FAS Information Paper

Information Paper Number	Revision:	Revision Date:	Originator:	Participants:	Technical Group (if applicable):
IP #1000	P	August 2014	N/A	N/A	

Email:	Phone:
N/A	N/A

Issue Comment#: #4	Indicate DO/ED Document
Indicate DO/ED Document ____ DO-178C/ED-12C: SW Airborne Sys & Equip ____ DO-278A/ED-109A:SW (CNS/ATM) Systems __X_ DO-248C/ED-94C: Supporting Information	____ DO-330/ED-215: Software Tool Qualification Considerations ____ DO-331/ED-218: Model Based Development & Verification Supplement ____ DO-332/ED-217: OO Technology and Related Techniques Supplement ____ DO-333/ED-216: Formal Methods Supplement ____ Other

URL to Original Issue Comment: http://www.faaconsultants.com/FAS/IP/List.asp

Information Paper Title:

Parameter Data Item Clarifications

Abstract: This IP clarifies the intent of the definition and scope of Parameter Data Items in ED-12C/DO-178C, to indicate which types and aspects of PDI are reviewed for DO-178C compliance as part of the certification or TSOA/ETSOA process, and which aspects are reviewed for compliance during the manufacturing process. This clarification is accomplished through a revision to DO-248C/ED-94C.

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Acronyms:

AC	Advisory Circular
CRC	Cyclic Redundancy Check
DP	Discussion Paper
FADEC	Full Authority Digital Electronic Control
FAS	Forum on Aeronautical Software
FAQ	Frequently Asked Question
N1	Engine Rotor Speed
PDI	Parameter Data Item
SAS	Software Accomplishment Summary
SCI	Software Configuration Index
TSOA	Technical Standard Order Authorization

Background:

The FAS group monitors and exchanges information on the application of the following “software document suite” that was developed by joint RTCA/EUROCAE committee SC-205/WG-71:

- DO-178C/ED-12C - Software Considerations in Airborne Systems and Equipment Certification
- DO-278A/ED-109A - Software Integrity Assurance Considerations for Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) Systems
- DO-248C/ED-94C - Supporting Information
- DO-330/ED-215 - Software Tool Qualification Considerations
- DO-331/ ED-218 - Model Based Development & Verification Supplement
- DO-332/ED-217 - Object Oriented Technology and Related Techniques Supplement
- DO-333/ ED-216 - Formal Methods Supplement

The goals of the FAS are as follows:

1. To share lessons learned in the use of the RTCA/EUROCAE “software document suite” and to encourage good practices and promote the effective use of RTCA’s and EUROCAE’s publications.
2. To develop and revise Frequently Asked Questions and Information Papers (IPs) relative to RTCA’s and EUROCAE’s publications or other related aeronautical software industry topics.
3. To identify and record any issues or errata showing the need for clarifications or the need for modifications to the “software document suite”.

This IP proposes to add further clarifications in DP#20 of DO-248C/ED-94C.

Clarifying Text:

4.20.9 DO-178C/ED-12C are recognized under the aircraft certification process (for example, AC20.115C and AMC20.115C). DO-178C/ED-12C compliance is determined as part of that certification process. DO-178C/ED-12C provides guidance related to Parameter Data Item Files. In some cases, however the contents of the PDI file are populated after certification (and after DO-178C/ED-12C compliance is determined), during the manufacturing process or maintenance process (to ease the understanding, we will always use "manufacturing process" in the rest of this paper). The problem statement is "how can compliance with DO-178C/ED-12C objectives A-5, 8 "Parameter Data Item File is correct and complete" and A-5, 9 "Verification of Parameter Data Item File is achieved" be determined if the PDI File is not yet populated at time of certification?

Introduction

When might an instance of PDI be populated?

In some cases, the contents of the PDI file are populated as part of the software development process that results in a certification or TSOA. In other cases, the contents of the PDI file are populated after certification or TSOA is completed.

In any case, the activities linked to the creation and verification of a PDI file should be planned according to ED-12C/DO-178C section 4.2. The requirement, integration, verification, configuration management and quality assurance processes should follow respectively sections 5.1, 5.4, 6.6, 7 and 8 of ED-12C/DO-178C.

Examples

The following examples highlight various processes to develop, implement and verify PDI. They are real life examples gathered from the Industry; some examples are very detailed and others give only an overview of the process used.
All of them are given only for information and are not intended to provide any guidance or direction on how to develop and verify PDIs.

Case 1 PDI file populated prior to certification

The PDI files that define the data parameters transmitted and received by components communicating over a data bus are typically populated during the software development process, and therefore compliance to the requirements for the data content can be verified prior to certification. The verification of the contents would be captured in Verification Results and summarized in the Software Accomplishment Summary. In this case, a change to the contents of the PDI file would require a Change Impact Analysis, re-verification and a re-certification.

Case 2 PDI file populated after certification

PDI files are used to calibrate equipment or to adapt equipment to a specific system installation, such as to:

- Define input/output routing
- Identify types of sensors connected
- Identify types of optional equipment installed
- Select options to enable/disable software functions

In this case, only the PDI structure is defined prior to the certification or TSOA. In this second group of examples, the contents of the file might be populated during product manufacture, during aircraft manufacture, or even by the aircraft operator after they receive the aircraft.

A few examples of this case, among others, are:

Example 1 PDI File populated during product manufacture

An example is the configuration files that capture calibration data for products during their manufacture. The contents of the file are potentially different for each product serial number manufactured. The structure of the file is captured during the certification or TSOA process, and software requirements are defined and executable code implemented to interface with the PDI file. However, the contents of the PDI file might be developed after the SAS is released for the initial certification or TSOA has been generated and approved. Therefore, the generation and verification of the contents of these files need to be approved as part of the manufacturing process. Typically this data, if incorrect, can have a safety effect, so it cannot be classified as User Modifiable Software or Data. Examples of this scenario are provided below:

Example 1.1

An example is an engine control system that is designed with a strain gauge pressure sensor to measure ambient pressure for accurate engine fuel flow calculations. The software is Level A and errors in the sensor can cause an engine flame-out. The pressure sensor is temperature and pressure calibrated during manufacturing of the FADEC. The software was designed to have a temperature/pressure lookup map loaded into flash memory to provide the required accuracy to meet the product specification. The software requirements specify the map size and value ranges for verification of the design robustness. The hardware design specification and software design are coordinated so the software meets the expected adjustment range. The certification process is based on these flexible map criteria, but no actual Parameter Data Item file could be assessed at certification time (however one or several Parameter Data Item file(s) is(are) populated at certification time, to allow verification of the operational software). Since there could be hundreds or thousands of possible different trim files, it would not be feasible to create all of them in advance. Therefore they are not part of the SCI and are not listed in the Software Accomplishment Summary. The data is loaded as part of the FADEC manufacturing process and checked as part of the product acceptance test. The actual values of the PDI file are not part of the design data but are instead treated as manufacturing data.

Example 1.2

An example is a hydro mechanical fuel control that has specific accuracies with respect to fuel valve command versus actual fuel flow delivered. This relationship is also a function of ambient pressure and fuel temperature. The fuel control hardware contains a flash chip that holds the lookup maps. The chip is read by the FADEC. Like the data in example 1.1, this data is manufacturing data that is verified and stored with the other production data.

Example 2 PDI File populated during aircraft manufacture

An example is the configuration files that capture rigging data or the aircraft configuration during the manufacture of an aircraft. As with examples above, the contents of the file are potentially different for each aircraft serial number. The generation and verification of the contents of these files are outside the scope of the aircraft certification. There are cases where this data, if incorrect, can have a safety effect, so it cannot be classified as User Modifiable Software or Data. An example of this scenario is provided below:

A flight control system has rigging data in a PDI file that is calculated and loaded during the aircraft manufacturing process. Although the executable object code of the flight control system typically has validity checks for the data, an error in the data within the valid ranges could have safety effects. Typically, the flight control system manufacturer would execute the process for generating the file, but the aircraft manufacturer would be responsible for

the verification, configuration management and quality assurance processes for the file.

Example 3 Engine Maintenance Implementation

The PDI file is loaded into an engine configuration plug. This type of data can be utilized by an engine control, and is loaded into the control or a memory device that is directly used by the control. This engine configuration plug is a memory device that remains with the engine even if the controls are replaced. When maintenance activities are performed on the engine, the PDI files may be updated to reflect normalized thrust settings, thrust ratings, or other parameters. When the PDI file generation and load process is performed in service use, the process is controlled via an approved configuration method such as a Service Bulletin.

PDI files generated during maintenance and loaded to engine configuration plugs contain data such as:

- Thrust ratings
- Engine configuration selections
- Engine Serial Number
- N1 rotor speed or Engine Pressure Ratio thrust trims

Example 4 Aircraft Manufacture Implementation

This example has been successfully used by an aircraft manufacturer during their manufacturing process. It is provided here as one means of managing PDI files populated during the manufacturing process. As the manufacturing process is outside the scope of DO-178C/ED-12C, it is not intended to prescribe a process or data items contents.

a. The PDI file is specified, developed and verified and is established following a planning document describing:
    i. The allocated software level of the file.
    ii. The means and rules applied to identify the PDI file.
    iii. The architecture of the system/equipment that receives the PDI file.
    iv. The list and description of the configurable functions/parameters.
    v. The means used to ensure compatibility between the PDI file and the application using it.
    vi. The means used to control the integrity of the PDI file.
    vii. The sharing of responsibility between the aircraft manufacturer and the equipment supplier.

viii. The PDI Life Cycle for each PDI file (specification, design, verification for the first instance of the PDI file and each subsequent instance)
ix. The reuse of any already approved PDI file.
x. The process applied to load a new PDI file.

b. The activities described in the Planning document are tailored according to the allocated software level of the file. The impact on the following is substantiated:
   i. Integrity check (such as checksum or CRC) of the file loaded into the system.
   ii. Level of verification and related independency constraint
c. This planning document constitutes a compliance document agreed with the Certification Authorities.
d. A unique specification is established for each PDI file. This specification is manually verified against the requirements (for the aircraft configuration ordered by the customer) and against the Parameter Data structure and rules/attributes (e.g. Parameter Data range, possible incompatible combination of parameters).
e. The PDI file is developed with tools for generating a loadable file. Depending on the project, tools are qualified in compliance with the applicable ED-215/DO-330 Tool Qualification Level.
f. The PDI file is verified during the system tests of the new installation.
g. The verification activities are recorded in a document containing:
   i. The Customized PDI file specification
   ii. The Compatibility matrix between the PDI file and the hardware/software equipment configuration
   iii. The PDI file Verification procedure and results
   iv. The Identification of the PDI file
   v. This document is a compliance document agreed with the Certification Authorities.

Clarifications

Clarification 1

In the case where a PDI file is populated after certification that has a potential safety impact if incorrect, the PSAC and SAS should identify the aspects of the PDI that will be managed by the software process, and those which will be handled by another process, such as the manufacturing process. The structure and attributes of the PDI should be defined during the software development, while the values of the PDI elements will be defined during the manufacturing process. The software plans should define the processes for compliance to ED-12C/DO-178C Objectives A5-8 and A5-9 that will be used during manufacturing, and describe how these processes will be communicated to the manufacturer. As the processes communicated to the

manufacturing process are part of the software plans, they will be subjected to review (4.1f) and be part of the certification process (9b). The Software Accomplishment Summary should indicate compliance to objectives A5-8 and A5-9 for the instances(s) of the PDI files that were generated and verified during development, describe how the processes will be communicated to the manufacturing process, and state that the manufacturer will need an equivalent and approved manufacturing process to populate and verify the contents of instances of the PDI files generated during manufacturing. This equivalent and approved manufacturing process is not further approved in this document as it is outside the scope of DO-178C/ED-12C compliance, aircraft/engine certification and TSOA.

Clarification 2

If the processes and/or tools used to verify the PDI files during manufacturing were approved under ED-12C/DO-178C, then any proposed changes to these processes and tools would need to be evaluated under ED-12C/DO-178C processes and re-approved. This could include re-qualification of the tools. Refer to ED-215/DO-330 section 11.2.3 for guidance on changes to previously qualified tools.

Clarifying Text:

4.20.10 Is User Modifiable Software guidance applicable to PDI when populated during product manufacture, during aircraft manufacture, or even by the aircraft operator?

Answer:
The PDI files may be populated by the product manufacturer, aircraft manufacturer or operator. This data may be classified as User Modifiable Software or Data, only if it is established that it has no adverse effect on: safety, operational capabilities, flight crew workload, any non-modifiable software components, or any software protection mechanism used.

Clarifying Text:

4.20.11 When tools are used to populate and/or verify a PDI instance, do they need qualification?

Answer:
If a tool is used to populate the PDI file, and verification of compliance to ED-12C/DO-178C Objectives A5-8 and A5-9 is not performed, then the tool

should be qualified per ED-12C/DO-178C Section 12.2 Criteria 1. If a tool is used to automate the verification of compliance to ED-12C/DO-178C Objectives A5-8 and/or A5-9, then the tool should be qualified per ED-12C/DO-178C Section 12.2 Criteria 3.

Rationale for IP:

Due to the potential for modification of a PDI file after the completion of a type certification this IP provides further insights into how address these modification to assure correctness in deployment.

Since FAS does not have the authority to make changes to DO-248/ED-94, this paper has been created to provide clarity in the meantime.