Transportation Research Part D 63 (2018) 433–444

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Emissions from auxiliary power units and ground power units during intraday aircraft turnarounds at European airports

Anil Padhra

University of West London, St Mary's Road, Ealing, London W5 5RF, UK

A R T I C L E I N F O

Keywords:
Aircraft turnaround
Auxiliary power units
Airport emissions

A B S T R A C T

It is widely known that emissions from aircraft engines, Auxiliary Power Units (APU) and ground handling equipment contribute to air pollution at airports. During the aircraft turnaround process, the main source of emissions is the APU. The use of the APU can be significantly reduced if the aircraft stand is equipped to supply external electrical power and pre-conditioned air to the cabin. This paper analyses the actual duration of APU and external power usage during intraday aircraft turnarounds at 125 airports during June 2015. The data is derived from flight data recording units of more than 200 short-haul, narrow-body jet aircraft, conducting some 25,195 aircraft turnarounds and thus provides the most detailed assessment of aircraft power usage available. A common practice is for the APU to be running for a short period on arrival at the stand (arrival-cycle) and then again for a short period prior to departure (departure-cycle). It is identified in this study that departure-cycle emissions are three times greater than arrival-cycle emissions. These emissions could be reduced if more accurate forecasts of departure times are available to flight crew. The provision of external ground power is found to reduce emissions by up to 47.6%. However, the study also highlights that when the source of external power is a diesel-fuelled mobile Ground Power Unit (GPU), there is a net doubling in emissions of hydrocarbons. APU usage is also observed to vary with outside air temperature (OAT) leading to possible increases in emissions of up to 6%.

1. Introduction

The operation of aircraft at airports is known to be a significant source of air pollution. The primary source of emissions is that produced by the main engines during the take-off, landing and taxi phase of flight. There are a number of studies that have quantified airport emissions from the main engines (e.g. Mazaheri et al., 2011, Herndon et al., 2008, Kesgin, 2006). However, very few studies have considered emissions during the turnaround phase when the main engines are operated for a very short time period or even switched off completely. The turnaround process generates emissions from a variety of sources including the aircraft's Auxiliary Power Unit (APU), mobile Ground Power Units (GPU) and service vehicles. Pollutant emission levels are dependent on the type of equipment, fuel type and power output. For comparative purposes, it is often quoted in terms of an Emission Index (EI) value, defined as the mass of a pollutant emitted, in grams, per kilogram of fuel combusted. The predominant role of the APU on the ground is to provide electrical power to the aircraft and supply bleed air to the air conditioning packs. Due to the relatively high fuel consumption rate and usage duration, the APU is a significant source of emissions. Schafer et al. (2003) took direct measurements of APU emissions at airports. They concluded that these emissions could not be neglected compared to main engine emissions due to similar EI values and the longer operating duration of APUs compared to the main engines. In addition to emissions, the environmental impact of APUs

E-mail address: anil.padhra@uwl.ac.uk.

https://doi.org/10.1016/j.trd.2018.06.015

includes elevated noise levels and as a result some airports have restricted APU usage to 5 min after arrival at stand and 5 min before departure. Detailed operational usage of the APU, including the duration of use and the mode of operation is difficult to obtain and very few airlines collect and analyse such data. The lack of transparency of APU usage prevents identification of operational inefficiencies and evidence of good practice. Furthermore, emission studies make use of likely estimates of usage parameters leading to inaccurate emission estimates. For example, Wade (2002) quantified the emission index for APUs for both military and commercial aircraft and then used the estimated operating time and number of cycles to determine emission values. Winther et al. (2015) quantified emissions from various sources including the APU and ground handling equipment at Copenhagen Airport, though used ICAO recommended Time-In modes for the APU. Stettler et al. (2011) estimated APU emissions for one mode of operation and assumed nominal run times of between 15 and 30 min. In recent years, many airports have provided ground power sources and pre-conditioned air that supply aircraft with electrical power and temperature-controlled cabin air, respectively. The change in the use of APU due to such provision is not known other than the generally accepted notion that APU usage is likely to be reduced.

In this study, detailed operational usage data of the APU and external power is analysed for 25,195 intraday aircraft turnarounds at 125 Airports in Europe. The data is gathered from 203 aircraft and includes arrival and departure times at stands, timestamps of APU and external power usage, the mode of operation of the APU and the fuel consumption at each mode. Such detailed observational data enables activities during the turnaround to be mapped, providing more accurate values of airport emissions and opportunities for efficiency improvements.

2. Method

Many commercial aircraft are fitted with a flight data recording unit which records key flight parameters received from numerous sensors on board the aircraft. Examples of parameters recorded include speed, altitude, fuel consumption, engine parameters, etc. The stored data is later extracted and analysed for operational and safety reasons. While the primary purpose is to record and store data in-flight, the data recording unit can also be used to record and store data while the aircraft is on the ground, for example during an aircraft turnaround. During a relatively short intraday turnaround, electrical power and air conditioning is required so that the crew and support staff can prepare the aircraft for the next flight. The industry definition of the start of the turnaround is defined as the point when the aircraft arrives at a stand and is stationary with the parking brake applied. The end of the turnaround process is defined as the point when the aircraft departs the stand and begins to move with the parking brake released. A very good review of the processes involved in a typical turnaround are detailed by Schmidt (2017). Fig. 1 shows the typical sequence of events during a turnaround which ensures that the aircraft is continually powered either from the main engines, the APU and/or an external power source. The data extracted and analysed from the flight recording unit includes a time-stamp of all these events. During departure from the stand, it is common practice for the main engines to remain switched off until the aircraft has pushed back. Upon arrival, aircraft often arrive at the stand with the main engines running, or more commonly, with at least one main engine switched off. As part of the data analysed for this study, the timestamps of operation for the main engines was unavailable and as a result fuel burn and emissions associated with the main engines is not analysed. The data is supplied by two major airlines operating a fleet of Airbus A320 family aircraft, operating to primary and secondary airports across Europe. Data for a total of 25,195 turnaround events was analysed for a period of one month from 1st June 2015 to 30th June 2015. The business model of the airlines can be described as low-cost/hybrid and as such the scheduled intraday turnaround time is short. The average turnaround time observed was 45 min with a

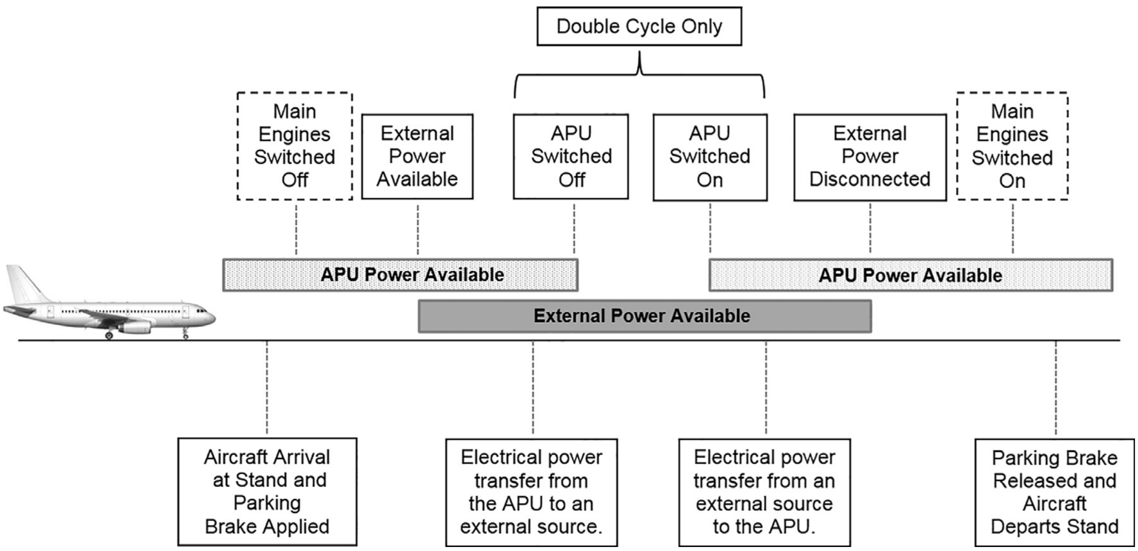

Fig. 1. Typical aircraft turnaround procedure. The dataset includes time stamps for all events except those involving the operation of the main engines, indicated by dotted lines.