Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

TESTING THE HEATHROW TERMINAL 5 BAGGAGE HANDLING SYSTEM – BEFORE IT IS BUILT

Roger Derksen – Vanderlande Industries/Transfer Solutions
Huub van der Wouden - Vanderlande Industries/Transfer Solutions
Paul Heath – British Airports Authority/Process Simulations Ltd

London Heathrow Terminal 5 will open in March 2008. This new core terminal building and two satellites will handle 30 million passengers a year, and all of these passengers will expect their baggage to accompany them on their flights. To achieve this, a new baggage handling system is being constructed that will handle more than 70,000 bags a day. Maintaining customer confidence in the reliability of the baggage handling system is vital to the successful delivery of the project.

The challenge for the baggage control system designers was how best to integrate and test the software systems of such a large and complex system within a limited time to test the software in its actual site environment.

This article explains the vital role that software emulation testing techniques played in factory integration testing. The advantages and limitations of these techniques are covered along with explanations of what can (and cannot) be achieved in the factory environment.

1. INTRODUCTION

Terminal 5 (T5) will be London Heathrow's fifth airport terminal.

When fully completed, T5 will provide a further 60 aircraft stands and will enable Heathrow to handle an additional 30 million passengers per year. It is planned to be become British Airways principle terminal at Heathrow. Terminal 5 will consist of a core terminal building and a satellite building (the second satellite is due to open in 2011)

The terminal will handle both intra and inter-terminal baggage with over 70,000 items of hold baggage needing to be automatically processed daily. For this purpose a complete new baggage handling system has been developed by Vanderlande Industries, an international company specialising in material handling systems based in the Netherlands, and the world's second provider of baggage handling systems.

From the early stages of the concept design phase, BAA (British Airports Authority), British Airways and Vanderlande Industries formed an integrated design team to jointly define the baggage system requirements, its design principles and the key measures of system performance. In order to achieve the required service levels, the baggage system encompassed many baggage handling functions, such as hold baggage screening, automated identification and sortation systems, early baggage storage systems, high speed DCV systems as well as baggage reconciliation systems.

2. Function and Architecture of a Baggage Handling System

The main function of a baggage handling system is to transport bags from a baggage entry point (e.g. a check-in desk) to a pre-determined output point in a timely manner (e.g. for loading into a container for loading into the aircraft).

Between bag entry and bag delivery, several processes are needed to be executed by the system. The bags will be:

- Automatically identified by their bag label
- Screened for explosives (by automatic in-line hold baggage screening machines)
- Stored in an early bag store (if passengers are too early for their flight)
- Manually encoded (for resolving problems with bag information)
- Sorted to flight allocated loading positions (automated sortation)
- Fast tracked (for late bags that require urgent processing)
- Manually handled (for large bags; and loading & unloading systems)
- Reconciled. (checked if bags are authorised to load onto aircraft e.g. to avoid that the bag will travel without a passenger).

In all these processes, software fulfils a major task.

Our explanation of the involved software components and their functions starts at the lowest layer of the baggage handling system architecture (see figure 1).

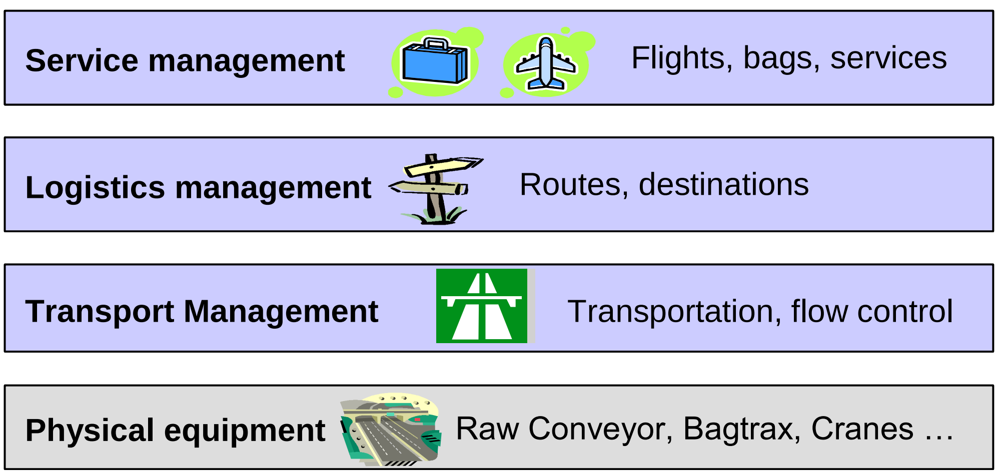

Figure 1 BHS Architecture

2.1 Transport Management

The physical system consists of transportation equipment like raw baggage conveyor belts, cranes, tilt tray sorters, and DCV systems. Each of these pieces of equipment is controlled by software, which is referred to as the transport layer. The major functions of this transport layer are to start and stop the equipment, transport the baggage in the right direction, to track the baggage during transport and to control the baggage flow. The transportation layer software is, with the exception of the flow control software, running on Programmable Logic Controllers (PLCs). For T5 there are more than 200 of these PLC's each running their own programme.

Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

Tilt Tray Sorter:	*The tilt-tray sorter is a high-speed automatic sortation system used to sort bags to bins. It is configured in a loop and consists of trays, which can hold one bag each. To discharge a bag the tray will flip and the bag will slide off from the tray.*
DCV:	*Destination Coded Vehicle Solutions for transporting bags reliable with high speed in tubs or carts. Vanderlande offers two solutions; Tubtrax® and Bagtrax®.*

2.2 LOGISTICS MANAGEMENT

To be able to transport a bag to a certain destination, the transport layer needs to contain knowledge about the destination of the bag and how to get to that destination. After a bag is detected in the system it sends the baggage information to the logistics management layer. This layer can be compared to a navigation system for a car. Based on a destination (final or intermediate) and the current position of the bag it calculates the optimal route, taking into account unavailability of routes and current load on the system to avoid traffic jams.

2.3 SERVICE MANAGEMENT

The logistics management layer determines the physical destination within the system based on information from the service management layer. The service management layer contains the actual flight plans. In these plans the flights (departing and arriving) are mapped to a certain destination in the baggage handling system. The service manager layer also contains knowledge about which bag belongs to which flight. After baggage information has been received from the logistics management layer, service management tries to match the bag to a flight, and based on several rules, send an instruction for the bag to the LM layer. Examples of instructions sent: go to an output point; go to the early bag store; go to a screening machine.

These are just the major components. In addition, components exist for managing the early baggage store, for manually identifying bags, for handling safety aspects, and for the visualisation of system status. And finally, the baggage handling system interfaces to a number of airport systems, exchanging data about flights, baggage, and passengers.

In this article, we will frequently use the terms “low-level controls” and “ high-level controls”. Low-level controls refers to the controls of the transport layer; high-level controls refers to the controls of the logistics management and service management layer..

3. RISK OF LATE DELIVERY

The stakeholders recognised that large software projects historically carry with them risks of late delivery and associated programme overruns. Some of the particular risks associated with the T5 project were:

- ***Multiple sub contractors****:* For the T5 project several sub contractors were used. For software development, it is common knowledge that the greater the number of interfaces, the greater the risk of product delivery. The fact that multiple vendors are participating in the delivery of systems only raises the likelihood of this risk.
- ***New Architecture***: Within the T5 project a new architecture was developed, which meant there was little re-use of previously developed, “off the shelf” components. For example, the entire Bagstore software (as well as the equipment) was newly developed for the project.
- ***Changing requirements***: With such a long project life-cycle (project duration to date is 7 years), requirements will change over time. For example; client project management

personnel change, bringing new views on requirements to meet the ever-changing business environment.

But it is not only the baggage software project that carries the risk of late delivery. The software is only one part of the complete project. A major part deals with the baggage handling equipment and its installation on site. When the software systems can be integrated on site, is closely related to these installation activities.

Starting from scratch, the development of a baggage handling system for a new airport looks roughly as follows:

1. Construction of the building and installation of utilities;
2. Installation of the physical baggage handling equipment (conveyors, scanners, cranes, etc);
3. Installation of electrical infrastructure: power cabling and network infrastructure;
4. Installation of equipment controls: computer hardware (mostly PLC's) and software used to control the physical part of the baggage handling system;
5. Configuration of low-level controls to work with the equipment as installed; testing of equipment controls;
6. Installation of high-level controls: computer hardware and software used to control the logistical functions of the baggage handling system; integration testing of high-level and low-level controls;
7. Integration and system testing of the baggage handling system, in isolation as well as within the context of other airport IT-systems;
8. Testing the operational use of the baggage handling system.

In every step new risks are introduced. Knowing that the opening date of the airport does not move (once the opening date has been decided upon, there is very little opportunity for the airport authorities to delay opening, without very serious cost implications), every delay is likely to have an impact on the successful delivery of the baggage software product..

Some examples of delays, from previous projects, that were outside the control of the baggage system delivery team were:

- The building construction was not completed on time – resulting in lost weeks of equipment installation time.
- Late in the project, it was discovered that somehow it was forgotten to put sprinkler systems in a part of the building where we were testing. The resulting scaffolding meant we couldn't use certain system parts for testing.
- A 3rd party supplier of an electric component had made minor changes to it. Undesirable side effects that only showed up during stress testing of the system.

In addition to the threat of losing test time due to other peoples activities, testing on site is very difficult in itself. Because of the size and complexity of not only the system, but also the scenarios that need to be run, much time, effort, and personnel are needed to execute the tests. In the complex environment of site commissioning, it is easy to make mistakes during the configuration of the system, and when things do go wrong, an entire day's testing could easily be lost. Additionally, the staff needed to operate the system and to handle the baggage is large and represents a significant commitment in resources (40+ staff to assist with large bag volume scenarios is not unusual)

Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

Taking this into account and given that in the life-cycle of a terminal or airport construction project, it is normally the installation and commissioning of the baggage system that is scheduled towards the end of the development period, any delays in the delivery, integration and testing of the baggage system software could have a direct and immediate impact on the ability of the airport to meet its planned opening date.

In order to mitigate this risk, it was decided that investment in methods to enable early software component and system integration testing would prove advantageous in the overall software development life-cycle and provide increased confidence in the successful delivery of the baggage system.

4. SYSTEM EMULATION

In previous projects, we have extensively used emulation models to test our low-level controls software.

Emulation models are very intelligent stubs. Webster's dictionary defines *to emulate* as: "to use as a model for one's […] behaviour." The emulation models we use are computer programs, which replace a part of the baggage handling system, and which behave (almost) the same as the part they replace.

To define and run our models we have used Automod™ simulation software. With Automod™ it is possible to simulate systems of any size or level of detail, from manual operations to fully automated facilities. It provides true to scale 3D virtual reality animations. The model can be viewed from any angle and any size. A special layer is available in Automod™ that makes communication with the controlling systems (like PLC's) easy.

An example of such an isolated model is the model of a single conveyor line, in which the movement of a bag on the conveyor is modelled by photoelectric cells along the conveyor line generating output signals to the controlling PLC.

Within the T5 project, we decided to extend the use of emulation by connecting the individual models into large integrated systems, in which the physical equipment was replaced by a number of interconnected emulation models.

We distinguish between two types of emulation: Low-level emulation and high-level emulation. The distinction lies in the part of actual system that is being modelled.

5. LOW-LEVEL EMULATION

Low-level emulation models replace the physical transport equipment, for example a conveyor line, and can be controlled by a single PLC. The software that is tested with low-level emulation is the transport layer. The models we have developed produce the same electrical outputs and respond to the same electrical inputs as their corresponding physical equivalent (motors, photo-electric cells, barcode scanners, etc).

Example of common functions of equipment that are emulated are:

- Transport
- Photocell functionality (triggering a photocell is used to determine the location of the bag, to determine whether transport must stop or re-start, to determine bag jams, etc.)
- Tracking functionality

Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

- Start / stop
- Technical errors (e.g. thermal overload of a motor)
- Generation of bags

Examples of more specific functions of equipment that are emulated are:
- Automatic scanning of baggage labels
- Screening of baggage (explosive detection)

Control panels are used to interact with the model. It is possible to generate a single bag, or multiple bags with a certain frequency. Motors can be stopped and started. Several errors can be generated using the panels

Because the low-level emulation models are controlled by PLC's, it is important that the layout of the model is as realistic as possible. If there are differences in length of conveyors, position of the photocells or speed of the conveyor, the PLC will not behave as expected. To be as realistic as possible, the actual design of the equipment is used as a basis for the emulation model.

The transport time between two photocells is emulation is equal to actual time using the real equipment; the same applies to the total transport time. It is not possible to speed up the emulation. For the PLC this would mean the bag reaches a photocell too soon which means the bag cannot be tracked anymore.

Within the T5 project, over 90 individual low-level emulation models have been created. Individual models have been integrated into 5 different configurations. A separate team spent 4800 hours on building and testing these emulation models.

6. Testing with Low-level Controls Emulation

6.1 Testing using individual models

The first application of low-level emulation is to test the individual PLC software. Static functions (no bags involved) as well as dynamic functions (bags involved) can be tested. A selection of what is tested with emulation during component testing:
- Starting and stopping (parts of) the system
- Error handling and recovery (the emulation provides some, but not all, failures)
- Status reporting of equipment (create an equipment failure with emulation and check if the status is reported correctly).
- Tracking – "following" each individual bag and its associated data in the controls software. Note that the basic principle is tested. Still a lot of configuration and testing needs to be done in the real system.
- Handling of unknown bags and missing bags
- Merge algorithms (with emulation it is possible to really observe the bags merging and check if the algorithms used are correct)
- Interfaces to other components (sending messages to other components depends on a bag reaching a certain location or a status change of the equipment)
- Duration tests (generate bags at high frequency overnight and check for example if internal numbering remains consistent)

Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

6.2 TESTING USING INTEGRATED MODELS

In the next and most important stage in low-level emulation testing, different models are interconnected to form one miniature baggage handling system, with several input and output points. On top of these interconnected models and their PLC controls, the high-level controls software is integrated. The existence of several different output points means that one of the core functions of high-level controls, determining a route for the bags depending on their barcode, flight planning, and security status, is exercised.

The individual models are easy to integrate. The modelling software contains hooks to connect one model to another, and to provide smooth real-time connections.

As an example, we configured a system consisting of the following interconnected models:

- A transfer unloading quay (area were bags enter the system and that contains an automatic scanner device)
- A tilt-tray sorter
- A manual identification area
- A build output area (normal output point of the system)
- A head of stand area (output point used for time critical baggage)

In the test environment we also involved a manual coding station including an actual hand scanner.

Using this configuration, it was possible to test the following system functions and interfaces:

Interfaces:
- Interface between conveyor and the tilt tray sorter
- Interface between the conveyor and the manual coding station
- Interface between the tilt tray sorter and the logistics management layer
- Interface between the service management layer and the manual coding application

Functionality:
- Routing involving the tilt tray sorter
- Handling of “no read” bags (route to manual coding)
- Manual identification of bags

Traditionally, these functions were either tested in a very static test environment (in which one specific scenario was modelled, in terms of messages exchanged, by hand); or not at all before going to site. This obviously meant that a lot of integration problems had to be overcome on site. Being able to configure different test environments by combining models in a variety of ways, allowed us to test every single interface in the system, horizontally (i.e. between transport areas) as well as vertically (i.e. between different architectural layers). This has saved the project a large amount of time and money.

This type of emulation has one obvious drawback: the system configurations that are assembled are frequently not “realistic” in the sense that that configuration can be found in the actual system. It would take too many models and too many PLC’s to achieve a level of realism that would allow actual testing of the behaviour of the high-level controls layers. For this type of testing we use high-level emulation.

Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

7. HIGH-LEVEL EMULATION

To overcome the problem mentioned above, we decided to develop a model of the physical transport equipment *including* its PLC controls. In this way, the entire transport layer could be replaced by one single model. The model interfaces with the other controls layers via the same communication protocols as were defined between PLC's and high-level controls components.

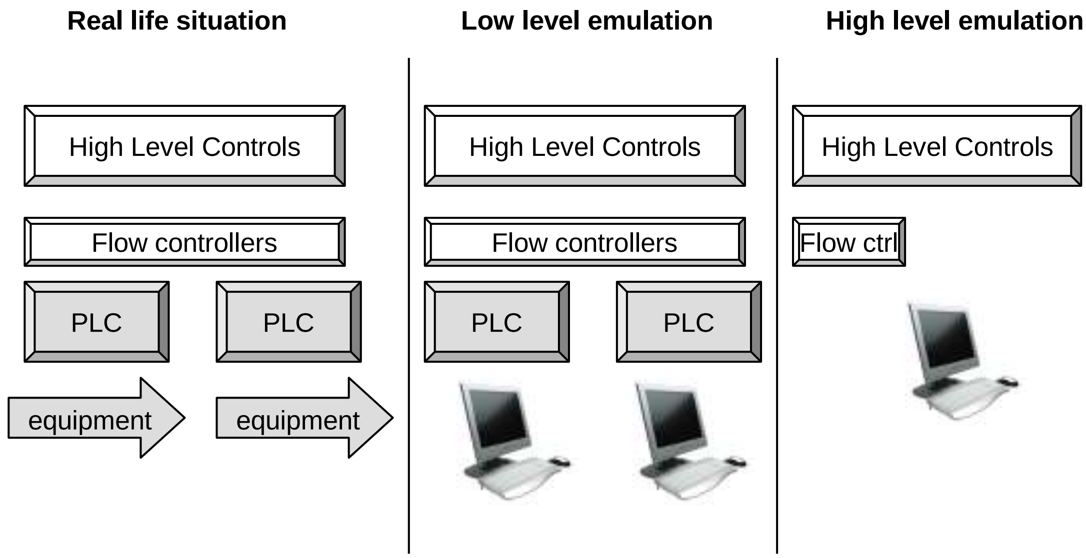

Figure 2: difference low / high level emulation

High-level emulation can be used to test the entire system, but also to test subsystems in isolation. The model used does not only emulate PLC's and equipment, it is also possible to emulate complete subsystems. This makes it possible to test the behaviour of a single component within the entire system without the disturbance of other components. For example, the early bag store functionality can be completely emulated, so the early bag store management software is not required for testing (early bag store will function as a black box).

Unlike in low-level emulation, photocell locations are not important, because no PLC is involved. However, the speed and length of the emulated equipment must be realistic, for example to calculate travel times and test realistic scenarios.

The high-level emulation model reads its test data from an input file (also called scenario file). In this file the scenario that must be tested is configured. The file contains the following information: which bags are entered at what position and with what frequency; the percentage of bags without label; the percentage of bags that have to be screened; the percentage of bags that that fail screening; the points in time a system failure occurs.
After the model is started the scenario file is loaded, and testing may begin. In contrast to low-level emulation, while using high-level emulation it is possible to vary the system speed.

Originally, the model was developed to validate the layout of the system and the major control algorithms of the system. In this version of the model, high-level controls components were also modelled. At a later stage, when the high-level controls components had been built, these components replaced their simulated counterparts.

Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

For the development of the high level emulation model approximately 6000 hours were spent.

7.1 TESTING HIGH-LEVEL CONTROLS EMULATION MODELS

Using high-level emulation, because the transport layer's PLC's are emulated as well, there are no restrictions to the system's layout. Tests can be performed using the entire system or just an individual subsystem, like the baggage store, which then can be tested in isolation.
So also for high-level emulation the application is wide. Several development teams within the T5 project use high-level emulation for testing and integrating their software.

The exact behaviour tested during component testing using high-level emulation depends on the functionality of the tested component. Testing of the early bag store component is used in the example below.

The early bag store is an automated warehouse in which bags are temporarily stored if they cannot be transported to their allocated loading position, because the flight the bags belong to, has not yet opened. The early bag store contains 30 racks, serviced by 15 automated storage retrieval cranes, and is able to store over 4000 bags. The bag store has its own transportation system (Tubtrax), which transports bags in tubs to a location where it is picked up by a crane. The crane transports the bag to a rack location where it is stored as long as required. If the bag has to leave the store, the crane picks up the bag and deposits the bag onto the transportation system. The bags are transported to a so-called unloader, where the bag is unloaded from its tub and transported further on normal conveyor lines.

Two components manage the early bag store: one regulates the flow of tubs, and the other manages the warehouse. Both components interface with each other.

In the high-level emulation model the entire early bag store is modelled including cranes, racks, etc. To test the full functionality of the separate subcomponents of the store, as well as the entire early bag store components, a high-level emulation model is crucial.

A selection of what is tested:

- Capacity of the store; the store must be able to store and retrieve 3600 bags an hour. These flows can easily be created with emulation (imagine what organisation this would take with the real system)
- Flow control algorithms; with high volumes, no congestion is allowed. Waiting time for bags entering the store must be minimal. It is important that empty tubs are in time at the right location so bags can be loaded.
- Error handling: test that the system also meets its requirements when system parts fail (e.g. cranes in error). Errors can be created with high-level emulation, and the effect can be tested.

High-level emulation is also used for component integration. The type of integration testing will be different from low-level integration. This integration level where no PLC's are involved is called high-level integration, referring to the high-level controls components that are integrated. With high-level integration interfaces can be tested, but also the complete integrated system using the complete system layout can be tested. Several types of tests are possible. A selection of what is tested:

Interfaces:

- The interface between components that were not involved in low-level integration (for example the early bag store management system and the logistics management layer)

Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

Functionality:

- The business rules of the system; e.g. early bag to the store, unauthorised to load bags to be delivered to the early bag store.
- Time transitions; transitions between “early”, “in-time”, “time critical” & “missed”.
- Load balancing; if there are multiple manned stations, it is important that baggage is divided equally over these positions to avoid that the work load is unequally divided across workstations.
- Baggage storage and retrieval; this time integrated in the entire system
- Real-life scenarios: test the behaviour of the system using real-life scenarios (realistic schedules, realistic baggage supply)

Non-functional:

- Performance, which is implicitly tested when testing real scenarios with heavy loads
- System capacities; test that the system is able to handle the required system capacities (number of bags per time unit)

Another application of high-level emulation is to prepare tests that are planned to run on site. Especially large scenarios that require a lot of personnel to execute are first run with emulation. The results of the test with emulation can be used to verify the results of the test with the real system.

The suitability of high-level emulation is immense. Especially the possibility to test the system with heavy baggage load has many advantages.

Some cautionary notes have to be made about high-level emulation. The model and the associated engine are complex software components in their own right and should be treated as such. Using early versions of the emulation model, a lot of problems found during testing were related to the emulation model itself. This delayed the progress of testing and frustrated the test personnel. So also for the development of emulation models the software development process must be followed, including proper model verification and validation.

8. TESTING ON SITE

As you will have understood from our explanation so far, each software component installed in its target operational environment (we refer to this environment as “the site”) will have undergone extensive factory testing. This is however just the start. After installation and configuration of the controls software (“commissioning”), another series of tests starts. We will briefly describe each type of test activity, and how site testing adds to the quality of the system by addressing functionality that was not tested in factory.

8.1 COMMISSIONING AND INTEGRATION OF EQUIPMENT AND LOW-LEVEL CONTROLS SOFTWARE

Low-level controls software interacts with physical transport equipment. It has been tested in factory on a model of this equipment, but the model will necessarily differ from the real world. In addition, mistakes will have been made during mechanical and electrical installation; some of the resulting defects will not have been caught by inspections and basic tests that were carried out before commissioning could start.

The most typical defects that we detect during this phase are:

Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

- Installation mistakes e.g. misconnected cables, misplaced photocells, and wrong conveyor speeds.
- Defects introduced by the behaviour of actual baggage during transport. Size, shape, and weight of the bags that are transported are among the real-world aspects that are not modelled in our emulation models. Tracking – "following" each individual bag and its associated data in the controls software – is one of the main functions of the system's low-level controls. It is highly influenced by the bags physical characteristics (round, flat, heavy, smooth, hard, etc), and the way the conveyors are built (horizontal or with a steep incline or decline; straight or curved; running at low speed or high). Most of our commissioning time is spent on making sure the different types of bags can be tracked correctly via a wide range of transport mechanisms.
- Visualisation defects. Both the actual system and the way it is represented in the graphical operator monitoring and control environment (SCADA), are based on drawings. When the equipment is installed, changes may have to be introduced that are caused by the actual site situation. These changes frequently do not make it in time to be included in the graphical overviews, leading to discrepancies. These are detected by exercising the SCADA system with the equipment as it is installed.

This testing phase is concluded by a Component Site Acceptance Test (CSAT), the objective of which it is to assure that equipment plus its low-level controls have sufficient quality to be integrated with other parts of the baggage handling system, and with its high-level controls.

8.2 INTEGRATION TESTING OF EQUIPMENT, LOW-LEVEL, AND HIGH-LEVEL CONTROLS

Factory integration will have assured that basic interaction between components to realise core baggage handling system functions will work on site without much problems. Tests are usually carried out with low baggage volumes (one to ten bags typically); baggage handling system functions that are tested include barcode scanning, bag tracing (building up history of the bag's locations in the system), manual coding, security screening, and determination of the bag's destination and route. In this area emulation testing will have its greatest contribution, and fewest defects are found during site integration.

The defects that are still found on site are among the following:

- Network configuration mistakes, resulting in components not being able to communicate
- Defects in handling exception situations – mostly scenarios with very low occurrence.

Note: We have chosen not emulate every single possible scenario in factory, leaving a number of combinations untested. The reason for not testing every combination is, paradoxically, there are some scenarios that are more time-consuming to replicate in the factory than on site.

8.3 SYSTEM TESTING WITH HIGHER VOLUMES

In factory we will have performed high-volume scenarios using high-level emulation to test the high-level controls functionality and performance, and its correct configuration. On site the main focus of high-volume scenario testing is on overall system robustness. A typical test would consist of a number of bags being entered into the system (ranging from 500 if only a small part of the baggage handling system is used, to 10,000 for a test of the entire system), where we would measure key performance indicators such as tracking performance, scanner rates, travel times, and system throughput. Defects we find using this type of testing could be:

- If baggage is entered at very high rates, baggage flow is temporarily halted causing a reduction of tracking performance (possible cause: insufficient conveyor friction)

Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

- If large hard case bags are discharged from the sorter, they come down at very high velocity, causing handling problems at high volumes (cause: shape and surface characteristics of the chute)
- During stress tests at peak performance, messages between components don't arrive in time.

Site testing therefore is still required to deal with the physical aspects of baggage transportation.

8.4 Emulation advantages from a site test perspective

Using emulation testing gives us the following advantages:

- We don't have to spend time and system resources on simple integration testing.
- When we start low-level controls commissioning, we use components with higher initial quality (less defects present), shortening test time.
- When we start system testing, we use high-level controls components that we know are able to handle integrated high-volume scenarios.

At the moment of writing, we are seven months away from handing over the system to the T5-Live team for their operational trials, and almost a year from the airport opening date. What we have seen so far in our site testing, is that most time is spent on aspects that we have not been able to address in factory testing. All components installed have a high quality at the moment of site installation, especially those components that have been part of many different emulation test environments. Although we do not have access yet to the metrics that would allow us to quantify our experiences, we are convinced that without our extensive factory test regime, the challenge of delivering the baggage system on time, would have been far greater.

9. The role of emulation when the system is operational

Once the system is operational, new software defects are likely to be detected, and changes to software will be requested. The fact that the system is operational almost 24 hours a day makes it crucial that software be tested properly before installation, and that the impact of installing new software as been analysed. For this purpose, a test environment in the office in UK is delivered that contains an environment to be able to perform both low-level and high-level component and integration testing. When new software is released it will be tested using this environment. Impact of the changed software can be analysed and a decision can be made whether or not to take the new software in operation.

10. Conclusions / lessons learned

The approach to integrate the many elements of the high-level baggage control system components into the emulation environment gave the project many benefits. It enabled us to deliver software to site with a much greater level of maturity, with many software errors solved that would not have been discovered until the advanced stage of site integration.

Having a controlled environment for which to perform a greater range of exceptional condition testing meant improved robustness of the shipped software.

Once configured, the emulation environment provides the perfect medium for testing of software modifications prior to implementation on production systems.

All of these benefits are helping BAA deliver a fully operational baggage system for Terminal 5, on time and on budget.

Transfer Solutions BV
Stationsweg 19
4141 HB Leerdam
T +31 345 – 616888
F + 31 345 – 616300
E info@transfer-solutions.com

www.transfer-solutions.com

Biography of the authors

Roger Derksen *is a senior consultant with Transfer Solutions, an IT consulting firm based in the Netherlands. He has been working with Vanderlande Industries as a test manager for several years. Roger is an ISEB certified test practitioner. For the T5 project he was responsible for the factory integration testing. Currently he is working as a test and integration manager for a project of the 70MB programme of Amsterdam Airport Schiphol. He is also the test & integration competence leader of this programme.*
Contact: rderksen@transfer-solutions.com

Huub van der Wouden *is a senior consultant with Transfer Solutions. He has been working with Vanderlande Industries in various international projects in roles such as project manager, integration manager, and test manager. Huub has over 20 years of IT experience, and is an IPMA certificated project manager. Currently he is living in London, working as site test manager for the T5 Baggage System Project, and enjoying this immensely.*
Contact: hgwouden@transfer-solutions.com

Paul Heath*- Director of Process Simulations Ltd. PSL have been providing consultancy services in the fields of baggage system requirements definition, simulation, software assurance and control system design and testing since 1990. PSL have provided services to British Airport Authority and Siemens Plc on a number of baggage handling projects at London Heathrow Terminal 4, Edinburgh and Gatwick Airports. PSL are currently acting as consultants to BAA on the Heathrow Terminal 5 Baggage System Project.*
Contact: paulheath@process-simulations.com