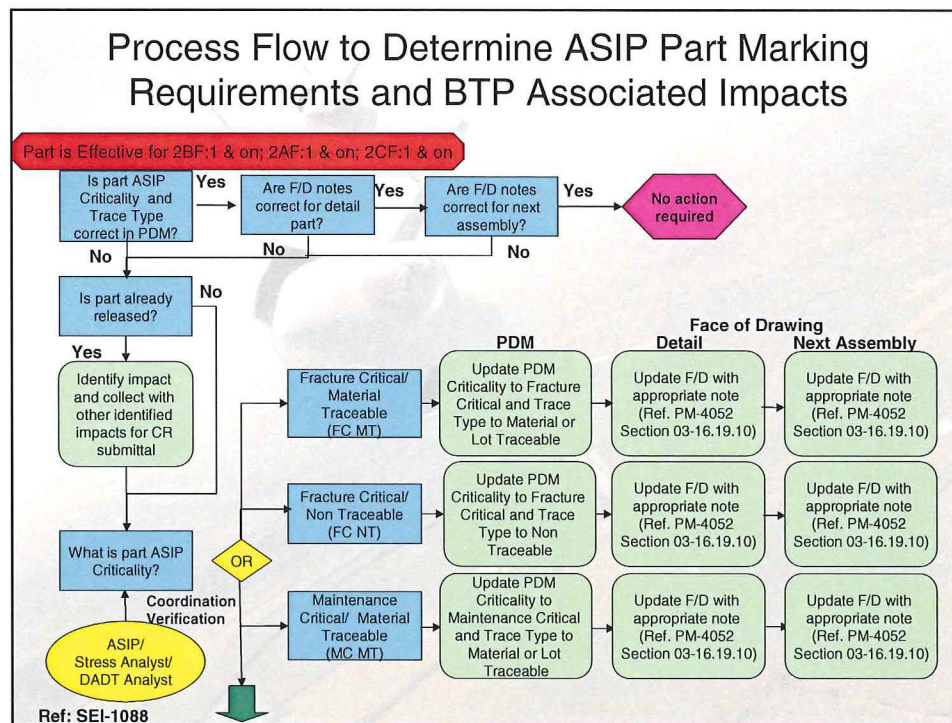
- DoD mandate requiring all defense contractors to serially label every component and subsystem not being met.
- Parts not identified as traceable
- Parts not included in list for supply to know what is traceable, what should be included in the air vehicle, and what should be shipped loose.
- Multiple suppliers providing the same part configuration and duplicate a serial number
- Serial numbers transposed or repeated
- Cost of program escalating based on having to input serial numbers into IMPCA, and also searching for parts (schedule impact)

\$5000
Threshold

Summary of Fracture Control Process



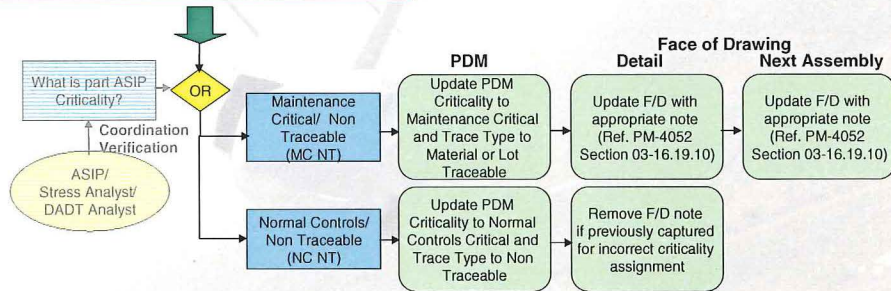
Process Flow to Determine ASIP Part Marking Requirements and BTP Associated Impacts



*Overall Struct
Integ Proj*

Process Flow to Determine ASIP Part Marking Requirements and BTP Associated Impacts

Part is Effective for 2BF:1 & on; 2AF:1 & on; 2CF:1 & on

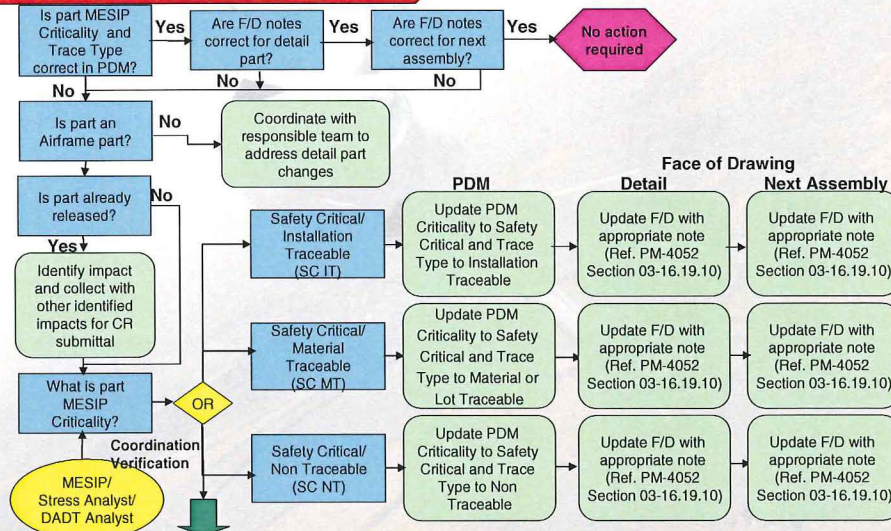


Ref: SEI-1088

*Mark Elect Struct
Integ Proj*

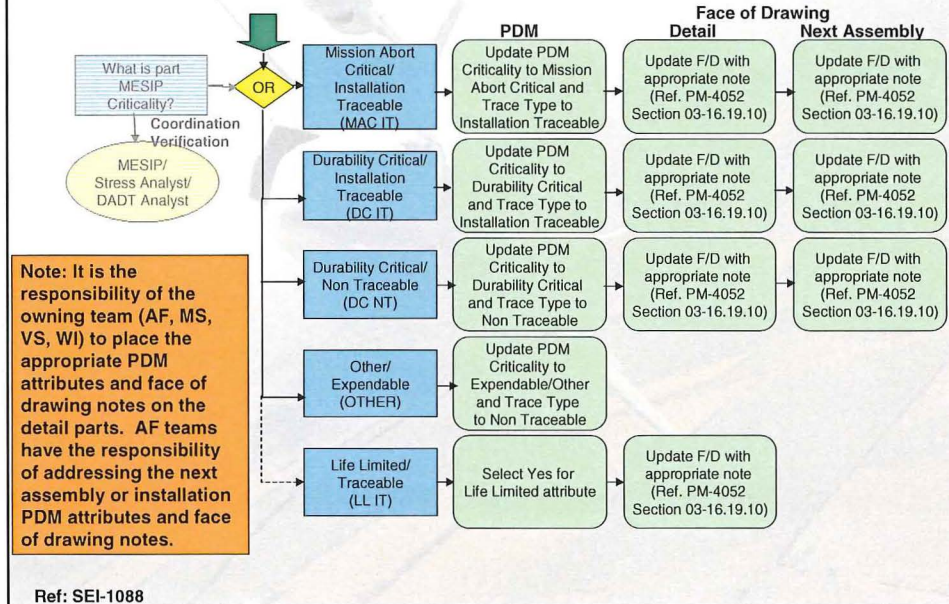
Process Flow to Determine MESIP Part Marking Requirements and BTP Associated Impacts

Part is Effective for 2BF:1 & on; 2AF:1 & on; 2CF:1 & on



Ref: SEI-1088

Process Flow to Determine MESIP Part Marking Requirements and BTP Associated Impacts



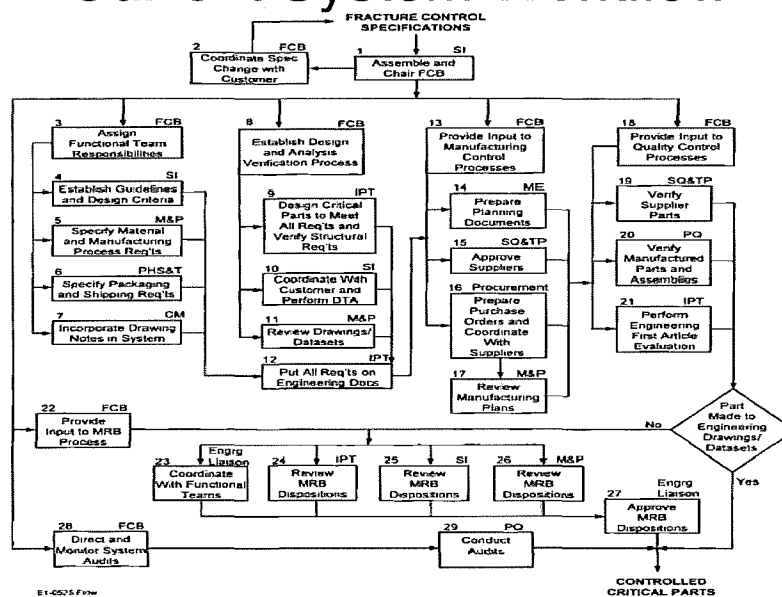
Current System (1 of 2)

- Currently no single system exists within NGIS that will provide 100% traceability from supplier to transfer to prime.
- These are incapable of providing the breadth and depth of functionality required to meet DoD Mandates.
- NGIS' current environment consists of legacy systems and manual operations.

Current System (2 of 2)

- The SE Integrative Report focuses on Critically Traceable parts from design to final delivery to the customer (LM Aero) and parts needing DoD UID.
- There were issues involved with some of the team members in each step that resulted in the last air vehicle delivered to have a total of 64 parts unaccounted for.
- The resultant failures of each team along the way has the potential of slowing down the program and hurting future programs.
- The failures also have the ability to create an impact in both schedule and cost.
 - Time spent resolving and correcting the errors

Current System Workflow



Issues Encountered (1 of 2)

- There is no automatic trigger to the subsystem IPT members and downstream members to let them know that the part is critical
- No documented process to tell that a part is critical until that part has been designed.
- Process not formerly documented for Subsystems
- Subsystems items are being recorded on paper rather than putting them in the system.
 - no requirements to place criticality on drawings

Issues Encountered (2 of 2)

- Prime contract spec is not being met, waiver for SDD.
- Design is not putting the Criticality on the drawing
- (ME uses the drawing to alert them that the part is critical so that they can flag the ASNR)
- Majority of ME's do not know that they are supposed to be flagging for an ASNR
- ME's are finding ASNR's are not loaded in IMPCA
- Suppliers - no requirements for them to mark the part criticality
- Manufacturing - no trigger (drawing is the trigger - but no criticality is listed on the drawing)

Unique IDentification

Definition

- The DoD vision for unique item identification is to implement policy, regulations, and supporting processes that establish a strategic imperative for uniquely identifying tangible items. Uniquely identified tangible items will facilitate item tracking in DoD business systems and provide reliable and accurate technical and financial data for management, financial accountability, and asset management purposes.

Timing (no later than)

- Have program implemented for LRIP 1 (2AF:5, 2BF:5, 2CF:4)

Affects and Effects

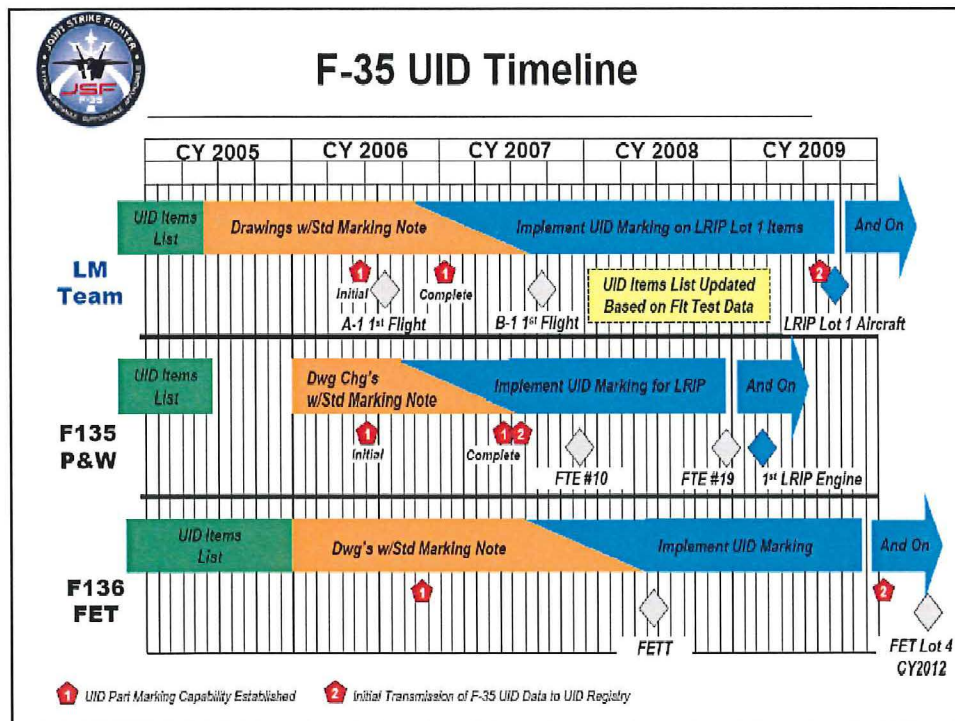
- Detail parts and Next Assemblies / Installations
- Dataset Notes required
- PDM attributes selection required

Status

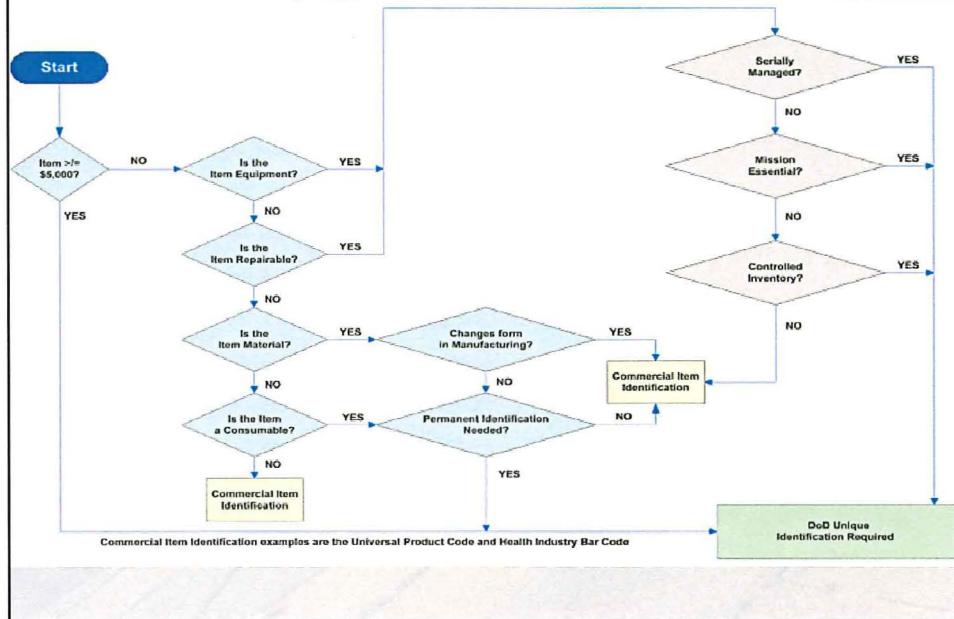
- Definition of affected parts described by a parts and spares list (2YZA00104 and spares list).
- Dataset notes available (PM-4052 3-16.19.8)
- PDM attributes not available (available April 2007)
- Not All Parts correctly marked and PDM attributed selected

Path Forward

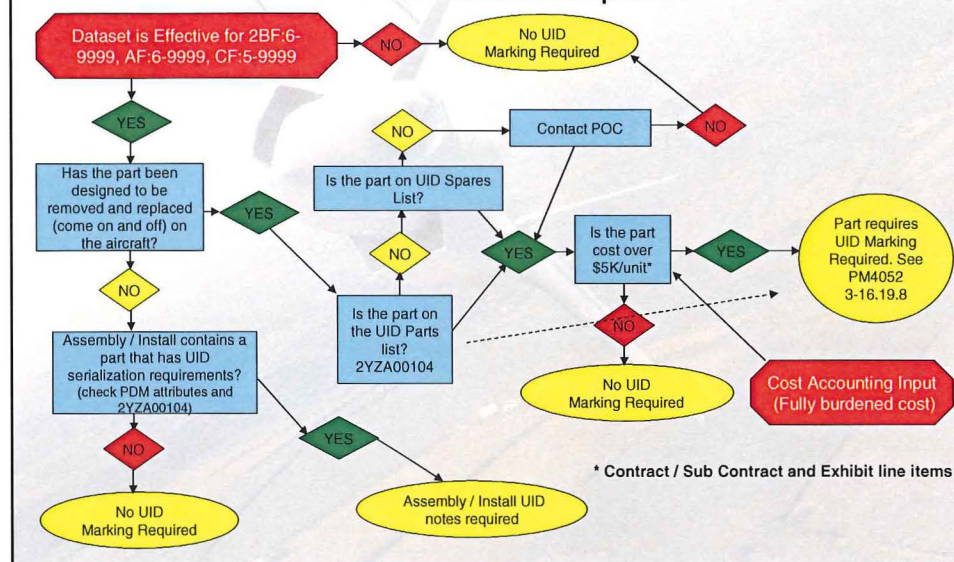
- Air Vehicle Project Engineering requested to produce CR for Released items
- Airframe IPTs to apply 2YZA00104 and spares list for all new releases / touched datasets.
- Airframe to use CR to correct previously released engineering.
- Part number rolls required to correct Dataset Markings.
- Part Number rolls not required for PDM attribute correction.



DoD UID Requirement Flow Chart



Initial Design Example Process Flow to Determine Unique Part Identification Marking Requirements and BTP Associated Impacts

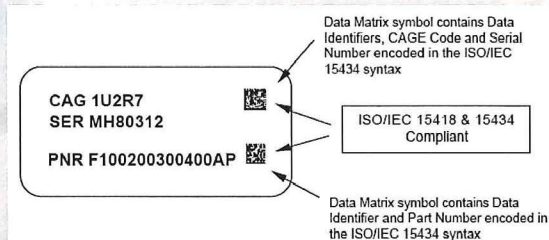


Notes PM-4052 3-16.19

Type	Note
Detail	THIS PART IS/HAS UID. BAR CODE PART WHERE SHOWN PER 2ZZP00008, CLASS X Y [X = CLASS 1 OR 3] [Y = METHOD A, B, C, D, E OR F], TYPE XX-2 [XX = 01, 03, 04, 05, 06, OR 07].
Assembly	THIS ASSEMBLY CONTAINS UID. BAR CODE PART WHERE SHOWN PER 2ZZP00008, CLASS X Y [X = CLASS 1 OR 3] [Y = METHOD A, B, C, D, E OR F], TYPE XX-2 [XX = 01, 03, 04, 05, 06, OR 07].
Installation	THIS INSTALLATION CONTAINS PARTS/ASSEMBLIES CONTAINING UID.

Identification Method

- 2-D Data Matrix Barcode
 - “damage tolerant”
 - contains redundant data
 - allows for readability of marks damaged up to approximately 25%.
 - allows up to 2,000 characters to be contained in a code that can be as small as one-tenth of an inch square



Missing ASNR Log Investigation

Note #	Flag Note	Text
14		THIS DRAWING INSTALLS THE FOLLOWING FRACTURE/MAINTENANCE CRITICAL PARTS. MATCHLINE REMOVAL, PROCESSING, INSPECTIONS, SERIALIZATION AND TRACEABILITY PER 22Z0006. FRACTURE CRITICAL, TRACEABLE (SERIALIZATION AND TRACEABILITY REQUIRED); 2CSH60154, 2CSH60156. FRACTURE CRITICAL, NON-TRACEABLE (SERIALIZATION AND TRACEABILITY NOT REQUIRED); 2CSH60155, 2CSH60157. MAINTENANCE CRITICAL (SERIALIZATION AND TRACEABILITY NOT REQUIRED); 2CSH60158.
15		INSTALL BUSHINGS J351E14 AND J351E15 PER LMA-P0033. INSTALL BUSHINGS WET WITH AMS 3201 PER 22Z00017. FILLET SEAL BUSHINGS WITH AMS 3201 PER 22Z00017.
16		PRE-INSTALL PREP-CUT HEAD-NUT-ADP (18A 2 1/8" x 181/16") PRE-INSTALL WITH ACCEPTANCE REQUIREMENTS TO LMA-P003 CLASS A. PRE-PENETRANT DITCH

•BTP NL (Notes List) callout drives ME requirement to code part in Impca for ASNR log creation

Missing ASNR Log Investigation

SEQ	R	PART NUMBER	INSTALL DWG	F/D	QUANTITY
080	R	2CSH70124-0001	2CSH70016		1
081	R	BRACKET, UNLOCK - FS331			
082	R	2CSH51133-0001	2CSH40003		1
083	F	FORWARD LIFT MNT (FC, NC)	RECORD ANSR INFORMATION FOR DETAIL		2CSH60154
084	R	2CSH51133-0001	2CSH40003		1
085	F	FORWARD LIFT MNT (FC, NC)	RECORD ANSR INFORMATION FOR DETAIL		2CSH60156
086	R	2CSH51133-0001-01	2CSH40003		1
087	F	FORWARD LIFT MNT (FC, NC)	FORWARD LIFT MNT IS REMOVED PER AUX# P01857		LC

•ME codes part as "F" in ASNR field on PCS/ Aloo record 6; This particular part is coded at the assembly installed level for the recording of the detail; There are instructions in Aloo record 8 for the mechanic specifying this.

Missing ASNR Log Investigation

ACCESSORY SERIAL NUMBER RECORD 03-29 12:04 TN05H130

PART NO	VEND NO	SER NO	LOT NO	RDI NO	ALOO	J351-2-8081	SEQ	0110	CAGE	N/A	REM:	CAT	F	CNT	I
2CSH51133-0001	EMC0001	NHA 2CSH40003		A4	2CSH60154-0001						00	10/03/06			
2CSH51133-0001	EMC0001	NHA 2CSH40003		A6	2CSH60156-0001						00	05/13/06			
2CSH51133-0002	EMC0002	NHA 2CSH40003		A5	2CSH60155-0001						00	05/14/06			

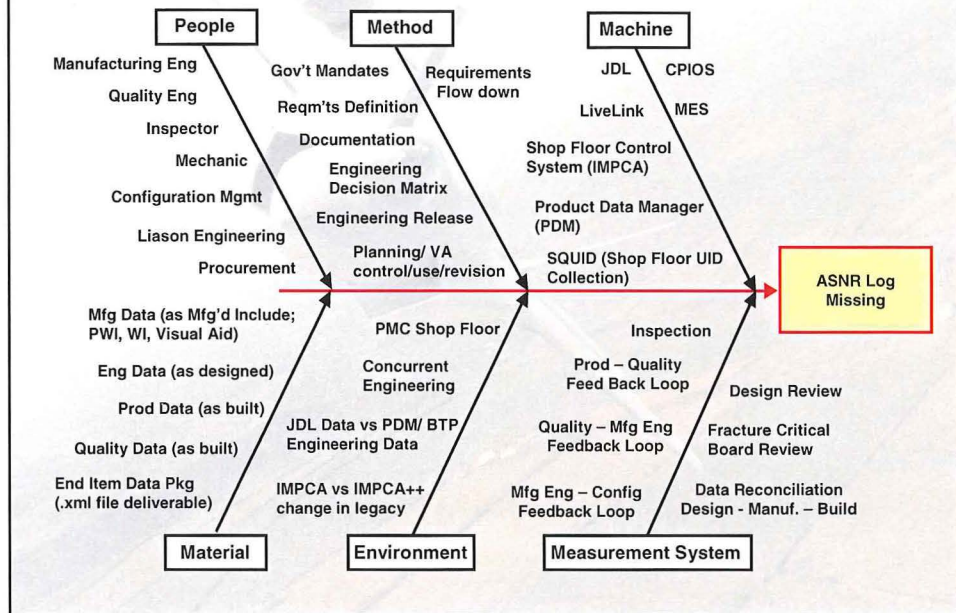
ENTER-ADD S/N F2-ASNR MAST F3-UPDATE F4-PRNT F6-HIST F8-REJ SCRN
 F5-QA CORR SF9-OVERRIDE P/N SFS-BUYOFF SF6-QA UNBUY SF8-RTRN TO QA
 MORE DATA EXISTS - PRESS PAGE DOWN KEY (18)

- ASNR screen for BF1; This is the all up viewed from QA screen
- Of the (9) ASIP parts requiring ASNR Log, (5) were correctly done while (4) are being investigated
- MESIP parts missing ASNR Log are still under investigation

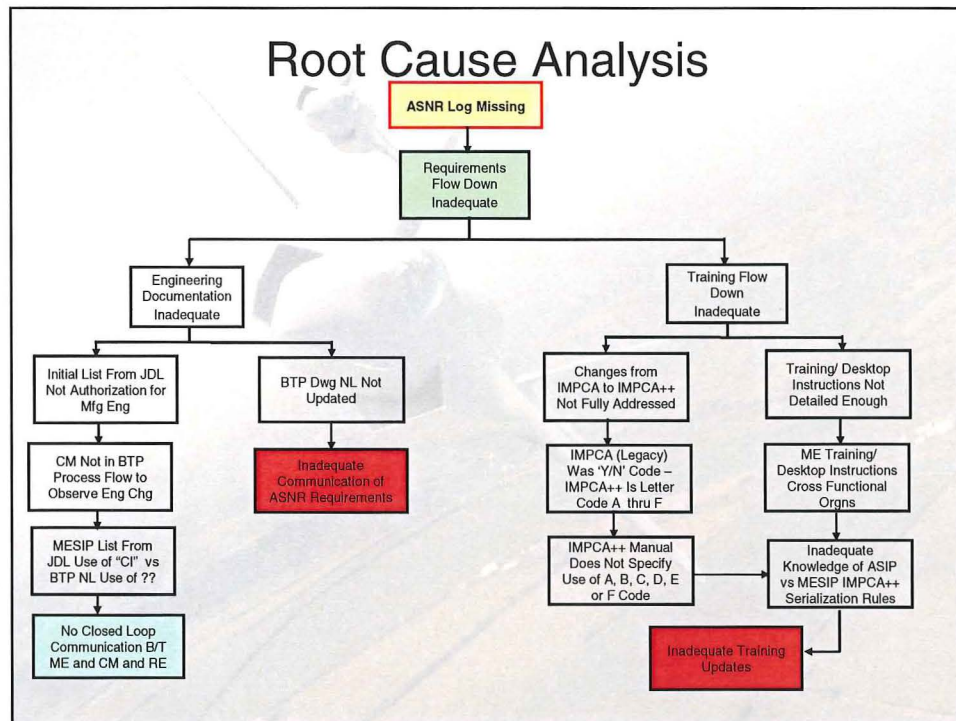
Immediate Corrective Action

- Quality Ensure Serial Numbers of Parts on ASIP and of Systems Parts Carrying Serial Numbers *Physically* Are Recorded on ALOO Face of Work Instructions if ASNR Log Does Not Exist at Time of Installation.
 - *Form 27-835 is Being Filled Out by QA if Work Instructions Call Out and Carry Recording on Face of ALOO Work Instructions*
 - *ME Ensure IMPCA is Functioning Appropriately for ASIP (FCT, SCT) Parts*
 - *QA Supply List of Serialized Parts for ASNR Master/ASNR Review*
 - *ME/ IT Drive Serialized Parts Data Back into .XML (As-Built BF1) File Using Excel Spreadsheet*
 - *ME/ CM Review BTP NL of (4) Missing ASNR Log Parts on BF1*

Cause and Effect Diagram



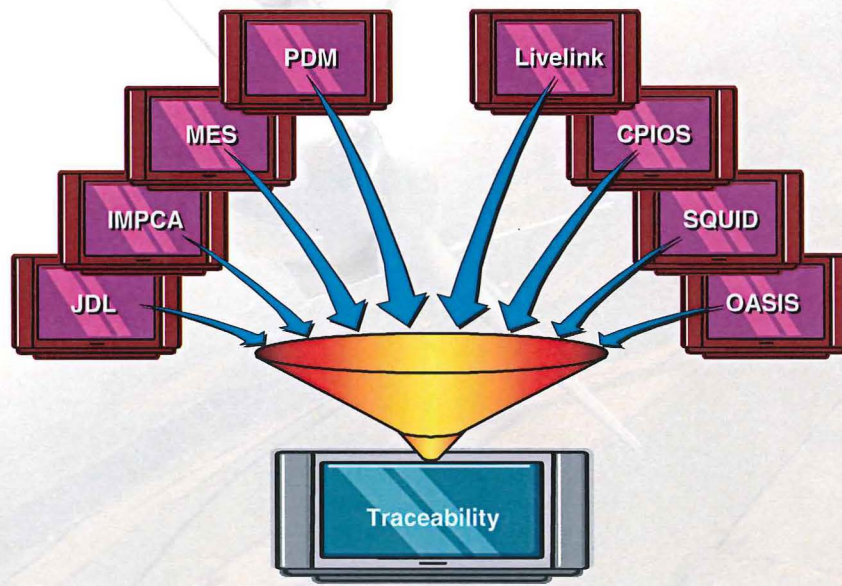
Root Cause Analysis



Meeting The Requirements

- Integrate all legacy databases and systems pertinent to traceability and UID and bring web capabilities using Java 2 Platform Enterprise Edition (J2EE) or Microsoft .NET framework.
- Provide a means of automatically identifying critical parts and parts requiring UID and tracking it throughout its build and installation process

Systems Integrated

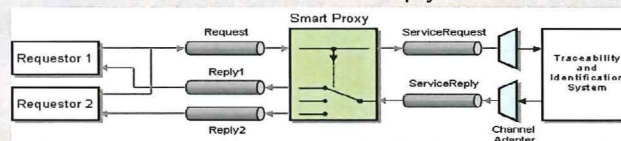


Key Features of System to Meet Requirements (1 of 2)

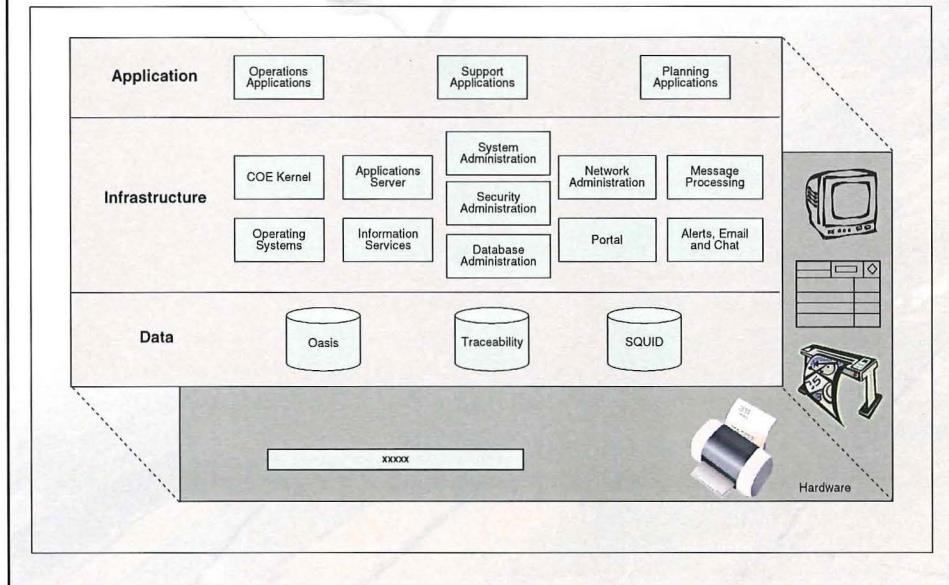
- Uses open standards
- Web-based and easily viewable
- Ties all legacy databases and systems
- Automatically produces an UID per DoD Flow matrix
- PC Based
 - PC processors have become fast enough to perform mainframe emulation
- N-Tiered
 - Any one tier can run an appropriate processor or operating system platform and can be updated independent of other tiers
 - More robust and eliminates single point of failure

Smart Proxy for Legacy System

- Many legacy systems were not built with features such as Return Address
- “wrap” access to the legacy system with a Smart Proxy
 - Enhances the basic system service with additional capability so that it can participate in a Service-Oriented Architecture.
 - Intercepts messages sent on the request channel to the Request-Reply service.
 - For each incoming message, the Smart Proxy stores the Return Address specified by the original sender.
 - It then replaces the Return Address in the message with the channel the reply channel that the Smart Proxy is listening on.
 - When a reply message comes in on that channel, the Smart Proxy retrieves the stored Return Address and uses a Message Router to forward the unmodified reply address to that channel.



N-Tiered, Service Oriented Architecture using Java



Key Features of System to Meet Requirements (2 of 2)

- **Web Based Service Oriented Architecture**
 - Respond quickly and cost-effectively to changing conditions
 - Simplifies interconnections to and usage of existing legacy systems
- **Use SQL**
 - Allow for automated database replication
 - High reliability
 - Highly secure
- **Virtual Private Network**
 - Ride on current NGC network using guard technology to communicate between Suppliers, Prime, Partners, and DoD systems.

System to Meet Requirements Risk

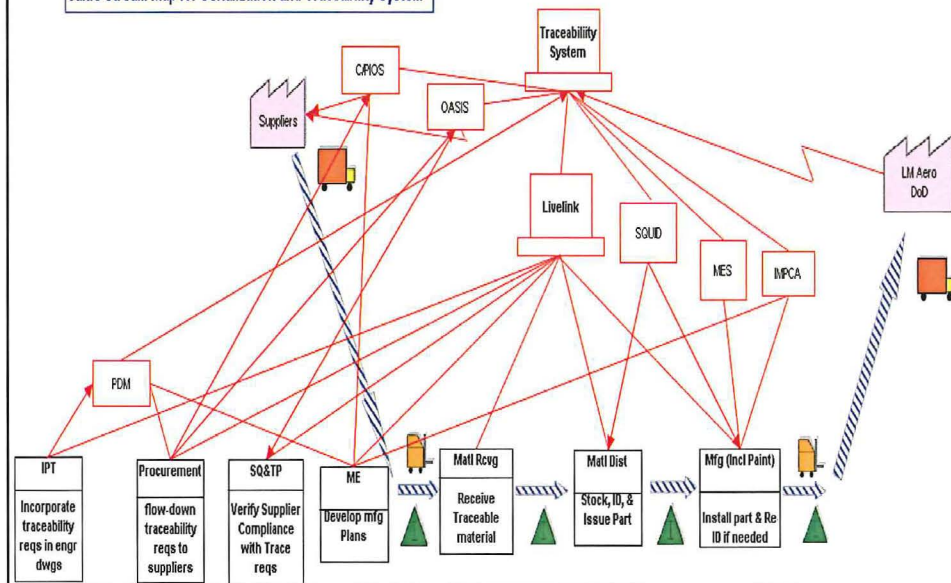
- Integration of legacy systems
- Reliability of Proposed System
- Security of Proposed System

Trade-Off

- System must meet three criterion:
 - Ensure that the part is marked per DoD mandates
 - Have the ability to track the parts and give it's current location
 - Give the history of all traceable parts from raw stock to final delivery. Final
- WhereNet System
- Lasers (Fiber vs. Diode)
- In-House vs. Contract

System to Meet Requirements

Value Stream Map for Serialization and Traceability System



System Interfaces

- Operate within the context of the Federal Enterprise Architecture
- Confirm to IEEE Std 1003.1-2001 as described in the Base Definitions volume of IEEE Std 1003.1-2001.
- Data sharing and application interfaces be accomplished through the use of a common service layer such as Data Access Agents (DAA).
- Interface Definition Language (IDL) scripts can be tailored to do specific tasks in order to implement the DAA through the use of Common Object Request Broker (CORBA).
- The capabilities that can be utilized for interfacing include the following:
 - Files (XML, CSV, etc)
 - Database Tables
 - Dynamic Data Exchange
 - Mail Messages
 - RS-232 Serial Communications
 - Import / Export Files
 - Dynamic Link Library
 - External Program Execution
 - FTP
 - TCP / IP Sockets
 - OLE Automation, ActiveX

Validation & Verification

- Test methodology should support a building block process for the integration of the systems.
- Serial approach with strict entrance and exit criteria building upon each other
 - Progress from unit-level testing through subsystems testing and into integration of third-party COTS products
 - Culminating in a system-level test incorporating all external interfaces.
- firm requirements baseline with clear measures of success for each test and each phase in the test process.
 - The tests should replicate the operational environment and run and pass at peak demands scenario prior to acceptance.
 - There should be strict entrance and exit criteria for each test
 - The baseline should be held firm and not change with software modifications
 - Live interfaces must be tested at both the functional and technical levels

Example of System for Meeting Requirements



NOC > Integrated Systems > Western Region > Western Region Master Scheduling > F-35
Search

F-35 Master Scheduling

February 19, 2007

B-2

F/A-18

F-5 / T-38

F-35

Fire Scout

Global Hawk

Targets

X-47B

MDay Calendar

Organization

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MS Home

SDD Schedules | LRIP Schedules

F-35 SCHEDULES

ITEM	DESCRIPTION
General Info	CPIOS parts numbers and model codes
PHDS	Delivery dates and critical path flow
Line Move Schedules	SWBS Start and Finish dates
Line Move Deltas	Start date delta to prior schedule
Paint	Paint Schedule
Historical Comparison	Rate Build Up Comparison
SDD Waterfall	F-35 SDD Center Fuselage Master Schedule
Traceability	
Load Dates By SWBS Positions NEW	SDD Jig Load Dates in Excel Format
Excel File	Print on 36" x 9.5" Paper Long Edge First 88% Normal Size
	Printing Directions
Generic Assembly Flow	
AA-1 8.5"x11"	
BF-1 to BF2 8.5"x11"	
BF-3 to AF-2 8.5"x11"	
AF-3 to BF-5 8.5"x11"	The SWBS dependencies and Tooling elements
CF-4 & On 8.5"x11"	
NGC to LMA 8.5"x11"	

NOC > Integrated Systems > Western Region > Western Region Master Scheduling > F-35
Search

F-35 Master Scheduling

February 19, 2007

B-2

F/A-18

F-5 / T-38

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Type	Version	Effectivity	Part No.	S/N	Criticality
	STOVL				
	CTOL				
	CV				

NOC > Integrated Systems > Western Region > Western Region Master Scheduling > F-35 Search

F-35 Master Scheduling

February 10, 2007

B-2

F/A-18

F-5 / T-38

F-35

Fire Scout

Global Hawk

Targets

X-47B

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Organization






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Locations

El Segundo
 902 Building
 2nd Floor, Col E50
 F-35 Building
 3rd Floor, Col C2,
 Cubicle 3W101

Palmdale
 Site 4
 Building 401; L25 Mezz

Type Version	Effectivity	Part No.	S/N	Criticality	
STOVL	BX-1	XXXX	XXXX	<input type="text"/>	
CTOL					
CV					
					
					

NOC > Integrated Systems > Western Region > Western Region Master Scheduling > F-35 Search

F-35 Master Scheduling

February 10, 2007

B-2

F/A-18

F-5 / T-38

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 902 Building
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 F-35 Building
 3rd Floor, Col C2,
 Cubicle 3W101

Palmdale
 Site 4
 Building 401; L25 Mezz

Type Version	Effectivity	Part No.	S/N	Criticality	
STOVL	Bx-1	XXXX	XXXX	<input type="text" value="Normal"/> <div style="border: 1px solid black; padding: 5px; font-size: 0.8em;"> Normal Fracture Durability Maintenance Mission Abort Safety of Flight </div>	
CTOL					
CV					
					
					

Part History

Part Num 2XXX00000-0001

Serial 20070213

Part Criticality Fracture

Effectivity BF1

Summary

Date		Dispo	Dept	Job Seq Num	Actv	Job
In -	Out				SSR	Oper
0329			L0XXXX	JXXX-X-XXXX	XXXX	0000
0230	0328		L0XXXX	JXXX-X-XXXX	XXXX	0000
0211	0229		L0XXXX	JXXX-X-XXXX	XXXX	0000
0201	0211		L0XXXX	JXXX-X-XXXX	XXXX	0000
0112	0201		L0XXXX	JXXX-X-XXXX	XXXX	0000

UID



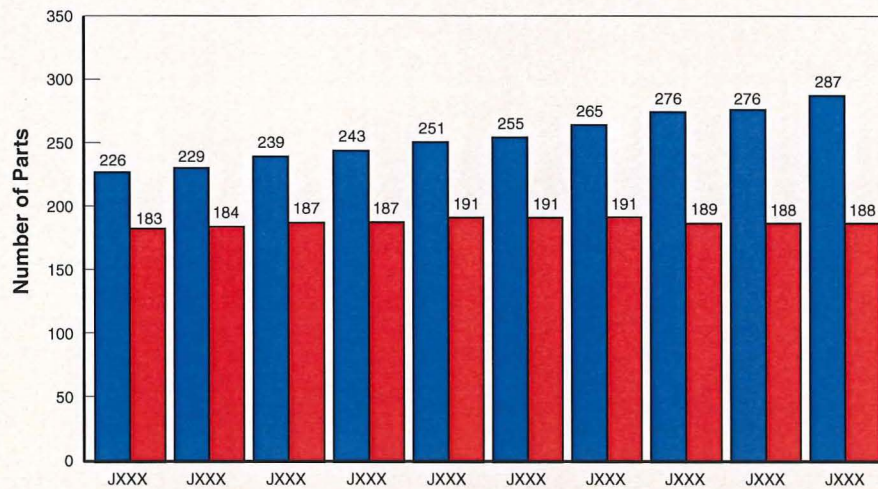
27-835

Reset

Air Vehicle Status

BG-1

Number of Parts Per Cost Center
Number of Parts Installed



Conclusion

- The issues facing Criticality Traceability came in many different forms and for varying reasons
- The current use of ad-hoc systems is not sufficient to ensure the capture of all critical traceable parts
 - 44 part numbers that were not accounted for and 20 that were not included in IMPCA
 - Currently there are 16 parts on air vehicle BG-1 that can not be located The proposed system has the ability of integrating legacy applications or presenting correlated data from distributed databases.
 - The system also brings capabilities such as managing workflows, increasing collaboration between work groups
 - Allow internal and external access to specific corporate information using secure authentication or Single-Sign-On.
 - Provide 100% traceability from raw stock to delivery

Reference (1 of 2)

STANDARDS AND GUIDELINES

- *IEEE guide for information technology-system definition-concept of operations (ConOps) document. IEEE Std. 1362-1998* New York: Institute of Electrical and Electronics Engineers, 1998.
- Koyanl, Sanjay J., Robert W. Bailey, Janice R. Nall, Susan Allison, et al. *Research-based web design & usability guidelines*. Washington, D.C. [?]: U.S. Department of Health and Human Services, 2003. Available at <http://usability.gov/pdfs/guidelines.html>
- W3C. *Web content accessibility guidelines 1.0* Cambridge, MA [?]: W3C, 1999. Available at <http://www.w3.org/TR/WCAG10/>
- *ATA Spec 2000* - Air Transport Association Spec 2000, Integrated Data Processing Materials Management
- *DFARS 252.211-7003(a)* - Item Identification and Valuation
- *ISO 15415* - Information technology — Automatic identification and data capture techniques — Bar code print quality test specification — Two-dimensional symbols
- MIL-STD-100 MIL-STD-130L, Change 1 – Department of Defense Standard Practice Identification Marking of U.S. Military Property

Reference (2 of 2)

NGIS DOCUMENTATION

- *Systems Engineering Instruction – Subsystem Equipment Criticality Management*, 8 June 2006
- *Systems engineering Instruction – Traceability of Air Vehicle Components*, 7 September 2006
- *Aircraft Structural Integrity Program (ASIP) Master Plan*
- *Mechanical and Electrical/Electronic Subsystems Integrity (master) Plan (MESIP)*
- *Safety Critical Functions List*
- *General Specifications for Control of F-35 Vehicle Critical Parts*, 17 October 2006
- *Subsystem Critical Parts List*
- JSF Durability and Damage Tolerance Control Plan
- *Business Area Procedure – F-35 Traceability of Critical Parts and Materials*, 22 June 2004
- *Business Area Procedure - Unique Identification of Aircraft Items*