Commonality Considerations in the Design of Flight Deck of Civil Aircraft

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Abstract. Commonality in the flight deck can reduce development costs, shorten the time of operational courses e.g. transition time of pilots and expand the market, thus is becoming one of the most important features of modern civil aircraft design. Benefits from commonality in the flight deck was discussed in this paper as well as the aspects of commonality. Since commonality would bring significant benefits to the aircraft company and improve its profitability, more effort should be devoted to it.

1. Instructions

Today’s aviation marketplace is global and highly competitive so the economics of the civil aircraft is becoming more and more important. But the marketplace is volatile: customer demands are constantly changing, and they seek wider varieties of products at the same price as mass produced goods [1]. In order to make a business success, commercial aircraft manufacturers are seeking the ways to get a balance point between developing a more advanced product that will meet the customers’ demand and cost saving using manufacturer’s existing resources such as the tooling, structure parts, system elements and software [2].

A concept so-called “Commonality” was introduced first by Boeing Company into the civil commercial aircraft [3][4]. A detailed review of commonality history and comparison were made between B757 and B767, including the aircraft configuration, airframe structures, system parts, engines and LRUs, as well as structures and lexicon for ATE Commonality. All mentioned above were from the manufacturing viewpoints, nevertheless, commonalities in the operating were also important. For example, a new model of civil aircraft would be accepted by the market if it had a significant feature of commonality on Human-Machine-Interface, operating procedures, flight crew alerting messages and so on. To some extent, the operation commonality is more important than others since it will significantly cut off the Direct Operating Cost (DOC) of the Airlines while operating a new model aircraft. Rational commonality design will shorten the training time and saving cost of flight crew and maintenance crew. Obviously, flight crew training plays an important role in operating a new model for airlines because pilots who can fly the aircraft shall be first employed. Also, cost of training flight crew has a higher proportion than other manpower training cost. Hence, this paper will focus on demonstration of commonality consideration in the design of flight deck.

2. Benefits from Commonality Design in the Civil Flight Deck

Commonality, an important characteristic of modern commercial aircraft design. It will not only reduce Research and Development (R&D) cost, shorten R&D cycles [5], but also shorten the training time of pilots, maintenance crew, and other manpower required by operating a new model. And for an airline
Civil aircraft manufacturers such as Boeing and Airbus are aware of the importance of commonality in flight deck performing in aircraft sales, which will also promote aircraft product sales to the airlines and obtain business success. Although B787 called ‘Dream Liner’ by Boeing was consider to be the most advanced model, large effort was addressed to the commonality design of the flight deck. Boeing called it operational commonalty, which was defined the similarity between airplanes in operation procedures, checklists, and flight crew interfaces [6]. Boeing claimed that the commonality simplifies training and can decrease airline operating cost. The intended commonality design with the 777, flying the 787 airplane would in many ways “feel” like a 777, while implementing new capabilities and simplify the flight deck [6]. Also the 787 inherits the advantages of Boeing products families, finally it will achieve a significant results: pilots with no experience in a Boeing flight deck will need 21 days of training. For an existing 777 pilot, it take 5 days of training to transition to the 787. Pilots of 757s and 767s will need only 8 days of training. For 737 pilots, it will take 11days of training to finish the transition to the 787, while 13 days for pilots of 717s, 727s, and 747s. See figure 1[6].

Also, Airbus consider the commonality design in the flight deck as a valued technique. It’s claimed that ever since the creation of it first aircraft, commonality has been prioritized throughout it diverse product line [7]. Both Airbus and airlines can benefit from commonality of the flight deck, since the commonality will simplifies many aspects of flying, make operations and training easier and less expensive for customers which result to more commercial orders. The commonality concept was taken to a new level with Airbus’ first single-aisle aircraft, the A320, whose cockpits and operating procedures were identical with the A318, A319, A320 and A321. Such commonality allows pilots to fly all these aircraft with a single type rating, so called Cross-Crew-Qualification of pilots, which reduces pilot training time while bringing significant savings [7]. A350 is the newest model that Airbus launched to the markets while keeping a high degree of commonality with the Airbus family for the best operational performance. Thanks to the commonality, training time of pilot to transition to A350 from other models will be very short, e.g. it will be available for the A320 Family, A340 and A380 pilots with anticipated durations of 11, 10 and 5 training days respectively. The standard length of a full A350 Type Rating training course for non-Airbus pilots will be 25 days (projected and subject to approval from the aviation authorities) [7]. See Fig.2.
Fig. 2 Days of Training to transition to A350 for pilots from other models

As description mentioned above, the effective brought by commonality in the flight deck is very significant. It is evaluated by Airbus the annual savings in training and payroll expenses from reduced transition time can up to U.S.$300,000 for each new Airbus aircraft added to the fleet [8]. Furthermore, it is also more economical for an airline to recruit new pilots who already are qualified for existing aircraft.

3. Aspects of Commonality Considerations in the Civil Flight Deck

3.1. Aspects of Commonality
As is stated above, most effective brought by commonality in the flight deck is the training time reduced of pilot transition. To achieve commonality among the family products, such aspects but not limited to should be taken into consideration while design a new flight deck: design philosophy, layout, alerting system for flight crew, operating procedure and information display interface.

3.2. Design Philosophy
Design philosophy play a top level role in designing a flight deck. It will affect the design proposal of system architecture, operating procedure, system logic, and feedback of actions adopted by pilots and so on. Philosophy needs to recognize that the basic flight crew tasks are to aviate, navigate, communicate and manage systems. For instance, the design philosophy determines the responsibilities of and the final command designated to pilot for the safe and proper operation of the aircraft. This requires a flight deck design that provides adequate information and features to support the designated responsibility and authority [9]. For example, one of the most representative philosophy of Boeing flight deck is that “The pilot is the final authority for the operation of the plane” while “The pilot is ultimately responsible for the safe operation of the aircraft. He has final authority with adequate information and means to exercise this authority” of Airbus [10].

It can be seen that pilots of Boeing has the final authority to operating the airplane without any condition while pilots of Airbus can obtain the final authority with adequate information and means to exercise the authority. It means that authority of pilots of Airbus is restricted. Different philosophy constructs different flight deck and leads to two distinct families of flight deck design feature in the end, which causes the time of transition between Boeing and Airbus will be long and raise the bar for an airline operating the two family aircraft simultaneously.

3.3. Layout
The most conspicuous feature of a flight deck is the layout. One can identify the flight deck to which aircraft model belongs through the layout even at a glance. Generally, flight deck layout includes crew seats, design eye position for each crew member, main instrument panel, overhead panels, pedestal and other device used during flight. Based on the condition that requirements and constraints of flight crew
and their main tasks of aviation, navigating, communicating and managing aircraft systems shall be meet, manufacturer can implement their own esthetics into products as to form generic features. The number of crew errors is directly linked with the complexity of the instruments layout. Standardizing the instrument layout will shorten the transition from one model to another but will increase the complexity of the original training [9]. However, location of every devices such as panels, operators, will affect the commonality but their weights of contribution to commonality are different. It will make senses to only keep main control panels’ layouts commonality that will affect the importance procedure. For instance, following features such as same location of fire extinguish control panels, same flight operating handles (yokes or side-sticks), similar throttle, similar locations of spoiler handles, similar location and shape of flaps handles will attribute a new flight deck to family product.

3.4. Alerting System for Flight Crew
Alerting System for flight crew is another components of commonality, which is designed to provide flight crew the messages when the system goes into abnormal situation. Components of commonality for alerting system should be same alerting level categories as “Warning, Caution, Advisory and Status”, same sorting sequence of alerting message that emerging, same color indicated for alerting levels. Also, inhibited logic and the manners of alerting such as vibration, tactile, lighting, voice and acoustic should be commonality in order to make pilots’ a familiar feeling as to shorten the transition time.

Furthermore, the coding of alerting message is also very important and shall be compliant to the same philosophy. For example, “L Hydraulic System Fail” and “Hydraulic System L fail” are two ways that provide the message of “left hydraulic system fail” to flight crew, but only one of them shall be implemented in a family product for retaining commonality.

3.5. Information Display Interface
Flight deck should provide adequate information to pilots for safe flight. The commonality of information display would give pilot a familiar feeling, simplifying the flight crew enhancing situational and aircraft status awareness. Attention should be payed to following items but not limited to fulfill commonality of information display interface [9]:

- Layout of information: location of information that displayed in the Display Units
- Graphic formats, including Graphical display elements, Mode of information coding, Method of presentation
- Phase related display rules: the way that information related with flight phase automatically be provided.

The display of information provided to pilots should be commonality with existing flight deck in terms of color, standardization, automatic, symbology, interaction techniques and operating philosophy. Fig.3 illustrates two types of display interface for PFD, which are selected by Airbus and Boeing respectively.

![Fig.3 PFD Display Interface Design](image-url)
3.6. Operating procedure

Operating procedure is considered the most important components of commonality since it directly determine the transition time to a new aircraft model for pilot. However, operating procedure has a strong correlation with the layout, alerting system and display interface of the flight deck. Similar with the layout. It is not necessary to standardize every operating procedure since new techniques introduced into the flight deck could result in the change of procedure. The similar procedures and crew discipline for abnormal and emergency situations should keep commonality, such as fire extinguishing procedure. In addition, the flight phases of the aircraft should be keep commonality in the aircraft family, since they significantly affect the operating an aircraft as well as the system design.

4. Conclusion

The commonality consideration in the flight deck was discussed in this paper. Essentially, the commonality is a strategy that an aircraft manufacturer to keep their generic products and promote them to the aviation market as well as a lower development cost. Commonality will help aircraft manufacturer to get a “win-win” situation with their customers. However, the techniques are always continuously improving and updating, how the flight deck is designed to balance between innovation, cost, and commonality with previous aircraft models should be further discussed and studied.

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