Chinese Journal of Aeronautics, (2017), xxx(xx): xxx–xxx

Chinese Society of Aeronautics and Astronautics
& Beihang University

Chinese Journal of Aeronautics

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ATM performance measurement in Europe, the US and China

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Received 13 June 2016; revised 5 October 2016; accepted 22 December 2016

KEYWORDS

Air traffic management;
Data;
Metric;
Performance;
Sampling;
Topology

Abstract Air traffic management (ATM) performance and the metrics used in its assessment are investigated for the first time across the three largest ATM world regions: Europe, the US and China. The market structure and flow management practices of each region are presented. A wide range of performance data across these three regions is synthesised. For topological and performance assessment, the notion of a 'sufficient' sample is often non-intuitive: many metrics may behave non-monotonically as a function of sampling fraction. Missing and under-developed metrics are identified, and the need for a balance between standardisation and flexibility is proposed. Longitudinal and cross-sectional metric trade-offs are identified.

1. Introduction

Air traffic management (ATM) performance assessment is a vital tool for improving air transport service delivery. We investigate such performance and the metrics used in the assessment thereof, across the three largest ATM regions of the world: Europe, the US and China. In addition to synthesising a wide range of data across these three regions, we set out to establish the importance of data sampling with respect to the characterisation and assessment of ATM.

In Section 2, we compare and contrast the market structure (development of airline operations) and flow management practices of each region. Data availabilities, metric definitions and high-level performance data are also presented. Since this paper is concerned in large part with the impacts of sampling on performance assessment, it is first necessary to set a higher-level context of how the three regions of interest are defined, and to present some data on their characteristics, in order to facilitate interpretation of the performance data available from the corresponding states, and the results of our analyses. We will briefly set the scene regarding the development of airline operations and flow management practice in these regions. It may naturally be expected that the drivers and constraints of market and operational development will affect the type of

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Peer review under responsibility of Editorial Committee of CJA.

Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.cja.2017.01.001

network that emerges, and hence the complexity metrics used in this paper to characterise these networks and metrics quantifying performance. It will later be demonstrated that the results for China reflect a different type of network evolution, such that more detail on this region's market development will be presented.

In Section 3, the impacts of airport and airline sampling are presented. Network topologies and delay performance are the focus of these analyses. In the concluding section, we discuss the context of international harmonisation and identify several challenges ahead regarding performance assessment and data management.

2. Regional contrasts

2.1. Establishing context

In the context of assessing the impact of sampling on performance data, it might be expected that at least the fundamental definitions of Europe, the US and China would be straightforward. Whilst this holds for the US, it is slightly more complicated for China, and much more complex for Europe. Unless otherwise indicated, the 'US' refers to air navigation services provided by the United States of America in the 48 contiguous states located on the North American continent south of the border with Canada, plus the District of Columbia, but excluding Alaska, Hawaii and Oceanic areas (the 'US CONUS'). Air transport movement data for China often include Hong Kong, Macao and Taiwan, whereas airport counts usually do not. 'European' data may refer to the European Union (EU), geographical Europe, or the area flow-managed by EUROCONTROL: comprised of 44 states participating in the European Civil Aviation Conference (ECAC). In Europe, the formation of nine supranational Functional Airspace Blocks is part of a move towards the goal of defragmentation: viz. a Single European Sky (launched in 2000 by the European Commission specifically in response to performance management and the challenge of increasing delays). The Single European Sky (SES) area comprises the 28 EU members plus Norway and Switzerland. Of these 'European' areas, the EU is the smallest, such that one has to be wary when referring to 'EU' data only. Complicating matters further, 'European' forecasts often refer to the ESR08 traffic region (EUROCONTROL Statistical Reference Area, comprising 34 traffic zones[1]). Turkey, for example, is in ECAC, included in ESRA08, and a member of EUROCONTROL, but is not in the EU or SES. In 2014, Turkey was the main contributor to European traffic growth, without correspondingly noteworthy delays, yet, in contrast, not subject to the determined costs air navigation charging methods central to the SES performance scheme.[2] The primary focus in this paper is ATM performance, and such data usually refer to ECAC (although the full European flow management and flight planning situation is actually even more complicated[3] than the summary presented here).

As will be discussed in Section 2.4, three primary types of data are collected within each region, involving automated tracking and network operational data collection, in addition to airline data sampling. Not only can the inclusion or exclusion of one or more states clearly affect the data, but, as will be demonstrated, topological and performance metrics can vary as a function of the number of airports or airlines included, and even these delineations are open to variable definitions.

2.2. Market structure

All three regions have witnessed considerable mergers, and groupings into global alliances, with most of the largest airlines now operating as airline groups. Major liberalisation in the airline industry first started in the US market in 1978. European deregulation occurred more gradually, growing from numerous bilateral 'open sky' agreements in response to a European Court of Justice ruling in 1986.[4] The main change here was deregulation of international routes within the EU in 1993 (to coincide with the launch of the single European market) and this was extended to domestic routes in 1997; the main multilateral agreement was between the EU and the US in 2008. Europe and the US are now both established free markets, with a full range of operator types, and with very limited state intervention in airline planning and operations. Recently, there has been a significant growth in low-cost carriers (LCCs),[2] serving fare-driven markets, as exemplified below by the fact that LCCs appear in the top four airlines by passengers carried in both Europe and the US.

Development in China has been more complicated, as the market has changed from a fully planned, state-controlled system, to more of a market economy, in which new forms of airline ownership and operations have emerged. The summary presented here draws mainly on three published works.[5–7] Chinese airlines were officially separated from military jurisdiction in 1980, and merged into three large airline groups in 2002 (Air China, China Eastern and China Southern). Regional airlines emerged essentially as supplementary carriers, with relatively greater regional and local government control and support. These comprise some quarter of all routes, albeit more policy- than market-driven.[8] (As will be observed later, this may have wider consequences for hub development.) 2005 saw investment deregulation and the emergence of non-state airlines (some private, some jointly-owned), including some LCCs, only to be followed by a suspension of new airline applications in 2007. Further state-led consolidation took place after the global financial crisis in 2008, with new mergers and acquisitions in place by 2010. In a comparison[5] of the relative efficiency of these airline types in China, it is stated that some route and schedule advantages remain for the larger airlines with state planning, relative to newer operational models, such as the LCCs. Although dominant status still continues for these three large groups, there is evidence[7] of significant competition between them for market share.

In Table 1, we summarise the market structure in each region, through the four largest airlines in each, drawing primarily on Flightglobal data (Flightglobal company profiles: https://www.flightglobal.com/. Accessed May 2016). Of note, is that some traditional demarcation between LCC and mainline (legacy) carriers is breaking down, for example with Vueling in IAG, and Transavia part of Air France-KLM. The Lufthansa Group owns LCC Eurowings and it is understood that the alliance is actively looking for further LCC partners. In the US, Delta and United both have some LCC ownership, whereas American does not. In China, there were 38 state-owned and 13 private airlines in 2014.[9] Only half a dozen or