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# AIRPORT LUGGAGE AUTOMATION USING PLC AND HMI

**Shrey Modi**

*Instrumentation and control, SardarVallabhai Institute of Technology, Vasad*

***Abstract—The Luggage Handling System is a major component of an airport today. The project "Airport Luggage Automation Based on PLC" aims at simplifying the said system although on just as a PROTOTYPE. The project contains mainly two aspects. The first is the movement of the luggage. The luggage will move on the conveyor belt. The overweight luggage gets separated on the weight basis. The bags that are qualified will move ahead and they will be separated on color code basis. All the data of the passengers will also be available by the use of the barcode sticker and scanner. The second aspect of the project is counting the number of luggage separated in different sections as well as overweighed and qualified luggage. The entire process can be viewed and controlled via HMI. The number of luggage can also be recorded and sent to the Airport Authorities for further analysis.***

***Keywords- PLC, HMI, Sensors, Separation (weight, color), Barcode scanning***

## I. INTRODUCTION

**Problem definition**

The present conveyor systems used at the airports have too complex fuzzy logics and often have space management issues viz. Denver International Airport, Sydney International Airport. Often it is observed that the entire project gets delayed due to the issues related to the inefficiencies faced in the setup of appropriate luggage handling system for the airport. Also in the systems that are working properly have their own issues to deal with. Many times it is observed that the luggage gets misplaced or there occurs a delay in handing over the luggage to its owner. Moreover there are no provisions for the special treatment for important personalities, students, senior citizens, differently abled passengers. Separate rules are mentioned in the aviation department for such cases, but due to the lack of proper technology the airports are unable to provide such facilities. My project aims at simplifying the above mentioned problems in a very cost effective and innovative manner.

Fig. 1 Typical conveyor system at airport

**Process**

The process is divided into two parts**: separation during departure** and **recognition and separation during arrival**.On the purchase of boarding pass, entire passenger data will be available with the airport authorities, thus analyzing and making it easy for them to recognize and categorize during arrival.

- On check-in, with the boarding pass, a color and a barcode is issued to the passenger with his/her particular baggage with a matching barcode and color tag on the bags of the passenger.
- After being scanned by the X-ray machine, the baggage will move to the weight separator unit.
- Thereafter the qualified baggage will pass through the color detector.
- The resulting baggage will head to the different sections of the warehouse on the basis defined in the system.
- During check-out, which is at the destination, the barcode scanner will scan the barcode sticker and the data of the particular passenger will be displayed on the screen (here on HMI) thus saving money and time.

Here it should be noted that a counter mechanism will also be running simultaneously, counting the baggage at each separation step, giving the valuable data at each point to the airport authorities.

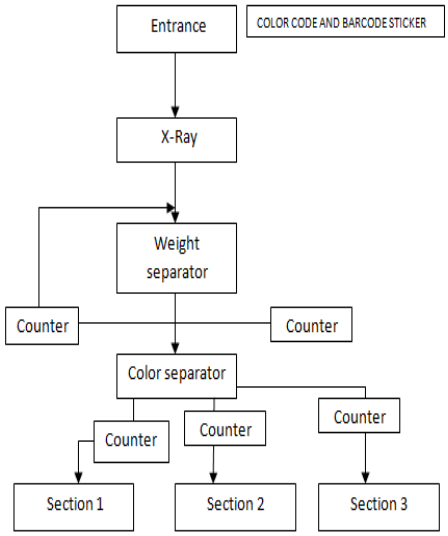


Fig. 2 Process Flow chart

The project not only disqualifies the overweight luggage and keeps a count of the same but also calculates the money that is to be paid for carrying the overweighed luggage (if it is within the upper limits set by the authorities).

The role played by the color detector is inevitable as it serves as the most important sensing and separation mechanism for diverting the luggage to the proper section and position in the warehouse, thus increasing the efficiency and solving the issues related to space management and delay in transportation of the luggage.

The barcode scanner becomes a handy tool during the departure as it solves the problems that the passengers face while searching out for their luggage. This system also aims at giving the data of successful task completion to the higher authorities. Hence our system makes the entire luggage separation at airport **Automated**and provides more precise data for future analysis.

## II. WORKING

The module design and the working of the project are completely based on the inputs received by the sensors which are placed on and below the conveyor system. These data are received by the PLC, where data is processed and a correcting action is taken and sent to the motor and the actuator system, fulfilling all the requirements of a complete feedback system.

Being a prototype and being provided with limited resources, we have made a look alike of the actual system and here instead of using a big conveyor we have used a small conveyor and instead of having all the processes done on a single go, we would separate the luggage on the MODE basis. This means that the separation will be done as per the command MODE selection from the HMI. If Weight Mode is ON then separation occurs on weight basis, if Color Mode is ON the color separation occurs and finally if Barcode mode is ON then the passenger details are displayed. The working of the system starts with the main ON command given by the operator, actuating the servo step motor which moves the connected conveyor in a specified direction. A proximity sensor attached above the conveyor will sense the luggage and stop the conveyor for a specified time interval, set in the system. This stoppage is meant for the sensing of the weight by the load cell placed below the conveyor. On measuring the weight, load cell gives a corresponding analog signal to the PLC. The PLC thereafter processes the data and starts the conveyor and actuates the appropriate pusher mechanism. If the baggage is overweight it will push the luggage into a different section. The normal luggage will move forward as the conveyor starts and the next step would be the color sensing system. Meanwhile, if the luggage is moderately overweight then it will actuate an algorithm in which the amount of rupees per extra kilogram will be calculated and displayed on the HMI screen. If the passenger agrees, then it will be put forward for the color sensing system. The color sensing systemis activated by changing the command via HMI. As soon as the Color Mode is ON, the same procedure repeats but now on the color basis. The third mode is the Barcode Mode in which the information of the passenger gets displayed along with the details of the destination and a photograph of the owner. Thus the owners of the overweight bags and left away bags can be identified. At the departure also with the help of stickers, bags

of VIP and senior citizens will be identified and can be separated and hence can be transferred to a separate conveyor so that they can get their luggage easily.

The system architecture is as shown in the figure.The sensors give input (digital/analog) to the PLC while the output is generated by the PLC after being processed and is given to the servo stepper motor and pusher/actuator. The HMI act as a device which can give input as well as output, one can change the set points or give ON/OFF or mode change command and can also get the visual of the output that the system generates on its screen. The curved box shown at the bottom of the diagram is the legend of the used symbols.

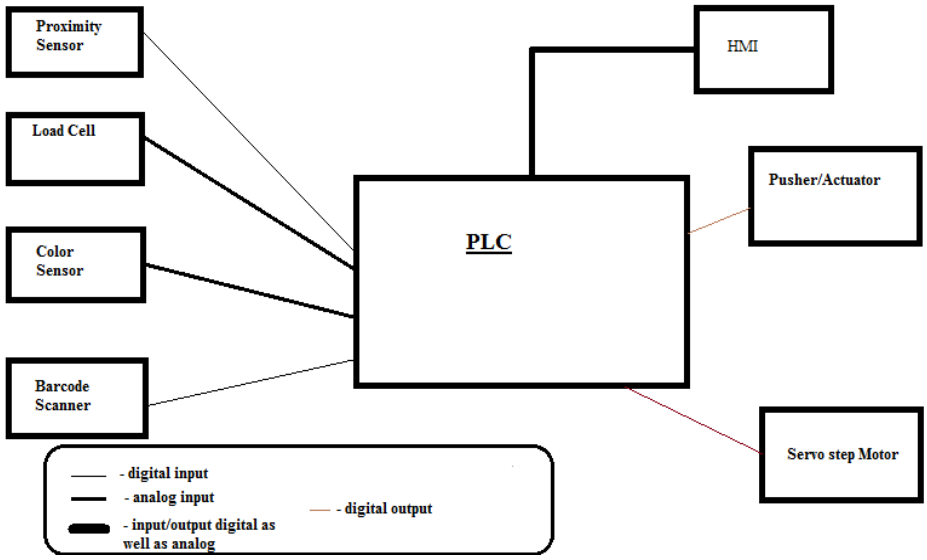


Fig. 3 System Architecture

The component used in the project and brief information about their role in the project is provided in the ensuing paragraphs.

***Major components*:**

**DELTA PLC SS2**(8DI/6DO/4AI/2AO)

This plc is 2nd generation DVP SS2 series plc that keeps the basic sequential control functions from the DVP SS type series but has faster execution speed and enhanced real time monitoring capability.

1.1.1 CENTRAL PROCESSING UNIT.

The central processing unit (CPU) is the heart of PLC. The CPU reads signals and follows the instructions that a programmer has stored in memory. As a result of solved program, the PLC turns outputs or field controlled devices turn on-off.

1.1.2 INPUT/OUTPUT INTERFACE SYSTEM.

It consists of following parts:

*The sensing section*: Sensing section is made up of limit switches, photoelectric sensors, push buttons and so far. These incoming hardware devices provides input signals and are known as field inputs.

Input section: The input section of PLC contains two major areas, which consists of the physical screw terminals where incoming signals from field input devices.

*Controller*: The controller is commonly known the central processing unit or simply the processor .This is the brain or microprocessor that controls or supervises the entire process. The CPU solves the user program and updates the status of the output.

*Programmer*: The programmer is a device where by the programmer or operator can enter and edit programs, instructions or data. The programmer can be a handheld unit, personal computer or an industrial computer programming terminal.

*Output section*:The result of looking at or reading the ON/OFF status of the inputs and using the information to solve the user ladder program is to send, updated signals to the output section is simply a series of switches, one of each output point, that are controlled by CPU and are used to turn output devices ON/OFF.

**HMI**(maximum up to 64 screens)

The user interface or human–machine interface is the part of the machine that handles the human–machine interaction. Membrane switches, rubber keypads and touchscreens are examples of the physical part of the Human Machine Interface which we can see and touch.

In complex systems, the human–machine interface is typically computerized. The term human–computer interface refers to this kind of system. In the context of computing the term typically extends as well to the software dedicated to control the physical elements used for human-computer interaction.

The engineering of the human–machine interfaces is enhanced by considering ergonomics (human factors). The corresponding disciplines are human factors engineering (HFE) and usability engineering (UE), which is part of systems engineering.

Tools used for incorporating human factors in the interface design are developed based on knowledge of computer science, such as computer graphics, operating systems, programing languages. Nowadays, we use the expression graphical user interface for human–machine interface on computers, as nearly all of them are now using graphics.Typical human–machine interface design consists of the following stages: interaction specification, interface software specification and prototyping.

**Conveyor System**(maximum load- 10kg)

A conveyor system is a commonly used system used to move various objects from one place to another. A conveyor system consists of a motor that runs the system, a conveyor belt on which luggage is kept and mechanical assembly to connect the various components with each other.

Conveyor belts are mainly manufactured using Teflon, Rubber etc. it contains two layers, the inner layer helps in providing tensile strength while outer layer is polished.

Belts should be strong enough to carry the weight of objects it is transporting.

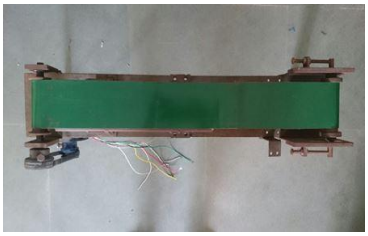

Fig. 4 Conveyor System

**Proximity Sensor**(nominal range- 5cm)

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact.

A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; a proximity sensor always requires a metal target.The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object.

Proximity sensors are commonly used on smart phones to detect accidental touch screen taps when held to the ear during a call. Used in machine vibration monitors to measure the variation in distance between a shaft and its support bearing.

**Load Cell (**capacity- 10kg**)**

The load cell 1002 is the smallest of our standard load cells. It is ideal for all applications which require a compact low capacity design with a low accuracy. It is simple to mount and is low cost. Standard applications include simple filling systems, such as coffee and beverage vending machines, level control in the filling of small containers and bottles, as well as compact letter, kitchen and baby scales. For larger platform scales four or more load cells can be connected together mechanically & electrically to produce an ultra-low profile scale. In industrial applications, this load cell is also commonly used as a small force transducer. The load cell 1002 can also be supplied with 1000 ohms input impedance making it suitable for battery powered devices. Also because of its low power requirements the 1002-K is more suited for use in potentially explosive atmospheres.

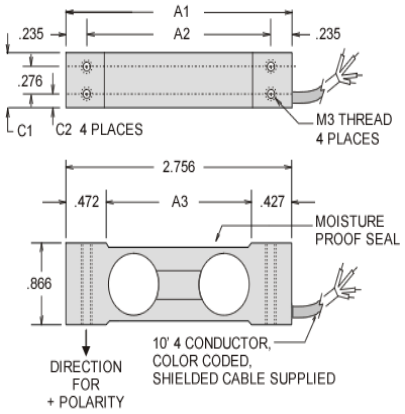


Fig. 5 Cross section of the load cell

**Servo Step motor**

Stepper motors are permanent magnetic motors that 'step' one increment each time the computer gives its control electronics one pulse. They do not require position feedback if run within their limits and when stopped they inherently hold their position. Servo motors are standard DC or brushless motors with an encoder feedback loop. The computer reads the position of the motor, controls the power applied to the motor. Stepper motors generally are just as accurate as servos and are simpler and more reliable and maintenance free in harsh dusty applications. The servomotor's encoder is susceptible to dirt and vibration causing problems. Servo's are faster moving point to point and are better at accelerating very heavy machinery, higher maintenance should be a factor in deciding which to go with. Stepper motor system can be just as fast as or faster than many servo systems because of the control's software's algorithms.

**Color sensor**

We found the best color sensor on the market, the TCS, which has RGB and Clear light sensing elements. An IR blocking filter, integrated on-chip and localized to the color sensing photodiodes, minimizes the IR spectral component of the incoming light and allows color measurements to be made accurately. The filter means you'll get much truer color than most sensors, since humans don't see IR. The sensor also has an incredible 3,800,000:1 dynamic range with adjustable integration time and gain so it is suited for use behind darkened glass. We add supporting circuitry as well, such as a 3.3V regulator so you can power the breakout with 3-5VDC safely and level shifting for the I2C pins so they can be used with 3.3V or 5V logic. Finally, we specified a nice neutral 4150°K temperature LED with a MOSFET driver onboard to illuminate what you're trying to sense. The LED can be easily turned on or off by any logic level output. Connect to any microcontroller with I2C and our example code will quickly get you going with 4 channel readings.

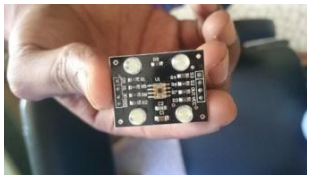

Fig. 6 Color sensor

**Barcode scanner**

Honeywell's Eclipse 5145 TM is a single-line, hand-held laser scanner with a compact form factor perfect for retail applications. A barcode reader (or barcode scanner) is an electronic device that can read and output printed barcodes to a computer. Like a flatbed scanner, it consists of a light source, a lens and a light sensor translating optical impulses into electrical ones. Additionally, nearly all barcode readers contain decoder circuitry analyzing the barcode's image data provided by the sensor and sending the barcode's content to the scanner's output port.

***Auxiliary components:***

**Switched Mode Power Supply**

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a source, like mains power, to a load, such as a personal computer,

while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. Ideally, a switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time. In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.The main advantage of the switching power supply is greater efficiency because the switching transistor dissipates little power when acting as a switch. Other advantages include smaller size and lighter weight from the elimination of heavy line-frequency transformers, and lower heat generation due to higher efficiency. Disadvantages include greater complexity, the generation of high-amplitude, high-frequency energy that the low-pass filter must block to avoid electromagnetic interference (EMI), a ripple voltage at the switching frequency and the harmonic frequencies thereof very low cost SMPSs may couple electrical switching noise back onto the mains power line, causing interference with A/V equipment connected to the same phase. Non-power-factor-corrected SMPSs also cause harmonic distortion.

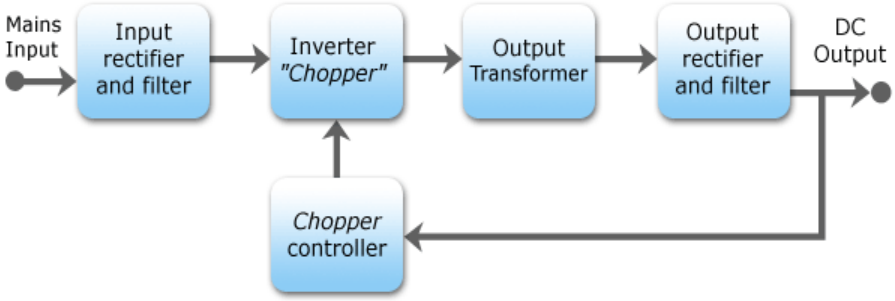


Fig. 7 Block Diagram of SMPS

**Actuator/ DVD Drive Loader**

The actuator is used for separation of the luggage from the main conveyor system to an auxiliary conveyor or to appropriate section in the warehouse. It is also used to disqualify the highlyoverweighed luggage from the normal ones. The problem arising with the pneumatic piston system is the high maintenance and high initial investment; hence we came up with the idea to use a DVD loader as a piston. The major advantage using this is the easy availability of the loader and the compactness of the model. Furthermore, in place of compressed and pressurized instrument air it operates on 24 V DC, and by short circuiting its forward and reverse terminals we can operate its entire movement as a cycle by giving it just a single pulse of 24 V DC. Moreover, it could withstand the mechanical stress to push the luggage and still maintain its functionality and operability.

**Electromagnetic Relay**

Contacts electrically isolated one from another. Electromechanical relays also have a contact resistance that tends to be lower than that of SSRs (tens of milliohms versus about 100 Ω). Contact capacitance is also less, which may benefit high-frequency circuits. Electromechanical relays are less likely to be turned on by transients than SSRs and may be less easily damaged by brief short circuits or overloads. First, relay coils are highly inductive, and the inductance value is not constant. Inductance is low immediately after it energizes and raises as current approaches a steady-state level and the relay armature closes. Second, electromechanical relays switch much more slowly as compared to SSRs (typically 5 to 15 micro sec versus about 1 mill sec). Coil inductance is the primary cause, but also the mass of armature and contact structures are also factors. Third, relay coil inductance can produce high-voltage transients when the device reenergizes. Snubber circuits can reduce the transients but can delay relay dropout as well. Arcs at the contacts of electromechanical relays can produce EMI when a contact bounces during opening or closing.

Fig. 8 Electromechanical Relay and SMPS

**Solid State Relay**

A solid-state relay (SSR) is an electronic switching device that switches on or off when a small external voltage is applied across its control terminals. SSRs consist of a sensor which responds to an appropriate input (control signal), a solid-state electronic switching device which switches power to the load circuitry, and a coupling mechanism to enable the control signal to activate this switch without mechanical parts. The relay may be designed to switch either AC or DC to the load. It serves the same function as an electromechanical relay, but has no moving parts. Packaged solid-state relays use power semiconductor devices such as thyristors and transistors, to switch currents up to around a hundred amperes. Solid-state relays have fast switching speeds compared with electromechanical relays, and have no physical contacts to wear out. Application of solid-state relays must consider their lower ability to withstand momentary overload, compared with electromechanical contacts, and their higher "on" state resistance. Unlike an electromechanical relay, a solid-state relay provides only limited switching arrangements (SPST switching).

Fig. 9 SSR

**Miniature Circuit Breaker**

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by over current or overload or short circuit. Its basic function is to interrupt current flow after protective relays detect a fault. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in varying sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits feeding an entire city. The generic function of a circuit breaker, RCD or a fuse, as an automatic means of removing power from a faulty system is often abbreviated to ADS (Automatic Disconnection of Supply).

## III. RESULT ANALYSIS

The operation of the project is finely showcased in the figures shown below:

The figure below shows the pusher/DVD Loader in action. The disqualified luggage is being pushed towards the right side upon signal given from PLC.

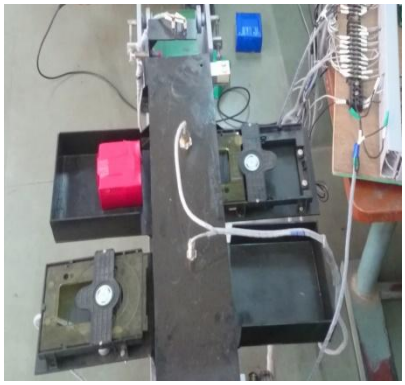

Fig. 9 DVD Loader pushing the disqualified luggage

The figure below shows the screen 1 appearing on the HMI. It contains: start/stop push button, indication lamp for the proximity sensors used, the pusher 1/pusher 2 activation lamp and separation mode selection buttons viz. color mode/barcode mode. Weight separation mode is the default separation.

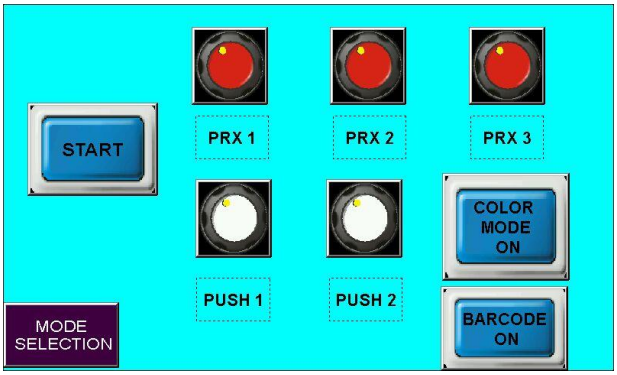


Fig. 10 HMI screen

The figure below shows the modes of separation screen in detail. The identification button is used at the time of arrival; it helps the passengers to identify their luggage.


Fig. 11 Modes of Separation

The figure below shows detailed weight separation mode. It includes 3 indication lamps to indicate the kind of luggage. If the luggage is overweight but in the allowable range then it calculates the total penalty to be given by the passenger.


Fig. 12 Weight Separation

Lastly the entire circuit board containing all the electrical components mounted and the entire conveyor system with all the mechanical components mounted is shown.

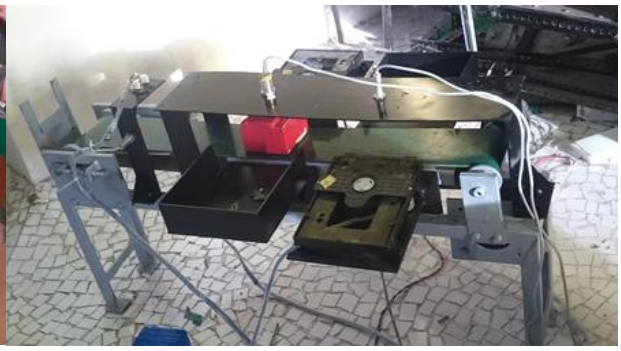

Fig. 13 Electrical board and Mechanical Structure of the project

## IV. CONCLUSION

To sum up, I would say that if the existing airports are renovated equipping them with these kinds of facilities then they can work as good as the modern day airports. The main conclusion drawn from the project is that one can develop a model with very low initial investment and still maintain the accuracy. By implementing these kinds of facilities airports can work more efficiently, less man force will be required, decrease in space management issues, more accuracy in delivering the luggage of the passengers, hustle free availability of luggage for VIP, senior citizens and differently abled people and more data for the Airport Authorities which can be used for further analysis.

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**CASE STUDY**:

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[3] DUBAI INTERNATIONAL AIRPORT