



A320 Family Aircraft configuration

SOFTWARE HAVE THEIR OWN PART TOO!

With the introduction of a data loading function on A320 Family aircraft Flight Control and Auto Flight computers, managing the aircraft configuration entered a new dimension. Flying a certified aircraft now requires understanding not only hardware Part Numbers, but also less immediately visible operational software ones.



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In 2009, a new data loading function was introduced on A320 Family aircraft Flight Control and Auto Flight systems computers. Although the operational improvements brought by Field Loadable Software (FLS) are widely appreciated, experience gained with them highlights a potential for aircraft configuration mismanagement as a result of improper software part number uploading in the computers.

In fact, the use of data loadable computers requires to manage not only hardware Part Numbers (PN), but also software PN and their combinations. This evolution calls for a change in mind sets and practices to properly manage FLS and data loadable computers configurations and in turn, the aircraft configuration. This article will highlight the underlying safety aspects of an incorrect use of FLS and review how to best prevent it.

FIELD LOADABLE SOFTWARE: WHAT IS IT ABOUT?

Field Loadable Software (FLS) associated with Data Loadable Units (DLU), were originally introduced to facilitate the evolution of standards and the management of spares. To do so, these computers provide an upgraded hardware that can accommodate different versions of operational software, i.e. different

standards. Updating the standard of a FLS can thus be done without removing the hardware itself from aircraft. Indeed, it simply consists in uploading the new version of the operational software from a media disk to the same hardware, either directly on-board or using a portable data loader.

Are all A320 Family aircraft concerned?

Field Loadable Software started to be introduced progressively on the A320 Family around six years ago. In practice, on the existing fleet, some aircraft have it (either from delivery or via Service Bulletin), others don't. However, even the non-equipped aircraft can accommodate a DLU

hardware without using the aircraft data loading function. In that case, the hardware needs to be fitted upstream in a repair shop, with the adequate operational software version. The DLU loaded with the relevant Field Loadable Software standard then behaves as a non-loadable computer.

“ On the existing A320 Family fleet, some aircraft have FLS, others don't. Yet, all aircraft can accommodate DLUs. ”

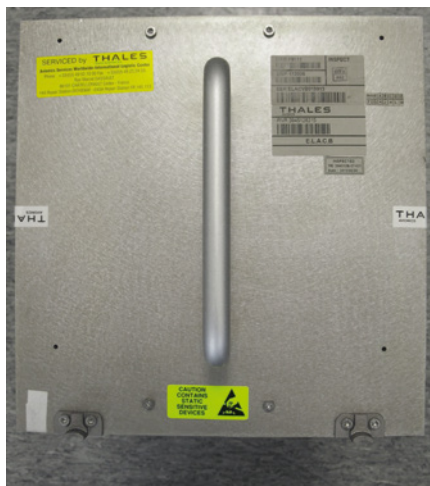
“ A quick glance at the hardware installed cannot tell everything about the FLS standard, and in turn, the actual aircraft configuration. ”

What does the data loading function change in practice?

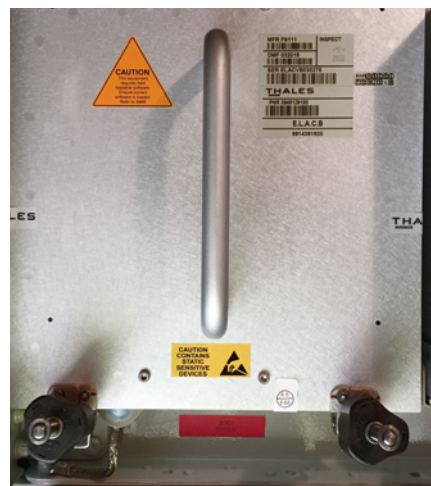
If a DLU loaded with the appropriate standard behaves exactly as a non-loadable computer, whether it is installed on an aircraft with the data loading function or not, the use of this new DLU introduces a major change in terms of spares and aircraft configuration management: the emergence of

a new, intangible and not immediately visible dimension.

Indeed, with the disconnection between hardware and operational software introduced by Data Loadable Units, the aircraft configuration consists of physical parts PN **as well as** operational software PN.



Non-DL ELAC



DL ELAC

In practice, it means that a quick glance at the hardware installed is not sufficient to identify the FLS standard, and in turn, the actual aircraft configuration. ■



WHAT IF THE AIRCRAFT FLIES WITH INAPPROPRIATE OPERATIONAL SOFTWARE? OR WHEN INAPPROPRIATE OPERATIONAL SOFTWARE CAN LEAD TO A NON-CERTIFIED AIRCRAFT CONFIGURATION...

No one would install an incorrect hardware PN on the aircraft as the aircraft would then be in a non-certified condition, with all the potential safety consequences it could have. Flying with incorrect operational software comes to the same thing!

operating such configurations, whether immediate or not, could not be studied and tested because exploring them falls de facto outside of the design studies. However, they do exist and can take on a potential significant safety dimension.

Indeed, uploading an operational software into a hardware which is not supposed to receive it, leads to a non-certified aircraft configuration. This implies that the consequences of

The cases that were observed in service are good examples to reveal that consequences are varied and may actually impair safety in very different ways.

Case 1: Excessive structural loads - unknown structural fatigue

Sharklet aircraft include a new Load Alleviation Function (LAF) that allows to limit wing loads. This function is key to ensure that wing loads remain within certification requirements. Fitting a Sharklet aircraft with a pre-Sharklet ELAC (Elevator and Aileron Computer) and/or SEC (Spoiler & Elevator Computer) standard leads to

losing this LAF function, thus exposing the wing to non-anticipated and studied loads. If the consequences cannot be detected immediately, such non-certified configuration leads to structural loads and ultimately structural fatigue that have not been studied as such, but could ultimately result in safety concerns.

Case 2: Falsely relying on a safety enhancement not implemented on the aircraft

In order to reduce the likelihood of tail strikes or hard landings, new ELAC standards were developed with an improved transition flare law to ground law. Flying with an aircraft supposed to be fitted with these new computers and actually fitted with an ELAC standard prior to these improvements leads to a situation where pilots believe they benefit from these improvements whereas they actually don't. It is like driving a car believing it is equipped

with ABS system whereas it does not have the function.

Similarly, ROPS (Runway Overrun Protection System) is only available with the latest loadable FAC (Flight Augmentation Computer) standard. Installing an older software on a ROPS-capable aircraft would lead to lose this safety enhancement function and the crew would not be aware of it.

“ Unexplored safety related consequences does not mean no safety consequences. ”

Case 3: Improper surfaces control and unexpected aircraft behavior

On Sharklet aircraft, in case Sharklet capable and non-Sharklet capable FLS are mistakenly mixed (knowing that this is a non-allowed and non-certified configuration), the behaviour and control of the aircraft might be impaired. Depending on the type of DLU concerned, possible consequences are:

- Mix of Sharklet capable and non-Sharklet capable ELAC/SEC Spoiler, Aileron and/or Elevator Surface actuator orders and monitoring provided by each ELAC/SEC might be different from one actuator to the other (as controlled by different units).
This may result in:
 - Force fighting in case of elevator double pressurisation (might lead to structural defect and/or Aircraft unexpected behaviour)
- Left and right Aileron surfaces synchronisation not properly applied as expected (might lead to Aircraft unexpected behaviour).
- Mix of Sharklet capable and non-Sharklet capable FAC
Installing a non-Sharklet capable FAC on a Sharklet aircraft may lead to erroneous characteristic speeds computation, which, in turn, may affect safety margins against the stall speed.

These cases are not an exhaustive list of the safety related consequences that may result from an erroneous combination of a DLU hardware loaded with the undesirable operational software standard. Some of the effects described are potential effects based on a purely theoretical analysis since these configurations have never been tested. However, unexplored safety related consequences does not mean no safety consequences!

With this in mind, the key question is: how to avoid installing a Data Loadable Unit with an inadequate FLS standard? ■



DID YOU KNOW

ISI (In-Service Information) Ref. 27.93.00001 “ELAC mixability and interchangeability matrices” details how to manage data loadable units and associated Part Numbers. This document can be found on Airbus World.

PREVENTION: HOW TO AVOID INSTALLING A DATA LOADABLE UNIT WITH AN INADEQUATE OPERATIONAL SOFTWARE STANDARD?

In view of the potential operational consequences described earlier, Operators need to be cautious with FLS and DLUs management in order to ensure their aircraft are operated in a certified

configuration at all time. Prevention starts with a good awareness of the most common factors that can contribute to having a DLU loaded with an undesirable operational software.

The investigation into reported events of improper operational software uploaded into Data Loadable Units highlighted a variety of initial contributing factors. Yet, they all have in common a major step being overlooked in the computer removal/installation AMM procedure: operational software identification through a LRU IDENTIFICATION check (LRU stands for Line Replaceable Unit)!

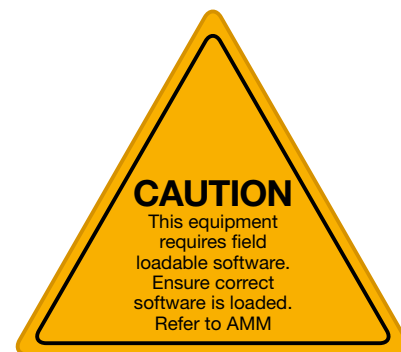
When operating FLS, strict adherence to all of the steps detailed in the AMM removal/installation tasks, and the LRU IDENTIFICATION step in particular, is the foundation of a good aircraft configuration management.

In more detail, investigation results highlighted that installing a DLU loaded with inappropriate software often results from the combination of being convinced to have the correct computer although not having it, and not taking the time to perform the procedure correctly, especially the operational software identification

step requested in the AMM installation and uploading tasks.

Being convinced of having installed the correct FLS standard although not having it, can in turn come from different reasons, such as:

- not having realized that the DLUs consist of two distinct parts, namely a hardware one and a software one, bearing 2 distinct Part Numbers and 2 FINs (Functional Item Number),
- being excessively confident in the shop that delivers the parts to be installed (the DLU received from the shop might not be loaded with the relevant operational software, i.e. the one that matches the actual aircraft configuration),
- relying on the spot on an old habit where a quick external glance at physical parts and their labels was sufficient to tell the computer standard.



Using existing safety barriers



As explained earlier, the introduction of Field Loadable Software comes with a change in philosophy and the emergence of a new intangible dimension in aircraft

configuration management. In contrast to hardware parts, operational software are always hosted. They are the invisible ones, behind the scene.

(fig.1)
 Preventing the installation of an improper ELAC operational software onto the aircraft thanks to the AMM

“ Operational software identification (LRU IDENTIFICATION) is the ultimate safety barrier to prevent inappropriate FLS and aircraft configurations. ”

Concerning the parts managed by the shop, the disconnection between the hardware and the operational software for DLUs also implied switching from a unique computer FIN integrating both the hardware and software parts, to two distinct FINs corresponding respectively to the hardware PN and the operational software PN. In some airlines though, the spare parts supply chain management tool remained unchanged and does not accommodate two different FINs for a single FLS computer. This limitation

induces difficulties to ensure that the computer delivered is loaded with the appropriate operational software version.

In any case, an ultimate safety barrier was developed and included into the AMM to prevent the installation of improper operational software onto the aircraft: operational software identification via LRU IDENTIFICATION action and cross check of that information with the PN displayed on the media disk **(fig.1)**.

4. Procedure

Subtask 27-93-00-280-052-A

A. Do a check of the reference of the software loaded in the ELAC

NOTE: This procedure is for the ELAC1. For the ELAC2, use the indications between the parentheses.

(1) Do the procedure to get access to the SYSTEM REPORT/TEST F/CTL page (Ref. AMM TASK 31-32-00-860-006) .

ACTION	RESULT
1.Push the line key adjacent to the EFCS 1(2) indication.	The EFCS 1(2) menu page comes into view.
2.Push the line key adjacent to the LRU IDENTIFICATION indication.	The LRU IDENTIFICATION page comes into view.

(2) Make sure that the P/N of the ELAC shown on the LRU IDENTIFICATION page is the same as the P/N on the media disk.

(a) If the P/N of the ELAC shown on the LRU IDENTIFICATION page is different from the P/N on the media disk, replace the ELAC.

NOTE: If the two ELACs were not loaded with the same software, make sure that the configuration of the ELAC1/ELAC2 is a permitted configuration.

Computer removal & installation is usually performed in line maintenance. In practice, it may for example mean being under operational pressure to keep the aircraft on schedule. However, performing this check of the software reference between the one

displayed in the cockpit, on the LRU IDENTIFICATION page, against the one showed on the media disk is the only way to detect any discrepancy whatever its origin. Indeed, as mentioned earlier, a quick look at the DLU hardware can only tell part of the story.



Further enhancing prevention...

The in-depth analysis of reported events allowed for better understanding where problems originated from, and thus for devising ways forward.

As of today, the available prevention measures include:

- The improvement of the IPC to include explicit content and reinforce awareness on FLS **(fig.2)**.
- The improvement of the ISI (In-Service Information) documentation as a support for your fleet management. This document offers a good overview of existing certified configurations by explicitly explaining the hardware PN & operational software PN combination compatibility with the aircraft configuration. This advice is provided on the understanding that an ISI is not an approved instruction; therefore once a configuration is identified by this means, the IPC must be checked in order to confirm that it is a certified one indeed.
- The introduction in the Field Loadable Software training on A320 Family aircraft, of more details on the recommended uploading procedure, as well as a reminder of these DLUs specificity compared to earlier standards of computers.

03C 103	3945129100	ELAC-ELEVATOR AILERON COMPUTER ELAC B-DL HARDWARE HAS P/N 3945129100. IT IS USED FOR DATA-LOADABLE HARDWARE PART NUMBER WITHOUT ANY INFORMATION REGARDING THE OPERATIONAL SOFTWARE LOADED. DATA-LOADABLE ELAC PN 3945129100 INTERCHANGEABILITY AND MIXABILITY CONDITIONS DEPEND ON THE OPERATIONAL SOFTWARE LOADED. SEE 27-93-34-01A 001K FOR DET	2CE1, 2CE2	002
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Going further, Airbus aims at facilitating the visual distinction of the hardware between the ones including the data loading function and the others. To this end, work is already ongoing in order to define and develop a new label that will be placed onto each DLU. This reinforced attention getter will aim at improving the visual identification of DLUs and thus, reminding the need to check the operational software PN. ■

(fig.2)
The IPC raises awareness on FLS



For those who have already experienced losing one of their favourite functionalities on their computer, smartphone or tablet because a new version of operating system had been developed and not yet updated on it, it is an unpleasant experience. When it comes to a Flight Control or Auto Flight computer loaded with a wrong operational software version, it can be far worse since it can affect safety. No doubt it is worth the very limited time and effort of a LRU IDENTIFICATION!

Safety first

Safety first, #21 January, 2016. Safety first is published by Airbus S.A.S. - 1, rond point Maurice Bellonte - 31707 Blagnac Cedex/France. Publisher: Yannick Malinge, Chief Product Safety Officer, Editor: Corinne Bieder, Director Product Safety Strategy & Communication. Concept Design by Airbus Multi Media Support 20152712. Reference: GS 420.0045 Issue 21. Photos by Airbus, A. Doumenjou, H. Goussé, P. Pigeyre, A. Tchaikovski, Lindner Fotografie.

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