J. W. GOTTSTEIN MEMORIAL TRUST FUND

The National Educational Trust of the Australian Forest Products Industries

GOTTSTEIN
TRUST

KEY ELEMENTS FOR THE SUCCESSFUL INTEGRATION OF IN-FOREST OPTIMISATION INTO AUSTRALIA

BRAD BARR

2006 GOTTSTEIN FELLOWSHIP REPORT

Joseph William Gottstein Memorial Trust Fund

The Joseph William Gottstein Memorial Trust Fund was established in 1971 as a national educational Trust for the benefit of Australia's forest products industries. The purpose of the fund is *"to create opportunities for selected persons to acquire knowledge which will promote the interests of Australian industries which use forest products for the production of sawn timber, plywood, composite wood, pulp and paper and similar derived products."*

Bill Gottstein was an outstanding forest products research scientist working with the Division of Forest Products of the Commonwealth Scientific Industrial Research Organization (CSIRO) when tragically he was killed in 1971 photographing a tree-felling operation in New Guinea. He was held in such high esteem by the industry that he had assisted for many years that substantial financial support to establish an Educational Trust Fund to perpetuate his name was promptly forthcoming.

The Trust's major forms of activity are:

1. Fellowships and Awards - each year applications are invited from eligible candidates to submit a study programme in an area considered of benefit to the Australian forestry and forest industries. Study tours undertaken by Fellows have usually been to overseas countries but several have been within Australia. Fellows are obliged to submit reports on completion of their programme. These are then distributed to industry if appropriate. Skill Advancement Awards recognise the potential of persons working in the industry to improve their work skills and so advance their career prospects. It takes the form of a monetary grant.

2. Seminars - the information gained by Fellows is often best disseminated by seminars as well as through the written reports.

3. Wood Science Courses - at approximately two yearly intervals the Trust organises a week-long intensive course in wood science for executives and consultants in the Australian forest industries.

4. Study Tours - industry group study tours are arranged periodically and have been well supported.

Further information may be obtained by writing to:
The Secretary
J.W. Gottstein Memorial Trust Fund
Private Bag 10
Clayton South VIC 3169
Australia

Brad Barr has worked in the forest industry since graduating from the University of Canterbury, New Zealand with a Bachelor of Forestry Science (Hons.). His first employment was with the N.Z Forest Research Institute, in Rotorua. The focus of the research was on wood quality and silvicultural interactions. Brad has had a solid grounding in forest inventory and value recovery assessment, and this led to an interest in cut to length, in forest optimisation when he began employment at Wespine Industries, Western Australia.


SCANIA

Executive Summary

Finland has a land area of thirty million hectares. Of this, twenty million hectares is forested - sixty six percent of the land area. There are 170 industrial scale (>10,000 m3 annually) sawmills, with a combined sawn output of 13.7 million cubic metres. In addition, Finland produces around 11 million metric tonnes of wood pulp. The 10,000,000 hectares of productive forest is held by 350,000 separate owners, giving an average holding size of about around thirty hectares. The result of the non-integrated forest ownership is that to source, manage and administer the resources needed to meet these massive industrial demands requires simple-to-use but comprehensive, planning, inventory, stock control and reporting systems.

The objectives of the training and study tour were to determine:

1. How the resource owners and their customers understand their own business and each others, and they translate this understanding into practical and accurate technical cutting instructions and medium term harvest plans.
2. How Finland has developed the harvesting contract workforce who have the technology, training, contractual scope and inclination to implement the above.

The first part of this report deals with the system structure and function of the Finnish forest industry that was observed during the training and study tour of the country as well as discussing some of the lessons that can be drawn relate to "system settings" that Australia may consider implementing to create the environment to get maximum benefit from the in-forest optimisers.

This second part of the report describes the technical process of how the different types of optimisation work, and some of their advantages and disadvantages. It will also explain in some detail how one may go about laying the foundations for a solid APT (control or cutting instruction) file that will serve well over a long period of time, as well as relaying the tips and tricks passed onto the John Deere training course attendees by their system specialist.

Executive Summary Part 1: Finnish Forestry – What is the System Structure and How does it Function?

The overall conceptual process of forest operational planning and implementation in Finland is no different to that in Australia. The process in Finland is made more effective by:

- A concerted effort from both processors and suppliers to understand each others needs. This creates a position for informed discussion, an iterative process, where both parties work towards a solution that best matches the customers needs while concurrently protecting the needs of the forest owner.
- Sawmills are the most particular of the customers with regards to log supply and expect a delivery of logs by a specified mix of log lengths and diameters. The cutting order is complex, and without a computer to assist, it would not be possible to achieve.
- Logs are delivered to mills in mixed lengths per truck bay. Greater tolerance is made towards marginally out of specification logs (diameter and sweep), and ensuring the right signals are sent to suppliers about quality and performance.
- Collecting forest information – using the technology afforded by modern harvesting systems.

- Process control
  - Operations. Harvesting and haulage contractors have agreed (measurable) performance targets that are regularly audited.
  - Communications infrastructure. Nearly all elements are linked seamlessly through digital communications. Cutting instructions and maps are beamed to the forest, daily production is sent back to truck despatch, the sawmill reports on receivals volume and quality and payment is made electronically to contractors and suppliers.
  - Reporting. In general, there are formal reporting mechanisms back to contractors and their principals each month. Included in the reports are details concerning: Percent rejects, attainment of the target distribution, and the length distribution of logs around the target/contract length.
- A well developed understanding of the system, and high levels of training in making most efficient use of the variety of technology employed.
- An important observation made during the visit to Finland is that compartments are selected to go into the harvest plan for a period in such a manner that the needs of all of their customers will be met at any point in time without unduly requiring individual compartments inherent potential to be sub-optimised. Expecting contractors to sub-optimise the forest to meet the market is viewed as a poor outcome and is avoided.
- Training of harvesting operators is at a tertiary level, and gives a thorough grounding in technical forestry (e.g. thinning objectivise) as well as machinery operation and maintenance.
- Sophisticated IT solutions to manage and make easier the complex set of tasks described above.

It can be concluded that clearly that there is significantly more to be gained from optimisation than just mastering the production of control files that meet orders, and coordinating and ensuring contractors have the training and a capability to implement them. It is the most important first step towards a generally more efficient system for two reasons:

- Information to manage the system
- enabling value recovery.

To ensure that this first step is made well, there are a number of recommendations that can be made to the Australian industry.

Contracts for harvesting and supply need clearly defined expectations. Sawmills and their suppliers also need to review their expectations given that current sawmill expectations for preferred long lengths could be retarding their maximum sustainable resource supply capacity by 3-4%.

Mills should review their log assessment and acceptance systems, and understand what impacts the way they handle out of specification logs has upon the work methodologies of log suppliers and contractors.

The quality, standard, frequency and timeliness of information flow back from mills to suppliers to contractors needs to be improved in Australia. To be effective in the forest as a value recovery tool, the people making the cutting decisions in the forests need to have up-to-date information about the decisions they are making and the effect it has at the customer's site.

The systems that are used for payment are vitally important to making any system work in Australia; they must encourage alignment of interests, such that all parties are working in the short, medium and long term in such ways that augment the recovery of value from the forest. The key is to take stock of the system and consider if the system of payment is self-supporting?

There is a general lack of understanding in the Australian forest industry about the concept of log value recovery. It is important the forest operational staff and their managers develop an understanding of log value recovery, and the impact that such things as; changing diameters, length mix, relative values, product prices, number of products and sweep specifications will have upon recovered value per hectare.

It is highly recommended that harvester training institutes in Australia should undertake to pass onto trainees (particularly those entering the softwood industry) the key elements of value recovery.

Although a large project to implement, a key factor in Finland's efficient system is the information technology infrastructure. Whilst this system was developed to cope with the record keeping and bureaucratic intricacies of a massive forest industry with non-integrated ownership, there is no reason why Australia cannot adapt such a system to our own conditions. With a focus on cut to length harvesting operations, it could be readily implemented.

Finland has a very strong focus on customer service. They are included in the planning process from the start, to ascertain their needs and develop a plan to harvest the right mix of forest areas to meet all customers' needs.

At this stage, Australia has quite some way to go. Put simply, sawmills and processors have not been engaged in the supply chain process. In most cases the processors are not currently interested, or sometimes they are not invited into the process. However, this engagement of processors is vitally important to ensure that the right drivers are fed into the implementation of optimised in-forest log making in Australia. It is difficult to emulate a customer focussed system if the customer is not contributing.

Executive Summary Part 2: Technical Aspects of In-Forest Optimisation

This second part of the report describes the process of how the different types of optimisation work, and some of their advantages and disadvantages. It will also explain in some detail how one may go about laying the foundations for a solid APT file that will serve well over a long period of time. It is beyond the scope of this report to go into the technical intricacies of specific software packages. However, links have been put on the Gottstein Website to enable interested readers to download the detailed information on producing APT files.

Exposure to the system in Finland revealed that the overall environment that forest harvesting operates in is of greater importance than the specific technical ability to write an adequate control file. This environment includes such important aspects as; contractual requirements, acceptance/rejection criteria, handling of reject logs, payment for services, value recovery expectations and contractor-principal relations. If the systems are not in place to handle the implementation of optimisation, then a well prepared APT file is meaningless.

The basis of the optimisation used in modern harvesters is the “value matrix”. Each basic product (e.g. sawlog, export, pulp) is ascribed a value. Subject to the physical constraints of the tree (length, diameter) the optimiser will allocate the log products in such a way to generate the highest value solution. One of the important things to keep in mind is that it is very uncommon to use actual $ values. Product values are expressed in “relative” terms. This relative value expresses a preference for one product over another.

Most commonly used is the distribution matrix, and this works by specifying, usually within diameter bands for a given product, the desired length mix in percentage terms. Over the course of the operation, the sawlog out-turn from the forest will very closely resemble the desired distribution. Nearly all systems in Finland run in “near optimal” mode and few optimisers are running in purely “value mode”. The first step in “near optimal” is that the control computer predicts the stem profile and allocates log products to obtain the maximum “value mode” solution (irrespective of trying to meet distribution demand). This maximum value represents the upper bound of what the control system believes can be achieved from this stem (based on the values in value matrix tables). The system then runs iteration after iteration to see how close it can get to the desired distribution for all log products, without the value trade-off exceeding preset limits.

There are numerous recommendations that can be made to the Australian industry concerning the technical aspects of putting together and managing a robust APT file.

Despite processors having the key roles in putting the distribution together; the distribution is not arrived without reference to the realities of the forest. There is quite some degree of consultation between mills and the procurement staff to make sure that the distribution is attainable given the realities of the forest. 80-90 % attainment of desired distribution is expected and achieved.

Stem quality codes that are inputted by the harvester operator are an important part of a successful system and it is the means to tell the optimiser control system about things that are happening on the tree that the harvester’s own sensors cannot tell it, like – branch size, pruned log, sections of live or dead branches, sweep, rot, scarring and forks. The latter elements are handled by manually overriding the computers solutions to dock out poor sections of stem, or reduce the suggested length of the log to meet sweep tolerances.

These codes should be consistent across an entire enterprise. This means that careful thought needs to be given in the early stages of implementing an optimising fleet of harvesters to set down meaningful quality codes that relate to log specification quality limits. Codes should not change regularly, as it means not only re-programming the control file (a relatively easy task) but also reprogramming the harvester operator (not an easy task).

It is strongly advisable that a consistent set of naming criteria be adopted for all harvesters working for a given company.

Testing APT files before their introduction to an in-field production harvester is an important part of the process that could not be stressed enough by the tutors at John Deere. Two items of software are needed for the best testing of APT files. The first is a SilviA Sim™ [1]which allows scenario testing of alternative cutting plans (APT) against a user specified set of STM files. The second piece of software is a T300 simulator, identical to that in the harvester.

1 SilviA™ is a registered trademark of CC Systems AB, Sweden

The John Deere system specialist believed that usual methods for calibrating harvesters by using actual trees in the forest is a substandard method and the preference at the John Deere factory is to use a series of metal pipes of a known diameter.

The regular carrying out of control measurements is an important part of keeping a harvester running smoothly. It is very important to draw the distinction upfront between a control measurement (checking regularly if things are working as they should) and a calibration measurement (correcting sensor interpretations when they are wrong).

Key Elements for the Successful Integration of In-Forest Optimisation into Australia

Table of Contents

Introduction

Navigating the path to successful implementation and integration of in-forest optimisation technology into Australia is one of the most exciting challenges facing our industry. The largest hurdle; that of recognising the potential of the technology, has now been overcome.

However, now is the time for a reflective investigation of what measures need to be put into place to enable the greatest gains from the technology. In-forest optimisation is a tool, and like any tool, knowing it can do a good job is a long way away from actually using it to do a good job.

It was postulated, based on preliminary investigations of the technology and its implementation that the two most important elements to making the system work might be:

1. The resource owner and their customers understanding their own business and each others, and jointly translating this understanding into practical and accurate weekly cutting instructions and medium term harvest plans.
2. A harvesting contract workforce who have the technology, training, contractual scope and inclination to implement the above.

A visit to Finland was made possible through the Gottstein Trust Fellowship, to investigate the validity of the above two elements, and use the findings to advance in the Australian forest products industry's understanding of how to achieve in-forest optimisation.

This report is divided into two parts. The first deals with the system structure and function of the Finnish forest industry. The lessons that can be drawn relate to "system settings" that Australia may consider implementing to create the environment to get maximum benefit from the in-forest optimisers. The many and varied elements that go towards making up the system in Finland will be bought together in a case study of two large forest companies operating in Finland, Metsäliitto and Metsähallitus. The second part of the report goes into some of the more technical aspects of the technology and training to make optimising work "on the ground".

Part One: Finnish Forestry – What is the System Structure and How does it Function?

Background to Finland's Forest Industry

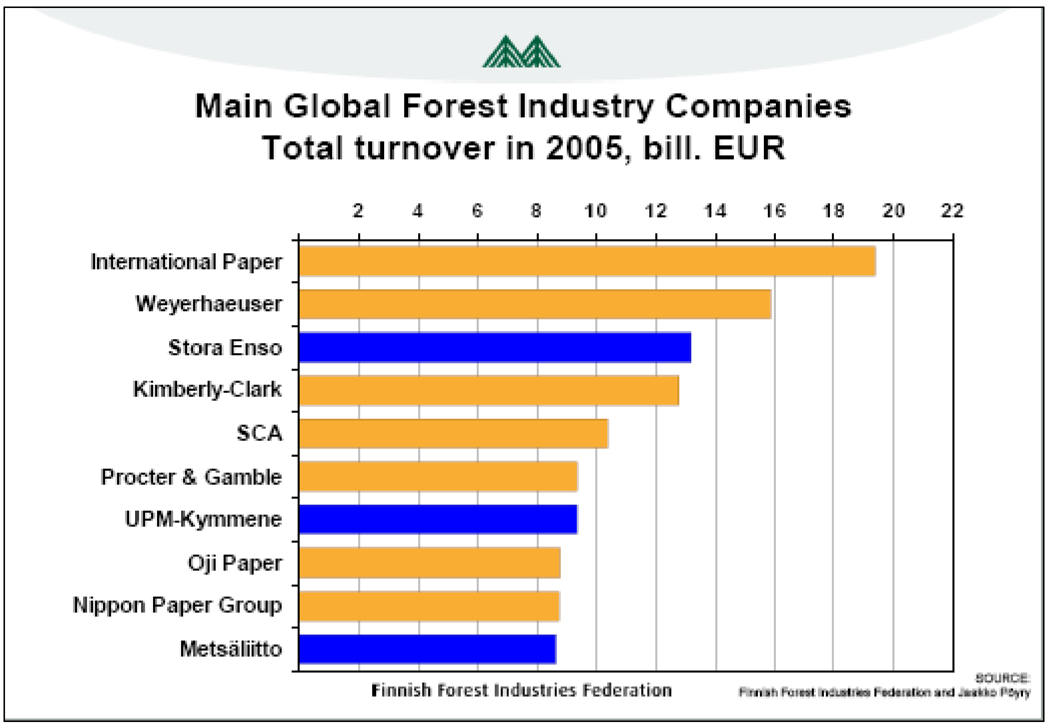
Finland is a large country by European standards, with a land area of thirty million hectares. Of this, some twenty million hectares is forested – a massive sixty six percent of the land area.

The thirty million hectares of land area is peopled by a modest number of five million citizens, making it almost as sparsely populated as Australia. It is also a land of lakes, there being 288,000 lakes. For those accustomed to the Australian landscape it is a dramatic contrast. Nearly as numerous as the lakes are the number of owners of Finland's forests. In contrast to Australia, some 75% of Finland's forests are owned by private individuals and the average holding size is less than thirty hectares.

The total round wood (log) consumption in Finland in 2004 was 79,000,000 cubic metres. 45% were softwood (pine and spruce) sawlogs, 54% were pulp logs and remaining 1% was for fuel wood (domestic and industrial) [2]. The very large majority (82%) of timber sales were by the means of standing sales, purchased by very large integrated processing companies. These processing companies have forestry divisions whose main role is the procurement of resource for the production process.

Naturally, these massive demands for forest products are met by a very large workforce. The total forest products industry directly employs 89,000 persons, or 1% of the total population of 5.2M persons. A testament to the continued improvement of efficiency in the Finnish industry is that in 1970 log consumption was 55M m^3 and forest operations employees were 90,000 people – 611 m^3 per employee. By 2004, 79M m^3 of log was produced by 22,000 employees – 3,590 m^3 per employee. This represents a 5.8 times increase in productivity per employee.

Figure 1 - Global Forest Companies by Turnover 2005



[2] METLA - *Metsatilastollinen Vuosikirja* – Finnish Statistical Yearbook of Forestry.

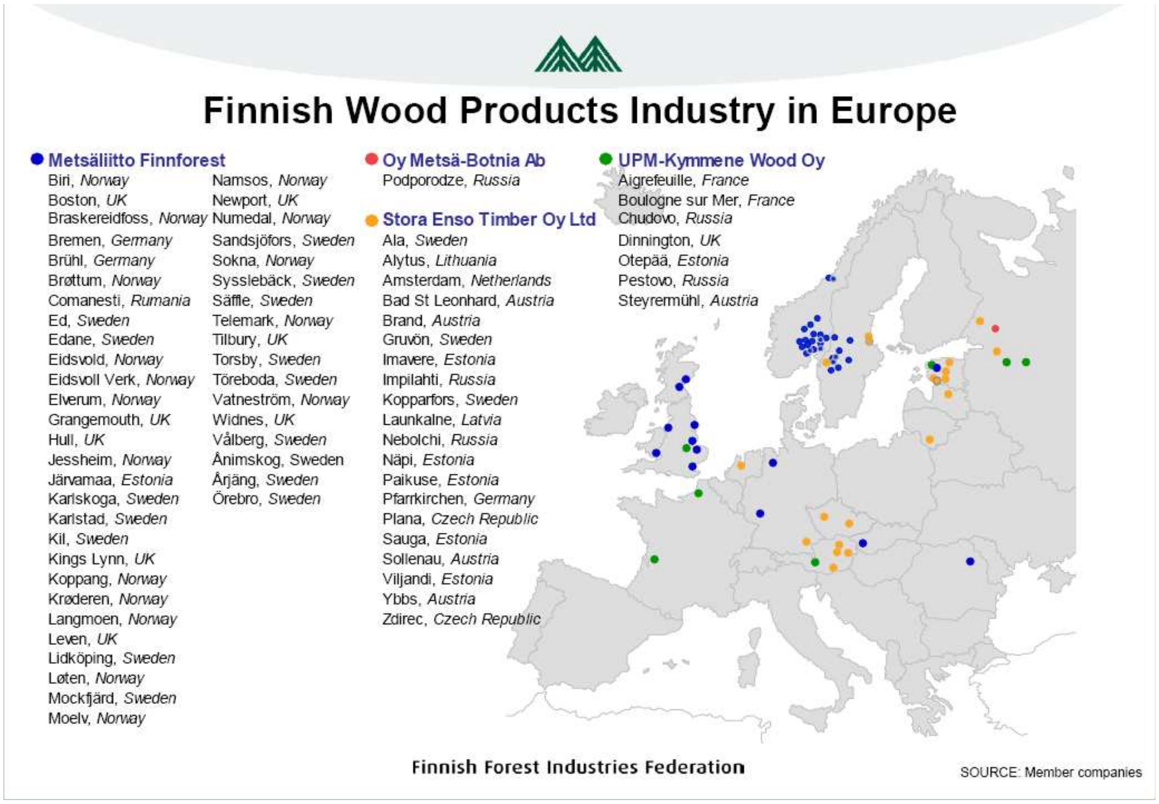


Figure 2 - Finnish Wood Products Industry in Europe

The chart above shows the major forest products companies' world wide. The bars indicated in blue are Finnish companies. It can be seen that 3 out of the top 10 companies by turnover are from Finland. These companies have operations throughout Europe and indeed the world. The map in Figure 2 shows the diverse locations that the large companies have operations.

With a very large processing industry, and thousands of individually small forest holdings owned by a multitude of citizens and companys, securing resource to keep the industry requires each large processor to maintain a large and very active procurement arm to their business. The procurement companies are viewed in Finland as the "forestry companies". It is these procurement companies that coordinate and contract private forest owners and growers. They also let contracts for harvesting, and work with their customers to build demand estimates to enable harvest planning. There is also quite a large degree of log sales across forest products companies. For example, a company may have a contract to harvest 100ha of forest, from which is expected a mix of sawlogs and pulp logs. The company holding the contract may only have a pulp mill of their own within economic haulage distance of the forest, so they will sell the sawlogs to a competitor at market rates.

There are 170 industrial scale (>10,000 m3 annually) sawmills in Finland, with a combined sawn output of 13.7 million cubic metres. Approximately 60% of this production is exported. The large proportion of the exported timber is kiln dried rough-sawn, with satellite planing mills in the country of destination finishing and dressing the timber.

Finland produces around 11 million metric tonnes of wood pulp, most of which is consumed domestically in the paper industries. These paper industries produced in 2003 13 million tonnes of newsprint, magazine paper and fine papers. A massive 95% of this is exported throughout the world.

One may wonder what the net result of massive industry needs and non-integrated forest ownership could be? One of the results is a system that requires Metsäliitto, one of the largest players in the forest industry, signing on average eighty individual contracts for wood supply each day.

Consider the downstream administration requirements for handling these eighty contracts; each of which may contain thinnings and clear fall components, with a contract typically affording a two year opportunity to harvest. Needless to say, planning disciplines must be focussed. On any given day across a large Finnish company, ninety forest operations are beginning, generating on average twelve different product assortments for up to eight different customers.

Importantly, these operations are not occurring in isolation. They have been initiated by harvest coordinators to meet the specific and exacting daily and monthly demands of their customers.

Sawmills order not only by length, or by diameter, but with very specific combinations of both, with the goal of meeting their customers orders and minimising waste. Within a given diameter range, usually specified in 10mm increments, resource procurers and their harvesting contractors are expected to deliver precise proportions of different sawlog lengths. The benchmark in Finland is for an 85% success rate, even at these fine degrees of resolution.

Without the assistance of relatively simple-to-use but comprehensive, integrated planning, inventory, stock control and reporting systems, managing this system would be impossible. An IT infrastructure is critically important to the entire process.

Forest Description

Over the whole of Finland, around 75% of the land is owned by private individuals or companies. In the south of the country, where the forest industries are most concentrated, some 92% of the forest land is in private ownership. This 10,000,000 hectares is owned by 350,000 separate owners, giving an average holding size about thirty hectares.

The dominant species in Finland is Scots Pine (*Pinus sylvestris*) – 65% of the forest estate. Spruce (*Picea abies*) dominates 25% of the forest land area and the remainder is a mix of Silver birch (*Betula pendula*), Downy birch (*Betula pubescens*), Aspen (*Populus tremula*) and Alder (*Alder spp.).* Several hundred years of intensive forest management have reduced the occurrence of true mixed species stands, as often replanting of an area is solely to one species or another – giving in many cases the visual effects of a plantation.

The standing volume in Finland defies comprehension. In 2004 there was 2,049 million cubic metres throughout their forests. The mean diameter at breast height (1.3m) is relatively small at 230mm, but this is an average across all age classes. Diameters at clearfall (locally termed as regeneration cutting) is closer to 350mm. As befits such a cold country, the trees do not grow very fast. Over the whole of the country, the mean annual increment (MAI) is only 3.6 m^3/ha/year, and within the relatively warmer south of Finland, growth is faster with an MAI of 5.2 m^3/ha/year[3].

Forest Silvicultural Management

Forests have been managed in Finland for many hundreds of years. As a result, much of the forest area outside of the national parks actually quite closely resembles what Australians would think of as plantation forests. Often of uniform species composition, the managed forests are well bisected by an excellent road network that simplifies the task of intensive silvicultural management. Managed forests' silvicultural prescriptions naturally vary with site and selected species, but there are some "typical" regimes.

Usually, a forest will be planted at 2000 stems per hectare. Technically, the first thinning is non commercial. The forest owner (not the forestry companies) will clean out forest before each operation – manually falling very small or dead trees, and removing where possible, hindrances to efficient logging. If this does not occur, then higher rates will be payable by the forest owner to the contractor when the first commercial thinning does occur.

The second thinning is at age 20 -30, depending on the site and species. The third thinning at age 40 years and clearfall is typically at age 80 -90 years in the south of Finland. This may be often at an older age in the more northern areas of the country.

In contrast to much of Australia, stem selection in thinning is actually the machine operators responsibility. In general, a machine operator in Finland has more responsibility towards forest management practice. Most existing operators (and nearly all new operators) are tertiary educated and many also have a degree.

The residual stocking to be maintained by the operator is based on a table referring to ground conditions and tree species. These tables are published by the Finnish Forest Research Institute. The harvester operator will install temporary sample plots during harvesting, using a basal area factor method. The residual basal area is compared against the published charts to ensure that correct practice is being followed. Some operators will also use a pole of known length to check pre and post operation stocking. Once an operator has some experience in assessing their own work, they may use the boom of the harvester as their sampling tool, and count the number of

[3] METLA - *Metsatilastollinen Vuosikirja* – Finnish Statistical Yearbook of Forestry.

trees in a given arc.

A common concern about operator selection of trees is how get around an operator taking the wrong trees or too many trees. The Forest Owners Association (if the owner is a member) will check over the thinning looking for damage, unsuitable quality trees left, and the log mix produced. The recourse is compensation if over cut or a rework if undercut. There are some quite clear regulations relating to forest management that must be followed and quite stiff prescribed penalties for breaches. There is also competition for private resource, both by forest companies and by the contractors (for the harvesting work) so it is in their interest to do a good job.

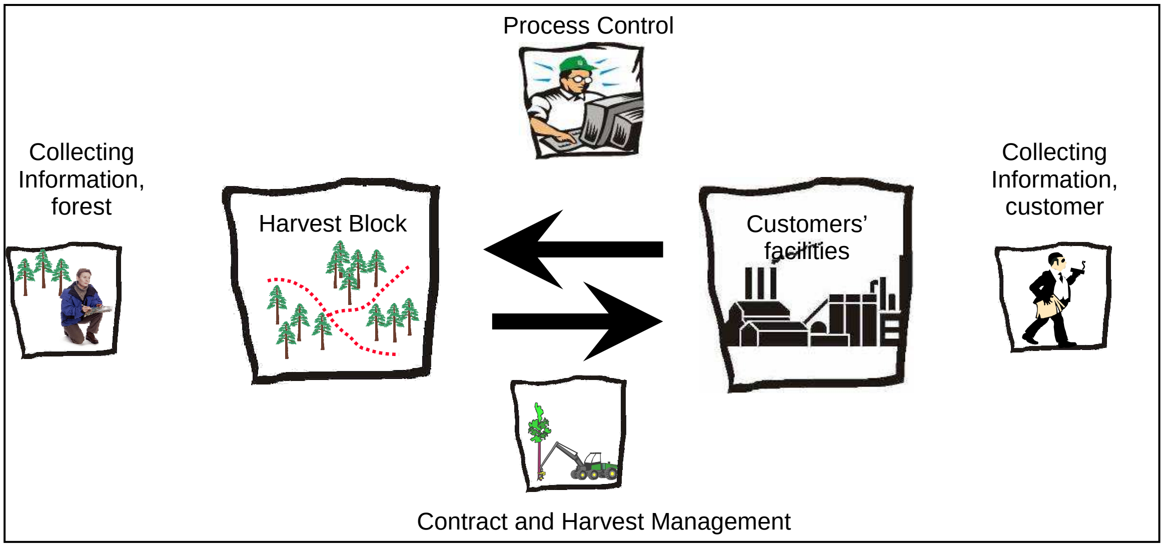
Forest Operational Planning

Overview

The overall process of forest operational planning and implementation in Finland is no different to that in Australia. With reference to the diagram below; there is the task of collecting forest information so that owners know what is in their forest. From the other side of the equation there is the requirement to understand the needs of individual processors and customers, in terms of volumes, and quality. The forestry company, using the forest information collected, then determines the most suitable forest areas to meet these needs. There is then the task to schedule the actual forest operations to harvest and deliver the log products. Managing the overall process requires a process control system. There are a number of areas in the process where the Finnish system differs from that of Australia. These areas will be covered in some detail in the paragraphs below. The key areas where lessons could be drawn for the Australian forest industry are:

- Making a concerted effort to understand the customers'(processors) needs and communicating with them.
- Collecting forest information – using the technology afforded by modern harvesting systems
- Process control – sophisticated IT solutions to manage and make easier a complex set of tasks, in the areas of:
  - Operations – harvesting and haulage contractors with technology
  - Communications infrastructure.
- Understanding of the system, and high levels of training in making most efficient use of the variety of technology.

Figure 3 - The Planning and Logistics Framework[4]



[4] Flow diagram courtesy of Tuomo Vuorenpää, Metsähallitus.

Collecting Information – Customer

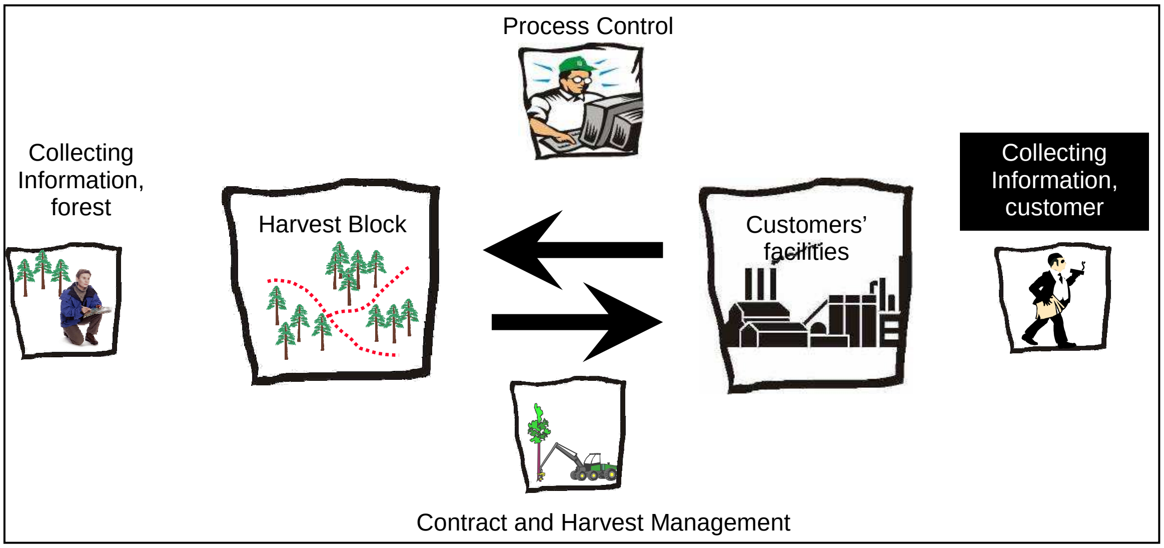


Figure 4 – Collecting Customer Information

Log Ordering Process – Customer Consultation, Control (APT) File Generation and Distribution

The level of customer consultation in Finland is quite apparent and obvious. It could be supposed that this is because so many of the companies are vertically integrated; i.e. the forestry company manages the forest procurement and harvesting as well as the sawmill/pulpmill. This is correct in many cases. One of the exceptions being Metsähallitus, who do not own any processing facilities. Despite this, the focus of their forest management is on providing products required by their customers, in such a way to maximise their return, and minimise forest wastage.

For all companies, forest wastage is a major concern. Because of the regular and comprehensive audits and checks carried out by the Forest Owners Association, it is not possible for unscrupulous procurement arms to get away with indiscriminately sacrificing overall forest returns by chasing particularly favoured lengths or assortments to the exclusion of volume recovery. This means that control files in the harvesters must be sensitive to forest recovery and returns to growers, as well as having the goal of providing what processors need. With the competition for resource, there is no long term gain to be had by processors encouraging the sub-optimisation of forest returns for their own short term benefit.

Sawmills are the most particular of the customers with regards to log supply. Whilst pulp mills have very exacting volume requirements, the customers' requirements for length and diameter combinations are much less exacting. Sawmills however, are often chasing a multitude of lengths, across a number of diameter classes, to achieve particular sawn product cross sections.

For a large sawmilling company, orders come from around the world. The sales coordinator will collate all these known and anticipated orders for sawn timber. Staff will then use sawmill simulation software to calculate what kind of log length and diameter combinations are needed to most efficiently meet (with the minimum wastage) the needs of the mill over the course of the year to meet the anticipated orders.

This requires a very high level of understanding on behalf of the sawmill about their customers and their needs. Further, this then needs to be translated into a predicted mix of log lengths and diameters. For the system to function efficiently, sawmills need to understand their own business very well, not to mention having a well developed appreciation of their own customers needs.

The key to the success of the system is the interface between the sawmill log buyers and the forest operations companies. As a body, foresters in Finland have many years of forest management and outstanding forest resource knowledge (volumes/size classes/quality) and using the IT infrastructure , have excellent tools to determine if they can meet customers needs. By knowing very well what their forest can produce, they are in a position to discuss with their customers, on the basis of solid data, what they can or cannot achieve.

Because both parties understand each others business (sawmill – particular log product needs, forest company – maximum utilisation of forest volume), and understand their own businesses (sawmill – meeting customers sawn timber orders, forest company – volume by hectare by quality type) – they are in the position for informed discussion on how they can cooperate to best meet objectives.

A sawmill may put together internally a desired log product distribution that would optimally meet their projected needs. This will then be presented to the resource procurement company as a basis for discussion. The procurement company tests this desired distribution in two ways – firstly by using their own harvesting simulation software (using previously gathered tree profiles) and secondly, by seeking the opinion of experienced staff who have knowledge of the upcoming forest quality and previous harvesting results.

Hence through an iterative process, both parties work towards a solution that best matches the sawmills needs while protecting the needs of the forest owner. For example, on first presentation, a desired distribution may be very heavily weighted towards the longer lengths, with no allowance for short logs. The forester will explain to this customer the effect this will have on total volume recovery and the impact upon returns to the forest owner. The two parties will usually then agree to add in what the Finns call “assistant lengths”. These are usually the shorter log lengths to aid recovery in trees with sweep or abrupt quality changes.

For about ten years now, the final compilation and distribution of control (APT) files has been the responsibility of the forestry company or the procurement arm of integrated firms. Previously they were generated by contractors following instructions from the forestry company. However, with the changes in IT systems and increasing complexity of systems, as well as with the realisation of the control files importance, the forestry companies have assumed the responsibility.

Forestry companies will typically receive orders from sawmills on a monthly basis. The overall product distribution (length by diameter combinations) may be changed from time to time, but usually it does not deviate very much from what was set at the start of the year. It may be that product proportions or preferred lengths may change, but major revisions are not common. The customer will typically order a certain volume (e.g. 40,000m^3) to be delivered on an agreed basis (daily or weekly targets), conforming to the agreed matrix distribution.

The matrix below is an actual order from Metsällitto's Finnforest Merikarvia sawmill – consuming nearly 2,000,000 m^3 per annum of log. Each column of the matrix represents the diameter classes that the sawmill requires. The rows are the lengths required. Within each row (diameter class) there is required a certain mix of lengths, expressed as a percentage. To illustrate, in the 240-259mm small end class, the sawmill requires predominantly 4.28 and 4.88m logs, with a smattering of 5.18, 5.48 and 4.58m. It can be seen, indicated by the red colour, that there are certain lengths within this diameter class that are of no use to the sawmill – like 3.87 and 4.08. The blue shading represents lengths that can be manually cut by the operator (the optimiser will not cut them automatically) and used as recovery logs.

		Diameter Class(mm)									
		150	160	180	200	210	240	260	280	300	320
Length (m)	370	0	0	15	0	0	0	0	0	0	0
	387	0	0	0	0	15	0	0	0	0	0
	408	0	0	0	0	25	0	0	0	0	0
	428	55	35	40	50	15	40	40	40	35	35
	458	0	10	5	10	9	5	7	7	10	10
	488	45	30	25	25	14	35	30	30	30	30
	508	0	0	0	0	16	0	0	0	0	0
	518	0	15	10	10	3	15	20	20	20	20
	548	0	10	5	5	3	5	3	3	5	5

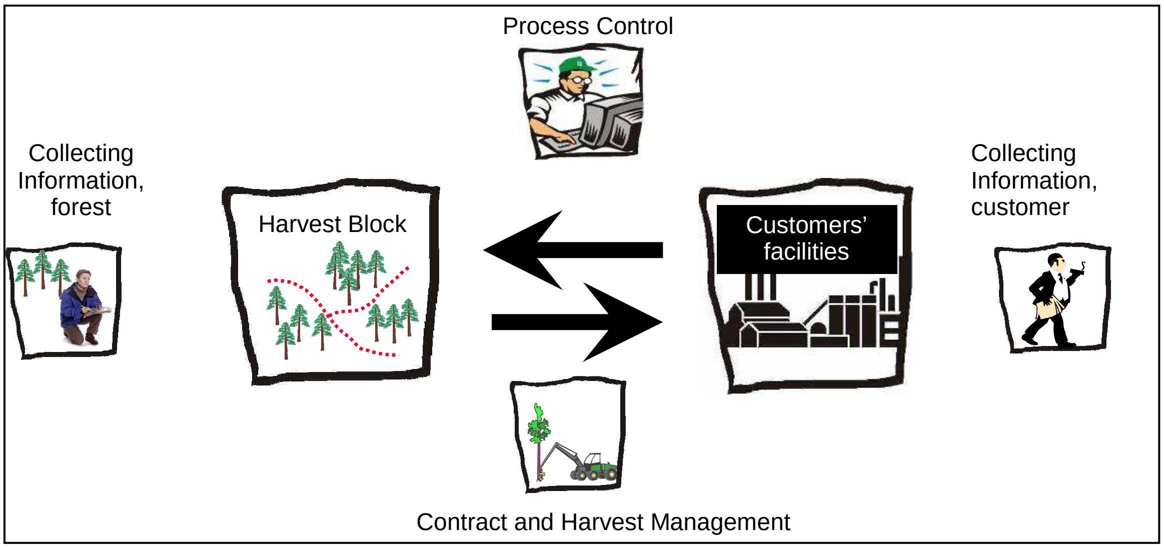
Figure 5 - Distribution Matrix – Finnforest Merikarvia Sawmill, Finland

The cutting matrix may look fairly complex, and without a computer to assist, it would not be possible for a person operating a harvester to satisfy anywhere close to this order. However, this distribution is in fact classed as an "open" order, in that there are broad options for lengths within each diameter class. Some customers, particularly smaller, more specialised mills may have a distribution that is much harder to meet without volume recovery losses in the forest.

In general, the more options within each diameter class the harvesting fleet is given, the easier for the distribution to be achieved without compromising the volume recovery in the forest. If mills have such very particular and exacting requirements that simulations by the forest company would show to have a negative effect on revenue, then price for those logs can be renegotiated in such a way to arrive at a revenue neutral situation for their production.

The control file is sent usually via wireless transfer in two parts or layers. The first part is the production layer containing the control (APT) file and the other is the GIS layer. The GIS layer shows such things as block boundaries, water courses, travel directions, conservation areas and the like. This is combined at the machine and a machine specific APT file is generated. Data transfer is handled by arrangement with telecommunications companies. The set up is such that it is not possible/allowed for work to begin until the information is received.

Customers Facilities - Customer Handling and Sorting



The large majority of logs (80%) are delivered by truck. Sixteen percent are delivered by rail, and the remaining four percent by water-borne transport. Observed turn-around times from trucks entering mill gate to leaving mill gate Vilpulla Sawmill were around twenty five minutes.

All mills visited had weighbridge facilities, though these are seldom used for payment (to be discussed further below). Most sawmills will have a log scanner, and likewise, these are usually not the means of payment for the logs. The main function of the scanners are to sort for diameter, length and quality. They are also used to determine reject proportions. Logs are delivered to mills in mixed lengths per truck bay.

The sawmills that were visited had a very large number of sorting bins. One mill had fifty four bins and the other a staggering eighty nine bins. The reason for the large number of bins is that the mills are sorting the logs into pre-determined batched sawmill cutting patterns. The logs are sorted by small end (top) diameter, and may be sorted so finely as 4mm classes. Sawmills may accept sawlogs down to 120mm under-bark.

Customer Order Satisfaction

The meeting of customer orders can be explored in two dimensions – gross volume, and secondly, attainment of distribution (if that is how logs have been ordered).

In terms of volumetric attainment of orders, mills receive ordered volume over the course of a month plus or minus one hundred cubic metres, which is an insignificant variance given that Vilpulla sawmill receives around 100,000 m^3 every month[5]. If customers for whatever reason do not look like they will get the volume ordered, it is the responsibility of the local forest department concerned to source wood from outside of their operational area, usually they may cooperate with other regions or companies to get in more wood[6]. This may actually involve buying logs off of a competitor (e.g. Stora Enso buying sawlogs off of Metsäliitto). The forest company that could not source the full supply locally bears the incremental cost of this extra transport.

In Finland the processors are the dominant players, and especially pulp mills. In some circumstances where a miscalculation has been made in the supply volumes and sources, the forest procurement company may actually send sawlogs to the pulp mill so that the process is not interrupted. This still works out cheaper than foregone revenue of sawlog, because the cost to the integrated companies of having a pulpmill shut for lack of log resource is so very much higher than the lost revenue from sawlog vs. pulp log pricing differential. This occurrence is very rare, occurring only in spring time and the end autumn when unseasonable rains can limit forest access. The forest owner is still paid the applicable sawlog royalty when this happens, but the log is simply delivered to the pulpmill instead of the sawmill.

The second area of order fulfilment concerns the degree with which the desired distribution was met. The goal in Finland is to minimise the deviations between the ordered diameter by length distribution and the actual diameter by length distribution.

[5] Juha Hirvasmaa – Production Planner, Finnforest Vilpulla Sawmill
[6] Juha Hirvasmaa – Production Planner, Finnforest Vilpulla Sawmill.

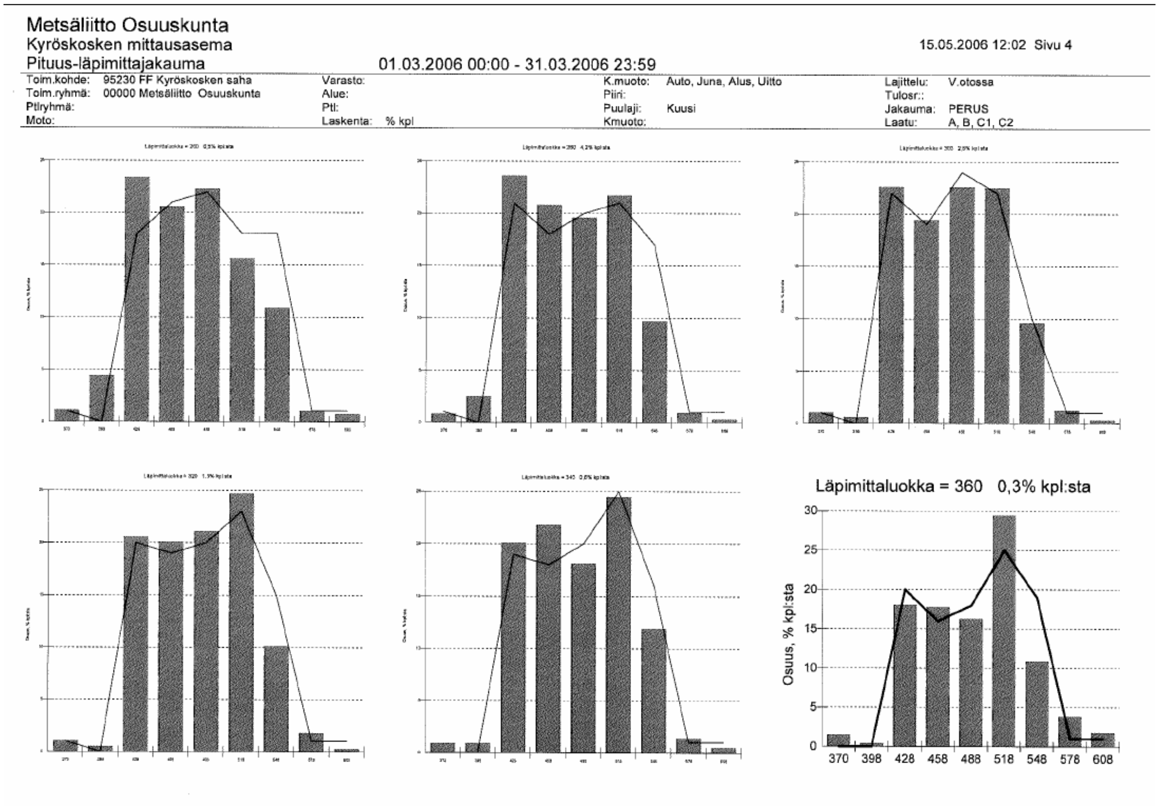


Figure 6 - Attainment of Distribution Matrix – Sawlog Operations, Metsällitto Group, Finland[7]

In every respect, the expectation in Finland is that the distribution will be met with an 80% or better accuracy. The graphic above shows an actual report from Metsällitto for the period of March 2006. Each chart shows the log length (cm) distribution for a given diameter range (from 260 SED in the top left chart to 360 SED in the bottom right). The bars represent the actual percentage cut by log length in the period. The thin line is the desired/ordered distribution.

This example was given to us to represent a very successful operation. It can be seen that the deviations from the desired length proportions are very minor, ranging from 6.5% total deviation to just 0.3% total deviation (bottom right hand). The overall accuracy was 87.5%. The reject rate for this period was a reasonably high 4.5%. Most of these rejects were for sweep.

There have been some successes with utilising the distribution matrix in Western Australia. A contractor producing small diameter and short length logs for preservative treatment and sale as fence posts has been using the distribution matrix. The results are presented graphically below. Although the example is simple – concerning just two log lengths (1.8m and 2.4m) it does serve to illustrate that a particular customer's desired distribution can be met quite closely.

[7] Vesa Virkkunen – Metsallitto.

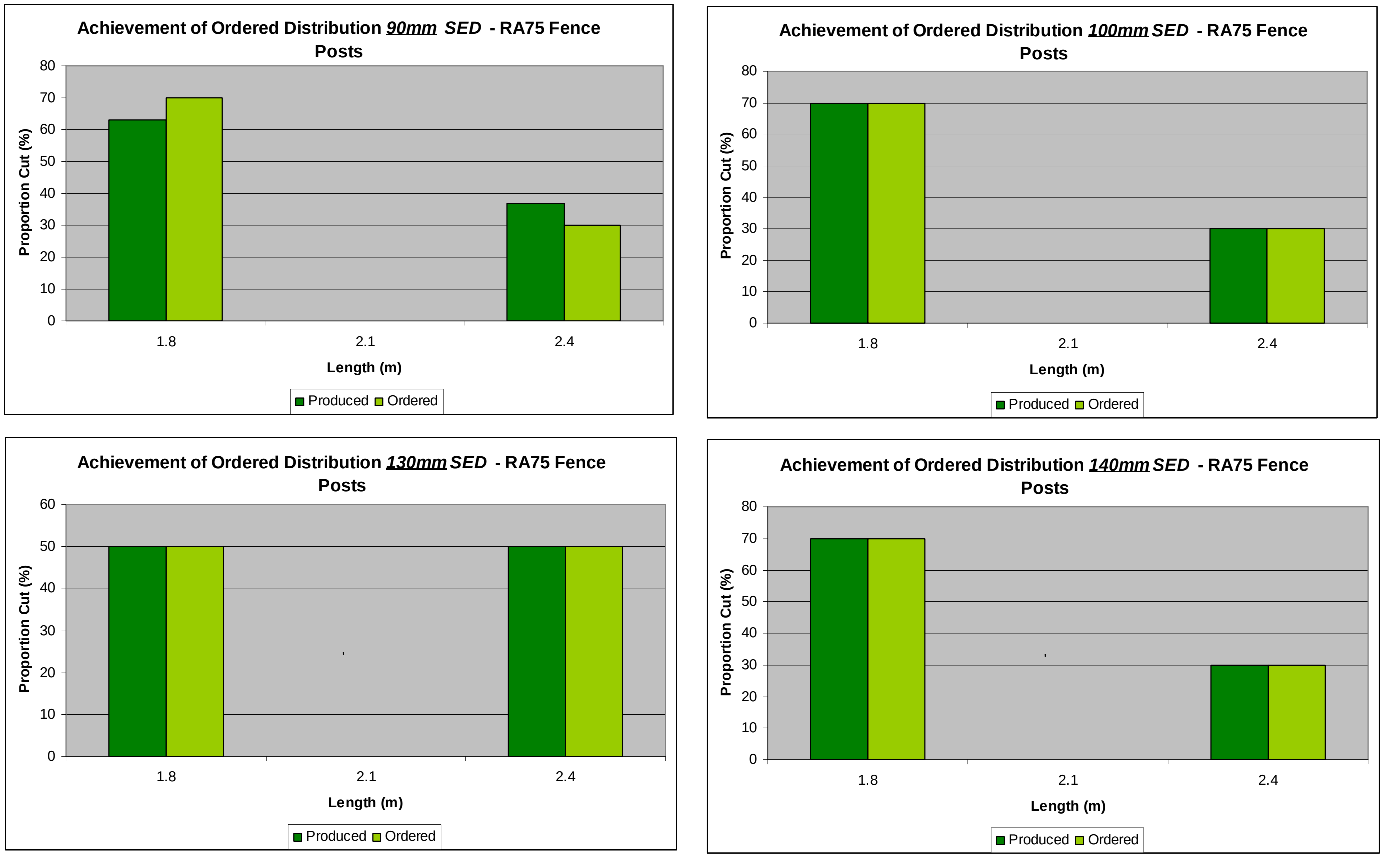


Figure 7 - Attainment of Distribution Matrix – Fence Post Operations, Western Australia

It is possible in some situations in Australia to have divergent expectations of the results of the optimiser. What happens if the customers expectations for length mix do not mesh with the reality of the forest? A customer may be expecting 95% 6.0m logs, but harvesting simulations or pre harvest inventory may show that the best outcome for total sawlog value recovery would achieve only 40% 6.0 by volume, with a number of "assistant" lengths needed to maximise volume recovery of sawlog to minimum contract specification. There is no question that optimisation of forest value is compromised if there are insufficient lengths for the machine to piece together a solution that gets as close as possible to contract minimum. It is simply a question of mathematics. If for instance you have 29m of sawlog quality stem, it is unavoidable that 5m of usable stem will be sub-optimised if 6.0m logs are the only option.

The solution in Finland is to reach a compromise agreement on a distribution that approximates the mills needs without sacrificing unduly the return for the forest company (and forest owner). However, in the situation where it is imperative that a given distribution be met, there are options that can be considered. Using simulation techniques, it is possible to determine with a high degree of accuracy, the extent that the best outcome for the forest company/owner is constrained by conforming to a very tight expectation. Negotiations can then be had to discuss some form of payment or compensation to keep the outcome revenue neutral for the forest owner. The sawmill obtains the length mix they desire, and the forest owner is no worse off.

It is important to consider implementing some sort of incentive system that rewards suppliers for attaining the desired distribution. This could be monetary, an increased order, or preferential supply rights when markets are tight.

Rejects

In Australia, there are often quite abrupt penalties to the contractor and forestry company for delivering reject logs to a customer. In most cases, there is no payment to the contractor for the reject volume, and the forestry company is required to remove the logs from the customers premises and dispose of them as they can. A predictable consequence is that contractors, and in particular, their employees will go to great to lengths to avoid the production of rejects. Depending on ones viewpoint this may or may not be a good thing. From a sawmiller with a narrow point of view, this ensures that all logs are within specification. However, what it means in practice is that rather than work hard towards achieving the preferred long log length (which could possibly send the log just under-diameter) the contractor may cut a “safe” short log that is well within the diameter and probably sweep specification. Bear in mind that a contractor, paid a piece rate, per cubic metre, will not usually move the harvesting head up the felled stem just to check that the long length log the customer would prefer is within spec. They are under time pressure to move onto the next stem and keep the production going.

The situation is Finland is quite contrasting. The contractor is paid in full, based on the volume measured by the harvester for all volume recorded as “sawlogs” (or any other grade/product) by the control and measurement system. If the control system believed the log to be in specification for length and diameter, and the operator assessed the sweep and branch size to be acceptable, then the log is paid for. The owner of the forest being harvested also gets paid in full for all products as measured by the harvester.

In most cases, there will be a certain proportion of logs in this population that does not make the grade. Inside Finland, the resource procurer (forestry company) assumes the risk with regard to reject logs. As mentioned the land owner and the contractor gets paid in full for reject logs delivered to the mill. However, depending on the amount of rejects delivered the resource procurer may be paid a reduced amount (or nothing) for the reject logs. However, contracts typically have performance measures or key performance indicators that mandate that; should the level of rejects in a given time period exceed an agreed amount, there may be contractual repercussions, and the contractor could get a bad name in the industry. This could of course affect the outcome of future contract negotiations.

Reject reports are issued on a very regular basis by the mills to their suppliers and the suppliers contractors. In many cases, the report relating to a given load may be sent back electronically to the harvester operator within minutes of the logs being assessed at the mill.

The factors that may cause a log to be rejected are the same as in Australia; sweep, mechanical damage, oversize knots/branches, splits, under-diameter and rot. Reject reports collected from sawmills during the tour of Finland would indicate that 3% scanner rejects is typically accepted before there are repercussions for the contractor delivering the logs. Effects upon the forestry company delivering the logs depend on individual arrangements. Some mills will pay for all rejects up until the 3% mark, and then stop paying. Others will pay to the supplier for all rejects at the equivalent rate for pulp-logs. VAPO sawmill (log input 550,000 m^3) accepts up to 5% rejects at no penalty, further rejects trigger a serious meeting with suppliers[8]. Sweep is the most common reason for out of specification sawlogs as this is one of the hardest characteristics to classify at modern harvest machine feed speeds. The Finnish classification of sweep uses a fixed increment per metre of log length. For the Finnforest Merikariva sawmill it is 1 centimetre per metre of log length. This system has some advantages over the percentage of SED system in popular use in Australia:

- the harvester operator does not need to do mental calculations about sweep based on the top diameter of the log, (which they've not yet seen).
- For a 6m log, the sweep is always 6cm, for a 4.8m log – 4.8cm.
- The effective result, when converted to the Australian % SED system, is that longer logs have a more generous sweep allowance, encouraging longer length log recovery.
- Increases in sawmill technology that can handle sweep with less effect on recovery may make it more desirable to have a higher throughput by having longer logs (even if they come with more sweep).

Reporting and Follow Up

Of some note is that many of the larger sawmills in Finland will send information about the load back after each load is scanned. Where possible the electronic information will be transferred to the logging truck delivering the load, and the information will be delivered wirelessly to the harvester when the truck is back in range. The forest companies have key performance indicators with their contractors. A contractor performing well gets a good name and an expanded/extended contract for doing well and the responsible forest supervisor gets a bonus.

In general, there are formal reporting mechanisms back to contractors and their principals each month. Included in the reports are details concerning:

- Percentage rejects.
- Attainment of the target distribution.
- Length distribution of logs around the target/contract length.

This formal reporting basis means that in future contract negotiations it is easy to see what one has done, and negotiate on a fair and informed basis.

[8] Ari Ronkainen, Mill Manger, Vapo Sawmill, Hankasalmi, Finland.

For most mills, the minimum expectation for attainment of the distribution matrix is 80 percent. Some mills are quite strict and will push very firmly the attainment of the distribution.

In terms of length distribution, the expectations in Finland are quite firm. If a log product (e.g. 6.0m) has a specified target length of 6.04, then the customer expects that 90% of all logs delivered will fall within the lengths of 6.01 to 6.09. This is universally achieved , and comments from contractors indicate that they could do better, but they do not make this widely known, as they receive no benefit for doing better than the contract minimum.

There is also significant reporting against value recovery. Because the forest owners association can levy quite heavy penalties for non-conformance, and publicise widely the transgressions of forestry companies, close attention is paid to ensuring a good result for value recovery. Operations in similar quality stands are regularly compared to one another to benchmark different operators ability to extract value from the forest.

Collecting Forest Information and Harvest Planning Systems Case Study – Integrated Planning at Metsäliitto and Metsähallitus

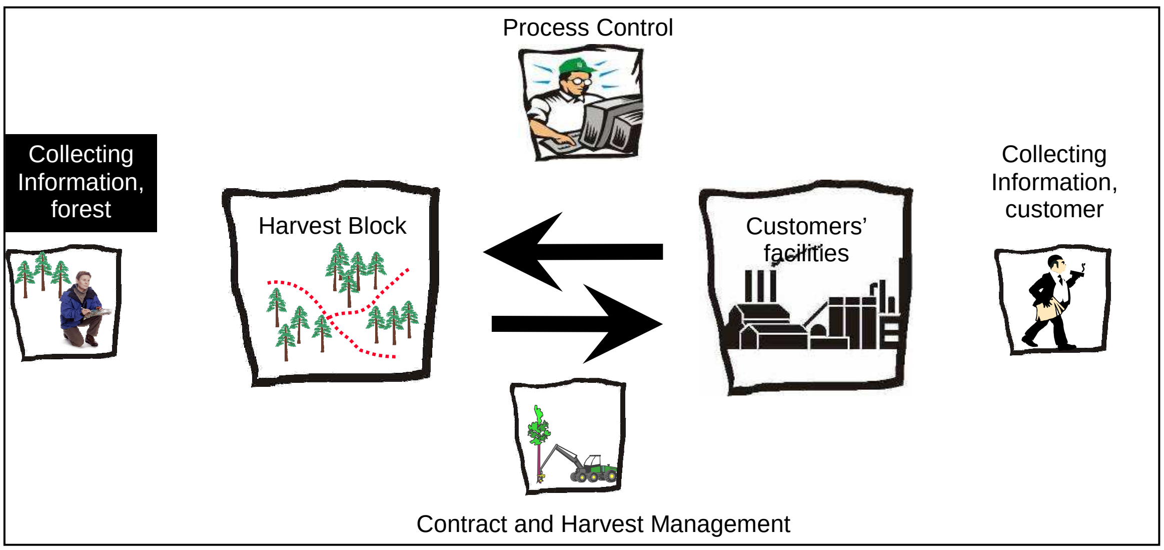


Figure 8 - Collecting Forest Information

The planning process utilised in Finland begins at the *landscape* level. Forestry companies are dealing with native forests, with multiple goals in mind (amenity, recreation, habitat and timber production). Areas of 10,000 to 100,000 hectares are viewed as a coherent entity. Areas to be totally excluded from forestry operations or areas where forestry operations are subject to restriction are defined during planning.

The harvest planning systems used in Finland centre around multi-layer GIS systems (ArcView and MapInfo). Most companies involved in resource procurement utilise nearly identical planning and IT infrastructures. In fact most have been built by the same company – Tietoenator (http://www.tietoenator.com). This company has produced planning systems for Metsähallitus, Metsäliitto, Stora Enso and UPM – the four largest companies in Finnish forestry.

During the visit to Finland, the planning systems were described in some depth by Mr Vesa Virkunen of Metsäliitto and Mr Tuomo Vuorenpaa of Metsähallitus.

Metsähallitus have over eight million hectares in their GIS system, with 1.3 million forest sub-compartments, and 750 end users. As with Australian forestry GIS implementations there are several key “layers” including:

- Aerial photos
- Terrain
- Roads
- Land-use
- Ecological area
- Compartments
- Treatment/operation maps.

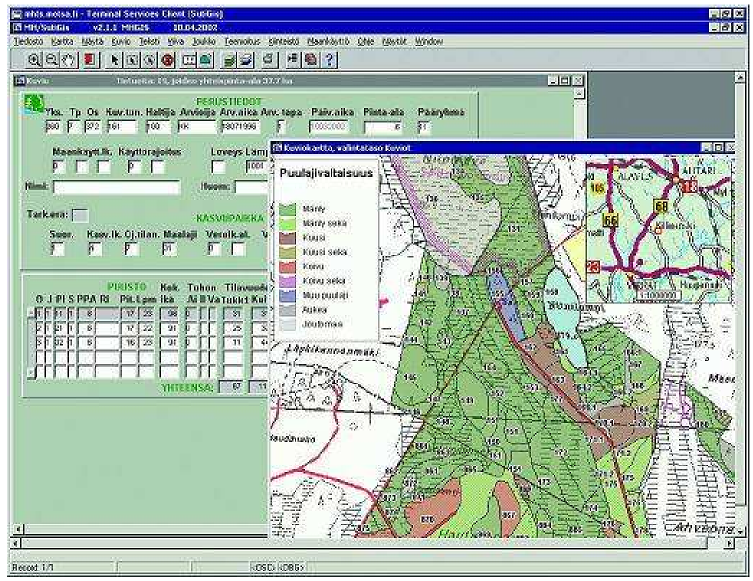


Figure 9 - Example GIS

The system is maintained as closely as possible to real-time. GIS data is collected from nearly all machines operating in the forest, and operational staff are tasked with maintaining the accuracy of the information.

Where the integrated system begins to show its worth is beyond the mapping and spatial statistics stage. Behind the map interface is a massive system of growth models, logistics software, harvest planning and compartment allocation models, reporting and communication services.

The scale of the task is quite staggering. Metsähallitus have contracted or working for them:

- 150 harvester and forwarder units
- 110 log trucks
- 115 full time equivalent managerial personnel

They produce 4.7M cubic metres of log per annum, or 40,000 m^3 per direct employee.

Just the Western division of Metsäliitto has:

- 97 harvesters and 102 forwarders
- 106 log trucks
- 20 full time managerial personnel

Production is 3.5M cubic metres of log per annum, or 175,000 m^3 per direct employee.

The system implemented at both organisations handles:

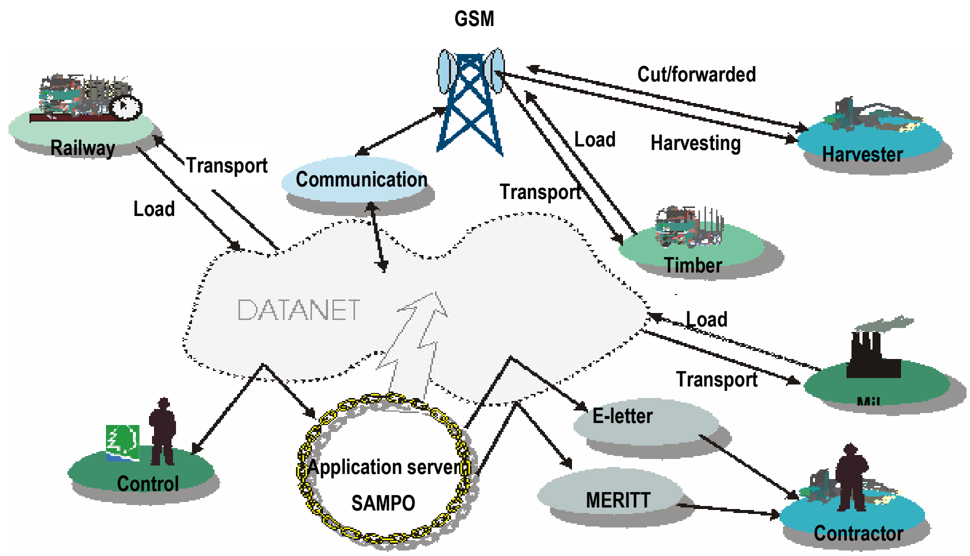


Figure 10 - Framework of Mobile Communications

- *Communication*

Finland is well served with mobile phone coverage (it is after all the home of Nokia). All elements are linked seamlessly through GSM digital communications. Cutting instructions and maps are beamed to harvesters and forwarders, daily production is beamed back to truck despatch, the sawmill reports on receivals volume and quality and payment is made electronically to contractors.

- *Contract management*

Details of all procurement and harvest contracts are kept in the database. Within Metsällitto's Western Division there are in excess of 15,000 contracts signed each year. The contract numbers generated upon signing a deal with a landowner are the primary means of tracking all future costs and revenues associated with that particular contract.

- *Forest operation planning*

All relevant site details are contained within the spatial database including:

⇒ Physical location
⇒ Anticipated volumes
⇒ Growth model characteristics (growth rate, MAI, diameter distribution)
⇒ Terrain class
⇒ Product assortments
⇒ Haul distances to customers (to assist marketing of products).
⇒ Contract terms and forest owner
⇒ Payment schedules

The pre-harvest inventory process at Metsäliitto is largely based on in-forest assessments of stocking and average volume. This is combined with the harvest planners experience to select the "right" combination of optimisation matrices to satisfy customers demands. If the sawmills needs change, it is possible for the planner to re-simulate the changes on historical stem information from similar forest types. This will determine if the new products will fit with existing products and if feasible volumes are present in the forest.[9] Presently, Metsäliitto is collecting stem profiles from all forests to build a "virtual" forest for each region and site type to aid further harvest planning.

All of this information is collated over the entire estate to determine the best mix of stands needed to most efficiently fulfil the known and anticipated customer demands for the coming years. Generated annually is a 1 year tactical plan, as well as a 40 year strategic plan. The 40 year plan takes into account predicted growth, using the growth models that work in the systems background when the planning horizon extends over 1 year.

The one year tactical plan described above is the nexus between mills, procurement, contractors and forest owners. Sawmills and pulp mills meet forest owners and tell what they need once a year. Then they produce a tactical plan for each 3 months period. The monthly plan must be very accurate and then allocated to forest blocks.

An important consideration that was picked up upon during the visit to Finland is that compartments are selected to go into the harvest plan for a year in such a manner that the needs of all of their customers will be met without unduly causing individual compartment sub-optimisation. Too often in Australia it seems the case that the best value out-turn from a forest is often compromised to meet short term customer needs, simply because the mix of compartments selected for harvest at a given point in time do not provide a match for the mix of products in demand. If for instance 2nd grade log is in demand, and the only product available is 1st grade log, then 1st grade log may be supplied at 2nd grade prices to a grateful customer, at the expense of the forests value.

This consideration cannot be understated if forests are to be truly optimised. If stands/compartments were to be allocated without regard to the total mix of products generated across an entire enterprise, then one would rapidly find a supply situation out of balance as the optimisers cut the highest value solutions. The key is to balance the plan, such that each harvest unit, optimising independently yields the overall log mix required for the market. Expecting contractors to sub-optimise the forest to meet the market is a poor outcome.

In some organisations contractors are very carefully allocated and their movements managed closely. In others, contractors that have good track records are allocated a yearly program that they may notify back to the forest company about the progression through the blocks that they

[9] Vesa Virkkunen – Metsäliitto

plan to undertake. These “key contractors” movements form the backbone about which smaller contractors are scheduled to fully complete the necessary volume by product mix to meet customer orders.

The average weekly productive capability of each harvest crew is known, for different operation types and terrains, as is the expected volume for the block. Creating a harvesting plan is as simple as dragging and dropping the blocks onto a contractor’s icon in the planning software. The software automatically generates a Gantt chart showing each contractor’s anticipated progression through each forest block. It is very seldom that the horizon of the tactical plan falls below two weeks, and day to day movements to meet customers’ orders are very uncommon.

The illustration below shows the harvest planning module of Metsähallitus’s system. Down the left hand side of the interface are the blocks on the harvest plan. To the right are the contractors who operate in the area, and the machinery type that they own. It can be seen that MKY Taurianinen Oy has five harvesters operating in this region, with two Timberjack and three Ponsse harvesters. Red bars against the contractor indicate an absence of work, green, a commitment. Simply by dragging the blocks from the left hand side of the screen to the right, the contractors works schedule can be filled in for the next three months (or more), and relevant maps generated and issued electronically.

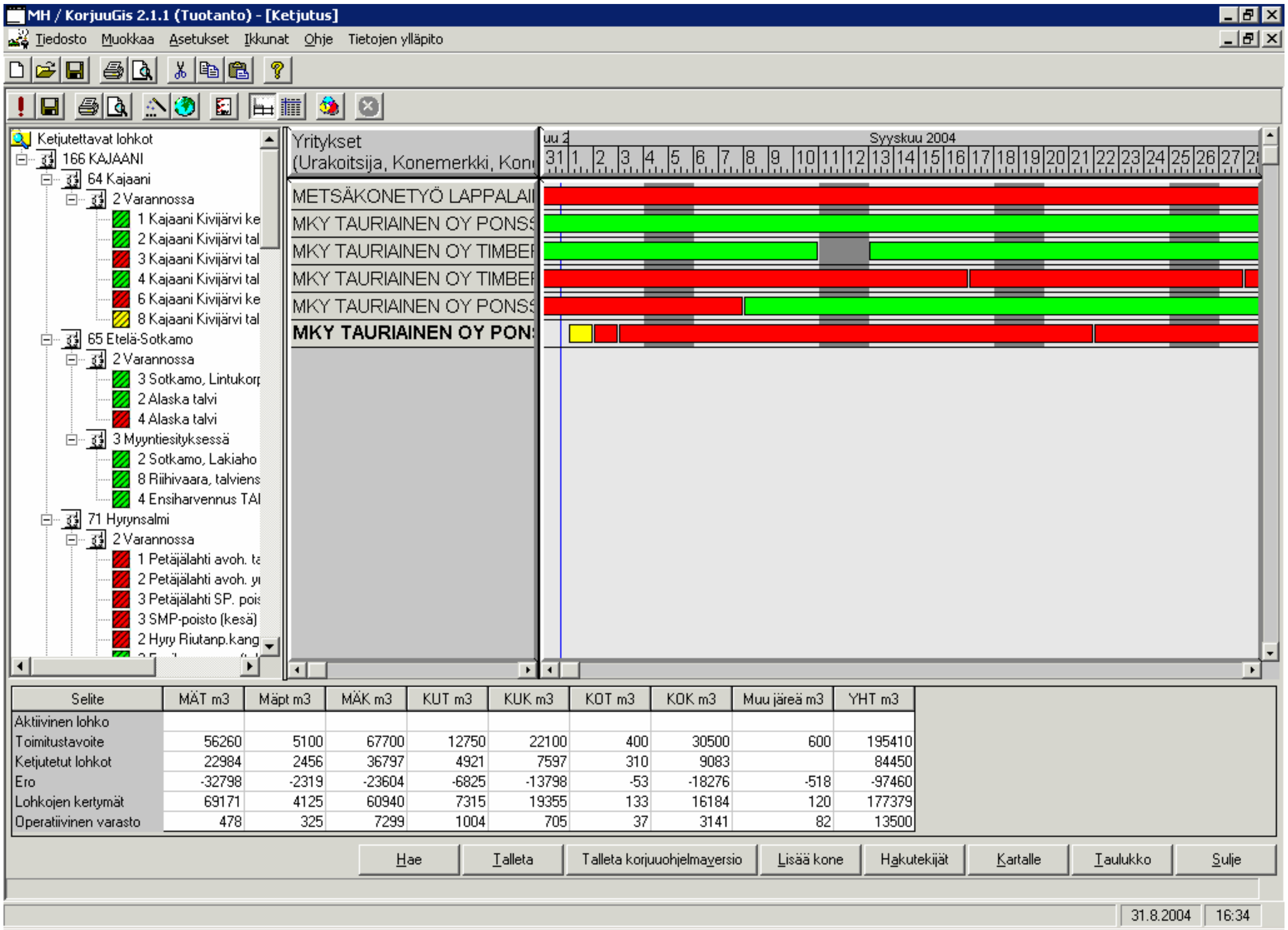


Figure 11 - Harvest Schedule GANTT chart

- *Customer Demands*

Upon consultation with forestry company staff, the customers submit to Metsäliitto/ Metsähallitus (as the case may be) the required or agreed distribution for the upcoming year. This then forms the base matrix and is what is used to generate the matrices for each machine.

- *Local Mapping*

Forest and Compartment information is spatially linked to the database. Users in the forest can mark log dumps, turnarounds and sensitive areas. Cut block boundaries are sent with the control (APT) file.

- *Cutting File Distribution.*

Each machine brand, even though all conform to the StanForD data format, has subtly different characteristics. With one or two machines in operation it is possible to manually make the changes necessary to ensure compatibility. However, in the situation with 100 or more harvesters, a more streamlined approach is needed. The way this is achieved is that a generic AP1 file containing assortments and OAI files showing map information are recombined in-situ within each harvester to produce a hybrid machine specific APT file for immediate use.

- *Transport to Roadside and Delivery to mill.*

As a forwarder extracts the logs from a block, the operator estimates the volume shifted from the forest to roadside. Software calculates, in a similar manner to an accounting ledger, the total volume cut to date by the harvester, the total estimated to have been moved to roadside, and the total known to have been delivered to mill by truck. This then gives a real time measure of how much volume is at each production point – forest, roadside, truck and mill. Once the last load has been moved from forest to roadside, an automatic reconciliation is carried out with the harvested volume and a final roadside volume calculated. Sometimes it may be several weeks between all logs being moved to roadside and final transport. To aid recognition of piles, the forwarder operator often takes a digital photo of the stack and beams that back to base also. Hence in many cases the transport scheduler has a very good knowledge of product volumes waiting on roadside.

- *Production archiving and reporting.*

Each machine reports daily, via the internet to the database belonging to the forest company that they are contracted to. Files detailing the volume by products by length and diameter mix (PRD) are transmitted daily back to base. These are used to determine final roadside or block volumes as well as to check progress against the current or next weeks targets (depending on planning horizons)

The reports are also archived against the block and contract number, for future validation of growth and yield models.

- *Customer Payment and Feedback.*

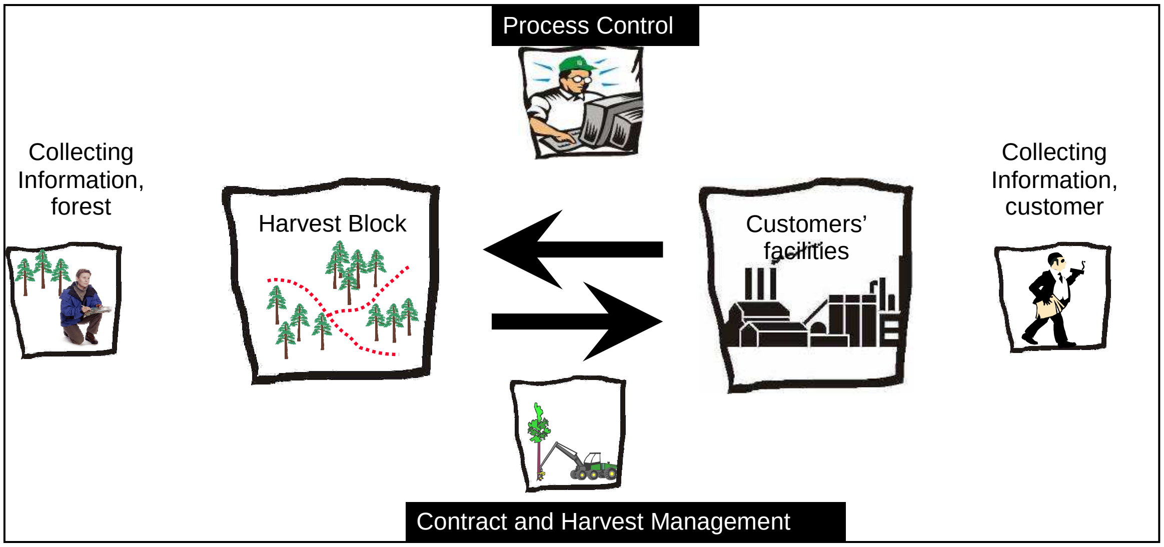
As detailed in the "Reporting" section above, load summaries from deliveries to mills are available on-line to staff and contractors. In the event of exceptionally good or uncharacteristically poor results, some reports are generated automatically and sent direct to the harvester and contractor. Usually this is for such things as gross under length logs that could mean there is a mechanical problem with the harvester.

Presently about 1/3 of the mills serviced by Metsähallitus are integrated into the reporting and information system. This allows them to actually pay for the logs on self generated invoices that are simply cross checked by the supplier – thus reducing the administrative overhead.

- *Contractor Payment*

Likewise, the system automatically generates invoices for the harvesting contractor – based on what the harvesting head has measured and the control system has recorded against assortments. Customers generate and pay upon their own invoices, forest company staff audit these invoices to ensure fair dealing. Haulage contractors are paid off of the weigh scales at the customers facilities. Payment data and actual funds are usually transmitted in electronic form. Over the course of the year the difference between what the harvesting machine has reported for volume and what the customers scanners/weighbridges report must is less that 0.05%. (5% maybe?)

Process Control and Contract and Harvest Management



The process control element of the forestry system in Finland bridges the gap between the potential asset – the forest, and the realised asset – logs delivered to customers. The control process is the assignment, monitoring and supervision of the harvesting contract workforce. It is also the moderating of customers' demands, responding to short term exigencies and ensuring that the information flows are routed to the right place to ensure that the correct or modified decisions can be made.

If the mix of compartments selected to best meet the customers orders is not working out as the inventory may have indicated, or customers needs have significantly and suddenly changed, then the solution for anything but emergencies is to select a new mix of forest compartments that will yield the correct or new mix.

Contractor Size and Management

The configuration of the harvesting workforce has been steady for a number of years – with universal adoption of the cut-to-length method carried out by contractors. Most contracting businesses are centred on what is known in Finland as a chain – 1 harvester and 1 forwarder. The average harvest unit size is around 30-40,000 m^3 for a harvester and forwarder "chain". Two thirds of contractors have just one logging truck.

Many years ago each operation was split, and a separate contractor did each step of the process – one business to harvest and prepare logs, the second to extract logs to roadside and another to load and deliver. These evolved into harvester plus forwarder plus (sometimes) log truck combinations. Nowadays there are some larger contractors who may be allowed to select where they work. This gives a higher level of responsibility to contractor, and they are able to select the progression of blocks that they will harvest, to best fit around their own operational requirements.

In most cases, once a harvesting deal has been signed between a landowner and the forestry procurement company, the forestry company has 2 years to complete the operation. This means that larger contractors may be able to determine their own movements for up to two years ahead.

Contracts are awarded by process of tendering, and in some circumstances this is a legal requirement. The process is quite intensive, especially for the government contracts with Metsähallitus, which require pre-screening of tenderers' taxation status, pension plans and waste disposal plans, not to mention their actual capacity to carry out the work and the type of equipment they will be running.

The assessment is based upon quality scoring examining; age of equipment, training, reliability, managements systems and suitability of equipment. The terms are typically 2-4 years with an annual revision of prices. Fuel is a very large component of the negotiation of price. The prices are based off of a nation wide table of costs, and tenderers' bid a multiple of these prices (e.g. 1.2 times the standard). Contractors must also complete an online learning module familiarising them with the environmental and legal responsibilities for parties contracted to Metsähallitus.

Within Finnish forestry in general, contractors feel about the same way towards the industry they work in as do Australian contractors. It is an industry that they strongly enjoy working in, but they feel that their contribution is not as highly valued as it could be. Universally, they are small family business owners, often multigenerational in tenure, and they find it difficult to interact with the larger Corporates' that hold their contracts. The harvesting contracting business owners in Finland are known to be able to afford to lead a comfortable lifestyle, but nearly all businesses still require the owner of the business to remain actively working within the company.

The relationship between contractor and principal is seldom strained, and in almost all cases, amicable. The contractors are aware of the industry and its drawbacks, but have a willing attitude. They are supported by a technology infrastructure that is there to make their jobs easier and smoother. Contractors visited were very professional and took great pride in their work. It is quite common for them to only see a forest officer every two to four months, so they must be self reliant, and in return are treated with a great deal of trust by their principals.

A key element that keeps the system working smoothly is that via a long historical process, a streamlined set of key performance indicators have been developed. All parties to the contracts are well aware of what they need to do to satisfy the contract.

A strong urban drift, and a negative viewpoint of working in the forest compared to working indoors has (along with safety issues) led to the universal adoption of mechanised harvesting. These same forces, unabated, are triggering large investments in innovations such as remote controlled harvesters, manoeuvred from the forwarder, to reduce the workforce requirements. Obviously this is not so productive as having two human controlled machines, but more productive than having an empty harvester or forwarder.

A view expressed in Finland is that there are too many contracting businesses competing for the work, with not enough people actually working for them to do the work. This is felt to be keeping contract rates very low, as the heavy capital investment made by small business owners drives them to tender for employment at low rates to ensure they get sufficient cash flow to keep their businesses afloat.

The operational expectations for the contractors in Finland are well established. As far as optimisation goes, there is no option. If one wishes to tender for work, then the expectation is that equipment will be fitted with the required technology, including GPS and computers in forwarders and harvesters, and mobile and wireless communications devices. In Finland a contractor just have to take or leave it as far as optimisation goes. Contractors are also aware of why they work. In one contractor's words, "If the sawmill does poorly then the industry does poorly. Everybody has to be happy, but money flows from sawmill".

Training, Workforce and Retention

There are around 13 dedicated Forestry Schools in Finland. The Kuru Institute that was visited on the Gottstein study is the largest. Many of these schools are long standing, Kuru having started in 1937. Kuru is fairly atypical in that it offers its courses in both Finnish and English. Because of the maturing of the industry in Finland (stable and not growing rapidly), many schools are increasingly looking to the Baltic states and Eastern Europe for students.

Training is at a tertiary level, and mostly focussed on machinery operation. Most schools have their own fleet of harvesting machines that work on contract to forestry companies. Some schools are more heavily focussed on simulator training and may have multiple simulators, others have significant larger fleets of real harvesters.

The term of training is four years. Operators learn both forwarder and harvester operation, and the goal over the course is to have them up to at least 50% of the speed of an experienced operator. Quite a lot of time is spent on field repairs and understanding the mechanics of the equipment that they use.

Further to the machine skills, students are given a thorough grounding in technical forestry. They learn about mensuration and the significance of silviculture and thinnings, as well as learning about the whole forest and forest products industry. Also given is instruction of site types, suitable silviculture and species differences. They learn about where the products they produce will be used, and what characteristics define the most desirable log products for each process.

Importantly, students also learn basic business skills, like book-keeping, finance, costing analysis and business writing. This is an important recognition that many will end up owning or running their own contracting business.

However, the industry is finding it increasingly hard to attract and retain skilled workers. Despite nearly all operators under the age of 30 having a tertiary qualification in forestry related disciplines, the job is not highly regarded. The hours are long, the conditions often testing, especially in winter, and the workplaces remote. Views canvassed while in Finland would indicate that a factory floor worker with less training and living within a city, in close proximity to their workplace, earns significantly more than an experienced harvester operator. Finland has, and is still experiencing a strong urban drift, especially amongst young people, and the technological progress within the forest industry has only slowed down, but not reversed the trend.

Contractor Payment

Contractors are paid by a table of forest volumes. These prices are negotiated independently by each different company, but are all based on a scale established jointly in the past. The prices vary depending on volume per hectare extracted, terrain type and operation (thinnings or clearfall). There is an automatic index for fuel price movements. Of some note is that contractors are paid the same for all products. It is just a flat $/ m^3 of production. Contractor payment to roadside is paid for by the information measured in the harvesting head and calculated by the control system. The accuracy of this is required to be within 4% of calibrated log scanners (over-bark), but most contractors report accuracies of +/- 1-2% over the course of a year.

Average harvesting costs (per cubic metre) across all operation and terrain types in 2004 were:

- Harvesting - €5.26
- Forwarding - €3.21

Simply converting from Euro to Australian dollars may give an idea of comparable prices, but another way to look at it that is more representative may be to look at the cost component of delivered price to the sawmill of the harvesting and extraction. In Finland, harvesting and extraction represents about 14% of total delivered sawlog price. Swedish harvesting and extraction makes up about 18% of the delivered price, and in Australia for sawlogs is in an approximate range of 17-21%. It would seem that contractors in Finland are providing their service at a relatively low cost compared to the total delivered cost of the raw product for processing.

Harvester and Forwarder Technology

Most often harvesters and increasingly forwarders have maps and GPS. The main reason that these systems developed is because there are quite often no discernible boundaries in Finland between forest blocks, which could be owned by different people. Hence having mapping and navigation technology on board helped avoid the cost of having foresters delineate boundaries manually with tape or spray paint.

John Deere Forestry has produced an off the shelf program called TimberNavi that can be used in harvesters and forwarders. However, on the whole this program is not used much in Finland as most large forestry companies have already developed their own systems in house. TimberNavi is more a solution for those that lack resources or need to build their own system but would like the functionality immediately. All the software viewed appeared to function in the same manner – with integrated GIS mapping, GPS navigation, proximity alerts, mapping of assortments and volumes in a cut block etc.

Log Making Methodology and Length

In any forest and in poor quality forest especially, the operator is still responsible for the final log product. As is the experience in Australia, if poor form trees are encountered the operator must take control and cut manually. The stem quality in final cutting (clearfall) in Finland is very good in Spruce. However, the pine trees exhibit a growth pattern similar to *Pinus pinaster* in Australia – that of a very straight bole, but with larger branching and rapid stem tapering in the crown. Further, a great deal of the reason for the very good quality clearfall stems can be traced back to the many thinnings carried out in the 120 year rotation, with high selection ratios enabling the selection of the best stems. First thinnings that were viewed showed a very high proportion of malformed and rough stems, with very high proportions of pulp log,, much the same as in Australia.

Some time was spent riding in the cabs of contractors harvesters. They spent very little time (if any) concerned with length or diameter issues, putting their trust in the computer systems. However they were quite particular about selecting the correct quality attributes. The clearfall contractor we viewed had three quality codes that he had to assess for:

1. A – no branches
2. B – green branches
3. C – dry branches

These codes have a very high degree of influence on the allowable products that the optimiser may select when working in different sections of the stem that may contain the features represented by the buttons.

The methodology with regards to sweep was difficult to assess. Because the specifications call for a maximum of 1cm per metre of log length, there is little point in cutting a log shorter to reduce the sweep as a proportion of SED (as would happen in Australia). Further, with the fairly high allowable reject rate (4-5%) there is little reason for the contractor to take up too much time being particular with sweep. Unless they are cutting a product like fence posts, or docking out large knot whorls, their obvious preference is to keep the harvesting head moving in a forward direction at all times.

If a contractor is working in poor quality forest, there is no apparent explicit tolerance for not achieving the required level on the distribution matrix. However, when asked to justify poor performance, contractors can make a strong case to contract principals about the quality of the forest. After all, if the forest is of poor quality with many docking cuts needing to made, then the mill reports on length/diameter/sweep will back them up.

The main lengths cut are 370, 400 430 and 670cm. If logs are cut manually then the most common lengths cut are 460 and 490 – for ease of extraction and loading.

The average number of product assortments per species is around five. Typically there are two species – pine and spruce in a harvest area, each with about five assortments, with usually two assortments for the hardwood species (birch). This makes a total of 10-12 separate assortments in a typical job.

Harvest Block Size

Figure 12 - Custom Built Forest Machine Transporter

Average cutting site is a very small 300 m^3. Metsäliitto report that their average cutting size is around 500 m^3. This may contain a mixture of clearfell and thinning.

Therefore it is possible that a machine may move two times per day, especially in thinnings. However, a large number of these moves are self-propelled. Because nearly all machines are rubber-tyred, they can shift themselves between operating compartments. For longer moves, there are specialised low loaders (pictured) that lower the centre of gravity of the machines whilst transported and allow to fit under quite low bridges that seem prevalent in Finland.

The cost of moving was conveyed to us at 1-2% of total contractor cost. Although sometimes daily moves can occur, the average is one move per week.

Log Truck Management

GPS Systems began being fitted to log trucks 15 years ago. The present costs are about € 15,000 and contracts are now starting to be conditional upon possession of the necessary equipment. This is a similar position to where in-forest optimisers were 10 years ago. It is now unthought-of to not have an optimiser and the perception in Finland is that GPS will soon be in the same basket.

Most forestry companies carry out their own truck scheduling. They use what is known as "truck route optimisation". This involves using computer programs that interact with the known positions of log stockpiles, and customers needs, as well as in-forest production trends. The module calculates the most efficient routes from the forest to the mills and minimizes trucks carrying empty loads, so that considerable cost savings are realized and transport operations emissions are reduced. It even considers road conditions, since – especially in the winter or rainy season – road quality influences route selection and presents major challenges to transport control.

Conclusions Regarding System Structure and Function and Recommendations for Australia

Enterprise Wide Logistics and Optimisation

As an outcome of the training and the study tour described in the above pages, it can be concluded clearly that there is significantly more to be gained from optimisation than just mastering the production of APT files that meet orders, and coordinating and ensuring contractors have the training and a capability to implement them. The Finn's quite clearly regard this as an extremely important element, but they have moved on, most significantly into the areas of enterprise logistics, scheduling, reporting and follow up. The construction of meaningful APT files and having a contract workforce equipped to handle the challenges are second nature to their forest managers.

Presently Australia is poised to implement on a large scale the forest manager – contractor component of the system. However, having seen the Finn's system in action, it would be a regrettable squandering of an opportunity to the Australian industry if the assumption was made that this now constituted full extent of optimisation. It is simply the first step towards a more efficient overall industry.

It is the most important first step for two reasons:

1. Information – The information gathered by the harvester in the process of producing the log products is the key platform for the information exchanged throughout the entire system – be it to forwarders, log trucks, despatch coordinators, foresters and mill procurements officers.
2. Value Recovery – The biggest losses in forest value are made not necessarily by cutting the wrong mix of products from a stem, but by the contractor not being allocated the right mix of products from the stand.. Inappropriate allocation of compartments and products, as well as the rigid implementation of quotas to put a band-aid over these allocation

mistakes are the enemy of value recovery. Collecting and analysing the information from the harvester will clearly show this practice to be severely damaging to a forest enterprises profitability.

It is the author's view that any work carried out now to implement the first stage of optimisation – the "customer-forest manager – contractor circle"; is done so with a view to how decisions made now could impact upon the ability to capture some of the future benefits of optimisation as the industry adapts to the opportunities.

Whilst some of the systems that are used in Finland may seem a long way off, it is important to consider how quickly technology adoption can occur once momentum builds, and that it is unwise as an industry to paint ourselves into a corner with long term arrangements that lack flexibility to evolve.

In-Forest Optimisation

Notwithstanding the above view that a broader idea of optimisation across the industry offers some major long term benefits, (and is still some ways from being achieved), the original postulations of this Gottstein study have been validated in regards to the in-forest optimisation component.

From the research carried out with the Gottstein Trust, direct experience at Wespine Industries and correspondence with other people in the industry, there are some key areas that need addressing for the best implementation of in-forest optimisation in Australia, and for laying the groundwork for future evolution to an enterprise/industry wide tool.

Contracts

Contracts for harvesting and supply need clearly defined expectations. These should be measurable, and should be measured and reported upon regularly to maintain a focus on their attainment. Key performance indicators in the case of harvesting contracts should specify:

- acceptable limits of value recovery (as opposed to volume recovery)
- product quality standards,
- product delivery expectations,
- safety and health indicators
- upholding of environmental standards

Haulage contracts should cover much the same areas, but with a focus on efficient haulage that has as its goal the servicing of customers wood yards, rather than the servicing of the harvesting contractors roadside stockpiles.

Customers too should be accountable to uphold key performance indicators. The obvious ones would be unloading times and safety and health.

Some forest owners in Australia are implementing "score cards" whereby the relative importance of each KPI criteria is weighted, and at regular review periods performance is evaluated. However, it could be considered worthwhile for contractors to meet with and assess their forest managers or processing customers against how they are helping the attainment of the contractors KPI's. Often, decisions made by processors may have unintended flow on effects to the forest owner and their contractors; this would be one mechanism to help identify issues and improve systems as a whole.

Another important feature of the Finnish system is that a number of forestry companies utilise "frame" contracts, which are analogous to what Australian's would term "evergreen" contracts. Provided that a contractor is meeting the performance targets in all areas of the business, then his (typically 3 year) contract will be rolled over for another year. This means then that a contractor always has at least three years to run in their contract. This stimulates continual reinvestment in equipment as and when needed, rather than like in Australia where a contractor will hold onto older equipment until a new contract period is confirmed (just in case the contract is not rolled over). However, price negotiations are still carried out on a regular basis and inability to agree on price can still trigger the end of a contract.

Sawmills and their suppliers also need to review their expectations (contractual and otherwise) when it comes to length mix. Some mills receive upwards of 90% of their intake as 6.0m logs. Even the most cursory analysis of inventory (MARVL) or STM data would show that this practice is crippling in terms of overall volumetric recovery of sawlog per hectare. The question needs to be asked is:

- Are sawmillers' willing to retard significant growth potential (in the face of declining resource availability) for the sake of maximising short term gain of preferred length logs?
- Are forest owners prepared to accept a 3-4% reduction in total volume of sawlog per hectare to keep customers flush with preferred length logs?

These are difficult questions, but they should be explored if people hope to grow the Australian forest industry on a rational basis.

Log Assessment and Reject Log Systems

Most Australian sawmills have log delivery assessment systems that are not conducive to optimisation. Logs are assessed on a "sudden death" basis. If a sawmill has a minimum diameter tolerance of 200mm and a log is delivered with a diameter of 199mm, then it is rejected and no payment is made. It is understandable that sawmills need to maintain control of the minimum quality of their supply, but it is also understandable that contractors will instruct their operators to avoid doing work they are not paid for by setting their minimum diameters to be quite some way above the sawmill minimum. Further, with a similar situation in sweep specifications, many operators will cut a "safe" short log rather than run the risk of getting an out of specification long log. This results in an unintended value and volume loss to the system.

One alternative method, and the one used in Finland is to prescribe a tolerance on logs that are out of specification. Depending on the mill an allowance is made for up around 3 to 5 percent of logs to be out of specification before sanctions are applied. These could be non-payment for further reject logs or a discount applied across an entire period's supply.

Another alternative is to devolve some responsibility to individual harvester operators to keep their machines well calibrated. This could be achieved by the sawmill removing under-diameter as a reason for rejection provided that the supplier can demonstrate that their contractors machines are regularly calibrated and their controls files specify a minimum diameter equal to that of the sawmill.

In summary, log buyers need to understand what impact the way they handle out of specification logs has upon the thought process of their log suppliers and contractors.

Monitoring and Reporting

The quality, standard, frequency and timeliness of information flow back from mills to suppliers to contractors needs to be improved in Australia. This does not necessarily mean having integrated IT systems like in Finland. More utility could be made of existing systems. Many sawmills have log scanners that record all sorts of information, including length, diameter, sweep, volume etc. The information from these systems may never currently leave the mill. However the data represents a huge resource for reporting back to suppliers about their quality and performance against expectations.

Processors' in Finland are regularly reporting back to their suppliers about length mix, diameter mix and reject proportions. Further, the information provided is timely – in other words delivered in such a timeframe that something can be done about it in the forest to prevent the situation deteriorating further. The information reported upon is also meaningful because in Finland it is related back to contractual performance indicators.

In the absence of scanners, the laying out and assessing of sample loads by forest officers or logyard staff, along with tally sheets that have a copy forwarded to the responsible supplier/contractor are just as useful.

To be effective in the forest as a value recovery tool, the people making the cutting decisions in the forests need to have up-to-date information about the decisions they are making and the effect it has at the mill. For instance, it is not enough to tell a harvester operator that two months ago they were cutting too many swept logs – in that time they will have cut many thousands more logs. Further, they probably cannot recall what thought processes and decisions they were making such a long time ago, so will not be in a position to modify that behaviour.

Payment

The systems that are used for payment are vitally important to making any system work in Australia. Payment systems must encourage alignment of interests, such that all parties are working in the short, medium and long term in such ways that augment the recovery of value from the forest system.

This should at the first instance flow from the sawmill who needs to set an example. If there are marketing or productivity benefits to be had by processing long (> 4.8m) logs, then it is essential that there be some payment consideration reflecting this. Processors should bear in mind that when setting up the value optimising tables in a harvester, the forest owner will be ascribing higher relative values to those logs that earn more revenue for the forestry company. If the processor wishes to maximise the production of preferred length classes, then price signals should be broadcast. A diligent processor should however keep themselves abreast of the value setting process to ensure that any premium they may pay is being reflected in the harvester setup.

Many sawmills in Australia currently have log price increments based on diameter – larger logs attract a higher landed cost. This may have some validity in terms of volumetric recovery, but it is a consideration that is in many cases being eclipsed by access to resource. Within economic forestry time horizons the attainment of large diameter logs is biologically incompatible with attaining maximum volume per hectare.

Increasingly it will be the attainment of maximum volume throughput for a sawmill that will determine its' competitiveness on the international market, not the average diameter of its feedstock. Engineering solutions are available and will continue to be developed to increase the recovery from smaller diameter feedstock. A solution is harder to find for a static or shrinking resource base.

Sawmillers should consider if the means by which they pay for their logs is encouraging silvicultural practices by their suppliers that will lead to maximising volume per hectare. Moving towards a flat rate per cubic metre of in-specification sawlog, irrespective of diameter may be one means to encourage forest growers to focus on the total volume per hectare rather than individual tree size.

From the point of view of the forest owner/manager, it is clear that there are some products that produce a higher average margin of return than others. The value matrix of an optimiser should be constructed to reflect this. Of course, without the correct allocation of forest blocks, an unconstrained optimiser cutting to value can (and often will) generate an imbalance of certain products over or under demand. This is where the data from the harvesters and inventory systems inform decisions about harvest block allocation and scheduling. The implicit difficulties of scheduling harvest against a backdrop of environmental constraints and market changes will always necessitate a certain level of individual cut-block sub-optimisation. They key is to manage the system such that the absolute emphasis is on cutting each block to value – not cutting each block to demand. The correct mix of blocks will take care of meeting demand.

It is understood that depending on the harvesting contract, a minority of contractors are paid according to the difficulty or time expenditure of cutting a certain unit size of product. For example 1 m3 of 0.05m3/piece chip log will take more time to cut, load and deliver than the equivalent volume of 0.3m3/piece sawlog. Hence some contracts specify a higher rate for the products that are more time consuming to produce.

This may have some validity, but it does not promote the alignment of forest owners/managers/processors and contractors interests. In fact it creates a divergence and a direct conflict of the contractors and forest owners interests. In the unlikely event that a contractor was to deliberately downgrade sawlog to chip log, their net revenue would actually be improved. This creates a situation where costly and resented enforcement becomes the norm.

A better system would be a where the contractors were paid a flat, or even higher price for producing the products that yield the forest owner a better return. Supervision or monitoring of contractors would be reduced as now it is in both partys' best interests to maximise the volume of higher margin products.

Of further importance is passing onto the contractor some component of any premiums paid to the forest owner/manager by their customers. If there is a premium for long length logs, then a consideration should be paid to the contractor. Again, alignment of interests is paramount.

The key is to take stock of the system and consider if the system of payment is self-supporting? Do contractors need constant monitoring to ensure they cut certain products, or do they chase them off their own initiative? Do sawmills pay in such a way to encourage the log supply they want, or do they pay for one attribute but really value another?

Training and Professionalism

There is a general lack of understanding in the Australian forest industry about the concept of log value recovery. Most people understand well how fibre or volume recovery works. Perhaps this is a consequence of a great deal of public sector involvement in the forest industry, where land managers must consider the views of a general public who are unaware that sometimes recovering the highest level of value from the state's forest may not equal full utilisation – resulting in some apparent "waste".

For quite some time, as long as customer orders were being met, then things were considered to be going well. However, with some privatisations of forest resource and most state agencies being tasked with being commercially focussed, the need has arisen for forest managers to be aware of how to extract maximum value from their forest.

It is important the forest operational staff and their managers develop an understanding of log value recovery. There are some excellent resources available in the literature, and some service providers specialise in value recovery implementation and audits (www.interpine.co.nz). An outstanding means by which to become acquainted with value recovery is to become familiar and work with a modern forest inventory program, such as ATLAS or MARVL. These systems essentially work in the same way as an optimising harvester, except rather than working off of a real stem they work on a "virtual" stem described by diameter and height measurements taken in the forest. Familiarity with scenario or "what if" analysis is the fastest way to gaining an appreciation of what value recovery means, and what impact such things as; changing diameters, length mix, relative values, product prices, number of products and sweep specifications will have upon recovered value per hectare.

It is just as critical that contractors' staff and operators understand what value recovery is and how to achieve it. It is highly recommended that harvester training institutes in Australia should undertake to pass onto trainees (particularly those entering the softwood industry) the key elements of value recovery, before production issues once they are employed focus then single-mindedly on volume production.

The Finns' approach to operator training is quite eye-opening and serves to reinforce the importance of a well trained workforce. It does not matter what systems are in place – just one operator in the forest who has not been equipped properly for the job can counteract any potential benefits to the system. Hence the Finns' focus significant resources to ensure that all operators are trained sufficiently to make the right decisions independent of constant supervision.

Whilst Australia has a skills shortage for harvester operators, and particularly for the hardwood (bluegum) sector, it would be unwise to focus solely on just getting operators with the motor-manual skills into the machines. The WA Forest Training Centre is presently exploring options to increase trainees' exposure to value recovery concepts.

Support

Finland has the benefit of many years of experience with optimisation. Each company has amongst its staff what could be termed "systems specialists" who understand the logistics/value/optimisation process in quite some depth. These people are invaluable resources. Australian organisations should attempt to emulate this situation, and create as senior roles within their organisations positions that have a focus on understanding the broader issues of optimisation, and work closely with and support the more operationally focussed staff to implement policies and procedures that will improve value recovery and customer satisfaction.

A key factor in Finland's efficient system is the information technology infrastructure. Whilst this system was developed to cope with the record keeping and bureaucratic intricacies of a massive forest industry with non-integrated ownership, there is no reason why Australia cannot adapt such a system to our own conditions. With a focus on cut to length harvesting operations, it could be readily implemented.

Irrespective of an enterprise wide logistics frame to support the process, efforts should be made as described above to automate or streamline wherever possible the monitoring and reporting tasks to enable rapid feedback and performance assessment.

Purpose, Culture and Attitude

There is a clear understanding about how to maintain industry effectiveness and efficiency across all sectors of Finland's forest industry. It is the business policy of the national government's forestry agency to deliver "fluently to the customer"[10].

A culture that promotes improvement and efficiency is paramount across all sectors of the forest industry in Finland. Whilst they have excellent information systems to provide the data for decision making, it would be worthless without a determination to continuously improve the forest industry.

All parties recognise the interdependence of their businesses. The revenue may flow from the sawmill or pulp mill, but that revenue must be sufficient to promote reinvestment into the growing, managing and harvesting of the mill's future resource.

Because of this recognised interdependence, the attitudes held by companies involved in the different facets of the industry are not adversarial. This is not to say that tough negotiations, disagreements and confrontations do not occur. However, general vibe in Finland seems to be that once the ink is dry it is more about getting on with the job. There is not such an air of recriminations and animosity that one can encounter in Australia.

Perhaps in large part this is due to each facet of the Finnish industry having an understanding of what the other partys' needs are, and how one party's actions affect another's.

Finland has a very strong focus on customer service. Customers of the large forestry are not viewed as an inconvenient but necessary step to enable payment for whatever logs they may receive. They are included in the planning process from the start, to ascertain their needs and develop a plan to harvest the right mix of compartments to meet all customers needs.

At this stage, Australia has quite some way to go, sawmills and processors have not been engaged in the supply chain process. In most cases the processors are not currently interested, or sometimes they are not invited into the process.

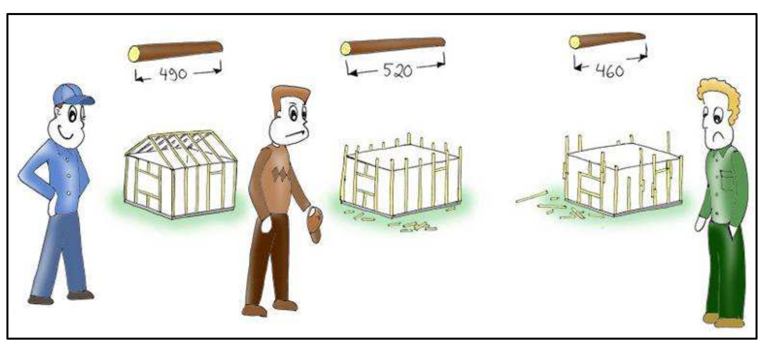


Figure 13 - Illustration from Harvesting Equipment Manufacturer Presentation on Value Recovery and Customer Satisfaction

[10] Heikki Kaarianinen – Metsahallittus Harvestin

However, this engagement of processors is vitally important to ensure that the right drivers are fed into the implementation of optimised log making in Australia. It is difficult to emulate a customer focussed system if the customer is not contributing.

Another missing element is that many Australian mills do not know exactly what type of log type they need to be productive and profitable. They might have a preference for longer logs (e.g. 6.0m) and reflect these in their orders and expectations, but are they aware of the length by diameter combinations that may yield a better match with the products they are marketing?

Australia could go a long way towards fostering a culture of “partnerships” within the forest industry, rather than adversarial arrangements.

Part Two: Technical Aspects of the In-Forest Optimisation Process, APT File Creation and Value Setting

This element of the report will describe the process of how the different types of optimisation work, and some of their advantages and disadvantages. It will also explain in some detail how one may go about laying the foundations for a solid APT file that will serve well over a long period of time. This includes getting to know your log specifications, codifying them in a consistent manner, thinking about naming conventions consistent across your organisation, and some considerations to be observed when putting together an APT file.

However, there is no exhaustive step by step explanation of the detail of how to navigate about and use SilviA. program. An excellent resource produced by John Deere entitled "Quick Tips for SilviA and Timbermatic 300" is available for download from the Gottstein Trust website.

It is considered more important to convey the key elements of what needs to be gathered and considered to put together the APT file. The actual putting together of most parts of the control file are fairly mechanical. However, as it will become clear from the descriptions below, there is a great deal of customisations and special features in the SilviA program. Separating out the important program options from those elements that even the John Deere staff do not know the function of is very important. These features, along with the elements of APT file creation that consistently catch people out will be covered in some detail.

Basic Value Matrix Optimisation

The basis of the optimisation used in modern harvesters is the "value matrix". Put simply, each basic product (e.g. sawlog, export, pulp) is ascribed a value. Subject to the physical constraints of the tree (length, diameter) the optimiser will allocate the log products in such a way to generate the highest value solution.

For example, a basic APT file may have the following broad values:

- Domestic Sawlog 500
- Small sawlog 300
- Export log 250
- Pulp log 150

Within each of these broad groups, it is possible to further describe them in a "matrix" format. The matrix is a 2-variable table – length and diameter. Below is a matrix for fence post cutting. Along the top are the diameter classes, and down the side are the allowable lengths.

It can be seen in the picture that is possible to set different prices for different length by diameter combinations, within a product group. This allows the targeting of particular length by diameter combinations that may be more valued by the forest owner or customer.

Length\Dia	75	100	110	120	130	140	150	160	170	180	190	200
182	950	950	950	950	950	950	950	950	950	950	950	950
212	950	950	950	950	950	950	950	950	950	950	950	950
242	950	950	950	950	950	950	950	950	950	950	950	950
272	950	950	950	950	950	950	950	950	950	950	950	950
302	950	950	950	950	950	950	950	950	950	950	950	950
332	950	950	950	950	950	950	950	950	950	950	950	950
362	950	950	950	950	950	950	950	950	950	950	950	950
392	950	950	950	950	950	950	950	950	950	950	950	950
422	950	950	950	980	980	980	950	950	950	950	950	950
452	950	950	950	950	950	950	950	950	950	950	950	950
482	950	950	950	950	950	950	950	950	950	950	950	950

One of the important things to keep in mind is that it is very uncommon to use actual real dollar values. Products values are expressed in "relative" terms. This relative value expresses a preference for one product over another. To use the real values would lead in many circumstances to a situation where there was insufficient difference in price between products for the optimiser to make a decision. There should be a minimum of 50 units difference between the broad products groups relative values.

Value based optimisation without any sort of distribution cutting (to be outlined further below) will cut out of each stem the solution that achieves the highest value, with no reference to what has been cut. Essentially, as soon as a stem has been processed, the results are "forgotten " by the harvester. This works well to maximise the theoretical value of a forest, but unfortunately can lead to problems in such situations where a very high value product actually has low demand. The optimiser, unaware of the demand side will work hard to produce the maximum volume of this high value product from every stem, possibly resulting in a large oversupply.

The method used in Scandinavia is to use some form of distribution cutting.

Distribution Matrix vs. Limitation Matrix

Most harvesting systems can have two options for managing log product distributions. The first, and most commonly used is the distribution matrix, and works by specifying, within a diameter band for a product, the desired length mix. For example, in the picture below, it can be seen that for sections of stem (that is sawlog quality) with a diameter of 500mm; that the desired length mix, over the duration of the harvesting operation is:

- 60% 6.0m
- 10% 5.4m
- 5% 4.8m
- 20% 4.2m
- 5% 3.6m

Length\Dia	180	200	250	300	350	400	450	500	550	600	650	700	750
305	0	0	0	0	0	0	0	0	0	0	0	0	0
335	0	0	0	0	0	0	0	0	0	0	0	0	0
365	0	5	5	5	5	5	5	5	5	5	5	5	5
395	0	0	0	0	0	0	0	0	0	0	0	0	0
425	0	5	5	5	5	20	20	20	5	5	5	5	5
455	0	0	0	0	0	0	0	0	0	0	0	0	0
485	20	20	20	20	20	5	5	5	10	10	10	10	10
515	0	0	0	0	0	0	0	0	0	0	0	0	0
545	20	20	20	20	20	10	10	10	10	10	10	10	10
575	0	0	0	0	0	0	0	0	0	0	0	0	0
605	60	50	50	50	50	60	60	60	70	70	70	70	70

The practical effect of this is that 6 times out of 10 when the harvester encounters a 500mm stem section, it will cut a 6.0m log. One time out of 10 is will cut a 5.4m log and so on. Over the course of the operation, the sawlog out-turn from the forest will very closely resemble the desired distribution. This is a very powerful tool and is well utilised by procurement companies seeking to provide customers with logs that best meet their needs, without sacrificing forest value recovery. The distribution type used in Finland is always the "sum to 100 within a diameter class". The "overall matrix summed to 100" approach is not used and is in fact incompatible with many IT systems in place there.

The Limitation Matrix is not widely used in Finland. It works by setting a limit upon production. For example, it may be specified that 4.8m K Grade logs for export should be cut up to a limit of 500 m^3. Once the harvester has cut this volume, it can be pre-programmed to cease cutting this assortment, or notify the operator who may then choose to keep cutting or not.

Its primary goal is to fulfil “once off” type orders. This is not a common occurrence in Finland, as log flows are well managed, to fulfil well understood and continuous orders. Consequently, contractors are seldom instructed to add or remove products from the cutting.

However, it could have an application in Australia, for handling volumes of logs that are prevalent in a forest but demand is limited. For example, from pulp log production in a thinning operation, there may be occasion to separate out larger diameter pulp to fulfil a limited export order. Once the order is fulfilled, that particular assortment can be set to no longer form part of the possible cutting solution.

It could also be used as a means to ensure that contractually specified minimum volumes of minor products are produced from a harvest operation, by inflating the base price of the product. This would have the effect of encouraging the harvester to seek out that product until the specified volume is met. This would of course have implications for overall value recovery from the forest, and should trigger investigation of whether the current mix of forest quality is appropriate to meet customer orders. The ideal solution where possible is to have all harvesting units cutting to the maximum value, and manage the product flows by appropriately allocating harvest areas.

Comparison of Distribution Optimising Methodology

In Finland the most used method for optimising towards a desired end state distribution is “near optimal”. Few optimisers are running in purely “value mode”. Decisions that are made by the optimiser only in value mode are made by the computer with no hindsight. In other words, the computer does not make the decision on the current tree with any reference to the past trees.

This has severe limitations when attempting to meet a specific order for products. Operators may compensate for the absence of certain products needed to meet an order by adjusting prices within the matrices, however the emergent flow on effects that may be detrimental to meeting orders for other products.

Optimisers running in Scandinavia are typically set up such that the computer compares its production to date to an “ideal solution” (based on customer demand). It can then either adapt values on the fly, or allow some latitude in value to achieve an outcome closer to the perfect solution.

Descriptions for the two methods used within the SilviA program are below:

Adaptive

The adaptive distribution optimising method compares production up until the current point to the target distribution, across all log products. With consideration of allowable deviation levels (typically around 5% of original values), it will adjust the relative values to favour a solution that will move the actual distribution closer to the desired distribution.

In practical terms, the control system will drop the value of over supplied products by up to 5% and increase value of oversupplied by up to 5%. It has been said in the past that the adaptive optimisation was slower with older technology; however this is no longer the case.

Near optimal

Near optimal is by far the favoured solution in Scandinavia, and is simpler to understand and implement, and leads to nearly identical results. The first step is that the control computer predicts the stem profile and allocates log products to obtain the maximum value solution (irrespective of trying to meet distribution demand). This maximum value represents the upper bound of what the control system believes can be achieved from this stem (based on the values in priority matrix tables). The system then runs another iteration to see how close it can get to the desired distribution for all log products.

It is possible that the solution that best meets customer needs may result in a large reduction in recoverable value from that stem. For instance, the optimal solution may be to cut the sawlog component of the stem to lengths of 5.4m with a 4.2m recovery log. However the preferred length for the sawmill customer might be 6.0m, and to cut this hypothetical stem purely to 6.0m would result in volumetric loss of sawlog recovery.

The system will compare the value generated from the optimal value solution to the value generated from the solution best matching the customers' needs. It will then cross check the percentage difference between these two potential outcomes to a permitted deviation level. This level is typically set to around 10%. If the solution closest to the ideal distribution is further from the optimal value solution that the deviation level, then the distribution solution is rejected, and the optimiser does another iteration. This iterative process continues until a solution is found that is as close as possible to the desired distributions without breaking the permitted deviation constraint.

To illustrate, the highest nominal value solution in the illustration below may be $1000 nominal dollars. The second solution best meeting customer needs may come to $890. Hence the system will re-optimise until the difference between the two solutions reduces to less that $100 (if 10% is used as criteria). This may sound like it would take a lot of computational time and slow down production. In reality, it is near instantaneous, and the best outcome that satisfies all constraints, while as close to the desired distribution as possible takes no more time that it does for the harvesting head to progress 1m down the stem.

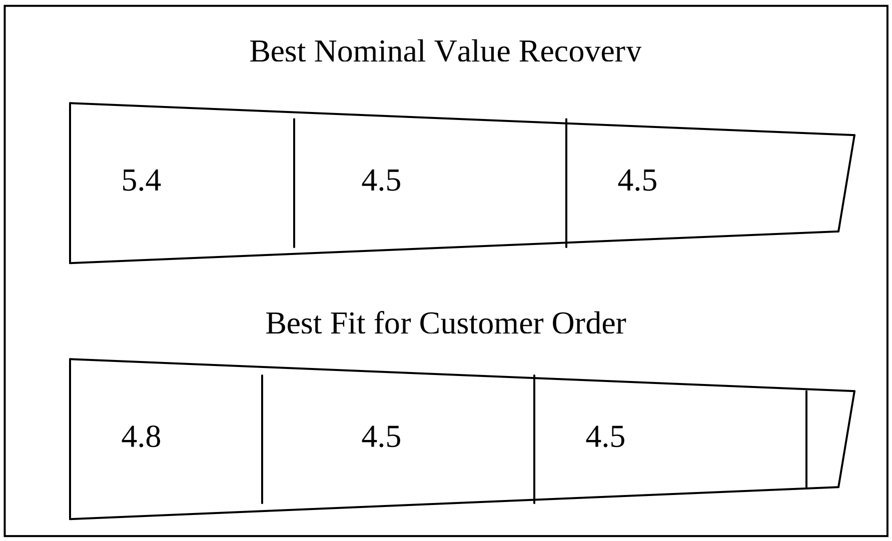


Figure 14 - Example of Distribution Decision Making – 2 approaches to log-making on the same stem

Both methods are comparing actual out-turn to a desired state, and are working towards filling in the gaps. Both contain checks and balances to prevent the system from compromising forest value to meet unattainable customer expectations.

Both options will over the course of harvesting a block, actively fill in missing length x diameter combinations where forest value can be preserved. Near optimal log making will fill missing length by diameter combinations faster than the adaptive.

A concept that is being worked on in Finland is that of a central computer server, that in real time takes delivery of all machines production statistics and works as a central distribution point. For example, if one machine in high quality forest is producing what looks to be the wholes weeks needs of a product, then the central system will update the other machines cutting lists to reduce or eliminate that product. It could also have major benefits for getting the proportions of products right within a diameter class. Some forests may suit certain length combinations than others, and rather than forcing the machine to cut all assortments, all the time, it may be possible to reallocate some length x diameter assortments from one machine to another. For instance there may be a low quality forest with a great deal of sweep forest that needs more short length sawlogs to be cut manually to achieve volume recovery targets. The central server would take this into account and increase the long length targets for the machines operating in the good quality forest.

At the moment, this must be done manually – a forester must make a call based on site inspection or actual outturns after a few days operation. Good quality forest could have the targets for long length sawlog set higher, and more latitude given to poorer quality forest to cut shorts, with the overall goal of meeting customers expected/agreed length mix.

Setting the Distribution Matrix

Finland's forestry companies have a quite involved process for understanding their customers needs, and doing their best to satisfy these needs from the forest areas they have under contract. This is achieved is by the use of what is known as the distribution matrix see Figure 14). The goal of which is to best match the forest potential to the needs of various customers. Importantly, it should be noted that the distribution is not arrived at purely without reference to the realities of the forest. There is some degree of consultation between the sawmill and the procurement staff to make sure that the distribution is attainable. It is important that this consensus be reached, as attaining the specified distribution is an important part of many contracts performance measures (both harvesting and supply contracts). Setting an unattainable target is in neither parties interests.

A range of 80-90 % attainment of desired distribution is typical, with questions asked if it falls below 85%. Only in the very worst forest does it get below the 80% level.

There can be a value difference between cutting for value and cutting for distribution. This can be managed by setting the allowable deviation between the "ideal optimal solution by value" and the "optimal solution for distribution". Finnish companies usually run at around 10-15%.
In reality, the issue is only detected in the last logs diameter as this is only thing that forest owner notice.

Appended on the Gottstein Website is a link to download a very good manual on the construction of log specifications, and APT files including distribution, value and limitation matrices.

SilviA Development

The SilviA program has developed over many years, in response to many different customers requiring it to do many different things. As a result, there are many elements contained within SilviA that may seem very important to the casual user, but in actual fact do very little. Similarly, a number of the critical variables that go towards making a successful APT file are squirreled away or relatively innocuous.

SilviA is able to produce compatible APT files for, and read output files (e.g. PRD) from, any StandForD compliant control system. This includes the likes of John Deere, Motomit, Ponsse, and Valmet. Likewise, other control systems manufacturers also produce programs that perform the same job as SilviA , like DASA's WinAPT. Because the end result needs to be an APT file that numerous manufacturers machines must be able to interpret and implement, then necessarily the program to create them would have similar functionality and work methods.

APT File Generation

Quality Codes

The use of quality codes is a means to tell the optimiser about things that are happening on the tree that the harvester's own sensors cannot tell it. The harvester can detect diameter and measure length. It can also predict taper and determine where on the stem diameter cut-offs between products (e.g. sawlog to 200mm SED) occur. The system cannot see things like; branch size, pruned butts, sections of live branches or dead branches, sweep, rot, scarring and forks.

The latter elements – sweep, rot, scarring and forks are handled by manually overriding the computers solutions to dock out poor sections of stem, or reduce the suggested length of the log to meet sweep tolerances.

The first three quality attributes mentioned can be best handled using quality codes. Most control systems have around eight available codes. In Finland, these codes are usually used to represent zones of live or dead branches. Some processors are not able to accept dead knots into their product, (as they fall out of timber, which may look unsightly in wall-lining boards, for instance). They may also represent zones free of branches that may be ideal for high quality veneer logs.

In Sweden and parts of Australia using optimisers, these codes are used to represent branch sizing. This is important for differentiating between logs that may or may not be suitable for structural uses. Grading of timber to meet the Australian standard requires typically that a knot may not occupy more than half of the cross sectional area of a piece of timber. Therefore, sawmillers are more interested in logs with smaller branches. Forestry companies operating in NZ and Australia commonly use a branch size limit on logs for structural end use of around 60-70mm. This limit has been found to achieve an acceptable level of downgrade in finished lumber. Manufacturers of products like treated fence posts are also interested in logs that have a small branch size – for ease of peeling to a marketable "perfect round". On the other hand, purchasers of logs for chipping may have no preferences with respect to branch size.

Hence it makes sense to classify the log products in terms of allowable quality features. Thus when the observable quality of a stem changes (be it due to branch size change in Australia) then the operator can inform the control system of this change, and select appropriate assortments.

The selection of the appropriate assortment can be viewed as a filing system. Into "File A" you place the log products that can be cut from small branch size sections of stem. In most cases this will be all products – you may not want to cut this into pulp-log, but if you must, there will not be any complaints from the pulp-log customer. Into "File B" you would place a smaller subset of products – maybe the Premium Grade sawlog is no longer in contention, but structural sawlog is still there, along with all the remaining products. This process continues, until your last "File" representing the lowest quality material with very large branches, may only have one assortment in there – pulp.

When an operator keys in a quality code, the appropriateness of a filing analogy becomes clear – the control system/optimiser will go to its filing cabinet and pick out the file for the quality code that has been selected. It will then optimise the allocation of those assortments to maximise the value for the stem. If, further along the tree, the quality changes again, the operator selects the new quality code, the control system puts away the last file, opens the new one, and re-optimises.

It is important to remember that the control system does not actually know what Code "A" means. All it knows is to refer to "File A" and optimise the placement of those log assortments that are in folder A to the current stem.

This means that careful thought needs to be given in the early stages of implementing an optimising fleet of harvesters to set down meaningful quality codes. If the codes meanings (e.g. A was 45mm last week, now it is 60mm) are changing regularly, it means not only re-programming the APT file (a relatively easy task) but also reprogramming the harvester operator (not an easy task).

Further, it will also mean that the STM profiles created from the earlier harvesting (which are tagged with the quality codes as well as diameter and length data) will not be compatible with future simulations using the new quality codes. For example, if in 2005 Quality "A" represented logs with branches less than 45mm, but in 2006 "A" was 80mm, simulations of future production from forests similar to those cut in 2005 will be erroneous if stem files from 2006 were used.

Assortment Naming

It is strongly advisable that a consistent set of naming criteria be adopted for all harvesters working for a given company. The reason for this becomes clear when one attempts to merge production reports from different machines to get an overall picture of production over a period of time. Operating on database style rules, each assortment that has a different name will be tallied separately.

For example:

- Contractor A may call sawlog "Sawlog"
- Contractor B may call sawlog "Log"
- Contractor C may call sawlog "Auspine" after the name of the mill.

When these volumes are tallied or collated into a grouped PRD file, getting an accurate accounting of the sawlog produced in the time period will be reliant on the forester/supervisor to know what each contractor (or operator) calls each product.

A superior approach is to have company-wide naming conventions. Two Australian forest owners are known to be using a simple and consistent naming system that conveys substantial information about a log assortment/grade without needing voluminous specifications to hand. It centres on a log name that is made up of:

1. Species Code (e.g. R for Radiata, P for Pinaster).
2. Quality Code (e.g. A for < 45mm branches, B for < 70mm branches).
3. Minimum SED
4. Allowable sweep (e.g. SED/5).
5. Product Type (e.g. S for Sawlog, C for Chip, L for LVL peeler).
6. Length range (e.g. 3.6m – 6.0m)

To illustrate, a mill may require radiata pine sawlogs, with knots less than 70mm, a minimum diameter of 200mm, sweep of no more than 1/5 SED, and lengths of 3.0m to 6.0m. Using the suggested naming conventions the product could be identified as follows:

RB2005S 36-60

For convenience, the allowable length can be left off. Either way, it succinctly identifies the key characteristics of this product, in such a manner that an operator or supervisor unfamiliar with the product could still produce the log product in a workmanlike manner in the absence of better log specifications.

Codifying Log Specifications

Considering the above discussion on log naming and quality codes raises the issue of how an organisations log specifications are organised. The clearest and easiest manner to facilitate their conversion to a workable APT file is to tabulate them. This simply means laying them out clearly, for ease of reference both for those who create the APT files, but also for those who may need to refer to them in the forest.

Laid out below in a tabular form are some sample log specifications, covering a range of sawlog, LVL peeler logs, "Pres" (posts and rails for fencing) and chip. The table has been put together in such a way to convey easily all of the information needed to put together the log definition side of APT file generation.

The table below the specifications allocates a branch size to each of the Quality buttons. The quality button applicable to each log product can be read off of the "individual branches" row of the log specification.

Pine Log Specifications

Product Code/Group		SAWLOG				PEELER/LVL		PRES		CHIP
Name		RA2005S-3060	RB2005S-3060	RC2005S-3042	RC1505S-2133	RB1507L-2681	RC1504L-2681	RA7510P-1848	RB1507S-912	RF752C-54
Diameter	Min	200	200	380	150	150	150	75	180	75
	Max	1000	1000	1000	250	600	600	200	650	350
Length	Min	3.05	3.05	3.05	2.10	2.70	2.70	1.80	9.00	5.40
	Incr	0.3	0.3	0.3	0.3	2.7	2.7	0.3	11.0	0.0
	Max	6.25	6.25	4.25	3.3	8.1	8.1	4.8	12.5	5.5
Sweep	% SED	20%	20%	20%	20%	15%	25%	x	15%	50%
	Absolute (mm)	-	-	-	-	-	-	10	-	
Multiple Sweep		20%	20%	20%	20%	15%	25%	➩	➩	50%
Individual Branches (mm)		45	70	100	100	60	100	45	60	no limit
Knot Cluster		➩	25%		25%	20%	25%	➩	➩	50%
Spike Knots (mm)		60						➩	➩	100
End Cuts		Square								no limit
Trimming		Flush			Flush	Flush	50mm	5mm	5mm	Flush

	A Quality	B Quality	C Quality	D Quality	E Quality	F Quality
Branch Size	50	70	100	150	200	Unlimited

Testing APT Files

Testing APT files before their introduction to a production harvester is an important part of the process that could not be stressed enough by the tutors at John Deere. A poorly executed APT file will not only perform poorly for the forest owner, it will also not achieve the customers needs and will most likely cause frustration and loss of revenue for the harvesting contractor.

Two items of software are needed for the best testing of APT files. The first is a licensed version of SilviA SIM. The SIM version of SilviA allows scenario testing of alternative cutting plans (APT) against a user specified set of STM files. Usually one will use the same STM files for each APT to test the effect of the APT file upon a matched dataset.

The second piece of software is a T300 simulator. T300 is the control system used in the John Deere series of harvesters. The simulator is actually the identical system as in the harvester, but the information fed usually from the harvesting head is only simulated. A user can also select appropriate local stem files for the simulator to work on. In the simulator the operator must actually make the same decisions as what a machine operator would in real situations.

Three stages were recommended by Mika Laakso of John Deere:

1. Simulation of the APT file using the laptop simulator of harvester. The goal is to look for errors and problems. Does the system flow, and are quick and smooth decisions being made? Are there any surprising log-products being cut or are they being cut in unwanted distributions. Some experience with how a machine performs in the field is useful at this stage. Perhaps an experienced operator may be able to provide some input. In other words, does it work?

2. Simulation using SilviA SIM – This is to investigate the overall product mix over a much greater sample of previous stem files – which could number in the thousands, as opposed to ten to twenty in the harvester simulator. The key goal here is to test the outcome from the point of view of the forest owner/manager. What product mix is created? – are there "orphan products" i.e. only 1 m^3 out of 1000 m^3. The best idea is to remove them from the APT file right away. Otherwise the harvester will cut these products in the forest and will never actually be able to make up a truckload to deliver them. Now is also the time to add or remove different log products that could be cut from the harvesting operation and test the value recovery consequences.

3. Once the final mix has been decided on, it is a good idea to check it again in the harvest simulator to ensure that any last minute adjustments to cutting tolerances, product mix etc do not have unintended consequences on how it may cause the harvesting machine to operate in the forest.

APT Tips and Tricks

Quality System Setting

The "Decreasing" Quality system is used when qualities are in ranked order – i.e. quality 1 is best and quality 6 is the worst. For example it could be used to tell the system that when quality button 4 is pressed, then the products to be selected may come out of the "folders"/assortments for which quality 4 and better has been specified.

The "Specifying" system says that, using the same example as above, if button 4 is pressed, then only the products from the Quality 4 folder may be selected (so none from folder 1, 2, or 3).

In practice, it is best to use the Specifying system, but set it up in such a way that mimics the operation of the Decreasing. For instance, if a product could be made out of Quality 4 and better, one could use the decreasing system by ticking the quality 4 box when creating the APT file. The same thing could be achieved using the Specifying system by ticking each of the Quality 1, 2, 3 and 4 boxes during APT generation.

This may seem like extra work, but the downside of going solely with the Decreasing system is that if you have allocated a quality button (e.g. 5) to a specific quality feature (e.g. pruned), for which you only have one desired product (Veneer bolt) then when that button is pressed on the harvester, the system will consider all products available in 1,2,3,4,5 and not just the specific product that you had in mind.

Starting Quality

Setting the starting quality for the optimiser should be decided based on the predominant quality of the stems to be harvested. There is little sense in letting start quality be set to A (in the examples throughout this report A = branches less than 45mm) if the trees being harvested are widely spaced trees on a fertile site, that have large branches. Quality "B" would be a better option in this case, to reduce both the amount of button pushing needed to be done by the operator and the instances of inappropriate first log selection.

For instance if the machine is told to assume A quality and the highest value A quality product is a 12m power pole, the machine may be halfway along to the 12m point before the operator can tell the control system that in fact the quality is B. The processing head will then have to move backwards to the highest value product in the quality B "file", which if that was a 3.6m log, will take a long and unnecessary amount of time. If the predominant quality in the harvest block was "A" then this would be an acceptable occurrence, but if the dominant quality was "B", then harvesting productivity is going to suffer.

Saving and Re-Use of APT Files

Once an APT file that works well in a number of situations has been constructed, stick with it. Rather than creating a new one all the time, just tweak the current one. As you will learn in your time with SilviA APT files, there are many, many options. It is easy to overlook fully specifying all of these, especially if one is in a hurry. There are many places at which a mistake could be made. One or two errors in an APT file can make or break its usefulness. If you have a file that you've put together over time and tested, then the chances are, there are no hidden mistakes in it. It is difficult to track down these small errors in an APT file, especially in the cabin of a harvester. If you have a file where you have ironed out all of the wrinkles, then use it as a template, and only make the same mistakes once. From then on, all that needs to happen is adding/removing products and tweaking on the margins.

Length Prognosis

The shortest length of log that you may cut determines what you should have as length before prognosis. For example with a 1.8m preservation log, one should set the prognosis to occur at 1.0m. With the computing power of modern machines, it is possible to set the prognosis at 0m. However, a longer length gives the taper algorithms more information to work with.

Max Deviation up/Max Deviation Down

The control system computer makes prediction of the taper and length of the stem piece. The computer then optimises the allocation of products to this stem shape that it has predicted. As the processing head moves up the stem piece, it compares the actual diameters against predicted diameters. If the computer finds that its prediction is too different from the actual, it will trigger a re-analysis of the product allocation.

It is possible to set in the generation of the APT file, what the acceptable bounds are to be before a re-analysis is triggered. If these numbers are set too high (e.g. +/- 5mm) then it will be more likely that the solution proposed by the optimiser is not the true optimum. In other words, the picture of the stem that the computer is seeing (and optimising on) can be increasingly divergent from the actual stem. It will not however cause out of specification logs, as the direct measure of the diameter will still occur for each log cut – it will just effect the prognosis. If set too low, the system may recalculate many times, particularly if the tree is of variable diameter (nodal swelling etc)which may slow the computer down.

In Finnish conditions, and with modern computers in the cabins, John Deere recommend trying +/-0, or failing that +/-1mm. However, with more variable radiata pine in Australia, it may be more sensible to work with +/- 2mm. It may be found that when a machine first moves into a new block it re-calculates more often. This is because the system is updating the coefficients used in the taper prediction, and it is more likely to get the predicted diameter incorrect until these coefficients are corrected (automatically).

Price Type

There are a number of price type options within SilviA . These represent a number of different payment methods for log volume. The reason for the many options is because harvesting contractors and forest owners are paid for their products based on the volume cut by the harvester. Hence the volume cut by the harvester should approximate as closely as possible the basis of measurement used at the final customer. Most sawmill customers in Finland, and many in Australia pay for their logs ultimately by a log scanner using the integration of sectional measurements. This is represented in SilviA by m^3f. Other options include calculating volume as a cylinder or based on mid diameter. However m^3f is usually most applicable.

Diameter and Length

Page 13 of the "Timberjack Quick Tips Guide for SilviA and Timbermatic 300"[11] shows in some detail how to enter into the APT file the diameter and length information for each log assortment. There is an option to add length trimming allowance. Usually it is easiest to include any contract minimum over-trim into the actual length matrix. The two pictures below illustrate the two different approaches.

The first picture shows the standard approach of including the minimum over-trims into the expected length of the matrix (e.g. 1.82 for a 1.8m nominal length). The second picture shows the other approach, with the expected length as 1.8m with the over-trim in brackets alongside – 180(2). The difference is that when you specify a separate over-trim, when viewed in run-mode on the harvester, the product description in the centre of the display will show the nominal length (1.8) but the measured length will always include the over-trim that you have selected.

Length\Dia	75	100	110	120	130	140	150	160	170	180	190	200
182	950	950	950	950	950	950	950	950	950	950	950	950
212	950	950	950	950	950	950	950	950	950	950	950	950
242	950	950	950	950	950	950	950	950	950	950	950	950
272	950	950	950	950	950	950	950	950	950	950	950	950
302	950	950	950	950	950	950	950	950	950	950	950	950
332	950	950	950	950	950	950	950	950	950	950	950	950
362	950	950	950	950	950	950	950	950	950	950	950	950
392	950	950	950	950	950	950	950	950	950	950	950	950
422	950	950	950	980	980	980	950	950	950	950	950	950
452	950	950	950	950	950	950	950	950	950	950	950	950
482	950	950	950	950	950	950	950	950	950	950	950	950

Figure 15 - Standard Overtrim Method - Incorporated

[11] Courtesy John Deere Forestry

Length\Dia	75(0)	100(0)	110(0)	120(0)	130(0)	140(0)	150(0)	160(0)	170(0)	180(0)	190(0)	200(0)
180(2)	950	950	950	950	950	950	950	950	950	950	950	950
210(2)	950	950	950	950	950	950	950	950	950	950	950	950
240(2)	950	950	950	950	950	950	950	950	950	950	950	950
270(2)	950	950	950	950	950	950	950	950	950	950	950	950
300(2)	950	950	950	950	950	950	950	950	950	950	950	950
330(2)	950	950	950	950	950	950	950	950	950	950	950	950
360(2)	950	950	950	950	950	950	950	950	950	950	950	950
390(2)	950	950	950	950	950	950	950	950	950	950	950	950
420(2)	950	950	950	980	980	980	950	950	950	950	950	950
450(2)	950	950	950	950	950	950	950	950	950	950	950	950
480(2)	950	950	950	950	950	950	950	950	950	950	950	950

Figure 16 - Alternative Overtrim Method - Seperate

Spare Lengths – Creating In-Forest Flexibility

Once harvesting at a site has started, there are many edits that can be made to the APT file to reflect changes in the forest, or market demand. However, one change that cannot be made is adding new product assortments, or altering the number of lengths within an assortment. For instance, if a harvest blocks is started with a fixed length pulp log of 5.4m, and halfway through, a second length is requested – that of 4.2m, it is not possible to make the change. Likewise if a new product is needed that is not on the original cutting list, then it cannot be added without a new site being created with a new APT file.

The method to avoid these issues is to ensure that even for products that only have one allowable length, make sure that when the APT file is created, that there is another length specified (it can be any length – the key thing is just to have one). This means that if another length ever becomes available, it is a simple task to modify the lengths. Until that time, it can be set in the APT file as being "forbidden", and will not be produced.

Likewise for new products, it is a good idea to have within the APT file a "spare" assortment, with a number of length and diameter classes for maximum flexibility. That way, should a new product be needed, it is simply a case of modifying the "spare" to reflect the new log specifications. This avoids the need to have a new APT file issues urgently.

Control System Set Up Features and Guidelines

Initial Machine Set-Up

The initial machine setup is an important element to ensuring that maximum benefits are attained from the investment in optimisation. There are two PowerPoint presentations covering the basics of measuring systems available for download from the Gottstein Trust website – one from John Deere and the other from Ponsse.

The John Deere system specialist who conducted the training in Finland was very much of the opinion that standard methods are calibrating harvesters by using trees in the forest is very much a substandard option. The method used at the John Deere factory in Joensuu, Finland is by using a series of metal cylinders or pipes, of a known diameter. The operator carrying out the calibration at the factory enters into the calibration module the actual diameter of the pipe compared to the measured diameter by the harvester. The machines calibration is then automatically updated. A similar procedure is used for length also.

Options are being investigated in Western Australia for how a field-mobile set of calibrations pipes could be produced. Some success has been had with using "perfect round" fence posts that have been peeled to a constant diameter by a lathe to calibrate the small diameter section of the diameter curve.

Control Measurements and Calibration

The regular carrying out of control measurements is an important part of keeping a harvester running smoothly. It is very important to draw the distinction upfront between a *control* measurement and a *calibration* measurement.

Figure 17 – Calibration Using Metal Pipes at John Deere Factory

A *Control* measurement simply involves recording (either manually or using a print off) the diameters and lengths of some selected logs, and then exiting the cabin of the harvester and checking the degree of error between the machine measurements and the manual measurements. The results of the control calibration should be recorded in a log book kept in the cab of the harvester.

A *calibration* measurement is where a module is activated within the control system, and the results of the operators manual measurements of logs are actually used to adjust the measurement parameters inside the control computer.

Calibrations should not be undertaken lightly, as an incorrect calibration can have unintended flow on effects. Further, a poor calibration can undo a great deal of good work carried out with steel pipes etc. Controls on the other hand should be done each day. Controls are all about checking to see if the system is operating within normal tolerances. If it is, then it should be left alone.

Chris Thompson, senior lecturer at Kuru Institute in Tampere, has contributed the following advice for a control and calibration procedure.

1. Undertake daily control measure. Is it in or out of tolerance?
2. If it is within tolerance, then keep operating.
3. If it is outside tolerance, then check another log
4. If still outside tolerance, check the mechanical operation of the measuring system on the harvesting head
5. If all of this is OK, then carry out a calibration onto a selected tree of good quality and form.

Many operators in Finland use a temperature compensation feature in their machines to adjust the base curve up or down for abrupt swings in temperature that can occur in a given day during winter. This temperature adjustment can also be used as a good way to move the entire calibration curve up or down without altering the shape of the curve at specific points. Carrying out a calibration over a very small diameter range can seriously degrade the performance of the machine.

The default curve in the system memory can be used in a tight situation. It was not necessarily set with a metal pipe but the default curve is good enough to start working. Some common problems that cause a calibration to go out are loose bushers on knives (if diameter measured at knives), and worn or loose o-rings near the potentiometer. Diagnostics can be run on most brands of harvesting machines that will check the potentiometers and report upon their alignment.

The contractor for Store Enso that was visited following the factory tour commented that he has to carry out a control measure either every site he harvests, or at each 1000 m^3 , whichever occurs sooner. Stora Enso allows a 2% error either way for diameter. However, the contractor checked each day for their own peace of mind the top diameters of selected sawlogs. The target for length is to have 80% of all logs cut within -2cm to +3cm of the target (contract) length. Presently he is running at nearly 85% within the bounds. Interestingly, he has never yet had cause to revisit the calibration, as none of his control measurements have been out enough to justify redoing the calibration.

Downloads from Gottstein Website

The following files will be of use for further exploration of this subject:

http://www.gottsteintrust.org/media/barr1.pdf

http://www.gottsteintrust.org/media/barr2.pdf

http://www.gottsteintrust.org/media/barr3.pdf

http://www.gottsteintrust.org/media/barr4.ppt

Acknowledgements

The study, associated tour, and reporting presentations were generously funded by the J.W Gottstein Memorial Trust Fund and Wespine Industries Pty Ltd.

Special thanks also to Mr. Simon Shackleton and John Deere Forestry for making available their training resources and for their hospitality in Finland. Thanks also to Mr. Ian Wilson of Grand Ridge Plantations for his assistance with preparing the funding proposal and with guidance throughout.

Thanks also to Mr Jim Priddle, Hamish Marshall and Adrian Wallis for their input into reviewing this report.