Understanding and Complying with EEE Parts and Assembly Management Requirements

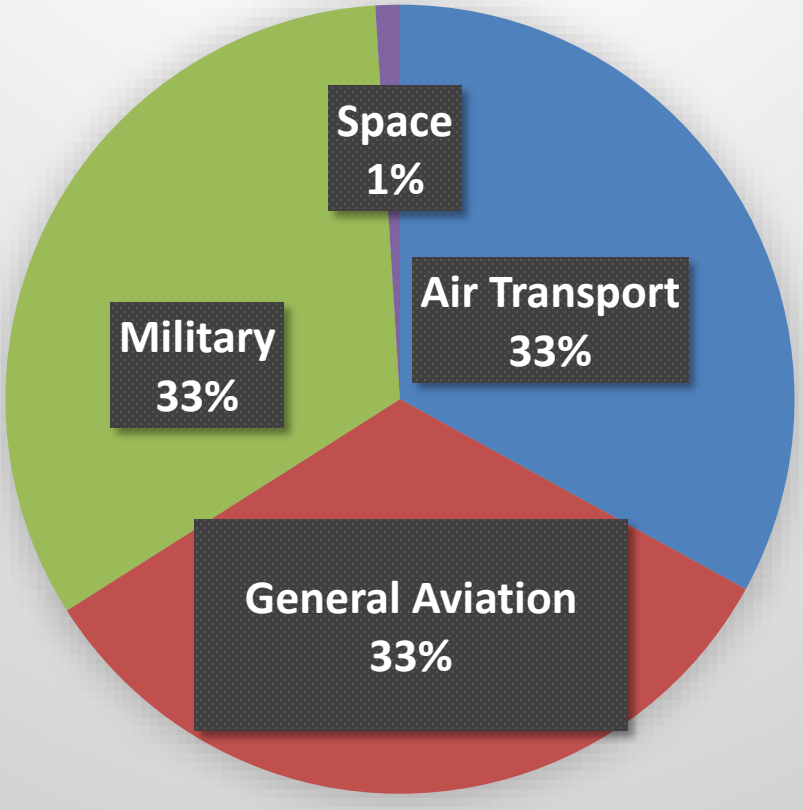
Parts Standardization and Management Committee

April 26, 2017

DfR Solutions

Avionics Market Segments

(Long Term Average)



Recent Technical Developments

- **Pb-free electronics is still an issue, but it's being managed**
  - *Similar to obsolescence*
- **Atmospheric radiation risks have increased**
  - *Single event latchup and other types of SEE*
  - *Multiple-bit and multiple-cell upsets*
  - *IEC 62396 series*
- **Microcircuit wearout requires attention**
  - *Publication of SAE ARP6338; Wearout*
  - *Publication of SAE ARP6379, Application-specific Qualification*
- **Counterfeit risks demand attention**
  - *48 CFR 252.246-7007 - Contractor Counterfeit Electronic Part Detection and Avoidance System*
- **AFE 75 has been completed**
- **Physics-of-failure methods are more critical, accurate, and easier to use**

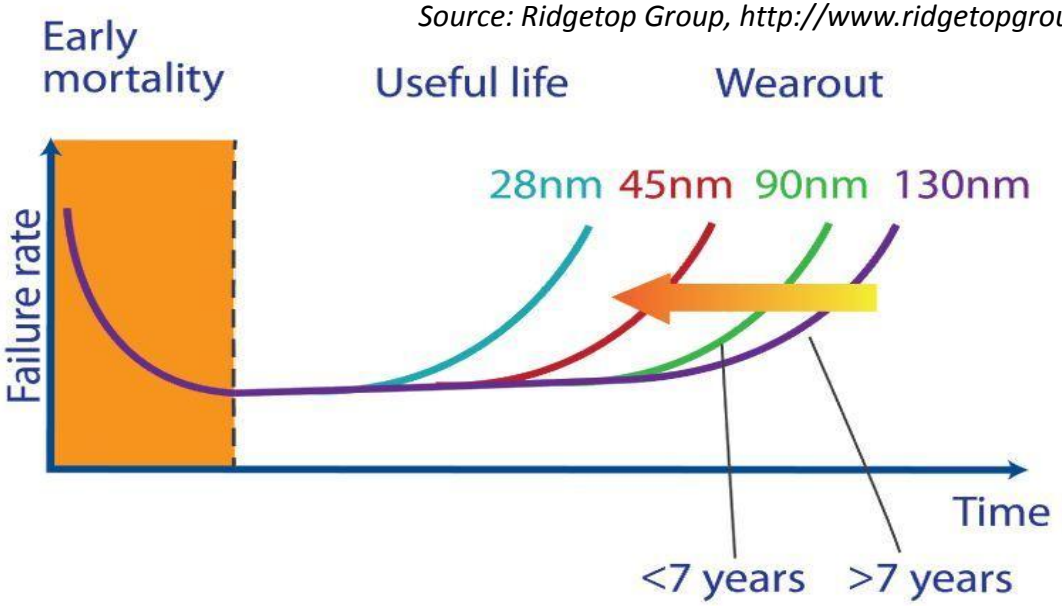
COTS AEH Issues and Emerging Solutions

AVSI AFE 75, Version 1.0b Date: 07 October 2014

1. COTS assemblies
2. Derating
3. Sparing reliability
4. Commodity memory
5. Atmospheric radiation
6. Life-limited semiconductors
7. Outdated reliability methods
8. Pb-free electronics
9. Errata
10. Counterfeit electronics
11. Undocumented features
12. Multiple, global electronics supply chain
13. Usage domain analysis
14. Production follow-up
15. Intellectual property
16. Unknow changes
17. Embedded controllers
18. Technology & component maturity
19. Component packaging and mounting
20. Device uprating
21. Additional handbook issues
22. Obsolescence management
23. Acceptable evidence for compliance
24. Multiple supply chains
25. Safe use of complex COTS in AEH
26. System-on-chip devices

Microcircuit Wearout

Source: Ridgetop Group, http://www.ridgetopgroup.com



Aerospace Applications often require 20+ year life

With semiconductor scaling, wearout is likely to occur earlier

Wearout Models (from AVSI 83)

	Model	Source	Comments
TDDB	$AF_{TDDB} = \left(\frac{A_1}{A_2}\right)^n \left(\frac{V_{gs1}}{V_{gs2}}\right)^\gamma e^{\left(\frac{E_a}{k} * \frac{T_1 - T_2}{T_1 T_2}\right)}$	AFE 17	Same as NBTI (power law for V); simpler than AFE17 equation (excludes additional T-dependency); Added area scaling Default Model
EM	$AF_{EM} = \left(\frac{J_1}{J_2}\right)^n \left(\frac{f_1}{f_2}\right)^n \left(\frac{V_{dd1}}{V_{dd2}}\right)^\gamma e^{\left(\frac{E_a}{k} * \frac{T_1 - T_2}{T_1 T_2}\right)}$	AFE17	Same form as NBTI (power law for V), but adds frequency dependence. Added current density scaling Default Model
HCI	$AF_{HCI} = \left(\frac{DC_1}{DC_2}\right)\left(\frac{f_1}{f_2}\right)^n e^{\left(\gamma * \frac{V_{ds1} - V_{ds2}}{V_{ds1} V_{ds2}}\right)} e^{\left(\frac{E_a}{k} * \frac{T_1 - T_2}{T_1 T_2}\right)}$	AFE17	Inverse exponential V acceleration; Includes missing frequency dependence from AFE17 equation. Added duty cycling Default Model
NBTI	$AF_{NBTI} = \left(\frac{DC_1}{DC_2}\right)\left(\frac{V_{gs1}}{V_{gs2}}\right)^\gamma e^{\left(\frac{E_a}{k} * \frac{T_1 - T_2}{T_1 T_2}\right)}$	AFE17	Same form as TDDB (power law for V); Added duty cycle scaling Default Model

"All models are wrong, but some of them are useful."
- Ralph Evans, former editor of *IEEE Transactions on Reliability*

Physics-of-failure Methods

- PoF methods have been around since the beginning of the solid state era
    - Many of the models and methods were developed at Bell Labs in the 1970s
    - “Automation” by finite element analysis began in the 1980s
- Aerospace has been skeptical of PoF (still not implemented widely)
- Testing and acquiring in-service data for each application are becoming cost-prohibitive (need to leverage across multiple applications)
- PoF tools (e.g., Sherlock) are becoming more accurate, easier to use, and more widely accepted in high performance industries
- PoF can help avionics OEMs and supply chains in qualifying and using COTS EEE parts and assemblies
- IPC is developing a standard to leverage PoF to satisfy reliability and qualification requirements more cost-effectively, and efficiently

The problem is……

- Manufacturers of electronic equipment and systems for the aerospace, defense, and high-performance (ADHP) industries must use EEE parts and sub-assemblies targeted for other markets.
- The other-market requirements typically are not as rigorous as ADHP, e.g., rugged environments, long lifetimes, high consequences of failure, configuration control, etc.

Therefore……..

ADHP manufacturers must develop and document processes to assure reliable performance of parts and sub-assemblies in ADHP applications

The good new is……..

The aerospace industry has developed a standards-based system to provide the necessary assurance.

MIL-STD-3018

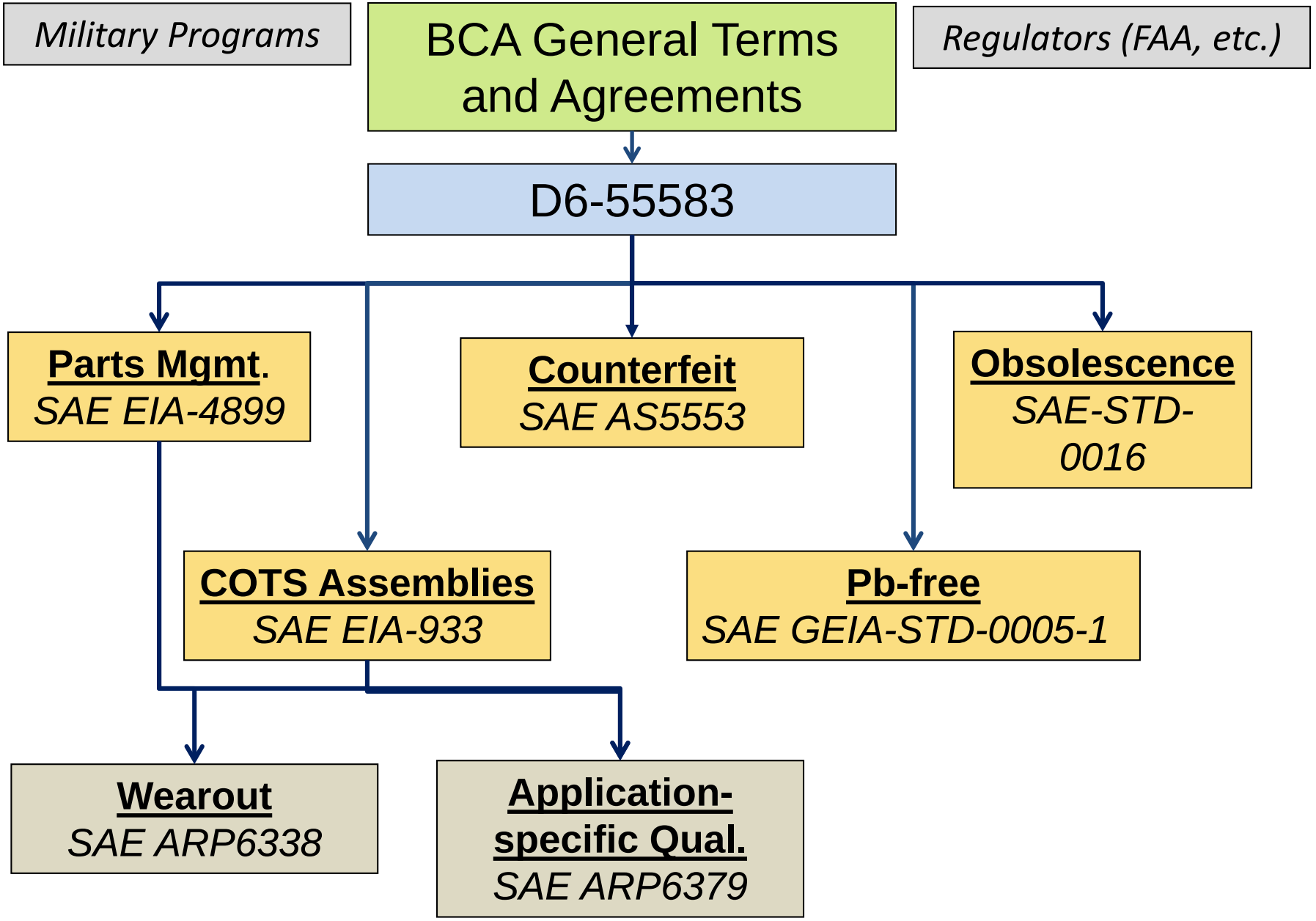
GENERAL REQUIREMENTS

4.1 Parts Management Program. A parts management program that meets the objectives of paragraph 1.2 shall be implemented. The comprehensive PMP encompasses the total complex of organizations, processes, and other elements involved in the cradle-to-grave management of parts. It includes choosing, designing, acquiring, stocking, requisitioning, moving, managing, issuing, and using weapon system parts across DoD and industry. When this document is used in conjunction with SD-19, "Parts Management Guide", it outlines parts management needs in contracts, parts management processes for prime contractors, suppliers, and subcontractors. General responsibilities for the contractor are identified below.

4.2 Parts Management Plan. A parts management plan responsive to the request for proposal (RFP) shall be provided. The plan shall address program management, Government participation, and parts selection throughout the system life-cycle. The contractor may include consideration of the concepts addressed in AIAA-R-100* and **SAE EIA-STD-4899.** The contractor shall work with the AA to implement contract requirements and support the efforts of the program. The selection and application of parts are the responsibility of the contractor whose primary requirement is to meet performance objectives of the system or equipment. PMAT (see 3.15) will be available, if needed, to advise and provide recommendations on parts management plans and processes, and on the selection and use of preferred standard and commonly used parts. Points of contact for these efforts are identified in http://www.dscc.dla.mil/programs/pmatdir/.

**Rev A, January 1, 2001*

Boeing Commercial Airplanes Document Tree



Evolution of D6-55583

Rev.	Date	Implemented by	Requirements	Industry Stds.	Verified by	Flow-down
New	1991	SCD, AA, SOW, etc.	Parts mgmt.			
A	1996	SCD, AA, SOW, etc.	Parts mgmt.			
B	1997	SCD, AA, SOW, etc.	Parts mgmt.			
C	2011	SCD, AA, SOW, etc.	1. Parts mgmt. 2. Counterfeit 3. Pb-free	1. IEC TS 62239-1 2. SAE AS5553 3. GEIA STD-0005-1	1. IECQ 2. Boeing 3. Boeing	Yes
D	2013	SCD, AA, SOW, GTR, etc. *(equipment)* GORD *(business unit)*	1. Parts mgmt. 2. Counterfeit 3. Pb-free 4. Obsolescence	1. IEC TS 62239-1 or SAE EIA-4899 2. SAE AS5553 3. SAE STD-0005-1 or IEC TS 63647-1 4. SAE STD-0016	1. IECQ 2. Boeing 3. Boeing 4. Boeing	Yes
E	2016	GTA *(monitored by SM)*	1. Parts mgmt. 2. Counterfeit 3. Pb-free 4. Obsolescence 5. COTS Ass'y.	1. SAE EIA-4899 2. SAE AS5553 3. SAE STD-0005-1 4. SAE STD-0016 5. SAE EIA-933	1. Boeing 2. Boeing 3. Boeing 4. Boeing 5. Boeing	Yes *(rigorously enforced)*

D6-55583 Requirements:

All Suppliers delivering Products containing EEE components shall develop and implement Plans compliant to:

Parts Management

SAE EIA-STD-4899, *Requirements for and Electronic Components Management Plan*

COTS Assembly Management

SAE EIA-933, *Requirements for a COTS Assembly Management Plan*

Lead-free Electronics Management

SAE GEIA-STD-0005-1, *Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder*

Counterfeit Parts Control

SAE AS5553, *Fraudulent/Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition*

Obsolescence Management

SAE STD-0016, *Standard for Preparing a DMSMS Management Plan*

Responsibilities of the Item Integrator

Prepare a Plan that documents processes that satisfy the requirements

Develop (if needed) and document processes that satisfy the requirements, including

- Flow down the requirements to all suppliers within Plan owner control, or
- Verify "acceptability" of items from suppliers below the flowdown limit

Verify that the Plan satisfies the requirements

- 2nd party approval for "specific" customers, or
- 3rd party certification for "generic" customers

Implement the documented processes on an ongoing basis

- 2nd party (customer) surveillance, or
- 3rd part surveillance, e.g., AS9100, IECQ, PRI

Electronic Parts Management

D6-55583, rev E, October 5, 2016

Introduction

The intent of this document is for Suppliers to define, document and implement Plans to manage EEE parts and commercial-off-the-shelf (COTS) assemblies that ensures Boeing Commercial Airplanes (BCA) cost-effective, functional, and reliable electronic equipment. The Suppliers are responsible for defining and implementing the requirements that are documented in their Plans.

Purpose

The purpose of this document is to specify Supplier Electronic Parts and COTS Assembly Management requirements.

Scope

This document applies to all EEE Parts and COTS Assemblies installed in BCA products.

What is a Plan?

- Documents the Plan Owner's process to satisfy a specific list of requirements
- Is not program-specific
- Is developed and implemented at the business unit level
- Is approved by the customer at the business unit level

3 TECHNICAL REQUIREMENTS

An Electronic Components Management Plan, hereinafter called the "Plan", compliant to this document ***shall*** include documented processes that are available for use by the Plan owner to accomplish the requirements of this clause. These requirements apply to all electronic components, including COTS, custom, and subcontracted components.

SAE EIA-4899B, Parts Management

3 TECHNICAL REQUIREMENTS

3.1 Component Application

The documented processes ***shall*** assure that the electronic component performs the function(s) allocated to it by the application design, reliably throughout its manufacturing, operating, storage, and transportation lifetime, using appropriate risk mitigations when required. Allocated functions include, but are not limited to, inputs and outputs for electrical, electronic, electromechanical, electro-optical signals, duty cycle, etc.

3.1.1 Operating, Storage, and Transportation Environmental Stresses

The documented processes ***shall*** assure that the electronic component satisfies its application requirements with respect to each of the manufacturing, operating, storage, and transportation stresses listed below, using appropriate risk mitigations as required.

(Following is a list of specific environment conditions, e.g., temperature limits, temperature variations, mechanical shock, mechanical vibration, natural radiation, etc.)

(EIA-4899 does not list specific parameters for the environmental conditions. The requirement is for a Plan that documents processes to understand program-specific environmental conditions, and verifies performance and reliability of the system in those conditions.)

SAE EIA-4899B, Parts Management

3.2 Component Selection

3.2.1 Component Specification

3.2.2 Component Availability

3.2.3 Standardization

3.2.4 Qualification

3.2.5 Reliability

3.2.6 Life-limited Components

3.2.7 Component Manufacturer and Distributor Quality System

3.2.8 Component Manufacturer Process Management

3.2.9 Using Components Outside the Manufacturer's Specified Temperature Range

3.2.10 Derating

3.2.11 Compatibility with Assembly/Manufacturing Processes

3.2.12 Maintainability and Testability

3.2.13 Materials

3.2.14 Lead-free Finishes

3.3 Component Life Cycle Management

3.3.7 Configuration Management

“It’s COTS, and I can’t be expected to assure its configuration, or its performance, or its reliability, or…….”

Is <u>not</u> an acceptable EEE Parts and sub-assembly management Plan

COTS Assembly Management, SAE EIA-933

For Each EEE Part or Assembly….

1. *Understand the System requirements allocated to the item.*
2. *Understand the capability of the "as-received" item, with respect to the allocated System requirements;*
3. *Prepare a System risk analysis, based on a comparison of (1) and (2); and*
4. *Document appropriate risk mitigation methods to assure that the item accomplishes its allocated System requirements reliably throughout the specified system lifetime.*

The application requirements……can be satisfied only by the integrator of the item; they cannot be flowed down to a supplier, subcontractor, or other organization that is not responsible for the integration of the item into the system.

The Hard Parts

- **Qualification**
  - Parts: SAE EIA-4899
  - Assemblies: EIA-933
  - Application-specific (see SAE ARP6379), based on
    - Credible data (in-service, testing, etc.)
    - Rational analysis (acceleration models)
    - Responsible conclusions
- **Configuration control (mostly due to obsolescence)**
  - Know when configuration changes
  - Know if the changes impact the performance or reliability of the item in the application
  - Qualify replacement item(s)
- **Flowdown to sub-tier suppliers**

Qualification of Parts or Sub-assemblies at the Box Level?

Options:

1. No!!!!!
2. Qualification test
3. Enhanced Qualification Test
   - Use process of (SAE ARP6379)
   - Conduct PoF analysis to assure that parts or assemblies are stressed adequately
   - Increase stress level
   - Increase stress time
   - Conduct wearout analysis (SAE ARP6338) for advanced-technology microcircuits

Configuration Control

SAE EIA-4899, ECMP

3.3.7 Configuration Management

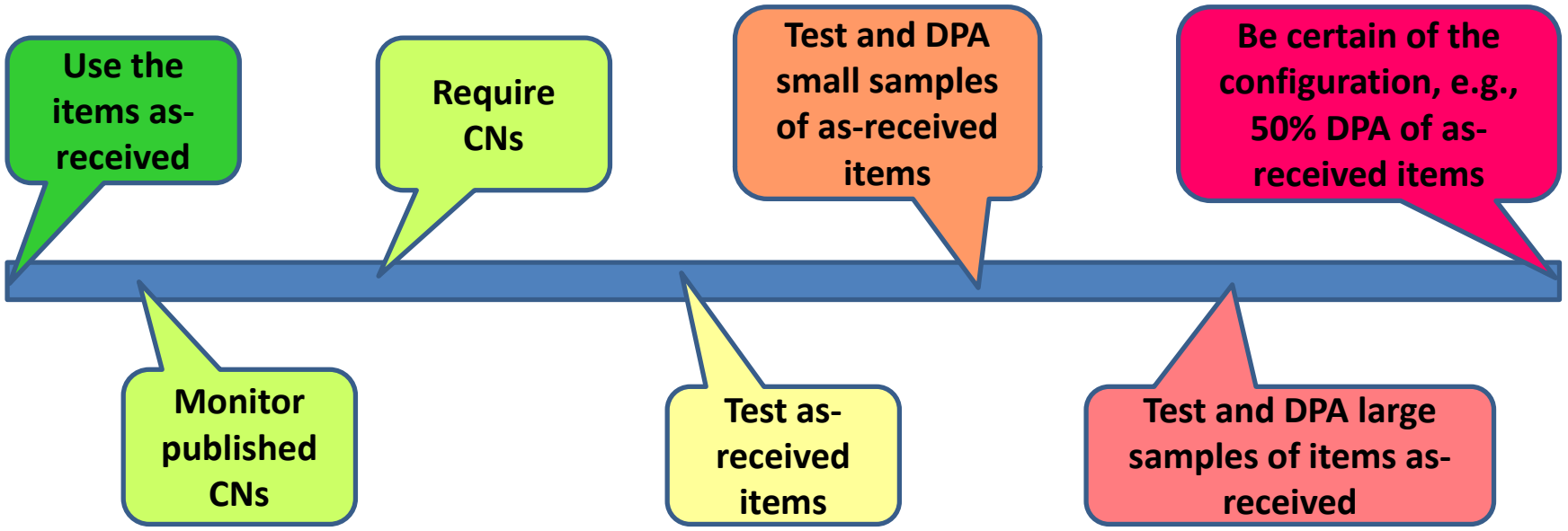
The documented processes ***shall*** assure that the equipment configuration is maintained relative to the component usage in the application, including a controlled parts list for each assembly and documentation of all changes.

SAE EIA-933, COTS Assemblies

3.10 Configuration Control

The documented processes ***shall*** assure that the configuration control processes and requirements used for the as received COTS assembly, including all internal parts and materials, are consistent with System requirements, using appropriate additional processes as required.

The Configuration Management Spectrum



Documented processes:

- **Identify the required location on the spectrum for each application**
- **Define how configuration control is maintained for each identified location**

The actions shown in the callouts are only examples; other actions are encouraged, as needed.

Flow Down

Boeing D6-55583

2.6 Flow down. If part or all of Supplier equipment is designed or manufactured by subcontractors, the Supplier shall document that the equipment complies with each of the requirements herein, as follows:

2.6.1 Electronic Components. Compliance shall be obtained by one of the following, in order of preference:

(a) The supplier flows down the requirement for all subcontractors to manage the EEE components according to an ECMP that conforms to the current revision of SAE EIA-STD-4899;

(b) The supplier verifies all subcontractors' products satisfy the requirements of the current revision of or SAE EIA-STD-4899.

2.6.2 Counterfeit Electronic Parts *(language above is repeated)*

2.6.3 Pb-free *(language above is repeated)*

2.6.4 Obsolescence *(language above is repeated)*

2.6.5 COTS Assemblies *(language above is repeated)*

EIA-4899

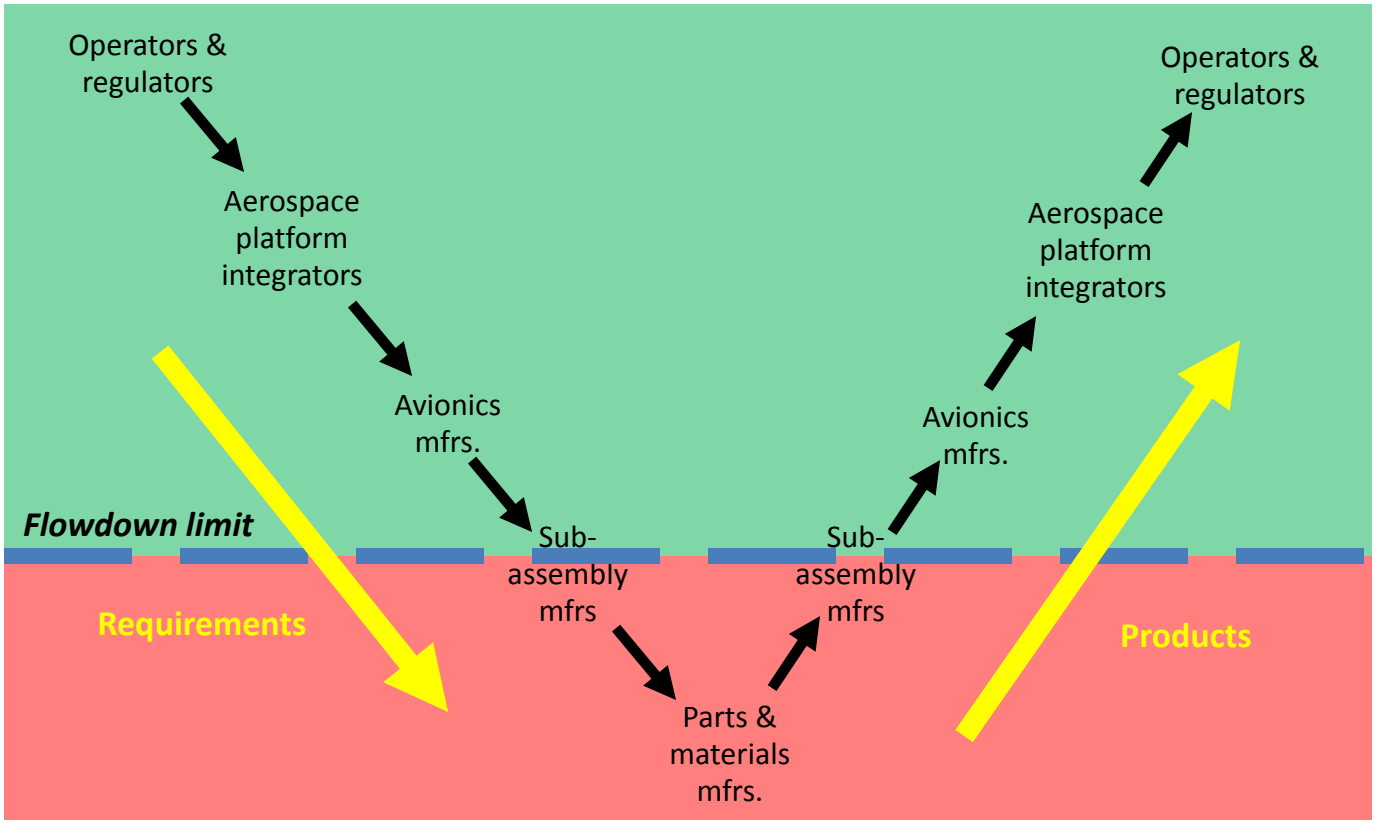
3.4 Subcontractor Management

The documented processes ***shall*** assure that all components supplied by subcontractors satisfy the requirements of the application and this Standard.

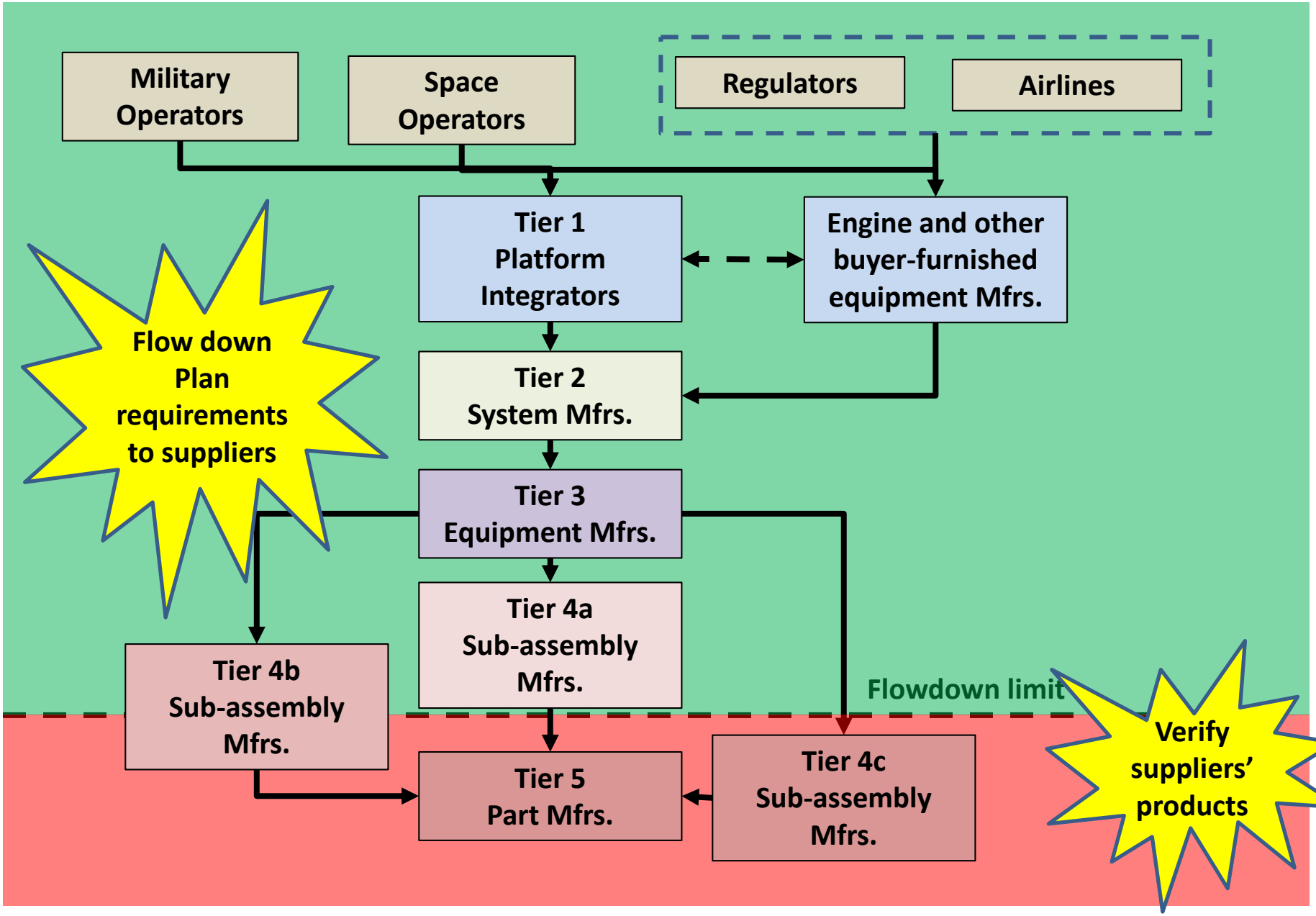
The documented processes ***shall*** assure the flow down of all applicable requirements of this Standard to the lowest applicable tier and verification of compliance.

Requirements and Products Flow

The system engineer's view of the supply chain



Another View……



Does Your Supply Chain…..

- Have documented processes that satisfy the industry standards for parts management, COTS assembly management, obsolescence management, counterfeit parts control and Pb-free electronics management?
- Understand the disciplines associated with qualifying COTS EEE parts and assemblies for ADHP applications?
- Know how to manage configuration of COTS EEE parts and assemblies in ADHP applications?
- Know how to flow down these requirements to their suppliers?
- Know how to verify acceptability of items obtained from suppliers below the flowdown limit?

Synergy - Leverage

- Requirements/needs are roughly the same across all military/aerospace market segments
- The supply chain is roughly the same for all market segments
- We are already leveraging this commonality (somewhat)
- How can we accelerate it