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Airport's electronical systems integration

E. DUDEK
WARSAW UNIVERSITY OF TECHNOLOGY, Faculty of Transport, Koszykowa 75, 00 – 662 Warsaw, Poland
EMAIL: emdudek@gmail.com

ABSTRACT

The paper pays attention to the increasing number of systems working on transport objects, as well as to the results of their implementation. System integration is proposed as one of the ways to increase functionality and safety of transport telematic systems. The paper defines and describes integration process and names its main purposes. In a similar way it presents two selected airport's systems, used as an example in order to show the influence of integration and the difference between independent subsystems and the integrated unit. At the same time it pays special attention to benefits arising from integration according to limitation of systems' inputs and outputs, which results in limitation of unnecessary repetitions of the same information as well as to repetitions of the same algorithms (elaborations of system's outputs) in different subsystems. Finally effects of subsystems' integration are presented according to the telematic services they realise.

Keywords: system integration, transport, airport

1. Introduction

Dynamically developing transport (the movement of people and goods in space using the appropriate means of transport), is the foundation of today's economy. In recent years it was possible to see an increase in population movement both for professional and private reasons. Unfortunately, the number of threats, aimed at transport objects (mobile and stationary) or their users, resulting from acts of nature and more frequently man, is also increasing. As transport systems are among the critical infrastructure of our country in accordance with the [4] they should be properly protected. The natural way to solve this problem is thus implementation of systems ensuring safety of people and objects. Increasing the number of operating subsystems, and what follows the number of physical elements and algorithms working, can cause problems with their service and maintenance or proper functionality. As renouncement of safety systems implementation is not taken into account, it is necessary to increase probability of systems' being fully functional even in highly complex and large-scale structures [5], while trying to limit the unnecessary repetitions of the same information and the same algorithm (working out of the same output) in a number of subsystems as well as unifying data definitions. All those objectives can be achieved thanks to system integration.

In transport infrastructure element that is presented in this article – at the airport, it is possible to identify a number of electronical systems, assuring the appropriate level of security to people, cargoes and aviation infrastructure. Basing on a unit consisting of two such subsystems, effects of subsystems' integration will be presented according to the telematic services they realise.

2. Electronical systems' integration

Systems' integration [7] rests on such their applications that constituent components cooperate with each other in such a way that events, conditions and other information appearing in one of the subsystems cause reaction of the other system. Integration refers directly to the systems' organization and is based on their junction so that they can benefit from each other's resources. This procedure, as mentioned in the introduction, is becoming increasingly important with growing complexity of systems and their coverage of ever further areas of life.

The main purposes of systems' integration can be defined as follows:

- creation of a new structure with improved characteristics (assuring improved quality),
- limitation of the total number of systems' inputs and outputs, thereby reduction of unnecessary repetitions of the same information,
- creation of a platform for information exchange (in order to increase operation safety),
- synergy obtainment,
- obtainment of an improved operating susceptibility,
- reduction of individual subsystems' response time as a result of the access to additional information,
- standardization of data definitions used.

Out of many different forms of electronic systems' integration it is worth distinguishing the concepts of systemic integration and application integration. Wherein systemic integration is understood as such integration, which refers to communication between systems, i.e. connection and data exchange via computer networks and communication protocols. It is therefore integration on a data level. Application integration concerns cooperation of applications, based on different hardware and software platforms, as well as data sharing across applications. Thus it is integration on information level. Application integration is realized through the creation of distributed processing environments, common programs interfaces, and data exchange standards. In this paper systemic and application integrations, according to their presented definitions, will be treated together as transport object's systems integration.

For electronic systems it is also possible to distinguish [1] the concept of integration on program levels (see figure 1), which definition corresponds to the interpretation accepted for transport object's systems integration.

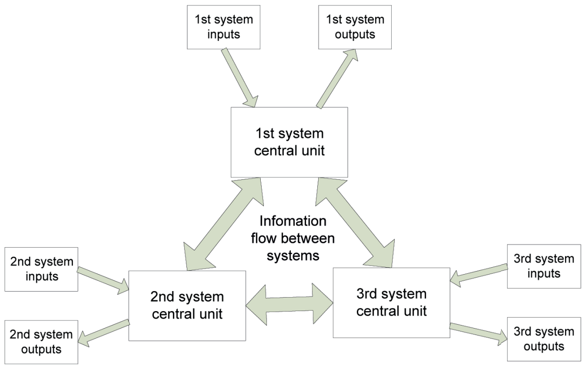

Fig. 1. Electronical systems integration on program level [own study]

3. Airport's selected systems analysis

The main objective of airport's operation is to handle aircrafts' and passengers' traffic flows. Let's focus on passengers' services in airport's passengers' terminal. A number of electronic systems such as: Fire Alarm Aystem (FAS), Intrusion Alert System (IAS), Close Circuit Television (CCTV) [6], Flight Information System (FIS) or Public Address Voice Annunciation (PAVA), is to be installed there. In our considerations let's focus on the last two systems.

3.1. Flight Information System

Flight Information System – FIS is a central data base based system that allows collection, maintenance and presentation of flights' data.

The main tasks of the Flight Information System's are already included in its definition – the collection, maintenance and presentation of flights' data. A more detailed definition of its tasks is outlined below:

- collection of data, concerning flights, such as arrivals and departures timetables (including: flight number, time of arrival/departure, airport of destination, type of aircraft, airlines, the number of passengers + crew), delays of flights according to the timetable,
- collection of data related to the airport's architecture and the organization of elementary operations of travellers' services at the airport's passenger terminal,
- gathering information on unpredictable and random situations, or events threatening people and environment safety,
- processing of current and historical collected data,
- presentation of the collected information regarding flights (such as: arrivals and departures according to the timetable, real arrivals and departures, delays) through various types of media such as displays, monitors, information boards, websites, telephone centres, voice information systems,
- presentation of data, improving passengers' movement in the airport's passengers' terminal, such as: the current list of check-in desks, the current list of boarding gates, the current list of luggage collection belts,
- presentation to travellers of additional information from security services,
- sharing of the collected data with the operational units, present at the airport: Customs, Boarder Security Service, Airport Security Service, or other,
- forward of the information displayed on airport's monitors and information boards to its website,
- carrying on of the analysis and flight statistics, including, inter alia, number of flights in a time period, number of a selected airline's or selected type of aircraft flights, number of delays with their reasons and duration, etc. in order to support future operation tasks at the airport.

For the considered system it is possible to determine [2] the set of its input elements $X_a(t) = x_{ia}(t)$, where $i = 1, 2, ..., 13$, and the succeeding values $x_{ia}(t)$ can be assigned to the following interpretations:

1. $x_{1a}(t)$: total number of check-in desks (departures),
2. $x_{2a}(t)$: total number of boarding gates (departures),
3. $x_{3a}(t)$: algorithm defining time gap between a finished check--in or boarding operation and a new check-in or boarding operation to be held on the same desk/gate,
4. $x_{4a}(t)$: departures timetable (flight number, time of departure, airport of destination, type of aircraft, airlines, the number of passengers + crew),

5. $x_{5a}(t)$: total number of gates to the airport's passenger terminal for arriving travellers,
6. $x_{6a}(t)$: total number of luggage collection belts,
7. $x_{7a}(t)$: algorithm defining time gap between a finished operation of giving entrance to the airport to arriving passengers or luggage collection operation and a new operation of the same type to be held on the same gate/belt,
8. $x_{8a}(t)$: arrivals timetable (as above),
9. $x_{9a}(t)$: delays of the departing aircrafts,
10. $x_{10a}(t)$: delays of the arriving aircrafts,
11. $x_{11a}(t)$: time,
12. $x_{12a}(t)$: set of safety statements,
13. $x_{13a}(t)$: airport's current safety situation.

For the Flight Information System it is also possible to determine the set of output elements $Y_a(t) = y_{ja}(t)$, where j = 1, 2, …, 18, and the succeeding values $y_{ja}(t)$ can be assigned to the following interpretation:

1. $y_{1a}(t)$: assignment of a flight number to the check-in desk (inputs: 1, 3, 4, 9, 11),
2. $y_{2a}(t)$: assignment of a flight number to the boarding gate (inputs: 2, 3, 4, 9, 11),
3. $y_{3a}(t)$: assignment of a flight number to the gate allowing entrance to the airport to arriving passengers (inputs: 4, 7, 8, 10, 11),
4. $y_{4a}(t)$: assignment of a flight number to the luggage collection belt (inputs: 6, 7, 8, 10, 11),
5. $y_{5a}(t)$: actual list of operating check-in gates (inputs: 1, 3, 4, 9, 11),
6. $y_{6a}(t)$: actual list of operating boarding gates (inputs: 2, 3, 4, 9, 11),
7. $y_{7a}(t)$: actual list of luggage collection belts (inputs: 6, 7, 8, 10, 11),
8. $y_{8a}(t)$: selected safety statement (inputs: 11, 12, 13),
9. $y_{9a}(t)$: current timetable for departures (flight number, time of departure, airport of destination, type of aircraft, airlines) (inputs: 4,11),
10. $y_{10a}(t)$: current timetable for arrivals (as above) (inputs: 8, 11),
11. $y_{11a}(t)$: delays of the departing aircrafts (inputs: 9, 11),
12. $y_{12a}(t)$: delays of the arriving aircrafts (inputs: 10, 11),
13. $y_{13a}(t)$: statistic/historical data: number of departing flights in a time period (inputs: 4, 9, 11)
14. $y_{14a}(t)$: statistic/historical data: number of arriving flights in a time period (inputs: 8, 10, 11)
15. $y_{15a}(t)$: statistic/historical data: number of a selected aircraft flights in a time period (inputs: 4, 8, 11)
16. $y_{16a}(t)$: statistic/historical data: number of a selected airline's flights in a time period (inputs: 4, 8, 11)
17. $y_{17a}(t)$: statistic/historical data: number of flight delays (in a time period) with their reasons and duration (inputs: 4, 8 , 9, 10, 11),
18. $y_{18a}(t)$: statistic/historical data: information about unforeseen, incidental or safety-threatening situations (inputs: 11, 13).

Undoubtedly, sets of input and output elements [$X_a(t)$ and $Y_a(t)$] of the Flight Information System could be defined in a different way. In most cases, determination of the number of elements as well as assignment of their interpretations depends on the requirements specified by the investor, user or system administrator. In this paper it was assumed that the set of input values has 13 elements, and the set of output values 18 elements with the interpretations given above.

3.2. Public Address Voice Annunciation

Public Address Voice Annunciation - PAVA is a distributed system that allows spreading abroad warnings and voice announcements for safety needs of people present in transport object's space. At the same time it fulfils communication tasks, giving opportunity to broadcast information, create music background and call on people.

The main task of the PAVA System is to broadcast voice statements: of evacuation, fire or warnings received from the Fire Alarm System or induced by an operator. However, it can fulfil other tasks as well. Thus, the detailed list of its tasks is presented below:

- broadcast of warning signals and voice statements for safety needs of people present in transport object's space,
- broadcast of evacuation statements for its efficient execution in case of fire or other dangerous situations,
- presentation to travellers of additional information from security services or organizational information regarding transport object,
- broadcast of data, improving passengers' movement in the airport's passengers' terminal, such as: opening of new check-in desks, boarding gates or luggage collection belts,
- broadcast of statements regarding flight delays according to the timetable,
- recall of passengers to the check-in desks or boarding gates,
- creation of music background, improving object's ambience.

For the considered system it is possible to determine the set of its input elements $X_b(t) = x_{ib}(t)$, where i = 1, 2, ..., 15, and the succeeding values $x_{ib}(t)$ can be assigned to the following interpretations:

1. $x_{1b}(t)$: set of evacuation statements,
2. $x_{2b}(t)$: set of safety statements,
3. $x_{3b}(t)$: set of organizational statements,
4. $x_{4b}(t)$: airport's current fire situation,
5. $x_{5b}(t)$: airport's current safety situation,
6. $x_{6b}(t)$: actual list of operating check-in gates,
7. $x_{7b}(t)$: actual list of operating boarding gates,
8. $x_{8b}(t)$: actual list of operating luggage collection belts,
9. $x_{9b}(t)$: delays of the departing aircrafts,
10. $x_{10b}(t)$: delays of the arriving aircrafts,
11. $x_{11b}(t)$: departures timetable (flight number, time of departure, airport of destination, type of aircraft, airlines, the number of passengers + crew),
12. $x_{12b}(t)$: arrivals timetable (as above),
13. $x_{13b}(t)$: set of statements recalling passengers to check-in desks, boarding gates or to the information point,
14. $x_{14b}(t)$: set of music files,
15. $x_{15b}(t)$: time.

For the described PAVA system it is also possible to determine the set of output elements $Y_b(t) = y_{jb}(t)$, where j = 1, 2, …, 10, and the succeeding values $y_{jb}(t)$ can be assigned to the following interpretations:

1. $y_{1b}(t)$: selected evacuation statement (inputs: 1, 4, 5, 15),
2. $y_{2b}(t)$: selected safety statement (inputs: 2, 4, 5, 15),
3. $y_{3b}(t)$: selected organizational statement (inputs: 3, 4, 5, 9, 10, 15),
4. $y_{4b}(t)$: opening of new check-in desks (inputs: 6, 15),
5. $y_{5b}(t)$: opening of new boarding gates (inputs: 7, 15),

6. $y_{6b}(t)$: opening of new luggage collection belts (inputs: 8, 15),
7. $y_{7b}(t)$: delays of the departing aircrafts (inputs: 9, 11, 15),
8. $y_{8b}(t)$: delays of the arriving aircrafts (inputs: 10, 12, 15),
9. $y_{9b}(t)$: recall of passengers to check-in desks, boarding gates or to the information point (inputs: 7, 11, 13, 15),
10. $y_{10b}(t)$: music background (input: 14).

Analogously as for the Flight Information System sets of input and output elements [$X_b(t)$ and $Y_b(t)$] could be defined in a different way. For the purposes of this study it was assumed that the set of input values of the PAVA system has 15 elements, and its output values 18 elements with the interpretations given above.

3.3. Integrated system (FIS + PAVA)

Analyzing both described systems (Flight Information System and Public Address Voice Annunciation) jointly, one comes to the following conclusions:

- 6 systems' inputs are common to both systems:
  - $x_{4a} = x_{11b}$,
  - $x_{9a} = x_{9b}$,
  - $x_{10a} = x_{10b}$,
  - $x_{11a} = x_{15b}$,
  - $x_{12a} = x_{2b}$,
  - $x_{13a} = x_{5b}$,
- 3 Flight Information System's outputs are the inputs to the PAVA System:
  - $y_{5a} = x_{6b}$,
  - $y_{6a} = x_{7b}$,
  - $y_{7a} = x_{8b}$,
- 3 systems' outputs are equal:
  - $y_{8a} = y_{2b}$,
  - $y_{11a} = y_{7b}$,
  - $y_{12a} = y_{8b}$.

Carried out analysis allows presentation of a new system, formed as an integration of subsystems FIS and PAVA (see Figure 2). The number of inputs of the integrated system decreases by 1/3 compared to the totality of PAVA and FIS (18 of 28), and the number of integrated system's decreases by more than 20% (22 of 28).

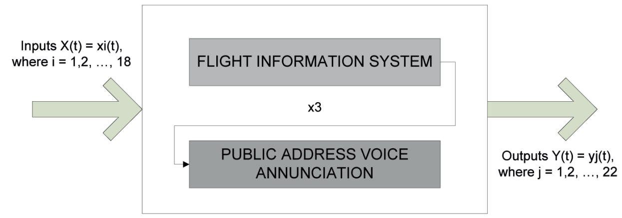

Fig. 2. Integrated system (FIS + PAVA), its inputs and outputs [own study]

4. Integrated system's telematic services

The essence of transport telematics systems' functioning is the implementation of services, designed for different target groups directly or indirectly related to the processes of people /freight movement. Services customers may be individual users of transport systems (travellers), infrastructure operators, maintenance services, operators, carriers and other groups related to transport.

In case of systems presented in this article, the outputs of those systems can be identified with the services they carry out. Therefore it was proposed to arrange them into telematic services groups according to the purposes they lead to. Table 1 presents a detailed summary.

Presented services (based on Flight Information System and Public Address Voice Annunciation) are designed rather for individual users such as passengers or for airport's maintenance services, but it is possible to widen their scope by distinguish telematic services for other groups of customers while analysing other airport's electronical systems.

5. Conclusion

With the growing importance of transport systems in our country, transport objects' safety issues become increasingly important. Due to the complexity and multiplicity of solutions applied, their integration seems worth consideration. Using an example of two selected airport's systems, presented in the article, the benefits of integration were shown, especially in the area of reducing the number of inputs and outputs of the systems, and thus the number of unnecessary repetition of the same information as well as the need to repeat the same algorithms (working out of the same outputs) in several subsystems. For the selected systems integration allowed total reduction of inputs by 1/3 and decrease of outputs number by 20%.

In the end the outputs of both subsystems were arranged into telematic services groups showing once again the benefits of system integration and reduction in integrated system's outputs number. This article may be a basis for further analysis of this problem.

Table 1. Services groups for PAVA and FIS systems [own study]

PAVA / FIS		services improving passengers' movement in the airport's passengers' terminal	safety related services	timetable related services	services improving airport's passengers' terminal ambience
		y_{9b}	y_{1b}, y_{3b}		y_{10b}
services improving passengers' movement in the airport's passengers' terminal	y_{1a}, y_{2a}, y_{3a}, y_{4a}	$y_{5a}=y_{4b}$, $y_{6a}=y_{5b}$, $y_{7a}=y_{6b}$			
safety related services			$y_{8a}=y_{2b}$		
timetable related services	y_{9a}	y_{10a}		$y_{11a}=y_{7b}$, $y_{12a}=y_{8b}$	
archiving services	y_{13a}, y_{14a}, y_{15a}, y_{16a}, y_{17a}, y_{18a}				

Auxiliary caption:
y_{ij}: check-in desks, boarding gates and luggage collection belts,
y_{ij}: safety statements,
y_{ij}: delays of the arriving/departing aircrafts.

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