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Challenges for ground operations arising from aircraft concepts using alternative energy

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ABSTRACT

Current research in the field of future aircraft concepts aims at accommodating ambitious reduction goals set by national and international regulators. These concepts should be investigated not only with regard to aircraft efficiency, but also in terms of their compatibility with airline operations, existing ground handling procedures and airport infrastructure requirements, as these influence the overall performance of a future aircraft concept. This paper addresses this aspect, focusing on case studies concerning hybrid-electric and universally-electric aircraft concepts, analyzing implications for current ground handling operations at the airport. Current bottlenecks, such as capacity shortages, and potential areas of improvement are identified based on a state-of-the-art reference ground handling process. To this end, requirements of different stakeholders, including airports, airlines and ground handling providers, are outlined. In the next step, insights are contrasted with operational requirements of the future aircraft concepts under consideration. The paper stresses the anticipated challenges involved in aligning future aircraft requirements with current procedures, discusses the necessary adaptions to operational processes. The results highlight changes that need to be made to the current system before an aircraft can enter service, and provide an initial basis for the strategic planning of the stakeholders involved.

1. Introduction

The development of future aircraft concepts focuses on operational efficiency to fulfil the ambitious goals promoted by national and international regulators, such as US NASA N+3 (Bradley and Droney, 2011) or the European Commission (EC) Flightpath 2050 (European Commission, 2011a). The vision of the EC for 2050 targets a 75% reduction in CO_2 emissions per passenger kilometer, a 90% reduction of NO_x emissions and a 65% perceived noise reduction compared to the capabilities of conventional aircraft from the year 2000. Furthermore, aircraft movements on the ground have to be emission-free when taxiing (European Commission, 2011a). Since further evolutionary improvements to the propulsion technology do not appear sufficient to meet these goals, the focus of research is on disruptive technologies, such as hybrid-energy and universally electric aircraft. Further promoted goals are the reduction of turnaround times by 40% by 2050 using novel handling concepts and the arrival and departure of each aircraft within 1 min of the scheduled time (ACARE, 2012), since today 70% of all flight delays are caused by problems regarding the turnaround of aircraft at airports (European Commission, 2011b). The consideration of these new approaches challenges the stakeholders involved (manufacturers, airlines and airports) in terms of providing operational compatibility with existing ground handling procedures and infrastructure requirements.

Throughout the history of aviation, airports have been repeatedly challenged by new aircraft programs, some which were revolutionary for their time, such as the Boeing 747, Concorde and recently the Airbus A380. Before B747 and Concorde were entered into service (EIS), a thorough knowledge of the terminal-related functions, ground handling characteristics and operational economics was essential so that aircraft servicing would not be

Abbreviations: APU, Auxiliary Power Unit; CDM, Collaborative Decision Making; DOC, Direct Operating Cost; EC, European Commission; EIS, Entry Into Service; FL, Flight Level; GSE, Ground Support Equipment; HTS, High-Temperature Super-conducting; LNG, Liquefied Natural Gas; MLW, Maximum Landing Weight; MTOW, Maximum Take-Off Weight; OWE, Operating Weight Empty; RPK, Return Passenger Kilometers; PAX, Passenger; SFS, Sideways Foldable Seat; SUGAR, Subsonic Ultra Green Aircraft Research; TRL, Technology Readiness Level; UESA, Universally-Electric System Architecture; ULD, Unit Load Device.

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determined by facility limitations (Callahan, 1970). Prior to the EIS of the A380, the stakeholders involved started analyzing their current airport systems to identify shortcomings and requirements for areas of improvement (Leung et al., 2007). Since the A380 is categorized as ICAO Code F, meaning a maximum wing span of 80 m and an outer main gear wheel span of up to 16 m (ICAO, 1999), airports had to expand their runways, taxiways and gate positions to accommodate this new aircraft type. When dealing with over 500 passengers entering and exiting the aircraft, airlines request increased waiting areas and check-in counters to process the passengers in a timely manner. From a turnaround perspective, the A380 challenges the current processes due to its double-decker design and huge transport capacity, even if its compatibility with existing procedures and vehicles was ensured during the design phase. In order to guarantee adequate turnaround times, the passenger egress and ingress requires boarding bridges on both decks, and a similar procedure is needed for catering and cleaning. Furthermore, due to the increased electrical power demand from the subsystems, the fixed ground power systems had to be modified and vehicles with an increased capacity for water and waste water or an elevated operating height for catering had to be developed. To handle the increased weight of the A380, more powerful towing trucks are required (Leung et al., 2007). Applying modified processes in conjunction with adapted GSE allowed new aircraft equipment types to be operated at existing airports.

To increase the operational efficiency of transport aircraft, the focus of research is on disruptive propulsion technologies, such as hybrid-energy and universally-electric aircraft. They require a new type of energy storage and supply and are challenging the aviation stakeholders once again. To address the implications arising from these propulsion technologies, this paper first presents a stakeholder perspective from airlines, aircraft manufactures, passengers and ground handling providers on the current processes (section 2). In section 3, a 2035 reference aircraft, hybrid-electric and universally-electric aircraft concepts focusing on the ground operation are introduced. Subsequently, the methodology for estimating turnaround times is explained and the findings for the investigated concepts are presented. Challenges arising from the outlined aircraft concepts on ground operations are discussed and the results provide an initial basis for strategic planning for the stakeholders involved (section 4).

2. Stakeholder analysis

The following section first presents a current state-of-the-art turnaround process for short-to-medium-haul aircraft. Afterwards, issues in the current ground handling process from different stakeholder perspectives, including airlines, airports and ground handlers, are outlined. A detailed literature review was conducted analyzing airside processes, with the goal of identifying bottlenecks within the current ground handling process. Within this analysis, the status quo across Asia, North America and Europe has been compared in order to detect similarities and differences. In this particular analysis, airlines are not differentiated by their underlying business model but general problems affecting airline operations are identified. The same principle applies to airports and ground handlers. In this case, the airport is the provider of infrastructure and landside operations, and not considered as another entity supplying ground handling services. Based on this review, the improvement potential has been allocated according to different categories, i.e. information sharing, processes, capacity, and policies (see section 2.3) and outlined for each stakeholder.

2.1. Turnaround process

The turnaround process starts when the aircraft reaches the parking position and lasts until the aircraft leaves it. The time required for servicing the aircraft directly influences the gate utilization and the number of flights that can be performed by day. In general, the turnaround time depends on the aircraft type, the number of passengers, the cargo to be loaded and unloaded as well as the business model of the aircraft operator (Guraly and Kral, 2010).

After the aircraft reaches the stand, the chocks are placed before the wheels and the ground power supply is connected. As soon as the doors are opened, the passenger disembarkation begins and cargo and baggage are unloaded at the same time. Meanwhile, the potable water is replenished and waste water service performed. According to requirements stated in EU-OPS 1.305 (FAR 121.570) (European Commission, 2008), the aircraft is refueled once the last passenger has left the aircraft. Inside the aircraft cabin, the catering provider exchanges the trolleys and the cabin interior is cleaned and prepared for the next flight. Once cargo and baggage unloading is complete, the loading process for the next flight begins. Once the fuel has been completely replenished, the passenger ingress is initiated and a final head count is performed before leaving the parking position. If the aircraft is parked at a gate position, usually a push back is required (Airbus, 2005).

Fig. 1 depicts a typical top view of the ramp layout at the gate position. The port-side doors are used for passenger egress and ingress, and the starboard doors are utilized for catering and cargo handling. The position of the service vehicles is predefined due to the interface locations of the aircraft. The reference turnaround process does not include additional operations, such as any de-icing required in order to remove frozen containment of the aircraft or failure of the auxiliary power unit (APU), both of which require support from start air and air-conditioning service vehicles.

2.2. Current bottlenecks for ground handling operations

The approach taken here was to analyze stakeholder requirements in terms of an efficient ground handling process, according to the reference turnaround procedures presented (see section 2.1) and to identify those areas where problems are currently being experienced. Based on a literature review, the stakeholder requirements were identified with regards to efficient ground handling processes (Guraly and Kral, 2010; Templin, 2007; Luis, 2010; Ahsbahs, 2008; Dürr, 2008; Tuinstra, 2009). Areas where problems occurred are grouped into four different categories, namely information sharing, processes, capacity, and policies. Table 1 gives an overview of the main concerns arising for every stakeholder in each of these categories.

Across airlines, airports, and ground handlers, some similar bottlenecks can be identified: first, for all three it is observed that the degree of information shared between the different parties involved is insufficient and thus results in the resources required being incorrectly allocated in the ground handling process. In this regard, available capacities at the airport, which includes ground handling resources, are not managed in an optimal way, leading to constraints in this area and therefore influencing airline operations. Another common problem concerning airlines and ground handlers equally is the issue of manipulation of processes in achieving punctuality in airline operations to avoid penalties.

In addition to these aspects, certain different areas affect the individual stakeholders specifically. Airlines, for example, consider the boarding procedure to be a serious problem, since it has a major effect on block times. They postulate that standard service agreements need to be reviewed. Airports and ground handlers consider

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