Agile Aircraft Integration for Quick Reaction Capability Programs

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Abstract. Military Quick Reaction Capability (QRC) programs are becoming more typical; with miracles expected. Higher performance and quality are demanded in less time with reduced cost. Aircraft platforms are continually modified for the latest mission system technology, which often requires a unique balance of secondary aircraft systems (structure, environmental control, and electrical). This paper investigates an agile integration architecture that is capable of reducing time and cost to the customer, while increasing mission performance and quality. A successful implementation would include increased risk mitigation for the program, as well as flexibility for future system evolution or even mission repurposing. With commercial aircraft as the platform for QRC mission systems integration, this paper shows how to create mission system modifications on a much shorter time scale then currently possible, by identifying and exploiting standard unifying aircraft features that exist across multiple platforms, or exist in reoccurring patterns on the same platform.

Introduction

A technology evolution and a shifting political landscape are consistently changing the type of threats we face and the type of war we fight. The military is diversifying, and the old programs and platforms of the Cold War Era are being combined and used in conjunction with platforms geared towards a new type of war. Even the acquisition process itself is changing. Quick Reaction Capability (QRC) programs are progressively more common, as faster acquisition and system integration times are essential to keep pace with technology and to stay ahead of dynamic threats. To the point, mission systems are often obsolete by the time they are delivered. Consequently, aircraft mission systems remain in a state of continuous modification. Mission systems can no longer stay static for any period of time and expect to address changing technology and global threats.

With faster acquisition and mission system integration come risks, such as undefined future growth, underdeveloped mission requirements, schedule pressure, poor OEM/vendor support, and cost. To incorporate a mission system onto a platform while addressing the aforementioned risks, it is necessary to combine subsystems effectively using an architecture that can accommodate present and unforeseen future needs. The focus of the paper is on using an agile architecture to address the transient aspects of mission systems on aircraft secondary systems, such as structure (racks/consoles), environmental cooling systems (ECS), and electrical (generation/conversion/distribution). By addressing change, an agile architecture can reduce risk and provide increasing competency in terms of speed, cost, quality, and scope.

Need For Efficient Department of Defense (DoD) Acquisition

The military is driven by the need to advance, and is always seeking a means to get a competitive edge or force multiplier. This is often achieved at the consequence of a program's cost and schedule. A congressional hearing, led by Congressman Carl Levin, revealed an average overrun of $295 billion dollars (23%) on 95 major defense projects in 2007 using Government Accountability Office (GAO) statistics. This was an increase from an average overrun of $42 billion (6%) on 75 major defense projects in 2000 (Senate Hearing 110-819 2008). Teal Group's Richard Abolulafia describes this issue:

> "The old way of ordering up a stable of new aircraft has become increasingly problematic - a process in which the market forces governing the building and selling of cars or computers or even commercial jetliners do not apply. America's defense industry has long been the only part of our economy immune from capitalism" (Hoffman 2001).

Likewise, in a speech given by Secretary of Defense, Donald Rumsfeld, in 2001, the state of the current DoD process was described as:

> "…prevent[ing] us from adapting to evolving threats with the speed and agility that today's world demands…We must change for a simple reason—the world has—and we have not yet changed sufficiently. The clearest and most important transformation is from a bipolar Cold War world where threats were visible and predictable, to one in which they arise from multiple sources, most of which are difficult to anticipate, and many of which are impossible even to know today. All this costs money. It costs more than we have. It demands agility… Successful modern businesses are leaner and less hierarchical than ever before. They reward innovation and they share information. They have to be nimble in the face of rapid change or they die. Business enterprises die if they fail to adapt, and the fact that they can fail and die is what provides the incentive to survive. But governments can't die, so we need to find other incentives for bureaucracy to adapt and improve" (Rumsfeld 2001).

Agility has become a requirement now more than ever. There is a true focus on reducing cost and schedule, as well as producing mission system platforms that are adept to change. This has led to a Fast, Inexpensive, Simple, and Tiny (FIST) initiative promoted by the USAF, and exemplified by Harvest Hawk and Condor Cluster (Ward 2011). In addition is the US Navy Open Architecture (OA) initiative, which is exemplified by HiPer-D, the Virginia (SSN 774) class nuclear-powered submarine, and A-RCI (Strei 2003). Both OA and FIST can arguably be considered subsets of Agile Architecture.

The DoD is reevaluating its program acquisition process to the extent that Lt. Col Dan Ward, USAF, stated that this "might mean using Air Force Instruction 63-114, Quick Reaction Capability Process, as the first choice instead of a last resort" (Ward 2011).

So what does all of this mean? QRC programs are focused solely on schedule, the ability to get the required technology to the battle field as soon as possible. It is important to understand the impact of implementing a QRC program, and to understand how effective mission system integration is directly tied to creating agile aircraft-system interfaces. It is also important to understand the typical factors that drive a program schedule.

QRC - Mission System Platform Integration Issues

Subcontractor / Vendor Coordination

When the system integrator is not the original equipment manufacturer (OEM) of the aircraft platform, coordination between the OEM and the system integrator is necessary. This process involves transferring OEM engineering through a proprietary information agreement (PIA), which is almost always a conflicted process. OEMs do not like to give up proprietary engineering, because this engineering is a competitive advantage. But at the same time, OEMs want to sell aircraft. Even when a system integrator and OEM agree on an engineering information exchange, often the OEM and system integrator do not operate on the same time schedule. This is especially true in the case of QRC programs where the system integrator may have an extended work week.

Similarly, engineering coordination with subcontractors and vendors increases schedule risk and involves strict, structured coordination. It can be difficult to motivate vendors and subcontractors to share the same sense of urgency that is required to meet a QRC schedule.

Qualification

Schedules are often driven by safety regulations and component/system qualifications. Platform and component certification processes are extremely involved. Certification is not only required for new developmental items, but also for items that are significantly modified. On an aircraft level this can include the consideration of:

- Flight limits (airspeed, maneuvering, electromagnetic environment, altitude, temperature, weather conditions).
- Loading limits (weight, center of gravity, fuel load, cargo, external store, armament loadings).
- Structural life (wear limits critical to continued safe operation).
- Propulsion system limits (propeller, rotor, and engine subsystem rotational speeds for startup and shutdown; torque input; torque output; fuel grades; lubrication systems temperature/pressure limits).
- Subsystem limits (electrical load limitations, operating restrictions during degraded flight modes).
- Remedial actions for excursions outside limits (inspection, repair, replacement).
- Maintenance (procedures, intervals, conditions for inspection, conditions for replacement or overhaul).
- Aviation critical safety item (CSI) control (Dept. of the Army 2007).

On a component level, qualifications can include: temperature and altitude, temperature variation, humidity, operation shocks and crash safety, vibration, explosion, waterproof rating, fluids susceptibility, sand and dust, fungus, salt spray, magnetic effects, power input, voltage spike, AF conducted susceptibility, inducted signal susceptibility, radiated and conducted susceptibility, radiated and conducted emissions, lightning, electric static discharge, icing, and flammability (RTCA 2010).

The qualification process itself often requires engineering analysis, modeling, and simulations (component, subsystem, total system); formal inspections, design reviews, and safety assessments; contractor flight and ground development tests; component qualification test of performance under specified conditions and duration; formal contractor demonstrations; and government testing (Army 2007).

Need for Agility

Need for Common Platforms

The concept of operations (CONOPS) determines the mission system and the mission platform. For an aircraft this will include altitude, range, speed, and environmental considerations. The temptation is to develop or select a unique aircraft platform and create a customized mission system that perfectly exceeds all the objectives of the CONOPS. However, new development should be avoided for both aircraft platforms and components. The schedule and financial consequences involved with engineering, qualification, and maintenance of newly developed items are incompatible with QRC initiatives and often unnecessary. Instead, the focus should be on identifying and using preexisting but appropriate aircraft platforms and mission system components that can be integrated together. When existing components do not exist, the focus of new design needs to be on creating plug compatibility in a way that will allow for facilitated re-use across multiple platforms.

Aircraft down selection has associated cost, schedule, and logistics issues that need to be considered. The preferred approach is to limit platform selection to a few select aircraft, each with a unique classification. This is necessary as it allows the company to develop a platform expertise and a relationship with an aircraft OEM in a way that would not otherwise be possible if each mission platform was unique. It allows for consistent design and implementation of secondary aircraft systems and interfaces that will further allow for agile system integration across all of the selected platforms. This consistency will provide the ability to rapidly switch platforms in a growth situation, and will allow for a limited amount of deferred commitment to the selection of a platform.

Small and large aircraft alike should employ the same mission system implementation processes that will utilize the same mission system interfaces. In the case of mission scope creep during program development, consistent agile system integration across multiple platforms will allow an overweight or oversize mission system to be migrated to a larger aircraft platform. Normally an overweight or oversized program would be forced to implement an intense weight savings incentive requiring custom designed components at the consequence of a program’s schedule and cost. This is not an efficient use of resources for what is typically a small quantity of aircraft. If a consistent set of integration processes and aircraft system interfaces have been employed across multiple aircraft platforms, the process of transferring a mission system to a larger platform would be greatly simplified and more cost and schedule efficient (even across the life of the program). Historically, the need to switch to a larger platform risks program cancelation. This need no longer be the case.

The concept of limiting aircraft platforms is not new. It is very similar to the product line offered by commercial aircraft manufacturers. They do not create unique platforms for each of their customers, but instead create classes of aircraft that their customers can choose from. At this point they integrate custom passenger carrying systems that utilize standard interfaces to meet the unique needs of their customers, such as varying sizes of first class seating versus economy seating. This process is more cost effective through the life of the program, with the customer choosing the best fit among a limited set of options rather than creating a new unique option.

When applying this concept to military programs and choosing a class of aircraft models suitable for mission system integration, the platforms included should ideally be models that have been previously modified for the military and that are still in commercial production. This will ensure that new aircraft and OEM support are still available and that spare aircraft components can be shared between programs. An example selection set that includes previously modified small, medium, large aircraft includes:

- Beechcraft King Air (C-12S, MC-12W, UC-12W).
- Gulfstream G550 (C-27B, SEMA, CAEW, HALO).
- Lockheed C130 (AC-130, DC-130, EC-130, HC-130, KC-130, LC-130, MC-130, PC-130, RC-130, SC-130, VC-130, WC-130).
- Boeing C-135 (KC-135, WC-135, OC-135, EC-135, RC-135, NC-135).
- Boeing 747 (C-19, VC-25, E-4B, YAL-1, SOFIA).

Through the development of multiple programs, incremental evolution of the aircraft platform will naturally occur (such as the development of wing hard points or external pods), keeping a platform competitive until a suitable replacement platform becomes available. For example, when the KC-135 tanker is replaced by the KC-767 tanker; the KC-767 would become the platform of choice for that size classification in the aircraft selection set (in terms of platform modification for special mission loads). An example of this replacement cycle is shown below in Figure 1.

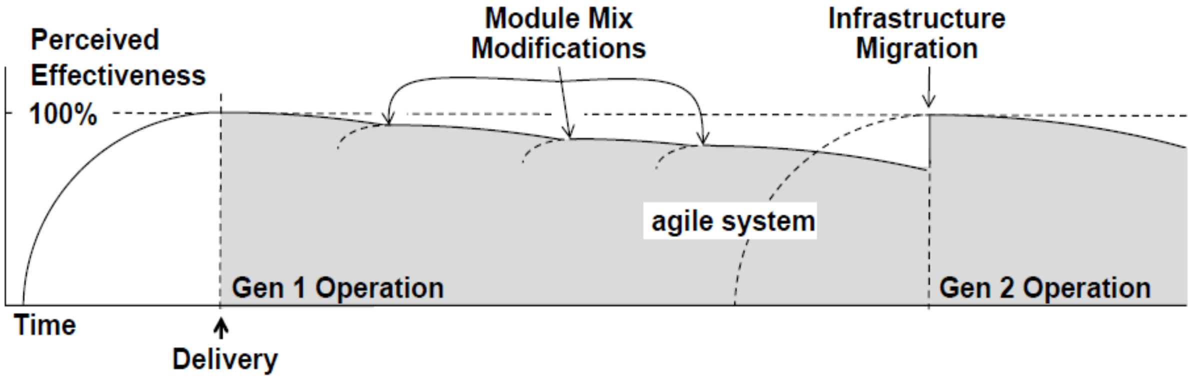


Figure 1: Life Cycle Migration (Dove 2011)

The purpose of limiting aircraft selection is to:

- Reduce the number of unique parts.
- Reduce maintenance training.
    - Allow for facilitated reuse of any new development on future programs.
    - Prevent negotiations for OEM information such as engineering and analysis.
    - Prevent reverse engineering of components or analysis when an agreement with the aircraft OEM cannot be reached.
    - Limit component or aircraft requalification.

Limiting aircraft selection may not always be possible (e.g. platform evolution or unique circumstances), but it needs to be a primary focus and should become normal practice. This focus is critical to creating a more efficient means of implementing mission systems on existing commercially available aircraft. This efficiency can only be accomplished realistically by focusing on a narrow set of aircraft, at least at first. The goal is to achieve the so-called Jevons effect, sometimes called a paradox: increasing efficiency of resource usage increases rather than decreases consumption. Thus, if a method for efficiently implementing mission systems on a platform is created, an increased demand for the platform and implementation method will naturally occur.

While this methodology is proposed at the corporate integrator level, it would be more efficiently negotiated on a governmental level. The DoD has more authority to negotiate for platforms and the engineering rights to platforms for the sole purpose of mission system integration. These rights could be temporarily distributed to a mission system integrator with strict PIAs and intellectual property controls put in place and enforced. This would prevent an aircraft OEM from improperly supporting a QRC mission system integrator, inadvertently or not, by withholding aircraft information which results in program cost increases and schedule delays. Currently, most mission system integrations onto commercial platforms require extensive amounts of reverse engineering of aircraft component designs and stress/loads analysis.

Reverse engineering an aircraft platform in a schedule-reduced environment forces an aircraft integrator to make overly conservative assumptions to simplify analysis and design. By the end of a platform's life, aircraft parts may have been reverse engineered multiple times. Parts may even be reverse engineered multiple times by the same company because program classifications or PIAs in place with the OEM may limit the sharing of platform information across contracts.

Integrator generated engineering rights should also be negotiated by the government to encourage sharing of common parts and integration methods. This type of arrangement will be against corporate interest, as the ability to maintain control of all proprietary information is a competitive advantage, but the DoD should negotiate for access to these rights. Incentives may be required, but the large amount of money involved in defense contracts and the risk of losing these sales may be enough motivation for a shift, especially if the proprietary information can be appropriately controlled.

By predetermining applicable platforms ahead of time, the DoD would have the opportunity to buy aircraft in larger quantities to be delivered on a preset schedule. This would allow the DoD to negotiate much like an airline company. In the case of a QRC program, this methodology could prevent the DoD from having to pay large expedite fees for aircraft. Aircraft from an initial purchase may be reallocated internally from another program of less priority. An argument against this method would be that limiting aircraft platforms could potentially limit mission capabilities, but this disadvantage would likely be overcome by the availability of a greater number of aircraft allotted for mission use.

Having a defined aircraft platform selection also provides an advantage to mission system developers. Mission systems can be designed with the constraints of a specific platform in mind. This would prevent mission systems from being designed free of constraints and then forcefully (and often painfully) retrofitted to an aircraft platform at a later date. If the platform integration methods are standardized, it may even be possible to successfully integrate variants of the same system onto different platforms.

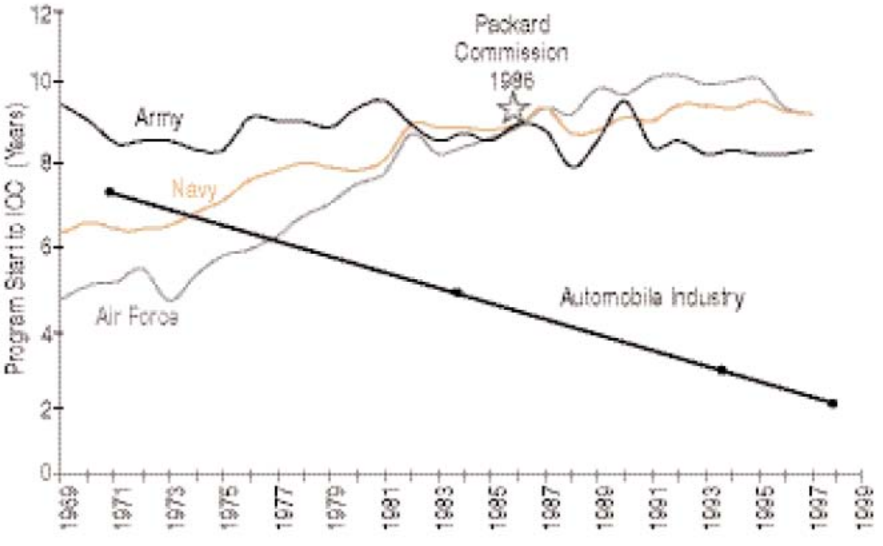
Need for Common Standards

The use of common standards and frameworks is the key mechanism that enables the agile principles of reusability, reconfigurability, and scalability; and is the founding principle of the OA initiative promoted by the Navy. USN Capt. Strei explained the consequences of not utilizing common standards when describing OA:

> "In the past the Navy has acquired systems that—although they performed their functions and tasks exceedingly well—were unique in their designs and engineering; required unique parts, equipment, and services to support them; were supported by a limited number of suppliers; and became unaffordable to maintain. There are numerous instances, moreover,

in which a system or platform was scrapped rather than upgraded or modernized because the cost to do so became prohibitive (Strei 2003).

The use of standards is of such importance that if a usable standard does not exist, a standard should to be created and implemented across all platforms. The use of standards is required for interoperability between systems (plug capability) and is the method that will allow custom components to progress towards an economy of scale. Interoperability between platforms produces flexibility during the initial integration of a system and is critical throughout the life of the system. Although operating costs and maintenance typically make up 65 percent of an airplane's lifetime cost (Hoffman 2001), parts, components, and systems are often not standardized. This has long-reaching consequences when it comes time to modernize a platform with new mission systems. Systems and components need to be properly evaluated in all uses across all platforms for functions that are executed repeatedly. These functions should be a focus for standardization. Plug capability is much more prevalent in the industrial world; it needs to become prevalent in defense. Developmental time in the automobile industry has been on a steady decline (shown in Figure 2), but not in the defense industry. This stagnation can be addressed, in part by focusing on standardization and agile integration.



Source: Lt. Col. Ross McNutt, Ph.D., USAF.

Figure 2: Program Time to Completion

A Focus on Agile Aircraft Systems

An agile integration process requires a greater focus on aircraft system interactions. It is important to understand how aircraft systems interact within the whole. This can be accomplished by understanding how they relate to the CONOPS and the mission system. The CONOPS is the overall descriptor that defines the mission system requirements and operation criteria. This will include the mission system requirements and aircraft system requirements such as altitude, range, speed, environmental considerations, and mission function/performance criteria. The mission system typically determines the secondary aircraft system requirements such as the electrical generation/distribution, structural, and environmental control requirements for the platform.

However, the aircraft systems can in some circumstances place requirements on the mission system as well. For example, an aircraft platform will create environmental considerations for a mission system (e.g. vibration), and once a specific platform is defined, there will be constraints on available weight, power, and cooling. This relationship is shown in Figure 3 by the diagram on the left. The CONOPS governs, from which both the mission system and aircraft system requirements are developed, with mission system requirements normally flowing down to create aircraft system requirements. The diagram on the right in Figure 3 shows three principal secondary aircraft systems contained within and constrained by the aircraft platform. These systems (structural, electrical, and environmental control systems) are the crux of an agile mission system integration.

The secondary aircraft structure is responsible for accommodating mission equipment and safely transferring mission system loads to the aircraft structure. The electrical system is responsible for mission power generation, distribution, power conversion, and load shedding/circuit protection in the event of a failure. The environmental control system (ECS) is responsible for climate control, which includes delivering cooling to mission equipment and removing waste heat. The ECS often controls both supply temperature and cooling flow to mission equipment with special needs. An agile implementation of these support systems will provide benefit (Moir & Seabridge 2008: 477-497).

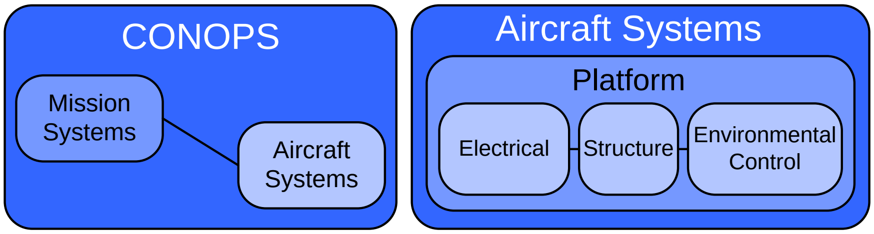


Figure 3: Requirements Hierarchy

Agile Concepts

System Architecture

From an abstract level, system architecture should strive to maintain isolation at the lowest level possible. This principle will promote interactions between systems (both aircraft and mission systems interfaces) to be parallel and not serial, creating a non-hierarchical interaction. Parallel interaction will preserve control at the lowest level possible where it is most explicit, and will increase reliability by preventing the formation of unnecessary dependant relationships between systems.

The mission systems should be matched to a complementing set of aircraft system inputs, such that the mission system receives standard electrical and cooling inputs from the platform directly. If this is not possible, the mission system should be matched to an intermediate conversion module that will convert an aircraft system output to the standard required by the mission system. This case is shown in Figure 5. When interfaced properly, the entire mission platform will be composed of independent modules (self-contained units). By creating independent modules, system complexity is reduced because all external interfaces are limited to only communication interfaces between isolated mission systems and standardized power, cooling, and structural interfaces. All internal mission system interaction, electrical control, and environmental control are handled inside a mission module. This promotes scalability (elastic capacity) by easing module integration, and promotes system evolution because a system can now be upgraded without affecting adjacent systems. In the simplest form, this is shown architecturally in Figure 4.

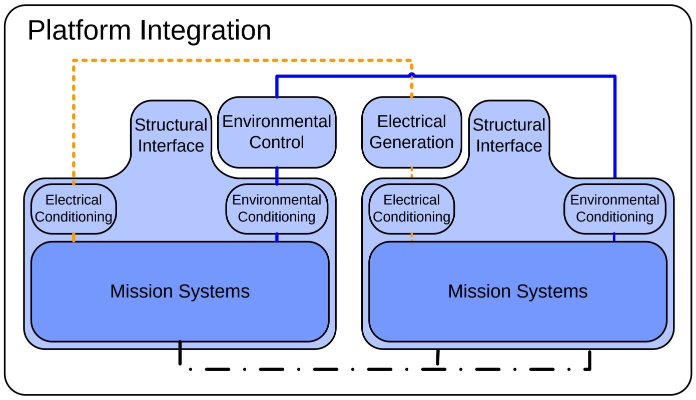


Figure 4: Platform Integration

The multiple structural interfaces (two are shown in Figure 4) are representative of the separate rack structures that will be required to integrate each independent mission system as a module with electrical, environmental control, and structural interfaces. The lack of a consistent power standard between more electric aircraft (MEA) architectures and tradition aircraft structures, requires that all power types be considered when creating an electrical rack interface standard (Avery, Burrow, & Mellor 2007). In an ideal scenario, the electrical power type generated by the aircraft platform could be connected directly to electrical conditioning equipment contained within each system module. This scenario is shown by Figure 4. However, it is likely that the electrical power generated by the platform will not be the correct type for the elements of the mission system. Because the mission system needs to remain independent of any given platform, an intermittent power conversion module that can convert the available aircraft power type to the type required by the mission load will be necessary. Figure 5 below illustrates the example where an additional structural module (rack) has been added containing the proper electrical power conversion equipment to transform the power generated by the aircraft engines to the type required by the two mission systems.

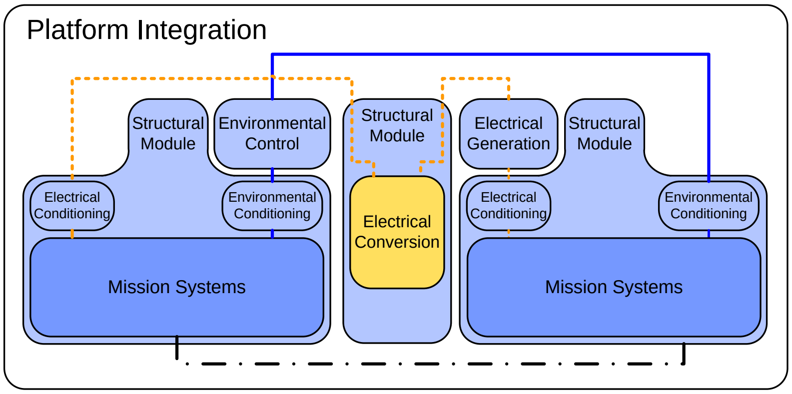


Figure 5: Platform Integration with Secondary System Converters

The idea of an independent module to support an aircraft secondary system does not pertain strictly to electrical conversion; other modules such as supplementary cooling modules or a communications module that facilitates information between systems could be added as necessary. While it is preferred that mission system modules are as self contained as possible, it is understood that this may not always be possible, especially when considering the wide variety of secondary aircraft system outputs an aircraft platform may produce and the variety of system inputs a mission system may require. The conversion subsystem needs to be self-contained, modular, and should be located as close as possible to the mission system it is supporting.

Exploit Common Aircraft Structures

Using a commercially available aircraft platform and modifying it to create a mission platform involves using an aircraft in a way that it was not designed. To agilely integrate a mission system onto a previously designed platform, the system architect needs to fully understand the aircraft's identity and exploit the specific aspects of an aircraft design that lend to a standardized integration method, while avoiding any unique elements that are not easily adaptable. The goal is to create a system integration method that is independent of the unique aspects of aircraft architecture.

By focusing on the aspects of an aircraft design that are patterned across an aircraft structure, features that were not originally designed to perform a desired function can be exploited and modified to provide that function. In other words, these repetitive features can be leveraged as standards or frameworks allowing for the creation of modules that plug-and-play anywhere these features exist within an aircraft platform.

The ideal feature will exist uniformly across a platform and will have similar features that exist on other platforms so that integration designs based on these features can be potentially adapted to other platforms. Exploiting common aircraft structures will allow for agile integrations to be created quickly, and modules integrated using these features will be reusable on future mission systems. This is opposed to the design of unique integrations where the installation of a module is strictly confined to a specific location on a specific aircraft platform. Some examples of common aircraft features and potential ways in which they can be used are given below:

Frames/Floor Beams/Stringers

Frames, floor beams, and sometimes stringers are all standard means to transfer a load to the aircraft structure. Although there are exceptions, their usefulness stems from a standard distance between elements and a fairly consistent cross section along the element itself, as well as between elements. This allows for the creation of repeatable and modular designs.

Seat tracks

Seat tracks exist on all commercial aircraft and exist across the entire aircraft in a repetitive pattern. They are designed for passenger seats, but are structural members designed to safely transfer loads to the aircraft structure. Because of this they can be exploited as a standard way to support a module such as a rack or console.

Wing Hard Points

Wing hard points are often used for external fuel tanks but can be used for numerous other things. Hard points could be used for electrical generation through the use of high power ram air turbines (RAT) or other purposes as shown in Figure 6; in this figure the program Harvest HAWK used existing wing hard points on a C-130 for mounting a targeting sight system under the wing fuel tank and Hellfire or Griffin missiles.

Figure 6: Mission Systems Mounted to Wing Hard Points (Wikipedia 2012)

Windows / Doors

Windows are often unwanted for military applications and are normally just replaced with plugs. But these existing skin penetrations could be modified for heat rejection through the placement of small external liquid to air heat exchangers. The penetration in the skin of the aircraft is already an OEM structurally reinforced area, and could be further reinforced to support the addition of a cooling module. The benefit is that once a modification is created, it could be scaled across the platform as required by the mission system heat load, and would provide future upgrade potential due to the repetitive pattern of aircraft windows.

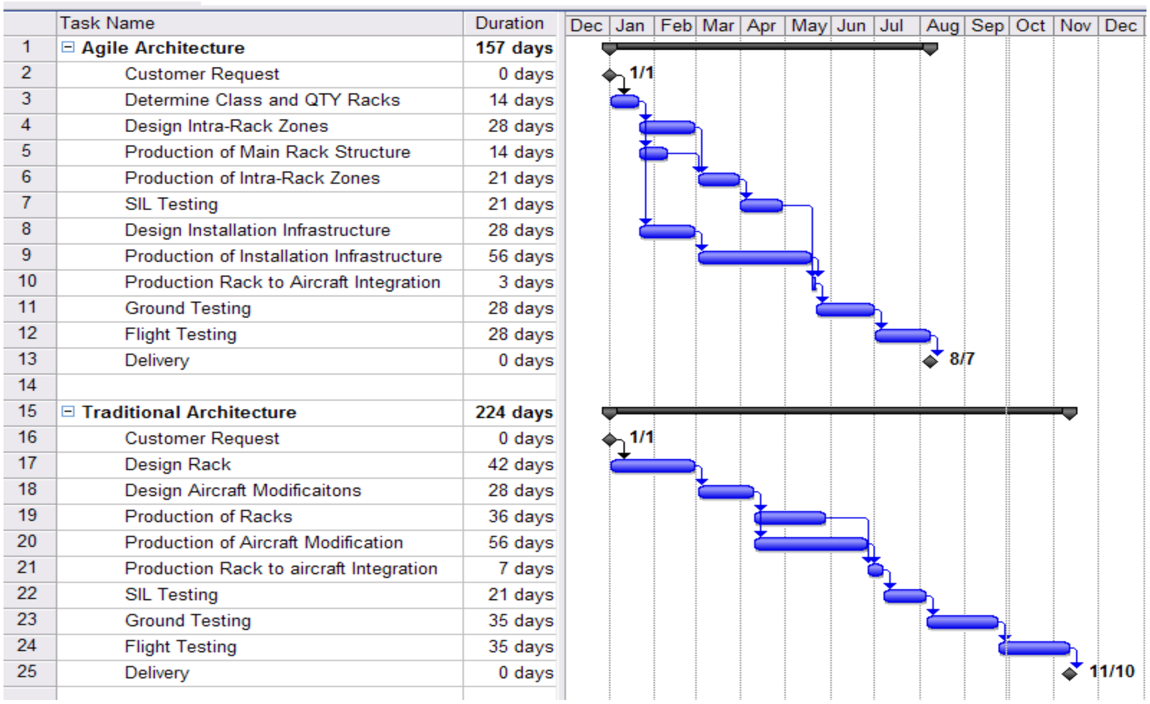
Commercial aircraft platforms have several doors for the emergency evacuation of all of the passengers. On a modified aircraft platform all of the doors may not be required for emergency evacuation due to a much lower number of passengers. Any extra doors could be repurposed to support a mission system. An example of this would be Senior Scout, which attached antenna arrays to paratroop doors and main landing gear doors (Keith 2009) or Harvest HAWK Capability II, which mounted a modular 30mm cannon in the troop door (Defense Industry Daily 2012).

Skin

The skin is often used for mounting small antennas, but also has the potential to transfer waste heat from the aircraft at altitude. A vapor cycle system could thermally bond condenser coils to an aircraft’s aluminum skin, utilizing the skin as a heat transfer medium without requiring the creation of skin penetrations.

Example of Advantages

Many advantages of an agile system integration have been previously described in “Agile Aircraft Installation Architecture in a quick Reaction Capability Environment” (Boss 2009). Of these advantages, the most important advantage of agile system integration for a QRC program is a reduced schedule. Figure 7 separates an aircraft integration schedule into the separate program phases and details out how some of the phases can be conducted in parallel through an agile implementation method. This is compared to the serial implementation normally employed with traditional system integration practices. The schedule shows that the ability to conduct some phases in parallel allows for a schedule reduction of 30% initially on an aircraft platform, and would allow for even further schedule reductions for future mission system integrations on the same aircraft platform (Boss 2009). The schedule components conducted in parallel are the design and implementation efforts of the system modules (equipment racks) and the aircraft infrastructure modification. The aircraft infrastructure modification includes the preparation of the structural, environmental, electrical, and mission interconnect infrastructure required to integrate mission systems in a plug-and-play fashion.



	Task Name	Duration
1	⊟ **Agile Architecture**	**157 days**
2	Customer Request	0 days
3	Determine Class and QTY Racks	14 days
4	Design Intra-Rack Zones	28 days
5	Production of Main Rack Structure	14 days
6	Production of Intra-Rack Zones	21 days
7	SIL Testing	21 days
8	Design Installation Infrastructure	28 days
9	Production of Installation Infrastructure	56 days
10	Production Rack to Aircraft Integration	3 days
11	Ground Testing	28 days
12	Flight Testing	28 days
13	Delivery	0 days
14		
15	⊟ **Traditional Architecture**	**224 days**
16	Customer Request	0 days
17	Design Rack	42 days
18	Design Aircraft Modificaitons	28 days
19	Production of Racks	36 days
20	Production of Aircraft Modification	56 days
21	Production Rack to aircraft Integration	7 days
22	SIL Testing	21 days
23	Ground Testing	35 days
24	Flight Testing	35 days
25	Delivery	0 days

Figure 7: Agile vs. Traditional Schedule Comparison(Boss 2009)

Cost is also reduced through agile system integration (Boss 2009). Standardizing structural, environmental control, and electrical components greatly reduces the amount of engineering, production, and tooling required because it allows for the facilitated reuse of resources for each subsystem integration. If multiple mission systems are designed utilizing the same standardized components, an economy of scale can be applied reducing costs even further. Another cost advantage is that agile system implementation allows for mission subsystem to be easily tested in a System Integration Lab (SIL) prior to platform installation. This ability allows defects to be identified before any mission systems are installed on the aircraft, and also allows for easier component access within a module for any system modifications. If system defects are discovered before aircraft integration, costly schedule delays or additional flight testing can be avoided.

Conclusions

Military programs are often plagued by undefined future growth, poor mission requirements, schedule pressure, poor OEM/vendor support, and cost. New developmental programs often create custom solutions that can limit future mission enhancements. To counteract these risks, there needs to be a focus on increased agility in the integration of mission systems. This will create an environment in which a program can adapt to change quickly. The key to an agile integration process is standardization. This includes the standardization or limitation of aircraft platforms and the standardization of secondary aircraft system interfaces employed within these platforms.

Standardized aircraft system interfaces should be created in a manner that allows for the isolation of mission subsystems at the lowest level possible. Mission systems or even subsystems should be capable of acting as standalone systems with proper aircraft system interfaces (structural, environmental control, and electrical). The concept is that a system (including conversion subsystems) must come as a unit, rather than separate parts, in order to produce a system that is readily scalable and can adapt to rapidly changing equipment configurations.

To create an agile implementation, industry examples should be sought and exploited. Competitive pressures that exist within the commercial market naturally produce elements of agility as products evolve through mass production and usage. The focus on agile concepts only serves to enhance and speed up this process. Common (standardized) aircraft structures should also be identified and exploited. This will allow for the development of a standardized interface for mission systems. Custom design should be avoided. The agile implementation of a mission system could become fundamental to the development of QRC programs.

Defense Secretary Robert M. Gates gave the following description of the MC-12, a mission system quickly integrated into a commercially available platform:

> "Platforms like the MC-12, though, give America distinct counter to their [enemy hiding amongst the population] efforts, an unmatched advantage. They give our troops an eye in the sky. They help us disrupt and hunt down our enemies, often before they strike, saving the lives of American troops while sparing innocent civilians…The MC-12 program offers a reminder that new combat platforms can be developed, built and deployed quickly. And the best solution isn't always the fanciest or the most expensive. Each day earlier one of these planes arrives downrange may well be the day that a Soldier's life is saved. So I ask you to sustain your effort and to keep pursuing ways to improve" (Miles 2009).

System architectures often fail because programs become too expensive, in the short term, to design in the traditional way. Scope creep and excessive requirements destroy programs that rely on highly customized platform implementations, preventing them from being deployed. Everyday counts. Programs should always seek to produce agile results as quickly and efficiently as possible to keep up with technology and threats.

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Biography

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