



Best Practices for Loadable Software Management and Configuration Control

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1. Executive Summary

With rapid technological advances over the past two decades, aircraft loadable software applications and their associated configuration management have grown in complexity and pose a major maintenance and financial burden to operators of older and current-generation aircraft. The risks of AOG situations and regulatory non-compliance posed by cumbersome and archaic systems and processes have added urgency to the development of efficient and robust software management systems.

Operation and maintenance of aircraft with loadable software systems require operators to have proper procedures and processes in place to address:

- Software change assessment
- Procurement and production
- Receipt and distribution
- Configuration control
- Quality audits and;
- Management of software libraries.

Operators need to tailor and optimise their processes within each of these areas to ensure timely availability and incorporation of software updates.

Vendor solutions leveraging off new-generation wireless- and web-enabled technology are now becoming increasingly available and rapidly growing in popularity. They offer efficient, automated and cost-effective solutions in relation to the whole end-to-end processes of software configuration management. Though initial cost impact and procedural hurdles might seem daunting, given the reliability and scalability of the solutions, the benefits far outweigh the implementation costs.



2. Background

The number of applications developed to control aircraft systems and flight functions has grown exponentially in just the last decade. Older Boeing 737s and Airbus A320s were loaded with, maybe 30 pieces of software that changed fairly infrequently. They could be kept track of on a sheet of paper.

With the introduction of the Boeing 777 in the mid-1990s, the number increased to 120+ pieces of software.

Fast forward to today's newest aircraft like the Boeing 787, and not only has the quantity of software jumped to as high as 500 units, but those 500 applications of software are not loaded to just 500 locations, they're being loaded onto 800 to 900 locations.

Software management has clearly become challenging, especially since most airlines are still using archaic distribution methods. Imagine piles of floppy disks, hours spent loading software parts into multiple Line Replaceable Units (LRUs) on multiple aircraft in multiple locations, while still being able to keep track of all aircraft configurations and aircraft equipment loaded.

The downside of aircraft software is that when things do not go correctly the aircraft simply sits on the ground.

With such experiences becoming more commonplace in the industry, the need for established software management and configuration control processes is no longer an option, it is a necessity (Teledyne n.d.).

3. Loadable Software Systems

Many aircraft systems comprise hardware and software components. A loadable system is different because it consists of loadable software parts and loadable (hardware) LRUs that are independently configured at the airplane level.

Software can be transferred into software - loadable LRU using equipment such as a permanently installed on board loader, a portable on-board loader or supplier automated test equipment.

A few systems can be loaded on-board by inserting the medium into the LRU itself. The appropriate equipment used to load an LRU depends on the system. For all loadable systems, the software parts installed as part of the system are identified electronically; a placard is not required on an LRU to identify what software parts are loaded in that LRU (BOEING n.d.).



4. Loadable Software Processes

To operate and maintain an airplane that contains software loadable systems, operators first must implement several procedures to accomplish the following:

1. Software Change Assessment
2. Procurement & production
3. Receipt & Distribution
4. Configuration Control
5. Quality Audits
6. Manage software libraries

4.1 Software Change Assessment

OEM or Vendors notify operators of Software upgrades through one of several mediums such as

- ↗ Service Bulletins (SB)
- ↗ Engineering Orders
- ↗ Service Letters (SL)
- ↗ Vendor Notifications
- ↗ OEM Specific Communications

Software upgrades receipted through any of the above mediums are generally registered through the operators Technical Library and processed to the relevant engineering department to assess applicability, validity and compliance requirements.

Engineering implement change requests into their operating systems creating engineering controls functionality and task cards that include data such as Document Numbers, Part Numbers, Aircraft effectivity, tooling, man-hours, skills, installation instructions and schedule timelines.

The following processes are considered as best practice ensuring that the aircraft loadable software is controlled and managed within a centralised location ensuring standardisation of the upgrade processes

1. Some operators have introduced processes wherein a single engineering or avionics office manages the software assessment, distribution and control for all software upgrade on aircraft.



2. Additionally, all loadable software introduced or upgraded on aircraft systems are accomplished via an engineering generated task card, engineering order or equivalent approved documentation.

4.2 Procurement and production

An operator is responsible for the purchasing and ordering of Loadable software. The operator is responsible for obtaining the appropriate documentation, including the appropriate licensing agreement for all intended installations. Service Bulletins (SBs) may be used by suppliers to provide software updates (CAA NZ 2010).

To order a loadable LRU with the software preloaded, the operator must order both the software and hardware part numbers and stipulate that the software is to be loaded into the LRU.

The part number of a software program or file is distinct both from the part number for the media set and the part number for the hardware LRU.

Loadable Software that is Part Number controlled is provided by LRU suppliers accompanied by an authorised release certification such as FAA 8130 or EASA Form 1.

With some applications, Software is downloaded by the operator directly from the vendor website and loaded onto loadable mediums; the NDB (Navigational Data Base) is an example of downloadable software.

The NDB is a database of navigation and route information used by the FMC (Flight Management Computer) to carry out navigation tasks. NDB software is typically revised every 28 days and becomes available approximately one week before it becomes effective. Unlike other loadable software, the NDB is date controlled as opposed to part number controlled (BOEING n.d.).

Software that is downloaded onto operators computers and then duplicated for distribution require operators to establish processes for software verification, identification of duplicated media as well as Vendor approval for duplication of software.

A recommended best practice is to ensure that duplication of media which is authorised by the supplier should be process controlled and error checked.



4.2.1 Software Duplication

Operators expect to be authorised by the owner of the software intellectual property rights to use and copy the software applications that are required to maintain the authorised configuration of their aircraft.

Therefore, the operator needs to respect the following needs:

- Protect the intellectual property rights contained in the software
- The software will be used by the operator only in applications that are authorised by the intellectual property rights owner (CAA NZ 2010).

Some operators have introduced a best practise for purchasing the required number of Media sets directly from the OEM or Software suppliers. This negates the requirement for downloading and duplication of software.

4.2.2 Operator Responsibilities

The operator is responsible for the copying procedure and the software tools used in the copying process. The operator should maintain a list of software applications for which permission to duplicate is authorised and use the designated master media set for duplication.

4.3 Receipt and Distribution

Operators should have procedures and processes to inspect software media upon receiving it from both internal and external sources. As a minimum, the inspection should examine the media for correlation between the documentation accompanying the media and the information shown on the media label describing its contents (CAA NZ 2010).

Software distribution for installation on aircraft at the main maintenance base or line stations will vary between operators. Operators will need to define processes for distribution of the software to be loaded onto aircraft in accordance with the instructions and time frame specified by the controlling document.



4.4 Configuration Control

The operator must implement procedures to control updates and modifications to loadable systems that occur after the airplane is delivered. The part numbers of the software loaded into a loadable system are part of the type certificate of the airplane. The operator must ensure that the configuration control documentation for each airplane reflects the current configuration of loadable software parts, and that the loadable software parts are certified for the airplane on which they are installed.

Loadable software requires the same configuration control as airplane hardware components. The software part numbers that are part of the delivered configuration of an airplane are documented in the engineering drawings provided with the airplane at delivery. In addition, a report listing the software part numbers delivered with a particular airplane is provided as an attachment to the airplane readiness log. However, this report, as well as the IPC, will not reflect any rapid revisions (RR) incorporated on a particular airplane that affected loadable software parts. The operator should review all RRs incorporated on a particular airplane for an accurate understanding of the certified configuration.

Some operators have developed a customized IPC bulletin to keep track of allowable combination of H/W and S/W for each tail number. Tracking and control is maintained by modification status per EO incorporation. With introduction of newer aircraft models, instead of IPC bulletin these operators also maintain a database of allowable H/W and S/W configuration including P/N, Location, ID, Tail No. etc.

The software loaded on a loadable LRU is reported electronically, so a marking on the LRU is not necessary. To verify that the appropriate software parts are installed, it must be possible to confirm that the appropriate software is loaded while the component is installed in the airplane. Relying on placards or other markings to determine the part number of the software loaded in a component is not recommended.

To confirm that the proper part number is loaded in a component, the operator should verify component status electronically by reading the part number from a front panel display, MCDU (Maintenance Control Display Unit), or other device designed for that purpose.

The operator's configuration control processes should ensure that the configuration of software part numbers installed on each airplane is documented. This documentation should be updated when service bulletins or other changes are incorporated and should be available when needed.



Personnel should be trained and aware of the airline's configuration control processes and the importance of maintaining the certified configuration of loadable software parts (BOEING n.d.).

4.5 Quality Audits

As part of the review of airworthiness or maintenance review, it is recommended that operators carry out an audit of all software installed in the aircraft. This will ensure that the software actually installed and the aircraft records match and that there are no configuration discrepancies.

Operators should verify on a regular basis that they have all the manufacturers' current Service Bulletins for the equipment installed in their aircraft (CAA NZ 2010).

4.6 Manage Software Libraries

It is recommended that operators establish and maintain a software control library (or libraries) for storing Master and backup copies of loadable software, associated documentation, and any media binders that are not kept on an airplane. Using a software control library can help operators ensure the availability and integrity of loadable software parts to support their airplanes (BOEING n.d.).

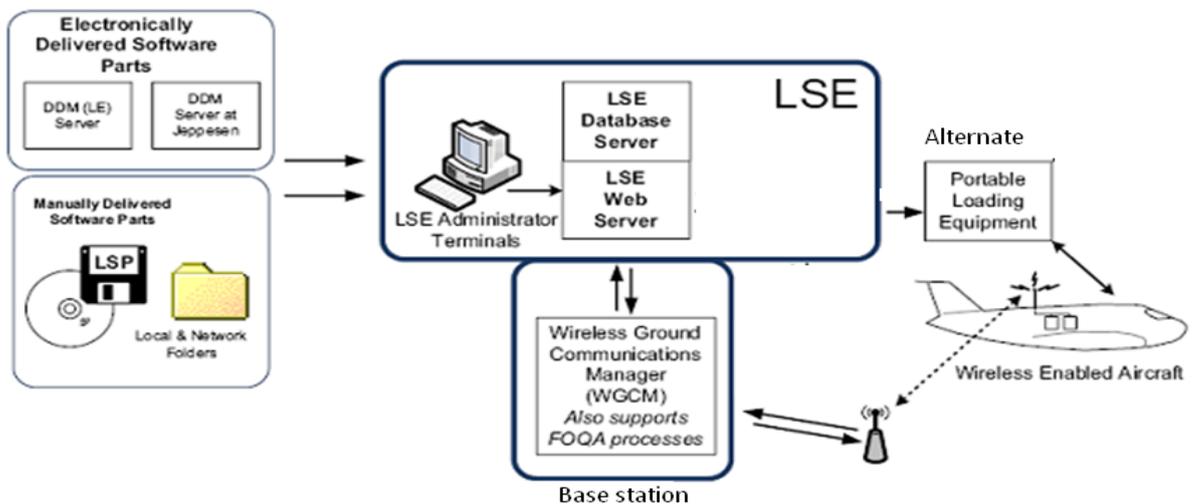
5 Wireless Solutions

The need to simplify management of aircraft loadable software for several hundred software applications on newest aircraft has resulted in Vendor solutions to optimize data distribution and streamline the processes with Configuration and Control of Loadable software upgrades.

Optimize Data Distribution, Configuration Control and Regulatory Compliance

Teledyne's Wireless GroundLink® Dataloading (WGL-Dataloading™) allows airlines to efficiently manage and transfer Software Parts (SPs) and navigation databases to their aircraft, instantaneously and reliably, with the press of a button. This integrated system enables airlines to transition from manual SP distribution based on floppy disks, CDs, PMAT (Portable Maintenance Access Terminal) and paper-based methods, to a paperless and automatic distribution process. By reducing the steps and time required to perform manual loads, Teledyne's WGL-Dataloading™ solution speeds-up information delivery, minimizes costs, and optimizes efficiency and process management.

Software configuration for the aircraft resides in the eADL (Enhanced Airborne Data Loader) (Teledyne Controls n.d.).





5.1 Wireless Solutions Considerations

Any aircraft with a Data loading capability can be adapted to e-Loading of software provided complementary component such as a Wireless link is installed and establishment of GSE ground base stations.

Operators considering to transition to the wireless software solutions need to consider the following:

1. Aircraft manufacturer certification and OEM STC approvals for initial installations
2. Local Regulatory approval may be required to permit Software download to aircraft
3. Precision set up with IT/GSE Base station for wireless transfers
4. Defined processes to provide full control for aircraft software configuration and software distribution
5. Validation processes to ensure proper aircraft configuration pre and post software upgrade
6. Validation processes to ensure configuration and control following replacement of an LRU with upgradable software
7. Cost impact to operators with transition from manual loading to wireless loading of aircraft software



6 Conclusion

Loadable software can be a useful tool for operators by providing them with the ability to quickly change or update functionality on their commercial airplanes.

If operators take the necessary steps to prepare for the maintenance of loadable software systems, they can keep fewer hardware LRUs in stock, increase hardware commonality, and reduce airplane modification time. The maintenance activity to use loadable software includes procuring the necessary loadable software parts and loadable LRUs, managing software libraries, preloading loadable software parts into loadable LRUs off the airplane, and verifying that loadable software part configurations conform to airplane certification documentation (BOEING n.d.).

Boeing currently uses floppy disks to deliver software to operators for several on-board software loadable LRUs. However, due to diminishing supply, use of floppy disks is being discontinued. The long range plan for replacing the floppy disks is implementation of Boeing electronic distribution of software (BEDS) by the end of 2014. In the interim until BEDS is implemented, the floppy disks will be replaced by integrated DVDs for delivering software for on-board software loadable LRUs. When BEDS is eventually implemented, all software that was being provided on integrated DVDs will be sent electronically to operators. Boeing encourages operators to prepare for receiving software on integrated DVDs as the processes and tools used to support this will also support the transition to BEDS (BOEING 2013).

Wireless solutions significantly enhance the ability to manage loadable software configuration and control. In addition, wireless solutions reduces the time spent duplicating and distributing software as well as time required to manually validate and track configuration of the software loaded on aircraft.



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