DEPENDABILITY MANAGEMENT IN AUTOMATED BORDER CONTROL

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Abstract: Expanding ABC deployments place dependability management at the forefront of system development. Current literature on immigration-related biometric applications is extensive and encompasses a wide range of perspectives to the technology and its application in different settings. However, issues associated with system reliability in terms of availability performance have received limited attention. Depending on the number of e-Gates, passenger volumes and set capacity levels, the failure of even a single e-Gate may significantly impact service availability and hamper passenger experience at a particular site. This paper addresses the practical relevance of systematic dependability management in automated border control. Depandability management has to form a strongly structured yet an integrated entity in the whole ABC development process. It supports the optimisation of border control capacity with respect to manual and e-service and other resources. Dependability management enables cost-effective operation for both system suppliers, maintenance suppliers, and most importantly, system owners.

Keywords: Automated border control, dependability management, reliability, availability, maintainability.

INTRODUCTION

Passport inspection as self-service is becoming more and more everyday phenomenon in air travel in Europe. Access control based on biometrics such as automated border control systems are perceived as the key instrument in processing increasing amount of passenger traffic in a convenient and fluent manner (e.g. Morosan 2012, Jain and Ross 2008, European Commission 2013). Along with expediting border check processes, the installation of e-Gates is also expected to produce cost-savings as it alleviates budgetary pressure towards border controlling authorities in terms of reduced need to employ additional staff (Home Office 2012). Announcements of further deployments reaching a significant scope have been made for example by Germany. By the end of 2014, 90 new e-Gates will be installed to the country's five large airports. The signed ten-year contract also includes a reserve of 180 additional gates (i.e. Secunet 2013, Planet biometrics 2013). In the near short-term, notable investments are also to be made in the UK, as automation is designed to form the country's "primary clearance route for low risk passengers" (Home Office 2012, 29).

Despite new installation notifications, automated border control is yet to develop as off-the-shelf. As according to a UK Border Force official, "e-Gates delivery will be based on a continuous improvement cycle" (Border Force 2012). Nevertheless, the changing ratio between manual and e-service inclines rather strict requirements to future e-Gates. If e-service is to emerge more as 'mandatory' than optional for service choice, the operational reliability ABC systems will have a much higher weight in determining the fluency of overall border clearance processes. Depending on the number of e-Gates, passenger volumes and set capacity levels, the failure of even a single e-Gate may significantly impact service availability and hamper passenger experience at a particular site.

Given the intensifying competitive environment within airport markets (Hvidt Thelle et al. 2012), each point of engagement of a passenger needs to support the commercial relationships between different stakeholders (most notably airlines and airports). Even short ABC system downtimes at peak hours may significantly alter passenger perceptions of service quality (more on customer satisfaction formation and self-service technologies, see i.e. Meuter et al. 2000, Forbes 2008, Robertson et al. 2012). In the airport environment, the number of passengers influenced by an abrupt service failure due to hardware deterioration or software error may be particularly high. Moreover, ensuring the safety and integrity of maintenance activities often requires the built-up of temporary protective structures, such as full-height boarding which changes the flow of people through terminal facilities. Meandering passenger itineraries may cause congestion and potentially restrain access to more commercially-oriented establishments, such as foodservice or shopping. Furthermore, transferring customers to minimised manual capacity may cause severe delays in throughput times and frustrate system operators and administrators as the agreed service levels become unmanageable, even if it would concern a limited period of time.

Current literature on immigration-related biometric applications is extensive and encompasses a wide range of perspectives to the technology and its application in different settings. However, issues associated with system reliability in terms of availability performance have received limited attention (e.g. Palmer 2007, Optimum Biometrics Labs 2008). As such, the scholarly effort dedicated to dependability management in different settings has been versatile (e.g. Kiritsis et al. 2003, Zio 2009, Söderholm and Norrbin 2013), and there is also a variety of guidelines, models and methodology available for practitioners (e.g. O'Connor 2002). The expanding scope of ABC deployment nevertheless places dependability management at the forefront of system development. This paper addresses the practical relevance of dependability management in the area of technology-enabled border checks. The findings presented here are based on research work of the FP7 integration project FastPass.

DEPENDABILITY MANAGEMENT

The IEC 60300-1 standard defines *availability performance* as "the ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided" (IEC 60300-1 2003, 25). In contrast, *dependability* unites availability performance and its influencing factors under one title. From a broad perspective, dependability expresses the confidence and satisfaction levels that users have towards a product's ability to reach expected performance. A dependable item is a product that will deliver anticipated service upon demand. (IEC 60300-1 2003) The examination of system availability performance often involves the use of the acronym RAM which integrates the concepts of reliability, availability and maintainability. In this paper, availability performance and RAM are used interchangeably. The relationships between the different components of performance are illustrated in Figure 1.

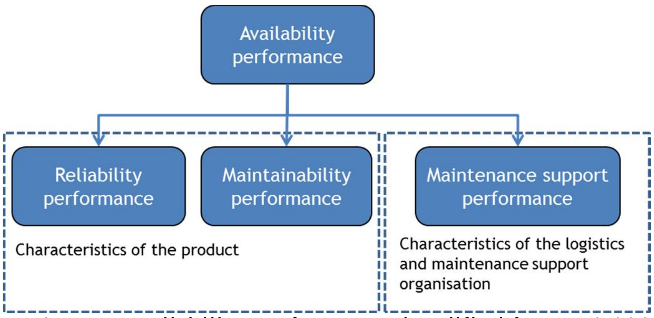

Figure 1. System availability performance (modified from IEC 60300-1).

In the context of biometrics, reliability tends to be associated with the system's performance in terms of accuracy (e.g. Jain and Ross 2008, Schouten and Jacobs 2009, Spreeuwers et al. 2012). Reliability is used to determine how the biometric system performs its matching function (measuring and evaluating system performance through i.e. FAR and FRR). More importantly, it indicates how different performance rates and their alteration affect the overall security and efficiency of the border check process.

Conversely, in dependability management, *reliability* refers to "a characteristic of an item, expressed by the probability that the item will perform its required function under given conditions for a stated time interval" (Birolini 2010, 2). In addition, *maintainability performance* is defined as "the ability of an item under given conditions of use, to be retained in, or restored to a state in which it can perform a required function, when maintenance is performed under given conditions and using stated procedures and resources" (IEC 60300-1 2003, 25). Finally, *maintenance support performance* characterizes "the ability of a maintenance organization, under given conditions, to provide upon demand, the resources required to maintain an item, under a given maintenance policy" (IEC 60300-1 2003, 25). Usually, the reliability and maintainability aspects of a product or a system are largely defined through decisions made during product development process (e.g. choices concerning component quality, system configuration and accessibility). Correcting the misguided choices made at the beginning of the product development process may prove costly or in some cases impossible at the later phases of the product's lifecycle. (Dhillon 1999)

Managing the dependability of a system and performing the required tasks defined in a RAM programme demands a definition of an appropriate system lifecycle. As emphasized above, the whole lifecycle of a product needs to be considered as early as possible in product development process (Murthy and Blischke 2009). While the phases of concept development and requirement definition to a large degree define the basis for lifecycle costs and dependability management of a system, dependability tasks have to be planned for the whole lifecycle. Figure 2 presents a generic lifecycle model which can be adopted as a top-level framework for discussing the requirements for system lifecycle management.

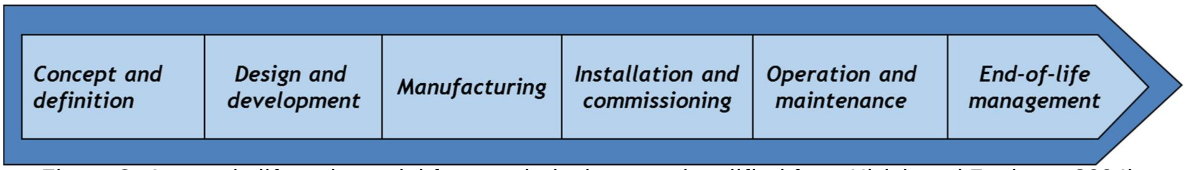

Figure 2. A generic lifecycle model for a technical system (modified from Ulrich and Eppinger 2004).

More specifically, the lifecycle model offers a platform for managing the dependability features of the system. In parallel with a holistic analysis of a system's lifecycle, the lifecycles of each individual sub-system and component at the lower levels of system hierarchy need to receive careful attention.

GENERAL GUIDELINES FOR RAM PROGRAMME

Successful management of the availability performance of an automated border control system requires the construction of an appropriate RAM programme. In order to support important aspects of the reliability performance, maintainability performance and maintenance support performance, the following non-exhaustive list of general guidelines are proposed for system designers:

- specification, evaluation and allocation of dependability objectives based on end-user engagement providing a ground for the other RAM tasks (customer requirements for availability, pursued warranty period failure rate and warranty costs, pursued life cycle costs and costs related to reliability improvement)

- adoption of a deductive top-down approach guaranteeing that further maintenance and other actions focus to the most critical system parts,

- implementation of failure analysis studies (e.g. Failure mode, effects, and criticality analysis (FMECA) and Fault tree analysis (FTA)) for the different phases of the project starting already as a concept phase reliability risk analysis,

- implementation of an iterative maintainability study for early versions of the system design with a focus on safety issues, accessibility, working positions, competence requirements, needs for special equipment and time consumption of maintenance activities,

- acquisition and management of reliability-related data from equipment currently in operative use,

- exploitation of reliability-related data in system design.

The creation of a detailed availability performance programme should strongly take into account the system owner's point of view and consider the following aspects: 1) use and application of the system (e.g. expected passenger capacity, utilization rate and specific modes of operation in different border types), 2) definition of failures in the context (e.g. functional failures in passport scan), 3) use environment (e.g. system exposure to stress), and 4) environmental conditions (e.g. temperature and concentration of dust and dirt).

PRACTICAL IMPLICATIONS

The architecture of an ABC system integrates several technologies (hardware and software components), some of which may not share similar durability to extensive use rates and use modes. Furthermore, the mechanical and moving parts within each individual component may pose different kinds of reliability risks. Enhancing *the reliability performance of ABC systems* thus requires a careful analysis of the reliability structure of the whole system. This entails the identification of the most critical system parts upon which further decisions are to be made (design phase decisions or preparedness during the lifecycle). Customarily, the allocation of resources and reliability improvement efforts to most critical system parts results in best outcomes. Maintaining an up-to-date criticality assessment of the system also serves as a source of information for planning maintenance efforts taking into account also the availability of spare parts. Considering a line of several e-Gates, reliability bottlenecks resulting in common-cause failures should be avoided whenever possible. The solutions for potential common-cause failures can vary from the component selection decisions and inclusion of redundancy in the system design to maintenance strategy decisions, such as setting up the requirements for maintenance response times and availability of spare parts. If the border check process would be integrated to a whole series of airport processes, the reliability structure of the system would also become more complex. This might also influence degree of required maintenance work and potentially impose additional maintenance costs.

With respect to *maintainability performance*, one needs to recognise that biometric systems are under continuous improvement and development cycle. Subsequently, within the lifecycle of the whole system several upgrades will and need to eventually happen. Thus, the introduction and integration of new technologies and solutions as add-ons or updates to the current system should be allowed as much as possible. Furthermore, the system should have replaceable parts in reasonable units to allow the technological development and daily maintenance. In practice, modularity should be introduced into the system to minimise the Mean-Time-To-Restoration (MTTR) and to lower costs and time required for system upgrades. It must be ensured that the software can be updated during the lifecycle, and that the repair of failures (and software updates) does not require the whole hardware being replaced.

Considering *the maintenance support performance* of an ABC system, the lifecycle support from component suppliers needs to be adequate. Reliance on single contractors should be minimised allowing system owners to arrange maintenance activities according to their strategic choices and needs. Overall, attention should be paid to measures that minimise administrative delays, mean logistic delays and the probability of spare parts shortage. Enhancing remote diagnostics or remote software updates might promote cost-savings for both suppliers and system owners, and at the same time improve MTTR of the system.

CONCLUSIONS

In this paper, we have discussed the design of ABC systems from the perspective of dependability management. The practical implications presented in this paper emphasise the role of systematic dependability management methods in guaranteeing the overall effectiveness of an ABC system over its lifecycle. Depandability management has to form a strongly structured yet an integrated entity in the whole ABC development process. In order to reach this, continuous and solid collaboration between various stakeholders during the system's lifecycle is required. It supports the optimisation of border control capacity with respect to manual and e-service and other resources. Dependability management enables cost-effective operation for both system suppliers, maintenance suppliers, and most importantly, system owners.

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