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Airbus Cabin Software

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The cabin software of the Airbus A380 is the second major aircraft subsystem to be described in an Impact column after the flight management system in 2010. We thank Holger Kienle for connecting us to Stefan, Oliver, and Matthias. —*Michiel van Genuchten and Les Hatton*

THE AIRBUS A380—the largest civil aircraft built so far—consists of approximately 4 million individual parts contributed by roughly 1,500 companies. However, not only did its obvious mechanical complexity challenge engineers but so did the software systems hidden within the aircraft comprising several MLOC. The code is distributed over more than 1,000 onboard systems; Figure 1 illustrates some central examples.

The systems shown in Figure 1 provide important functions for wings, navigation, and cabin. The high-lift system (HLS) is responsible for controlling all electrical and hydraulic systems within the wings. All control surfaces also depend on the electrical flight control system (EFCS), which submits the pilot's control stick commands to the surfaces. Within the cockpit, the air data and inertial reference system (ADIRS) provides important flight parameters such as speed, altitude, flight vectors, and so on. The flight management systems (FMSs)[1] support the pilots in planning and optimizing travel routes to minimize flight time and fuel consumption, while the in-flight entertainment (IFE) system provides on-demand video and games for passenger entertainment during the flight. Another relatively new system is the airline network architecture (ALNA), establishing GSM and Internet connectivity between cabin and ground. Finally, the cabin intercommunication data system (CIDS) is responsible for controlling all cabin-related functionalities as well as most other systems in the cabin.

Cabin Intercommunication Data System

Table 1 gives an overview of the roughly 7,000 Airbus aircraft that have been built so far; a CIDS has played a part in more than 6,000 of them since the first A320 was delivered in 1988. Based on the system sizes, we can calculate the software mileage metric for the A320 (0.003) as well as for the A380 (0.000003), as proposed in a previous column.[2] (For more calculations related to previous columns, see the "Compound Annual Growth Rate in CIDS" sidebar.)

The CIDS used in the Airbus A380 has become one of the largest onboard software systems. Today, with all its subsystems, it comprises more than 5 MLOC, written mostly in C, Java, and VHDL, which Airbus and various subcontractors developed and distributed over more than 600 line-replaceable units such as servers, network nodes,

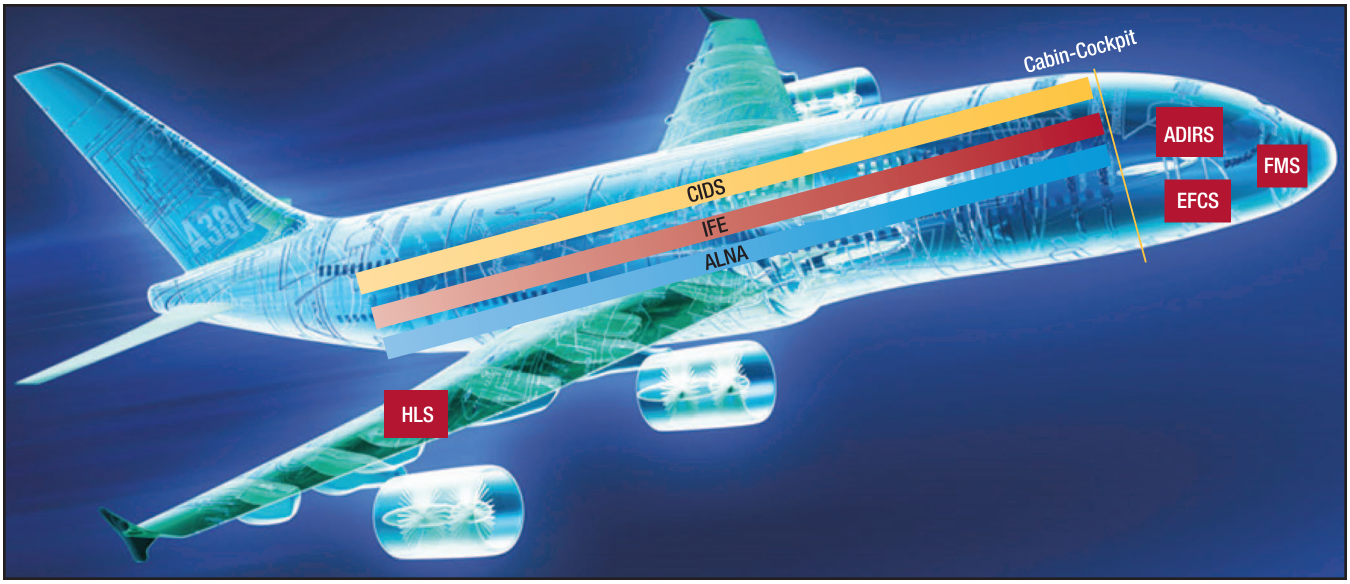

FIGURE 1. Central software systems in the Airbus A380 providing important functions for wings, navigation, and cabin: the high-lift system (HLS), the electrical flight control system (EFCS), the air data and inertial reference system (ADIRS), the flight management systems (FMSs), the in-flight entertainment (IFE) system, the airline network architecture (ALNA), and the cabin intercommunication data system (CIDS).

TABLE 1 Overview of Airbus aircraft types.*

Aircraft type	Launch of development	Entry into service	Number of delivered aircraft	Aircraft currently in service	Current CIDS server (MLOC)
A300/310	September 1967	May 1974	816	493	Contains no CIDS
A320 family	February 1981	March 1988	5,264	5,103	1.6
A330/340	June 1987	January 1993	1,283	1,263	Data not available
A350 XWB	October 2005	2014	0	0	1.8
A380	December 2000	October 2007	84	84	2.6

** As of September 2012.*

adapters, control boxes, and user panels. It integrates elements from various systems operating under real-time constraints and high safety requirements but also comprises GUIs, such as the flight attendant panel. Moreover, additional cabin systems (such as IFE), which are usually contributed by third parties, must be under the CIDS's control for safety reasons. (Take potentially safety-critical announcements that need to interrupt all IFE as an example.) In total, the CIDS itself provides more than 30 functions, such as cabin illumination control. While in the first A320 CIDS generation, the cabin lights could merely be switched on and off or dimmed in three predefined steps, the LED-based illumination ballast units in modern aircraft, such as the A380 or A350 XWB, are able to display complex light scenarios: they can create specific atmospheres—for example, during dinner or to minimize jet-lag effects by simulating an artificial course of a day. Moreover, the first A320 allowed light control only for three zones in the cabin; the A380 can manage 16 zones and 64 independent rooms, and the upcoming A350 XWB will be able to address the light strips within the cabin in 12-inch segments.

Safety First

In the passenger cabin, the CIDS must allow independent announcements for every cabin part and must fulfill real-time requirements to provide lip synchronous transmission (that is, with a delay of less than 10 ms[3]). Moreover, it also controls some safety-relevant cabin functions such as smoke detection in the cargo areas. Consequently, a major part of the complexity of all aircraft software is owed to nonfunctional requirements known to conflict with each other and hence require a good balance of architectural decisions. The CIDS is no exception. For instance, in addition to safety and performance requirements, it needs to fulfill high availability requirements. The current solution for overcoming this dilemma is a central cabin service bus that, on the one hand, successfully connects all subsystems with each other while ensuring fast and deterministic data interchange as well as allowing redundant system operation, but, on the other hand, reduces changeability due to its strictly defined data format.

Aircraft must be certified before they are allowed to fly.[1] During the certification process, all software functionalities must be categorized into one of five so-called design assurance levels according to their criticality; these range from A, which means potentially catastrophic for the aircraft, to E, which causes no effect on safety or crew workload.[4] Functionalities on different safety levels must be isolated from each other because software on higher safety levels requires enhanced safety precautions. Thus, for good reasons, the development of aircraft software is driven by safety-oriented software engineering techniques such as comprehensive modified condition/decision coverage testing, creating significant software development costs estimated to be about six times larger than those needed for the development of comparably sized business software or shrink-wrapped systems.[5] Fortunately, the safety levels for cabin software are relatively moderate—for example, the cabin smoke detection is usually classified on level C (major failure)[4] similar to the cabin

COMPOUND ANNUAL GROWTH RATE IN CIDS

Figure A illustrates the growth of the C code in the cabin intercommunication data system (CIDS) server software in the A320, A380, and A350 XWB over the past 10 years. On average, the compound annual growth rate (CAGR)[1] for the A320 CIDS's core (the so-called director main board) was about 1.06 from 2002 to 2011. However, there was no significant development activity on this system part between 2002 and 2006, so this value isn't representative. From 2006 to 2011, when various new functions were added, the CAGR was 1.11 and thus comparable with other reported values. The growth of the A380 CIDS can be traced back to 2004, when an early version of the system that comprised about 1.8 MLOC started growing with a CAGR of 1.07 until 2009. A CAGR of 1.11 was computed for the CIDS of the new A350 XWB (although, this is not yet in service) in the past two years. Overall, the calculated CAGRs are at the lower end of the spectrum compared to other systems presented in previous Impact columns; this, however, seems reasonable owing to the relatively stable high-level requirements, perceived low changeability, and the enormous certification effort required for avionic software.

Reference

1. M. van Genuchten and L. Hatton, "Compound Annual Growth Rate for Software," *IEEE Software*, vol. 29, no. 4, 2012, pp. 19–21.

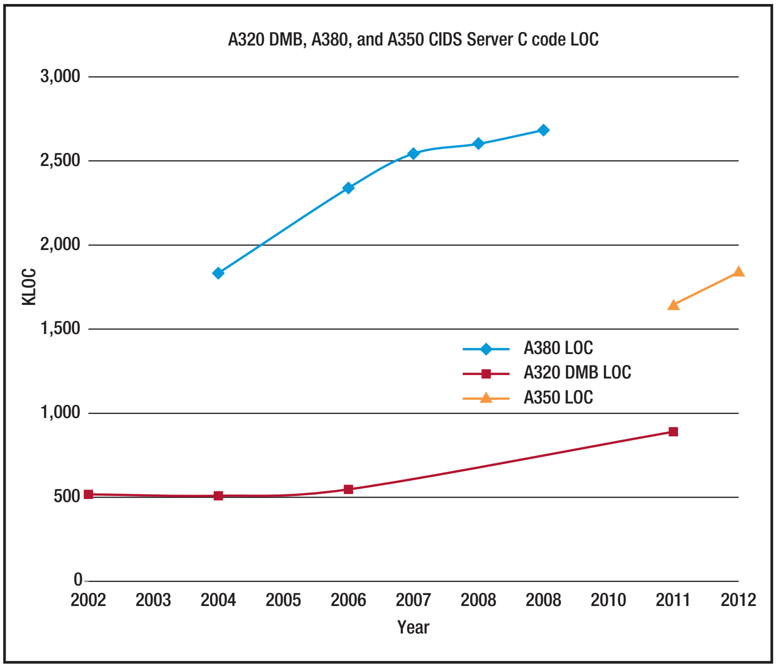

FIGURE A. Code size development for the CIDSs in the A320, A350, and A380 within the past 10 years. (For the A320, we tracked only the C code of the core component, the so-called director main board.)

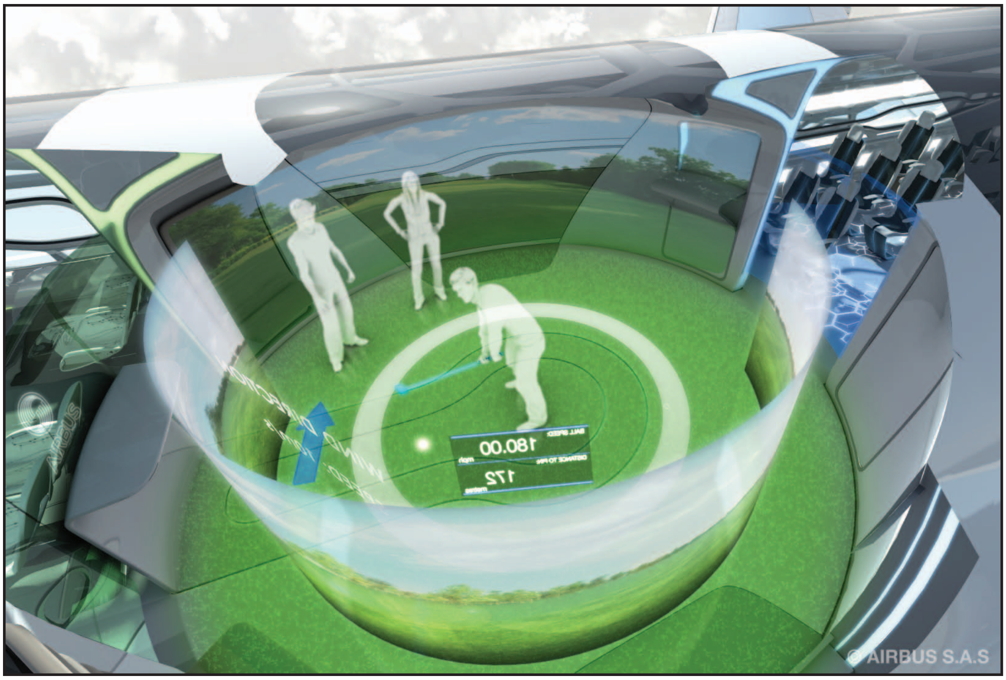

FIGURE 2. A virtual interaction zone for the cabin as envisioned for the Airbus 2050.

interphone functionality, which allows communication among the crew.

More Facts and Figures

The size of CIDSs and the number of controlled subsystems has been continuously growing over the past few decades. In the 1980s, when the first CIDS was created for the A320, it only provided basic but safety-relevant functionality such as support for passenger announcements or light control. The first CIDS for the A320 was mostly written in assembler language and executed on a (redundant) server with a single processor. As we have mentioned, newer CIDSs are coded in high-level languages and comprise various peripheral devices as well as different specialized processors such as digital signal processors for audio processing or a separate smoke-detection board in the A380 CIDS. This integration of new hardware also led to various new software functionalities such as a software-loading system, playback of prerecorded audio messages and boarding music, a smoke-detection system, and components for controlling water and waste.

It is interesting that the lifespan of an aircraft (30 years or more) is usually multiple times that of its cabin, so the latter is often replaced during so-called heavy maintenance visits when an aircraft is completely overhauled every five to seven years. Obviously, the physical cabin configuration affects cabin software as well, so its configurability is of high importance. Thus, the cabin structure—that is, the number of seats or arrangement of cabin zones—is adjustable in the software through the use of configuration files. These files, for example, cover the location of every seat (required for reading light control or on-demand video), the positions of flight attendant handsets, airline-dependent light scenarios, aircraft-specific zone configurations, and so on. All these settings are changeable and usually determined through intensive consultations with the airlines that have ordered a specific aircraft configuration. Most airlines even prepare a number of different configurations (for example, for summer and winter flight schedules), which can be uploaded with little effort once they are created.

Technology advancement has already significantly affected aircraft cabin systems and created a need for even more flexible cabin configurations. To better deal with expected future challenges, a stricter separation of concerns seems unavoidable for upcoming CIDS versions.

Software-intensive amenities for passengers that are envisaged in Airbus's recently released vision, "The Future by Airbus" (www.airbus.com/innovation/future-by-airbus/concept-planes/the-airbus-concept-cabin), comprise not only classic customer-relationship management functionality such as automatically stored seat configurations or food and drink preferences, but they also foresee augmented reality applications in the cabin that could visualize meal ingredients and duty-free catalogs, or even allow a virtual interaction zone (see Figure 2) where passengers could, for example, play golf tournaments in a virtual golf court or have business meetings with projected counterparts.

We can safely assume that an aircraft cabin in the 2050s will contain far more software than today. Following its current annual growth rate, the A380's CIDS server should reach more than 34 MLOC by then. However, aircraft manufacturers are likely to concentrate on their core competencies and purchase features from specialized third parties. Nevertheless, like today, third-party software will also need to be controllable by the CIDS to ensure that, for example, a virtual golf tournament is interrupted when safety instructions are announced or when an emergency situation occurs. Eventually, however, technological progress in other areas might make the life of avionic software engineers easier in the future; for example, if hypersonic travel becomes a reality and allows flying from New York City to Sydney in about an hour, neither food preferences nor interactions zones will likely be necessary for aircraft anymore.

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