Optimised Transport and Logistics Planning for Agriculture and Bulk Commodities

CSIRO Mathematical and Information Sciences have significant expertise in providing analytical decision support for the bulk materials handling industry. This includes estimating benefits provided by proposed capital investments, planning and operational scheduling, dynamic rescheduling, evaluating changes to operating policies through scenario analysis, capacity and bottleneck calculations and analysis of variability in blending and throughput performance. This document provides a summary of some their experience in this industry with particular emphasis on transportation and logistics.

Analysis of the Goonyella & Blackwater Rail Corridors

The CSIRO has conducted a study of the Goonyella and Blackwater Rail corridors to investigate the capacity of the rail network to deliver coal from various mines in this coal chain to the Dalrymple Bay and Hay Point Coal Terminals.

The study involved the building, testing and evaluation of a discrete event simulation model of the coal chain. The model was used to evaluate the effects of various parameters and operational policies on system throughput. The major features of this simulation model include:

- A detailed rail network. The overall topology of this network is shown in Figure 1. It includes large single-track line segments as well as the location of all passing loops.
- The simulation model simulates the movements of trains across the network using location specific logic to prevent collisions. In the collision avoidance logic, loaded trains are given preference over unloaded trains.
- The model includes a variety of system parameters as inputs, which can be varied to evaluate their effect on overall system performance. These include the number of consists, travel speeds, loading rates at each mine and unloading rates at the terminals.
- Historical dispatch data from the train depot at Jilalan is used to provide realistic distributions of train trips.

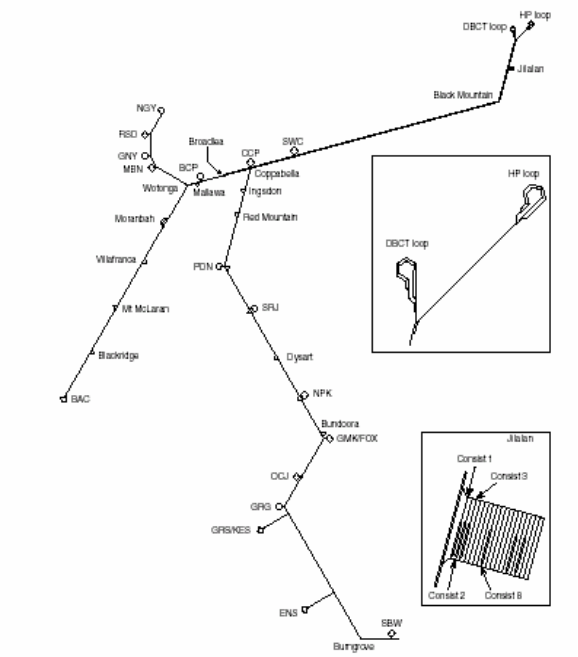

Figure 1 - Rail Network Topology

The model was used to evaluate a variety of scenarios and the sensitivity of the system to different parameters. This allowed some conclusions to be drawn that would not otherwise have been obvious. For example the study showed that increasing the average train speed is likely to have a much more significant effect on the throughput of the system than purchasing additional consists.

A similar study was also conducted to investigate the effects of various railing policies including campaign railing, railing to stockpile and railing to shipping (just in time). Again the effects of variability in the different parts of the system were taken into account so that realistic estimates of KPIs such as throughput, queuing and delays could be produced.

The same model could be used to investigate other system and capital expenditure projects, such as the addition of an overpass, the addition of a siding and the increase in capacity through the addition of new services.

This example shows how a simulation study can be used to provide advice on the effects of major investment decisions taking into account some of the variability that has to be expected in the

© 2005, CSIRO Mathematical and Information Sciences

system as well as features of the actual operating conditions.

Capacity Planning for Rail Corridors

The above approach specifically embeds some of the current operating conditions into the railing model, for example by using a historical pattern of train dispatch. A related capacity question that is of interest in planning rail corridors is one of what the maximum capacity of the network would be if changes to the rail network and other conditions allow different rail schedules. To this end the CSIRO has built single-track rail evaluation software that includes an optimization (genetic) algorithm to schedule trains in a near optimal manner. Some of the features of this system include:

- Optimization of the number of passing loops for a given number of consists or the number of consists given the passing loops.
- Optimization of the location as well as the number of passing loops.
- Evaluation of rail corridor capacity using optimized schedules which allow for trains overtaking each other while at all times maintaining feasibility of the schedule.
- Varying system parameters such as travel speeds, loading rates at mines etc.

This software has been used, for example, to analyse the Newlands system operated by Queensland Rail. It showed that there was sufficient capacity in the existing rail infrastructure to significantly increase the number of consists.

Intelligent Simulations for Coal Terminal Operations

Dalrymple Bay Coal Terminal (DBCT) in Queensland is a long-term user of CSIRO's *intelligent simulation* technology. CMIS has been delivering simulation systems to DBCT since 1997, over which time they have undertaken expansion activities worth over $A 370 million.

In intelligent simulations, the activities of critical sub-systems in the simulated environment are guided by informed decisions that are arrived at through rigorous analysis akin to that which occurs in real-world systems. Unlike conventional simulation methods, intelligent simulations provide far more realistic and reliable results, in relation to both detailed operational matters and overall system performance.

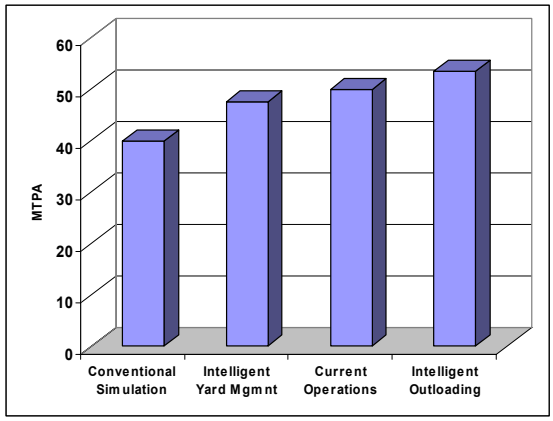

Figure 2 – Simulated Throughput (MTPA)

The intelligent simulation system developed by CSIRO accounts for all of the detailed operational constraints facing the terminal, as well as the requirement to serve all of the users competing for terminal capacity in a fair and equitable manner. The latest versions of the system are highly configurable and permit a wide range of future options for terminal expansions and operational policies to be quantitatively assessed and compared with confidence.

Harvest and Intake Logistics in Winemaking

As part of the *Adaptive Supply Networks* project CSIRO is working with a major Australian wine producer with the aim of revolutionising the way in which grape harvest and winery intake — the movement of grapes, juice and wine into the winemaking processes of a winery — is planned and managed for the benefit of all stakeholders.

The critical goals for the stakeholders — a network of grape growers, harvester operators, transport operators and wineries — are maximising value realisation from the grape assets and maximising revenue from the capital assets such as harvesters, trucks and equipment in wineries. Achieving these goals requires that the actions of each of the stakeholders are coordinated, activities occur at optimal times, and that plans are adaptable to unforeseen changes.

Ripened grapes must be harvested as close as possible to their ideal harvest date and time, bearing in mind the resource limitations of the stakeholders. Once harvested the grapes must be

© 2005, CSIRO Mathematical and Information Sciences

transported to a winery before berry deterioration occurs — typically less than six hours for reds and two hours for whites. Efficient and adaptive logistics plans are necessary, because berry deterioration (and imperfect winery actions that often follow unforeseen logistics events) lead to irreversible losses of value. In addition, flows of unfermented juice and incomplete wine between wineries need to be integrated with grape logistics and other winemaking considerations.

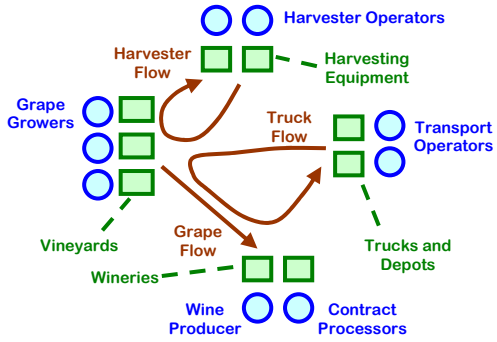

Figure 3 – Harvest and Intake Interactions

CSIRO is working with the stakeholders to develop and deploy computerised decision tools and transformed business processes that bring about improved accuracy and timeliness in information flows and adaptive, effective and value-maximising plans for harvest and intake logistics.

Truck & Rail Movement of Rice

The CSIRO has developed a large optimisation model that looks at the Australian rice harvest. This model considers the questions of transport of rice and rice paddy in the context of the complete farm-gate to port supply chain. Some of the transport-specific features of this model include:

- Allows a mixture of rail and truck transport on different routes.
- Determines optimal mixture of company and contract truck transport given costs and constraints on the use of each.
- Plans transport needs over the duration of the complete harvest processing cycle (12 months) or over shorter time horizons
- Transport is optimised taking into account storage availability and costs, processing capacity, etc

This model has been used for various strategic planning exercises and has shown how to significantly decrease overall transport costs.

Rail Crew Rostering

The CSIRO has significant experience in rostering across several industries including rail crew rostering. One of the CSIRO's rostering engines has been developed for use by The Preston Group in creating a software system for the Australian National Rail Corporation.

National Rail's rail timetable includes more than 1500 trips a week. The rosters for all crew have to conform to complex industrial regulations and work rules. In developing rostering software for National Rail, CSIRO's main objective was to minimise the overall roster cost accrued from using the available crew while providing the required number of crew for each train trip in the schedule. However, rosters should also adhere to "quality of life" standards for drivers, in terms of satisfying personal preferences.

At National Rail, monthly rosters were previously drawn up using spreadsheet-based solutions. The resulting schedules had to be carefully checked against the rules. This was a tedious job and often took days to complete. The new staff scheduling software shortens this process considerably. The system produces rosters for nearly 500 crews in less than 4 hours.

Adaptive Supply Networks

The CSIRO Adaptive Supply Networks (ASN) project offers new technologies for controllable, robust and efficient supply chain management. Adaptive supply networks are networks of business partners who cooperatively and collaboratively perceive and adapt to the challenges in their operational environment to ensure coordinated flow of resources, goods, services and information. Transport and logistics planning is a key concern in this context.

The technology solutions being developed in the ASN stream target facilitation and decision support for:

- Better business relationships and collaborative participation,
- Better acceptance and co-ownership of decisions,

© 2005, CSIRO Mathematical and Information Sciences

- Better communication of decisions and reasons,
- Better ways to adjust plans and find expected costs of decisions in changing conditions.

Key supply network functions that can be revolutionised using ASN technologies include strategic and tactical planning, operations management and disruption sensing-and-recovery. In adaptive supply networks these functions must transcend the traditional boundaries that lie within and between organisations. Therefore ASN technologies are designed for collaborative decision-making in networks of participants which often exhibit appreciable diversity in capabilities and business goals.

The expected benefits to industries adopting ASN technologies include:

- More controllable, robust and efficient operations,
- Increased compliance with the agreed decisions,
- Increased revenue and reduced costs for all participants,
- Increased competitive advantage and reduced risk for all participants.

The ASN research and development program focuses on industry needs for future supply network systems. Industry-specific solutions are built upon a generic ASN platform, and our current emphasis is on agri-business and health industry segments, amongst others including the automotive industry and resource-intensive manufacturing. An integral part of this research framework is a close collaboration with leading industry partners within each segment. These partners provide domain knowledge and industry guidance, and support rapid technology transfer, adoption and commercialisation of ASN solutions for the benefit of the partners and their industries.

Summary

CSIRO has diverse experience in dealing with supply chains for bulk-materials handling in a whole-of-systems approach. This experience ranges from railway scheduling and network capacity planning through to operational terminal scheduling. Together with CSIRO's ongoing research in leading edge technologies for adaptive supply networks CSIRO in an unparalleled position to provide end-to-end solutions for informed, optimised and adaptive transport and logistics.

For further information contact:

Dr Mohan Krishnamoorthy
Research and Business Leader,
CSIRO Mathematical and Information Sciences
Private Bag 33
South Clayton, VIC 3169, Australia
Tel: (03) 9545 8042
Fax: (03) 9545 8069
Mohan.Krishnamoorthy@csiro.au

Mr Roger Wallis
Business Development Manager
CSIRO Mathematical and Information Sciences
Private Bag 10
South Clayton, VIC 3169, Australia
Tel: (03) 9545 8040
Fax: (03) 9545 8080
Roger.Wallis@csiro.au

Dr Simon Dunstall
ASN R&D Leader
CSIRO Mathematical and Information Sciences
Private Bag 33
South Clayton, VIC 3169, Australia
Tel: (03) 9545 8022
Fax: (03) 9545 8069
Simon.Dunstall@csiro.au

or visit http://www.cmis.csiro.au/.

© 2005, CSIRO Mathematical and Information Sciences