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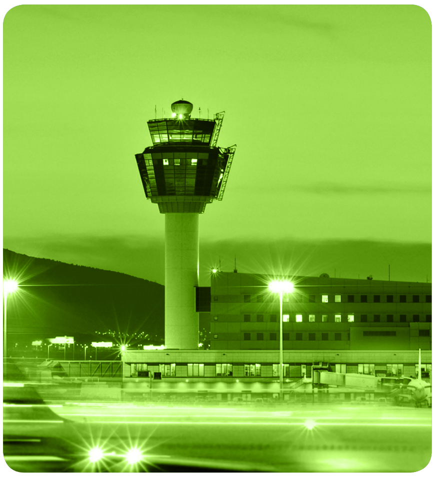

NEWSLETTER

008 | December 2018

A NEW AGE IN PREDICTIVE ANALYTICS AND PREDICTIVE MAINTENANCE

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The TransformingTransport consortium is pleased to announce the project's successful midterm review which took place in Valencia at the beginning of September, 2018. The partners showcased in real time 13 pilot demonstrations and presented in detail all the project achievements that took place during the first half of the project.

Some of the preliminary results are detailed in this newsletter.

Big Data will have a profound economic and societal impact on mobility and logistics. Improvements in operational efficiency empowered by Big Data are expected to save as much as around EUR 440 billion (500 billion USD) in terms of fuel and time within the mobility and logistics sector, as well as reducing 380 megatons of CO_2 emissions.

Freight transport activities are projected to increase by 40% between 2005 and 2030, and by 80% between 2005 and 2050. Against this backdrop, making the current mobility and logistics processes significantly more efficient will have a profound impact towards achieving this goal whilst minimising harm to the environment.

The mobility and logistics sector can benefit radically from Big Data technologies, as it already manages massive flows of goods and people whilst generating vast datasets that support innovative Big Data solutions. To illustrate, a 10% improvement in efficiency will lead to cost savings of EUR 100 billion according to experts in the industry. This represents huge opportunities for improving operational efficiency, delivering a better customer experience while creating new business processes and business models.

The **TransformingTransport** project demonstrates in a very realistic and measurable manner the transformations that Big Data can bring to the mobility and logistics market. Structured into 13 different pilots which cover key transport infrastructure areas across Europe, TransformingTransport proves that Big Data solutions are technically and economically viable and able to transform transport processes and services. The key enabling Big Data technologies employed by TranformingTransport to bring about this transformation are predictive data analytics and predictive maintenance.

Predictive analytics is a significant next step from descriptive analytics. While descriptive analytics answers the question "what happened and why?", predictive analytics attempts to answer the question "what will happen and when?". For example, predictive analytics may help predict whether there may be a delay in a transport process, helping transport authorities to be proactive and take action to decrease or prevent delays. Indeed, predictive analytics is considered a key technology and technical priority of the European Big Data Value Association (see: *https://bit.ly/2IfLJh1*).

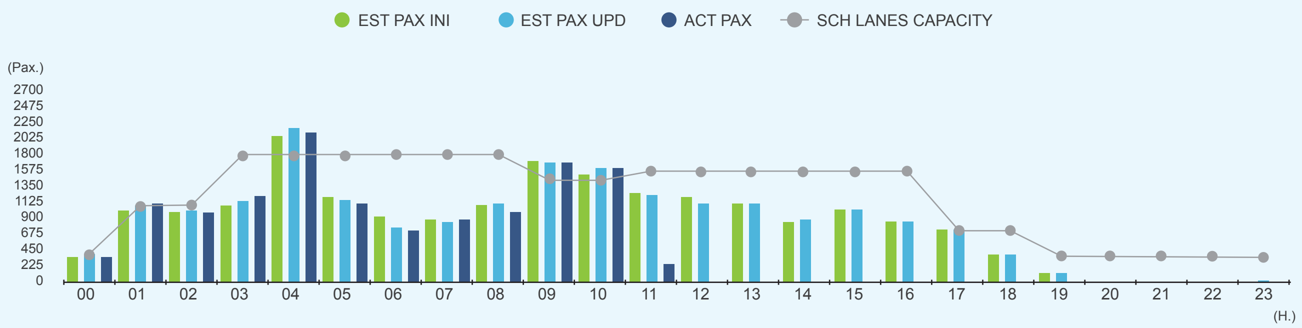
Predictive maintenance builds on predictive analytics and goes one step further. While preventive maintenance typically follows a fixed schedule, predictive maintenance takes into account predictions gained from data about the actual condition of equipment. In this way predictive maintenance helps authorities identify the best time to conduct maintenance tasks. It can produce much more effective scheduling of maintenance tasks which in turn would decrease downtime costs and performance losses. To put it simply, based on the data collected, predictive maintenance helps optimise maintenance frequency and avoids unnecessary routine inspections. This also means there would be more regular maintenance for equipment that tends to fail more frequently, ensuring that the equipment would be in service for much longer.

SMART PASSENGER FLOW PILOT – HOW PREDICTIVE ANALYTICS HELP ATHENS AIRPORT TO OPTIMISE RESOURCES

With passenger demand increasing annually, the challenge for **Athens Airport** has been to identify intelligent ways to improve and streamline the flow of people through the airport – i.e. increase throughput – while at the same time safeguarding the safety and the experience of passengers. Increasing throughput requires sophisticated data analysis to build powerful Big Data models that can segment passengers and identify patterns and trends that will lead to actionable strategies on behalf of the airport.

The **Smart Passenger Flow pilot** developed and tested predictive models that forecast passenger volumes in the airport, along with passenger distribution throughout the day and demand on airport resources. With the development of new accurate **forecasting models**, **simulations** of the passenger flows will be able *to foresee possible bottlenecks or underused infrastructure*. This will help ensure that the supply of airport resources can meet forecasted demand.

Comparing the results of the predictive model that the pilot developed to the actual passenger figures of a specific date confirms the new model's high level of accuracy.



MTB - Schengen Total Pax (Current Day)

Comparison of future estimation (green), updated estimation (some hours in advance – light blue) versus actual passengers (dark blue) at the security screening area.

The above results of the passenger flow data analysis provide insights that were not previously exploited. Such insights can assist both airlines and the airport to optimise operations to a much higher degree of efficiency than before. The above use cases demonstrate only part of the analysis that can be performed using data analytics. More touchpoints and additional data sources, such as **Wi-Fi location based services** and **video analytics** can be integrated into the data analysis, which can increase the accuracy and the validity of existing results, and introduce additional dimensions that can ultimately help increase passenger satisfaction.

Conclusions

Athens international airport is currently in the process of designing and implementing the next airport expansion phase, after achieving record growth numbers during the last four years (close to the Airport declared capacity).

Understanding the current passenger needs and getting insight on passenger flows, behaviours and segments provides additional input to the terminal design process. It also helps optimise current use of airport terminal resources.

Data analytics help us understand what impacts terminal operations, thanks to new models that analyse the current situation (i.e. descriptive models) and those that attempt to predict the future ones (i.e predictive models). The data analysis would require several data input streams, both historical ones and real time operational ones.

Overall, the pilot was able to predict closely the flow of passengers arriving at the security areas. This not only helps optimise security operations in terms of allocated personnel, but also helps ensure the appropriate service levels needed to enhance passenger satisfaction.

Next steps

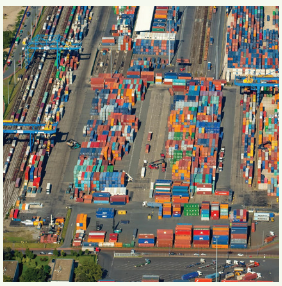
While the current data analysis provides insight mainly for passenger flows, there are more areas that this analysis can be extended to. Data analytics can be used to improve passenger experience and advance the concept of smart sales. By segmenting and analysing passenger behaviour and by engaging additional data sources such as airport concessionaire data from points of sales, the analysis and insights will help the airport improve retail revenues while serving passengers' individual needs based on their likes and preferences. Phase two of the pilot will be focus on these novel topics.

HOW DEEP LEARNING HELPS PROACTIVELY MANAGING TERMINAL PROCESSES

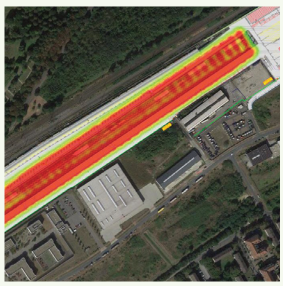
Analysing port logistics in a smart manner can improve port operations to save both time and money. TransformingTransport is piloting the concept of the **Terminal Productivity Cockpit (TPC)**, which exploits advanced data processing and predictive analytics to facilitate proactive decision-making and process adaptation, ultimately achieving more efficient port operation. In particular, the productivity cockpit leverages cutting-edge predictive business process monitoring solutions, i.e. real-time predictive Big Data analytics for terminal processes based on deep learning technology.

The piloting site for the TPC is duisport, Germany, representing the world's largest inland container port with **4.1 million** containers handled in 2017. As of June 2018, **30 million data entries** from nine devices, including fault messages and regular status and location updates, were exploited for data analytics. Visual and statistical analytics techniques (e.g. heat maps – see below) are used to reconstruct processes and loading unit movements in the terminal.

Data integration and Aggregation
(GPS / XYZ mapping; from states to moves)



Data streams from terminal equipment (1.3 mio states / month)



Intregrated data of container moves (10,000 moves / month)

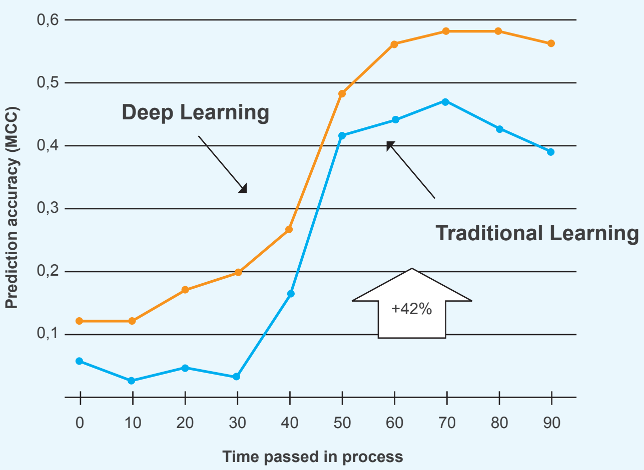
More specifically, real-time process information is fed into a **prediction pipeline** to receive predictions for proactive decision making, using state-of-the-art prediction models (deep neural networks).

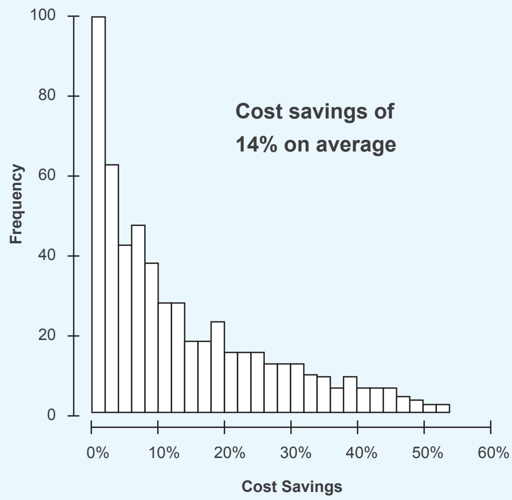
The TPC features a web-based dashboard that presents data it has accumulated and processed to decision makers. The dashboard was continuously improved by considering feedback from several user studies. It displays the current state of the terminal, the predictions from the predictive models and several KPIs computed from live data for comprehensive decision making support.

Results from the first project phase indicate strong potential for achieving accurate predictions through deep learning.

Indeed, prediction accuracy can be significantly improved, which is pivotal for exploiting predictions to improve operational decision making. To illustrate why prediction accuracy is important, a too high rate of false warnings from the prediction pipeline will mean that a logistics operator will not trust the predictions.

The **deep learning technique** employed in TransformingTransport delivered accuracy improvements of **up to 42%** compared to traditional prediction techniques. Moreover, the predictive pipeline developed in the duisport pilot provides additional information for decision making. Quite similar to today's weather forecasts (that indicate the chances for rain), the TransformingTransport prediction pipeline computes a reliability indicator that provides an estimate of the reliability of the prediction. Experimental results indicate that using such additional information for decision making delivers cost savings of 14% on average.





More information about the prediction techniques employed in TransformingTransport can be found in the following research papers:

- *A. Metzger and F. Föcker, “Predictive business process monitoring considering reliability estimates,” in 29th Int'l Conference on Advanced Information Systems Engineering (CAiSE 2017), Essen, Germany, June 12-16, 2017, ser. Lecture Notes in Computer Science, E. Dubois and K. Pohl, Eds., vol. 10253. Springer, 2017. [Online]. Available: https://doi.org/10.1007/978-3-319-59536-8_28*
- *A. Metzger and A. Neubauer, “Considering non-sequential control flows for process prediction with recurrent neural networks,” in 44th Euromicro Conference on Software Engineering and Advanced Applications (SEAA 2018), Prague, Czech Republic, August 29 31, 2018, T. Bures and L. Angelis, Eds. IEEE Computer Society, 2018.*

BIG DATA PREDICTING THE FUTURE

The rail industry in the UK has seen its fair share of service delays and cancellations due to faulty rail infrastructure. The government has often fined rail and train operators as the industry continues to suffer from a negative reputation.

Large sums of money are being spent every year on scheduled preventive maintenance to ensure that the trains keep running. However, such maintenance is often undertaken more frequently than needed, incurring higher maintenance costs than necessary. For example, assets that are used once a month are scheduled at the same maintenance frequency as those used many times a day. Preventive maintenance also hampers the operator from accurately assessing the probability of failure across the different parts of the railway infrastructure.

It is therefore of great interest to train operators and infrastructure owners to reorganise maintenance planning and initiate a shift towards predictive maintenance. The latter can help determine the condition of in-service equipment in order to predict when maintenance should be performed.

This approach is expected to bring notable cost savings compared to routine or time-based preventative maintenance as the tasks are performed only when required. To support this promising method of rail asset maintenance, Thales UK is leading a **Proactive Rail Infrastructure pilot** in the UK which is funded in part by the European Commission under the TransformingTransport project. The pilot is working on revolutionising how faults and wear of rail assets are identified by applying Big Data processing methods to provide rail infrastructure managers and operators with predictive maintenance systems.

More specifically, the pilot is working on three different cases involving assets that fail often, are very costly or cause the most delays. The first of the three cases revolves around point machines and track circuits, overhead line equipment, and train-to-track interface. A team of data scientists from Thales and the University of Southampton are working on these subprojects and have been running Big Data analytics by leveraging vast quantities of historical data sets.

Valuable insights into the causes of rail asset failure have emerged to rapidly improve diagnosis and prognosis, particularly in relation to the point machine. This means it is now possible to identify different types of fault characteristics emerging for a point machine. The results of the analysis – or more specifically the algorithm that classifies faults – were presented to the European Commission during a live demonstration in Valencia in September 2018. Network Rail, the UK Infrastructure owner and end user of this pilot expressed their recognition of the outputs achieved to date and acknowledged that this was an important milestone in the development of the system.

Further development of predictive models for all use cases will continue until the end of the TransformingTransport project in June 2019. By then, the models should be able to accurately predict the remaining useful life for some assets and reduce the number of false alarms. Lastly, anomaly detection algorithms will also be developed to complement the predictive system and provide the operator with additional decision-making support tools.

BIG DATA TO IMPROVE CRANE OPERATIONS IN PORTS THROUGH PREDICTIVE MAINTENANCE

Maritime commerce relies on quay cranes which are pivotal for supporting the transport of goods across port terminals. These however must be regularly maintained to ensure smooth port operations. Any issues with the cranes and their different parts could cost companies and ports huge amounts of money as containers start piling up.

For the most part, maintenance operators usually conduct manual maintenance procedures and rely on previous knowledge to decide when and which part of the crane should be replaced. The practice is not always the most efficient maintenance method, begging for a more high-tech approach to overcome issues with key crane parts.

One of the most critical parts of a crane is the spreader, which refers to the elevator system used to move the containers. Spreaders have locking mechanisms called twistlocks, considered the most vulnerable parts of the crane. If these twistlocks break down, they can disrupt the whole logistics chain and cause significant financial losses.

With this in mind, the Transforming Transport project launched two pilots, one in **Valencia Port** (Spain) and another one in **duisport** (Germany) to upgrade the maintenance of twistlocks. The pilots have successfully deployed two monitoring solutions to capture the activity of a spreader in real time, focusing specifically on how the twistlocks behave. Based on duisport's current insights, spreaders are responsible for the number one failure of cranes, representing 36 % of overall crane failures. It is worth noting that twistlocks are usually replaced after a certain number of "twists", without taking into account the actual wearing out of the part.

To help overcome this challenge, the Valencia Port pilot deployed an Internet of Things (IoT) infrastructure that records the spreader status in real-time. The pilot gathers the speed of the twistlocks' open-close movement, which helps identify any potential problems before they happen. It relies on the use of an industrial Programmable Logic Controller which gathers and transfers data wirelessly to a Big Data processing infrastructure.

In summary, the pilot detects abnormal operation of the spreader based on twistlock movement. Detected operation patterns are then compared continuously with maintenance orders through a predictive model to alert or warn about when a spreader will require maintenance.

Following a similar approach, the duisport pilot uses crane data regarding condition and faults to predict the next maintenance date for the twistlocks. To process the data more effectively, the pilot experimented with different supervised machine learning techniques, such as multilayer perceptrons, resilient backpropagation and gradient descent. The result is a prediction model that can compute the probability of failure.

Thanks to these efforts, both pilots developed the analytic foundations and the data infrastructure for supporting an effective predictive maintenance strategy. In the following months, the pilots will deploy their solutions in real environments to check the accuracy of the proposed analytical models with the help of maintenance staff.

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