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SIMULATION - A KEY TOOL TO ACCELERATE AND ADD CONFIDENCE TO POSTAL NETWORK CONFIGURATION

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ABSTRACT

Postal operators are increasingly facing new challenges to maintain competitiveness – most have already played the "card" of facility consolidation and introduction of automation to reduce processing costs.

How exactly, should a given infrastructure/network and transportation strategy be changed to meet the upcoming challenges? Should mail streams be consolidated to enable further automation? Should the product portfolio be revised to accommodate for new competitive marked drivers?. Obviously, the postal industry has a strong need for advanced decision support tools that can address its dynamics and complexity. This paper will explain how postal organisations have benefited from discrete event simulation to accelerate and add confidence to decision making.

The simulation model described in this paper is designed for "End-to-end" analysis of the logistic value chain. In that way it can establish a nation wide (or area wide) general view of the cause-effect relationships in a complex postal system.

1 THE MANAGEMENT CHALLENGE

The marketplace for postal services is being deregulated and opened for competition and mail volumes drops. Many issues have to be raised, considered and answered to develop the most appropriate solution for a future postal network strategy.

Throughout the world, postal administrations face the requirement to continuously analyse, improve and re-engineer their services, as well as to improve the performance of how the products are processed from collection through to delivery.

It is a huge challenge to develop and implement an integrated business solution that has a balanced response to a range of different change drivers including technology change-push, changes in demand (e-mails potentially reducing amount of letters) and de-regulations. Business changes that follow from these drivers include strategic network reconfigurations, new product developments, service quality improvements, cost control, etc.

Generally, a postal network is comprised of a number of facilities having some processing equipment which fit into the logistic strategy chosen by management. Hence the postal network represents a very complex production system where millions of dynamic delivery points have to be serviced every day within a short timeframe.

There are many questions to be asked before formulating a successful logistic strategy and change process. First of all, did you ask all the right questions, and did you get all the numbers right. There is an imminent risk that several complex relationships and interactions were not considered adequately.

To build this knowledge, pilot implementations can be made. However, experimenting on a real system can be costly or impractical.

Logistic simulation models is the most appropriate analytical tool for a true representation of a postal logistic system. It can be a realistic no-risk environment for analysis of alternative solutions while they still are on "the drawing board" – simulation accelerate the decision process and establish valuable insights that builds confidence to the solution.

It is our experience from using simulation for more than a decade in the postal environment, that postal management recognise the benefit of simulation.

Leading postal organisations USPS, Canada Postal Corporation, Deutsch Post, Norway Post, Belgium Post (La Poste), Swedish Post and Post Denmark has successfully used simulation to accelerate and support decision making to develop and validate:

- Automation strategy for mail processing.
- Mail processing concepts – like sequencing.
- Mail stream consolidation strategies.
- Facility location and network strategies.
- Cost & marketplace target product portfolios.
- Staffing and workload levelling tactics.
- Facility capabilities and layout requirements.

Simulation has provided managers in these organisations with a tool to quickly assess new ideas and scenario alternatives and to visualise and communicate the solutions to others.

In the following sections we will introduce the postal network planner simulation tool developed by PA Consulting Group. The simulation model can be configured with postal product portfolio and services, processing and network capabilities. It simulates the ability to deliver mail and monitor metrics like achieved delivery service and incurred costs to let the user understand the true business implications of various scenarios. We will also describe some of the applications and benefits of using simulation in the postal environment.

2 POSTAL NETWORK PLANNER FRAMEWORK

This section outlines the applied modelling framework for the Postal Network Planner (PNP) simulation tool. The tool has been developed by PA Consulting Group and represents a new generation of simulation applications based on years of experience married into a new innovative design. PNP is targeted network design that focuses on the strategic questions outlined in the previous section. This kind of analysis are characterised by being data intensive and highly complex. Therefore, the PNP development prioritised:

- Flexible, intuitive and user-friendly configuration of postal networks concepts allowing a non-simulation specialist to configure the model without extensive training in programming models.
- Business-oriented, process of defining, executing and documenting otherwise very complex simulation scenarios.

The technical architecture was developed to accommodate those requirements, as illustrated in Figure 1. Scenarios are intuitive configured and validated in the user interface. The animated simulation on a map visualise the mail flow. The simulation findings are explored by user configurable reports and plots. The technical architecture consists of two main components:

- **A User Interface**, where a Microsoft Access database is designed for administration of data and configuration of scenarios as well as analysing simulation results in an efficient and reliable way. By changing data and parameters, any scenario can be set-up. Where appropriate, PNP can also interface to other systems for data exchange. The build-in scenario analyser validates the scenarios and highlights configuration inconsistencies.
- **A Dynamic Simulation model** of the processes, resources, flows, etc on a map. This has been developed using the flexible and powerful Arena simulation software package that supports the creation of a fast, animated, flexible, parameter-driven dynamic simulation model.

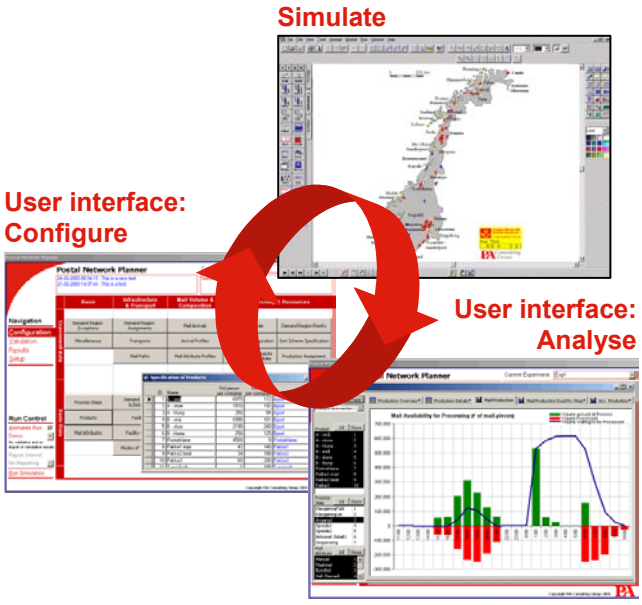

Figure 1: Architecture of Postal Network Planner.

The PNP models all process steps, from entry of mail at an origin processing facility to the final sort at a destination processing facility. This "end-to-end" approach avoids sub-optimisation of the results. For example, a postal operator will be able to see the service and cost implications of changes in originating operations on transportation and destinating operations.

The model covers a multi-day period with a scope typically covering the following characteristics of a postal distribution network:

- Mail arrivals to initiate the model.
- Facility mail processing.
- Transportation of mail between facilities.
- Cost drivers for transportation and processing.
- Cut-off times, work windows and other constraints or operating rules influencing operations.

The relations between the simulated postal processes are illustrated in Figure 2. The high level functionality of the five process steps are described below.

A1: Collect mail

- User-defined products with any combination of shape and class can be defined to represent letter mail, parcels, packages, newspapers courier etc.
- Mail arrival profiles represent the volumes entering the model by time of day and facility.
- The products make-up-profiles determine the way in which mail is handled throughout the model.
- Transport from the collection unit to the originating facility, including estimation of costs.

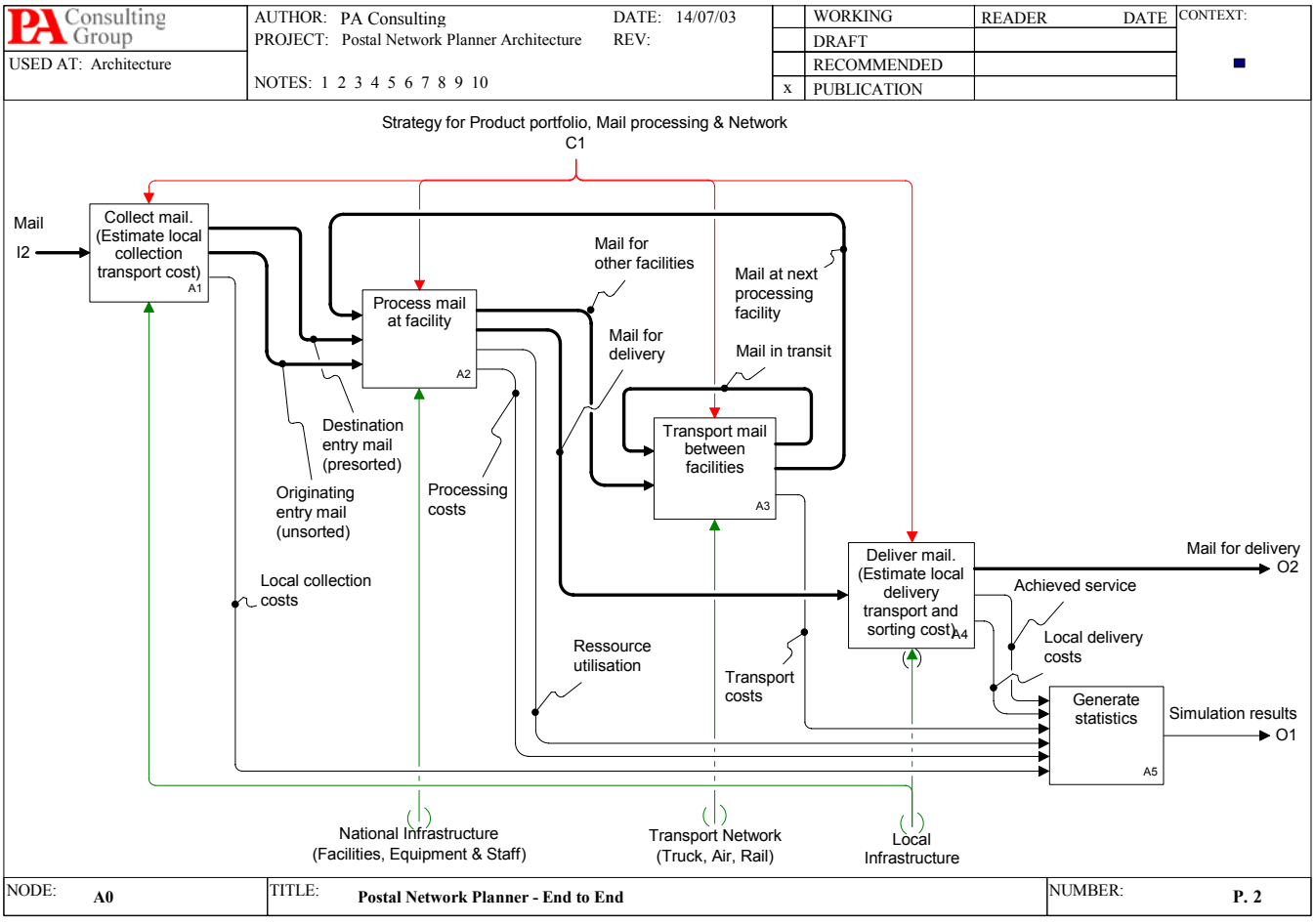

Figure 2: Process Relations of Postal Network Planner

A2: Process mail at facility

- Mail undergoes a sequence of facility operations. Each mail processing facility has product specific sort scheme and associated processing rules.
- Production schedules specify when each of these processing activities occurs and also reflects resources and equipment available to process the.
- The resources capacity constrain the speed at which mail is processed. Hence volume will stage if mail arrive faster than the processing rate.
- Mail handling and internal transportation operations may be setup between operations.

A3: Transport mail between facilities

- Transport routes are set up to reflect the transportation network (road, air, and rail) between facilities, logistic platforms, etc.
- The production assignment and mail path rules determine whether mail need to be transported to another processing operation at a different facility.

A4: Deliver mail

- Mail has now completed its processing and reached the destination facility.
- Estimate the cost of transport to the delivery unit, processing at the delivery unit, and delivery to the recipient.
- Estimates on-time performance.

A5: Generate statistics

- Capacity and resource utilization by time of day.
- Queues of mail by time of day waiting to be processed, dispatched, or transported.
- Utilization of transportation cubic capacity.
- Achieved on-time service performance
- Operational costs by product type by cost components (e.g., labour and transportation).

During, simulation, various statistics are collected for processing, handling, staffing, transportation, service and cost. Figure 3 illustrate important key performance metrics (values are scrambled) They are used to establish an overview of how a scenario did perform

In the following at few examples of explorative and user configurable graphs/reports will be given to illustrate the power of PNP as an analytical tool to build insights to the business. The mail availability for processing graph shown in Figure 5 is a time persistent plot of when mail become available for processing (positive bars) and when

ProductClass	PctService	Piece Cost
First Class Mail	97,06%	kr 6,05
Second Class Mail	98,45%	kr 4,37
Commercials	99,91%	kr 3,24
Parcels	91,45%	kr 40,83

EquipmentClass	Utilisation	Availability
Other	38,86%	16,19%
Sort Automated	44,53%	89,18%
Sort Manual	15,11%	56,09%
Mailprep Automated	26,14%	62,50%
Mailprep Manual	12,71%	58,77%

Figure 3: Reported Key Performance Metrics

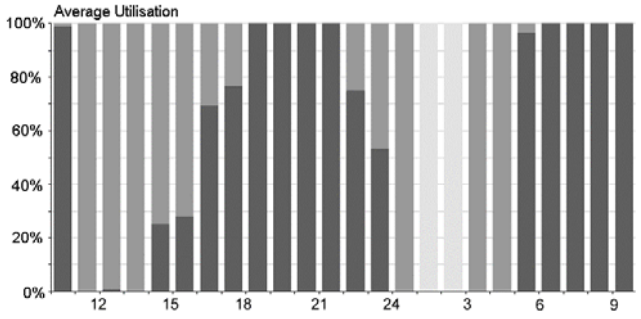

Figure 4: Equipment Utilisation Plot.

mail has been processed (negative bars) and staged mail (line). The analyst use the report configuration options the report form to control what to plot and how to aggregate. This example show the automated mail processing of the originating sort for two letter products.

The graph provides valuable information in understanding and designing a smooth mail flow where the processing windows and mail arrivals are synchronized. On the plot we see significant mail volume arrive around midnight. The mail is staged, since processing do not begin before 5:00. Consequently staging space is needed and valuable time is lost. Either is the mail available unnecessary early or processing begin too late. The originating sort is performed by several Letter Sorting Machines, which also do other operations. For instance with the utilization report, Figure 4, is explored how well the operational set-up utilise the scheduled capacity through the day. It shows the utilised time (dark), unutilised time (grey) and closed time (light grey) for all Letter Sorting Machines within sorting facility 1. (configuration options are not show to save space). Several other view are available to support the understanding.

On the utilisation plot we see that there are not scheduled with any activity between 1:00 and 3:00 and the equipment is idle until 5:00 – consequently capacity is available to process the staged mail.

To understand how the work schedule configuration impacts the rostering feasibility the resource requirements plot on Figure 6 may be applied. It show how much staff is needed by hour based on the selected processes. In this plot all operations for sorting facility 1 is shown.

The plot shows significant variation in how much staff is required over the time. This makes rostering very difficult for this operational setup.

The on-time performance matrix (also referred to as achieved delivery service) is a very important report to understand the reasons for, and identify the week origin-

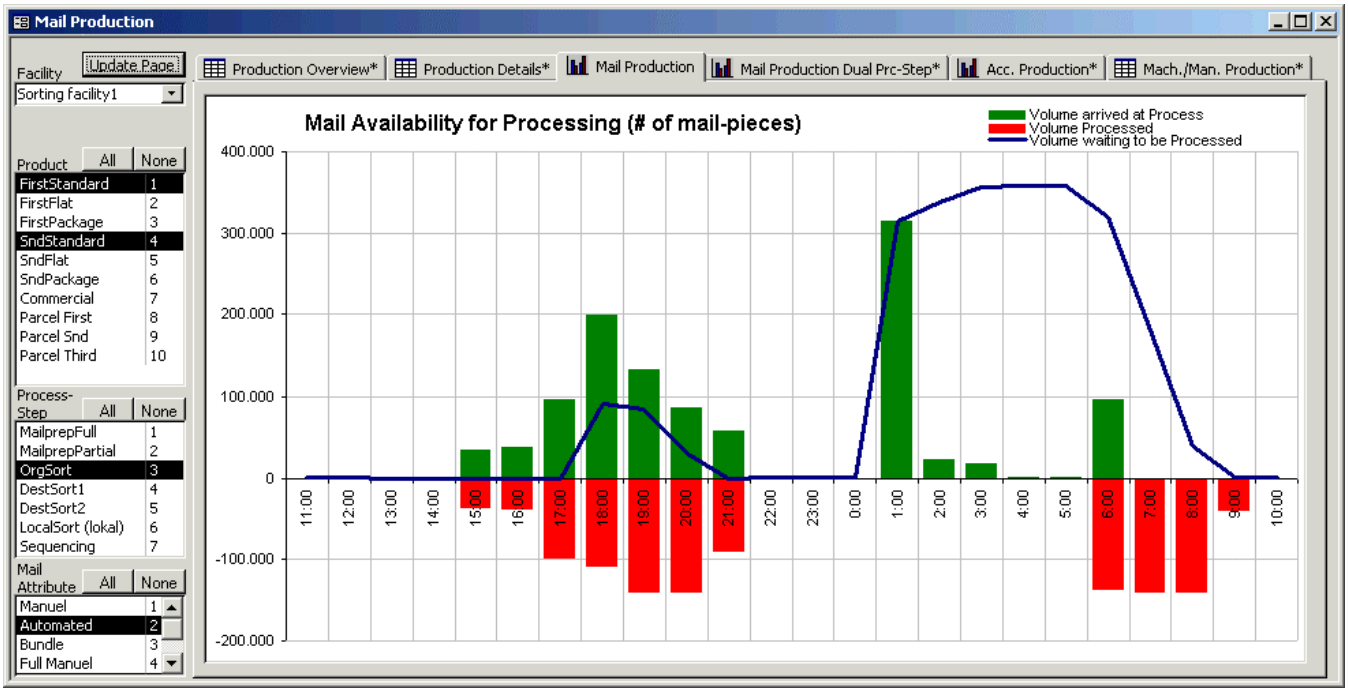

Figure 5: Mail Availability for Processing Graph

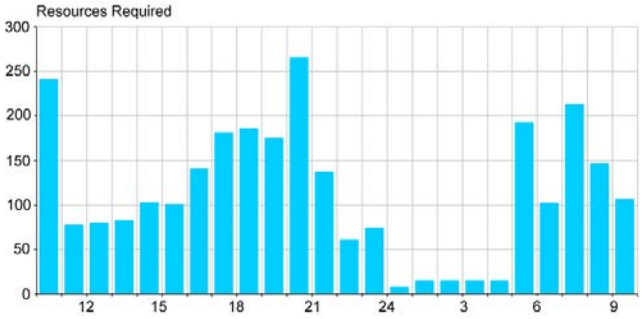

Figure 6: The Resource Requirement Plot.

destination links. See Figure 7. It shows the fraction of mail that reaches its destination on time. Each field show the target origin-destination service day and the percentage meeting this target. The most common reasons to a week link is mail that miss a sort window or a transport leg. Quite often we have also seen design failures in the operational setup – simply because nobody have had a complete overview and understanding of the nationwide origin-destination relationships without access to the PNP tool.

FromName	ALT	BDØ	BRG	DRA	FAU	FIN	FLØ	GJØ
ALT	1: 100%	1: 100%	2: 100%	1: 100%	1: 100%	1: 100%	2: 100%	1: 100
BDØ	1: 93%	1: 93%	1: 93%	1: 93%	1: 93%	1: 93%	1: 93%	1: 93%
BRG	2: 95%	1: 95%	1: 100%	1: 100%	1: 95%	1: 95%	1: 100%	1: 100
DRA	1: 15%	1: 98%	1: 88%	1: 100%	1: 98%	1: 98%	1: 98%	1: 100
FAU	2: 0%	2: 0%	2: 0%	2: 0%	2: 0%	2: 0%	2: 0%	2: 0%
HØF	2: 100%	1: 100%	1: 100%	1: 100%	1: 100%	1: 100%	1: 100%	1: 100
KRS_N	2: 100%	2: 100%	1: 100%	1: 100%	2: 100%	2: 100%	1: 100%	1: 100
KRS_S	2: 91%	1: 63%	1: 91%	1: 63%	1: 63%	1: 63%	1: 91%	1: 63%
LHA	2: 91%	1: 91%	1: 86%	1: 100%	1: 91%	1: 91%	1: 91%	1: 100
MJØ	1: 100%	1: 85%	1: 85%	1: 85%	1: 85%	1: 100%	1: 100%	1: 85%
MOL	2: 99%	1: 99%	1: 99%	1: 99%	1: 99%	1: 99%	1: 99%	1: 99%

Figure 7: The On-time Performance Matrix

The build-in Activity Based Costing (ABC) model allow to distribute the cost to the products and operations that incur the cost. This allow for very realistic reporting on product profitability. It is possible to build ABC reports showing which pairs of origin-destination areas it is profitable to serve and on which we loose money – and why!

As outlined, PNP can provide a complete picture of a networks configuration and operation. It can provide insight and understanding that are prerequisites for creation of innovative and improved solutions.

3 BUSINESS BENEFIT CASES

In this section will be given some real examples from the postal industry of benefits realised by use of simulation for network development. Benefits can be categorised in to 1) improving process and structures, 2) accelerate and add confidence to decision making and 3) lowering cost and time required to develop the solution.

Canada Post Corporation (CPC) management perceives the challenge they face to operate in a highly competitive environment, an environment which demands optimal performance, efficiency and profitability in addition to flexibility to change. This requirement leads them to continuously analyse, improve and re-engineer their distribution business, plant operation, transportation and network. (N. Larsen and A. Greenland 99). Canada Post management needed a simulation tool that could provide a broad, end-to-end, view of their operations so they could balance the competing demands of investment in transportation versus sorting.

The list of business issues to be addressed was quite long. A few of those which have been addressed using simulation to date include:

- Development and optimisation of the product portfolios offered.
- Quality and service improvements.
- Identification and optimisation of product synergies in terms of processing and transportation.
- Operations planning, particular where special conditions apply, like pro-active Christmas planning.

A major advantage of the simulation model build for the purpose was its capability to bring a clear understanding of system-wide postal operations, preventing the building of islands of improvement.

It facilitated cross-functional understanding, making large amounts of important information easily available from one source. Several surprises was experienced, "Why did we do it in this way when is was a better this way? because we used to and did not know" It reduced the time delay between strategy development and operational implementation and facilitated the often difficult communication between market planning and operations. It helped take away a lot of risk in the business decisions to be made.

The risk of not making the right strategic automation decision was a major concern for the **Belgium Post. (La Poste)** as it was facing a comprehensive audit of its business strategy including its business alliances, product portfolios and the modernisation of its production facilities (Larsen et al. 02). The production facilities included semi automated sorting centres, minimally automated post offices and manually operated distribution post offices. The main transport infrastructure is based on a complex network of road and rail transport routes.

The major strategic production system issues to be addressed were identification of the optimal automation level and localisation of outward sorting, inward sorting and letter carrier sequencing for each of the letter mail products.

The applied simulation approach enabled the project team to set-up, quantify, and create an objective evaluation and comparison of a large number of strategic automation alternatives within a very short period of time.

To set up a scenario, a full range of "end-to-end" production system issues was to be addressed, including:

- The number and location of sorting facilities.
- The processing concept including level of centralisation and level of applied automation of the sorting activities.

- quantifying the operational costs of labour, transportation and sorting for each scenario.
- The need for investment in automation, accommodation, network and infrastructure

The simulation analysis showed that the sorting costs could be reduced by up to 45% and transportation costs by up to 30%, depending on the scenario configuration. Significant improvements within the existing production structure were also documented, and those "quick wins" was immediately pursued. The simulation analysis enabled this postal administration to determine and select an overall automation strategy for letter mail sorting.

The United States Postal Service (USPS) – the worlds largest network – are under similar pressure to continuously improve their business and adopt to market conditions. Their strategy was to create a flexible logistics network that reduces total costs, increases operational effectiveness and improves consistency of service by eliminating service failures and inefficiencies, and enhances differentiation through superior customer service (USPS 2002). This is a gigantic challenge, because it simultaneously address the size and complexity of the worlds largest network, the services it produces and the applied procedures and business rules.

The analytical approach developed by PWC Consulting realised that size and complexity would dictate a stepwise modelling approach to break down complexity. Optimisation and simulation network models were used to determine which facilities will be viable and necessary within the future infrastructure and which distribution and transportation roles will be performed by those facilities. This network complexity is illustrated in Figure 8. It shows the several hundreds of Sectional Centre Facilities. The remaining several hundreds of USPS mail processing and handlings facilities are not shown.

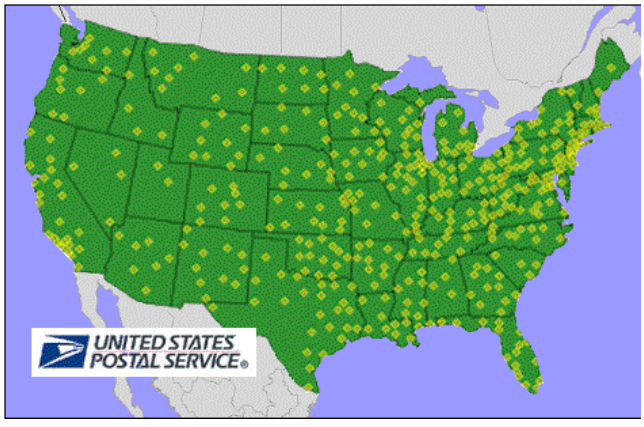

Figure 8: USPS Sectional Centre Facility Map

In this approach, optimisation is used to draft the network configuration based on constraints due to a selected strategy and then simulation is used to test that strategy's and networks feasibility under realistic conditions. The Simulation model calculates metrics like operational costs and achieved service performance.

In the spring 2003 (USPS 2003), USPS Vice President for Network Operations Paul Vogel reported "Optimisation and Simulation. These two models allow for exploration of different network alternatives and provide insight into cost and service implications."

"Among the lessons that have been learned through the Network Integration and Alignment (NIA) process," reported USPS Senior Vice President John Rapp to the Task Force, "were that excess capacity clearly exists within the current network, that people – and not computers – will ultimately design any new network, that varied data sets create different solutions in terms of "rightsizing," and that any model implementation will have a small number of key drivers."

"The next phase of network analysis," reported NIA manager Pranab Shah, "is focused on modelling a predefined concept of distribution that will enable the Postal Service to more effectively balance operations strategies against service requirements and network costs. This concept identifies what processing activities a facility may perform and thus what role they play in a network, how products or shapes may be handled differently throughout the network, and what type of transportation is used to connect these facilities." This approach towards network optimisation mandates a shift in USPS focus from optimising the performance of a particular product line or geographic area to optimising the performance of its entire logistics network and mailing industry value chain. USPS optimisation analysis will determine the fundamental design of a least-cost service-responsive logistics network.

Norway Post has been using simulation successfully for more than 10 years to analyse and improve networks, infrastructures and facilities. (Larsen et al. 02) Based on this success, Norway Post decided to further improve the infrastructure and its operational capability in distinct regions. Postal network operation is known for a cost structure which primarily are based on fixed costs. The objective was to challenge that cost structure and to develop a network that quickly can adapt to market changes and thereby to adjust the operational costs for processing and transport as market conditions change.

Currently the postal operation in the Oslo region (The capital, an area larger than Austria) is de-centralised into 6 centres. The logistics and the operation is quite complex and costly due to long distances, tight service commitments and different automation levels across the centres.

Management have considered several alternative automation strategies, including number and location of facilities for the Oslo region. One solution would maintain operation of all centres and modernise the major Oslo centre. The more dramatic solutions propose to develop one or two new state of the art green field. This approach has some clear benefits, but it also represented huge invest-

ments with significant uncertainty to the operational and service implications.

The PNP simulator described above allowed the project team to model each alternative rapidly. The simulations addressed the end-to-end processing and transportation dynamics from collection to delivery within the Oslo region, including 100 of the most important logistic nodes (centres and delivery offices).

The simulation analysis provided a base line and a comparison of the alternatives to identify the best solution to the future centre structure in the Oslo region. Based on existing sorting strategy and service commitments - the need for equipment, staffing, operation windows, transport network, cost for processing, transport and facility accommodation was determined. Service deteriorations was identified and where appropriate eliminated by modifying operation, capacities, transport schedules, etc.

After a few iterations it was possible to develop a solution based on one sorting centre for the entire Oslo region with surprisingly convincing capabilities:

- Extended mail collection and deposit time window
- Delivery commitments are met and the mail exchange with the centres outside the Oslo region can be improved.
- Flexible and highly automated production and several non-value-adding operations eliminated
- Cargo for air transport can be packed directly to destinations saving handling time and cost at the airport.
- Equipment utilisation and productivity improved significantly (hence smaller facilities are needed).
- Transport costs significantly reduced with a logical and manageable transport network with few routes and exchanges between these.

Management used the simulation findings to make objective decisions about complex and political sensitive matters. Based on those findings, management has desired to develop a new national network strategy where some of the "sacred cows" are brought to the surface. Figure 9 illustrates the Norway network complexity – Norway has a length that corresponds to the distance from the north to the south of Europe.

The new proposed solution implies:

- A coordinated network and service development, where the product portfolio is designed for efficient processing - while still meeting the demands from the market place.
- Standardisation and consolidation of mail streams (service, shape etc.) to reduce handling, establish easier control/management and to increase the degree of automation of mail that traditionally could not be automated

Figure 9: Animation of Norway Post Network Operation

4 SUMMARY

This paper discussed the reasons for why the postal industry should use discrete event simulation to improve the performance of postal networks. Simulation will accelerate and add confidence to decision making. It improves the match between strategy and the applied network structures, product portfolio, technology etc. A configurable and flexible Postal Network Planner (PNP simulation tool) is introduced for "End-to-end" analysis of the postal logistic value chain. It can establish a nation wide general view of the cause-effect relationships in a complex postal system. Several real examples from the postal industry show how simulation is a prerequisites for creation of innovative and improved solutions.

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