PARTNERING TO IMPROVE THE SOFTWARE APPROVAL PROCESS FOR AIRCRAFT CERTIFICATION (1998)

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Abstract

Manufacturers of aviation products and certification authorities often experience difficulties and false starts in the software approval process; this leads to schedule delays and cost escalations for the manufacturers and increased workload for the certification authorities.

This paper outlines "best practices" for certification authorities and software developers during the software approval process of civil aviation products. Emphasis is placed on the partnership between industry and the certification authorities to improve the certification process with the common benefit of reduced cost, time, and workload.

Best practices are captured in a tutorial of the software approval process to provide both manufacturers and certification authorities a common understanding. These practices are particularly applicable for certification projects within the United States but might also have application for international certification projects.

The best practices were initiated by the author and refined at the Federal Aviation Administration's Streamlining Software Aspects of Certification workshop. The insights and criteria are an integration of input from the author, avionics manufacturers, aircraft manufacturers, software developers, and certification authorities. Responsibilities of both the certification authorities and the industry for effective partnership and successful software approvals are clearly outlined and delineated.

Introduction

There are numerous manufacturers entering the avionics world. Most new avionics manufacturers embed software in their products and often find the software approval process for certification of airborne products to be confusing and onerous.

The software approval process is a partnership between the Federal Aviation Administration (FAA) and the manufacturer applying for certification (known as the "applicant"). This paper provides an overview of that partnership for the software approval process—emphasizing the characteristics of a good certification program. Both the FAA and the applicant's roles and responsibilities are presented.

Many of the concepts presented are based on the author's experience in both industry and the FAA. Additional input was obtained from Streamlining Software Aspects of Certification (SSAC) team members (contributors are listed in the Acknowledgment section). Please note that this document is not an official FAA position but merely presents the author's experience and integrates industry's input. Some of the material is conceptual and is dependent on a good working relationship between the applicant and the FAA.

The process presented is within the context of a type certification (TC) program and builds on the joint work between FAA and General Aviation Manufacturer's Association (GAMA) presented in "The FAA Type Certification Process" job aid. However, the process can easily be applied to the supplemental type certification (STC), amended type certification (ATC), and technical standard order authorization (TSOA) processes, as well.

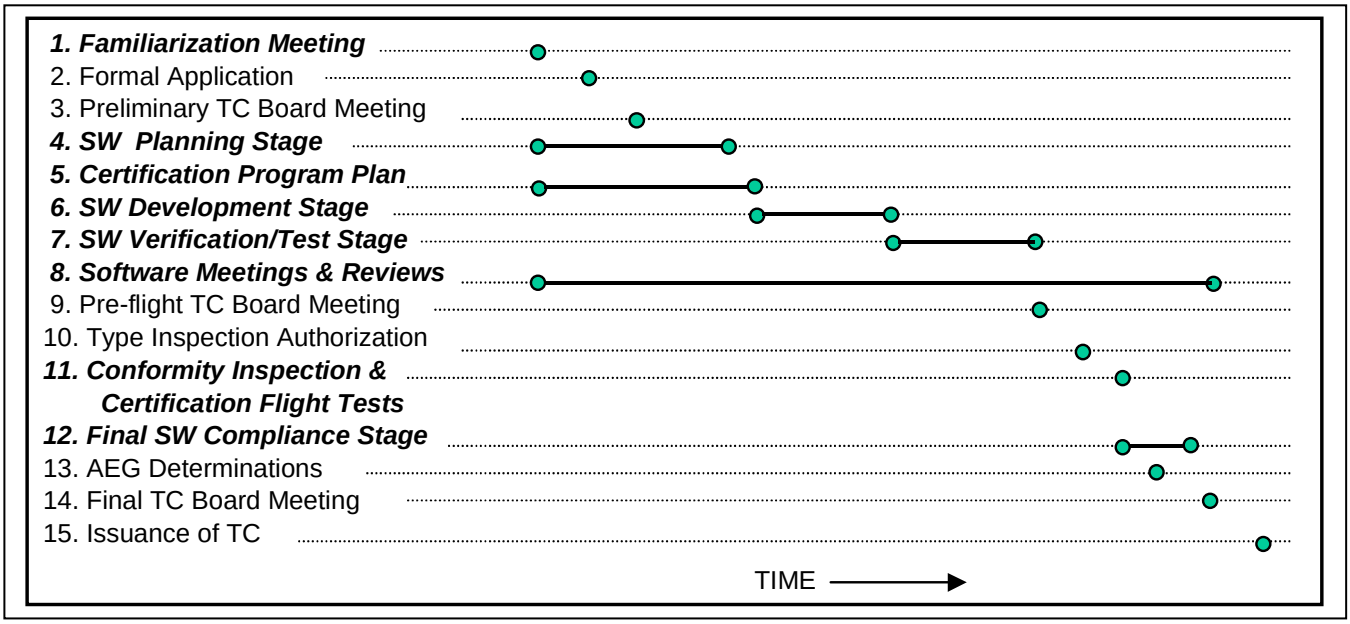

Figure 1 – Tasks in a software intensive TC program.

Certification Overview

The typical certification program has 15 tasks, as illustrated in Figure 1. The software intensive tasks are highlighted with ***bold italic***. These tasks may not be sequential; i.e., there may be considerable overlap. The Gant chart in Figure 1 illustrates the typical order of events.

Of the 15 tasks in the software intensive type certification, eight tasks are software-specific. All 15 tasks will be discussed in this paper, but the eight software-specific tasks will be addressed in more detail. Within the software-specific tasks, the roles of both the FAA and the applicant/developer will be addressed. These descriptions are not comprehensive and only provide an overview of the best practices. Each program has peculiarities and variances that may deviate from the order of tasks shown in Figure 1.

The Partnership Process: Tasks and Best Practices

There are typically 15 tasks in the software intensive type certification program, as discussed in the previous section and illustrated in Figure 1. This section will briefly describe each of the general tasks and show how the eight software-specific tasks (i.e., tasks # 1, 4, 5, 6, 7, 8, 11, and 12) fit within the overall certification project. The software-specific tasks are identified with ***bold italic*** font and address the typical roles and responsibilities for the FAA and the applicant. These roles and responsibilities summarize the best practices for a successful certification program. The order, depth, and specific details of each role/responsibility varies from program to program. The details should be worked out between the certification authority and the applicant early in the program.

1. The ***Familiarization Meeting(s)*** provides a forum for both the FAA and the applicant to discuss potential program avenues and risks. The familiarization meeting(s) should occur as early as possible to allow both the FAA and the applicant to plan resources. Following the initial familiarization meeting, there may be additional software-specific meetings. Software planning issues, approaches, levels, and potential risks should be discussed at the familiarization meeting or at the subsequent software-specific meetings.

The FAA's roles/responsibilities for the familiarization meeting and subsequent software-specific meetings are:

- Coordinate with applicant to develop an agenda, prior to the meeting.
- Follow the agenda to assure that all necessary subjects are addressed.
- Introduce the FAA certification team.
- Encourage an atmosphere of open communication and cooperation.
- Stress confidentiality.
- Be flexible (i.e., allow open discussion).
- Listen to and understand the applicant.
- Discuss the certification basis and applicable standards, policy, guidance, and regulations.
- Discuss the certification process and expectations.
- Discuss any available training.
- Discuss the safety assessment process and the tie to software (i.e., establish the software level). Reference appropriate documents (e.g., RTCA DO-178B "Software Considerations in Airborne Systems and Equipment Certification;" SAE Aerospace Recommended Practice (ARP) 4754 and 4761; Advisory Circulars (AC) 25-1309[ ] or AC 23-1309[ ]; and applicable paragraphs of the Code of Federal Regulations (CFR)).
- Discuss schedules and expectations.
- Address any potential issues.
- Provide a list of software approval process documentation (e.g., DO-178B, Advisory Materials, Notices, Orders, Regulations, and job aids).
- Describe the typical software approval process and available documentation (e.g., the job aid entitled "Conducting Software Reviews Prior to Certification" (referred to as the "Software Review Job Aid" for the remainder of this document)).
- Discuss architectural and systems ties to software.
- Discuss the various software projects, developers, sites, and plan for vendor oversight.
- Discuss plans for designee management and involvement.
- Discuss software-specific aspects of the certification plan.
- Leave with clear assignments.
- Sign the documentation of meeting results, actions, and agreements, after the meeting.

The applicant has the following roles/responsibilities tasks for the familiarization meeting(s):

- Schedule the meeting as early as possible in the project life cycle.
- Prior to the meeting, seek FAA input to develop an agenda.
- Prior to the meeting, prepare questions and areas of concern to present at the meeting.
- Research FAA documents, requirements, and web-sites prior to the meeting.
- Be knowledgeable of current and on-going software policy and guidance activity (e.g., RTCA activities and FAA web-sites).
- Introduce project team members, certification liaison personnel, designated engineering representatives (DERs), and other attendees.
- Provide system description and intentions.
- Discuss safety program and software levels.
- Identify novel features, new approaches, and deviations from existing certification policy, so that issue papers, special conditions, or policy can be addressed early.

- Identify schedule objectives, or take action to do so.
- Identify special software considerations (e.g., service history, special design approach, and software tools).
- Develop a plan for frequent communication with the FAA. This might include quarterly program status meetings, regular specialist meetings, and/or monthly schedule submittal.
- Identify preliminary schedule and documentation product delivery requirements.
- Identify planned processes and team.
- After the meeting, document questions for FAA to address in the future.
- After the meeting, prepare meeting minutes, summarizing meeting results, actions, and agreements.
- After the meeting, obtain written FAA agreement on meeting minutes by having mutually signed meeting minutes.
- In subsequent software-specific meetings, follow up on issues and actions from previous meetings.

2. Formal Application occurs when the applicant formally submits the TC application to the FAA. At this point, the project is assigned a FAA project number.

3. The Preliminary TC Board Meeting is attended by both the FAA and the applicant. The preliminary TC board meeting formally conveys the applicant's intents and the FAA's position. Discussion items include topics such as certification basis, FAA expectations, and certification schedules.

4. The ***Software Planning Stage*** includes the development, review, and approval of all software planning documents. Products of the task are the Plan for Software Aspects of Certification (PSAC), the Software Development Plan (SDP), the Software Quality Assurance Plan (SQAP), the Software Configuration Management Plan (SCMP), the Software Verification Plan (SVP), software development standards, and any other required planning documentation. The PSAC is a particularly important document at this phase in the program. The PSAC documents the applicant's programmatic plans (e.g., software level, unique software issues, and software development schedule) and serves as an agreement between the FAA and the applicant. The planning phase should be completed prior to starting the software development and should be coordinated with and approved by the FAA (i.e., software plans should have FAA approval prior to software development).

The roles/responsibilities of the FAA during this task are:

- Review the PSAC as soon as possible and provide specific written feedback.
- Coordinate with FAA certification team (i.e., program manager and personnel from flight test, systems, propulsion, and airframe, as appropriate) regarding appropriateness of software levels identified in PSAC.
- Determine the level of FAA involvement in the software development project (e.g., number of reviews, amount of delegation, and required documentation) and document that involvement.
- Provide documentation summarizing the level of involvement and delegation to the FAA program manager and the applicant's team.
- Specify to applicant which software plans must be submitted to the FAA.
- Identify potential issues that require new policy or issue papers, and begin to address those issues.
- Provide prompt response to issue papers having potential program impact.
- Provide feedback and agreement on applicant's delegation plan.
- Provide written approval of PSAC as soon as possible.
- Review the SDP, SQAP, SVP, and SCMP, as required, as soon as possible after submittal to assure that if those plans are

followed the objectives of DO-178B will be satisfied.
- Coordinate concerns with the applicant.
- Do on-site or desk-top review of the planning stage (using the Software Review Job Aid), as needed.
- Communicate all concerns in a timely manner with the applicant.
- Document agreements with the applicant.
- Coordinate with National Resource Specialists (NRS), Technical Specialist (TS), Headquarters personnel, and Directorate personnel, as needed. (Note: Roles and responsibilities of these key players are being document in FAA policy.)
- Plan future activities.

The applicant's roles/responsibilities during the software planning stage are:

- Involve designees early in the process.
- Prepare PSAC that is detailed enough to establish a binding agreement.
- Coordinate draft PSAC and proposed software levels with applicant's certification team and FAA engineer responsible for software approval.
- Submit the PSAC as early as possible in program to get agreement with the FAA.
- Respond to FAA feedback, resubmit PSAC and follow up on approval, as required.
- Notify FAA of any significant changes to previously agreed to/identified plans.
- Provide prompt response to issue papers having potential program impact.
- Propose delegation plan (i.e., identify proposed designees and their planned activities/approvals).
- Provide FAA with a prioritized list of submitted documentation (i.e., communicate to the FAA the critical and immediate needs for data review).
- Discuss safety assessment process status/updates (continuous throughout development life cycle).
- Obtain FAA written approval or agreement on any updates to PSAC.
- Prepare the SDP, SQAP, SCMP, SVP, and development standards.
- Coordinate plans with designees.
- Submit software plans, as required by the FAA.
- Coordinate approval of all software plans prior to development activities.

5. The ***Certification Program Plan*** (CPP) (or equivalent documentation) records the FAA's intended involvement within the software aspects of the program, the required document submittals, anticipated delegation plan, significant program issues, milestones, and any other important programmatic issues. The CPP is developed by the FAA based on the applicant's input from the previous tasks and should be completed as soon as possible after the approval of the PSAC. The CPP is primarily used for internal FAA coordination but should be provided to the applicant to clarify the FAA's expectations throughout the program.

The FAA's software-specific roles/responsibilities for this task are as follows:

- Perform an assessment of expected level of FAA involvement in the software program.
- Review the applicant's plan for designee coverage.
- Document involvement plans (e.g., number of software reviews, required data submittals, and delegation agreements) and include in the CPP.
- Document potential risks of the program.
- Coordinate CPP with FAA certification team.
- Coordinate CPP with applicant.

The applicant's role/responsibility for the CPP task is to review the CPP and provide feedback to the FAA, in a timely manner.

6. The ***Software Development Stage*** is the phase in which the applicant develops the software, following the approved plans. The applicant develops requirements, design, code,

and other development data; while the FAA monitors adherence to the approved plans and compliance to the objectives of DO-178B. Any deviance from the plans should be coordinated between the FAA and the applicant and resolved as quickly as possible.

The FAA's roles/responsibilities during the software development phase are:

- Review applicant's documents, as needed (using an engineer/inspector team).
- Communicate all concerns with the applicant.
- Clearly state expectations.
- Communicate with other FAA certification team members.
- Follow the Software Review Job Aid during on-site and desk-top reviews, as needed.
- Document concerns and issues throughout the program.

During this task, the applicant carries out the following roles/responsibilities:

- Follow approved plans and transition criteria.
- Coordinate any changes to process through updated PSAC and/or letter to the FAA.
- Maintain open communication with the FAA.
- Continue to share concepts with FAA and applicant certification teams to clarify/refine requirements, design, human factors, etc. to mitigate certification risks.
- Document evidence of process compliance.
- Perform internal software reviews using the Software Review Job Aid.
- Coordinate and prepare for software reviews before the FAA or designees arrive.
- Maintain continuous designee involvement.

7. The ***Software Verification/Test Stage*** includes verification throughout the development process and software tests toward the end of the project. Verification is integral throughout the development program; however, there is a lot of activity developed around the test phase. During this task the applicant performs verification and test activities; while the FAA monitors the activities.

The FAA's roles/responsibilities during the software verification/test stage are as follows:

- Review the applicant's documents, verification process and results, and test program, as needed, through on-site or desk-top reviews (using an engineer/inspector team).
- Communicate with designees to understand and address any software issues.
- Oversee designee activity.
- Follow the Software Review Job Aid, if on-site or desk-top reviews are needed.
- Clearly explain expectations to the applicant.
- Communicate all concerns with applicant.
- Communicate with other FAA certification team members.

The applicant's roles/responsibilities during this task are as follows:

- Maintain focus, despite schedule pressures.
- Follow transition criteria and approved plans.
- Maintain open communication with the FAA.
- Discuss issues and concerns with the FAA as they arise.
- Continue to share concepts with FAA and applicant certification teams to clarify/refine requirements, design, human factors, etc. to mitigate certification risks.
- Implement peer reviews and internal reviews.
- Document verification and test results, including problems.
- Document evidence of process compliance (e.g., problem tracking, configuration management, and quality assurance).
- Coordinate and prepare for internal reviews, walkthroughs, and inspections.
- Maintain continuous designee involvement.

- Use the Software Review Job Aid as guide to prepare for FAA or designee reviews.

8. ***Software Meetings and Reviews*** occur throughout the software development and approval process to address issues. These meetings involve the FAA and applicant's software specialists and are intended to resolve software issues as they arise. In an aggressive TC program, with multiple software components, these meetings should be held regularly. A clear and consistent communication path between the FAA, the applicant, and the software developer is essential for a successful program.

Depending on the criticality of the software, the amount of designee support, and the experience of the applicant or software developer, on-site or desk-top software reviews may be performed by the FAA and/or designees. For additional information on the software review process, reference the Software Review Job Aid.

The FAA's activities during this task are as follows:

- Work for early resolution of issues.
- Coordinate agendas of meetings.
- Coordinate involvement of correct people at meetings (i.e., seek NRS, TS, Headquarters, or Directorate advice, as needed).
- Prepare for meetings (e.g., review minutes of previous meetings and carry out action items due from previous meetings).
- Involve certification team, as needed.
- Keep commitments.
- Agree on timeframes and expectations.
- Use the Software Review Job Aid when performing software reviews.
- Work for early resolution of issues.
- Leave with clear assignments.
- Document meeting/review agreements and required actions in a timely fashion.

The applicant's activities during this task are as follows:

- Review previous meeting actions and discussions.
- Keep a master action item list.
- Have frequent and open communication with FAA.
- Coordinate software reviews with FAA.
- Use the FAA Software Review Job Aid to prepare for FAA or designee reviews.
- Involve designees throughout the project and in all meetings with FAA.
- Request meetings with FAA NRS, TS, Headquarters, and Directorates, as needed.

9. The Pre-flight TC Board Meeting occurs prior to the certification flight test program and addresses issues to be resolved prior to certification flight testing.

10. The Type Inspection Authorization (TIA) is the document that records the tests and conformity to be performed during the certification program. The TIA gathers input from certification specialists of all disciplines and must be completed prior to certification flight testing. The TIA is typically revised multiple times throughout the TC program to address new test plans and aircraft configurations.

11. ***Conformity Inspection and Certification Flight Testing*** is the process of configuring and flight testing the aircraft. The aircraft must be in a well-defined and documented configuration prior to certification testing. Conformity inspections assure that the configuration being tested is the configuration being certified. Certification flight testing typically results in changes to systems requirements that affect software. Both FAA and applicant should have a process in place to address issues that occur during the flight test program.

The FAA's roles/responsibilities are as follows:

- Coordinate conformity expectations between certification engineers, manufacturing inspectors, and the applicant.
- Address changes in direction, as they occur.

- Coordinate with flight test and the certification team on any safety of flight issues/concerns.

The applicant's roles/responsibilities during this task are as follows:

- Provide training on conformity to employees and subcontractors/suppliers.
- Explain innovations and logic clearly to FAA.
- Minimize change to prior agreements.
- Thoroughly test on bench early and prior to aircraft installation.

12. The ***Final Software Compliance Stage*** includes resolution of software issues identified in problem reports and flight testing and submittal/approval of the software accomplishment summary, configuration indexes, and other documents required by the FAA. A software meeting or review between the applicant and FAA software specialists may be required to resolve all software issues and grant software approval.

The FAA's roles/responsibilities during the final software compliance stage are as follows:

- Address any open items from previous meetings, reviews, or discussions.
- Coordinate with designees any final compliance expectations (e.g. internal reviews or delegated objectives).
- Follow the Software Review Job Aid for the final compliance stage.
- Communicate, document, and track all issues with the applicant.
- Communicate with certification team and any national resources, as needed, to assure resolution of all open issues.
- Approve required documents, when all identifiable deficiencies are resolved, as soon as possible after receipt.

The applicant's roles/responsibilities during this task are as follows:

- Conduct internal reviews and involve designees.
- Review and document software problem resolutions and screen for safety related issues.
- Coordinate with the certification team regarding any systems, safety, or flight test issues.
- Perform final configuration management lockdown and prepare configuration indexes.
- Use the Software Review Job Aid to prepare for audits and correct deficiencies.
- Conduct software conformity reviews.
- Prepare software accomplishment summary.
- Produce and submit all mandatory and requested data.
- Notify FAA of readiness for review, when required.
- Hold review and establish list of action items, when required.
- Execute corrective actions, as necessary, and resubmit documents.

13. Aircraft Evaluation Group (AEG) Determinations are typically completed during or after the certification flight tests. AEG determinations include the FAA's evaluation of the operational and airworthiness aspects of the product.

14. Final TC Board Meeting is a meeting between the FAA and applicant at the end of the certification program. In some cases the certificate is actually issued at this meeting. In other cases, the open certification issues are clearly communicated and documented.

15. The Issuance of TC is the final task of the certification process. For major TC programs, this is typically accompanied by media coverage and speeches from the applicant's high level management. The overall program rarely ends with the issuance of the TC. There are typically many follow-on issues to be addressed. The follow-on plan and agreements between the FAA and applicant should be clearly documented prior to issuance of the TC.

Conclusion

Fifteen general tasks and 8 software-specific tasks have been outlined. Although the FAA and applicant's roles and responsibilities are discussed separately, it is important for both to work together throughout the entire certification process. Early agreements and continuous communication throughout the certification program are essential to the success. The FAA and applicant are partners in the certification process, not adversaries--both have a stake and desire success.

This paper provides both the certification authorities and the applicant a glimpse of the other's activities and needs. Hopefully, this information will encourage the partnering process, lead to better planning by all stakeholders, and result in successful software approvals.

The process presented has focused on the software aspects of the certification program. There are many other safety and non-software activities that occur in the certification program. Likewise, emphasis has been placed on the TC process within the United States; however, the process presented may be applicable to non-TC and international projects, as well.

References

"Conducting Software Reviews Prior to Certification." A job aid developed by the FAA (June, 1998). Available at web-site: http://www.faa.gov/avr/air/air100/sware/sware.htm.

RTCA DO-178B, "Software Considerations in Airborne Systems and Equipment Certification," dated December 1, 1992.

"The FAA Type Certification Process." A job aid developed by FAA and GAMA (May, 1996).

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