The Birds Project

The libBirds Library, Plan for Software Aspects of Certification

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Version 0.5
10/31/01

1. Purpose of the PSAC Document

This is a standard "Plan for Software Aspects of Certification" document, corresponding to the guidelines in RTCA DO-178B. It describes the general characteristics of the system and its software, certification considerations, life cycles and life-cycle data, and scheduling of the software-development effort.

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2. System Overview

2.1. Overview of the System

The libBirds library is intended to be a library of code which has been pre-certified under DO-178B, and which is therefore available for use as "previously written software" in building airborne-software applications. In other words, libBirds is not a complete system, but can be used as a software component of an airborne system without further development or certification effort.

The libBirds library is available for free use by anyone, under the terms of the GNU Lesser General Public License (LGPL). The associated documentation (such as the DO-178B documents) is also available for free use, under the terms of the GNU Free Documentation License (FDL). The text of both licenses appears later in this document.

The libBirds library attempts, philosophically, to meet the following additional criteria:

1) To supply a minimal C-callable API appropriate for writing simple embedded airborne applications, such as file-system functions, string manipulation functions, timekeeping functions, and so forth.

2) To supply only the most reliable types of functions. For example, heap (memory-allocation) operations are omitted, functions such as `strcpy` are omitted in favor of `memcpy`, functions such as `fgets` are omitted in favor of `fread`, and so on.

3) To retain maximal portability from CPU type to CPU type is desired, with a minimum porting effort. If hardware is designed with the requirements of existing libBirds code in mind -- i.e., with supported hardware peripherals -- then no effort at all is needed.

2.2. System Functions

2.2.1. Fixed-Size Datatypes for External Operations

2.2.1.1. Description

The library shall provide a set of fixed-size integer datatypes (i.e., in which the datatypes consist of known numbers of bits), so that external interfaces and the internal characteristics of the file-system can be dealt with on a consistent basis. Application software is free in most instances to use the normal C/C++ integer datatypes such as `int`, `long int`, `unsigned int`, and so on, but should use the fixed-size datatypes when accessing files or hardware interfaces, to insure maximum portability.

Fixed-size datatypes supported shall include 8-bit signed and unsigned integers, 16-bit signed and unsigned integers, 32-bit signed and unsigned integers, and 64-bit signed and unsigned integers.

2.2.1.2. Hardware-Software Allocation

This functionality is implemented in software.

2.2.2. Endian Conversions

2.2.2.1. Description

Because the aim of the libBirds library is to provide maximal portability, and yet byte-ordering within multi-byte datatypes differs from CPU type to CPU type, byte-ordering conversion functions are provided. For most coding purposes, byte-ordering preferences of the CPU are unknown and irrelevant, but they become relevant in file operations and when accessing multi-byte hardware interfaces. Therefore, application software should employ the appropriate byte-ordering conversion functions in these circumstances.

The libBirds library shall provide the following functionality: conversion (in either direction) between the CPU’s native 16-bit or 32-bit integer datatypes, and 16-bit or 32-bit big-endian integer datatypes. Also, between the CPU’s native 16-bit or 32-bit integer datatypes and 16-bit or 32-bit little-endian integer datatypes.

2.2.2.2. Hardware-Software Allocation

This functionality is implemented entirely in software.

2.2.3. Timekeeping Functions

2.2.3.1. Description

The libBirds library shall provide, at a minimum, the ability to determine the amount of time which has passed since system power-up. The granularity of the time measurement is not significant in libBirds, but for design purposes can be regarded as being of the order of magnitude of 10 ms. or smaller.

2.2.3.2. Hardware-Software Allocation

This shall be implemented by means of an interrupt service routine based on a hardware timer, such as an integrated CPU timer.

However, only the interrupt-service routine itself shall be provided by libBirds. The low-level details of setting up the interrupt and vectoring to the ISR are handled by a board-support package (not a part of libBirds), and hence this hardware dependence is transparent to libBirds.

2.2.4. String and Memory Manipulations

2.2.4.1. Description

Operations shall be provided such as comparing or copying strings or memory, case conversions, and so on. The extent of this functionality is not specified in the Requirements Process.

2.2.4.2. Hardware-Software Allocation

This functionality shall be implemented entirely in software.

2.2.5. Text-Display Functions

2.2.5.1. Description

A set of functions shall be provided appropriate for outputting data to a text-oriented display. By a "text-oriented" display is meant a display screen considered as rows and columns of characters, and not accessible other than at integral character cells. This concept is not dependent on the display hardware actually being text-oriented at a hardware level, of course, since a graphical display can also logically be considered as a text-oriented display.

The types of functions provided by libBirds shall include (but not necessarily be limited to) positioning the cursor at arbitrary text cells and displaying a character or string at a given text cell.

Arbitrary 24-bit color mappings shall be provided at the software level, though not necessarily at the hardware level.

2.2.5.2. Hardware-Software Allocation

The implementation of this functionality will vary depending on whether the actual display screen is text-oriented or graphically-oriented in hardware. The primary implementation difficulty is the conversion of character data to pixel data.

In the former case, this functionality can be completely provided by a board-support package (separate from libBirds). In the latter case, libBirds must break text operations down into pixel-manipulations, and the board-support package must provide the raw pixel manipulations.

Thus, libBirds is aware of hardware dependence only to the extent of knowing whether the display hardware is text-oriented or pixel-oriented.

2.2.6. Graphical Display-Output Functions

2.2.6.1. Description

A set of functions shall be provided allowing output to a graphically-oriented display screen.

The functionality provided shall include, but not necessarily be limited to: the ability to output text in various fonts and sizes to arbitrary pixel locations; the ability to draw arbitrary lines or filled areas; the ability to display arbitrary graphics files in BMP format. Both aliased and non-aliased fonts shall be provided.

At a software level, 24-bit colors shall be provided, whatever the actual capabilities of the hardware display.

2.2.6.2. Hardware-Software Allocation

This functionality is provided entirely in software, except that the hardware display must have the capability of manipulating arbitrary pixels. The raw-pixel manipulations are provided by a board-support package (separate from libBirds).

2.2.7. Keyboard-Input Functions

2.2.7.1. Description

Keyboard data is provided to the application software by means of a FIFO buffer and associated functions for adding/removing data to/from the buffer. Separate buffer events shall be generated for key-depression and for key-release.

Keystrokes shall be debounced prior to their press/release events being added to the keyboard FIFO.

2.2.7.2. Hardware-Software Allocation

An interrupt-service routine shall scan the keyboard with some (unspecified) degree of regularity, debounce the keystrokes, and insert key-pressed and key-released events into the keyboard buffer.

The physical keyboard, of course, shall be in hardware.

Low-level details of setting up the interrupts, vectoring to the ISR, and fetching raw data from the physical keyboard are handled not by libBirds, but by a board-support package (separate from libBirds).

2.2.8. Filesystem Manipulations

2.2.8.1. Description

The ability to create or read "files" shall be present. The file-system is intended to be general-purpose, but limited in ways appropriate to embedded systems and to the use of flash-memory as a storage medium.

In particular, the following characteristics of familiar filesystems in Microsoft Windows or UNIX shall be provided: sub-directory structures; long filenames; files up to 2 Gbytes in size; reading and writing files sequentially; reading files randomly.

The following familiar filesystem characteristics shall not be supported: random writing; timestamps; ownership; permissions; sharing.

The filesystem software shall not be reentrant.

Files may be deleted, but their allocated space is not necessarily immediately reclaimed. The reclamation may require "garbage collection", as described in the next section.

2.2.8.2. Hardware-Software Allocation

The design criteria assume the use of flash-memory as a storage medium. In other words, the hardware medium must have the following properties: It may be erased in relatively large "erasable blocks", and erasure consists of setting the block to bits that are all 1; any bit which is 1 may be changed at will to 0, but not necessarily vice-versa. Of course, a file-system based on these limitations may also be implemented in other media (EEPROM, RAM, or magnetic disk), as well as flash-memory, though not with maximum efficiency.

All other capabilities are implemented in software.

In accordance with common practice, erasable blocks are sub-divided into smaller blocks ("sectors").

The following low-level functions are to be provided by a board-support package (separate from libBirds): mapping of the erasable blocks by address and size; erasure of blocks; reading sectors; writing sectors.

2.2.9. Filesystem Garbage Collection

2.2.9.1. Description

Because the file-system is conceptually based on flash-memory as a storage medium, as described above, space which has been used but subsequently deallocated cannot be immediately reclaimed. This is because bits which have been changed from 1 to 0 cannot be returned to 1 unless the entire block containing them is erased.

The libBirds library shall provide a garbage collection facility capable of reclaiming used file-system space by temporarily buffering a block of data within RAM while the associated flash-memory be being erased, and then writing the buffered data back to flash-memory afterward with reclaimed 0-bits changed to 1-bits as appropriate.

2.2.9.2. Hardware-Software Allocation

The hardware-software allocation for this functionality is the same as described above under "Filesystem Manipulations".

2.2.10. Audio Playback

2.2.10.1. Description

Audio clips stored within the file-system as files in the WAV format may be played back through an audio codec, if one exists.

2.2.10.2. Hardware-Software Allocation

A compatible audio codec must exist within hardware to use this feature. An interrupt-service routine is used to transfer audio data from the file-system to the audio codec.

The low-level details of setting up the interrupts, vectoring to the ISR, setting up the codec, and outputting data to the codec are handled by a board-support package (separate from libBirds).

2.2.11. Serial I/O

2.2.11.1. Description

The libBirds library shall provide functions that can be used for simple serial i/o. "Simple" serial i/o is defined as i/o involving only 8-bit data without parity or handshaking, and with loose (or no) timing constraints. This functionality is provided by means of FIFO buffers into which serial data is placed or removed.

This same mechanism shall also be used if ethernet or other network services are provided.

2.2.11.2. Hardware-Software Allocation

Providing this functionality is based on the existence of hardware UARTs, and an interrupt-service routine servicing these UARTs. The interrupt-service routine receives data from the UARTs and places the data into a "received data" FIFO from which the application software can remove it. Similarly, the application software can place data into a "transmitter" FIFO from which the interrupt-service return removes it and gives it to the UARTs.

Low-level details of setting up the interrupts, vectoring to the ISR, and inputting/outputting data from/to the UARTs is handled by a board-support package (separate from libBirds).

2.3. System Architecture

Because the libBirds library is intended to be as portable as possible, it requires no specific system architecture.

For example, no specific requirements on the quantity or address range of RAM is made. It is assumed, though not required, that the total system RAM is greater than 128K bytes. Where specific system functions have significant memory requirements relative to 128K bytes, it is stated in the design data.

Also, certain functionality (such as audio playback) requires the availability of compatible hardware (such as an audio codec). In no case does libBirds have specific knowledge of these hardware peripherals or access to them. Instead, all such access is via functions provided by a board-support package (separate from libBirds). The board-support functions needed are specified in the design documentation.

2.4. Processors

The libBirds library can be used with any CPU supported by the GNU **gcc** C/C++ compiler. For practical purposes, this means that almost any popular 32-bit CPU is supported.

2.5. Hardware-Software Interfaces

As may be deduced from the descriptions of the hardware-software allocations in the ’System Overview’ section, libBirds as such has almost no dependence on or knowledge of the hardware.

Instead, there is a hardware-abstraction layer (HAL), whose functions are defined in the libBirds design data, but which are actually provided by "board-support packages" (BSPs). The BSPs are separate from libBirds, and have life cycles separate from libBirds.

Since libBirds provides specifications for all HAL functions, as well as the test suites used for software verification of the BSPs, it is hoped that certification of the BSPs for given versions of libBirds will be a comparatively simple effort.

2.6. Safety Features

Because libBirds is a reusable library rather than a complete system, it does not attempt to provide safety features as such. The libBirds library promotes safety primarily in omitting functionality that can easily be misused to the detriment of system reliability, such as dynamic memory allocation.

3. Software Overview

3.1. Resource Sharing

The libBirds library is intended to be used in a single-tasking system without multiple CPUs or (if multiple CPUs are present) without shared memory. It uses no globally accessible memory, other than memory allocated specifically for the use of libBirds, and not used by other (properly designed) software. It shares no communications channels. It expects compatible peripherals to be accessed only by means of libBirds functions. The libBirds library provides no functions capable of retaining permanent control of the CPU.

Thus, the only applicable questions about resource sharing are the proportion of total RAM and total CPU time used, and the maximum execution time required by a libBirds function. RAM usage should be deduced from the specifically required system functions by referring to the design data.

Unfortunately, questions about CPU utilization cannot be answered since libBirds specifies no specific CPU or clock speed. Hence, it should be concluded that libBirds is not suitable for use in applications where hard limits CPU utilization are needed.

3.2. Redundancy

Not relevant, since libBirds is a reusable library rather than a complete system.

3.3. Multiple-Version Dissimilar Software

Not used by libBirds.

3.4. Fault-Tolerance, Failure Detection, and Safety Monitoring

Not provided by the libBirds library.

3.5. Software Timing and Scheduling Strategies

The libBirds library assumes that libBirds functions and all other code for the system (such as application code) run in a single foreground execution thread. Thus, application code passes control to libBirds functions when it wants to do so, and receives control back when the libBirds function has terminated.

However, libBirds functions can only provide certain functionality by depending on some underlying interrupt-service routines, as follows:

1) The libBirds "kernel" ISR executes at regular intervals by means of a CPU timer or other hardware timer. This ISR handles the following tasks: updating the master system

clock; scanning/debouncing the keyboard; transferring audio data from the file-system to the audio codec; user-defined operations via a function call reserved for this purpose.

2) Interrupt-service routines for each supported UART.

While libBirds provides the ISR, low-level details of setting up the hardware (interrupts, timers, UARTs) and vectoring to the ISR are handled not by libBirds, but by a board-support package (separate from libBirds).

4. Certification Considerations

4.1. Software Level and Means of Compliance

The software is suitable for certification via RTCA DO-178B at level C.

4.2. Justification of Software Level

Since libBirds is a reusable library, rather than a complete system, it requires no safety justification as such.

4.3. Potential Software Contributions to Failure Conditions

Because the conditions of use of libBirds cannot be known (it may be used in developing software for any software of level C, D, or E), there is no way to know how libBirds may potentially contribute to failure conditions. In other words, there is no justification for using libBirds in developing software at levels A or B.

5. Software-Component Life Cycles

For this project, there is only one software component, namely the libBirds library, and hence only one life cycle.

5.1. Life Cycle of libBirds Library Development

5.1.1. Life-Cycle

The life cycle of the libBirds library begins with the Planning Process. Upon the end of the planning processes, three separate chains of development begin, and these chains persist until the end of the development effort.

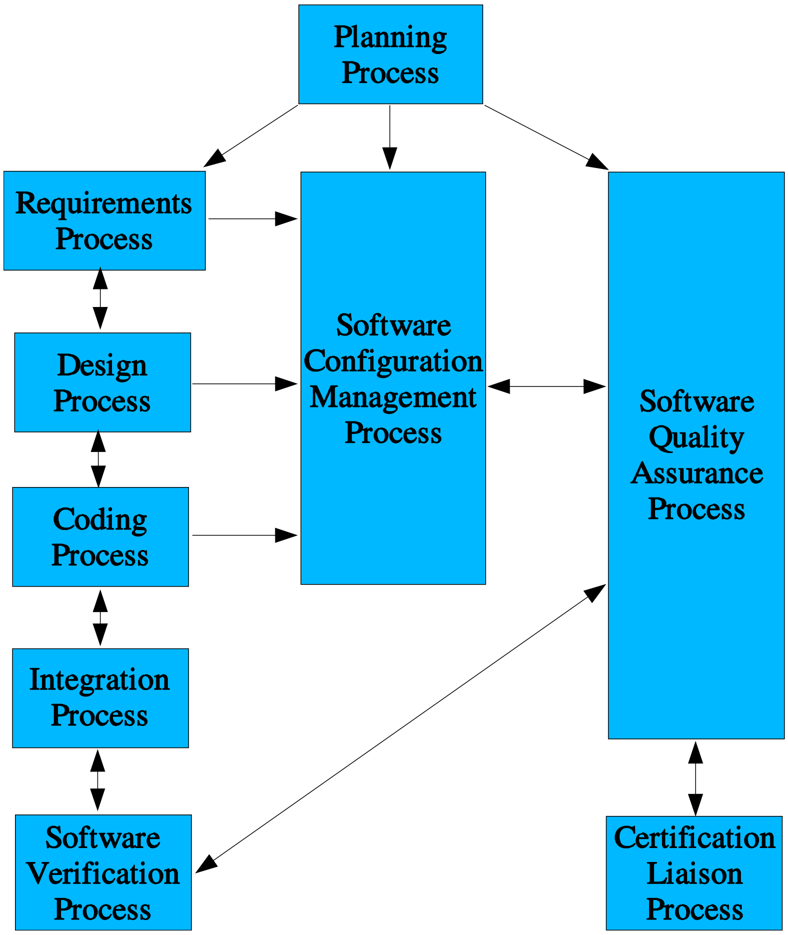
Two of the of the development chains consist of one process each: namely, the SCM Process and the SQA Process.

The third development chain consists of 4 processes: the Requirements Process, followed by the Design Process, the Coding Process, the Integration Process, and the Software Verification Process. For simplicity, we'll refer to this as the "RDCIV chain." The development effort basically progresses through these processes, in the order given, but can backtrack to an earlier process upon discovery of errors that can only be corrected in the earlier process.

Upon completion of the development effort, which is the release of the software by the SQA Process, life cycle data is available for input to a Certification Liaison Process. However, the Certification Liaison Process is really outside of the scope of the libBirds development effort, since the software produced is merely a reusable library and not a complete system.

Although not possible for the first libBirds release, due to non-availability of personnel, it is hoped that subsequent releases can be reviewed by DER as part of the development effort, allowing very rapid signoff of form 8110 for developers using the libBirds library. When this becomes possible, it will form part of the Certification Liaison Process.

Figure 1. Life Cycle Summary



5.1.1.1. Life-Cycle Processes

5.1.1.1.1. Planning Process

The Planning Process precedes all other life-cycle processes It produces or identifies all other Plans or Standards guiding the remainder of the software-development effort. The specific aim of the libBirds Planning Process is to address all of the issues outlined in DO-178B section 4.0.

5.1.1.1.1.1. Transition Criteria and Satisfaction of Objectives

The Planning Process is followed by three separate chains of life-cycle processes, with the three development chains running simultaneously in parallel. These chains are the SCM Process, the SQA Process, and the RDCIV chain (see the ’Life-Cycle’ section). The transitions from the Planning Process to these development chains do not necessarily occur simultaneously.

The Planning Process transitions to the RDCIV chain when the PSAC, SDP, SVP, SECI, SRS, SDS, and SCS documents have all been successful reviewed and signed off. Note that the PSAC, unlike the other documents mentioned, is not actually completed at this point since it contains some high-level requirements (notably under the heading of ’System Overview’) that are not known until the Requirements Process.

Subsequent changes to these documents may require a return from the Design Process, Coding Process, or Software Verification Process to the Requirements Process, but the Planning Process is never re-entered in any given life cycle.

The Planning Process transitions to the SCM Process upon successful review and signoff of the SCMP.

The Planning Process transitions to the SQA Process upon successful review and signoff of the SQAP.

5.1.1.1.2. Requirements Process

The purpose of the Requirements Process is to develop the high-level software requirements. In the case of libBirds, this is essentially a development of the functional requirements. However, the intention of the libBirds Requirements Process is to address all of the issues outlined in DO-178B section 5.1.

The Requirements Process also addresses all considerations of DO-178B section 6.3.1, which according to DO-178B may form a part of the Software Verification Process. This can be done because at the proposed software level (’C’), there is no requirement of independence.

5.1.1.1.2.1. Transition Criteria and Satisfaction of Objectives

The Requirements Process transitions to the Design Process upon successful review and signoff of the SRD. The completion of the incomplete PSAC produced in the Planning Process is also needed, along with its review and signoff.

5.1.1.1.3. Design Process

In the case of libBirds, the main purpose of the Design Process is to develop low-level requirements (primarily API definition) from the high-level requirements provided by the Requirements Process. However, all of the issues outlined in DO-178B section 5.2 are addressed.

The Requirements Process also addresses all considerations of DO-178B sections 6.3.2 & 6.3.3, which according to DO-178B may form a part of the Software Verification Process. This can be done because at the proposed software level ('C'), there is no requirement of independence.

5.1.1.1.3.1. Transition Criteria and Satisfaction of Objectives

The Design Process transitions to the Coding Process upon successful review and signoff of the SDD.

5.1.1.1.4. Coding Process

The purpose of the Coding Process is to produce source code and object code conforming to the SDD, SDS, and SCS. It addresses the issues outlined in DO-178B section 5.3.

5.1.1.1.4.1. Transition Criteria and Satisfaction of Objectives

The Coding Process Transitions to the Integration Process when the source code and object code are prepared, have been verified conformant with the SCS and SDS, and have been verified conformant with (and traceable to) the SDD.

5.1.1.1.5. Integration Process

The purpose of the Integration Process is to integrate the software with the target hardware. Since the aim of the libBirds project is to produce a highly portable library, rather than a hardware-specific library or a physical device, there really can be no required Integration Process.

For any given target architecture, the general-purpose libBirds library is combined with a specific 'board-support package' (not a part of libBirds as such) that provides the Hardware Abstraction Layer specific to that target. It is in the Integration Process of the board-support package life cycle or the application code life cycle (both of which are independent of libBirds) that the integration occurs.

5.1.1.1.5.1. Transition Criteria and Satisfaction of Objectives

At the option of the developers, the Integration Process may either proceed directly to the Software Verification Process without any effort whatever, or else to optionally coordinate with board-support package (BSP) development-effort Integration Processes. There are no pre-defined criteria associated with this decision.

5.1.1.1.6. Software Verification Process

In the words of DO-178B section 6.1, "The purpose of the software verification process is to detect and report errors that may have been introduced during the software development processes." The libBirds Software Verification Process attempts to address all of the issues outlined in DO-178B chapter 6, except the following:

1) The Requirements Process addresses all considerations of DO-178B section 6.3.1. This can be done because at the proposed software level (’C’), there is no requirement of independence.

2) The Design Process addresses all considerations of DO-178B sections 6.3.2 & 6.3.3. This can be done because at the proposed software level (’C’), there is no requirement of independence.

3) Reviews and analysis of the outputs of the Integration Process (DO-178B section 6.3.5) are not addressed here (or elsewhere) since the entire Integration Process is optional. Refer to the ’Integration Process’ section of the PSAC for further explanation.

5.1.1.1.6.1. Transition Criteria and Satisfaction of Objectives

The Software Verification Process has several outputs:

a) Review and analysis of the source code.

b) The SVCP.

c) Review and analysis of the test results.

d) The software-test results themselves.

The Software Verification Process can transition to various other life cycle processes:

1) To the SQA Process upon successfully creating all Software Verfication Process outputs.

2) To the Coding Process upon detection of errors in software testing.

3) To the Requirements Process or Design Process upon detection of errors more appropriately resolved in the SRD or SDD than in the code.

5.1.1.1.7. Software Configuration Management Process

The Software Configuration Management Process (or just ’SCM Process’) for the most part operates simultaneously with the other life cycle processes. DO-178B chapter 7 sets out the objectives and activities of the SCM Process in some detail. In summary, the SCM Process provices the following activities:

1) Identifying configurations.

2) Implementing change control.

3) Establishing baselines.

4) Archiving the software and the life cycle data.

Though for graphical reasons the figure at the top of the ’Life-Cycle’ section of this document depicts the SCM Process as spanning merely the Requirements, Design, and Coding Processes, it actually spans all other life cycle processes, and beyond. Once data is archived by means of the SCM Process, it is theoretically intended to remain archived as long as the libBirds software is present within any airborne units.

Of course, since the Birds Project is not a manufacturer of airborne equipment, and the libBirds library is intended to be used by manufacturers of such equipment, it is not really within the capability of the Birds Project to guarantee this essentially indefinite data retention. It is therefore assumed that users of the libBirds library have prudently archived the version of libBirds they are using -- i.e., all code and life-cycle data -- within the SCM Processes of their own development efforts.

5.1.1.1.7.1. Transition Criteria and Satisfaction of Objectives

The SCM Process does not transition to other life cycle processes, since it operates in parallel with such other processes.

Ultimately, the SCM Process exists to archive life cycle data, and to perpetually maintain this archive subject to the limitations described above. The outputs of the SCM Process are the SCI and the SCM Records demonstrating archival activity. The SECI, which may legitimately be viewed as an output of the SCM Process, is actually produced by the Planning Process, but may subsequently be altered by the SCM Process.

5.1.1.1.8. Software Quality Assurance Process

The objectives and activities of the Software Quality Assurance Process (or just ’SQA Process’) are set out in chapter 8 of DO-178B. Basically, the SQA Process examines the outputs of the other life cycle processes and determines their internal consistency. In other words, it acts to assure that what has actually been accomplished is what was required to be accomplished.

Among the important activities of the SQA Process are these:

1) Establishement and management of the problem-reporting system.

2) Final release of the software.

The SQA Process operates simultaneously with the other life cycle processes, and spans the Planning Process through release of the software. Furthermore, the SQA Process is independent from the other life cycle processes, in the sense that separate personnel are involved and that the authority for the SQA Process is separate from the authority for the the other life cycle processes.

The SQA Process is the only life-cycle process required to have this characteristic of independence at the proposed software level (’C’).

5.1.1.1.8.1. Transition Criteria and Satisfaction of Objectives

The SQA Process transitions to the Certification Liaison Process upon release of the software. The outputs of the SQA Process are the SQA Records.

The primary output of the SQA Process is the Software Conformity Review, which is the last step in the release of the software. The Software Conformity Review, however, takes into account not only the life cycle data in general, but also various other SQA Records.

5.1.1.1.9. Certification Liaison

Since the product of the libBirds development effort is a reusable library rather than an actual airborne device, there are really no certification efforts associated with it, and thus no real Certification Liaison Process.

However, since the intention of the libBirds project is to not merely provide software but to make it very conveniently usable by developers, a very useful certification activity would be review and approval by a DER. This "pre-approval" by a DER would allow immediate signoff of 8110 forms for developers using the libBirds library, very simply and relatively cheaply.

It is not known as this is written whether such DER activity will actually occur. Hence, it should be regarded as an optional activity that may be omitted.

5.1.1.1.9.1. Transition Criteria and Satisfaction of Objectives

The outputs of the Certification Liaison Process can be these:

1) Informal notification that a DER finds the life cycle data acceptable and will be available to sign off (via 8110) upon demand, for a known fee.

2) Notification of life-cycle data problems that will require repair before the DER finds the data acceptable.

Upon the former (option #1), the Certification Liaison Process ends, but there are no further processes to which a transition can occur. Of course, the availability of signoff would be published, so that libBirds users could be made aware of it.

Upon the latter (option #2), problem reports are filed concerning the problems which have been found. Also, a transition may (or may not) occur to an earlier life cycle process so that the problems can be fixed. The reason for this uncertainty of action is that while approval by the DER is a desirable result of the development effort, it is not a crucially necessary one from the point of view of the ’Birds Project’. These findings are often a matter of opinion, and a different DER might view the life cycle data differently.

5.1.1.2. Organization

The Birds Project differs from most organizations involved in airborne software development, in the sense that it is not a commercial organization engaged in manufacturing a product. Instead, it is an effort to freely provide certification-friendly materials to the aviation community, as a service. Furthermore, at least at the time of inception of the libBirds development effort, it is not really "organized" at all, consisting merely of an ad hoc assemblage of a few individuals.

For this reason, the organization of the libBirds development effort cannot be understood in terms of an "org chart" with a neatly defined flow of authority. Instead, it can only be understood in terms of the actual individuals involved.

5.1.1.3. Organizational Responsibilities

At the proposed software level (’C’), the minimum number of individuals required for the development effort is two, to meet the ’independence’ requirements of DO-178B

Table A-9: one individual for the SQA Process, and one individual for all other activities. If the optional Certification Liaison Process is undertaken (see the ’Certification Liaison’ sub-section of ’Software Component Life Cycles’ in the PSAC document), then a third individual (a DER) is required.

For the initial release of libBirds, only the minimum number of personnel is used. For later releases, more or other personnel may be used. In this section, all personnel involved in all releases are identified, and their levels of involvement in these releases are made clear. Because there is no corporate entity providing authority for the development activities, we also provide brief resumes of participating individuals, so that their qualifications for their activities are clear.

Ronald S. Burkey, lead developer for libBirds v1.00, has a B.S. degree in Mathematics and a Ph.D. in Physics. He has been professionally involved in designing electronic hardware and firmware for airborne applications (and non-airborne applications) since 1984. He has been responsible for both DO-178A and DO-178B certification efforts.

TBD, SQA Manager for libBirds v1.00.

5.1.1.4. Certification Liaison

Because libBirds is a reusable library rather than a complete airborne product, no direct interaction with certification authorities is required.

5.1.2. Life-Cycle Data

5.1.2.1. Data Items

Because libBirds is a reusable library rather than a complete airborne product, no occasion for submission of life cycle data by the Birds Project arises. Rather, all of the life cycle data items described below are made available to developers wishing to use the libBirds library, or to anyone else, along with libBirds source code. The status of this data within the development efforts of libBirds users cannot in principle be known to the libBirds development effort, and hence cannot be specified here.

The following items or categories of life cycle data items are created.

The Plan for Software Aspects of Certification (PSAC) is created by the Planning Process, but the ’System functions’ section is provided by (and hence the PSAC is completed by) the Requirements Process.

The Software Development Plan (SDP) is created by the Planning Process.

The Software Verification Plan (SVP) is created by the Planning Process.

The Software Configuration Management Plan (SCMP) is created by the Planning Process.

The Software Quality Assurance Plan (SQAP) is created by the Planning Process.

The Software Requirements Standards (SRS) are created by the Planning Process.

The Software Design Standards (SDS) are created by the Planning Process.

The Software Code Standards (SCS) are created by the Planning Process.

The Software Requirements Data (SRD) are created by the Requirements Process.

The Software Design Description (SDD) is created by the Design Process.

The Source Code is created by the Coding Process.

There is no Executable Object Code in general, since libBirds is a reusable library rather than a complete product. Creation of Executable Object Code is performed by board-support package development efforts (separate from libBirds). For specific CPU types used in the libBirds Software Verification Process, however, Executable Object Code in the form of linkable libraries can be provided.

The Software Verification Cases and Procedures (SVCP) and Software Verification Results (SVR) are created or completed by the Software Verification Process.

The Software Life Cycle Environment Configuration Index (SECI) is created by the Planning Process, but may be altered by the SCM Process prior to creation of the Executable Object Code (if any) or transition to the Software Verification Process.

The Software Configuration Index (SCI) is produced by the SCM Process.

Problem Reports are sanctioned and maintained by the SQA Process, but may actually be produced at any time, by anyone with access to the libBirds problem-reporting system.

SCM Records are produced by the SCM Process.

SQA Records are produced by the SQA Process.

The Software Accomplishment Summary (SAS) is produced by the SQA Process.

5.1.2.2. Data Relationships

All relationships among life cycle data items seem clear from the ’Life-Cycle’ section above.

5.1.2.3. Data Formats

All data items other than Source Code and Executable Object Code are made available as Adobe PDF files, viewable with the freely available Adobe Acrobat Reader program. This includes the SVR, and all SCM Records and SQA Records (such as review and audit forms). If necessary, hand-written data is scanned in order to produce the necessary PDF files.

Source Code is made available as a UNIX ’tar’ file, compressed with the ’gzip’ utility. Executable Object Code (actually, linkable libraries) for the specific CPU types used in the Software Verification Process UNIX-type ’ar’ libraries.

Though not specifically a life cycle data item called out by DO-178B, the SCM archives are also available as gzipped ’tar’ files of ’cvs’ repositories. These archives contain not only all source code and documentation for the software release, but also the historical antecedents. In other words, they contained all of the source code and documentation for prior releases as well.

In summary, all life cycle data items are available in an on-line downloadable format rather than as hardcopies.

5.1.2.4. Means of Submitting Life-Cycle Data

Since libBirds is a reusable library rather than a complete product, no direct submittal of data by the Birds Project is envisaged. However, all life cycle data (code and documentation) are available to software developers, certification authorities, or any other parties, via download over the Internet.

In practice, it is envisaged that developers wishing to use libBirds for their projects will download the source code and other life cycle data, will archive them within their own SCM Processes, and will perform whatever submissions are required.

6. Schedule

Because libBirds is a library reusable by developers of airborne software, rather than for use in any specific standalone hardware-based device, there is no obvious reason for any scheduled interactions with certification authorities.

The libBirds library is not a commercial project with a planned release date or other milestones. Hence it can be released whenever it happens to be ready.

In summary, there is no relevant scheduling data that can be presented for the initial development effort.

7. Additional Considerations

7.1. Alternate Methods of Compliance

No qualification means alternate to DO-178B are used.

7.2. Tool Qualification

In general, a tool requires qualification if its output is used without examination. If the output of the tool is itself verified (by review, testing, or analysis) this constitutes an implicit qualification of the tool itself. With that in mind, we can examine the tools used, one-by-one, and determine their need for qualification:

Native compiler, linker, library archiver, and low-level libraries (**gcc**, **ld**, **ar**, and libgcc.a). These are used for creating desktop-computer executable code for testing purposes, or for creating embedded code if the target processor just happens to be the same as that of a common desktop computer (like Intel ’x86 or PowerPC). These tools do not require qualifiation, since their outputs (the executable code) are tested.

Cross-compiler, linker, library archiver, and low-level libraries (**gcc**, **ld**, **ar**, and libgcc.a). These are used for creating embedded Executable Object Code from a desktop computer, but for a different target CPU type. Technically, these tools also do not need qualification, since libBirds does not produce Executable Object Code for these environments as part of its life cycle data. Rather, separate board-support package development efforts create this Executable Object Code. [As a practical matter, however, the Birds Project wants the libBirds library to be as easily usable by developers as possible, and this means that this issue cannot be side-stepped. Easing BSP qualification is handled by crafting the test suites so that they can be executed in either the desktop environment or in the target environment (albeit with perhaps more effort).]

Coverage tool (**gcov**). This is a tool which provides a survey of all source-code lines, indicating which of them have been exercised in testing and which have not. The coverage tool must be qualified, since there is no direct way of verifying its output. The qualification shall be done by creating a C-language program in which various bits of code are known to execute or not execute, and then to test it with **gcov**.

Code-formatting tool (**indent**). This tools puts the C-language source code into a standard format. Although the outputs from **indent** are not examined, it is still not necessary to qualify the tool. This is because the SCS does not place a requirement on the format of the output code, but simply requires that **indent** has been run. Therefore, whatever output ’indent’ produces is correct by definition.

Concurrent versioning system (**cvs**). This is the archiver used for the Source Code and other life cycle data. It is qualified by creating a suite of data that must be archived, and then retrieved and compared against the original data. In addition to this qualification, part of the release procedure is to retrieve the archived Source Code and check it for accuracy. Unfortunately, the latter step alone is not adequate to bypass qualification, since the qualification process needs to insure not merely that the current release can be retrieved, but that prior releases can be retrieved as well.

All other tools used either have outputs which are examined, or which feed into operations whose outputs are examined. Therefore, no other tools require qualification.

7.3. Previously-Developed Software

Previously-developed software is not used by libBirds.

7.4. Option-Selectable Software

The libBirds library is not, and does not contain, option-selectable software.

7.5. User-Modifiable Software

The libBirds library is not, and does not contain, user-modifiable software.

7.6. Commercial Off-the-Shelf Software

The libBirds library does not use COTS.

7.7. Field-Loadable Software

The libBirds library is not field-loadable as such, but could conceivably be used by a developer producing a field-loadable program. If so, any considerations relating to this will be outlined in that developer's life cycle data.

7.8. Multiple-Version Dissimilar Software

The libBirds library does not use multiple-version dissimilar software.

7.9. Product Service-History

Not applicable.

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Version 1.1, March 2000

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If such an object file uses only numerical parameters, data structure layouts and accessors, and small macros and small inline functions (ten lines or less in length), then the use of the object file is unrestricted, regardless of whether it is legally a derivative work. (Executables containing this object code plus portions of the Library will still fall under Section 6.)

Otherwise, if the work is a derivative of the Library, you may distribute the object code for the work under the terms of Section 6. Any executables containing that work also fall under Section 6, whether or not they are linked directly with the Library itself.

6. As an exception to the Sections above, you may also combine or link a "work that uses the Library" with the Library to produce a work containing portions of the Library, and distribute that work under terms of your choice, provided that the terms permit modification of the work for the customer's own use and reverse engineering for debugging such modifications.

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For an executable, the required form of the "work that uses the Library" must include any data and utility programs needed for reproducing the executable from it. However, as a special exception, the materials to be distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

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