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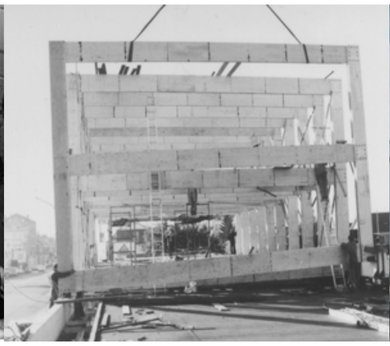
Matti Kairi

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Author Matti Kairi	

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INTERACTION OF R&D AND BUSINESS DEVELOPMENT IN THE WOOD PRODUCTS INDUSTRY, CASE KERTO®– LAMINATED VENEER LUMBER (LVL)

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In this study I have examined the problems and successes involved in the development of a wood products industry innovation, Kerto-LVL, starting from the product idea and proceeding through various phases until its breakthrough in international markets. The main research question in this study is: *How to develop a new structural product in the wood products industry, when it is not just an improvement or substitute for an existing one, and what kind of interactions between business and R&D are necessary in order for the cooperation to function smoothly and lead to a profitable business.* In the early stages of the development process a product is in the *solution market*.

The selected method used in this study is action research, concentrating on one product and its business development as a case study. I have selected various concepts to describe the position of Kerto-LVL in the market at different stages in its development. To explain the interaction between R&D and business development I have set out to define a number of hypotheses.

I have divided the development process into three stages: the pilot plant, industrial and breakthrough stage, which illustrate the focus of the Kerto team's operations at certain periods in time. At the end of each chapter describing a particular stage, I evaluate how the content of the selected concepts developed during this time. As a result, six hypotheses emerge. The first three define the prerequisites for a successful development process at a general level and the hypotheses 4 to 6 describe the structure of the operations themselves:

1) *Commitment* as a dynamically changing process.
2) Starting the change in operating practice.
3) Autonomy requirement for a developing business idea.
4) Formation of innovation structure and partnership.
5) *Partnering* leads to a merging of business ideas and strategies on the *solution market.*
6) Contents of the 100% product and its operating system.

The prerequisite hypotheses were extended from the definitions given in existing literature on business development and R&D. This was necessary because the precise interaction *between* R&D and business has not been analysed in previous research. Hypotheses 4 to 6 significantly add to the understanding of the interactive relationship between the *innovation structure* and *partnership*, set up to develop a new product.

In addition to the hypotheses, in this study I have also developed the content of the selected concepts further to describe in greater detail the dynamic change that is closely linked to a new wood product's development process. The manufacturer of the product, R&D and customer need to work together to create a connection between the *technology push* and the *market pull*. Moving up to a higher position in the *value chain* requires more and more market input and most often higher *value chain, partnerships* and expertise.

In my opinion, further research is needed to gain a better understanding of the interdependence between the given concepts at different stages of the development process. The *key technology model* showed its profit-creating capacity and performance, and therefore offers a lot of potential for further research.

Key words: value chain, innovation structure, operating system, 100 % product, stratified product concept, solution market, partnership, LVL.

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Tutkimusala Puutekniikka
Esitarkastajat Professori John P. Klus, University of Wisconsin, Madison
Tekniikan tohtori Pauli Jumppanen
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Tekniikan tohtori Pauli Jumppanen
Työn valvojat Professori Pertti Viitaniemi, Professori (emeritus) Tero Paajanen

Tässä työssä olen tutkinut puutuoteteollisuuden innovaation Kerto-LVL:n kehitysprosessin ongelmia ja onnistumisia sen tuoteideasta eri vaiheiden kautta tuotteen läpimurtoon asti kansainvälisillä markkinoilla. Päätutkimuskysymys on: Miten kehitetään uusi rakenteellinen tuote puutuoteteollisuudessa, kun se ei ole vain tuoteparannus tai olemassa olevan tuotteen substituutti ja millainen vuorovaikutus on liiketoiminnan ja T&K:n välillä tarpeen yhteistyön sujumiseksi niin, että syntyy kannattavaa liiketoimintaa. Tuote on kehitysprosessin alkuvaiheessa *ratkaisumarkkinoilla*.

Tutkimustyöni perustuu metodiltaan toimintatutkimukseen ja kohdistuu yhden uuden tuotteen ja sen liiketoiminnan kehittämiseen case-tutkimuksena. Siinä yhteydessä olen käyttänyt erilaisia käsitteitä kuvaamaan Kerto-LVL:n asemaa markkinoilla sen eri kehitysvaiheissa. Itse T&K:n ja liiketoiminnan kehittämisen vuorovaikutteisen toiminnan olen kiteyttänyt hypoteesien muotoon. Käyttäen yksittäistä case-tutkimusta voin kuitenkin vain indusoida hypoteeseja ja demonstroida tuotteen kehitysprosessia. Kerto-LVL case tarjoaa mielestäni ehjän ja hyvin dokumentoidun kokonaisuuden asetetun tutkimuskysymyksen arvioimiseksi.

Kehitysprosessin olen jakanut kolmeen vaiheeseen, Pilot plant, Teolliseen ja Läpimurtovaiheiseen, kuvaamaan niiden toiminnan painopistettä. Kunkin vaiheen lopussa arvioin valitsemieni käsitteiden sisällön kehittymistä ko. vaiheen aikana. Tulokseksi olen saanut kuusi hypoteesia. Niistä kolme ensimmäistä kuvaa yleisemmin toiminnan edellytyksiä ja loput kolme itse toiminnan rakennetta:

1. *Tahtotila* dynaamisesti muuttuvana prosessina.
2. Toimintatavan muutoksen aloittaminen.
3. Kehitettävän liikeidean autonomian vaatimus.
4. *Innovaatiorakenteen* ja *kumppanuuden* muodostuminen.
5. *Kumppanuus* johtaa liikeidean ja strategian sulautumiseen *ratkaisumarkkinalla.*
6. *100% tuotteen* ja sen *käyttöjärjestelmän* sisältö

Toiminnan edellytyksiä kuvaavia hypoteeseja sain laajennettua siitä mitä niistä on kirjallisuudessa todettu. Se oli mahdollista, koska tarkastelun lähtökohdaksi valitsemaani T&K:n ja liiketoiminnan vuorovaikutustilannetta ei sellaisenaan ole kirjallisuudessa käsitelty. Toiminnan rakennetta kuvaavien hypoteesien merkitys on huomattava. Ne lisäävät oleellisesti uuden tuotteen *innovaatiorakenteen* ja siihen liittyvän *kumppanuuden* vuorovaikutteisuuden ymmärrystä.

Olen kehittänyt valitsemieni käsitteiden sisältöä entistä tarkemmiksi kuvaamaan uuden puutuotteen kehittämisprosessiin liittyvää dynaamista muutosta. Uuden puutuotteen kehittäminen on niin monimuotoinen prosessi, että avainasemaan on nostettava eri osa-alueiden saaminen hallittuun vuorovaikutukseen. Tuotteen valmistaja, T&K ja asiakas on saatava toimimaan yhdessä niin, että syntyy esitetyllä periaatteella kytkentä *technology push*:n ja *market pull*:n välille.

Jatkotutkimuksena esiin nousi selkeästi tarve tutkia esitettyjen käsitteiden keskinäistä riippuvuutta toisistaan kehitysprosessin eri yhteyksissä. *Avainteknologiamallin* soveltamisen kehittämisessä on paljon potentiaalia.

Asiasanat: Arvoketju, innovaatiorakenne, käyttöjärjestelmä, 100 % tuote, kerroksellinen tuote, ratkaisumarkkina, kumppanuus, LVL

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Four years ago, when I was finalising my licentiate's thesis on jointing techniques, professors Tero Paajanen and Pekka Kanerva strongly urged me to continue my research towards a doctoral dissertation, convincing me that I was very close to this objective already. With their support and encouragement, I decided to continue my work, while changing my research subject from jointing techniques to a much more general subject: the interaction of R&D and business development in the wood products industry. I am indebted to prof. Paajanen for letting me complete my dissertation while continuing my work in the Wood Product Laboratory. He also played an important role in guiding and reviewing my work, even after retiring as Professor Emeritus.

I decided to focus my research work on the process leading up to the development of Kerto®-LVL into a commercial product. I have had the opportunity to work towards the success of this product for more than 25 years. Another key person in this process was Reijo Hirvensalo, who in the early 1980s was looking for case projects related to his consulting work. Our repeated discussions and joint writings created the theoretical base for describing the Kerto®-LVL development process in perspective and for evaluating it in scientific terms. At the same time, it became clear to me which research method to use. I would also like to thank Reijo Hirvensalo for his untiring effort in commenting on my work as it progressed towards its ultimate goal.

The pre-examiners, professors John P. Klus and Pauli Jumppanen, provided me with valuable comments in the course of my work, helping me to realise the significance of my extensive research work at an early stage.

Key persons in this case study were Ari Martonen, President & CEO of Finnforest Plc, and Ari Tiukkanen, manager of the Kerto unit. They gave me permission to use unique material concerning Kerto®-LVL right up to its breakthrough stage. I am also indebted to Kari Liski for his accurate comments related to the development process.

In the course of my work, I had the opportunity to discuss key issues with numerous experts in this field. In particular, I would like to thank Jyrki Kettunen, retired Research Director of Metsäliitto, for reviewing my work in its various phases and for providing me with valuable background information on how my research subject relates to Metsäliitto Yhtymä's research work. I would also like to thank the representatives of the Finnish Plywood Association, the Finnish Forest Industries Federation, Wood Focus Oy, VTT and the Confederation of Finnish Construction industries for taking the time to discuss my work and for providing me with useful insights into a wide range of subjects. In addition to these key people, I had the privilege to talk to numerous professionals, who spared no effort in providing me with vital background information.

I am also indebted to the staff of the Wood Product Laboratory for helping me out in my daily work, so I could find more time for my research work.

I would like to thank Auri Paajanen for translating my thesis into English, and for her readiness to discuss the meaning of the original text in the course of the translation work. As a result of this effort, the text improved throughout. The language of the final text was competently revised by Olof Andersson, with Johanna Kairi and Jukka Keitele giving it the final touch. I would like to thank them all for helping me out in the final hectic stages of my work.

Without the support and encouragement of my wife Tuula this thesis would not have materialised. I am also grateful to our grown-up children, Johanna, Jussi and Niina, for actively encouraging me to take on this challenge at my mature age.

Finally, I want to express my gratitude to Lahti Region Business Centre Ltd and Teknologiasta Tuotteiksi foundation for their financial support.

Lohja, May 2005
Matti Kairi

Abbreviations

COV	Coefficient of Variation (%)
CPD	the common *construction product directive* of EU (89/106/ETY)
CSTB	Centre Scientifique et Technique du Bâtiment in France
CTB	Centre Technique du Bois
CTBA	Centre Technique du Bois et de L'Ameublement
DGfH	Deutsche Gesellschaft für Holzforschung e.V. (German Association for Wood Research)
DIBt	Deutsches Institut für Bautechnik, Berlin
DIN	Deutsche Industrienorm
DIY	do it yourself
FIM	Finnish mark, currency of Finland until 2001, EUR 1.00 ~ FIM 6.00
FMPA	Forschungs- und Materialprüfungsantalt, Stuttgart
FPL	Forest Product Laboratory in Wisconsin, Madison
GNS	Gang-Nail Systems, Incorporation, see appendix III
HUT	Helsinki University of Technology
HUT/LSEBP	Helsinki University of Technology/ Laboratory of Structural Engineering and Building Physics
LVL	Laminated Veneer Lumber
ICT	Information and Communications Technology
IT	Information Technology
Plc	Public limited company
PLT	Wood Panel Technology
PMT	Mechanical Wood Technology
RECC	Real Estate Construction Cluster
SBA	Strategic Business Area
SBU	Strategic Business Unit
SME	small and medium size enterprise
SPT	Suomen Puututkimus Oy; a Finnish wood industry-owned R&D company; since 2001 part of Woood Focus Oy
TEKES	Technology Development Centre in Finland
TUT	Tampere University of Technology
TUT/LSE	Tampere University of Technology/ Laboratory of Structural Engineering
VTT	Technical Research Centre of Finland

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1. INTRODUCTION

1.1 Development goals of the Finnish wood products industry

During the 1990s, the Finnish wood products industry saw strong development in the construction and interior decoration sectors. In the construction sector, the competition between different materials continues, while the operating environment of the wood products industry is changing due to the globalization of trade and the consolidation of the industry (Finnish Forest Industries Federation 1999, 3).

Wood has its own unique and strong tradition in furniture design and as an interior decoration material. Wood also benefits from the positive association between objects made of wood and leisure activities. The superior characteristics of wood compared with alternative materials help it to maintain its market position in both construction and interior decoration. Wood feels warm and is pleasant to touch. It is flexible and can be sized and worked by the user to meet individual needs. In addition to its aesthetic value and flexibility, wood also benefits from its status as an ecological material. The competitiveness of wood in both of the above sectors is not only developed by material providers and operators of the material provider network; designers actively search for new uses to create a new look – and wood can also act as an inspiration for new designs. For a DIY enthusiast, wood provides an ideal challenge and an opportunity for personal achievement. The increase in leisure time also contributes to the popularity of wood.

However, as a material in load-bearing structures, wood is facing a wholly different battle. As the competitiveness of concrete and steel structures is constantly maintained and enhanced, the mechanical wood industry has to rise to the challenge. In my opinion, R&D activity in basic products is crucial for competitiveness. However, within the mechanical wood industry this is not self-evident. It has been suggested that all essential basic product development has already been completed in this mature industry.

The findings of the Mechanical Wood Processing (PMT) and Wood-Based Panels (PLT) Technology Programmes 1992 – 1996, supported by the National Technology Agency, TEKES (Klus and Hirvensalo 1997, 27-34), led to the idea that the Finnish wood products industry should be developed as a sector in its own right. The aim of this approach was to meet the challenges of alternative construction materials, such as steel, plastic and other wood-based materials used in the construction industry. Subsequent preliminary studies were carried out at the beginning of 1998 to formulate a vision for the wood products sector. The "Vision – 2010" is defined as follows (Finnish Forest Industries Federation 1999, 9):

By 2010, wood will be Europe's leading material in system solutions for the building construction industry and in consumer products related to quality housing.

As a part of the final version of the vision, approved in August 1999, a survey describing the present situation of the wood products sector (Finnish Forest Industries Federation 1999, 4) defined the current business concept as follows:

In the wood products industry, the large companies produce cost-effective basic products such as sawn timber and wood-based panels mainly for the international market, whereas small companies produce re-manufactured products for the domestic market. The operations are targeted in accordance with a group market and product approach.

The current polarisation – large companies operating in the basic industry and exporting most of their goods, and small companies manufacturing wood products for domestic markets only – has been an underlying principle in the wood industry's R&D activities until recent years. In neither market, this method of operating has established no immediate contact with the end user. As a consequence, any attempts to further develop basic industry products have proven unprofitable. In addition, the efforts of the small companies in their drive for exports have often proven insufficient (Paajanen 1997, 121).

The Finnish vision was updated in 2003 as part of a Pan-European project entitled:
"Roadmap 2010 for the European woodworking industries".

1.2 Case Kerto® Laminated Veneer Lumber

In this study, I refer mainly to my own experience as a basis for exploring the development of a new Finnish basic wood product, Kerto®-Laminated Veneer Lumber (Kerto-LVL) for international marketing, comparing this case with the corresponding research activity in the plywood and sawmilling industries during the same period.

Kerto-LVL took 25 years to make a breakthrough. The development project was carried out within the Metsäliitto Group's mechanical wood industry, currently known as Finnforest Plc (Finnforest). The project start dates back to 1973. I joined the project at the very beginning, first as a research assistant at VTT (Technical Research Centre of Finland), and the following year I did my master's thesis as a part of the project (Kairi 1975). From 1975 onwards I was employed at Metsäliitto, first as a development engineer responsible for the site of the pilot plant line and subsequently as a product manager in Finland, and later in Germany. At the beginning of the 1990s, I worked as a production manager at the Lohja factory and finally as R&D manager responsible for Kerto-LVL.

The new product development was a success (Kettunen 2002, 71). As a result, I was given more responsibilities as a representative of Finnforest within Suomen Puututkimus Oy (SPT) – a wood industry-owned R&D company – as well as being offered membership of the managing committee for the “Wood in Construction Technology Programme” (PRT) by TEKES in 1995 – 1998 (Tekes 2000, 5). During the course of this programme, I became interested in comparing the R&D activity in the Kerto-LVL business with the product development conducted in the mechanical wood industry in general. I asked myself if it would be possible to learn from the difficulties met and new operating methods developed in the Kerto-LVL business and apply this knowledge for improving the operating methods of the mechanical wood industry, which had found itself in a situation where change was a necessity (Finnish Forest Industries Federation 1999, 8-11).

The Kerto-LVL development project met all the characteristics of and achieved all the targets stated in the Finnish wood products industry cluster’s Vision 2010. A detailed analysis of a product lifecycle is necessary for developing new theories to explain the interaction between R&D and business. A product lifecycle is also needed as a framework for adapting the theories for other products.

At the beginning, Metsäliitto’s product idea consisted of finding an economical method of obtaining, from the same raw material *with slightly higher production costs,* a structural product which would possess *clearly higher characteristic strength values* than those achieved by converting the log into sawn timber. To manufacture Kerto-LVL, softwood logs are peeled into veneers in the same way as in the plywood manufacturing process. The veneer sheets are then glued together to form a continuous wide billet, with all wood veneers and fibres oriented primarily lengthwise in relation to the processing direction. The billets can be cut to size as structural beams, columns and boards to be used as such, or for further processing into building components. Wood defects can thus be distributed and therefore, in comparison with sawn timber, the result is a significantly more homogeneous product, with high-quality weather-proof characteristics.

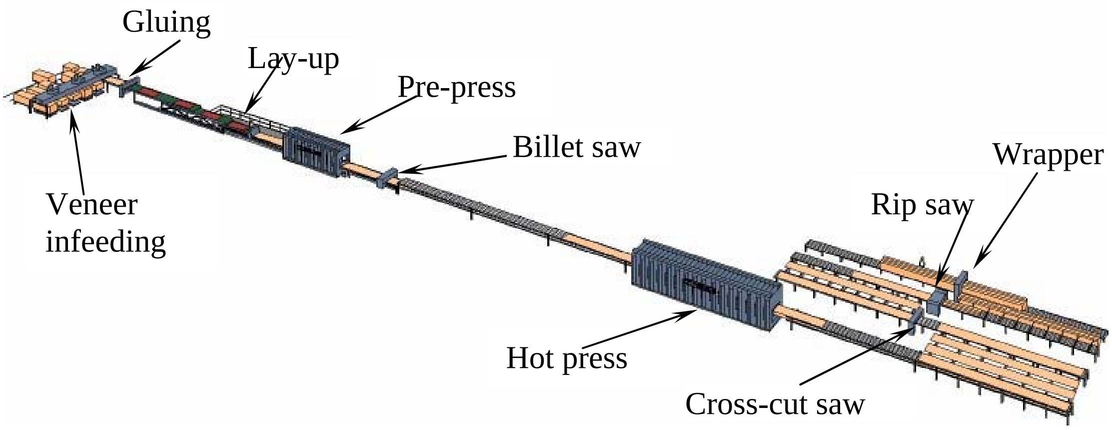


Figure 1 LVL production diagram (Raute Wood 2000).

In the Nordic countries, a niche market was developed for Kerto-LVL between sawn timber and glulam (Figure 2). Later on, the development of the product idea became market-driven, as the intermediate processing industry identified Kerto-LVL as a multifunctional basic product. This enabled the development of more competitive components and integrated product parts, which could form a basis for a product family. An example of this is the Sibelius Hall in Lahti, Finland, (Figure 3), where stress-skin elements are used in the walls, roof and balcony, with structural beams internally and boards externally where the elements are glued structurally together.

Figure 2. In the Nordic countries, the section of Kerto-LVL as a beam is typically between solid timber and glulam (source: Finnforest).

Figure 3. The Sibelius Hall in Lahti, Finland, is a good reference of the integrated use of Kerto-LVL as a sub-product (source: Finnforest).

The original product innovation for Kerto-LVL came from the United States. New veneer-based products were developed and commercialised in the 1970s, almost simultaneously by Trus Joist Corporation (Trus Joist), today a subsidiary of Weyerhaeuser Corporation; and in Finland by Metsäliiton Teollisuus Oy, today Finnforest, a member of the Metsäliitto Group. However, their product ideas were clearly not the same. In the following chapters I will concentrate on the development of the Finnish Kerto-LVL product. The US LVL product is discussed in section 4.1.

From the point of view of the product and production technology, the Kerto-LVL development cycle exhibits more similarities with plywood than with any other product. However, the sawmilling industry, glulam industry and Kerto-LVL share the same end user group and market, i.e. the construction industry.

Obtaining market-specific type approval has proven essential in bringing a new structural wood product to the market. This is particularly the case in the German market. In Europe, LVL has been specified with local type approvals. Since the beginning of 2005, a new harmonized LVL standard EN 14374 "Timber structures - Structural laminated veneer lumber - Requirements" has been available. The main difference between EU and US standardization is that the new European standard contains not only the basic LVL, but also its variation as a plate with about 20 % of the veneers glued crosswise (LVL-Q) as well as its structural use as a large-sized board.

The following figure shows milestones of the Kerto-LVL development process:

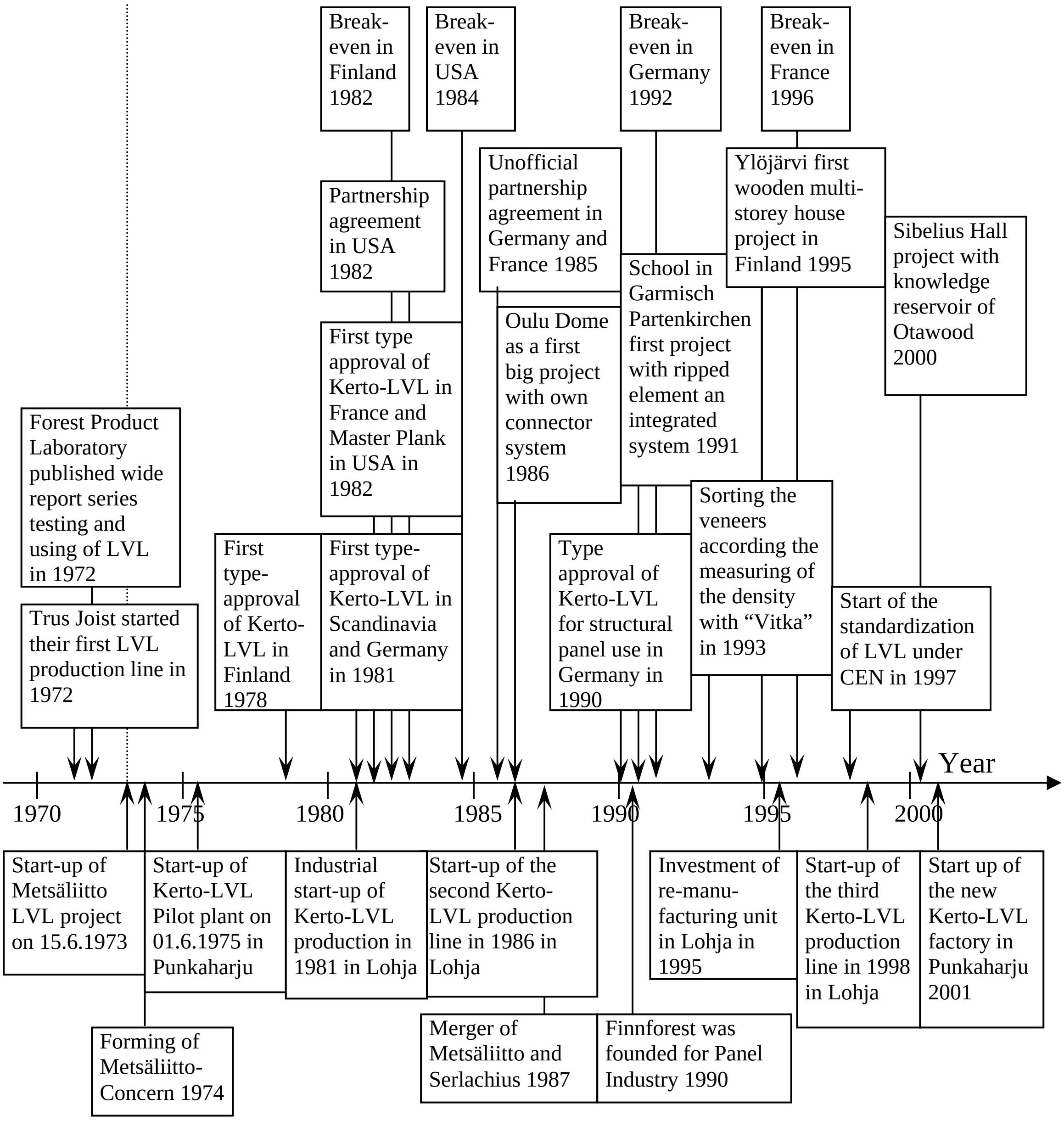


Figure 4. Milestones of the development of Kerto-LVL as a product and as a business.

On the whole, the development process presented a clear upward trend. In 1988 – 1996, there was an obvious recession in the activities of strategic operations (Figure 5), which meant that the building of more capacity and thus the modernisation of other parts of the production unit could not be determined until 1997 (cf. the lower part of the time-line in the figure above). The interval between investments in the second and third production lines was over 10 years.

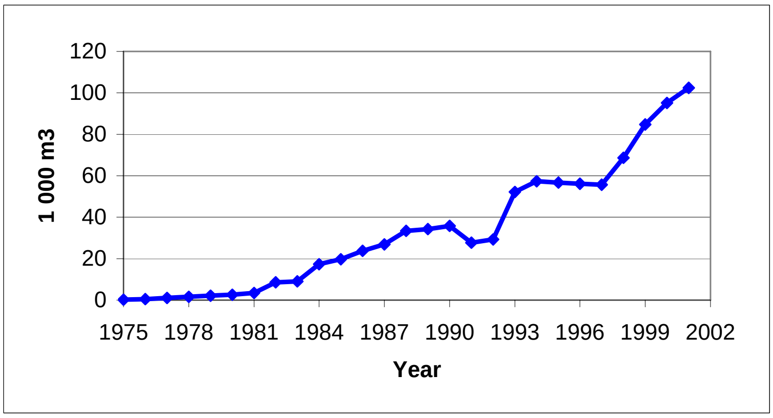


Figure 5. Production volume of Kerto-LVL (source: Finnforest).

1.3 Research question

In the wood products industry's business and product development, each participant in the chain traditionally develops its own operations independently (Figure 6). As a result, parties are seeking separately a competitive edge via:

– raw material
– production costs
– stock turn-over times

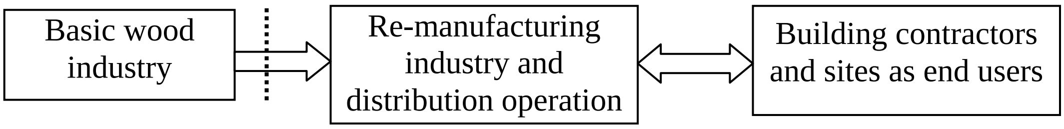


Figure 6. Traditional development process in the wood products industry. There is no real feedback from the re-manufacturing industry and distribution operation to basic wood industry.

The basic industry developed its manufacturing techniques to gain efficiency for its products in their existing markets. In other words, the product is a direct substitute for products already in the market and the seller manages the distribution of products by tendering to suppliers. The interaction works reasonably well between end users, the re-manufacturing industry and the seller, but not between them and the basic wood industry. The reason for the dominating role of raw materials and their manufacturing techniques in profitability is the so-called dominant preconception (Uotila 1994, 9) in the basic wood industry, according to which raw materials come first and customers second. (Jääskeläinen 1983, 2). This has been the *dominant paradigm* in mechanical wood industry as well as in agriculture R&D processes (Kettunen 2005).

The development of Kerto-LVL was initiated in the early 1970s according to the process shown in Figure 6 on the basis of the common operating practice. Test marketing, initiated in 1975, was targeted at the domestic market and it was carried out by Metsäliitto Group’s sales company, Metsäliiton Myyntikonttorit Oy (Metsäliiton Mk). Despite its good contacts with construction companies and builders, the sales company did not succeed in marketing its new product.

Subsequently, a couple of projects were carried out in which the development team of the Punkaharju plywood mill, which was responsible for the development of the product, operated directly with the builder and contractor companies, who acted as end users. However, this was an exception to the prevailing practice within the wood products industry. As the results proved positive and the alternative was to terminate the project, the development process presented in Figure 7 was adopted in 1977 (Metsäliiton Teollisuus Oy 1977). The development team of the Punkaharju mill was also made responsible for the organisation of the new operating practice. The mill’s development team managed the operations, despite the fact that -- from the customers’ perspective -- it assumed the role of a material supplier. The development team chose a *new paradigm* where the R&D process and the business were engaged in continuous interaction.

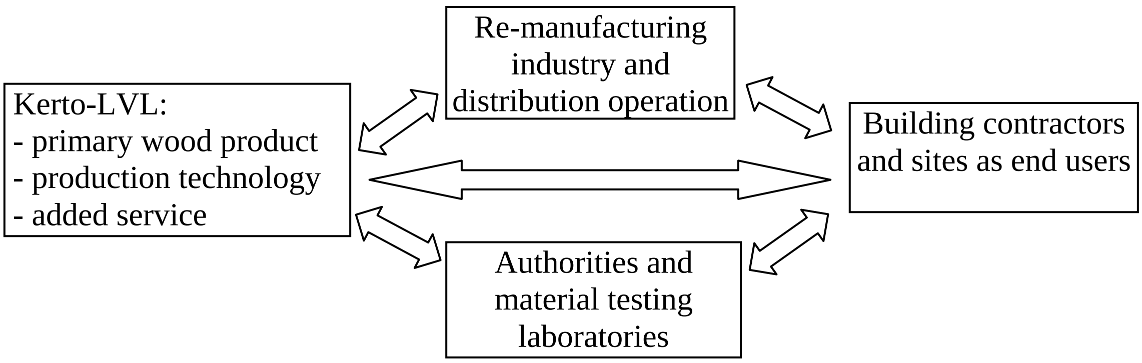


Figure 7. Interactions in the development process chosen for Kerto-LVL in the domestic markets in 1977, where the customers are builder and contractor companies and the product is a customized building component.

Figure 8 illustrates the building industry added *value chain* for Kerto-LVL. An optimal *value chain* was achieved when an interactive operating practice as presented in Figure 7 was developed in cooperation with a few active building contractors.

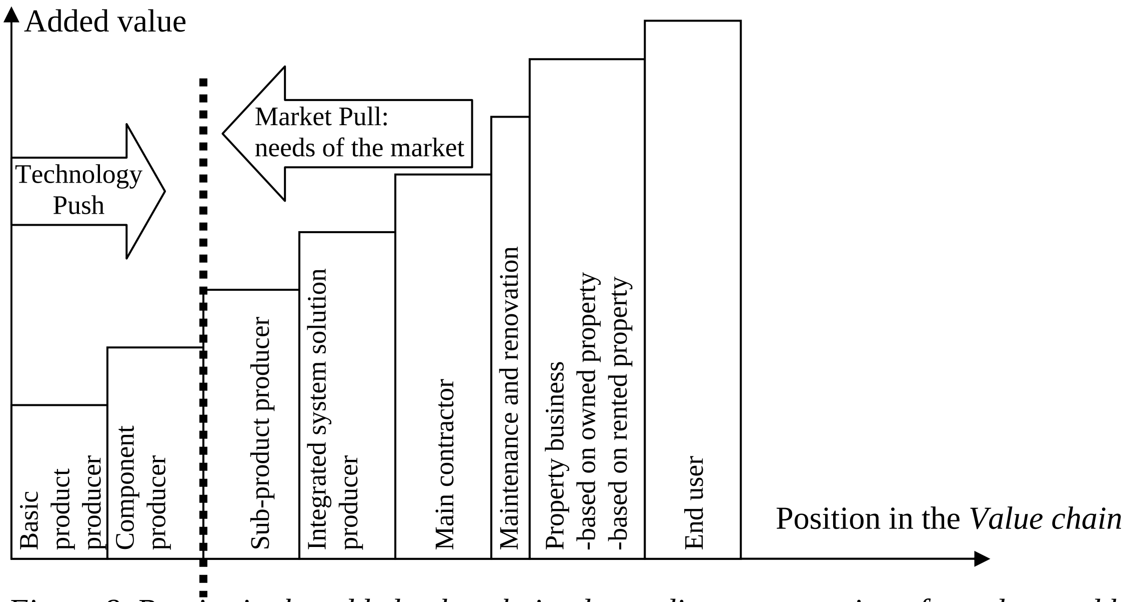


Figure 8. Barrier in the added value chain, demanding restructuring of product and business development processes (Jumppanen 2003).

During the Kerto-LVL product and business development process, it was concluded that it was impossible to penetrate the market solely by means of developing the product and production technology. It became essential to identify and find ways to overcome the development barrier illustrated in Figure 8, and to respond to the needs of the market; otherwise, the product would encounter operational obstacles in the phase marked with a dashed line in the added *value chain*. To avoid this, it became necessary to develop a new, more sophisticated product with added performance, a partly new production technology and at the same time, adopt a new business operating practice (Figure 9).

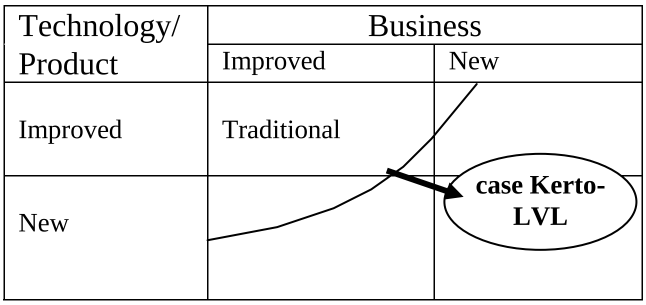


Figure 9. The development of Kerto-LVL resulted in a new product as well as a new technology and business operating practice.

This development process was characterised by strong interaction between technological R&D and business, which subsequently led to a close cooperation with the customers, i.e. building contractors and the building component industry, and subsequently prompted several customers to change their business operating practice.

Thus the main research question in this study is:

How to develop a new structural product in the wood product industry when it is not just an improvement or substitute for an existing one, and what kind of interaction between business and R&D is necessary for the cooperation to function smoothly and lead to a profitable business?

To approach the question, the following issues need to be taken into consideration:

- how does the development activity in Kerto-LVL differ from that of other products in the wood products industry?
- what are the special characteristics of the sector that have to be considered?
- what kind of changes are required for the development process?
- what kind of organisational processes are needed to support the development of a new product?

1.4 Aim of the research

The aim of this research is to describe the development of Kerto-LVL from idea to business and use this experience to induce hypotheses on the necessary phases involved in a successful development process.

1.5 Research methodology and structure

Action research appeared to be a natural methodological choice for this study. The relationship between R&D and the business has been discussed in an extensive number of scientific publications; e.g. Miller and Morris "*Fourth Generation R&D*" (1999), and several doctoral theses have been written on the subject; e.g. Nihtilä J. "*Integration Mechanism in New Product Development*" (1996), Rinne S. "*The negation selection model and its impact on the product development of an investment good*" (1989). These studies generally approach the question from an external observer's viewpoint. In certain cases however, the observer has been involved in the process as an action researcher. In the present study, an opportunity emerged to make use of the experience of a person who at the time of developing the product held a key position in the production line. Hence, the process is essentially viewed from an internal viewpoint, which for the same reason is inherently subjective.

Another aspect in this study is the dynamic relationship between R&D and business relations. Previous research considered static relations between these two, whereas the development of Kerto-LVL essentially needed dynamism. Relevant literature that would have taken a two-way dynamic relationship into account had not been published at the time of the Kerto-LVL business development.

An overview of the development of the Finnish wood products industry is given to establish the necessary operating environment and to compare the case of Kerto-LVL with general developments in the Finnish wood products sector. The various theories on R&D will serve as a basis for analysing the success of Kerto-LVL.

The Kerto-LVL development process can be divided into the following stages:

1. Business start-up in the form of a pilot plant, characterised by ad hoc solutions, several trials and errors with product variations.
2. Establishing the industrial stage, characterised by the development of standard products, optimisation of product variations for volume production, creating a basis for future competitiveness.
3. Product breakthrough, characterised by the extension of the product family to encompass *standard, component* and *customised products* and *sub-products, turnkey products* and their corresponding business.

The frame of reference for Kerto-LVL development is illustrated in the following figure.

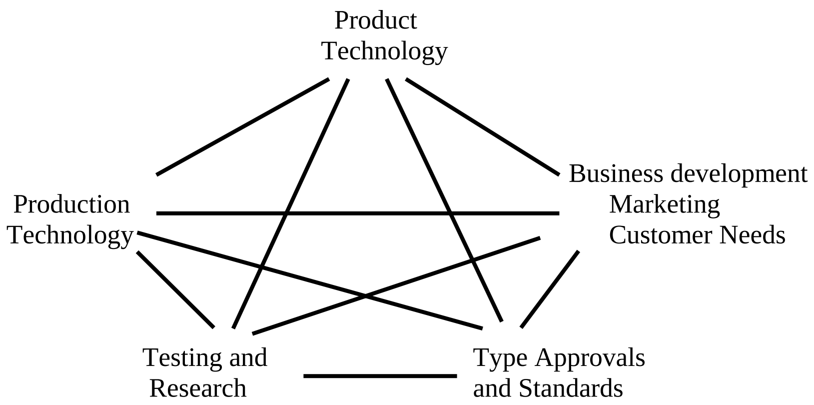


Figure 10. Main areas of the development project.

Process development concentrated on five main areas. These appeared to be closely linked throughout the project. The areas of research and the interconnections between them were analysed in the respective stages of the study.

When analysing the results, it became evident that all the observations could not be explained by existing concepts. New concepts had to be devised to formulate a theory. The course of action comprised three stages. First, the phenomena were described using current concepts wherever possible. The second stage was to extend the description to encompass entirely new concepts, which could lend themselves to the description of factors contributing to the success of the process under scrutiny. The third stage consisted of eliminating those concepts, which had proved unessential for the formulation of a theory, and the chosen concepts were defined further. The following figures illustrate the interaction between the research method and the Kerto-LVL development process.

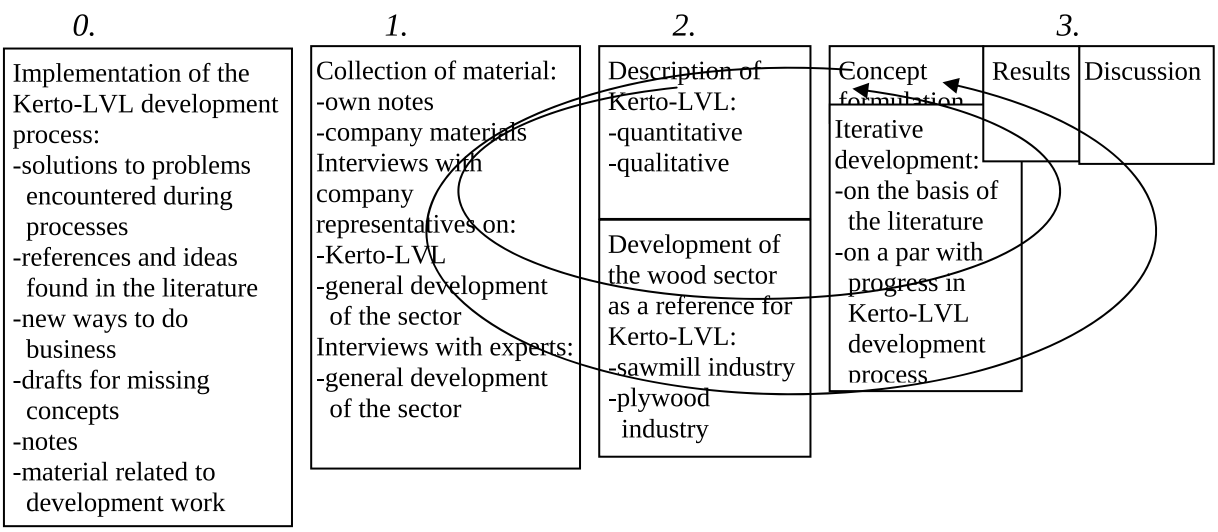


Figure 11. Stages of the research process.

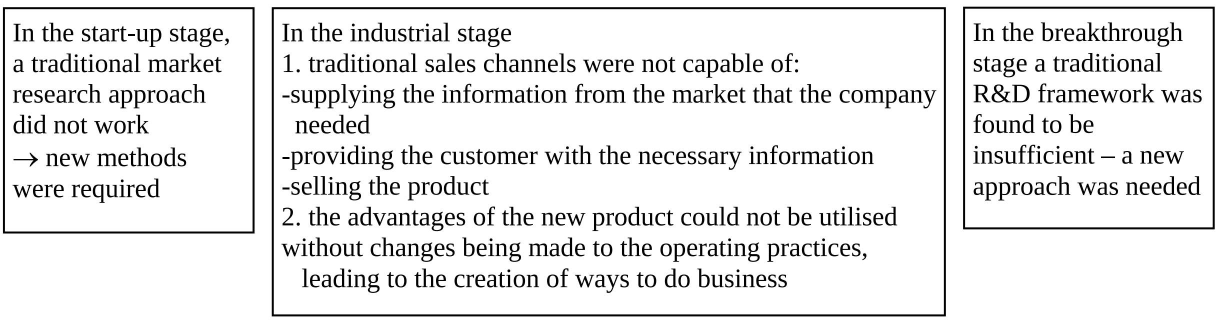


Figure 12. Needs for the establishment of a complementary theory in different stages of Kerto-LVL development.

1.6 Scope of the study

The building industry is the most important customer for the wood products industry. In this study, the product and the interacting business development process involve developing a structural wood industry product for the customer.

This research refers to the Kerto-LVL product development project with the object to analyse the following issues:

- the interactions between business and R&D
- the product development process, when the product is
  - new
  - intended for structural use in building industry
  - innovative
- the basic industry is in charge of the development
- an international network involving:
  - Finland, Germany, France and USA as market examples
  - architects and designers
  - builders
  - sales channels
  - sub-product producers (re-manufacturers)
  - research institutes
  - authorities
  - Finnforest

The Kerto-LVL case will only be covered until 1997, since the material related to more recent development activities is regarded as confidential.

The following themes will not be covered:

- organisational issues
- management systems
- economic analysis

1.7 Structure of the study

I carried out this research in two phases:

1. During the first phase, my aim was to develop, together with the development team, Kerto-LVL into a structural product and succeed in making it profitable. When we encountered a problem, we had to solve it; either by using information that was available in the literature or by ordering systematic external testing of the technology or of the product itself. Also, we solved parts of the problems by devising our own solutions. At the time, I rarely analysed the solutions or factors that could lead further into theory. They remained at a level that was necessary for the business and product development processes. Later on I realised that we had come up with ideas that had previously been published, and vice-versa: the research community had reported a solution after we had already resolved the problem in practice within the Kerto-LVL development environment.

2. In the second phase, in 2001, I started research on the subject of Kerto-LVL development, which was to become a doctoral dissertation. In this project I referred to the observations I had made at the time of the development and integrated them into a current theoretical framework. The results are presented here as concepts and hypotheses, which have emerged as a result of both phases of the research.

The structure of my study is a consequence of the above two phases. The structure is:

- In chapter 2, I describe the operating environment within the wood products industry and the development processes it has used normally in R&D and in business development.
- In chapter 3, I select the concepts and present the hypotheses I have formed during the course of the research.
- In chapters 4 – 6, I describe in detail the various stages of the Kerto-LVL development process (by referring to the practical solutions implemented in phase 1). The concepts presented in chapter 3 are re-introduced and discussed at the end of these chapters in order to indicate how the substance of these concepts developed during each phase. In conclusion, in chapter 7, I justify the formation and evolution of my hypothesis by using the concepts and observations presented in chapters 4 – 6.

2 WOOD PRODUCTS INDUSTRY AS A FRAMEWORK FOR KERTO-LVL

This chapter describes the operating environment in which Kerto-LVL was developed into a marketable product and business. At the beginning of the chapter, sector products are defined and positioned with regard to their main developments and customer approach.

The different position of wood as a raw material when compared to other building materials is outlined. Also, the significant efficiency improvements carried out in wood procurement and their impact on the Finnish wood industry are described. This chapter also summarises developments in the Finnish plywood and sawmilling industry from the 1970s until the 1990s to an extent relevant for understanding the development of Kerto-LVL.

Furthermore, the general R&D tradition within the wood products industry is evaluated from the point of view of Kerto-LVL development. It serves as a basis for comparing business development between the Kerto-LVL, plywood and sawmill industries.

A customer-oriented approach is applied to describing the products at the end of the present chapter.

2.1 Development of the business and mechanical wood industry structure

Until the end of the 1990s, the total turnover of Finland’s mechanical wood products industry had been less than 40 % of the pulp and paper industry’s turnover (source: Statistics Finland). The wood products industry has gone through a fundamental change process since the end of the 1970s (Klus and Hirvensalo 1997, 9-11). One consequence of this has been a general consolidation of the industry:

- In 1979, the five largest sawmilling companies accounted for less than 30% of the overall production; in 1989 the figure was approximately 60% (Pöyhönen 1991, 2).
- In 1980 there were 17 plywood industry companies, ten years later only 4 (Koponen H. 2002, 19-40, 141).

As explained in section 1.1, the primary industry possesses a thorough knowledge of the bulk production technology; however, the concentration of the re-manufacturing industry on the domestic market dominated by SMEs was perceived as a weakness. This was reflected in the production volumes and export shares of various products as late as in the 1990s, Table 1 (Tekes 2000, 97).

Table 1. Essential parameters in the mechanical wood industry 1994-1998 (Tekes 2000, 97).

	Production (billion EUR)			Exports (billion EUR)		
	1994	1998	change %	1994	1998	change %
Primary products[1)]	2.53	2.90	14 %	1.62	1.97	22 %
Processed products[2)]	1.20	1.90	58 %	0.42	0.47	12 %
Total	3.73	4.80	29 %	2.04	2.44	20 %

[1)]Primary products include sawn timber, plywood, LVL, particleboard and fibreboard.
[2)]Processed products include building joinery, house and furniture industry products and other wood products.

From this table it can be concluded that in 1994 exports accounted for 55% of the total production and the share of the basic products came to nearly 80%. Similarly, in 1998 51% of the total production was exported, and the share of basic products constituted over 80% of the mechanical wood industry’s total exports. The industry’s dependence on primary product exports has actually been growing in the 1990s.

Whereas in Finland the relative shares of sawn timber and plywood have been on the increase until recent years, internationally prospects are less favourable. The general perception is that their competitive position is weakening. According to Schuler (2002), “mature” lumber and conventional plywood are expected to continue to lose market share to materials with less maintenance, which are stronger and whose performance is more predictable. In any case, both sectors will face tough international challenges. In my view, they will need new product concepts as well as significant investment in R&D to tackle these challenges.

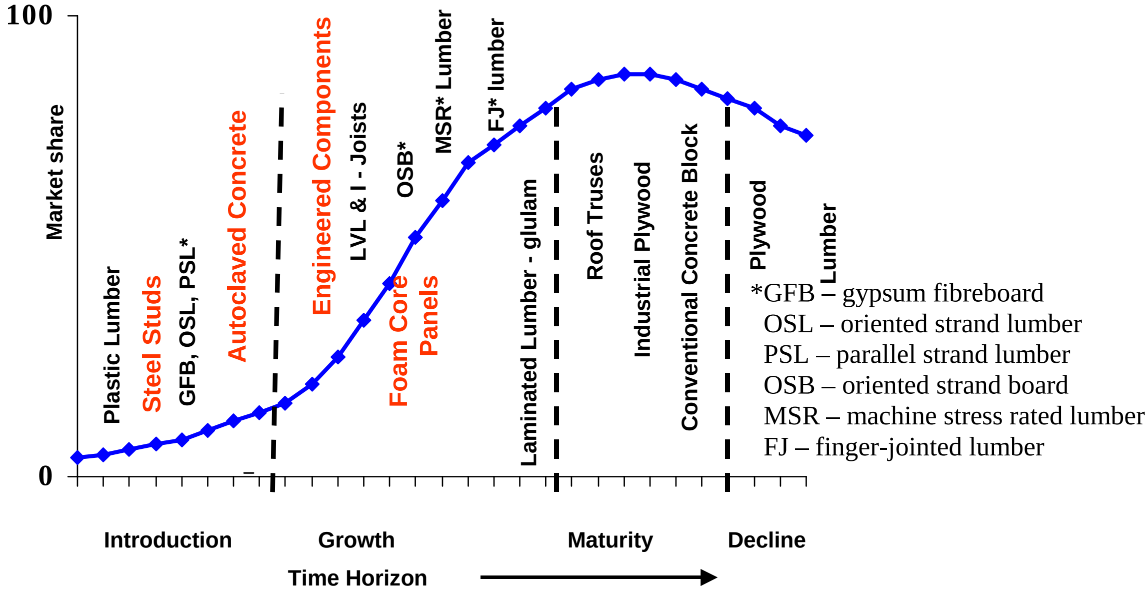


Figure 13. Construction "Product Life Cycle" (Schuler 2002).

2.2 Wood industry raw material

An inhomogeneous natural material, wood is different compared to other primary industry raw materials, such as metals and concrete. As a result, the wood products industry is subject to raw material constraints which hamper R&D efforts and business development.

The importance of raw materials has become more evident in the sawmill industry. In the 1980s, they accounted for 60-70% of total costs. The quality of logs varied greatly at the mill (Uotila 1994, 4).

In order to establish more homogeneous log groups matching the demand for specific products, the logs are normally sorted into classes. The main sorting criteria are quality, top diameter and length. In some cases, the classification is refined based on taper, sweep and ovality. Depending on the order file, the same log class is sawn using a specific sawing set-up. Typically from 8 to 12 sawn timber pieces, depending on the top diameter of the log, are obtained from one log. Their length was earlier limited by the length of the original log (Usenius 2005). This limitation has later been solved by finger jointing, which causes some decrease in tension and bending strength (STEP 3 1995, 6/15).

Market- and product-based raw material procurement began to manifest itself in the mid-1980s. Sawmills started to specialise in sawing only one species, spruce or pine (Silén 2002), concentrating on bulk production, and product-based segmentation did not emerge until the 1990s. At that time, an essential change took place in raw material procurement, following the development of computer-based tools for wood procurement, making it easier to handle the large volume of orders at sawmills (Örn 2003). Until then, the forest departments of the larger companies had supplied spruce and pine logs to sawmills and pulpwood to pulp mills according to diameter. Because the pulp industry generated a significantly higher turnover, it determined the rules for wood procurement until the beginning of the 1990s (Metsä 2003, Liusvaara 2003, Silén 2002). A breakthrough in the interaction between harvesting and individual sawmills was achieved when the measurement of logs was integrated into cross-cutting in the forest, allowing the cutting settings to be adjusted according to the sawmill's specific requirements (Örn 2003).

In contrast, the plywood industry is less dependent than the sawmill industry on the quality of raw materials, since veneer manufacture constitutes an intermediate stage in the visual sorting of raw materials before the manufacture of the end product. Veneer selection permits achieving a desired quality for the end product and ensures on principle a reject-free production. Log characteristics, such as minimum diameter, straightness and the suitability of the log length to function as a bolt in rotary-cutting are crucial factors in efficient raw material utilisation in plywood manufacture. Raw materials posed a problem when plywood volumes increased significantly in the late 1960s. Soon there was a shortage of birch raw material. As a consequence, there was a substantial price increase for birch logs compared to spruce logs, and the industry started to replace birch with spruce wherever possible.

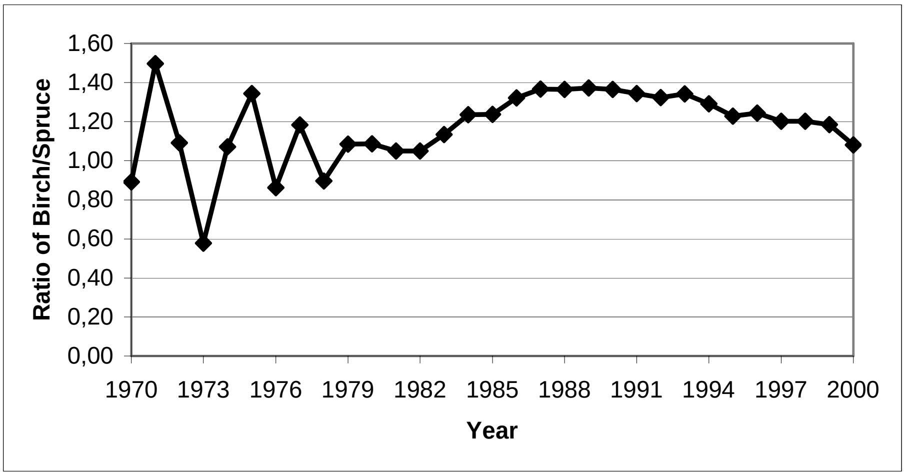


Figure 14. Average stumpage price difference between birch and spruce logs in Finland in 1970-2000 (source: Finnish Forest Research Institute).

Forest utilisation was becoming a problem in the late 1960s, as the total volume of growing stock in Finnish forests was decreasing (Tomppo 1998, 42). Since then, various methods for forest improvement have been adopted as a part of more active forest management planning. The drainage of peatlands has permitted achieving an increase in forest growth of over 10 million m^3/a, which corresponds to nearly 15% of the total growth of Finnish forests (Tomppo 1998, 48). In contrast, the concrete industry has faced problems related to raw material availability since the 1980s, largely due to the increasing focus on environmental issues. Gravel procurement became more difficult after esker protection programmes were implemented.

In addition, the efficiency of forest management and harvesting methods have improved in step with developments in the wood industry. The forest sector has changed rapidly. In the 1950s, the forest sector employed 500,000 people part-time, in the late 1990s, it employed 20,000 people full-time (Tomppo 1998, 63). The figure below summarizes the developments in this field.

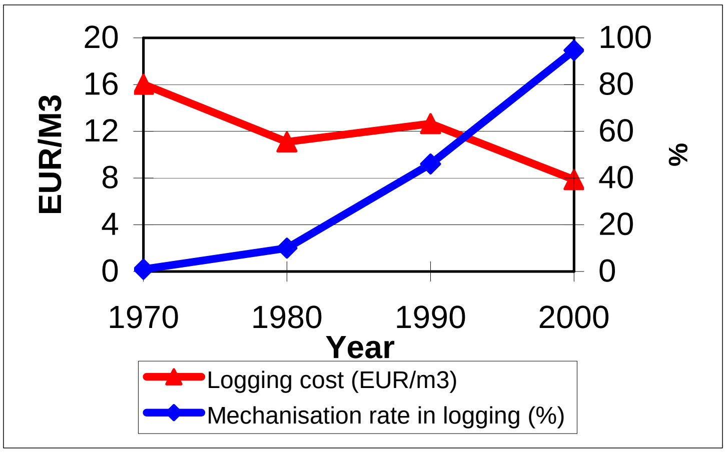


Figure 15. Mean logging cost for pulpwood and sawlogs, including felling, pruning, cutting and forwarding, in year 2000 value. The costs are based on the wholesale price index. The figure also shows how the mechanisation rate in logging has developed (Metsäteho).

Since 1990, most of the logging carried out by the timber companies and the Forest and Park Service has been mechanised. Forest workers fell and prepare only a small percentage of the total amount of trees felled. The mechanisation of logging has increased the efficiency of wood procurement. The use of the harvesters has enabled sorting of the material during felling, and cutting has become more precise (Lähteenmäki 2002).

2.3 Development in plywood industry

The developments in the plywood industry during the same period provide an interesting comparison with the Kerto-LVL business, as the plywood and LVL industry share the same technological stages in production as well as the raw material, i.e., rotary-cut veneer.

The Finnish plywood industry has succeeded in increasing its production and export volumes after periods of recession in the 1970s and 1990s. The share of plywood exports has remained at a remarkably high level. Even in the least successful year in 1991, 72% of the total plywood production (Finnish Plywood Industry Association 1970-1996) was exported.

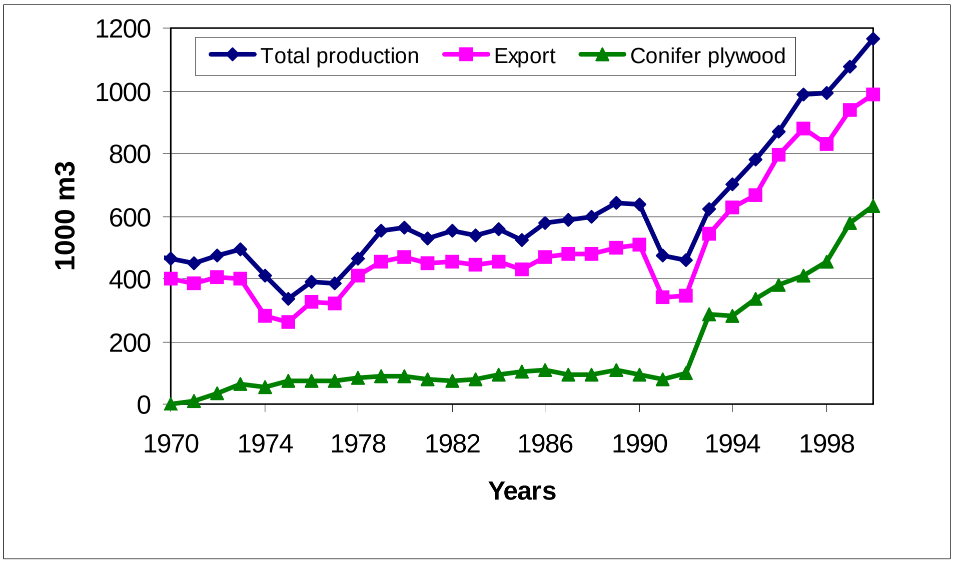


Figure 16. Plywood production volumes in Finland and share of the exports and conifer plywood (Finnish Plywood Industry Association 1970-1996; Forest Industry Statistics 1996-2000).

During the past 40 years, more changes have taken place in the plywood industry than in the sawmilling industry. Until the late 1990s, these changes had been seen mostly as opportunities for further development. The main developments in the plywood industry were (Liesiö 1981, 3-6; Koponen H. 2000, 106-125, 141-143 and 167; SVY 1973-1991; Haukkamaa 2002):

- Introduction of phenolic glue at the beginning of the 1960s, which enabled the development of a new product range.
- In the 1960s, the development of film-faced and fibreglass reinforced plywood for concrete shuttering and vehicle manufacturers.
- By the end of the 1960s, almost the entire product range was different from the product range in 1950s.
- At the beginning of the 1970s, when the availability of birch logs became a problem, a large share of the birch material was replaced by spruce.
- In the early 1980s, Germany replaced the UK as the main export country.
- During the 1980s the ownership of plywood mills was consolidated among fewer and fewer owners; in ten years the number of manufacturers came down from 17 to 4.
- A new supply philosophy emerged in Germany in the 1970s. Within the "Producer – Agent – Importer – Wholesaler" delivery chain, the agent's functions were partly taken over by the producer's own sales offices. In the 1980s, the agents were omitted from the chain altogether. The importers held their position, and also took over the wholesalers'

function in many cases. The first direct sales to end users were made by the company's own sales office in the late 1980s.

- In comparison, in 1994, nearly 80% of bulk products and 70% of speciality products were sold via sales offices. The products were delivered directly to all types of end user via a wholesaler who had a storage facility. The role of the importer had become marginal.
- From the late 1980s until the late 1990s efficiency improvements in logging benefited the plywood industry.
- The early 1990s marked the beginning of the modern Finnish spruce plywood industry. The utilisation of new materials and technology resulted in a doubling of the plywood volume during the 1990s.

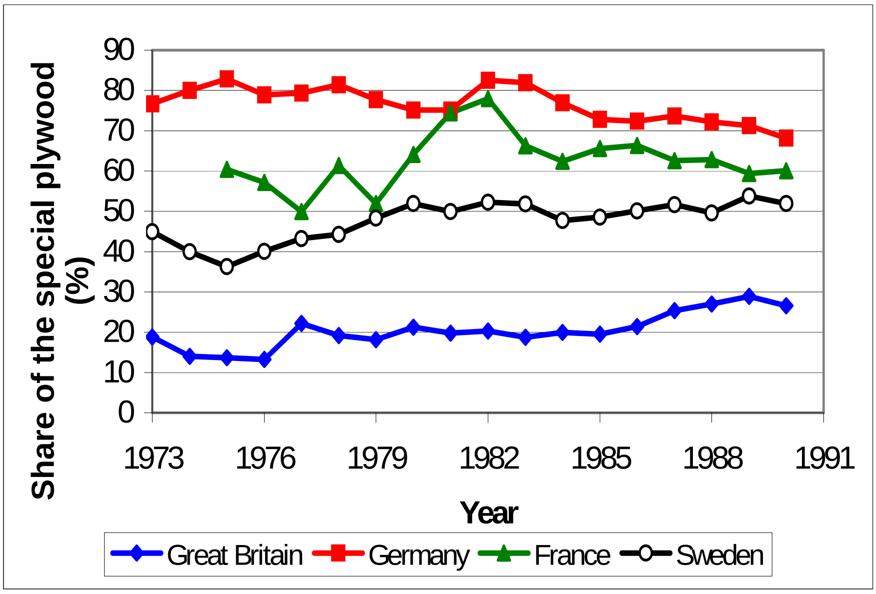


Figure 17. Share of re-manufactured, i.e. special, plywood in the main export countries (Finnish Plywood Industry Association 1973 –1991).

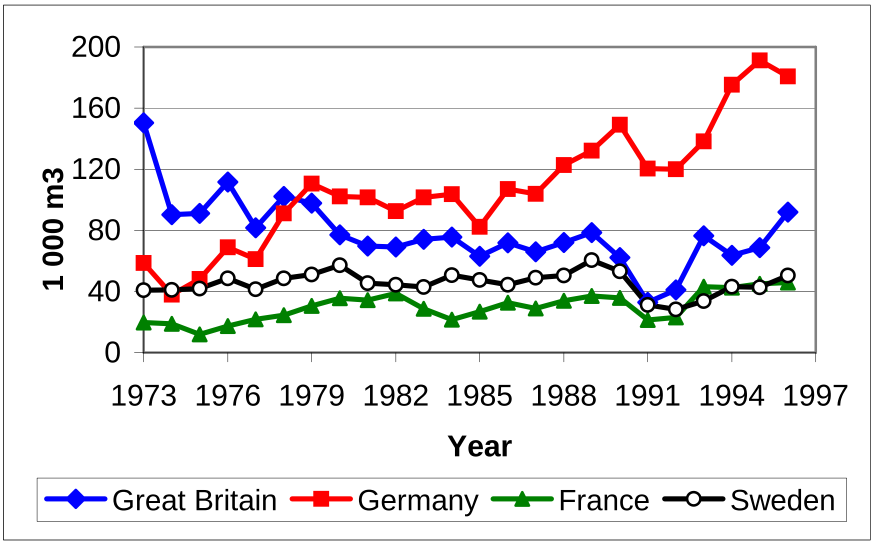


Figure 18. Exports of Finnish plywood to key markets (Finnish Plywood Industry Association 1973 –1991, Forest Industry Statistics 1992 – 1996).

In the late 1970s, the plywood industry was plunged into a deep crisis in the same way as other wood-based industries. A series of situation reports concerning the entire wood sector were commissioned by the Finnish government. These examined the possibilities available for different wood industries -- plywood, wooden house manufacturing, joinery and glulam -- to operate at a European scale. The most long-term approach was given in the so-called Tunkelo report (1977), which focused on the future prospects within the plywood industry. The report was based on a ”future study” approach, which was entirely new to the wood processing industry (Kettunen 2002, 65). In the product policy section of the report (Tunkelo 1977, 198 – 216), the author suggests that almost none of the plywood producers had prepared a development strategy for their products. Kettunen summarises the situation as follows (2002, 69):

- Nearly all the mills had ongoing extension projects despite the shortage of raw materials.
- No consensus was reached on methods to restrict the capacity.
- Birch plywood did not face any significant competition in its key fields of application.
- The Finnish companies’ market share in these was over 80%, in other words competition and weak profitability were not due to any overseas operators.
- All the companies had adopted in their R&D the role of a “thief”, i.e. competitor’s product was copied and brought to the market at a lower price.

The report presented three alternative visions for the future of the Finnish plywood industry (Tunkelo 1977, 246-263):

1. According to the first vision, there would be stable progress until 1990, the year in which the production was planned to reach 350,000 m^3/a. The drivers of development were evaluated based on the prevailing, rather difficult situation, so the prospects appeared pessimistic. However, realisation of this vision would have required clear efficiency improvements and rationalisations, as well as the closure of 7–10 mills.
2. The second development vision relied on speciality products, a birch plywood-focused product policy, customer-orientated marketing and a production volume of 450,000 m^3/a. It also assumed closure of 3–4 existing mills.
3. The locomotive growth vision was similar to the previous one, but also involved the establishment of 3–4 new spruce plywood production lines based on thicker veneers to serve the needs of the building industry. The production would rise to 650,000 m^3/a.

Development actions

The findings of the Tunkelo report were put into use at the beginning of the 1980s through branch rationalisations carried out by Oy Wilh. Schauman Ab, currently known as UPM Wood Products Oy, with Risto Lähteenmäki as managing director (Koponen H. 2000, 54). The problems had been acknowledged, but in order to carry out the necessary changes, an external evaluation source was needed. The following changes carried out at Schauman Wood Oy were directly or indirectly driven by the Tunkelo report (Lähteenmäki 2002):

- Concentrating the production in a few locations permitted a temporary reduction of investment requirements by extending the production series.
- Concentrating manufacture of competing products to one manufacturer increased the product lines' capacity utilisation rates.
- Subsequent increases in capacity utilisation rates emphasized the need to enhance the level of automation as a means to boost production line efficiency.
- The need for R&D decreased momentarily, when corporate acquisitions brought in new information which could be put to immediate use.

Metsäliitto's plywood industry also saw new opportunities for R&D and decided to establish an R&D unit, including a laboratory, at the Lohja mill. Its function was to coordinate R&D work carried out at external institutes. A good example of this was the development of plywood concrete shuttering panels (Kettunen 2002, 69).

In 1984, Oy Wilhelm Schauman Ab began to classify its plywood products according to a Strategic Business Area (SBA) division. As a result, the following end use-based division was implemented:

SBA I: Plywood products for the vehicle industry
SBA II: Plywood products for the concreting industry
SBA III: Plywood products for the building industry
SBA IV: Plywood products for the shipbuilding industry
SBA V: Plywood products for the packaging industry
SBA VI: Plywood products for special uses
SBA VII: Plywood products for wholesalers and trading partners

The above division reflected a clear change in the industry towards a more marketing and customer-orientated approach. The SBA division distinguished between demand behaviour, customer behaviour and competitive behaviour, competence requirements, and success factors. In the 1990s, the Metsäliitto plywood industry introduced a similar division (Kamensky 2000, 93 – 95).

In addition to product development, the focus in R&D was on improving production efficiency. Improvements in production and automation systems resulted in the following cost savings between 1980 and 1988:

Table 2. Direct variable cost savings obtained from production automation (Kontinen et al. 1992, summary).

Year	1980	1988
Labour input h/m^3 (direct labour hours)	15.4	8.7
Raw material consumption m^3 /m^3	4.17	3.34

Re-manufactured plywood products were developed in the 1970s. In 1970, their share of plywood production was below 30% , in 1979 over 55%. Their growth slowed down in subsequent decades and in 1990 they accounted for 59% of total plywood production (Finnish Plywood Industry Associaiton, 1970 – 1991). The re-manufacturing industry had not succeeded in developing new products with significant commercial potential, despite a substantial increase in the product range and number of product variations (Koponen H. 2000, 184).

In the late 1980s and early 1990s, the consolidation of the industry provided the rest of the birch plywood manufacturers with an opportunity to improve their customer orientation and thus enhance their product's competitiveness. In addition, the consolidation of the industry resulted in shorter distribution channels (Lähteenmäki 2002) and contributed to the development of the SBA division in R&D. The Strategic Business Unit (SBU) level was achieved for main products, which were assigned specific R&D personnel (Kamensky 2000, 94).

While Finnish manufacturers invested in spruce plywood capacity, the shortage of raw material also became apparent on the US and Canadian West Coast. This was due to environmental protection measures, which became known as the Spotted Owl effect, restricting the harvesting of publicly owned forests. The result was a decrease in plywood exports to Europe, which constituted an opportunity for Finnish spruce veneer.

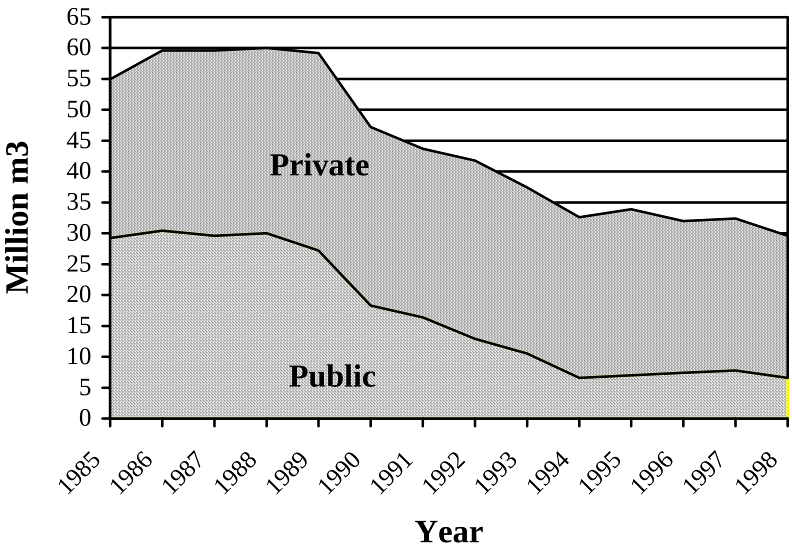


Figure 19. US Experience :Total Timber Harvest - Public & Private - Washington & Oregon. Court-ordered harvest restrictions on Federal lands. Two major impacts: Total harvest down 50% and private share now about 78% (Source: USFS PNW –RB - 231 , May 2000).

2.4 Development of the sawmilling industry

2.4.1 Basic solid timber

The central role of the sawmilling industry for the Finnish economy is illustrated by the fact that sawn timber products represented a higher export value than other industrial goods well in the 20th century. In 1929, the export value of pulp and paper products surpassed that of sawn timber for the first time. The situation did not change until the 1960s, when the metal industry rose to second place (Ahvenainen 1984, 437).

In the late 1990s, Finland was the eighth largest producer of coniferous sawn timber world-wide and third largest in Europe. Among sawn timber exporters, Finland currently is third biggest in the world. At the end of the 1990s, the value of coniferous sawn timber exports amounted about to EUR 1.4 billion, accounting for 4% of the total export revenues of the Finnish industry. Because of the large share of domestic production inputs, the sawmilling industry's net export revenue at times constituted up to 10% of the total export revenue (Juslin 2000).

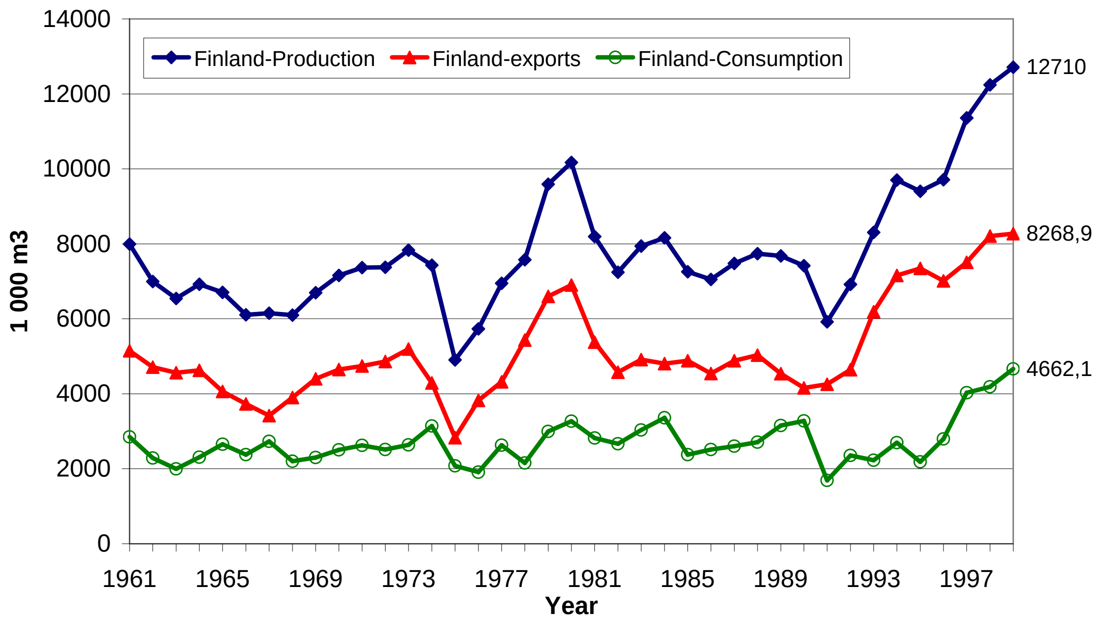


Figure 20. Volumes of Coniferous Sawn Timber – Finland (Source: FAO 1999-2001; Helsinki University of Technology, Wood Product Database 2001)

The Finnish sawmilling industry has always utilised the most valuable part of the forest, i.e. saw logs, sawing them cost-effectively into planks and boards of varying size and quality. The starting point for marketing was to sell the entire product range at the maximum average price, in order to achieve an optimal overall result. Bulk production of this kind resulted in hundreds of items of different sizes and quality classes (Paajanen et al. 2004).

The distribution channels for sawn timber marketing have traditionally been long. Initially, an extensive size and quality range was sold as standard products via agents and representatives to importers and other intermediaries (Paajanen et al. 2004). The end user's needs were not taken into account to any major extent in guiding the mills' product range and operations (Paavilainen 2002).

This *multi-product model and strategy* prevailed until the late 1980s. In this strategy, the earning capacity of a sawmill was based on cutting the logs into standardised products with an optimal raw material utilisation ratio. Selling the products required a multi-level marketing system. Manufacturing techniques were designed to achieve low production costs by mechanisation and rationalisation. Since the technology used in Finnish sawmills was similar to that used in the main competing countries, it was difficult to achieve an essential improvement in the production technology and thus gain a permanent competitive advantage. Re-manufactured products accounted for less than 10% of the exports (Paajanen et al. 2004).

The sawmilling industry is known to be sensitive to economic fluctuations. As seen in Figure 20, the production in 1973 was at the same level as in the record year 1961, nearly 8 mill. m^3/a. In 1975, as a consequence of the energy crisis, sawn timber production fell to its lowest level for 20 years (Ahvenainen 1984, 441). Demand decreased so much that Finnish production levels went down by a third, from 7.4 mill. m^3/a to 4.9 mill. m^3/a, in one year. According to Ahvenainen, the cost effect of the raw material on the production has been delayed by about 2 years, resulting in wood price increases and decreases lagging behind sawn timber prices by one economic cycle (Ahvenainen 1984, 299 and 411). During economic booms, sawmills have benefited from low-cost raw material, while during economic downturns they have been forced to use expensive wood. This has made upward and downward trends more pronounced (Uotila 1994, 4). In addition, the so-called "warehouse effect" due to a long logistics chain, worsened the situation further. Until the late 1980s, there were many intermediate storage facilities involved between the sawmill and end users, such as the sawmill's own warehouse, port warehouses, importers' warehouses in the purchasing country or the local sellers' own warehouses. When these were nearly full and the purchasing countries were experiencing a building industry recession, it took a long time for new orders to arrive from the market (Paavilainen 2002).

Until the late 1980s, the consumption of sawn timber depended strongly on new construction projects. Because of the sector’s sensitivity to economic fluctuations, the products’ unit pricing has been uncontrollable from the end user’s point of view (Paavilainen 2002).

As a consequence of the economic recession in the late 1980s and early 1990s, the production fell in 1991 to its lowest level since the 1970s, to below 6 million m^3/a. The decrease was one sixth of the production level of 1990, and it included a similar “warehouse effect” as in the 1970s. However, as the recession in the building sector continued, demand for sawn timber picked up relatively quickly. At that time, sawn timber consumption no longer depended so strongly on new construction projects, as repair and renovation of old buildings, which was less dependent on economic cycles, had become more common (Paavilainen 2002).

It was not until the 1990s, however, that a strategic change took place in the sawmill industry: the industry began to question the prevailing multi-product approach in favour of production methods derived from product properties and categories, alternatives in raw material quality and price, as well as new models in wood procurement (Paajanen et al. 2004).

From 1992 onwards and throughout the late 1990s, volumes increased to reach a level of 10 million m^3/a. The reason for this was the increased use of timber in the DIY segment caused by a change in the type of housing, bringing about a significant increases in house and garden building and maintenance (Silén 2002).

During the 1990s, the earning capacity of the sawmilling industry displayed a clear upward trend. Whereas in the 1980s the EBDIT had been negative for four years, in the 1990s there was only one negative year.

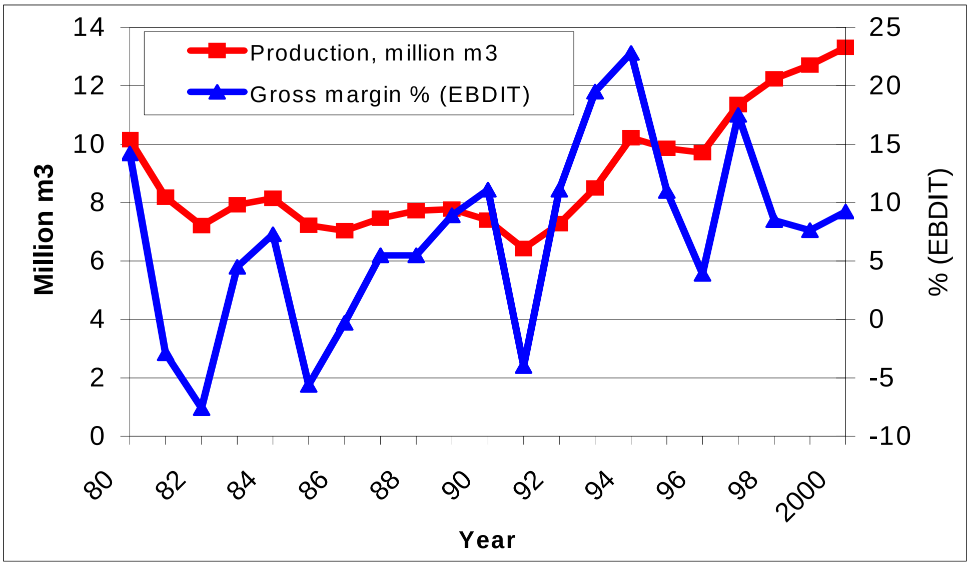


Figure 21. Earnings capacity of the sawmilling industry in 1980–2000. The increase in volumes has improved the earning capacity. EBDIT= Earnings before Depreciation, Interest and Taxes (Source: Finnish Forest Industries Federation, Sept. 14, 2001).

In the early 1990s, significant technical development took place in the sawmilling industry as operations were automated from harvesting to finished products (Figure 15). Also, at that time sawmills reclaimed control of their raw material procurement, which had been earlier managed exclusively by the pulp and paper industry. These developments opened the way for mass production sawmills (page 35).

The sawmilling industry's R&D efforts have focused on solving the problems described above. It was not until the early 1990s that a significant change took place. This change will be discussed in more detail in section 2.5.

2.4.2 Glulam

The manufacture of timber-based glued structures was initiated by Oy Laivateollisuus Ab, currently known as Late Oy, in 1957 (Mekaaninen puuteollisuus 1964, 1277). The production volume of their main product, glued laminated timber, grew steadily until the 1970s, but then started declining. In the late 1980s, the downward curve became more pronounced, with glulam volumes decreasing from over 30,000 m^3/a to 10,000 m^3 in 1992. The considerable decrease in volumes was due to a recession in the building industry, but also to a change in building legislation: glulam structures had been previously categorised as so-called light-weight structures, which did not require building an air raid shelter, if the volume of the building was less than 3,000 m^3. This legal requirement was modified in 1991 and an air raid shelter is now required if the surface area of the building exceeds 600 m^2 (Rajajärvi 2005). Thus, the glulam industry lost one of its competitive advantages.

Glulam remained in the *customized product* and *sub-product* categories for several years. Manufacturers supplied the main supporting beams to the main contractors, with the offer including design, manufacture and erection. It the 1990s glulam finally became a *standardised product*, which producers, technical wholesalers and distributors kept in stock (Lehtonen V. 2004). This permitted regaining the volume level of 30,000 m^3/a in the domestic market.

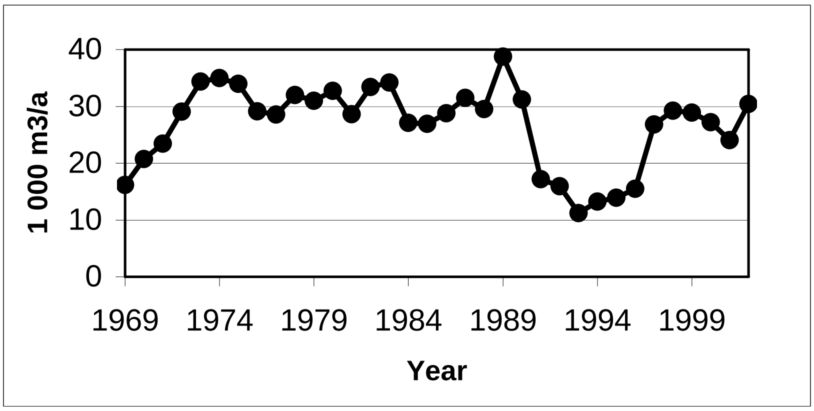


Figure 22. Glulam use in Finland (Lehtonen V. 2004)

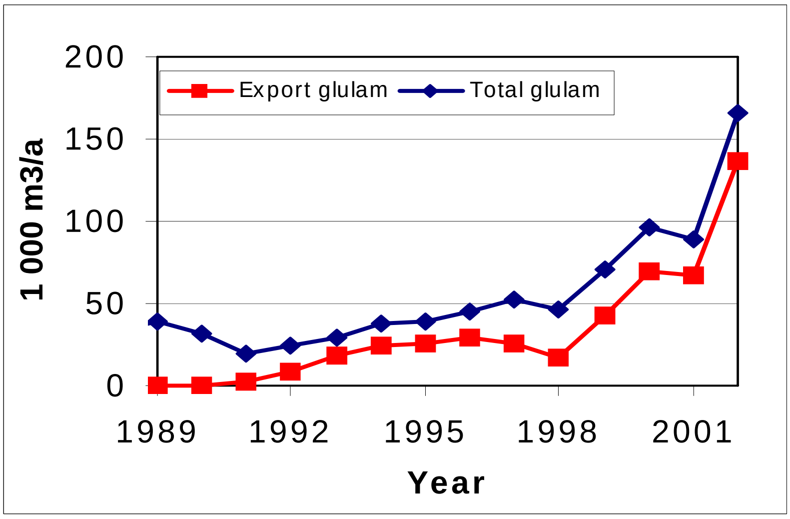


Figure 23. Finnish glulam production and exports (Lehtonen V. 2004).

Export volumes started to grow in 1993, when the Japanese market was opened for glulam. Two Finnish companies started actively supplying glulam to Japan, when deliveries from manufacturers on the US and Canadian West Coast were hampered by the Spotted Owl effect, see Figure 19. However, exports to Germany and other European countries remained at a very modest level throughout the late 1990s and the beginning of the next decade (Nurmi S. 2004; Tekes 2000, 18).

In Germany, glulam production started in 1951 under the supervision of the authorities. In 1967, 40 companies had been awarded a “großer Nachweis A” gluing permit for the manufacture of large section supports, and in 1996 their number had increased to 80 (Wiegand 2004). Until the beginning of the 1990s, the marketing of the product faced similar obstacles as in Finland. As a product category, glulam functioned as a customised sub-product. In the 1980s a couple of manufacturers tried to bring a standardised stock beam to the market, but local carpenters considered it too expensive. However, the prefabricated house industry and post-and-beam building methods favoured by architects added to glulam’s reputation as a high-quality, crack-free sub-product, integrated into the interior design as an exposed element. Consequently, since the early 1990s, glulam is frequently used as a standardised component. In 1998 its volume exceeded 0.5 million m^3, most of which was distributed via wholesale chains as a distribution market product (Barkmann 2004).

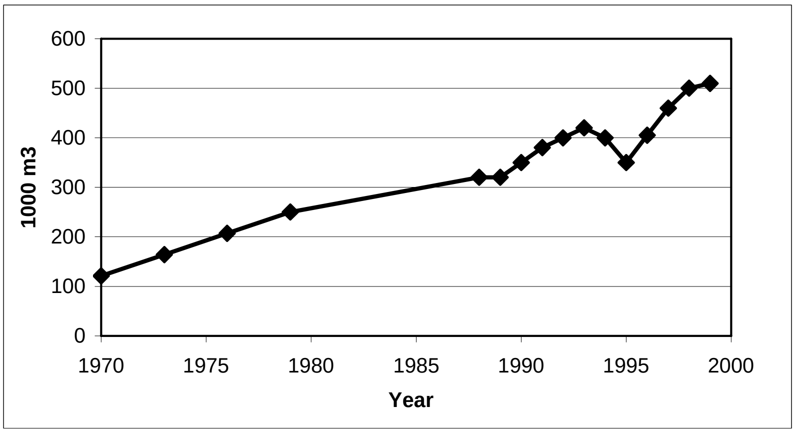


Figure 24. Glulam production in Germany (Klemm 1987, 658-662; The European Glued Laminated Timber Industries 2000).

The favourable volume development in Germany was the result of determined efforts in product development. The main differences compared to Finnish glulam included a clearly better visual quality, as required by the German customers, sophisticated connection techniques and the use of a light-colour melamine urea formaldehyde (MUF) or polyurethane (PU) glue. Some glulam producers invested in high-capacity production lines exceeding

60,000 m^3/a, whereas a larger-than-average glulam factory used to have a capacity of 10-15,000 m^3/a. Several competitive "*Ingenieurholzbau*" companies with volumes of 10,000 m^3/a are currently still in the market. They have specialised in their particular knowledge areas and their products fall in the customised *sub-products* category (Barkmann 2004).

In France, glulam volumes have remained at a level of 80,000-100,000 m^3/a for several years. In 1998 the leading company in France, Weisrock S.A. went bankrupt. It had been in severe difficulties for years due to technical and economic risks in the company's projects, and the bankruptcy news did not come as a surprise. The failure of Weisrock is indicative of the prevailing French situation: unlike the German market, there is quite limited demand for visually impressive wooden constructions (de Launay 1999).

2.5 R&D in wood products industry

Several reports were commissioned as a consequence of the economic recession in the late 1970s, cf. page 22. It had become crucial by that time to acknowledge the lack of an R&D culture and competence in the Finnish mechanical wood industry (Kettunen 2002, 65). Such a tradition had been lacking until the early 1990s, when all of the largest mechanical wood processing companies together launched a joint research organisation, Suomen Puututkimus Oy (SPT, Finnish Wood Research Ltd.) (Paajanen 1998, 6). It was a separate organisation detached from the Finnish Forest Industries Federation (FFIF), which at that time still focused on pulp and paper industry products and their marketing via sales organisations (Metsä 2003).

Prior to the establishment of SPT, some R&D activity was carried out by branch associations, such as Suomen Sahanomistajayhdistys r.y. (SSY, Finnish Sawmill Association) and Suomen Puulevyteollisuuden yhdistys r.y. (Finnish Panel Industry Association), with Suomen Vaneriyhdistys r.y. (SVY; Finnish Plywood Association) as its member association. However, these activities had a very short focus, as they consisted of projects with annual budgets (SSY and SVY annual reports 1970-1990). Following the establishment of SPT, they became centrally managed by the new limited company (Metsä 2003).

During the early days of SPT, the wood sector's economic performance and profitability were declining continuously. Also, capital expenditures for R&D showed that the companies did not have high expectations concerning the capacity of R&D to solve their problems; the prevailing idea was that R&D must be necessary since everybody else is doing it. The originators of SPT shared a common vision of the industry's future. Jyrki Kettunen from Metsäliitto contributed essentially to the establishment of SPT as a small limited company, which made it possible to avoid bureaucracy. Pertti Sierilä from FFIF along with Risto Lähteenmäki from Schauman actively supported SPT's functions right from the start. The research counterpart, VTT, with Tuija Vihavainen as its representative, provided considerable support to the project. As SPT's resources were very limited, without the companies contributing to its research activity by any significant work input, the operations would not have been productive (Metsä 2003).

SPT's board decided on research activity guidelines and strategies. The operations were implemented by the research committee through 9 annual meetings. Its members were R&D professionals appointed by the participating companies - one from each company. The research committee reviewed project proposals and selected the ones to be implemented, and subsequently appointed a committee member as a chairman responsible for the project. Researchers and participating companies' own experts were invited to join the project groups. I was appointed as a representative of Finnforest in the research committee in 1994 (SPT 1995).

During the 1990s, the National Technology Agency, Tekes and the industry carried out several technology programmes, which together constituted the largest centrally prepared and co-ordinated collection of development programmes ever implemented in the Finnish mechanical wood industry. SPT was responsible for carrying out these programmes. The following development programmes were aimed exclusively at the wood industry:

Mechanical Wood Processing Technology Programme (PMT)	1992-1996
Wood-based Panels Technology Programme (PLT)	1992-1996

The PMT programme concentrated on the sawmilling industry and the PLT programme on the panel industry, especially the plywood industry. Both programmes were successful. Their example helped to launch several subsequent projects, which benefited from established contacts and working practices, along with a shared enthusiasm.

In the 1990s, the KANSA project (The Profitable Sawmill), a key project within the PMT technology programme, was a central contributor to the strategic change within the sawmilling industry. It laid out the principles for market-oriented sawmill operations, based on product groups. First, the product segments that were relevant for Finnish sawn timber were determined by means of market research along with their requirements for the properties of wood, then production processes were devised for the new product groups, and finally issues relating to the supply of optimal raw material in Finnish forests were addressed. This meant modifying the prevailing raw material centred operating practice to adopt a product group-focused approach to sawmill operations (Paajanen 1997).

The outcome of the KANSA project was a clear indication of better profitability for sawmills specialising in product groups as compared to the traditional bulk production sawmills. The KANSA project led to a number of subsequent development projects, concentrating on product-focused, selective wood procurement and harvesting automation, on transport to sawmills using only one wood species as well as on integrated information systems to enable the sawmills to better manage the entire delivery chain from forest to products. These have all been implemented in the sawmill industry, although bulk sawing remains to the present day a common operating practice.

Examples of the outcomes for R&D carried out in companies include productivity increases by means of automation technology, such as machine sorting; implementation of quality systems; development of apprenticeship contracts and professional qualifications; and transfer to a non-hierarchical organisation based on team work. New export markets were created for sawn timber, e.g. Japan (Paajanen et al. 2004).

The outcomes of the PLT programme proved useful to Schauman Wood Oy and Finnforest, who simultaneously founded the modern Finnish spruce plywood industry at the beginning of the 1990s. The programme was not the only contributor to developments in spruce plywood, since the Tunkelo rapport (1977) had already given rise to development projects. However, the wood industry branch rationalisation that was initiated in the early 1980s postponed these projects until the 1990s. The PLT programme did nevertheless produce a conscious effort that was needed to change the industry’s strategic thinking; consequently, several open questions could be centrally resolved and investments launched in a timely manner (Lähteenmäki 2002; Metsä 2003; Paajanen 2004), see also page 24.

An important characteristic of the PMT and PLT programmes was that they were directly business oriented. They included a business counterpart which could benefit from the results either immediately or in the long run (Klus and Hirvensalo 1997, 40-41).

As the companies’ operations expanded and the consolidation of the wood industry progressed, SPT’s operations expanded as well. For the participating companies, the R&D cost incurred from financing SPT’s operations was insignificant in comparison to the sector’s turnover. More important than the financial contribution was the fact that the companies contributed their experts’ knowledge by sending their representatives to the research committee. The members of the research committee, for their part, benefited from gaining more experience in R&D during the course of the PMT and PLT programmes (Metsä 2003).

Halfway through these projects a new programme was initiated, focusing on wood construction:

Wood in Construction Technology Programme (PRT) 1995-1998

The point of departure for the PRT programme was challenging: Its focus was on bringing about a cooperation between basic industries within the wood products sector and the building industry. Tekes selected a support group to take charge of the preparatory work for the programme. Its members included representatives of the wood industry, builders and building contractors, which however did not take part in the meetings at all during the course of the project (Tekes 2000, 1). The management group in charge of the implementation of the programme included construction companies’ and building contractors’ representatives. I personally had the chance to take part in the management group as an invited wood products industry representative.

Prior to launching the programme, according to Tekes, wood construction did not have an opportunity to develop in the prevailing conditions, because Finland was lacking an intermediate processing industry, system providers, speciality contractors and procurement practices based on competition between different solutions. The development of the branch required – in addition to traditional, typical goals of technology programmes – the formation of a new industrial structure (Tekes 2000, 3).

The Programme directors defined as a general goal the creation of an internationally competitive basic production, intermediate processing and speciality contracting, making possible economically and ecologically sustainable wood constructions of high-quality designs (Tekes 2000, 5). Later on the promotion of exports and the creation of cooperation networks were included in the goals (Tekes 2000, 16-19).

The PRT programme was divided into the following thematic areas which were assigned projects (Tekes 2000, 6):

- Topics derived from performance requirements
- Building systems and processes
- Product development
- Pilot building and process testing
- Utilisation of the results and technology transfer

The PRT programme was clearly less structured than the PMT and PLT programmes. In contrast to the PMT and PLT programmes, it did not involve a participant to whom the results from projects would have appeared as immediately relevant. During the course of the programme, several projects involving the construction of wooden blocks of flats have been implemented. They were, however, mostly pilot projects, and therefore their competitiveness remained at a modest level. In my opinion, the PRT programme clearly indicated to the wood products industry that its responsibility was to function as an initiator towards the building contractors. As the construction industry is not committed to the use of any material in particular, building contractors would opt to change to a new material only if it leads to a more competitive business and suited their operating practices.

2.6 How Kerto-LVL differs from plywood and sawn timber

The main difference between Kerto-LVL and LVL in general and plywood and sawn timber is the “age” of the product: the industrial production of laminated veneer lumber dates back over two decades in Europe. In comparison, the industrial production of plywood made from peeled veneers began in Europe and in the USA in the late 19th century (Koponen H. 2000, 16). There are documents mentioning sawmilling in Finland and exports dating back to the 16th century.

The key field of development in the sawmilling industry until the 1990s was raw material management. Still to the present day, the operations are more raw material centred than in veneer-based plywood and Kerto-LVL industry, and even more so in comparison to steel or precast concrete industry. In plywood industry the main focus in development has been, on the one hand, on productivity increases by means of production automation and rationalisations and on the other, on the development of customised products first based on a SBA and later on a SBU (Kamensky 2000, 94).

The case of Kerto LVL is particularly interesting for two reasons, which make it exceptional as a Finnish wood product from the 1970s to 1990s:

- Since its development was carried out in close cooperation with chosen end user companies in Finland and with partners in export countries, Kerto-LVL can be categorised in its early stage as a *customized product* on *solution market*. However, in the following stages it gave rise to a product family in both the *solution* and *distribution market*.
- North American LVL and I-beams have tried to enter the European markets since the 1970s but despite determined efforts have not succeeded in threatening the Kerto-LVL markets, in spite of the favourable dollar exchange rate. The North American suppliers' efforts have been considerable especially in the 1990s, after Trus Joist founded an European sales office in Brussels in 1992.

Prior to the 1974 investment decision (Metsäliiton Teollisuus Oy 1974, 5), the general idea was to develop a structural beam product with higher strength values as a substitute for other products on the market, since the distribution network was already in place. It would have been a typical industry-driven *technology push* situation, in which the new product was supposed to fit an existing distribution network (Hietala 1974, 10). Since this was not the case, the only alternative was to carry out the R&D project in interaction with business, which meant that instead of the *distribution market*, the developers had to target the product right from the beginning at the *solution market*. The new approach led to cooperation with building contractors, designers and authorities both in Finland and in export countries, and consequently the developers had the possibility to influence the building contractors' business solutions in the domestic market since the end of the 1970s and in the export market since the 1980s.

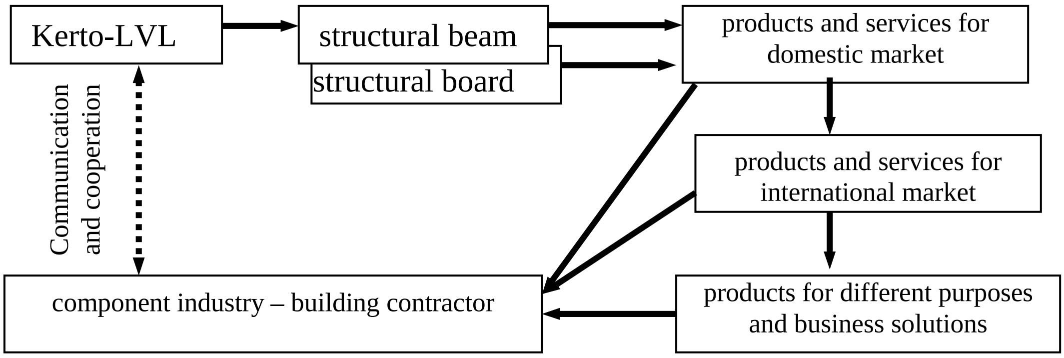


Figure 25. Evolution of development project from a structural beam product to cooperation between primary industry and building contractors, as seen in the 1980s.

The cooperation described above was the key to the interaction between R&D and business. It was also the basis for the research question put forward in section 1.3.

2.7 Building industry as a customer of the Finnish mechanical wood industry

The building industry uses more than 60% of the woodworking industry's products, either as such or re-manufactured (source: VTT 2004).

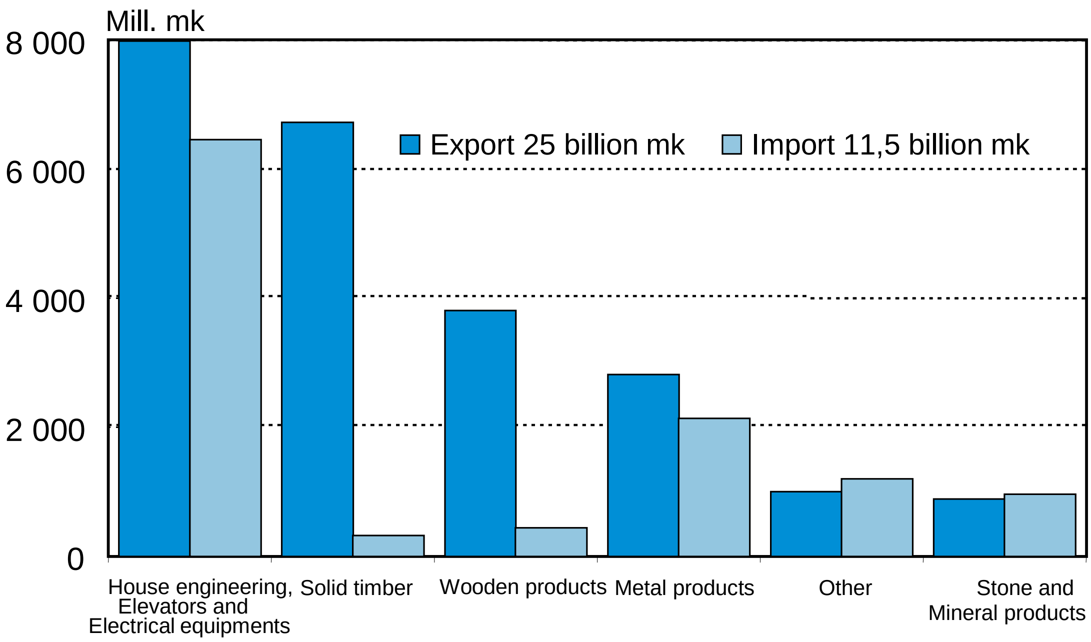


Figure 26. Foreign trade of building product industry in Finland 1999 (source: foreign trade statistics/VTT Anna-Leena Perälä)

Table 3. Building product markets (Rakennustuoteteollisuus 2002)

	Imported products %	Deliveries in domestic markets %	Exports of the industry %	% of total volume
Concrete and stone products	13	74	13	15
Wood products	3	43	54	30
Metal products	29	30	41	45
Other products	25	53	22	10
Total	20	40	40	100

The building industry experienced a sharp recession in 1990-1991. The recovery took several years: the upward trend did not resume until late 1995, lasting until the end of 2000. Consequently, building contractors were cutting down their activities, so that in the end they no longer employed in-house R&D personnel or specialists in wood construction. Instead, the work was outsourced to subcontractors who were selected on the basis of competitive tendering (Salo 2002). Since the wood products industry has lacked a re-manufacturing industry which would provide *sub-products*, this has led to a situation where wood products companies, as material suppliers have less contact with on-site operations than concrete industry companies providing sandwich elements (*sub-products*) currently have.

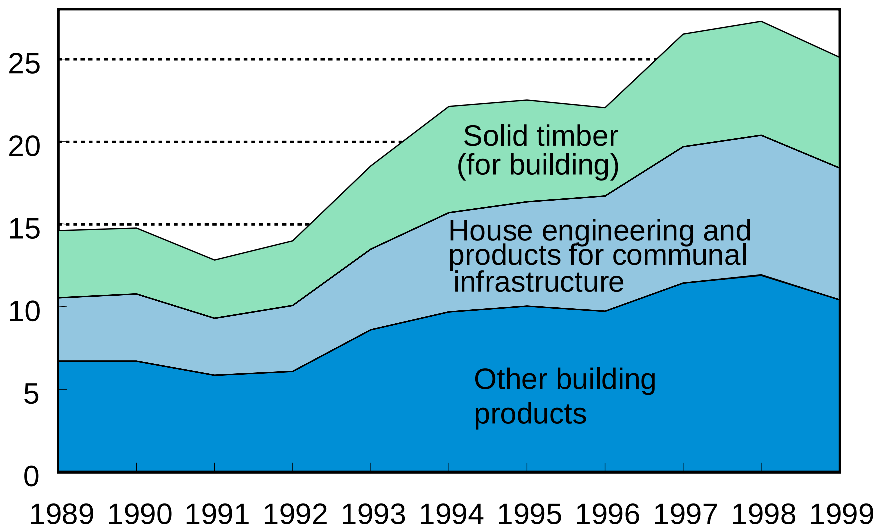


Figure 27 Finnish exports of building products (source: foreign trade statistic/VTT Anna-Leena Perälä).

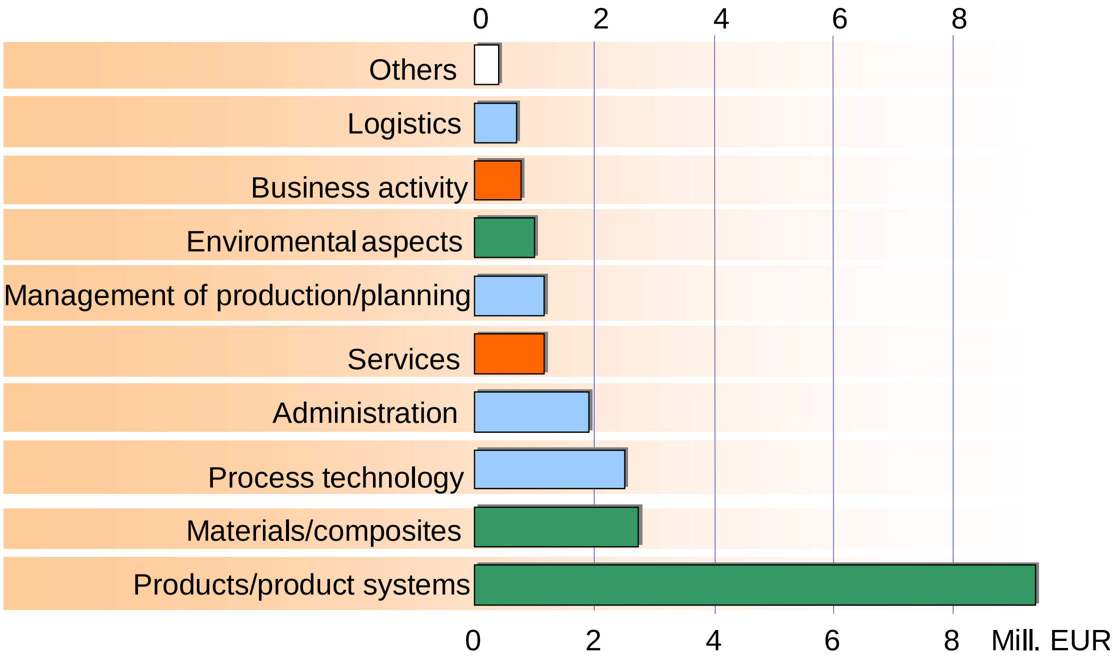


Figure 28. R&D objects of wood product industry using EUR 22 million in 2001 (source ISBN 952-5004-41-4 URL:http/www.vtt.fi/rte/dms/t&k/rakennusalan_t&k_2003.ppt)

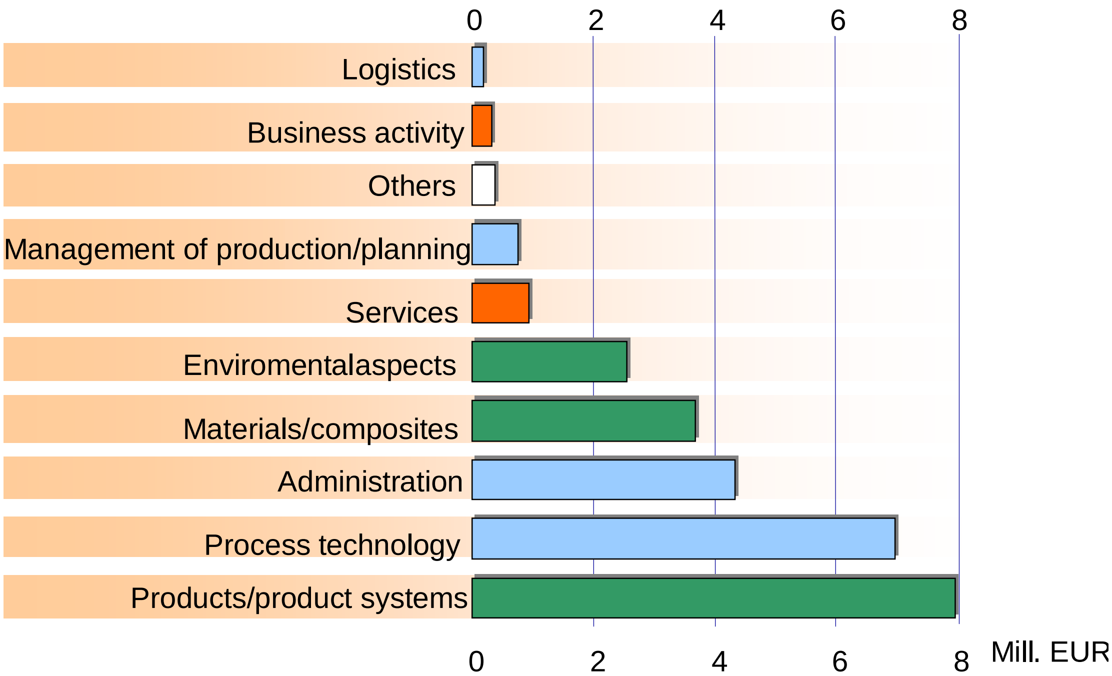


Figure 29. R&D objects of concrete and stone industry using EUR 28 million in 2001 (source ISBN 952-5004-41-4 URL:http/www.vtt.fi/rte/dms/t&k/rakennusalan_t&k_2003.ppt)

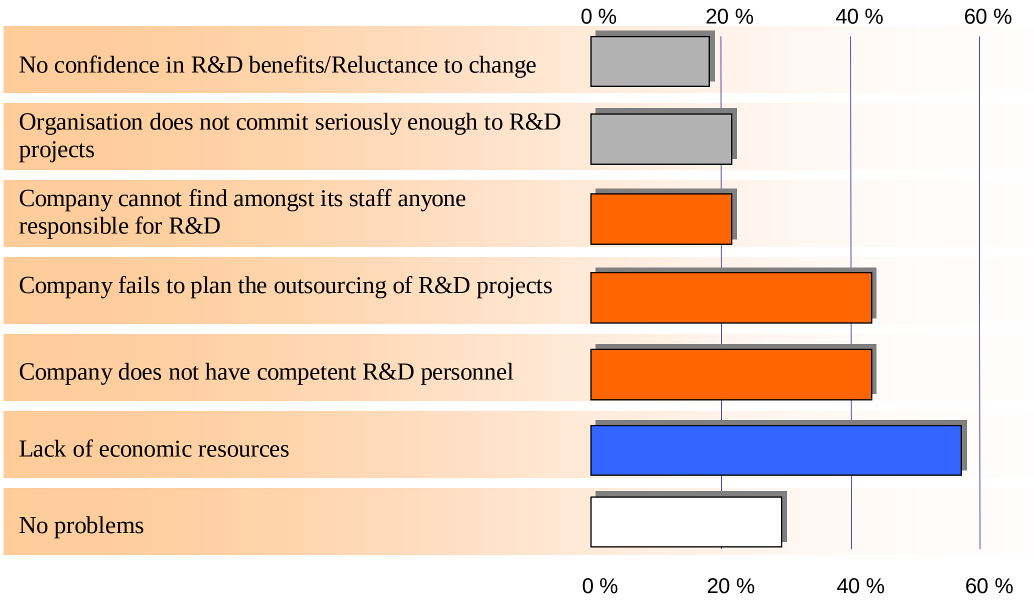


Figure 30. Constraints of R&D in wood product industry (source ISBN 952-5004-41-4 URL:http/www.vtt.fi/rte/dms/t&k/rakennusalan_t&k_2003.ppt).

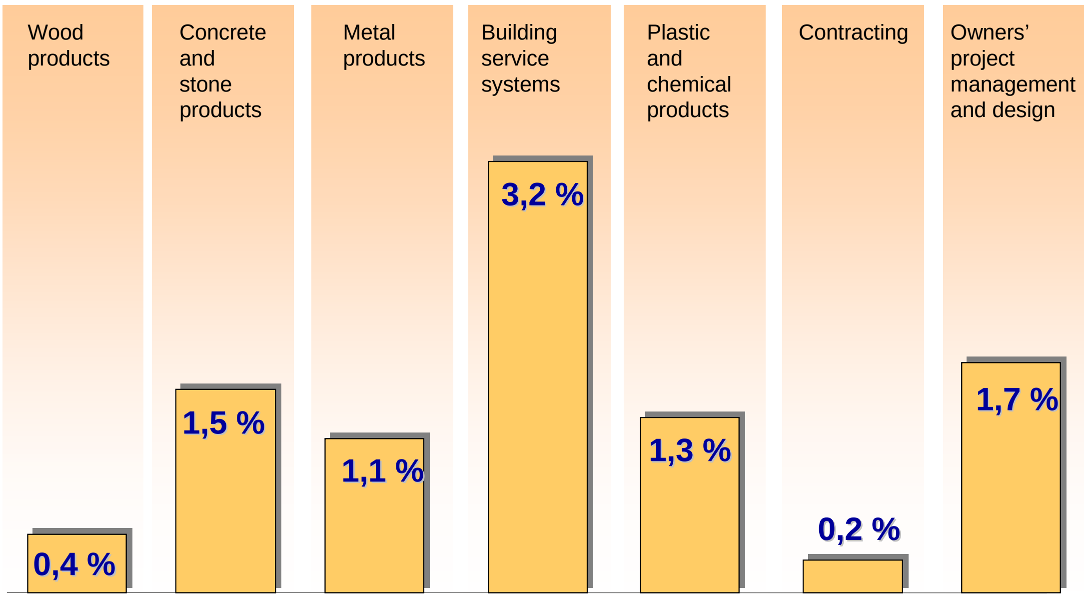


Figure 31. Share of R&D related to volume of business – the average of the whole real estate construction cluster in Finland is 0,9% (source: ISBN 952-5004-41-4 URL:http/www.vtt.fi/rte/dms/t&k/rakennusalan_t&k_2003.ppt)

The figure below illustrates the share of companies' R&D services outsourced from research organisations.

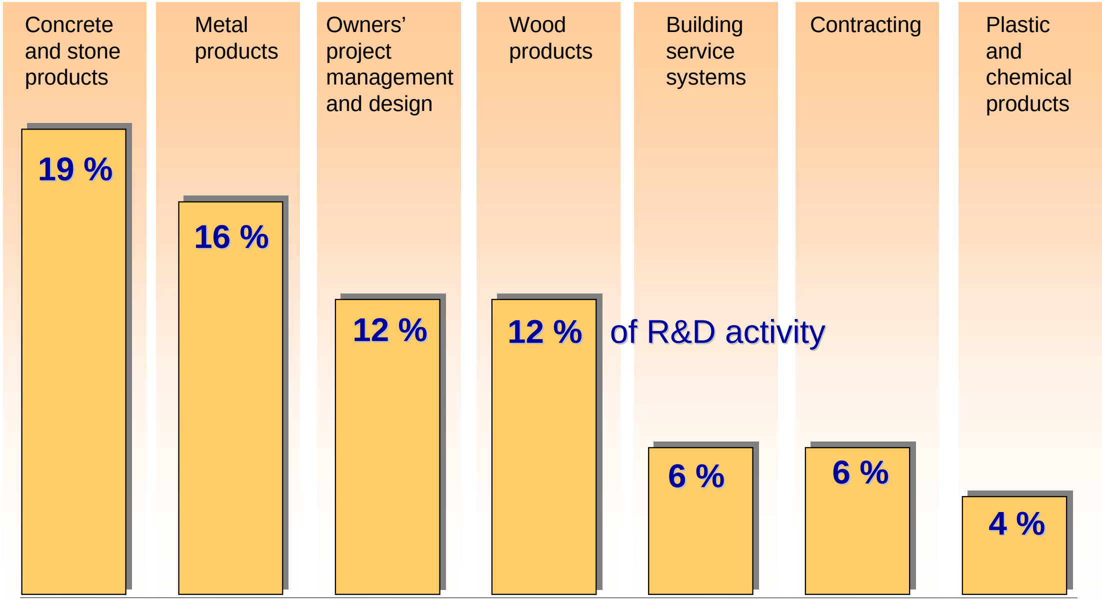


Figure 32. Networking with research organisations or other companies in R&D activities (source: ISBN 952-5004-41-4 *URL:http/www.vtt.fi/rte/dms/t&k/rakennusalan_t&k_2003.ppt)*

3 CONCEPTS OF THIS STUDY

This chapter describes the concepts used in this study and presents the hypotheses based on these concepts. First, the concepts of R&D and innovation are defined and Kerto-LVL is positioned with regard to traditional approaches to R&D within the wood products industry. The following main concepts are used:

- Business idea and its sub-concepts
- Key technology model
- Innovation structure

3.1 R&D as the concept in this study

R&D is in industry defined as work that tries to find new products and processes or to improve existing ones (Hornby 2000, 1085). In a larger sense, it comprises all generations of new scientific knowledge that allow or lead to the development of products and services (Kangasluoma 1979, 7). Industrial R&D has three strategic purposes (Roussel et al. 1991, 17):

- to defend, support and expand existing business
- to drive new business
- to broaden and deepen a company's technological capabilities

Within the scope of this study, R&D is considered as a broad concept containing both technical and business viewpoints, as well as their interactions. I shall take into account the following aspects from Roussel's three strategic purposes:

- to support and expand existing business
- to drive new business
- to broaden the company's technological capabilities

The above theories and the experience gained from the Kerto-LVL development process suggest the following three main concepts:

- Business idea, which represents the actual way a business carries out its operations in practice
- Key technology model, which indicates what kind of R&D is necessary and how different levels of R&D interact.
- Innovation structure, which describes who the participants in R&D are and what kind of processes exist between the participants

These concepts are system theoretical by nature as well as strongly interconnected.

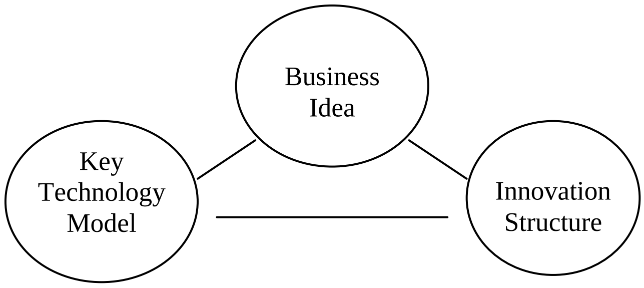


Figure 33. Interaction between the main concepts of this study.

There are three key terms to define (Roussel et al. 1991, 13) and (Kangasluoma 1979, 7):

– research: basic research and applied research
– development
– technology

According to Roussel et al. (1991, 13-14), to academics and those who work in research institutes, *research* means an orderly approach to the revelation of new knowledge about the universe. This is defined as *basic research*. In industry, the *research goal* is knowledge applicable to a company's business needs that will enable the company to participate in the forefront of new technology or lay the scientific foundation for the development of new products or processes. This is defined as *applied research*.

The purpose of *development* is to apply scientific or engineering knowledge, to expand it, to connect the knowledge in one field with that in another.

In the general case, *development* seeks to move product or process concepts through a series of definite stages to prove, refine, and make them ready for commercial application.

Technology is viewed as the application of scientific and engineering knowledge to achieve a practical result. It is the *process* that enables a company to say: "We know how to apply science/engineering to…"

3.2 Contents of the innovation concept in this study

The concept of innovation has many definitions and sub-categories. The dictionary (Hornby 2000, 670) specifies it as a new idea or way of doing something that has been introduced or discovered. In a definition by Jämsä (1994a, 122), an innovation is an invention that is widely used or brings notable profit. An invention, for its part, is a technical novelty, which most probably has been patented. Kotler (1994, 348) gives a wider definition for innovation as a new or improved product, service, system, process or method. An innovation is in essence a commercially successful invention. According to von Hippel (1994, 429-439), the locus of innovation is the physical or virtual "site" where the needed knowledge and the problem-solving capabilities of one or several companies are brought together to create innovation.

Innovation can be approached from different viewpoints, depending on the environment in which the related invention takes place. The present study focuses on innovation processes within tangible investment products. The following table encompasses the relevant processes and approaches to innovation that are relevant to the scope and position of the method of this study:

Table 4. Five approaches to innovative activity.

	Degree of novelty and the scope of development	Focus area
Private inventor "Gyro Gearloose"	Visualizes a new approach to the manufacture of an existing product in the market or to a current operation	Incorporating the invention into the corporate objectives in order to turn the invention into business
Invention within the organization	Improves the current manufacturing method or operating method	Taking small steps towards an investment-focused development
Invention made in basic research	Knowledge transfer from the basic research stage through a spin-off into a narrow world-wide business area	Synchronizing participants' motives and operating methods
The "Kerto-LVL" Model, see Figure 35	New technology, operating method and market within the existing business area → wide-scope operations	Implementation in basic production → long-term and interactive operations
Key Technology Model, See definition in chapter 3.5	Interaction between focused research, development and business	Creates a more dynamic innovation structure which makes it possible to achieve results faster

3.2.1 Private inventor

If the inventor is a private person, who operates strictly within a technology-oriented approach without knowledge of the physical or chemical factors that are relevant to his/her study, or without a basic or applied research background relating to these factors, he/she is considered an independent entrepreneur operating separately from, and outside of, a large company. We are probably talking of a *technology enthusiast* (Moore 1995, 15-17). In

Jämsä's study (1994) the focus is on what happens and what factors are involved when an external person presents an innovation to a company with a view to having it exploited. Jämsä views the innovation mostly from the inventor's point of view and describes the path from invention to innovation, as presented in Figure 34. The path is shown as culminating in the *contact person*, i.e., the person in the company to whom the inventor presents his ideas. Influencing him are, on the one hand, society and the company, and on the other, the information about the invention mediated by the inventor. On the basis of these, the contact person has to evaluate the invention and make the decision about his attitude towards it. The interest of the contact may lead to a utilisation agreement and an innovation process, which in turn may succeed or be interrupted.

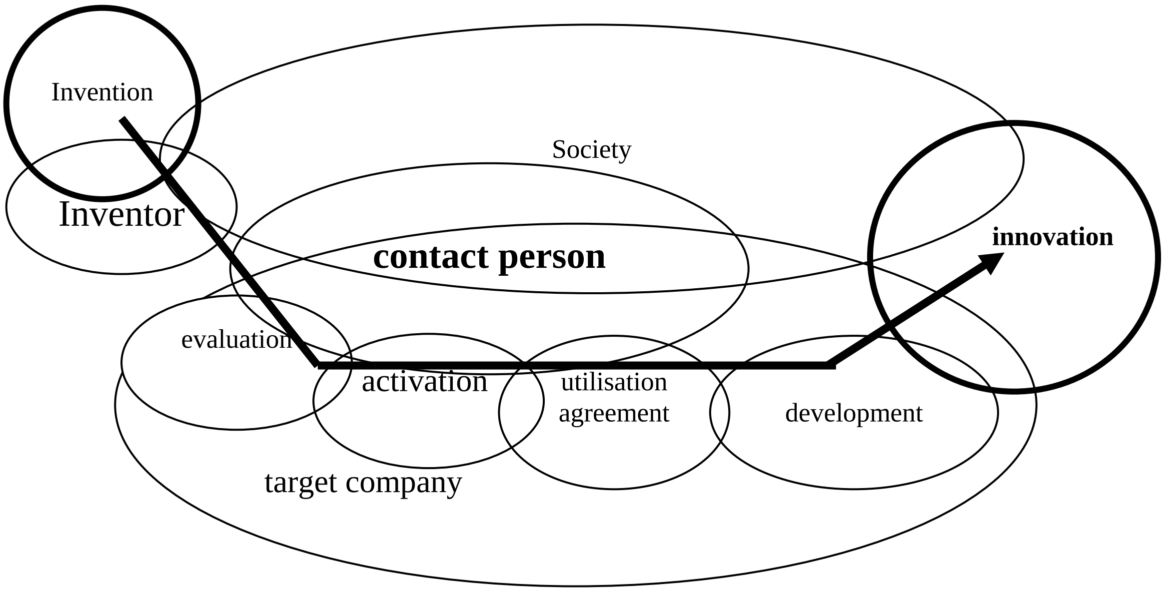


Figure 34 Principle of the exploratory research framework: an external inventor's idea is developed into an innovation (Jämsä 1994, 26).

3.2.2 Invention made in basic research

The innovations that stem from an area of scientific research are traditionally based on an invention made in basic research. The prerequisite for these inventions is an overall knowledge of the topic area, including marketing needs, as well as related applied research and basic research. Hasu (2001) describes in her thesis "Critical Transition from Developers to Users; Activity – Theoretical Studies of Interaction and Learning in the Innovation Process" the stages of a development project involving a cold laboratory technician's know-how about measuring low-temperature phenomena on the one hand, combined with medical researchers' competence in neurophysiology on the other. The focus is on an innovation process where the aim was to develop and commercialize a new brain-mapping device for hospital use. Many different interest groups worked together in order to achieve this. However, the innovation process was affected by the participants' diverging and imbalanced motives, which led to trouble at the implementation stage (Miettinen et al. 2003, 31-32). The above example illustrated the development of a product system which in its early stages depends on the active cooperation between the *technology enthusiasts* and the *visionaries.* The life cycle model calls this the *early market*, faced with the risk of *the chasm* (Moore 1995, 15-17).

The defining characteristic in the innovation described above is a technologically distinctive new invention, whereas the Kerto-LVL development process was based on applying existing technology in a new way.

3.2.3 Innovation acceptance

The next model corresponds to the definition of innovation by Kettunen (2000) (adapted from EIRMA 1976, see also Meristö and Karjalainen 2001 and Meristö et al. 2001, 409-441). Compared with previous models, this approach contains a social viewpoint. In order to become an innovation (**I**), a technological invention has to gain the type approval of the marketplace, technological institutions and society. In other words, it has to fulfil the following criteria:

1. Technological applicability
2. Economic profitability
3. Social acceptability

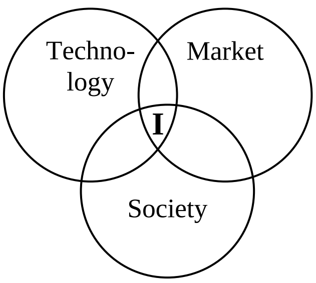


Figure 35. Innovation acceptance (Kettunen 2000).

This innovation acceptance model includes exactly the same critical areas of the development process as we had to take into account at the end of the 1970s when developing Kerto-LVL as a complete product. It was the first time that a development project was carried out on an interactive basis with different parties. The situation shown in Figure 10 illustrates a special application of this model. Initially, when we started developing a new product idea, we needed new *technology* as well. At the same time, it became necessary to get a statement from the *authorities (society)* on the technical values of the new structural product. Without that, we could not have started *marketing* the product. Afterwards, the authority approvals would prove to be the most difficult part of *innovation acceptance*. Our solution was to establish an interactive development process together with some end users in the domestic market.

3.3 Product positioning within the development process

In Kotler's major classification (1994, 436 – 437), products are divided into either consumer and industrial goods or investment products. In this study, mechanical wood industry products are classified as *industrial goods*. Kotler divides industrial goods further into three groups: *materials and parts, capital items, and supplies and services*. Within the wood products industry, industrial products are generally categorised into *commodity products and special products* (Mali et al. 1986, 69).

For the purposes of this study, it is necessary to compare the essential characteristics of commodity products with various special products, since both categories demand their own, different approach to R&D. According to Mali et al. (1986, 71-72), *commodity products* share the following essential characteristics:

- They are manufactured in large volumes
- Different suppliers adhere to nearly the same product type according to a set of generally accepted requirements
- They are sold at a world market price
- They are sold for many purposes and in large series to a so-called *mass market*.

Special products have the following defining characteristics:

- They are manufactured in relatively small volumes
- Different suppliers manufacture the products to comply with operational requirements based on their operating principles and end use (technical speciality product).
- They are designed to solve customers' specific problems
- Their pricing is based on the benefit to the customer

- They are delivered to a relatively large number of customers, who purchase a fairly small amount each.

R&D needs are different for commodity and special products. In commodity products, improvements concern processes, raw materials and efficiency. All the development measures are targeted at improving the cost structure. Sawn timber and spruce plywood are typical examples of commodity products. The R&D in special products requires a wider approach, which pays special attention to the customer's product needs.

Combining the classifications of Kotler and Mali makes it possible to describe the positioning of Kerto-LVL as presented in Table 5. It also shows the differences between LVL consumption patterns in the US and European markets. In North America, LVL was originally used as flange material in load-bearing I-joists, in other words as a substitute for large-dimension sawn timber. LVL as such acted as a *substitute* for steel beams, which were used as support beams for I-joists in portal frames and purlins. Also Kerto-LVL was sold in the US market according to this consumption pattern, see Appendix III.

In Finland and Central Europe, the opportunities to compete were different. Kerto-LVL was not competitive as a direct substitute for sawn timber, and unlike in the USA, I-joist did not exist in the market. Instead, in many structural applications Kerto-LVL provided the user with a significant competitive advantage vis-à-vis the other alternatives available.

Table 5. Positioning of LVL within the product sphere in the USA and in Europe; product classification according to Kotler and Mali.

Product	Industrial		
	Material and parts	Capital items	Supplies services
Commodity	US manufactured LVL in the USA Kerto-LVL in the USA, US manufactured LVL in Europe		
Special	Kerto-LVL in Europe		

The table below illustrates the situation for sawn timber and plywood. Again, Kerto-LVL appears in the table. When Kerto-LVL is used as a part in demanding structures, it can be classified as an investment good. It can include supplies and service modules, such as the integration of other suppliers working in the project closely into wood component deliveries, or organising tightness testing, as required in Germany.

Table 6. Positioning of Finnish wood products and of Kerto-LVL within the product sphere in Europe; product classification according to Kotler and Mali.

Product	Industrial		
	Material and parts	Capital items	Supplies services
Commodity	Sawn timber Spruce plywood		
Special	Birch plywood Glulam	Kerto-LVL in Europe as a part in demanding structures	Special dried sawn timber

Over a long time-scale, the above-average success of a company is founded on a *permanent competitive advantage* (Porter 1985, 24 – 43; 1990, 39). The type and scope of the advantage can be combined into the notion of *generic strategies*, or different approaches to superior performances in an industry. Each of these archetypical strategies, illustrated in Table 7, represent a fundamentally different conception of how to compete:

- In the *cost leadership* strategy, there are many types of products of good, not superior quality.
- In the *differentiation* strategy, a company is offering a wide array of high-quality products.
- *Focused differentiators* concentrate on specialized types of products that involve specialised technology, which command prices high enough to offset higher labour costs.
- *Cost focusing* companies offer relatively simple standard product types at a lower price than their competitors.

Table 7. Generic strategies and LVL according to Porter (1990, 39).

Competitive scope	Competitive advantage Lower cost	Differentiation
Broad target	Cost leadership LVL in USA I-joist with LVL in USA US-manufactured LVL in Europe	Differentiation Kerto-LVL in Europe in 1990's
Narrow target	Cost focus I-joist with LVL in Europe	Focused differentiation Kerto-LVL in Finland in 1970's und in Europe in 1980's

The table below represents the positioning of wood products according to a strategic classification.

Table 8. Generic strategies and wood products according Porter (1990, 39).

Competitive scope	Competitive advantage Lower cost	Differentiation
Broad target	Cost leadership Sawn timber Spruce plywood Glulam in Germany	Differentiation Plywood in vehicle and concrete forming industry Glulam in Germany and in Finland
Narrow target	Cost focus Spruce plywood as a floor panel	Focused differentiation Furniture plywood and facade plywood

As seen in the tables above, Kerto-LVL and US LVL are positioned similarly in the USA, but differently in Europe. Therefore, the US LVL has continuously been faced with difficulties when trying to penetrate the European markets. Similarly, the strategic positioning of other wood products differs from that of Kerto-LVL, with the exception of glulam in Germany and in Finland, which present more similarities with the positioning of Kerto-LVL. In Europe, the I-joist has not had a proper *operating system* of its own (see chapter 3.5.3), and consequently it has remained a special product with a narrow market.

According to Kotler, companies must decide what demand technology to invest in and when to transit to a new demand technology (1994, 355). Ansoff calls a demand technology (1984, 38) an SBA, namely "a distinctive segment of the environment in which the company does or may want to do business". The plywood industry has benefited from this approach, see chapter 2.3.

For the purposes of this study I have defined the product concepts with regard to market and distribution options as follows:

Table 9. Classification of wood industry products according to this study.

Product	Market	Implemented by	Distribution channel
Commodity product	Mass market	Re-manufacturer End user	Deliveries to wholesalers in series of thousands of m^3 and further in truck loads to local distributor's warehouses
Standard product	Distribution market Kerto-LVL in Finland in 1993	Local structural designer calculates simple straight standardized beams using producer's operating system	Industrial distributor orders standardized beams into warehouse according to length and cross-section
Component product; as the product's lifecycle expands it moves from the solution market into the distribution market	Distribution market Kerto-LVL in Finland 1984 and in Europe 1995	Structural designer prepares a series or project based order catalog of cut-to-size and notched components, with working drawings. Re-manufacturer produces the components according to working drawings.	Industrial distributor orders the components according to the order catalog. Components are delivered to building site for direct installation, or to element producer's assembly line.
Customized Product; in the early stages of a product's lifecycle it is in the solution market	Solution market Kerto-LVL in Finland 1977 and in Europe 1984	A selected group of designers dimension customized products optimally. Re-manufacturer manufactures them ready for installation. Main contractor is responsible for installing the customized components in situ	Manufacturer manages direct delivery to end customer via a chosen sales organisation, if it provides logistical added value.
Sub-product	Solution market Kerto-LVL in Finland 1995 and in Europe 1988	Re-manufacturer takes responsibility of the design, manufacture and installation of the entire sub-product.	Direct project delivery from re-manufacturer to end customer
Turnkey product	Integrated system product market Kerto-LVL in Germany 1992 and in France 1996	Manufacturer takes responsibility of the entire construction project: design, manufacture and installations.	Direct project delivery from manufacturer to end customer on a turnkey basis

Other classifications are also applicable, but the division presented above was chosen in this study to reflect the positioning of Kerto-LVL within the wood product and market spheres in various contexts.

3.4 Summary of theories on R&D within the scope of this study

The literature on R&D theories can be divided into two categories:

- Reference books and articles on the business environment by researchers.
- Analyses and theses focusing on a specific topic within a defined subject area.

Below is a summary of both of these categories.

Table 10. Publications relevant to the subject of the study.

Researcher	Topic	Theory
Porter M. (1985)	Competitive Advantage–Creating and Sustaining Superior Performance	The Generic *Value chain* and competitive advantage cost leadership cost focus differentiation focused differentiation
Roussel P. et al. (1991)	Third Generation R&D: Managing the Link to Corporate Strategy	Three Types of R&D. Partnership between General and R&D Manager. The R&D Portfolio
Kotler P. (1994 and 2003)	Marketing Management	Generic *Value chain*, pp 43-45 Early-adopter theory, p. 346 Product Life Cycle, pp 354-380 Push versus Pull Strategy, p. 618
Moore G. (1995)	Inside the Tornado Hyper growth of the market.	The Early and Mainstream Markets with the Chasm. 100 % Product
Christensen C. (1995)	The Innovator's Dilemma	Established Technology versus Disruptive Technology It is not allowed to listen to your customer's wishes only (p. xii)
Ulrich K. and Eppinger S. (1995)	Product Design and Development	Variants of Generic Development Process
Cagan and Vogel	Creating Breakthrough Products	Fuzzy Front End as a series of funnels
Charan R. and Tichy N. (1998)	Every Business is a Growth business	There's No Such Thing as a Mature Business. The "Mature Market" Trap
Klus J. and Hirvensalo R. (1997)	The Mechanical Wood Processing and Wood-Based Panels Technology Programmes 1992-1996	R&D Structures, p. 31 Innovation Structure, p.46 Key Technology Model, p 34 Existence of the Theory and R&D project, p.48 Knowledge Reservoir, p. 53
Miller W. and Morris L. (1999)	Fourth Generation R&D, Managing Knowledge, Technology, and Innovation	New market knowledge and new technology

Product design and development

The prerequisites for developing successful new products, on the one hand, and the factors which have lead to failure, on the other, have been combined into a wood industry-specific theoretical knowledge base to help new developers avoid the severest mistakes. The table below lists some failure and success factors and observations found in the relevant research.

Table 11. Analyses and theses focusing on a specific topic within a defined subject area

Researcher	Topic	Theory
Rothwell R. et al. (1974)	SAPPHO survey study	Pairwise comparison between successful and unsuccessful innovations
Mali et al. (1986)	Mekaanisen metsäteollisuuden tuotekehitys Suomessa – "Product development in Finnish Mechanical Forest Industry"	Extending the product development concepts' validity range by adding new concepts, pp 48-59. Product requirements considering the *Value chain*, pp 69-72, see Figure 8 on page 9.
Carlson (1987)	Statistics of R&D projects founded by SITRA, the Finnish National Fund for Reseach and Development, in 1967 – 1985.	No mathematical statistical model is available to predict the success of a project
Rinne (1989)	The Negation Selection Model and its Impact on the Product Development of an Investment Item	The research has drawn up a series of negations/negative factors which the R&D activity needs to eliminate to avoid any risks to the product's marketing potential
Cooper (1994)	Third Generation New Product Development (NPD) processes	The importance of the team approach and upfront planning. Study of NPD-project is process-oriented.
Jämsä (1994)	The Conditions Required for Inventions to Achieve Utilisation Agreement	The transfer of an invention to a company from an external inventor needs a Godfather inside the company.
Alajoutsijärvi (1996)	A dyad made of steel: Kymmene Corporation and Valmet Paper Machinery and their relationship, local network and macro environment 1948-90	A priori model for describing and explaining the long-term development of the buyer-seller relationships in investment goods market.
Nihtilä (1996)	Integration Mechanism in New Product Development	Process of cross-functional integration in NPD.
Katila (1999)	Locus of Innovation in the Biotechnology Industry – Determinants and Consequences	Longitudinal research design when the changes in the innovation locus are observed over time.
Lanning (2001)	Planning and Implementing Change in Organisations – a Construct for Managing Changes in Projects	Hermeneutic, constructive case study aiming at the understunding of the phenomenon and constructing a useful and theoretically grounded solution for a relevant problem.
Hasu (2001)	Critical Transition from Developers to Users – Activity-Theoretical Studies of Interaction and Learning in the Innovation Process	Qualitative case study focusing on the "gray area" between R&D and introduction onto market, an area in which developers and users actually meet and interact.
Blomqvist (2002)	Partnering in the Dynamic Environment: The role of Trust in Asymmetric Technology Partnership Formation	Multi-theoretical research perspective with the complex nature of the research task.

3.5 Business idea

An enterprise always has some kind of *business idea*. It is a detailed description of the success factors that the company possesses (Normann 1975, 37-55; Jahnukainen et al. 1980, 15-17). The *business idea* can also be viewed as a concrete and holistic way in which the company carries out its business. Defining a business idea requires a profound understanding of the function of the enterprise as a whole and of that of its constituent parts in order to carry its operations out in practice.

A *business idea* consists of the internal and external factors of a business, which appear inherently linked together according to a complex pattern. It is the result of the overall know-how which results from the interaction between a business and its environment, and from the resources which make this interaction possible. At the most basic level it details the way the business works and makes a profit.

The business idea includes the following constituent parts:

1. Market or market segment
2. Products and/or services
3. Structure, resources, operating methods

The market segment and the product portfolio define the environment in which the business operates. The organisational structures and the resources determine the way in which operations are carried out.

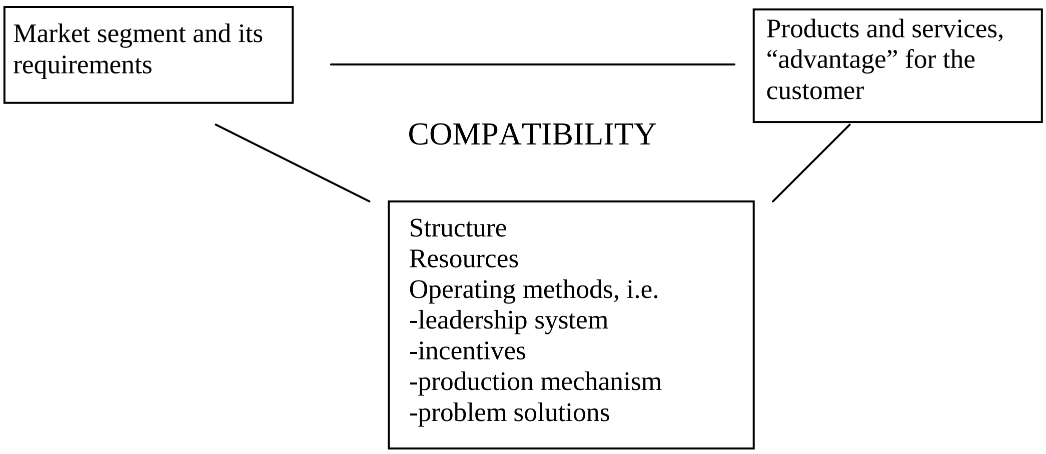


Figure 36. Main parts of the business idea (Normann 1975, 44; see also Jahnukainen et al. 1980, 16).

In addition to the main parts of a business idea, it can also be defined with regard to the basic characteristics. A business idea is based on a *system approach*, i.e., it consists of several parts which link together into a complex entity or system. A successful business idea is based on the compatibility of its parts – and that all its constituent parts support and complement each other.

A business idea represents the actual way of operating and being profitable, a long-term and often superior knowledge which guarantees the company's success in the market. A business idea is not finished before it has been put into practice. It is often the result of a long development process – imitating somebody else's idea rarely works. It can be regarded as a *unique* way of operating. A business idea has its own life-cycle, in the same way as the product itself does.

The concept of the business idea has evolved over the years. In this study, I follow the 1970s model, because it allows me to view the development of a business idea in correlation with the time the Kerto-LVL business idea was developed and put into practice.

In my description of business ideas I have used the following concepts, as they permit to simplify the presentation of the hypotheses. They appear in the order they emerged during the Kerto-LVL innovation process and during this research:

- *Stratified product*
- *100% product*
- *Operating system*
- *Value chain*
- *R&D portfolio*
- *Product platform*
- *Partnering*

3.5.1 Stratified product

In marketing, the product is seen as an entity, which consists of the basic product, the assisting parts and the added services. The basic product is the service or tangible product, which the customer buys. The assisting parts convey the shape to a product. Trademark, product name, form and technical certificates are examples of some assisting parts. The added services typically give more value to the customer. Examples of these are education services and installed product components (Lahtinen et al. 1993, 21-23), Figure 37. In this way, the stratified product concept is part of the business idea, as shown in Figure 36.

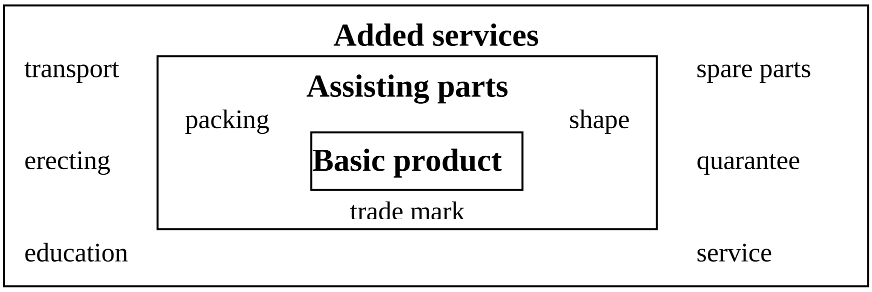


Figure 37. The stratified product concept according Lahtinen et al. (1993, 21-23).

The stratified product concept has evolved over the years through the development of business. In the late 1980s, the term was *hybridized* product. One of its developers was Noel M. Tichy from the University of Michigan and it has been applied successfully by Jack Welsh of General Electric. The stratified product approach looked for ways to combine the focusing of the business and the business growth. In Tichy's observation, a continuous focusing of operations enhanced the competitiveness of the enterprise, enabling it to become the market leader in the sector. In this situation the slow-down of the enterprise growth became a problem, because the market had reached its limit at a certain point. Tichy suggested already at that time that the product concept should be extended (Kivikko 2003). In his evaluation report of Tekes's SMART programme (*Smart Machines and Systems*), Kivikko (Tekes 2001, 108) defines the *hybridized* product as an offering and what is ultimately being sold as performance. A hybrid product consists of:

- material basic modules
- service modules relating to usability, serviceability, recyclability etc.
- complementary products or services, and
- finance modules

In this study, a *stratified product* is considered as an integrated part of the business idea. A new stratum cannot be built before the previous one is sufficiently complete.

3.5.2 100% product

Virtually all contemporary thinking about high-tech marketing strategy has its roots in the *Technology Adoption Life Cycle*, a model which grew out of social research begun in the late 1950s about how communities respond to *discontinuous innovations* . Truly discontinuous innovations are new products or services that require the end user and the marketplace to dramatically *change their past behaviour***,** with the promise of gaining equally dramatic new benefits (Moore 1995, 13).

Generally, the product life cycle is presented graphically as an S-curve (Miller and Morris 1999, 46-47) (Figure 13 on page 17), whereas the Technology Adoption Life Cycle model is presented as a bell curve (Moore 1995, 14; Rogers 1962, 243,247). The model identifies different consumer communities within each stage of the product life cycle. In Moore's model, consumers are divided into five constituencies according to their characteristic attitude towards technological investments (1995, 15-17):

1. Innovators = *Technology enthusiasts*
2. Early adopters = *Visionaries*
3. Early majority = *Pragmatists*
4. Late majority = *Conservatives*
5. Laggards = *Sceptics*

The commercialization of a new product often appears problematic due to the contrasting behaviour of the project operators. Moore uses the concept of the *Chasm* to describe this situation, see Figure 38. Normally, this is connected to the *high-tech* sector, but also conventional sectors with *high-change* where discontinuous forces are driving an analogous kind of situation (Moore 1995, 8).

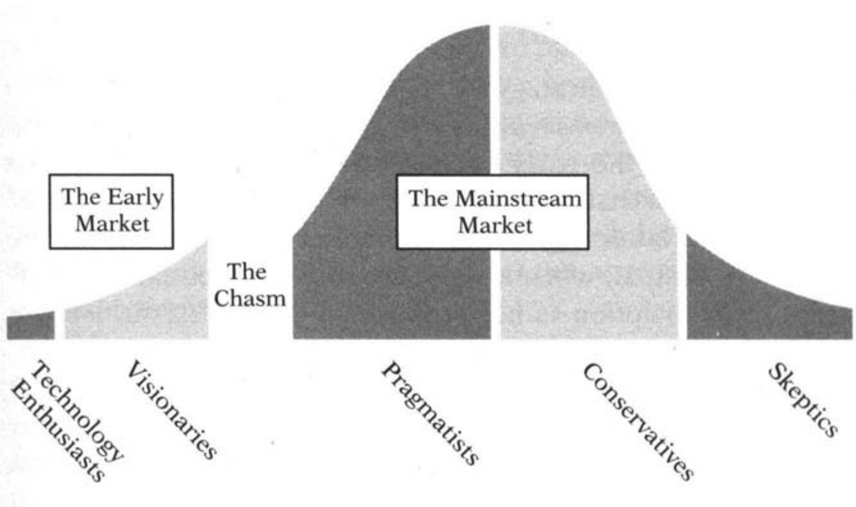


Figure 38. The Technology Adoption Life Cycle of an innovative product. According to Moore (1995, 19), the Chasm represents the critical point of this approach.

Innovative products initially enjoy a warm welcome in an *early market* from technology enthusiasts and visionaries, but will then fall into a *Chasm* if they fail to gain acceptance within a *mainstream market* dominated by pragmatists and conservatives (Moore 1995, 19-20). Figure 38 represents a situation where visionaries introduce new products to the market at a too early stage, when they are still incomplete. Pragmatists are only happy with the whole product, because they want a 100% solution to their problem. *The 100% product* is defined as *the minimum set of products and services necessary to ensure that the target customer will achieve his or her compelling reason to buy* (adapted from Moore 1995, 20-21 in a sense used by Finnforest).

The technical and service content of the *100% product* concept evolves with the markets: At the early market stage, when the product is new and adopted by visionaries only, these complete it to suit their needs. From the visionaries' point of view, the product is already then a 100% product and acts as a customised sub-product in/for a *solution market*. As the product becomes more widely known and its use expands, a wider user group will know how to benefit from its technical properties, and more integrated services are created to complement the product. As a consequence, the *100% product* gains a wider definition.

These modules can be combined according to customer needs and contexts. The *stratified product* and *100% product* are synonyms to a certain extent; the *stratified product* includes the *100% product* in its operational level and is the *100% product's* strategic platform.

3.5.3 Operating system

The operating system is known from the IT industry (source:diana.icu.ac.kr/ICE0120/ workshop_C/Introduction_to_Operating_System.ppt_http://www.freepapers.net/essays/ Operating_systems.science.shtml):

An operating system is a programme that acts an intermediary between a user of a computer and the computer hardware. The purpose of an operating system is to provide an environment in which a user can execute programmes. The main purpose of an operating system is to make the computer system convenient for the user to use the computer hardware in an efficient manner.

Operating system in this study means a structural wooden product that is specified in either a standard or technical type approval as a material with reference to other standards for adapting material usage for structural construction, i.e. jointing by gluing or with mechanical fasteners. The *operating system* includes all the services contained in a *stratified/100% product* that enable the customer to use the product in an appropriate, efficient and effortless manner, regardless of his/her level of competence. This is illustrated in Figure 37. The *operating system* incorporates different degrees of readiness for re-manufactured products or solutions with all the needed information on how to design them, assemble them in the factory and erect them on the building site.

3.5.4 Value chain

The added *value chain* concept, as illustrated in Figure 8 on page 9, relies on every operator in the delivery chain having their own business level and idea. Every operator contributes its own output to the end product, creating an added value making the product a *stratified product*. As an enterprise moves from a lower degree of processing towards an Integrated System Solution level, it crosses a certain functional boundary. This creates a situation where the enterprise either provides the other companies with an opportunity for a positive win-win situation or causes a defensive position, when the operators from a higher level in the added *value chain* see the new participant as a competitor or otherwise as a burden.

3.5.5 The R&D portfolio

Business portfolio planning became a powerful tool in the 1970s and 1980s. As a consequence of this, the R&D portfolio saw an important development in the 1990s. The target for a company in both business and R&D portfolio planning is to reach the optimum point between the risk and the reward, stability and growth. To assess these, several scoring methods can be used, such as the matrix in Ansoff's window (1958, 394). A more developed model, such as the one used by Moore (1991, 109), divides the matrix into 9 categories:

Markets	Product		
	Known to the enterprise	New to the enterprise	New to the world
Known to the enterprise	70 %	50 %	30 %
New to the enterprise	45 %	20 %	10 %
New to the World	20 %	7 %	1 %

Uncertainty increases ↓

——— Uncertainty increases ———→

Figure 39. Evaluation Matrix for the R&D portfolio (Moore 1991, 109).). The percentage figures correspond to the relative proportion of successful new products. The figures are indicative (Klus 2004).

The pairs for comparison are chosen according to the characteristics of the marketing situation: The evaluation of a new product has to take into consideration several alternative pairs, such as:

- Product – Market
- Product – Technology
- Product – Quality
- Product – Organisation
- Market – Organisation

The enterprise has to make sure that uncertainty will not increase too much or in the wrong direction. On the other hand, if the risk-taking works out, the enterprise wins a remarkable competitive advantage vis-à-vis other manufacturers.

3.5.6 Product platform

The definition of platform has been borrowed from the computer business where it means the type of computer system or software that is used (Hornby 2000, 965). A new system or software has to be compatible with a platform built earlier, if this has been agreed upon.

Wheelwright et al. (1992, 70-82), in their "*Mapping the Five Types of Development Projects*" divide projects into five types: derivate, platform, breakthrough, research and development and alliances and partnerships. *Platform projects* entail more product and/or process changes than derivatives do, but they do not introduce the untried new technologies or materials that breakthrough products do. Ulrich et al. (1995, 20) have also divided development processes into five large groups: generic (market pull), technology-push, platform products, process-intensive and customization. In *platform products* the company assumes that the new product will be built around the same technological and commercial sub-system as an existing product.

In this study, a *product platform* is the basis and the environment, which gives a new industrial process enough support for it to enter an immediate development path. The new industrial process needs to run parallel with its platform environment with regard to technology, organisation, raw materials, commercialization, related norms and production method, to avoid a fundamental conflict situation with other products from the same platform environment. The new procedures have to result in a high enough turnover to have a significant impact on the company's overall business.

3.5.7 Partnering

In the 1990s, a large number of innovative technology-based SMEs appeared in Finland. They lacked the resources and skills needed for growth and internationalization. These young companies needed to cooperate with large and resourceful partners. Also large companies felt that the world had become so uncertain and complex that they needed small firms to complement their knowledge and increase their flexibility (Blomqvist 2002, 1). A true partner relationship based on trust between two companies of different size, which operate in different countries, is a difficult process. The formation of such a partnership takes time and involves many stages. According to Ford (1998, 29), the stages in forming a partnership are the pre-relationship stage, exploratory stage, developing stage and stable stage.

Nowadays, partnering is considered a natural practice within the ICT industry. It is used to find innovations and to ensure a better position in the market. However, a partnership is not a panacea (Smeds 2005, 25). According to current research, two out of three initiated partnerships fail (Vihma 2005, 25).

Blomqvist describes in his doctoral thesis (2002) the role and nature of trust in asymmetric technology partnership formation within the ICT industry. The figure below illustrates the basic situation in such a partnership.

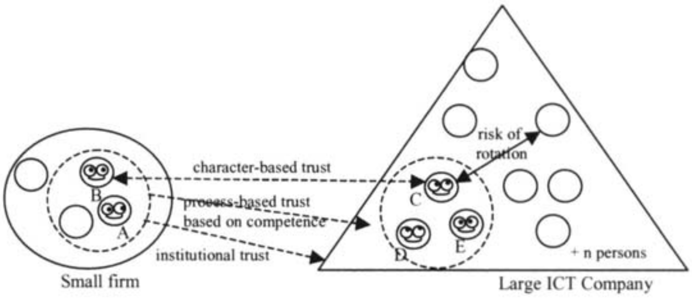


Figure 40. Organisational and personal trust in asymmetric technology partnership (Blomqvist 2002, 163).

Partnership can be limited to a particular area of the business chain. It can be a unique technology or marketing related cooperation. In this study, I have viewed partnerships in the wood products industry as characteristically beginning from technological cooperation, which, if successful, will lead to cooperation in marketing. This is the reason why finding the right partner and establishing a truly interactive relationship was an essential part of the integrated development project.

As the wood industry follows the added *value chain,* as shown in Figure 8 on page 9, partner relationships are of vital importance especially when the company decides to transfer its products to a higher value level in the export market. It then becomes possible to create a positive win-win situation as well as a real *technology push* and *market pull* effect, as illustrated in Figure 8.

3.6 Key technology model

In the early 1990s, the PMT and PLT technology programmes were established to develop new methods for exploiting the results of applied and basic research in wood products companies' product development. In a traditional innovation chain model, R&D is viewed as a process comprising a number of stages from basic research to finished product. The technology programmes resulted in the introduction of the key technology model. This model integrates product and process development, as well as basic and applied research, with business objectives (Figure 42).

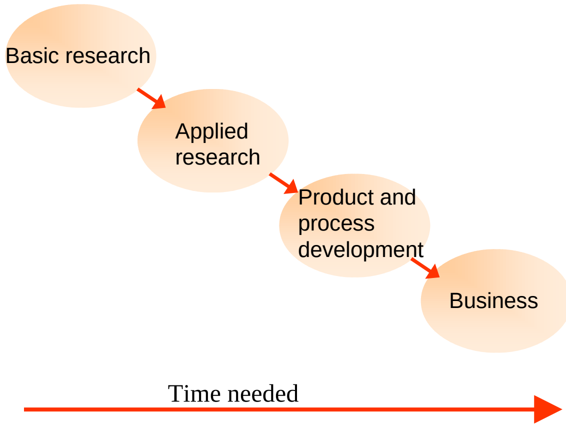


Figure 41. Classical innovation chain where a company's R&D activities utilize results from basic and applied research (Tekes 1997, 7).

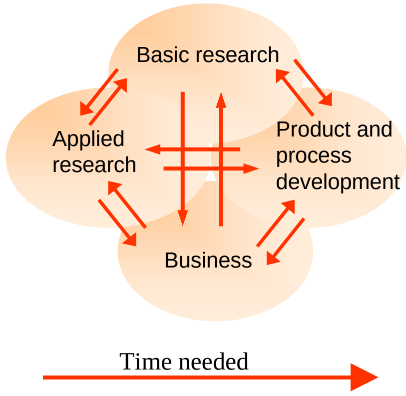


Figure 42. Implementation of the key technology area (Tekes 1997, 7 adapted by Hirvensalo).

The key technology model is in practice the only way to achieve results in R&D in an industry where basic research has been scarce and non-coordinated. The key technology areas are sub-areas in wood science, where achieving sufficient theoretical knowledge is a prerequisite for finding a solution to the industry's problems. Within the context of basic research, applied research and development work, this operating model has to be focused on finding customer-based solutions instead of making the production technology more effective (Paajanen 1998, 6-7).

3.7 Innovation structure

For a new product to be a success, there must be a positive combined effect of interactions between several factors. The chances of success can be enhanced by taking the critical factors seriously into account in the early stages of product development. Mali et al. (1986, 53-54) illustrate the innovation structure as an interactive plan.

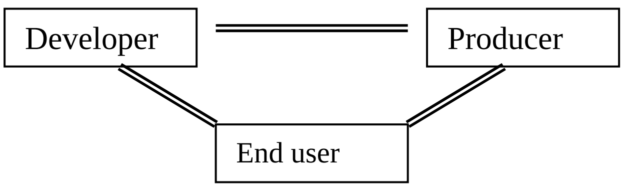


Figure 43. Simplified innovation structure (Mali et al. 1986, 53).

Even an incidental innovation complies with the structure shown in Figure 44 below, whereas in a systematic innovation the structure is developed further (Klus and Hirvensalo 1997, 46-47). The innovation structure consists of the knowledge and the participants (people and organisations) necessary to bring the idea to success. All the relevant knowledge should be present and there should be a functional interactive process between the various parties.

Problems in the innovation structure start to surface when it is not clear what knowledge is relevant. This can be caused by a lack of understanding, dominant preconceptions or different interests.

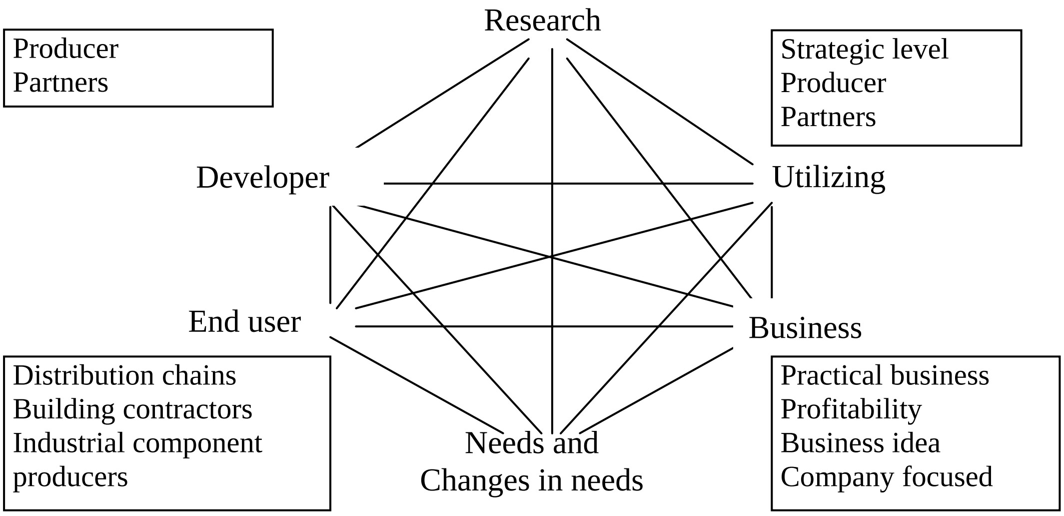


Figure 44. Systematic innovation structure (adapted from Klus and Hirvensalo 1997, 47).

The development of a new product proceeds with maximum efficiency when the product’s innovation structure works interactively as an entity between the different parties. In the above figure, the interaction can be seen as functioning in all directions between the six angles so that there is a balance. As is widely known, during the early stages of a development process, when the product is about to enter the market, there can be areas in the innovation structure that remain incomplete. If the structure has been completed but does not yet work interactively in all directions, some areas will require more resourcing than others, and hence the product’s innovation structure is not yet in balance.

<u>Interconnections between the main concepts</u>

The development of a business idea requires simultaneous development of the innovation structure and key technology model. In order to carry this out efficiently, sub-concepts as presented above come in handy. They serve to enhance the interactions in the development process.

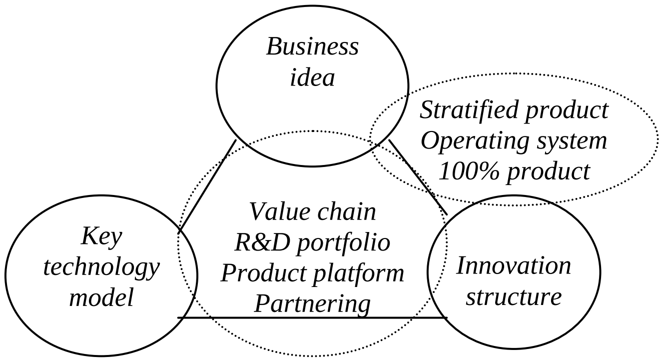


Figure 45. Interactions between the concepts used in this research. Some sub-concepts may be common to all three main concepts, depending on the situation.

3.8 Hypotheses of the study

The following hypotheses were developed either during the Kerto-LVL innovation process or during the present research:

The hypotheses were based on the following assumptions:

- *the primary industry takes the initiator role*
- *traditional operating practices prevail in the sector*
- *the product is new and not a direct substitute for an existing product*
- *the product is a structural building product*
- *several parties are involved in implementing the product*
  - → *a certain knowledge input is a prerequisite*
  - → *the knowledge is not yet widely shared by the user community*

1. Hypothesis; commitment

Commencing the development of a new product and overcoming the *Chasm* requires a *commitment*, consisting of the following factors:

- A *product platform*, which serves as the basis and the environment. It gives a new industrial process enough support to embark on an immediate development path. The constituent parts of the process need to be compatible with the raw materials and technologies that the company uses. For the purpose of commercialisation, the *product platform* must offer sufficient and functioning contacts to potential market areas in a way that enables the developing company to make use of the new product's properties throughout the *value chain*.

- *Visions* regarding the potential of the *business* which is being developed, the *business idea*, the necessary changes to the *value chain* as well as the potential *partners*. Furthermore, the process should state clear *targets* for the product's technical properties and include an estimate of necessary investments.
- *Resourcing* the development, which involves assigning key persons to take charge of the process, and providing the necessary financing.

Maintaining the *commitment* and ensuring the necessary investment requires *project milestones* to be met in order to maintain the management's trust.

2. Hypothesis; starting the change in operating practice

To bring about a *change* in a network, the companies who actively participate in it must simultaneously visualise and identify their own *commitment* and also the opportunities arising from changes in the *value chain* as a whole. For a *change* to be implemented, there must be a shared *commitment* among the key persons as well as an application of the *key technology model.*

3. Hypothesis; autonomy requirement for a developing business idea

If a company perceives a new need within the existing market or, alternatively a whole new market, and provided that the necessary business idea significantly differs from that used to define its previous activity, the development and implementation of a new business idea requires an autonomous business unit. The business unit then takes responsibility for R&D and business.

4. Hypothesis; formation of innovation structure and partnership

The formation of an innovation structure and partnership is a coalescent process.

5. Hypothesis; in partnering the business ideas and strategies merge

As it develops, partnering leads to a reconciliation of company's strategies and a merging of business ideas in selected product segments on the *solution market*.

6. Hypothesis; contents of the 100% product and its operating system

The contents of the *100% product* and its *operating system* evolve as a function of the market development stage.

The development processes corresponding to the above hypotheses are covered in more detail in chapters 4, 5 and 6.

4 START UP OF KERTO – LVL BUSINESS

This chapter outlines the product's history and the reasons why Metsäliitto became interested in the new product in the early 1970s. Next, the steps (1) leading through the pilot plant stage to the decision to invest in a industrial manufacturing line and to the organisation of the products' business are described. At the same time, the functionality of the innovation process is evaluated (2) in the various stages of the project on the basis of the assessment concepts presented in Chapter 3. The figure below illustrates the most important events in the project's start-up phase in Metsäliitto. R&D costs in relation to turnover are also shown.

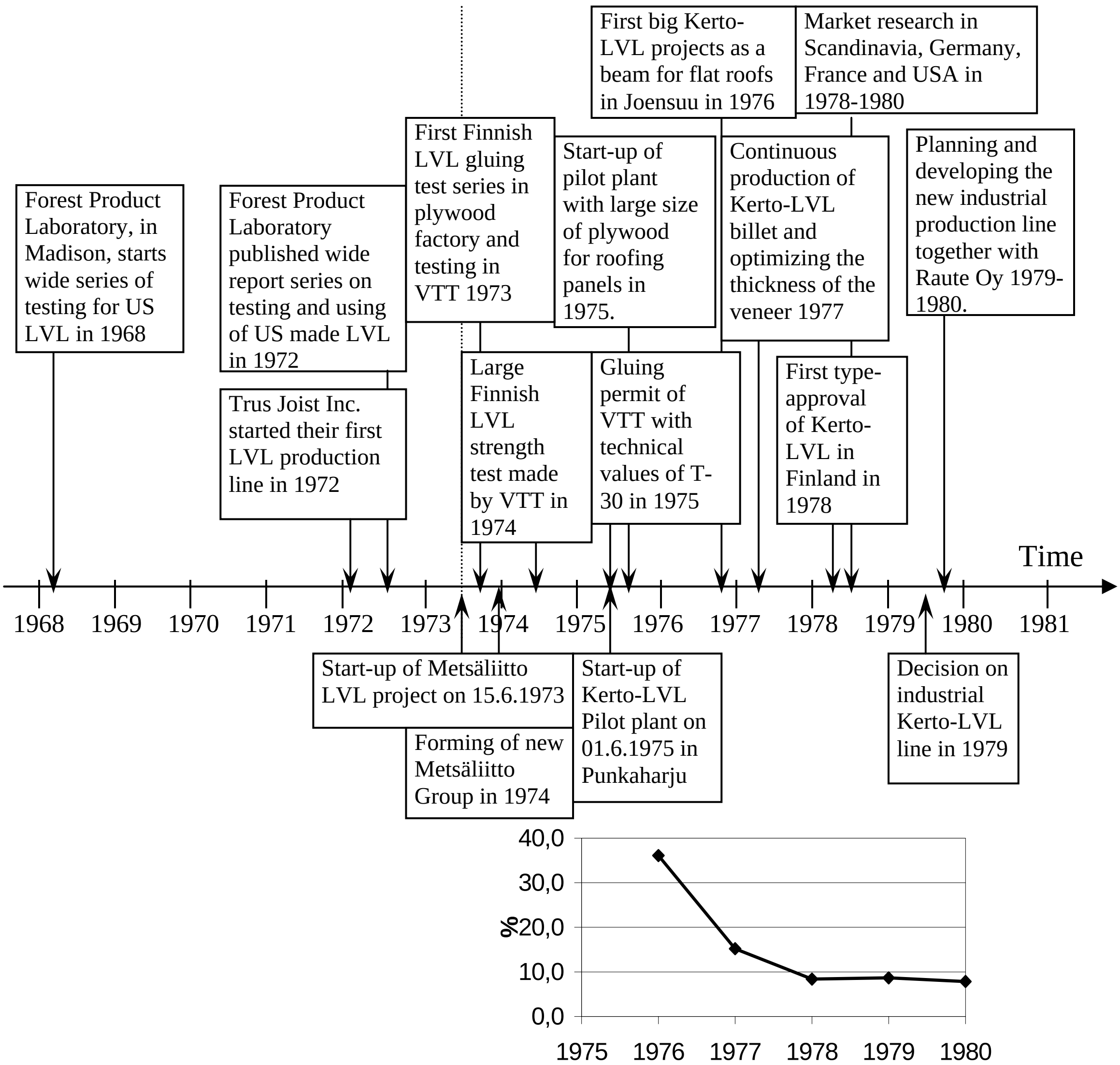


Figure 46. Main milestones of the development of Kerto-LVL as a product and as a business during pilot plant stage. The name Kerto was registered in 1975. Trus Joist Inc. started production of Micro=Lam® LVL in 1972. Relative R&D costs of the Kerto-LVL's turnover are shown at the bottom right. During the starting year, 1975, the R&D costs represented 126 % of turnover (source: Finnforest).

This chapter describes the phase during which the main emphasis was on implementing the *technology push* aspect of the innovation process. When the Metsäliitto-LVL team succeeded in this after several phases, achieving an acceptable level of technical type approvals as a result of successful cooperation with the authorities, the focus was transferred towards business development.

4.1 History of LVL

The technique of gluing veneer sheets oriented longitudinally in parallel to the processing direction is not a new invention. In the US the manufacture of aircraft components/parts by gluing 3.6 mm (1/7 inch) Sitka spruce veneers along the length of the grain began in 1944. Luxford (1944) demonstrated that a material produced by this method possessed at the very least the same strength values as the equivalent timber material. Preston (1950, 228-246) investigated the method of gluing veneers and found that the strength could be increased by using thinner veneers.

It took several years for lengthwise glued veneer to gain commercial significance in construction. Research carried out by the American Peter Koch (1967, 42-48) can be considered as the starting point for further development. Koch demonstrated that the mean strength values of beams glued from 4.2 mm (1/6-inch) thick rotary-cut southern pine veneers were significantly better than the values of solid timber. Furthermore, in his research the yield obtained from rotary-cut material was higher than the yield obtained by sawing. The test pieces glued in the laboratory were made using a similar method to that used in glulam manufacture, i.e. gluing the veneers horizontally with a room temperature-setting phenol resorcinol adhesive. In testing, following the same procedure as with glulam, lamellas in the beams were placed horizontally. In this position the effect of the facing layers for the strength of the beam was decisive. At that stage, it was not economically viable to proceed to industrial production of a 178 mm LVL slab, because of the expensive adhesive and gluing process.

In the late 1960s, the Forest Products Laboratory (FPL), in Madison, Wisconsin, initiated an extensive research programme whose aim was to improve the manufacturing techniques, product values and quality assurance methods for LVL. A breakthrough was achieved when a significantly lower-cost thermosetting phenol adhesive and hot pressing were implemented. In

1972, R. C. Moody of the FPL published research on the tensile strength of the product. 50x100 mm (2- by 4-inch) Douglas fir timber made by laminating butt-jointed 3.2 mm (1/8-inch) grade C veneers (see Figure 48), indicated an average tensile strength of 37.6 N/mm^2 (5450 psi) and a coefficient of variation (COV) of 9.5 %. These results appear to indicate that existing allowable design values may be up to double those assigned for sawn timber (Moody 1972).

The high characteristic tensile strength, combined with assured quality, were the decisive characteristics that led to the manufacture of a new product, Micro-Lam® (Nelson 1972), by Trus Joist on the US West Coast in 1972. The company's main products are shown in Figure 47, including an open-web truss with wood and tubular steel members for a longer span, and I-joists with the upper and lower flanges made from high-quality sawn timber and a plywood web glued together. This was developed as a substitute for solid timber, see Appendix III. As the production increased, the quality of the timber flanges under tensile stress and especially the quality of finger joints were difficult to control. Therefore, both the upper and lower flanges of the joists were replaced by LVL. As a result, in the US distribution markets, LVL became a substitute product for sawn timber and for its further processed products, open-web trusses or I-beams.

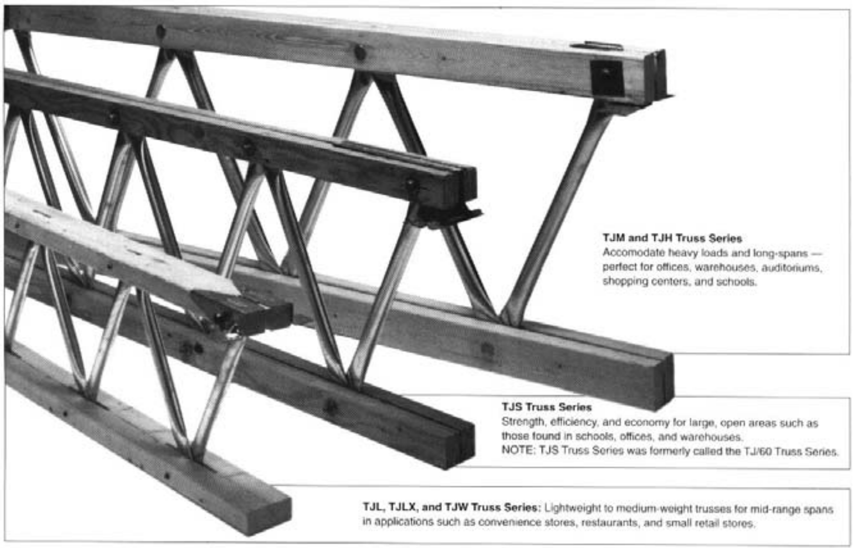


Figure 47. On the left Truss Joist I-joist with 9 mm plywood web and Micro-Lam®-LVL in upper and lower flanges. On the right wood and steel composite open-web trusses introduced by Trus Joist at the beginning of the 1970s. In the middle TJ/60 series with Micro-Lam®-LVL in upper and lower flanges.

The technique for manufacturing Micro-Lam-LVL was first based on heat-curing of phenol resin glue, an adhesive frequently used in the plywood manufacturing process, under high pressure. The function of the hot pressing line was new in the wood-based panel industry: Whereas normal plywood manufacture is based on separate production phases, Trus Joist developed the first continuous gluing – lay-up - hot pressing line (Troutner 1970).

Research published by Koch (1973) compared the characteristics of LVL and southern pine sawn timber, both produced from southern pine logs. Twelve logs with diameters ranging from 279 mm (11 inches) to 432 mm (17 inches) and with a length of 5185 mm were cut into two blocks. The first one was peeled into 6.4 mm (1/4-inch) thick veneers. A 133 mm (5¼-inch) core was left in the middle of the block which was sawn into two 50x100 mm posts. The dried veneers were cut into 384 mm wide sheets and glued with resorcinol glue into butt-jointed billets, which were ripped edgewise into beams of 38x89x2591 mm, as shown in Figure 48. The net cubic volume of LVL and two pieces of sawn timber were measured. The second block was band-sawn using optimised posting for green standardised sizes of sawn timber, and the sawn timber was then kiln-dried to 10 % moisture content. Subsequently, the sawn timber was planed to the final standard dimensions. Finally, the net cubic volume of the dry, planed, trimmed planks and boards recovered from each log was measured. The yield was 41.1 % when sawing two pieces of 50x100 mm timber and 59.6 % when producing LVL.

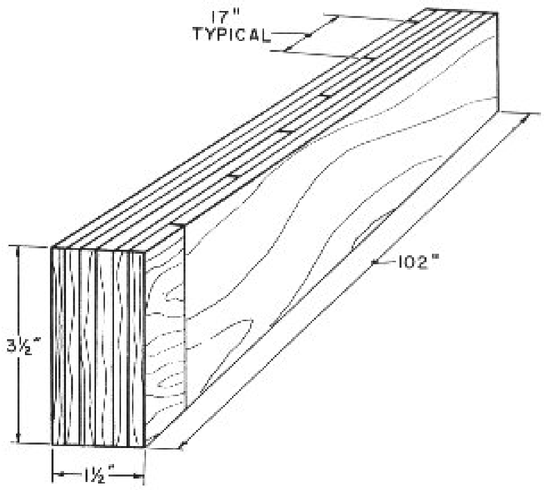


Figure 48. Butt joints were arranged in a stepwise pattern to be repetitive every 2591 mm (102 inches,) should the timber be fabricated in long lengths. The thickness of the veneers was 6.4 mm (1/4”) (Koch 1973).

The modulus of rupture (MOR) was tested using the ASTM D 198 test method in 4-point loading with the span of L=2286 mm and space between loading points in the middle a = 1016 mm. The results are shown in Table 12 below.

Table 12. Summary of results of bending tests according to Koch (1973, 24). 95 % exclusion limit or characteristic value has been calculated using formula (1). With 92 test pieces k_s is 2.0.

MOR (N/mm^2)	LVL	Sawn from veneer cores	Sawn from sawlogs
Average	64.2	43.2	63.6
Standard deviation	12.9	12.2	22.6
COV (%)	20.1	28.2	35.5
95 % exclusion limit	38.4	13.2	18.4
Number of tests pieces	92	18	57

The characteristic value is determined using a so-called 5 %-fractile value and following the norms on test methods (RIL 205-1997, 122). The literature also mentions the term 95 % exclusion limit. The characteristic value F_k is calculated using the formula 1, (RIL 120-2001, 98-99):

$$F_k = \bar{x} - k_s s \qquad (1)$$

where $\bar{x}$ is the average value of the series
k_s is the value depending on the number of tests
s is the standard deviation of the test series

In this test Koch examined for the first time the characteristics of LVL with the beam placed edgewise. The beam acted as a direct substitute for solid timber. The conclusion from the tests was that if an economical manufacturing procedure can be found, it should be more profitable to produce LVL than plywood. Until the 1980s, the design method with wood was based on the allowable stress values. Common practice, especially in Germany, was to use the mean value of the test results divided by a certain safety factor. The result was the allowable stress, which the designer was not allowed to exceed when calculating the load. The allowable stress method did not take into account the varying strength distribution of different materials. At the time, the 95 % exclusion limit, later on 5 % characteristic value, was just emerging as a basis for structural calculations, and thus the effect of controlling the distribution could not be utilized to the maximum extent, cf. page 74.

Table 13. Use of LVL and its segmentation as a product according Koch (1973)

Product	Floor beam Roof beam
Customer	House builder/distributor's timber sites Prefab producer
Competing product	Sawn timber 2x10" Small size of glulam

4.2 Metsäliitto as a platform for emerging business

The current organisational structure of the Metsäliitto Group dates back to 1974. The development of Metsäliitto from a central organisation representing forest owners and raw material suppliers into a forest industry enterprise involved in mechanical wood processing and pulp and paper manufacture is summarised in Appendix II.

<u>*Metsäliitto as a business enterprise*</u>

At the pilot plant stage of the new LVL, the organisational structure of the Metsäliitto Group was as shown in the following figure:

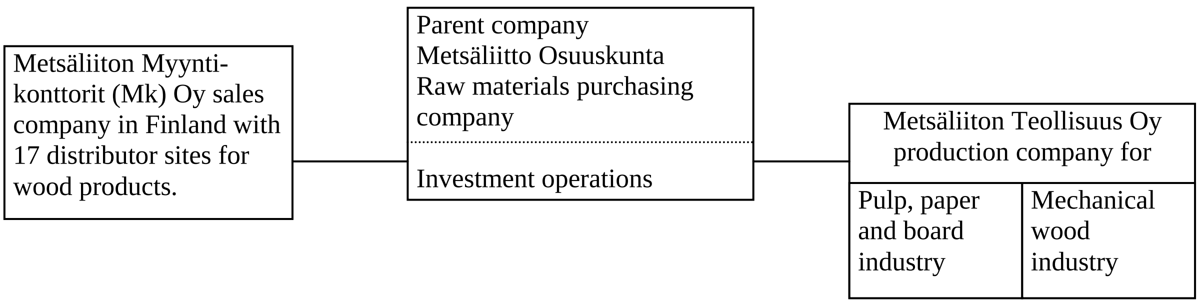


Figure 49. Organisational structure of Metsäliitto in 1974 (Zetterberg 1983, 235). The mechanical wood industry took care of the pilot plant stage and Metsäliiton MK of marketing in Finland.

In overseas trade, the mechanical wood industry, like all other enterprises, sold its products through agents to importers based in the market area. To make marketing more efficient and to communicate directly with the buyers, a sales office, Finnforest Ltd, was established in the main export country, the UK, to take charge of the agent functions. The office was based in London in 1972 (Zetterberg 1983, 210). In 1976 a sales office, Finnforest GmbH, was established in Düsseldorf, Germany (Zetterberg 1983, 272).

R&D in Metsäliitto in the 1970s

The foundation of Metsäliiton Teollisuus Oy coincided with the organisational development of the research and development activity into one entity, and Jyrki Kettunen was appointed its director (Kettunen 2002, 115). The development vision of the corporation was defined by the chairman of the board Veikko Ihamuotila as follows (Kettunen 2002, 9):

- The purpose of the Metsäliitto Group is to demonstrate that wood material can be processed into products with higher value. This is the only way to increase forest owners' income.
- Competitive end uses should be developed for all wood raw material growing in Finnish forests.
- To be competitive internationally, the forest industry needs domestic alternatives for process equipment and chemicals. There is a need to encourage the enterprises manufacturing these products; this should not, however, involve taking unnecessary risks.

The above vision clearly supported the development of new innovative products. As a consequence, several new projects were initiated in the early 1970s, both in the wood products industry and in the pulp and paper industry. To monitor the development of wood products and their commercialisation, a committee had been established within Metsäliitto Osuuskunta in the early 1970s. Its members were representatives of marketing and sales organisations and production and development, and it was chaired by the managing director of Metsäliiton Mk, Mikko Wuoti, later CEO of Metsäliitto Group (Kettunen 2002, 91).

From the 1950s until the present day, the major technological and strategic challenges faced by Metsäliitto in the raw material sector have been related to the need for balanced use of spruce raw material (Kettunen 2002, 18). The production of glulam as a heavy construction material had been studied earlier, but its competitiveness was found to be insufficient (Kettunen 2002, 70). In this environment, the platform for developing the new product, Metsäliitto-LVL, was relatively good. It was not possible to evaluate the marketing opportunities for the new product at this early stage.

In a review of the company's strategy dated March 17, 1976, the role of R&D was formulated as follows: "*In supporting forest economic operations the main emphasis shall be accorded to maintaining the operations during a weak economic cycle. This will be achieved primarily* *by developing the upgrading chain and consequently by raising the value obtained from the wood material.”* This redefinition of the strategy signified an attempt to move the focus to processed products, which would lead to a more critical approach to establishing new sawmills.

4.3 Evaluation of the LVL idea in Metsäliitto

4.3.1 Evaluation process and results

In Metsäliitto, the LVL product idea consisted initially of the realisation that peeling of the wood material into veneers and gluing the veneers into slabs would result in a significantly more homogeneous truss or post than sawn timber or even glulam. The idea was introduced by a Finn, N. R. Alenius, whose other designs included e.g. the continuous block board production line, the so-called Anra process (Alenius 1964); see Appendix I (Salmenlinna 1975). Essential additional information was found in articles published in the Forest Products Journal (Bohlen 1972, 18-26; Schaffer et al. 1972 and Moody 1972), the latter of which were based on long-term research work carried out in the FPL. At Metsäliitto there was already at the beginning of the 1970s a need to find alternatives to investing in new sawmills. In this situation, the new product proposed by N.R. Alenius attracted considerable interest. After calculations and preliminary tests, a decision was made to conduct a feasibility study on industrial production of LVL and a costing unit was established in the head office on June 15, 1973.

In the project plan, the work was divided into three stages:

Stage I: Sub-projects carried out during 1973 (see Table 14).

Stage II: Provided the outcome of stage I would be positive, the project could proceed to the pilot plant stage, which would involve testing the manufacturing technique, and a relatively comprehensive test marketing programme. This stage was estimated to last for 12 months in 1974.

Stage III: Designing a full-scale plant and conducting the remaining analysis. On this basis, according to the calculations, an investment decision could be taken in April 1975.

The essential components of Stage I are outlined in the following. The work was essentially carried out as team work, with the central unit assuming responsibility for the project. At the practical level, the operations were managed from June 5, 1973 until the end of Stage I by Markku Lehtonen of the R&D department.

Table 14. Development steps preceding the pilot plant stage shown as separate projects, see also Figure 10 (Metsäliitto memo 1/1973 and memo Feb. 27, 1973).

Stage of the project	Development actions	Responsible party
Product	Optimized veneer thickness for product Gluing quality depending on veneer thickness Evaluation of profitability	Metsäliitto and VTT VTT Metsäliitto
Production technology	Contact drying of the veneer Continuous process Weather-resistant gluebonds Optimized thickness of veneer in production Minimizing hot pressing time	Master's thesis in HUT together with VTT Metsäliitto VTT Metsäliitto Master's thesis in HUT together with VTT
Sales and marketing	Market research based on interviews Estimation of market volume	Master's thesis in HUT together with VTT VTT
Investment plan	Investment calculation, estimate of production costs, estimate of prospective profits Process layout plan raw material base and yield ratio Invitations for tenders to machine and equipment suppliers Preliminary financial plans and negotiations with investors	Metsäliitto Metsäliitto Metsäliitto Metsäliitto Metsäliitto
Type approval and building standards	Test run Statement of technical values for new Finnish LVL product	VTT VTT

Two separate mill tests were carried out as preliminary tests at the Lohja plywood plant for the purpose of *product evaluation*. Using a hot press, veneers were glued into 37 mm thick sheets which were then cut into 100 and 150 mm high test pieces. The veneer material was 2.8 mm thick pine and the number of plies was 15. The first results from a test series glued on Nov. 8, 1972 were promising. The standard deviation of results was minimal. Within the test series, the characteristic edgewise bending strength was ***50 N/mm²*** (Metsäliitto memo 3/1972), which exceeded the then best sawn timber stress grade T-400 by 32% and that of the highest quality glulam, LT 400, by nearly 10% (RIL 63 c 1973, 14 and 61). The second test was a partial failure due to quality defects (VTT 1973), but if these were disregarded, the T-400 level could be achieved.

Nowadays the sawn timber grade T-400 corresponds to T-40, with a characteristic bending strength of ***38 N/mm²*** (RIL 120-2001, 29) as a beam. The current equivalent for the special grade for glulam LT50 was LT400 (RIL 120- 1978, 72) until 1983, when this special grade was replaced by a slightly higher limit grade L40, with a characteristic bending strength of ***40 N/mm²*** as a beam (RIL 120-1983, 7 and 72) (RIL 120-2001, 30).

With regard to the *suitability of the wood raw material,* the emphasis was on optimising veneer thickness. Test peelings were carried out first within HUT in cooperation with VTT on a laboratory scale, and the results were used as a basis for mill tests in the plywood plant; the species used were spruce and pine, with veneer thickness as the other variable. The glue consumption could be reduced by using a thicker veneer. On the other hand, the test peelings resulted in increased yield if the veneer thickness was decreased, when the log diameter was less than 300 mm. In addition, the cutting force required for peeling increased in proportion to veneer thickness, so the diameter of the rotating spindles had to be increased when the veneer thickness reached a certain level. Also, the core diameter increased which resulted in lower yield. According to Koch's suggestion, the core would be used as a raw material for two pieces of stud timber, see page 73. However, this did not succeed, because the length of the bolt used in Finland was too short, only 1.32 m or 1.62 m. Consequently, the maximum veneer thickness in peeling was defined as 4.8 mm.

As the *consumption of raw material* for LVL was somewhat *higher* than for sawn timber, but *lower* than for glulam, and the characteristic bending strength *higher* than that of glulam, the product idea was regarded as promising, at the very least. Consequently, the product value of LVL was higher than the value of sawn timber or glulam, cf. page 76.

To *evaluate the profitability of the new LVL product,* a project group in charge of analysing the production conditions carried out cost calculations to determine a realistic price for the new product. The decisive criterion was the bending strength of the new product compared to that of substitute products (Metsäliitto memo 1-2 and 3/1972). In 1972, the comparable price of LVL was estimated at FIM 775/m^3, when compared against the retail price of finger-jointed T-400 grade sawn timber. The price of glulam varied in the range FIM 600 – 900/m^3, so the retail price of the new LVL product could be estimated at about FIM 700/m^3. As the retail price of spruce plywood was FIM 450/m^3, the new product gave clearly higher added value, despite the fact that the production costs and the fixed costs of these products were practically at the same level. The production costs were calculated by carrying out factory-scale test runs, arriving at a price of FIM 361/m^3. The margin between the production cost and the estimated retail price was so large that it was considered justified to continue the analysis.

Three basic requirements were set for the *production technology*. *First*, LVL should be manufactured in one way or the other as a continuous billet. The originator of the LVL idea, N.R. Alenius, was given the task of designing a new continuous pressing line that would be suitable for the production of LVL. The outcome was a complex mechanical entity with a capacity of 50,000 m^3/a and a high level of automation (Alenius 1972). It would have involved a substantial risk both with regard to technical performance and marketing. Therefore, the Metsäliitto development group decided to look for other, simpler alternatives than the technique proposed by Alenius. As a consequence, the pilot plant stage based on the "Anra-line" technique was adopted as a basis for project development.

The *second* requirement was that a low-cost, weather-resistant hot curing phenol glue would be used.

The *third* requirement was that the hot pressing time should be reduced, because it is critical for the profitability of the production. The press temperature required in plywood manufacture, 125-130 °C, was increased radically to 150-175 °C. In order to achieve this, the variation of the moisture content in wood had to be controlled by applying significantly smaller tolerances. Too high moisture in individual veneers leads to excessive local steam pressure within the product, resulting in damage commonly referred to as the steam blow phenomenon. The conclusion was that better control of the process would allow the temperature to be raised to the target level of 150 °C by using current technology (Kairi 1975).

The main emphasis in the *commercialisation of LVL*, at this stage of the project, was to carry out a market research survey based on interviews (Hietala 1974). The survey was conducted on from June 1 to December 31, 1973. Answers were received from 79 construction companies (accounting for about 27 % of the production in the building sector), 10 design offices, 18 manufacturers of pre-fabricated houses (about 40% of the production in the building sector) and 9 enterprises operating in vehicle manufacture. The results showed that the main use for LVL was as secondary roof beams in halls, as rafters and posts in walls and as main supporting elements in small houses. By estimating the expansion of these end uses, an annual potential of 50,000 m^3 was established. The requirements included (Hietala 1974, 10):

- Strength grading of the material was seen almost as a necessity
- LVL was foreseen to replace big-size timber, small-size glulam and I-joists (plywood web joists) in these end uses.
- In these uses, the erection work was expected to be carried out almost exclusively by building contractors.
- Savings obtained with cut-to-size standard lengths would be the most important benefit to the builders

In addition, secondary and potential markets were evaluated and the use of LVL in entirely new end uses was assessed. As a conclusion, it was stated that in the light of the collected information an annual potential of 180,000 m^3 could be achieved in the domestic market (Hietala 1974, 12). Hietala defined the market prospects as follows:

- Demand for finger-jointed and cut-to-size timber was growing rapidly (Hietala 1974, Appendix 5) and the supply could not meet the demand
- The price of LVL, the speed and reliability of delivery were seen as the main factors influencing the purchasing decision (Hietala 1974, 18).
- The LVL could be up to 40% more expensive than ordinary structural timber (Hietala 1974, 15).
- In the first mill tests, the COV of the bending strength for LVL was lower than for sawn timber, and consequently LVL should be assigned a lower safety factor than sawn timber (Hietala 1974, 20)

It is worth noting that, while supply and demand were analysed by asking the customers about the availability of competing products, Hietala (1974, 16) ascertained that there was no evident lack of any product which would have constituted a market niche. The product would have to create its own market as a substitute for other products.

On the basis of market research, a decision was made to continue the analysis with the aim of developing a structural LVL beam product as a substitute for large-sized structural timber, small-sized glulam and I-joists.

The structural use of LVL requires that its strength grading is certified by *an official authority*. To this end, after the preliminary tests, Metsäliitto ordered a test series from VTT in the autumn of 1974. For these tests, the hot press at the Punkaharju mill was used to produce altogether 100 units of approved 47 mm thick panels with a width of 1.2 m and a length of 3.6 m. The minimum space between the butt-end joints was 100 mm. The VTT test reports A5834/75 and A6644/75 recommended values corresponding to sawn timber grade T-30.

4.3.2 Decision to invest in pilot plant stage

The board of Metsäliitto Teollisuus Oy decided on the March18, 1974 (Metsäliiton Teollisuus Oy 1974, 5) to set up a manual pilot plant line at the Punkaharju plywood mill. The primary aim was to concentrate on the manufacturing technique. A secondary aim was to carry out test marketing of the LVL product. The production line's capacity was calculated to be 4,000 – 5,000 m^3/a, and taking into account the overall potential in the domestic market estimated by Hietala (1974, 12) of 180,000 m^3/a, selling this volume should not have constituted a problem. On the basis of the experiences gained from the pilot plant line, the question was raised whether to establish a larger-scale industrial production line at Punkaharju or elsewhere. The investment cost of equipment and research costs, excluding the buildings, were estimated at about FIM 0.7 million (in terms of 1974 monetary value) (Lehtonen 1974).

4.3.3 Assessment of process with selected concepts

The new LVL product development project was initiated as a technical analysis. In the following section, the situation at the beginning of the project is analysed in the light of selected concepts. This is intended to serve as a comparison with the assessment of the pilot plant stage in section 4.5.

Business idea and stratified product

It was in the interest of both the owners and the mechanical wood industry in general that Metsäliiton Teollisuus would start developing a new product, though it was not yet understood that this would lead to a new business idea. From Metsäliitto Osuuskunta's point of view, it was – and still is – essential that the manufacturing industry should pay a high enough price for the raw material to the forest owners. In this way, an alternative use could be found for solid coniferous wood, instead of using it exclusively for sawn timber. Against this background, the *LVL business idea in its initial stage* was based on a conventional substitution – distribution market approach. Specific attention was not paid to how the end users' business would benefit from the potentially special characteristics of the product. The aims during this stage were to develop the manufacturing technique and achieve a domestic volume of 4,000 m^3/a, as pointed out in the paragraph above.

I have identified the business idea at that stage, as shown in Figure 50. Since the project remained the central organisation's responsibility, its benefit for forest owners was an important element in the business idea.

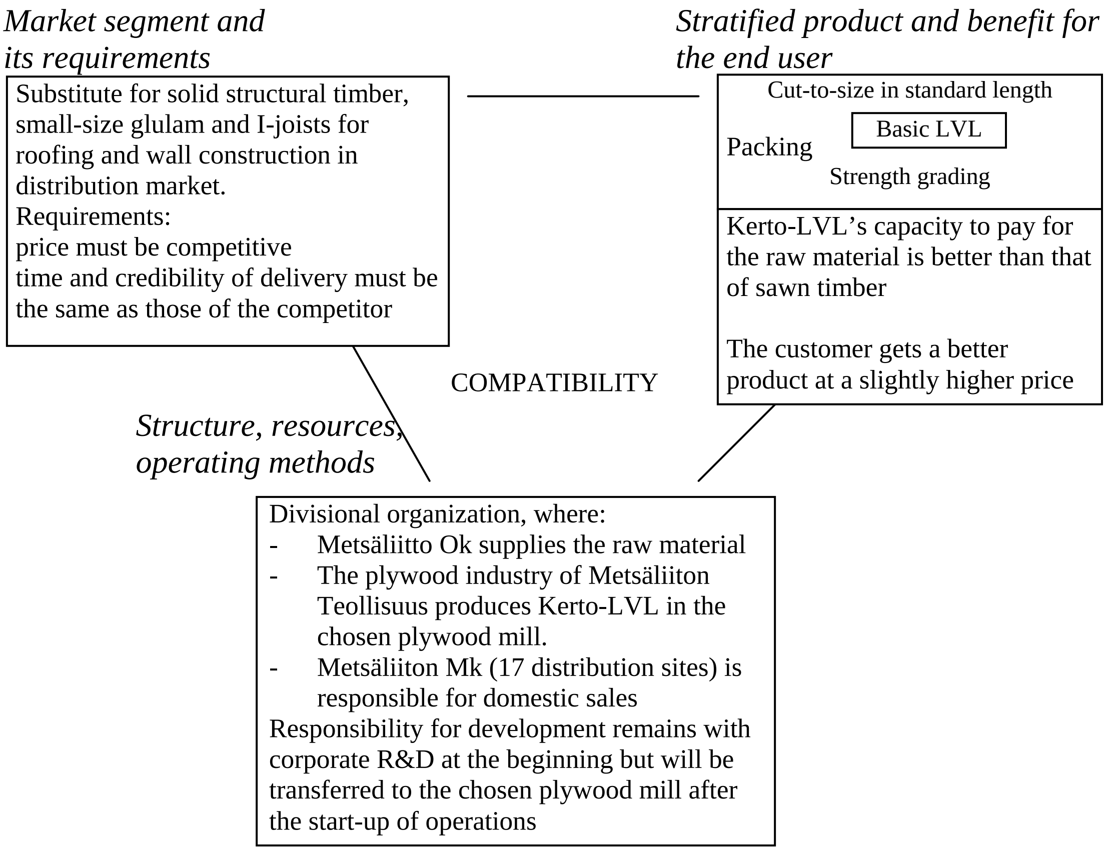


Figure 50. Business idea of the new LVL product before the start-up of the pilot plant. The stratified product included a cut-to-size product in standard lengths, as well as a packed component delivered to the distributor's warehouse.

The concepts of the *100% product, operating system, partnering* or *key technology model* were not yet known within Metsäliitto.

Value chain

At this early stage, the *value chain* was not yet known as a concept. It was viewed simply in terms of the selling price, which had to be competitive. Metsäliiton Teollisuus positioned itself entirely as a material producer and the benefit to the customer was estimated exclusively in terms of price.

Product platform

The product platform had been properly established for the new LVL product right at the beginning because:

- the directors of the *forest owners'* Metsäliitto Ok acknowledged the new product's high capacity to pay for the raw material. Therefore, the new LVL product benefited from a strategic preference.
- from the plywood industry's point of view, the new product was close enough to plywood, and the required technical development step did not seem unrealistic.
- the investment policy did not involve an excessive business risk, since it was possible to proceed to industrial manufacture through a pilot plant stage, which covered all the aspects of the industrial process.

Metsäliitto demonstrated a positive attitude towards R&D, at roughly the same point in time as several development projects were initiated or already under way, and with similar aims; see Appendix II.

R&D portfolio

The position of the new LVL product in Metsäliitto's R&D portfolio, as a *standard product* in regard to its marketing and production technology, is illustrated in Figure 51. From a marketing point of view, the aims were defined in terms of the substitute idea and the existing distribution markets. The market was defined as the construction industry, with the contracting companies themselves as the main target group.

The technology was not new as such: it had been adapted from the production of thin block board using the “Anra-line” technique. Because of the greater thickness of the new LVL billet, the moisture and heat transmission had to be analysed more carefully, compared to other products, to be able to use higher pressing temperatures.

Markets	Product		
	Known to Metsäliitto	New to Metsäliitto	New to the world
Known to Metsäliitto	New LVL product		
New to Metsäliitto			
New to the world			

Techno-logy	Product		
	Known to Metsäliitto	New to Metsäliitto	New to the world
Known to Metsäliitto	New LVL product		
New to Metsäliitto			
New to the world			

Figure 51. Positioning of the new LVL product with regard to product and market knowledge on the left and to product and technology on the right prior to the pilot plant stage in 1974.

The emphasis was on the technological implementation. The marketing was placed in the hands of the existing sales organisation without a deeper analysis of the market segment (Figure 50), which, however, constituted the main aspect of the business idea.

Innovation structure

In terms of its innovation structure, the R&D project was similar to traditional development projects in the industry at this time. Research consisted of testing the product and conducting market interviews. The project followed the simplified innovation structure (Mali et al. 1986, 53). The main emphasis in the innovation process was almost exclusively on the production technology. Questions related to the raw material supply were mostly concerned with conventional optimization issues (see Figure 52).

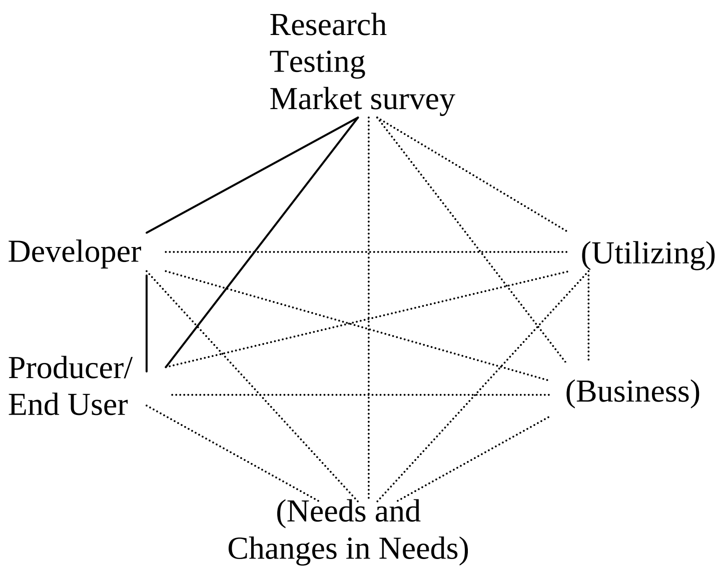


Figure 52.At this stage only a part of the innovation structure was available (represented in the figure by a continuous line) and research consisted of testing and interviews

From a technical point of view, the role of *developer* was held by Markku Lehtonen from the Metsäliitto head office and by the manager of Punkaharju plywood mill, Keijo Tolvanen. Punkaharju plywood mill acted as *producer*. HUT and VTT were responsible for *testing*. The other parts of the innovation structure were still not in place.

On the commercial side, the development group within the Metsäliitto's head office acted as a *developer*, Metsäliitto Mk was in charge of the *end user* of the product and the University of Helsinki carried out the *survey*.

Strength grading was based on a Statement by VTT (1975c). It was a pre-stage type approval, because the entire practice of type approval was new and there was lack of experience.

4.4 Development process with pilot plant stage

The next table contains a summary of the technical measures carried out during the pilot plant stage, of the test marketing and of the actions by authorities, which are essential for formulating an investment proposal of this kind. The brand name Kerto-LVL came up as the result of an internal competition to find a name for the company's new LVL product in spring 1975.

Table 15. Sub-projects of the pilot plant stage between 1975 – 1980.

Stage of the project	Development actions	Responsible party
Product	Developing an optimized veneer thickness and the structure of Kerto-LVL Gluing quality Developing an optimized glue mixture	Factory[1)] Factory and VTT Factory and glue producer
Production technology	Start-up of the continuous hot pressing process Contact drying of veneers; a pilot-scale 10-opening press dryer was purchased Gluing system Developing a lay-up system Optimizing the hot pressing time	Factory Factory and Raute[2)] Factory and Enwe Oy[3)] Factory Factory
Sales and marketing	Test marketing in the domestic market New technical operating system for Kerto-LVL in the domestic market Market research in Scandinavia, Germany, France and USA	First: Metsäliiton Mk, from spring 1976 onwards: factory Factory Factory with company's plywood export professionals
Investment plan	Investment calculations, estimates of production costs, estimates of potential profits concerning the industrial line Enquiries to machine and equipment suppliers; Planning of the industrial production line Raw material plan Financial plans and negotiations with investors	Factory Factory and Raute Metsäliitto Osuuskunta Metsäliiton Teollisuus head office
Type approval and building standards	Test run with new product Statement on the technical data for type approval of Kerto-LVL in the domestic market Initiation of type approval procedure in Scandinavia and in Germany	Factory and VTT VTT Ministry of Interior Affairs in Finland Factory with VTT

[1)] Punkaharju plywood mill
[2)] Raute Oyj is a company selling veneer machines and equipment, founded in 1908 in Lahti.
[3)] Enwe Oy was, in the 1970s, a relatively small company selling plywood machines and equipment.

In the following, I shall examine the product and the production technology under the same heading, because they – in addition to being my direct responsibility – have been interrelated since the beginning of the project. Thereafter, I shall outline the type approval procedure for each market area and review the corresponding market studies.

4.4.1 Product and production

For the purposes of the pilot plant stage, a continuous pressing line "Anra-line" was bought from the bankrupt Gutzeit Oy box factory (see Appendix I). The operation of the pressing line was modified to enable fixing the mobile press to the floor. The idea was to lay up the billet into a rigid structure that would remain intact when fed into the hot press after the pre-pressing phase. This succeeded when the veneer sheets were butt end jointed and had a minimum thickness of 3 mm. The unheated pre-press was fitted on wheels to make it easier to insert veneer sheeets. It was used to insert one press-length of the billet at a time into the hot press.

The pilot plant line, comprising continuous lay-up of the veneers and stepwise hot pressing, was a substantially cheaper, simpler and more reliable manufacturing process than Trus Joist's continuous press (Troutner 1970), cf. Appendix I.

The equipment of the Anra line was a synthesis of the manufacturing techniques used for plywood and thin block board manufacture: the glue spreading technique was adopted from the plywood industry, whereas the hot pressing was an original Anra-line technique. The veneer lay-up system represented a new technology, comprising a long conveyor.

In the plywood structure the "glued veneer sheets" and "dry veneer sheets" alternate. In Finland the thickness of each veneer in the panel has normally been 1.5 mm. The glue is spread on both sides of the veneers simultaneously by feeding the veneer through a glue roller. To minimise the transport distance, which involves a risk of getting dirt and impurities on the bottom face of the veneer, the roller is situated right next to the lay-up station. In the lay-up stage, a glued veneer sheet is stacked on top of the dry bottom veneer sheet, and from then onwards the layers of dry and glue-covered veneer sheets alternate. In this way, the glue amount used on each gluing line is 150-160 g/m^2, and the calculated glue consumption about 100 kg of liquid glue per 1 m^3 of product.

Problems were encountered in handling thick veneer sheets. The glued veneer sheets were glue-spread on both sides in a similar way to plywood, but the transport distance was essentially longer compared to plywood lay-up.

The original assumption was that by using a thick veneer and spreading the glue on every second veneer sheet, the glue consumption would be about 40 kg per 1 m^3 of product. The saving would be up to 60% compared to conventional plywood. The 4.5 mm thick veneer used in test runs had a rougher surface than a 1.5 mm thick veneer. It was assumed that by increasing the glue amount to about 180 g/m^2, the gluing could be carried out in the same way in Kerto-LVL as in plywood manufacture. This assumption was proven wrong in practice. There was so much glue on the veneer sheets that it spread all over the conveyors, and the production had to be suspended for cleaning the conveyors. If the glue amount was reduced to avoid this, the quality of glue bonds did not meet requirements.

The solution consisted of reducing the veneer thickness from 4.5 mm to 3.3 mm. Subsequently *all* the veneer sheets were fed through the glue roller, which minimized the amount of glue, and at the same time both faces of the veneer sheets were thoroughly covered with glue. The top and bottom face veneers consisted of two plies of 1.5 mm thick veneer sheets which were stacked together before feeding them into the glue spreader. The space in between these veneer sheets stayed dry, and by turning the glue-spread side inwards, clean face veneers could be obtained. In addition, the thin face veneer sheets were overlap-jointed, and the thicker inner layers were butt end-jointed, which resulted in a 12% increase in bending strength and in tensile strength parallel to the grain direction, compared to the earlier test results of VTT Statement A5834/75 (VTT 1975a).

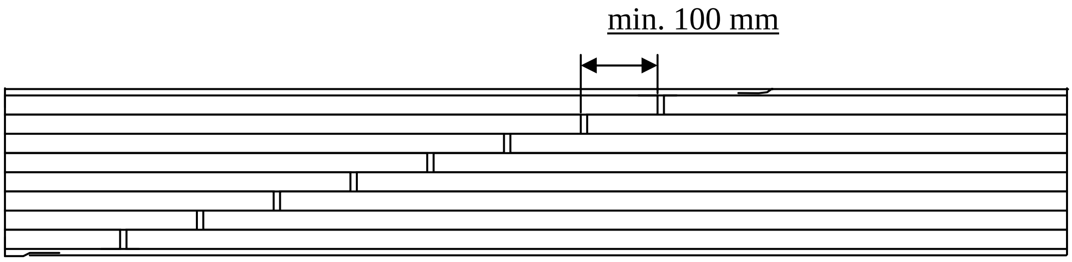


Figure 53. Structure of Kerto-LVL in the pilot plant stage. The thickness of the face veneers was 1.5 mm and the thickness of the inner veneers 3.3 mm.

The time needed for making a functional new product was 9 months from the start-up phase, after which a test production could be initiated.

4.4.2 Development in the domestic market

Product and market

Since the manufacture of Kerto-LVL as a beam did not succeed directly after start-up of the pilot plant because of gluing problems, 15 mm and 21 mm thick spruce plywood had to be introduced as a substitute product. The optimal thickness for the production capacity of the pilot plant had been calculated as 39 mm. Nevertheless, spruce plywood proved to be a profitable temporary alternative, which found an outlet as a roofing felt base material. The company’s distributors, assisted by the R&D department, started successfully marketing this new *large-size panel for roof sheathing*, with a maximum length of 5.4 m, with both its longitudinal edges tongued and grooved.

The marketing of the Kerto-LVL panel had to be carried out according to a radically new philosophy. The product was a substitute for the so-called rough tongue and groove board which was widely used at the time. The price in FIM/m^2 of the competing *product made of sawn timber* was significantly lower than that of the Kerto-LVL panel, but it required the use of a 2- or 3-ply roofing felt, depending on the slope of the roof. The Kerto-LVL panel provided a more stable and even surface, which meant that a 1- or 2-ply roofing felt was sufficient, and thus by adding up the costs of material and labour, the overall cost of the new product was lower when compared with its sawn timber alternative. The roofing felt manufacturers were opposed to the new product since the market for felt fell dramatically. They tried to tackle the situation by granting a warranty for the roofing felt, provided that it was installed in accordance with their guidelines. The warranty conditions covered only 2- or 3-ply felts, irrespective of the roof sheathing used. As a consequence, one roofing felt manufacturer signed an agreement with the Kerto LVL manufacturer, which made it possible to continue marketing and generate cash flow, which was a prerequisite for the financing of the development project.

In 1976, when the gluing quality of Kerto LVL manufactured as a beam had reached an acceptable level, and the Metsäliiton Mk organization was about to launch the sale of the product, there was an unexpected setback: the product no longer had a market as a substitute for solid timber in its planned end uses. The reason for this was a rapid increase in the production of structural finger-jointed timber, causing the price level to fall dramatically. Metsäliiton Mk could only conclude that the pricing of Kerto-LVL as a beam had been too optimistic for the chosen market segment. In addition, demand for I-joists and small-size glulam did not develop as expected. As a result, the trust and confidence in the development potential of the new product was called into question. The distributor executives stated explicitly that the product possessed no marketing potential.

In this situation, the manager of the unit decided to transfer responsibility for marketing the product to its manufacturer – in practice to myself. On the basis of technical calculations, we concluded that by increasing the height of the beam from 150 – 200 mm, which is a typical range for structural sawn timber, to 300-400 mm, it would be possible to double *the spacing* *between beams* in roof constructions compared to a solution based on sawn timber. We switched from a centre-to-centre spacing of 600 mm (k-600) to a new centre-to-centre spacing of 1,200 mm (k-1200). At the same time, this technique enabled lengthening of the span between the transverse beams of a roof from a maximum span for sawn timber of 4 m, up to 8 m. In this way, it was possible to reduce significantly the wood material consumption per square metre of roofing. In addition, the use of LVL beams in roof constructions permitted easier installation of thermal insulation between the narrow and high beams. As a consequence of these changes, the number of orders received from local building contractors increased so much that in the autumn of 1976 the sales of LVL for use as a beam exceeded the sales of panels for roof sheathing, both in terms of price per m^3 and total sales volume. Subsequently, the beams were prefabricated according to customer specifications into ready-to-use components by nailing the necessary structures onto the edge of the beam and by adding notches for hidden eaves gutters at the end of the beams. Architects still favoured a gently sloping roof or even a flat roof in the design of detached and semi-detached houses well into the mid-1970s. This favoured LVL because sawn timber was not ideal in low roof constructions with span lengths over 4 m.

Though technical calculations demonstrated the specific benefits offered by Kerto-LVL, the construction companies' decision-makers had to be convinced that the product offered a sufficient overall benefit. After all, we were suggesting a change in their design calculations, which would lead to a fundamental change in their operating practices, when roof joists were delivered to the site as customized products ready for erection, eliminating the need for doing construction work in situ.

An additional challenge arose from our position as an exclusive supplier, which led to a business practice where my task as product manager for Kerto-LVL essentially involved establishing and maintaining long-term customer relationships with designers and building contractors, based on mutual trust. This approach proved successful in the "Rantakylä regional building project" in Joensuu, eastern Finland, where together with the designer, Juhani Väisänen, we identified a competitive roofing solution, which received the type approval of Heimo Kettunen, project manager for the building contractor Pohjois-Karjalan Rakennustyö Oy. After type approval, the designer could define the material in drawings in the following terms: "Kerto-LVL or a corresponding glulam". However, it was well known that from an economic point of view there was no "corresponding" glulam structure available, unless the entire design was redone on the basis of the characteristics of glulam. In practice, this double design work would have been too expensive, and thus the first version was retained. In the planning phase, which could last for up to one year before implementation, it was crucial to convince the designer that selecting Kerto-LVL for the supporting structure was the right decision for the customer, even though there was only one supplier.

Establishing a successful long-term customer relationship required, right from the beginning, that the project would offer a win-win situation. In addition, the required quality control and precision of deliveries led to a *paradigm shift* in the Kerto-LVL unit’s operating practice, which was supplier-focused according to the prevailing trend in the plywood industry. It was absolutely vital that both quality control and delivery would be up to standard. For example, the customer focus in operations required that a sufficient standard in gluing quality would be reached by the autumn of 1976. During the pilot plant stage I visited nearly all the sites in which the customer was involved as a building contractor. This enabled me to establish personal contacts, to get direct feedback and to nurture the customer relationship.

After the Joensuu project, I started building relationships on a supplier-designer-building contractor basis, first in Lappeenranta in south-eastern Finland and later in the Helsinki region. By the end of 1978, there was enough experience to allow us to refer to previous relationships when establishing new contacts.

A design with a wider spacing of beams and longer spans was also well suited for use as roof elements in large halls. Kerto-LVL was thus viewed as a competitive secondary beam in roof construction. The increased span permitted widening the spacing between primary supporting beams, initially from k-3600 to k-4800 and later even to k-6000.

After initial technical difficulties, the sales volumes began to rise steadily, though the estimated domestic volume of 4,000 m^3/a proved to be clearly too optimistic.

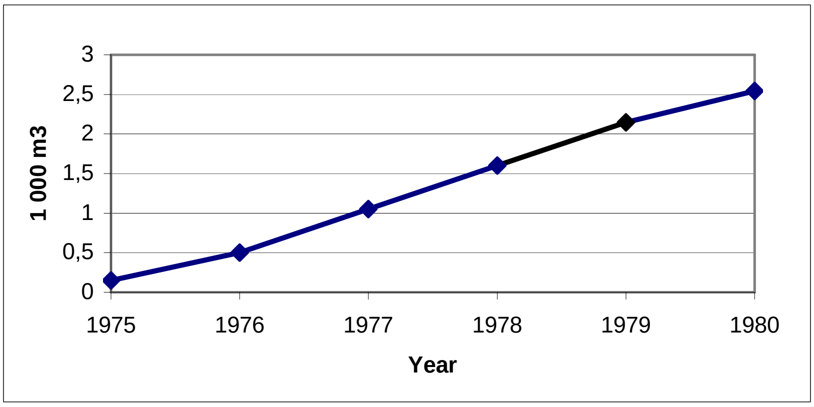


Figure 54. Rising demand for Kerto-LVL during the pilot plant stage.

<u>Organisation</u>

The new construction method was technically so advanced that the distributors were unable to sell the new solution. As a consequence, a *product manager model* was introduced into the project in the spring of 1976.

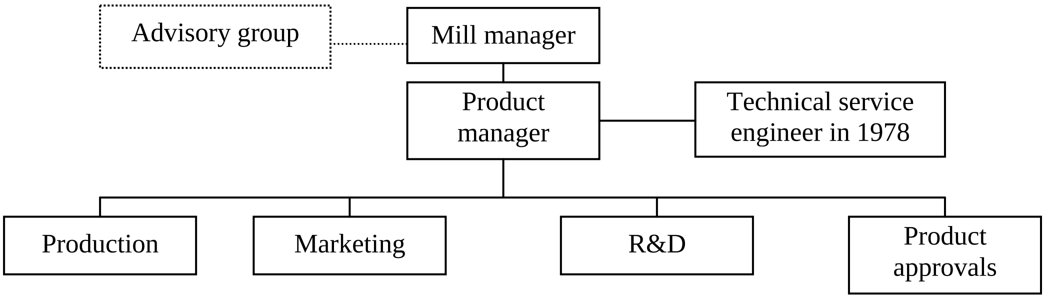


Figure 55. Product manager organisation for Kerto-LVL during the pilot plant stage 1976-1981.

Within this independent organisation, the product manager was answerable directly to the Punkaharju plywood mill manager and responsible for operations in the pilot plant stage, including the marketing of the product. The advisory group supported and periodically controlled the activities during the pilot plant stage. The members of the advisory group were the R&D department and financing department managers.

When marketing the Kerto-LVL beam, the product manager operated directly with the end users, i.e., building contractors and manufacturers of pre-fabricated houses. This was a clear exception to prevailing practices. The distribution level was omitted from the distribution chain for the beam product, which meant adopting a *solution market* approach. Previously, the sales operation had been carried out between the distribution company and the buyers for the building contractors, whereas in this new approach the negotiating parties were the product manager and the building contractor’s project manager. In addition, the business transaction was preceded by technical discussions involving the following participants:

- the structural designer
- the building authority
- the contractor’s project manager
- the Kerto-LVL product manager

This marked the beginning of an interactive technical approach to marketing of the product, and the first step in creating its technical substance. As more projects were initiated, there was a need to strengthen the organisation to produce an even more technical substance. A full-time technical service engineer was appointed in 1978 to provide assistance to the product manager. His main task was, together with the designers, building contractors and building authorities, to develop a functional technical *operating system* for the new product when used in roof constructions.

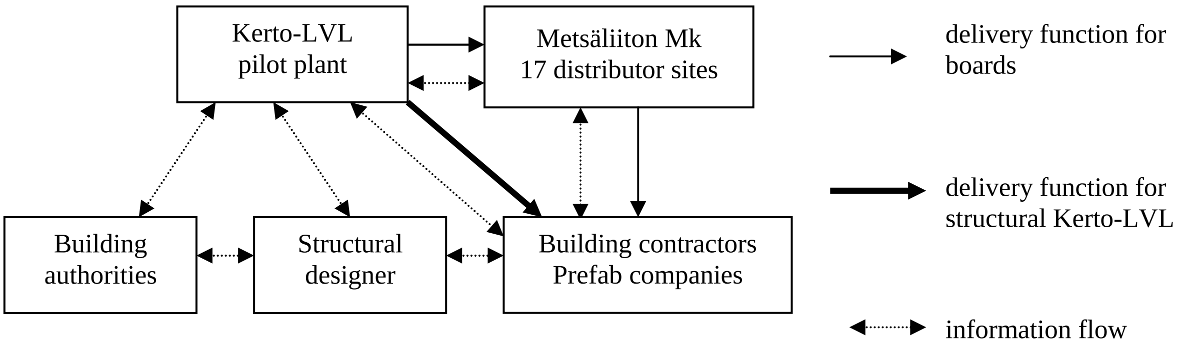


Figure 56. Distribution of Kerto-LVL one year after the start of the pilot plant stage.

For the building contractor’s project manager the new product provided an interesting opportunity to compare his pricing and cost calculations in two ways. The use of Kerto-LVL beams in roof constructions made it possible to compare the labour input of the new industrial solution with that of a conventionally nailed structure assembled on-site. Also, because of the direct interactive contact with the producer the project manager could work together with the producer to simplify the structures.

Type approval of Kerto-LVL

On the basis of a continuous external quality control and a factory internal quality control, both carried out by VTT, a type approval application was submitted to the Ministry of the Interior. In the type approval (Type approval 1978) the product was found to possess strength characteristics which, for the first time, exceeded the strength values of the then generally used glulam grade L40 (RIL-120 1978, 72).

The application procedure was relatively simple and straightforward. It consisted of a statement by VTT, which defined the technical capacity of the product and the development of its quality assurance. The Ministry of the Interior issued an official certificate, which placed the product in a range of general building instructions.

4.4.3 Development of the export market

Sweden and Denmark were viewed as important markets, because the traditional way of using sawn timber and glulam in construction presented significant similarities to that of Finland. Therefore, after initial contacts, a sales engineer responsible for the Scandinavian market was appointed in early 1979. However, since the experience of the Scandinavian markets does not provide any specific additional information for the purposes of this study, it will not be covered in more detail.

Market research in Germany

The German market was significantly different to the domestic and Scandinavian markets. As a product manager, I initiated research into the potential volume for Kerto-LVL in Germany in the autumn of 1979, in cooperation with the Finnforest GmbH sales office in Düsseldorf, which was in charge of the agent functions for panel industry. The sales office would organise meetings with potential customers. The target group consisted of manufacturers of prefabricated houses, glulam factories, building contractors and various factories producing different *customized products*.

My aim was to find a couple of large end users for the product. For this reason, I concentrated on a few of the most significant prefab companies and special product manufacturers (differentiation with broad target, Table 7), which supplied timber components for the concrete shuttering industry as their typical main product. The German carpentry industry was not given any specific attention at this stage.

The market research carried out in Germany during the pilot plant stage can be summarized as follows:

- It was not possible to develop a similar market in Germany for the Kerto-LVL beam for the span length of 4-12 m, because in Germany a larger range of dimensions and longer timber were available than in the Finnish market. In addition, DIN 1052 (1969) would have required stability calculations, which would have been difficult to carry out for the narrow and high Kerto-LVL beam. Because of this norm, the cross-section of timber typically follows a pattern where the maximum height is four times the thickness in the cross-section of timber. For this reason, specific stability calculations are not required.
- Roof or ceiling elements were rarely used; the construction was carried out in situ using solid sawn timber and advanced techniques involving dowel-type fasteners.
- There were various solid I-beams on the market, which were used as support beams for concrete shuttering. There would be a possible use for Kerto-LVL as a component for these: either as flanges, or as a web with a special veneer lay-up.
- Different kinds of industry components could be immediately seen as possible end uses for the product.
- Local glulam factories regarded Kerto-LVL as a competing product, but there was also potential interest in cooperation, because the manufacture of small-dimension glulam was not considered viable. The product differed visibly from the local manufacturers’ glulam, whose quality was close to that of furniture material.
- The production of prefab factories was – and still is (!) – based on a practice where all the drawings are type approved centrally by an acknowledged research and testing institute like the “Forschungs- und Materialprüfungsantalt Stuttgart” (FMPA). As a consequence, it is nearly impossible for a new product with only one producer to establish a similar process.
- The authority-based type approvals have a more significant role in Germany than in Finland. Without type approval, the potential end users are normally not even interested in the product.
- There was an organized and powerful registered agents’ and importers’ association, Verein Deutscher Holzeinfuhrhäuser e.V. (VDH). In 1978, it had 243 members (VDH 1978), 200 of which operated in a market suitable for Kerto-LVL. The association enforced strict control over its territory. It was impossible for a Finnish enterprise already in the market to avoid contact with this importer without this affecting the sales of some other product within the company’s product range.

The results of *the market research* failed to clearly indicate any significant potential volume for Kerto-LVL as a substitute or close substitute for other products in any application, with the exception of some *customized* uses within the industry. When estimating the use of wood in construction in general, it should be noted that in Germany the use of the so-called "Ingenieurholzbau" in engineered wood construction was continuously expanding. The strength values of the new Kerto-LVL product were clearly better than those of sawn timber, and Kerto-LVL was clearly a more technically advanced product. Consequently, following a sufficient additional technical contribution to Kerto-LVL, the German market could become interesting both in terms of volume and price level.

Change in marketing structure

The glulam factories differed from other end users in that they purchased the sawn lamellas for their production either directly from local sawmills, or, if an agent was used, primarily from sawmills in Sweden. As the importer did not have working business relationships with the glulam factories, Finnforest GmbH was able to sell its goods directly to the end users. This was the first time a Finnish basic wood product could be sold directly to customers in Germany without using an importer.

To secure its position in the plywood market, Metsäliitto decided at this early stage to offer an opportunity to the importers that were interested in the emerging markets for Kerto-LVL. In this perspective, the representatives of Metsäliitto and of VDH agreed to hold a meeting early in 1980. The report of the meeting (VDH 1980) unambiguously indicated that Kerto-LVL would be sold in Germany exclusively through VDH importers, with the exception of any glulam factories listed in the report.

Type approval of Kerto-LVL for the German market

Since Kerto-LVL was a construction product manufactured by gluing, its manufacture for the German market required a Gluing Permit called "Bescheinigung C". The application was submitted to the FMPA in 1978 and the permit was obtained in the spring of 1979. The manager of the FMPA issued a statement which recommended a similar use for the product as for glulam, and included the technical data corresponding to the highest quality grade in Germany, "Güteklasse I".

The director of the highest authority on construction materials in the German Federal Republic, the Deutsches Institut für Bautechnik (DIBt), stated right after "Bescheinigung C" had been awarded that Kerto-LVL could not be regarded identical to glulam, but instead would need its own specific type approval. However, according to the director of DIBt, this was a simple formality, since the strength values did not present any problems.

The application for type approval of Kerto-LVL was submitted in June 1980. The type approval procedure took 10 months. However, including the time needed to obtain the "Bescheinigung C", the entire procedure took 3 years. During the start-up phase of industrial production, the product was technically type-approved for the German market as a beam and column. Later it was discovered that the decision by the German type approval authorities to require a specific type approval for Kerto-LVL limited its use in relation to other products already on the market, e.g. glulam. Subsequently, *every use or application involving joints*, which differed from the uses of a rectangular beam or column, had to be approved by DIBt.

Market research and type approval in France

As a product manager, my first direct contacts with companies in this sector took place at the end of 1979. At that time, I analyzed the market structure and the options for distribution channels. In France the use of wood was not at the same volume level as in Germany. For structural uses the main products were glulam and green timber. However, the techniques used for joints presented more similarities with Scandinavian techniques involving nails and bolts rather than with advanced German techniques based on dowel-type joints. There were no particular uses or products for which Kerto-LVL could serve as a substitute.

The distribution chain did not require involving an agent and importer – which was unavoidable in Germany. Metsäliitto's own distributors of sawn timber and plywood assumed the agent's and importer's role. The central issue in the French market was to ensure the active participation of a potential partner rather than tackle the territorial limitations presented by interest groups.

At the time, the French standards (Réglementation Générale pour la Construction 1971 and Règles Spéciales 1971) were not as detailed as the German DIN 1052 (1969). There were no limits on the use of a narrow and high beam like there were in Germany. This offered a more realistic opportunity for the use of the product as a beam than in the German market. At this stage I did not start a procedure to obtain a product type approval. However, Centre Technique du Bois (CTB) would provide the testing, in a similar way as VTT in Finland.

The conclusion from the analysis was that France was a potential market for the product. Consequently, the Kerto team decided to initiate marketing procedures. I was assigned the task of finding a local partner that would be interested in launching the new product in the market.

Market research and type approval in USA

Because until the mid-1970s there was only one global producer of structural LVL products, situated on the US West Coast, researchers and trade journals became interested in the Finnish LVL product already at the pilot plant stage. Amongst Metsäliitto's plywood importers at that time, Mc Causey Lumber (MCL), under the leadership of Jim Gilleran, contacted the Kerto-LVL producers in 1977. MCL's product range included scaffold planks made from sawn timber. Jim Gilleran was particularly interested in the suitability of Kerto-LVL as a scaffold plank, because in the late 1970s Trus Joist had started marketing its Micro-Lam product to complement its product range in support structures. The results of the quality assurance conducted by VTT and the quality assurance agreement were translated into English and submitted to the American authorities responsible for type approvals.

The feedback from the American authorities was positive. The Finnish LVL product could be used as a substitute for American LVL, provided that an authorised testing organisation in the US verified VTT's quality assurance results by comparative testing. If strength results coincided, then Finnish LVL could replace Micro-Lam with a similar cross section. Because of the raw material used, the Finnish plank was more than 20% lighter than its US competitor. Micro-Lam was made from Douglas fir veneers with a density of more than 600 kg/m^3, whereas Kerto-LVL was made from Norway spruce veneers with a density of about 500 kg/m^3. However, because of their use as a scaffold plank there was more pressure to use scarf-jointing in veneers instead of butt-end joints, in order to increase the bending strength measured flatwise in particular.

MCL purchased the first test series of scaffold planks in the autumn of 1979. The volume was 37 m^3, which corresponded to one truckload of planks. Kerto-LVL received the brand name "Master Plank®". The first and most decisive marketing action in penetrating the US market was the participation of MCL and myself in the annual meeting of the Scaffold Industry Association (SIA) held in June 1980 in Reno, Nevada. As a part of the meeting there was a demonstration by the manufacturers. The most important contacts for future developments were established in Reno.

4.4.4 Decision to invest in the industrial production line

Because of the progress in the technical manufacture of the product and its authority-based type approval, by the end of 1978 we had reached a level that was sufficient for the pilot plant stage. During that year we had reached a sales and production volume of 1,600 m^3. The demand was continuously rising in the spring of 1979 and export opportunities seemed promising (see Figure 54). Vieno Uusitalo, Metsäliitto’s Chairman of the Board, was favourably impressed by the development when he visited the pilot plant. Within the Metsäliitto organisation, the plywood and particleboard units in Lohja were operating under the direction of the Kirkniemi paper mill and its manager Ebbe Sommar, later CEO of Metsäliiton Teollisuus, which was an exception to the practices in the mechanical wood industry. In Mr. Sommar’s view, Kerto-LVL offered a new lease of life to the old and unprofitable plywood mill. On this basis, he firmly supported the plan to invest in building an industrial production line at Lohja.

Metsäliitto’s board meeting on August 8, 1979, chaired by Vieno Uusitalo, made the final decision to go ahead with the project at the Lohja mills. The investment proposal was presented by Jyrki Kettunen. In his address, he pointed out a number of issues related not only to the production technology but also raw material procurement. Marketing the product was seen as the most significant risk. If marketing was a success, it would probably soon become necessary to expand the mill for a significantly larger production (Metsäliiton Teollisuus Oy 1979b, 5).

The reasons behind the investment decision were not directly market-related, because the market was clearly seen as a risk. Kerto-LVL had three basic advantages, which supported a positive decision:

1. The good wood raw material yield in manufacture compared to glulam (see Table 16).

2. The better strength obtained from the same raw material. Small deviations of strength properties in relation to strength-graded timber and glulam, and thus better strength characteristics, cf. Type approval of Kerto-LVL (1978).
3. The utilization of over-mature spruce forests in Southern Finland (Kettunen 2002, 18).

Based on the research concerning raw material utilization made by Koch (1973), we made numerous tests with Kerto-LVL and calculation-based comparisons with glulam during the pilot plant stage.

Table 16. Raw material yield of Kerto-LVL compared with glulam (Kairi 1979).

Production of 1 m^3 of Kerto®-LVL requires:	Production of 1 m^3 of glulam requires:
• 2.6 m^3 of logs with bark and a medium diameter of 32 cm and minimum diameter of 25 cm • the logs are rotary-peeled into veneers, which are mixed after peeling and drying; sorting is not needed	• 2.1 m^3 of logs with bark to get 1 m^3 of 33 mm thick lamellas • lamellas must be sorted in the sawmill for glulam production • 1.4 m^3 of sawn timber to get 1 m^3 of glulam
Total: 2.60 m^3	Total: 2.1x1.4 = 2.94 m^3

The pressure to make an investment decision was to some extent linked with the licence agreement made between American Trust Joist and Swedish glulam manufacturer Töreboda Ab in the autumn of 1978. Töreboda Ab was acquired by a new owner during the same year. The LVL product did not fit well with glulam from the new owner’s point of view, so Trus Joist signed an agreement with Stora Kopparberg AB instead, which at the time was still operating in the plywood industry (adapted from Kettunen 2002, 70). The agreement covered the manufacturing of Micro-Lam LVL and its marketing in Europe, excluding the UK. The launch of a competing product was a clear threat to Metsäliitto’s plans to find a competitive use for its owners’ solid timber raw material. However, the licence agreement was cancelled after several developments in 1982.

Kerto-LVL industrial production process and product innovation

The planning for the first industry-scale Kerto-LVL prototype process in Europe was started in spring 1979. After listing the development requirements, measures were taken to find a suitable equipment supplier. A decision was made early to opt for a Finnish equipment supplier, because there were a significant number of unresolved issues related to the manufacturing technique. Effective communication with the supplier was therefore a decisive criterion. After evaluating the reference lists of veneer and plywood industry equipment suppliers, Raute stood out as the only possible option. During a planning period of 9 months the technical experience gained from the pilot plant stage was transferred for inclusion in the plans for the new industrial production line.

To complement the technical experience gained from the previous stage, the following development tasks were carried out:

- Adapting a logic control system for monitoring a continuous production line and developing the manufacturing system into an industrial process.
- Modifying the structure of the product to enable scarf-jointing of veneer sheets on the production line (Kairi 1987).
- Implementing glue streak spreading with the extruder technique.

Experience of logic control had been gained in the Silko project, which preceded the Kerto-LVL project by a couple of years, cf. Appendix II.

At the production line planning stage, a decision was made to start using *scarf-jointed veneer sheets* in Kerto-LVL manufacture. Traditionally, scarf-jointing had been used as a *separate* stage in plywood manufacture. In the new production line, however, this operation was integrated into the lay-up process. To make scarfs at the ends of the veneer sheets, the line included a scarf saw adapted from plywood scarf jointing techniques. The veneer sheets were scarf-sawn on-line and transferred to the lay-up station. During lay-up, the veneer sheets were simply laid up in succession so the grain direction was the same for all of them, and then pre-pressed together with the entire LVL billet (Kairi 1987).

Glue spreading had proved to be a problem during the pilot plant stage. As a result, a new glue spreading technique suitable for a continuous lay-up was developed in-house (Priester 1980). To ensure smooth automated transfer of veneer sheets from the feeding station to the lay-up station by means of a conveyor belt, the bottom face of the veneer had to be glueless. Two options were available for glue spreading: either employing *a curtain spreader* as used in priming and coating technology, or using glue *streak spreading with the extruder technique*.

The curtain spreader technique was tested by purchasing second-hand equipment for test runs. The results of the tests indicated that this technique was well-suited for applying a fine paint or varnish. However, the capillary action in the liquid glue and the viscosity fluctuation range was found to differ significantly from those of paint coatings. In addition, a curtain spreader is very sensitive to small particles typically contained in glue.

There was very little previous experience of streak spreading of glue using the extruder technique. In glulam manufacturing, the maximum width was 300 mm, whereas Kerto-LVL required a width of 2,000 mm. Priester (1980) carried out an initial survey and a small-scale test run, which demonstrated that the principles established in the glulam industry were also applicable to glue-spreading of wide veneer sheets. Subsequently, a test series was made to find an optimal extruder pipe profile with holes of the right size. A more reactive glue better suited for streak spreading was developed in cooperation with the glue supplier. The cooperation with the glue supplier was so successful that the solution was ultimately developed into functional glue-spreading equipment. Over the years, the Kerto-LVL unit has sold several streak spreading lines to producers around the world as an integrated part of Raute’s production line deliveries. Spreading the glue on one side only made it possible to abandon the use of thin surface veneer sheets with a thickness of 1.5 mm.

4.5 Assessment of the process concepts selected in the pilot plant stage

In the following sections, I shall assess only the operations that were carried out in Finland, since the export activities had not yet been properly launched at the pilot plant stage.

Business idea and stratified product

Test marketing efforts were concentrated on finding an outlet for larger production volumes in the future. The situation changed radically when the substitute market approach was no longer a viable option (page 90). A new business idea was developed in cooperation with the designers and the contractors. Kerto-LVL was a *customized product on a solution market*.

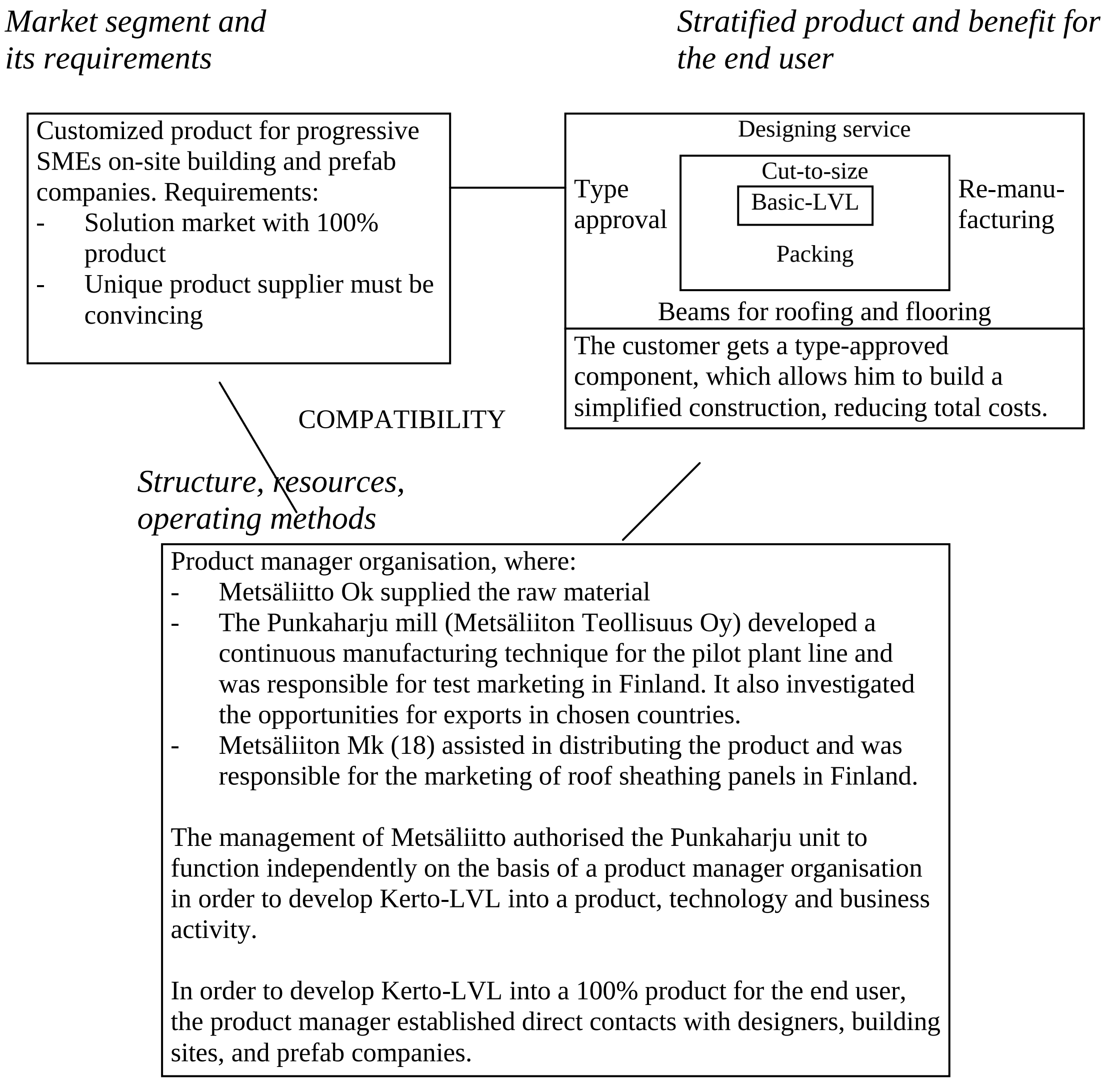


Figure 57. Developments in the business idea and stratification of Kerto-LVL during the pilot plant stage, see Figure 50.

As a result, the product concept was substantially extended, making it clearly more stratified compared to sawn timber or to the previous plan (page 58 and Figure 50 on page 83). In addition to the previous product specification, the end product included a design service, re-manufacturing of notches and holes and a specific type approval by an authority.

100% product and operating system

Together with the designers, the Kerto-LVL team developed the first version of an extensive *operating system* for the product, which, along with the service, provided a *100% product* to a defined customer segment. As a consequence, customers were willing to modify slightly their own operating principle, as they were now able to work with one supplier for over two years without having to initiate a tendering process. This resulted in a win-win situation.

<u>*Value chain*</u>

However, the focus of operations remained on the technical side. The *value chain* principle proved to be a functional guiding principle already during the pilot plant stage. The switch from a material producer to a component producer had already been partly implemented (page 90). The following developments can be identified:

- The decision to opt for a more expensive material in bitumen roofing felt, which was used for water sealing of flat roofs or pitched roofs led to important overall cost savings both in terms of material and labour.
- In halls and structures involving the use of secondary beams/timber joists savings were achieved in material and labour costs, as the producers of Kerto-LVL established direct contacts with the buiding contractors.

Operating directly with the end users was new in the wood products industry. Moving the business focus closer to the customer for the first time provided the opportunity to understand the customer's immediate problems, enabling the Kerto team to develop its business.

The business focus was transferred from a production-centred approach towards a more customer-oriented method of operation. This resulted in a situation where the profitability no longer depended on general unit pricing within the sector, but was instead based on value-added pricing. This was logical since already during the pilot plant stage the business evolved from material supply towards delivery of a sub-product where some services were included. Within the *value chain*, the business position of the Kerto-LVL unit corresponded to that of a component producer.

<u>*Product platform*</u>

The product platform was still suitable for the new product. The directors of Metsäliitto offered the Kerto-LVL unit the possibility to function independently right after the start-up of test production in spring 1976. At the same time, Metsäliitto's decision to invest in an industrial production line gave the company the possibility to:

- utilize the stock of spruce logs available in Southern Finland
- continue with operations at the Lohja plywood and particle board factory by shutting down unprofitable plywood manufacturing and switching to LVL production

Partnering

Since Kerto-LVL required its own usage-based *operating system*, it had no immediate competitor whom the builder could approach to invite a tender. This was seen as a problem in building projects involving the public or municipal sector. In these projects, roof structures had to be designed in a way which enabled a competitive tendering between material producers. To gain access to important public-sector projects, we had to develop the customer relationship towards a partnership using all available means. In this case, the building contractor would justify, on our behalf, why it was sensible to include Kerto-LVL in construction plans already in the tendering phase.

Analysing the depth and quality of partnerships, I found that, at a personal level, trust was established almost immediately or not at all. This observation is supported by Blomqvist (2002, 270): "*Individual-based trust needs to be established fast*". Customer needs were the starting point for the cooperation, and at least for a formal competitive tendering phase. In spite of the partnerships, the building contractors did not take any strategic decisions towards engaging themselves with Kerto-LVL as a product. However, as operations at this stage were concentrated on the domestic market, Metsäliitto's name served as proof of the viability of the new business. As a nationwide forest owners' enterprise, Metsäliitto was seen as a trustworthy cooperator.

R&D portfolio

The transfer from the planning stage to the pilot plant stage caused dramatic changes in the product – market matrix. Metsäliitto realised at the very beginning of the pilot plant stage that Kerto-LVL as a product did not fit into the Group's predominant operating practice. Instead of the known-known square, its correct position was in the new-new to Metsäliitto square. The product was not a direct substitute for sawn timber, I-joists or glulam, and the company's own sales channel did not succeed in marketing it. Therefore, the company considered it necessary to change the operating practice.

The Kerto team had to put in a fair amount of marketing effort per order achieved. As a consequence of this, the marketing costs were at a much higher level than is customary in the primary wood industry sector. The fact that the product had only one supplier constituted a risk. Thus, there was a risk of concentrating on too demanding a market segment with regard to the knowledge and experience that the team possessed, but those involved did not acknowledge its importance at the time.

Correspondingly, in the product – technology matrix, Kerto-LVL's position should have been in the known – new square in stead of the known – known square. The technology used in the pilot plant line was based on the improved Anra line technique. Continuous lay-up and stepwise hot pressing were suitable for the manufacture of various types of LVL structures. The new solution was a substantially cheaper and simpler manufacturing process when compared to Trus Joist's continuous production line. From a technological point of view, the project was progressing according to plan.

Markets	Product		
	Known to Metsäliitto	New to Metsäliitto	New to the world
Known to Metsäliitto			
New to Metsäliitto		Kerto-LVL	
New to the world			

Figure 58. The position of Kerto-LVL at the start of the process had to be modified. Instead of the known-known square, its correct position was in the new-new to Metsäliitto square during the pilot plant stage in 1975-1981. This led to a new operating practice in marketing.

Techno-logy	Product		
	Known to Metsäliitto	New to Metsäliitto	New to the world
Known to Metsäliitto		Kerto-LVL	
New to Metsäliitto			
New to the world			

Figure 59. The technology was in principle known before the pilot plant stage. It was being developed to enable the implementation of an industrial production line.

In terms of the product, the emphasis was shifted towards the right in the "new to Metsäliitto" square of the matrix. Kerto-LVL beams were clearly heavier than planned. Their handling was more difficult than expected and their erection nearly always required the use of a specialized hoist on-site.

Key technology model

Instead of a key technology model, at this stage a classical innovation chain was still adhered to. Because the innovation structure was not sufficiently developed (Figure 60), any basic or applied research, or testing, which would serve as a response to the needs of the market, therefore could not be carried out.

<u>*Innovation stucture*</u>

At this stage of the R&D project, the operations had evolved to resemble closely a systematic structure, but the main focus in development was still on testing and interviews. The pressure came essentially from the *developer* and *utilizing* counterparts. In Figure 60 below, the arrows illustrate the imbalance of the situation. The main shortcoming from an economic point of view was the fact that the main customer group (*end user*) consisted of SME building contractors; for them, solving their immediate problems constituted a priority. Their internal problem analysis resulted in an immediate *need* to find a technical solution. However, the concept of *needs and changes in needs* within the innovation structure would have required identification of development needs related to a widening of the scope of end uses.

From a technical point of view, HUT and VTT continued to be in charge of *testing*, the Kerto-team acted as *developer* and the Lohja mill - as the new manufacturer of the product - was both *producer* and *utilizing* counterpart, as well as being responsible for the *business*.

From a marketing point of view, the *survey* function was taken on by HUT (Kivelä 1977). Structural engineer Juhani Väisänen took on the role of *developer*. The *utilizing* counterpart was the Kerto-LVL business unit. Together with the site, local building contractors acted as *end users* instead of Metsäliiton Mk’s organization. The *business* was the product manager’s responsibility.

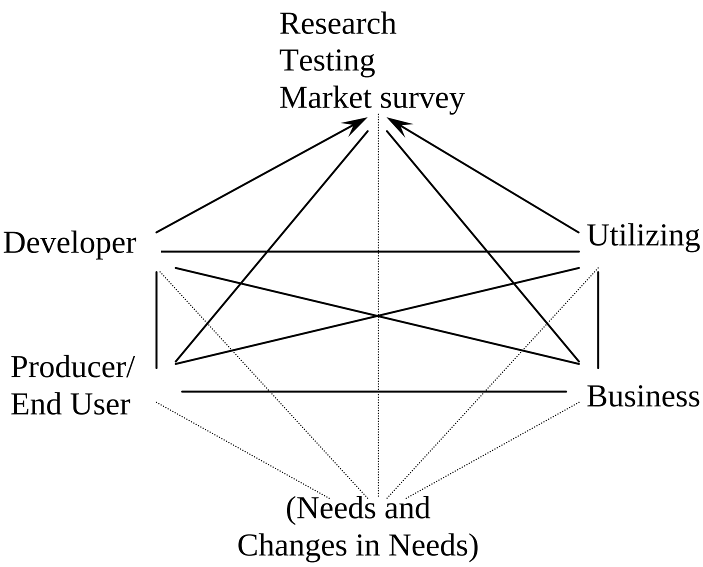


Figure 60. In the pilot plant stage, the innovation structure is almost completed. Only the needs and changes in needs function is not yet developed.

5 ESTABLISHING THE INDUSTRIAL STAGE FROM 1981 TO 1987

This chapter covers the developments in Finland, Germany, France and the USA until the end of 1987. Up to that point in time, the Kerto team carried out its export operations within an organisational structure in which the product manager held a central role. As a consequence of the merger between Metsäliiton Teollisuus Oy and G. A. Serlachius, a clear strategic change began to take place in the Group's operations in early 1987, changing the Kerto LVL project's export strategy at the end of that same year.

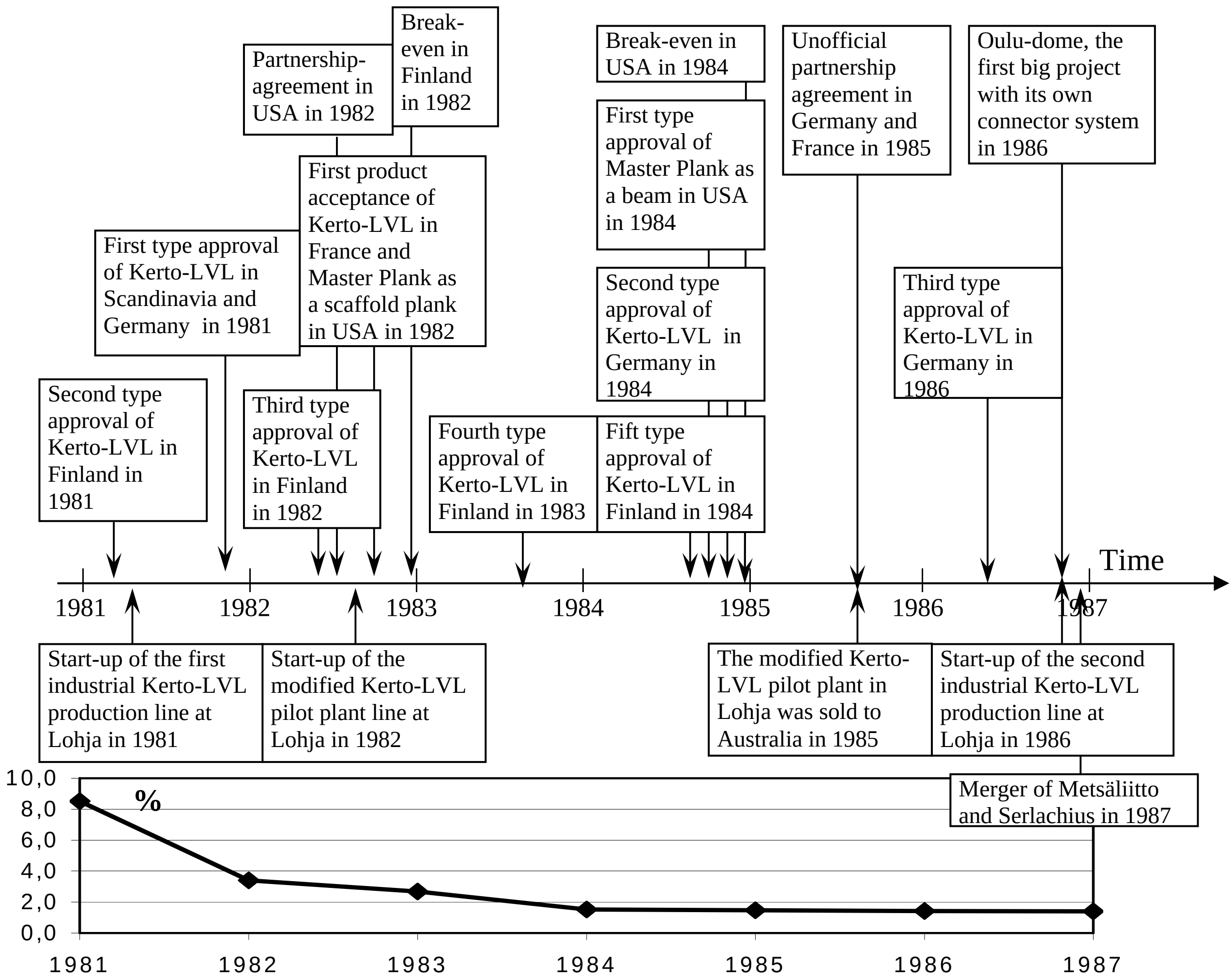


Figure 61.Most important steps of Kerto-LVL at the start of the Industrial stage 1981-1987. In the USA, Kerto-LVL has a brand name "Master Plank®". At the bottom, the relative R&D cost of the Kerto-LVL's turnover (source: Finnforest).

The relative R&D cost naturally decreased as the Kerto-LVL volume grew. The overall expenditure stood at the same level during the industrial stage, when the change in the index was taken into account.

This chapter describes the phase during which the experience and knowledge gained from the pilot plant stage at the Punkaharju mill were applied to industrial-scale production at Lohja. At the beginning of the industrial stage, the main focus was on developing the "*technology push*" aspect of the innovation process, in the same way as during the previous stage. After a troublesome learning process, the Kerto team, reinforced with new members, succeeded in bringing the industrial production to an advanced level, both in terms of technology and product quality. In cooperation with the authorities, the current high level was achieved in technical type approvals. In a similar way as during the pilot plant stage, the focus was subsequently transferred towards business development.

5.1 Metsäliitto as a platform for Kerto–LVL

The Metsäliitto Group's organisational structure was laid down between 1981 and 1987. The mechanical wood industry, which was part of Metsäliiton Teollisuus Oy, was further divided into panel industry and sawmill industry (Zetterberg 1983, 282). Both of the above sectors operated under the direction of the CEO Ebbe Sommar. The entire R&D activity within Metsäliiton Teollisuus Oy became centrally managed by the R&D department, directed by Jyrki Kettunen.

The products were assigned a development role according to their market position. These were: leader (Kerto-LVL), follower, production genius, retardant and thief. The role names are revelatory of the degree of intensity and systematic character of the developments. Since the product manager-centred organisation structure had previously served the market launch phases well, the general R&D function of the company would clearly support the further development of Kerto-LVL (Kettunen 2002, 92 – 96).

5.2 Development task and goals

<u>*Investments*</u>

During the industrial stage of product development, the following essential investments were carried out:

- In 1980 an investment of EUR 1.9 million was made in the first industrial production line for Kerto-LVL, including external manufacturing facilities and premises.
- The renovation of the debarking plant and the transfer of the pilot plant unit from Punkaharju to Lohja was carried out in 1983 at a cost of EUR 0.5 million.

- The second industrial production line for Kerto-LVL, the so-called US line, along with the automation of dried veneer sorting, required an investment of EUR 4.1 million in 1986.

Because of the marketing risks involved, the start of the industrial stage was cautious. A new production line for Kerto-LVL was built at the Lohja plywood mill in 1980. It was a more sophisticated system with a higher level of automation, though its pressing area was only 2.5 times larger than the pilot plant's press. The pressing area of its single-opening press was slightly over 30 m^2, while in the typical multi-opening plywood press of the early 1980s the pressing area was 100 m^2. The production line's capacity was calculated to be about 14,000 m^3/a, based on three-shift operation five days a week with a total of 240 working days in a year. This resulted in large volumes compared to the traditional production capacity of a glulam line, taking into account that the combined production volume of the five Finnish glulam manufacturers was about 33,000 m^3/a (Lehtonen V. 2004).

As this was an external manufacturing facility, the drying capacity was increased by extending the drying length available to the existing jet dryer and by building a storage suitable for long beams and slabs at the end of the production line. The idea was to build the new production line close the old plywood mill to allow plywood manufacture to continue in conjunction with the new LVL production. When the sales of the new product would reach a sufficient level, the company would be prepared to replace plywood entirely by Kerto-LVL and the old plywood mill would be used for building additional production capacity for Kerto-LVL.

However, it became evident already in 1983 that reduced plywood manufacture at the Lohja mill was not profitable. At the same time, the Punkaharju mill wanted to reclaim the premises taken by the Kerto pilot plant line. The markets had grown enough to make it possible to shut down plywood manufacture at the Lohja unit and transfer the pilot plant line into the empty premises. This increased the nominal capacity to over 18,000 m^3/a.

Marketing in the USA created important contacts with potential companies in the industry, which were either direct or indirect competitors to Trus Joist. Trus Joist had been unwilling to sell the manufacturing technique it had developed or the product itself to these companies due to their pricing policy. Consequently, Raute, with the support of Metsäliitto, sold its first production line to the American nail plate truss manufacturer Gang-Nail Systems Inc. (GNS) in 1984. The production line's capacity was equivalent to that of the first line at Lohja. However, the goal of GNS was to build significantly larger capacity right from the start. This led to the development of the new US-line unit at Lohja in 1986, providing a capacity of 30,000 m^3/a.

The investment was based on solid long-term cooperation with GNS on the US East Coast. To minimize its tied-up capital, the company wanted a subcontractor to supply an LVL product to enable a market opening and to allow them to create demand for their own planned LVL product. In this way, a large part of the Lohja unit's production in 1984 was sold in one go to the USA . The cooperation had every chance of becoming successful, since there was no LVL capacity on the US East Coast to meet the existing demand.

As the production was expanded in 1986, there was demand for close to 80,000 m^3/a of spruce logs. The additional capacity required an increase in veneer drying capacity, which was achieved by extending the drying area for the second time. In addition, a veneer sorting line with 6 sorting boxes was installed at the end of the jet dryer. It included an automated veneer moisture measurement system and a separate sorting option for too narrow and short veneers. Kari Liski was the key person at Lohja during this broad technical development in the 1980s.

Because suitable space was not available for the technically outdated pilot plant line at the mill, and its capacity had proved too small for efficient production, a decision was made to sell it to Australia at the beginning of 1986. Also, Australia did not present an imminent danger as a competing supplier (Metsäliiton Teollisuus Oy 1985, 3-4).

Development of the production process and the product

The investment in *the second line* had brought only one additional process change the Lohja unit, i.e., the need for sorting dried veneers into different grades during the mechanized stacking process.

Due to the combined effect of developments in industrial manufacturing techniques and product characteristics, the COV in bending strength could be reduced from 15% (VTT 1981 and VTT 1980) to the level of 10% (VTT 1988). When more improvements were achieved in product's technical structure, its characteristic bending strength increased to exceed 23%. This improvement brought a direct benefit, as it could be included in the export countries' type approvals.

From its position as an equipment supplier, Raute was able to develop and simplify the production line and the manufacturing technique in such a way that the new doubled capacity did not require more floor space than the previous line. The old 1-opening hot press was modified into a 2-opening one. As a result, twice the volume was obtained with the same labour input.

Marketing organization

The product manager organisation was modified in order to assign a specific production manager. At the same time, the focus of my role as product manager was moved closer to customers, with product quality as my primary concern. Product quality assurance was thus my direct responsibility until 1985.

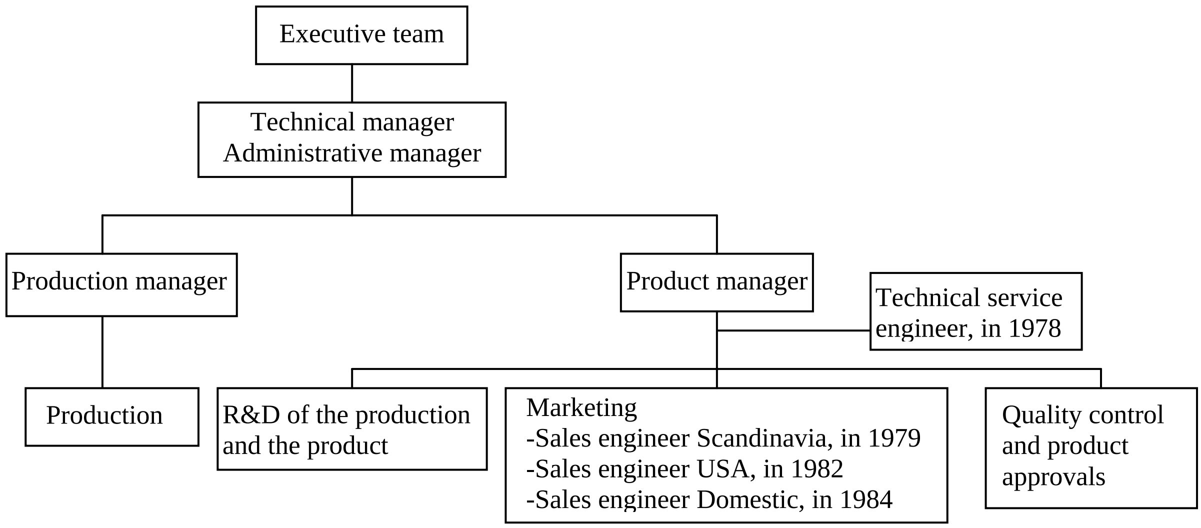


Figure 62. Product manager organisation for Kerto-LVL during the industrial stage 1981-1985.

As a product manager I moved to the Düsseldorf sales office, Finnforest GmbH, from where I continued to market and develop Kerto-LVL in close contact with the customers. In addition to the German market, Finnforest GmbH was responsible for sales in the rest of Western Europe, where France stood out as the most important individual market.

5.3 Domestic market

Marketing and product

The general use of the product as a structural post and beam in construction projects or as a component in manufactured sub-products became more established between 1981-1987. An open platform building system of the type used in North America did not exist in Finland, and every construction project was either purpose-designed on-site or modified from prefabricated units. In Finland, the product could not enter the market as a direct substitute in the same way as LVL worked in the USA.

The use of Kerto-LVL as a straight roof beam in small houses, kindergartens or schools, and as a secondary beam in halls, was initiated in 1976 and became established in the mid-1980s. This sizing system differed clearly from that used for sawn timber. In the manufacture of nail plate trusses together with Kerto-LVL, the adoption of the new sizing system took 7-8 years.

Finnish companies' exports to the Soviet Union can be seen as a domestic breakthrough in the marketing of Kerto-LVL. Oravaistalo Oy, Huurre Oy and Ekengren Oy delivered large-scale building projects in which Kerto-LVL was used as a load-bearing structure in box elemenents for roofs and floors. In practice, these companies saw Kerto-LVL as the only alternative for load-bearing structural beams, due to its advanced strength properties. At that time, all participants clearly changed their operating practices. The Kerto-unit adapted its own production to comply with new stricter tolerance levels, with exact and unnegotiable delivery deadlines, required by the prefabricated element manufacturers. These took a significant risk in starting export projects with a tighter time schedule than in previous projects. For this purpose, they invested in and developed the layouts for element production lines to achieve considerably shorter turnaround times. The risk was worth taking: the projects became a success for all three companies.

These large orders enabled the Lohja mill to manufacture the product for the first time in longer series, which in turn provided the opportunity to break in the new production technology. The gross margin was raised to zero level in 1983 and since then it has remained clearly positive. During the same year, the labour input fell below 10 h/m^3 and subsequently below 7.5 h/m^3 in 1985 (Jalasjoki et al. 1992), which was at the time significantly less than the labour input in plywood manufacture (Table 2 on page 16). When a positive *market pull* was achieved and the production technology was functioning, the most serious investment risks had been successfully warded off. Consequently, the investment in the new production line in 1986 appeared clearly more justified than the decision in 1979 to invest in the first pressing line.

Together with the Kerto team, I identified two SBAs for Kerto-LVL, with their own specific target groups and product requirements:

1. When used as *customized* straight load-bearing structural *beams* on-site, Kerto-LVL was characterized as:
   - a product which was, by its span length and cross-section, positioned between sawn timber and glulam.
   - being a simple construction, and thus price per covered area becomes the decisive factor, and
     - cutting and jointing, usually by means of nailed joints, was primarily carried out on-site.
     - amongst the product properties, only strength was utilized, in particular bending and shear strength, along with the modulus of elasticity.
     - a major part of the volume during a so-called normal year went into this segment
     - the operations were characterized as seasonal
   - delivery: large consignments were delivered directly from the mill, whilst smaller deliveries were available from Metsäliiton Mk’s distributor sites.

2. As *customized components* in elements of the prefab industry, Kerto-LVL had the following essential characteristics:
   - a stricter control of dimensional tolerances compared to the pilot plant stage
   - the demand for different types of notches and scarfs was rising constantly during the 1980s
   - the volumes in Finnish building contractors’ export projects could occasionally become rather significant, e.g. in Finnish projects to the Soviet Union in 1982 and 1985–1987; see next figure.

Volume expectations were based on those of glulam. When the volume for glulam was around 30,000 m^3/a, the conclusion was that the volume for Kerto-LVL could rise to 10,000 m^3/a. The volume estimate was based on an average 3:1 consumption ratio of primary and secondary supports in a hall building. There was the possibility of additional volume achievable through growth in terraced house construction.

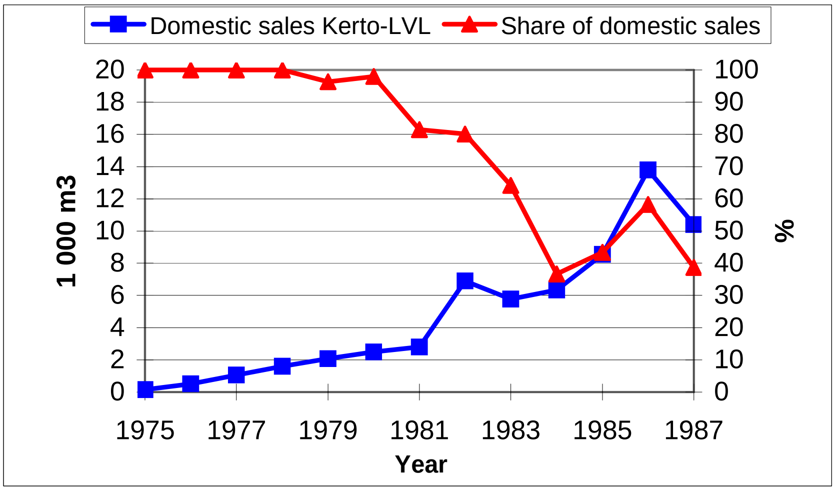


Figure 63. Progress of Kerto-LVL sales in the domestic market. Large projects to the Soviet Union account for the volume increases in 1982 and 1985-1986 (source: Finnforest).

Competing products

During the 1980s, the I-beam was still seen as a competing product. It had several suppliers, all of which left the market during this period. In 1986 only the Titaniitti fibre board web I-beam made by Pyhännän Rakennustuote (RIL 120 - 1986), used for the company's own prefabricated house production, remained in the market.

Marketing organization

Following the start-up of the industrial manufacturing phase, the domestic marketing operations were carried out by the product manager-focused organisation. Metsäliiton Mk, however, decided at the beginning of the 1980s to transfer its focus towards more technically advanced products. By 1983, Metsäliiton Mk's distributor sites had appointed 11 professionals in various parts of Finland with either a master builder or building engineer (B. Sc.) education to take charge of the technical sales operations. During negotiations it was established that the mill's direct customers would be large manufacturers of prefabricated houses, to be specified later, and project suppliers, whilst other deliveries were made via Metsäliiton Mk's distributor sites. This required them to keep certain specified standard beams in stock. This local knowledge possessed by the 18 retail distributor sites was seen as an additional advantage.

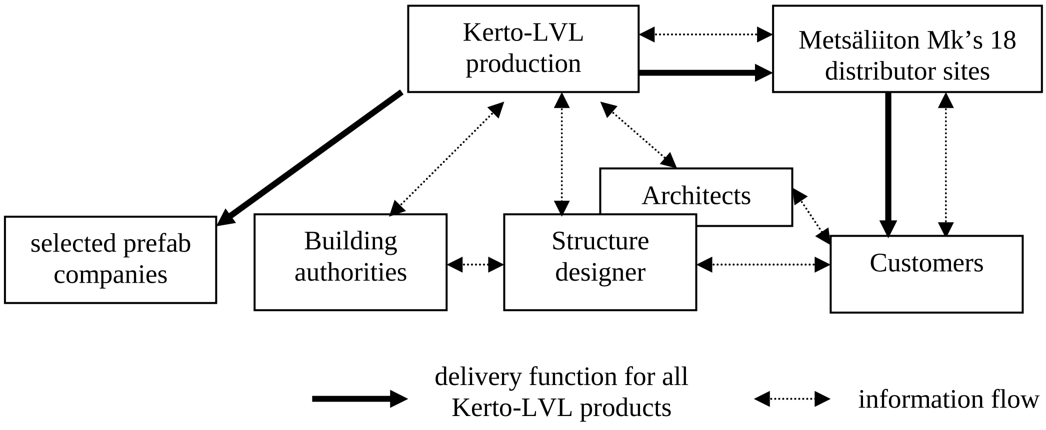


Figure 64. Kerto-LVL:n marketing organization during the industrial stage from 1981 to 1987.

Since the product manager concentrated on launching exports, the production unit needed more staff with commercial and technical backgrounds in domestic sales. In 1984, the domestic market got its own sales manager. The main focus in his activity was on promoting the new product to building authorities, architects, design agencies and technical colleges.

Type approval of Kerto-LVL in Finland

After a demanding production start-up phase, VTT, as a third party, first recommended the adaptation of the old type approval system for the new production line. During 1981, VTT carried out 154 bending tests as part of the external quality control (VTT 1982). As a result, in 1982 the bending strength could be raised to a level that was 10% higher in comparison to the pilot plant stage. The increase in bending strength was brought about by the new industrial manufacturing technique and by the product's scarf-jointed structure.

The results of the tests also provided a basis for revising all domestic type approval values. The process consisted of 4 steps and took 4 years. Altogether the process took 10 years from first official tests to establishing an appropriate technical level for Kerto-LVL, see Figure 65. The last phase of the revision process in 1984 added a new value, the so-called depth effect, cf. RIL 120 (1978, 72). The depth effect, otherwise used for glulam, was applied for beams with a height of over 300 mm. The quality of the raw material, spruce or pine, had in practice remained at the same level during the entire period.

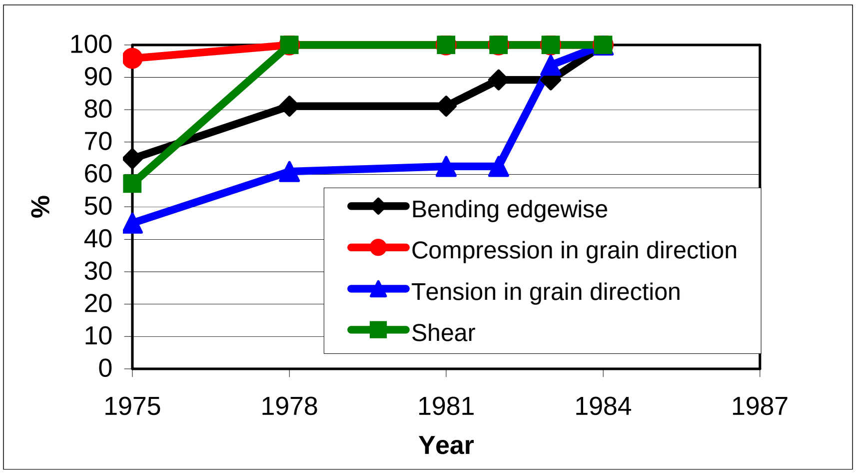


Figure 65. Relative development in the main strength properties of Kerto-LVL in the domestic market (VTT 1975a and 1975b), (Type approval 1978, 1981, 1982, 1983, 1984).

Product application development

Since the strength values for Kerto-LVL were significantly higher compared to those of other products, the R&D which had been concentrated on the product itself became more focused on end-use applications that could benefit to the maximum from the product's superior technical properties.

Our first application was the solid I-beam, which was developed in cooperation with HUT's research group, directed by Pekka Kanerva. The product was given the brand name Maxi®-I. It utilised two basic characteristics of LVL, which made it a superior construction material (*technology push* situation):

1. The continuous 1.8 m wide slab permitted large-size wooden I-beams and box beams to be structurally glued together.
2. Turning 26% of the inner veneers symmetrically crosswise perpendicular to the grain direction of the face veneers during the lay-up optimized the shear strength of the I-beam web (Penttala et al. 1987). This permitted the construction of a primary beam in which the bending and shear strength as well as the modulus of elasticity contributed equally to the beam's sizing.

The benefits of the I-beam included optimal use of wood material, a fire resistance rating of 0.5 h and suitability of the web structure for feeding through electrical and heating systems (Kairi and Lehtonen 1983).

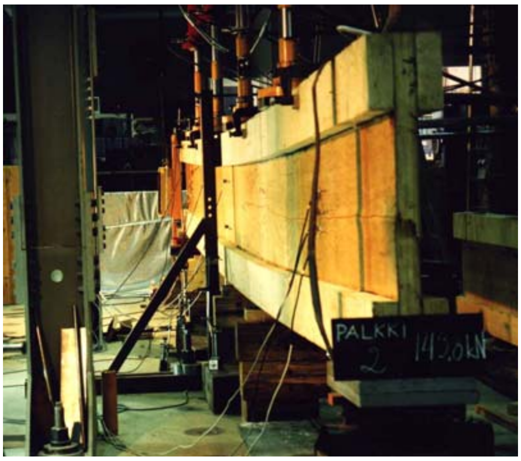


Figure 66. On the left: Maxi-I beam in bending test at HUT/TRT. The beam height was 900 mm, the span was 10.8 m and the achieved breaking load was 143.8 kN. On the right: Enlargement of Kerto-LVL unit in 1997. The span of the main beams is 26 m and spacing 6 m (source:Finnforest).

A critical drawback was that as a one-off product the Maxi I-beam did not integrate well into high-volume production. Entering in competition with glulam as a direct substitute was not seen as a good option because it would have required its own specific project set-up.

As part of the Maxi I-beam project, a first new LVL variation, Kerto®-LVL-Q, was created. As it was necessaray to distinguish the original Kerto-LVL with all the veneers longitudinally from its variations, we started to call it Kerto-LVL-S. In order to optimise the new application's structure, shear strength tests were carried out edgewise. On the basis of the results, a calculation model was devised. Three large span I-beams were tested to verify the theoretical calculations. The actual failure loads obtained from the tests were 3 – 11 % higher than the theoretical failure loads (Penttala et al. 1987, 11). A separate type approval was specified for the finished product, detailing the calculation models for the desired cross-sections.

Another application was to use the product as a truss, making use of its better strength properties compared to glulam. Kerto-LVL-S had higher bending and tensile strengths. Shear strength properties were also significantly better than those of other wood products. The compression strength and the modulus of elasticity were, however, at the same level.

Table 17. Relation of Kerto-LVL and Glulam L40 compared with some technical properties (Type approval, 1984 and RIL 120, 1983).

	Kerto-LVL/Glulam L40
Bending	1.19
Tension	1.52
Compression	1.00
Shear	1.46
Modulus of elasticity	1.18

Development of the jointing technique

The techniques used for joints were underdeveloped, which is why I chose to devise a special nailplate in cooperation with Markku Lehtonen from Metsäliitto's R&D department and Pekka Kanerva from HUT. It was patented (Kairi and Lehtonen 1986) and in Germany it received the name "Multikrallendübel" (MKD). A 10 mm thick steel plate has the same format as joint geometry. On both sides 50 mm long special nails are upset welded to the steel plate. The nail plate is pressed between two LVL members connecting on the one hand two members of LVL together and on the other the cords, diagonal and vertical sticks together. Oulu Dome was built in 1985 using this joint technique.

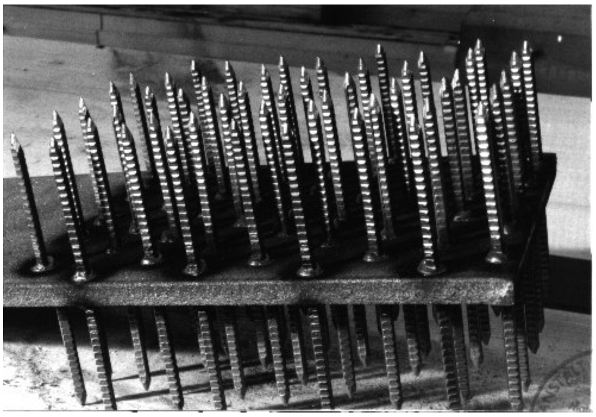



Figure 67. Multikrallendübel (MKD) as the nail plate was called later in Germany (Finnforest).

At this point, problems related to the manufacture of the joint pieces remained largely unsolved. Upset welding of nails was labour-intensive before the development of robotic techniques.

Figure 68. Oulu Dome was built in 1985. Its diameter is 115 m and the free height from the middle 24 m. The volume of primary and secondary beams was 560 m^3 and floor area 10,700 m^2, which resulted in a total wood consumption of 0.052 m^3/m^2 (Seppälä 1988).

5.4 German market

The German market was seen as technically challenging. Provided that Kerto-LVL's high strength values could be applied in engineered wood construction in Germany, the market could be seen as promising. The price level was also good and stable. In these circumstances, the aim was set to achieve an official German type approval for Kerto-LVL as a basic product, and to develop the basic product to better match demand in the German market.

<u>Marketing</u>

In 1980 a couple of VDH importers had announced their willingness to take charge of the product's marketing. They had experience mainly from the plywood business. I supported their marketing efforts, but only a few industrial component applications were found, and the construction use of the product proved too difficult. In 1981 Finnforest GmbH was in a position to start selling the product directly to carpentry industry companies and building contractors. If the importers had not been allowed to market the product, the company's plywood sales in Germany would have been affected. As found out during the pilot plant stage, the importers did not have working business relationships with the glulam factories, and therefore Finnforest GmbH had no other option but to sell its goods directly to the end users.

As a conclusion, the situation at the time was found to be similar to that in Finland, see page 90. The seller had the capacity to sell the product as a substitute for another product already in the market. If new methods of application needed to be found for the product, which required technical measures to develop the *operating system*, the importers' point of view was that this was the manufacturer's responsibility. Because this enabled the manufacturer to establish a direct relationship with the end user, the only function that the importer could assume in this type of delivery chain was the credit responsibility when invoicing for the deliveries. Carpentry firms and building contractors were not used to doing business with importers and thus treated them with reservation. Additionally, the storage of high-length items did not present problems for the carpentry firms, whereas the importers' warehouses were designed to store 1,250x2,500 mm size panels. It thus became evident to all parties that the distribution of the new product could not rely on importers.

In the early 1980s, I contacted potential partners by visiting various companies in Germany. I was assisted by the Finnforest GmbH sales personnel in arranging these visits. Almost immediately, we had to abandon the objective we had in mind during the pilot plant stage, i.e. to find just a few large customers. A new goal had to be set, which was to establish partnerships with companies that would have good capacity to make use of the product's good technical properties as components in their own products, or alternatively by developing it further into new structural *sub-products* for a chosen market segment. As a consequence of the re-defined goal, our efforts in finding potential customers were targeted at companies that were pioneers and visionaries in their own particular field.

It soon became clear to me that launching the marketing whilst I was based in Finland was not a practical option. The companies I contacted did not see this action as credible and required local technical knowledge instead. As a consequence, I was transferred as a product manager to Düsseldorf to work for Finnforest GmbH for two years. My three main tasks and responsibilities were defined as follows:

1. Bring the second round of the type approval procedure to a conclusion, so that building regulations would not obstruct sales of the product in the market.
2. Identify and attract new clients with whom it would be possible to develop new end uses on an interactive basis.
3. Raise the visibility of Kerto-LVL in order for potential clients to view it as an existing product already in the market.

In 1985 I began contacting a wide range of professionals in the field. Carpenters, wood architects, designers, training staff at technical schools, and professors received regular updates on implemented projects from the Finnforest GmbH office in Düsseldorf. Over the period of two years over 1,600 contact addresses were collected and saved in the active file.

In 1986 we made the first training trip to the production facility in Finland, with the aim of familiarising the participants with the manufacture of a new European wood product. The group consisted of a total of about 15 architects, designers, carpenters and professors, who were not all acquainted with each other prior to the trip. During the trip, the group developed into an interactive, critical group, who took an active part in evaluating the product information they were provided with. The company achieved its objective in procuring feedback, and at the same time could list the needs for additional requirements and substance deficiencies, which needed working on to make the product more customer-orientated. These trips became an annual occurrence with participants also from other countries.

Products

At the beginning of the 1980s, all LVL product applications were wood industry components, such as:

- webs in solid I-beams, used as frames in the concrete shuttering industry, see next figure.
- ladder rails, consisting of top-quality visual outer plies
- narrow and high beams, and large-size panels for exhibition stand structures
- *customized* beams, such as horizontal wind braces used in prefabricated house construction (Meickl 1985).

The first industrial component that was important in terms of volume was the web based on a 200 mm high I-beam used for concrete shuttering. The Kerto-LVL web had two critical properties, i.e. high shear strength compared to sawn timber, and high dimensional stability. Together with Gerhard Strobel from Hördener Holzwerk GmbH (HHW), we developed in 1984 the first commercial Kerto-LVL-Q product application comprising 3 cross-veneers, for concrete shuttering purposes. The web was not type approved separately, but as a complete I-beam.

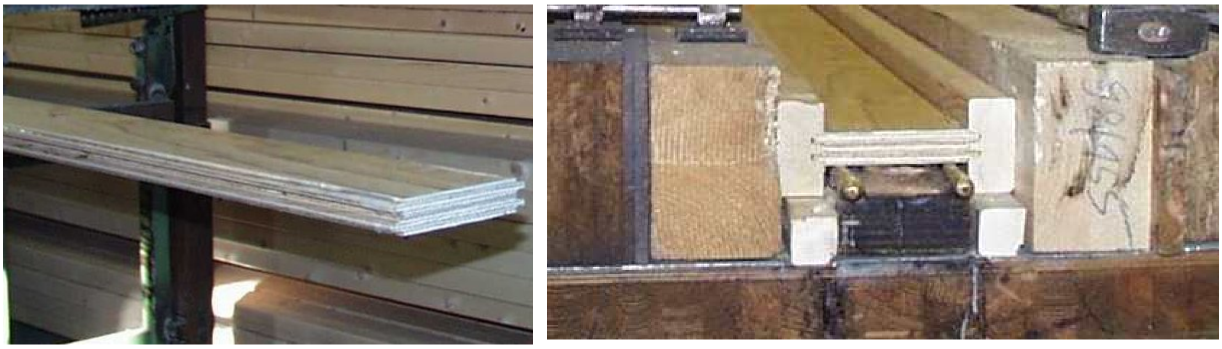


Figure 69. Kerto-LVL-Q as a web in heavy duty I-beam for concrete shuttering developed by Hördener Holzwerk GmbH (HHW) (source: Finnforest).

In the Hannover area there were several joinery firms building stands for exhibitions. One provider was willing to take the risk and start using the new product as a 33 mm thick large-sized slab, which had two cross-veneers in a similar way as plywood. Exhibition structures were not permanent structures, and therefore the authority requirements governing the product’s structural quality were less strict than those for building industry components.

However, it was not until 1984 when the first prefab house manufacturer customer was acquired. Their component was adapted to the customer specification and was essentially different to standard Kerto-LVL. They either contained cross-veneers or, with a special permit, could be re-glued into large section main supporting beams.

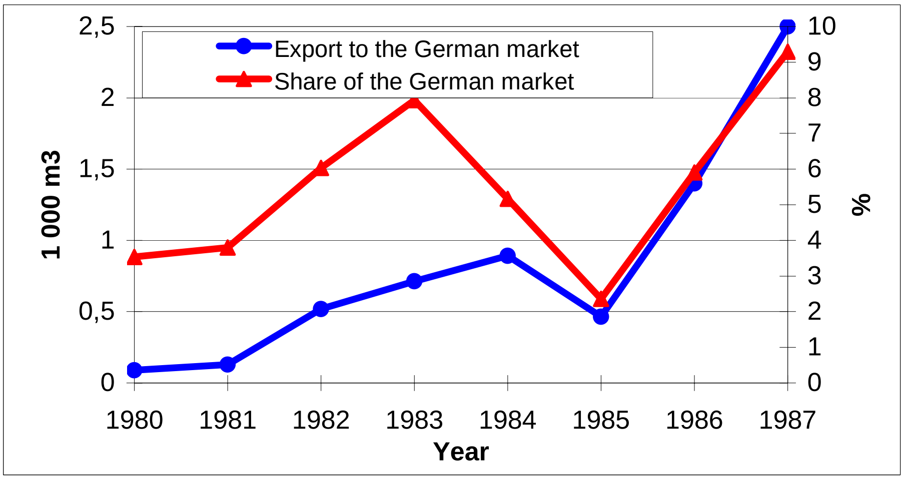


Figure 70. Kerto-LVL exports to Germany during the industrial stage. Sales and share of the total sales.

Searching for partners

In an attempt to reach a new potential customer group, I started analysing German carpentry companies specialising in wood construction and their operating practices. In Germany there were more than 8,000 relatively small size carpentry enterprises, the majority of which were concentrated in the southern states. The companies had 8 employees on average (Kabelitz 1985). In Germany the carpentry firms acted typically as subcontractors to main contractors, manufacturing or assembling components or component parts. Their operating practices could be characterized as traditional. Modern materials, such as glulam, were hardly used at all in the 1980s, because according to public opinion they were too expensive. Also, their use would have required better management of the product's technical characteristics than what most of the carpentry firms were used to (Barkmann 1997).

I was looking to establish contact with a couple of pioneering enterprises that would have been willing to start a non-conventional type of cooperation, consisting of Finnforest GmbH and the partner developing new end uses for the LVL product. After interviewing professors at technical universities and research institutes, I reached the conclusion that a pioneering company corresponding to the profile I had in mind was Merk Holzbau GmbH & Co (Merk), based in Aichach near the city of Augsburg in *southern Germany*. Its owner and managing director Karl Moser was actively involved in development projects conducted by Deutsche Gesellschaft für Holzforschung e.V. (German Association for Wood Research) (DGfH). Merk supplied demanding applications according to the specification levels required by the customer, and the design work was included in the offer. The company's turnover was at the time over EUR 10 million, and the number of employees was 150. Its annual timber consumption was between 12,000 – 16,000 m³/a (Moser 1984).

Merk was first approached with a cooperation proposal at the end of 1981. The use of the product as a large size panel was brought up in the negotiations. Product representation in southern Germany was also raised as an issue. However, the first test series was not delivered until the summer of 1984. This was followed by the first project delivery in 1985. Subsequently, Merk partly changed its strategy. The use of the product as a substitute in structural applications became a background activity whilst the main focus became developing comprehensive solutions with the integrated use of the Kerto products. It was no longer offered as a specific component, which would have been easily displaced by another manufacturer's component. The company tested the large-sized Kerto panel, which had been accorded a project-specific product type approval. The results proved promising with regard to Merk's business idea. However, the project-specific type approval procedure was laborious and time-consuming, preventing any significant volume increase.

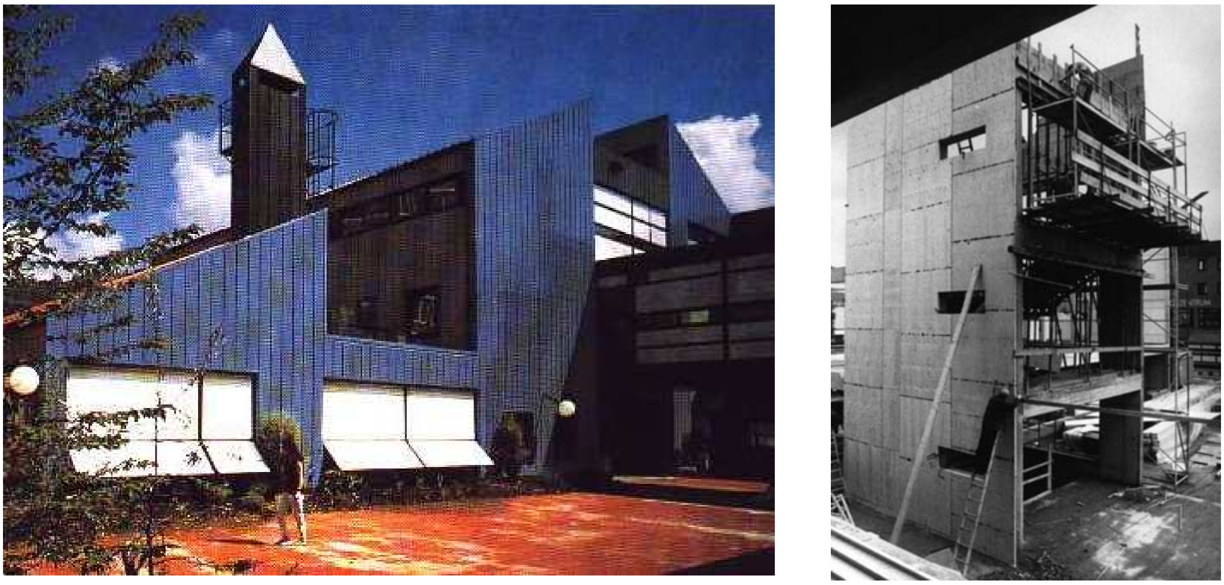


Figure 71. The complete three-storey timber skeleton structure of the Center for Technology and Economy, in Albstadt Germany. The wall diaphragms consist of Kerto-LVL-Q plate strips with a width of up to 1.8 m and length of up to 12 m, which are arranged crosswise. The project was started in autumn 1987 with special type approval by the University Karlsruhe (Blaß 1989).

The next pioneering enterprise was found in spring 1987 when contacts were established with Rolf Barkmann, the owner and managing director of Barkmann Holzbau GmbH (Barkmann). The enterprise was at that time a typical German carpentry firm. It was based in Lienen, near Osnabrück in *northwestern Germany*, with 8 employees and a rather small manufacturing facility. Its glulam consumption was approximately 500 m^3/a. The first project with Barkmann was carried out in summer 1987. Barkmann built a first storage hall with a new type of three-hinged frames constructed from Kerto-LVL, involving doweled joints.

<u>*Marketing organization*</u>

The position of importers in the marketing strategy, illustrated in Figure 10, became established towards the end of the 1981 – 1987 period. In the early stages of the marketing project, universities and building authorities were the most important contacts because of their involvement in the product type approvals, but also because their first-hand knowledge was useful in finding pioneering enterprises. The contacted enterprises, for their part, turned to building authorities to enquire about Kerto LVL's reliability as a product.

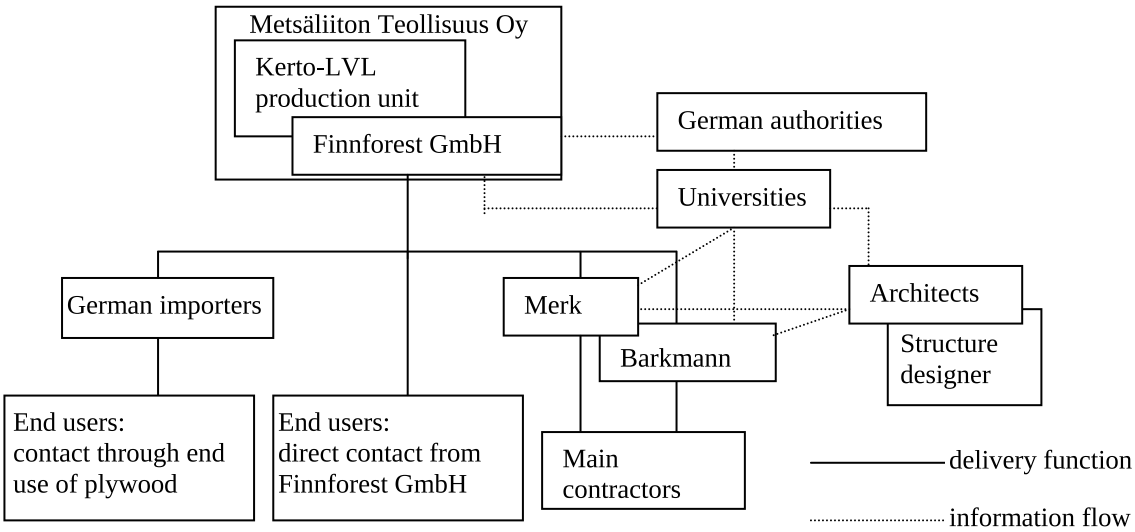


Figure 72. Organization of Kerto-LVL marketing in Germany between 1981 – 1987. Finnforest GmbH operates on an agent basis.

Type approval in Germany

During the pilot plant stage, the first Kerto-LVL type approval had been nearly finished. The final type approval, achieved in April 1981 (DIBt 1981), assigned the product as a material the highest glulam quality grade in Germany, the "Güteklasse I". The product's cross section dimensions had been limited to a beam width of 27 – 75 mm and a maximum height of 600 mm. Cross veneers were not included in the type approval.

The type approval procedure in Germany reflected the situation in the domestic market six years earlier: building authorities treated the new product with reservation and preferred to wait for possible negative feedback from the market. The Kerto team was faced with a lengthy type approval project comprising several phases.

Further development of the product

In the German market analysis, carried out at the pilot plant stage there was not an existing use for the product as a beam in the same way as in the domestic market. Potential volumes were as industrial components, and as special profile structural products for glulam factories. Therefore, I was given the task of raising the product's main strength values to a level that corresponded to its performance *as a beam*. I started this project immediately at the beginning of 1981, after it had become clear that only the “Güteklasse I” level could be achieved during the first round of the type approval procedure, see page 128. This took 5 years (DIBt 1984 and 1986).

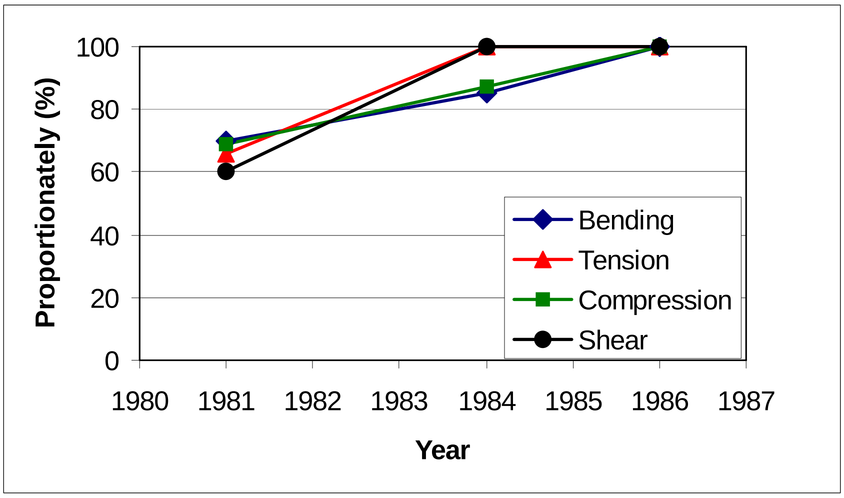


Figure 73. Development of the main strength properties of Kerto-LVL in German market (DIBt 1981, 1984 and 1986).

When the maximum height of the beam remained at H= 600 mm, raising the strength values did not present a problem. However, a problem became that DIN 1052 did not stipulate the depth effect of a bent beam. The aim was to raise the maximum beam height from 600 mm up to 900 mm, in order to allow Barkmann to supply three-hinged frames competitively. Beams from the above height category were tested, and the breaking load obtained as a result fell, as expected, significantly below the level of 100-200 mm high beams. The German building authorities finally conceded, and consequently Kerto-LVL became the first wooden support in the German market that had the depth effect included as a value in the type approval (DIBt 1986). The strength values for Kerto-LVL as a beam, still in current use, were established at the same time. When compared to German glulam, all the main strength values were significantly higher for Kerto-LVL, with the exception of the modulus of elasticity, which was at the same level.

Table 18. Relation of some technical properties of Kerto-LVL and "Güteklasse I" glulam (DIBt 1986 and DIN 1052, 1969).

	Kerto®-LVL/Glulam "Güteklasse I"
Bending	1.43
Tension	1.52
Compression	1.45
Shear	1.67
Modulus of elasticity	1.09

A similar comparison with Finnish glulam gave a narrower result. The conclusion was that the new product worked particularly well as a component in demanding truss structures and framed designs. In Germany, the jointing techniques were significantly more advanced than in Finland. Separate tests were carried out with nails, dowels, type A ring connectors and one type of nail plate at the FMPA (1983). In the test report the results were evaluated using the German method for allowed values; the *mean values* of the breaking load were divided by the calculated allowed value of the connectors. The result was required to exceed a safety factor of 3. As expected, the required safety level in joint capacity was achieved, but not exceeded. Only the results of the type A ring connector were below 3.

Because the tests carried out in Finland had indicated that the yield capacity of joints was higher with Kerto-LVL than with sawn timber, this was expected to happen also in the tests conducted by the FMPA. Therefore, tests were conducted simultaneously with sawn timber using nail joints. The safety factor obtained as a result was only 2.1, which meant that Kerto-LVL achieved a breaking load that was 38% higher in comparison to sawn timber. The fact that sawn timber did not achieve the required safety factor did not present a problem, because no negative observations had been reported regarding nailed structures that were in use in various parts of the country. In this context, the type approval for Kerto-LVL assigned the same joint capacity for nails, bolts and screws as those of sawn timber and glulam (DIBt 1986, 5), whereas effective dowels, the type A ring connector and nail plates were not included in the type approval at all.

Because the yield capacity of joints constituted the sizing property in trusses and framed structures, the beam's superior strength characteristics could not be utilised in a competitive manner. The joint standards for conventional wooden structures dated from the 1950s and

1960s. As a consequence of the new tests, their validity was called into question. The biggest issue was the difference in the quality of solid timber in the 1980s and 25 years earlier. When the DIN 1052 standard was found to be out of date in many respects, the development of a custom-made joint technique for Kerto-LVL became the only solution.

The MKD technology with nails developed in Finland provided an opportunity to substantially enhance the product's joint capacity. In cooperation with Merk, a type approval procedure for the MKD technology was initiated in Germany. The required strength tests were carried out at the University of Karlsruhe. The results of the tests clearly indicated that it was necessary to apply a reduction in the allowable strength value of the nails (Ehlbeck and Siebert 1987, app. 14), despite the fact that the allowed number of successive nails was increased only to 6. In comparison to the DIN 1052 standard, a reduction is to be applied only when the number of successive nails is above 10 (Deutsche Norm 1969, 13). The actual type approval was not achieved for MKD until four years later, in spring 1991. This delay was mainly caused by the essential differences to the existing DIN 1052 standard, described above.

Stability calculations for a narrow and high beam constituted an additional challenge. Stability calculations became an issue when there was demand for the product as a beam in three-hinged frames, cf. Figure 75. As the beam height was greater than 4 times the beam width (Meickl 1985, 1-6), the stability had to be demonstrated with a calculation model. This was a demanding and complicated task, so a decision was made to modify the beam structure by placing in the lay-up some of the veneers crosswise to the grain direction of the face veneer, which resulted in a higher stability as a beam.

In addition to its use as a beam, the market surveys indicated that several structural uses were available for the large-sized Kerto-LVL-Q panel. The decision to apply for a type approval was made in 1987, and the tests were started during the same year. A part of the veneers was laid up crosswise in a similar way as in the Maxi I-beam designed for the domestic market. For the purposes of using the product as a slab, standard structures had to be devised as a function of different thicknesses. The result was an optimized proportion of cross-veneers of 1/5. Due to moisture-induced changes, the position of the cross-veneer in the panel cross-section was specifically defined. Kerto-LVL-Q needed its own general strength values specified in the type approval. The application was submitted to DIBt at the end of 1987 and the type approval was awarded in 1990 (DIBt 1990).

5.5 France

Marketing

In France there were two companies who could potentially act as Kerto-LVL importers: The first contact was established with Copap S.A., which was a company specialising in the imports of sawn timber and further processed timber products on an agent basis. They already represented a couple of Metsäliitto Group's sawmills. The second company that was contacted was the Group's plywood importer, Rambert S.A., who acted as a buying importer.

Rambert S.A. was selected, because the managing director Gilles de Launay was willing to personally commit to opening markets for the new product right from the start. The idea was to find end uses for the product as an industrial component, and thus create a sufficient turnover to support the development of more advanced applications. After three years of continued searching, a new contact was made in Southern France; the company was Ricard S.A., and it was in the process of designing and developing its own component system for concrete framework forming. Kerto-LVL was adopted as the load-bearing structure in the new system, "La Finlandaise®", see appendix V. After a short introductory period, the volumes started increasing rapidly. The proportion of the industrial use was high in the first couple of years, and increased in 1987 to close on to 85%. The steady volumes enabled also Rambert to appoint a technical expert for the development of other new applications.

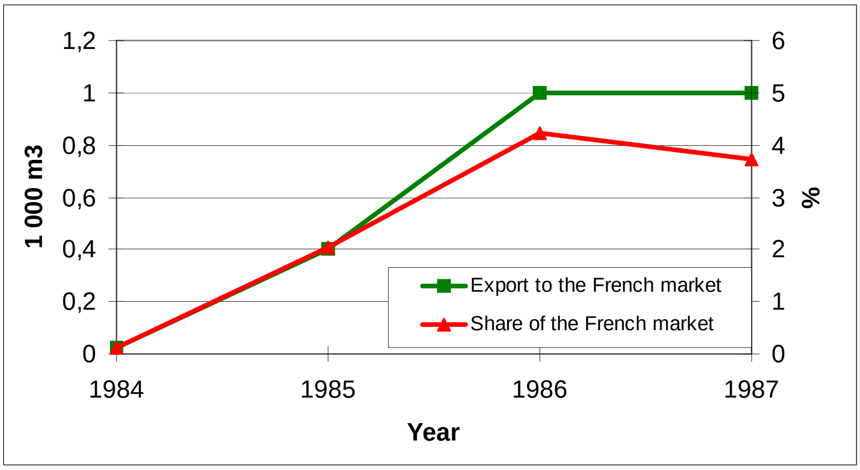


Figure 74. Development of the Kerto-LVL volume in the French market during 1981-1987.

In France the wood construction sector had the same basic structure as in Germany. However, company size was generally smaller than in Germany, i.e. approx. 3 employees (compared with 8 in Germany), whereas the number of “charpentier” enterprises in the market was high; over 17,000 (in Germany 8,000).

In France there was glulam available typically for over 12 m spans, and solid timber for a maximum of 5 m spans, but the remaining 5 - 12 m span range had no suppliers at all except for some small local I-beam producers. Within this niche there was the option of producing a new structural system. The narrow and high cross-section could be utilised particularly in hall constructions. Steel frames and trusses were the competition. Local relatively small-size metal workshops dominated the market, by using standard design layouts.

Until that date carpentry firms had attempted to compete with steel materials by producing bolted trusses and frames according to the steel structure designs. Their design and assembly were remarkably labour-intensive compared to steel structures. A major drawback was that glulam structures were more expensive than steel trusses.

Type approval in France

In France the type approval practice “l’avis technique” applies to products which significantly differ from other products in the category, such as glulam, sawn timber or plywood. It is awarded by the national research centre CSTB.

The building authorities regarded LVL as a classic product, which differed from the existing products only by its strength properties. The French authorities required only a simple procedure whereby the CTB tested the product to determine the strength value requirements in a statement, as well as to agree to ensure a continuous quality control.

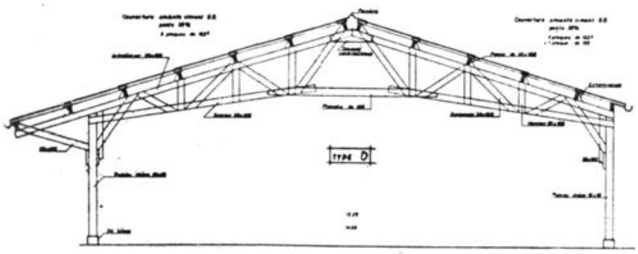


Figure 75. Barn in France. Picture on the left; Kerto-LVL frames in Clermont-Ferrand. Picture on the right; an example of the typical traditional nailed and bolted frame made with solid timber.

The application for the “avis technique” was submitted to CTB in September 1981. Since the CTB had established relations with VTT earlier, it accepted VTT’s test results as the basis for the approval. A limited number of additional tests were carried out to verify the test values. The statement including the strength values for Kerto-LVL was issued in summer 1982 (Crubile and Loiseau 1982). The strength values of Kerto-LVL were found to be significantly superior to the French glulam grade “Catégorie I”, see next table. The difference was not found to be as significant as in Germany. This difference was all the more evident when the prevailing practice amongst the French glulam factories was to offer “Catégorie II” glulam in order to avoid an external quality control.

Table 19. Relation of Kerto-LVL (Procès-Verbal Nº CØ-82-32 du Centre Technique du Bois 1982) and the French Glulam Catégorie I and II (Syndicat national Lamellé-Collé 1980, 2 - 8) with regard to some technical properties.

	Kerto-LVL/Glulam Catégorie I	Kerto-LVL/Glulam Catégorie II
Bending	1.20	1.5
Tension parallel to grain	1.20	1.5
Compression parallel to grain	1.33	1.67
Shear	2.08	2.08
Modulus of elasticity	1.01	1.13

For the purposes of quality control, a CTB representative carried out a survey at the mill, which concluded that the existing quality control agreement between VTT and the manufacturer was sufficiently comprehensive to provide quality maintenance in the French market.

The building inspection authorities had to be contacted next for the purposes of inspection of the materials used and the sizing of the structures. A preliminary ruling was awarded by an independent inspection authority, Société de Controle Technique (SOCOTEC), which is the largest amongst 4 official authorities in France. In a letter dated November 18, 1982 (Vidon 1982) SOCOTEC defines the product as a plywood and glulam derivative, and assigns a safety factor of 2.75 with regard to the breaking load which has to be taken into account when calculating the sizing values.

In France the building inspection authorities, SOCOTEC, VERITAS, CEP and APPAVE were private companies. Insurance companies were involved in the procedure in that an insurance was awarded only if the structures had received a type approval by one of the above authorities. The costs incurred were charged to the contractors.

5.6 US market

Penetrating the US market was not an immediate strategic goal after the start-up of industrial production. The executive team adopted a critical standpoint on this matter, because there was no known history of a Finnish company exporting basic softwood products to the USA. Instead, the situation had always been the other way round. Due to the variable US dollar exchange rate, it was not considered as a viable business. However, as the manager of MCL, James Gilleran was convinced of the opportunities for Kerto-LVL, I carried out the necessary preparatory measures. Kerto-LVL thus became the first European softwood-based wooden primary product to enter the US market, although marketed under a different name, Master Plank®.

The innovation process and capacity in the USA

In the US market Gang-Nail Systems, Inc. (GNS) had developed new end uses for engineered wood products. GNS was a market leader in nail plate connectors and in software used to produce the calculations for nail plates in wooden frames and trusses.

The owners of GNS wanted to retire and therefore sold the company to Redland Corporation, who specialised in roof tiles. The new CEO of GNS, Carlos Rionda, adopted a strategy which consisted of extending the operations to a wider-scale roof structures business, which would include roof tiles, see Appendix III. LVL fitted into this plan ideally. With the help of James Gilleran, I contacted the owners of GNS in 1981. These contacts led to the construction of a production facility in Wilmington on the US East Coast in 1984 and to the manufacture of LVL under the trade name Gang-Lam®. *Metsäliitto made a "Know-how" sales contract with GNS.*

Marketing

The cooperation between Metsäliitto and MCL in the US market received a boost when the industrial production line in Lohja started to operate at full capacity. In 1982 a new sales engineer was appointed for the US market.

MCL's operations were split right from the beginning between two markets. On the one hand, MCL wanted to secure its sales by becoming a sufficiently large operator in the scaffold plank business. The largest volumes, however, could be seen as coming from the structural roofing business. MCL lacked the technical know-how and a distribution network needed to become an active player in this sector. MCL's managing director started actively to look for potential allies by contacting Trus Joist's competitors. I participated in this project at the beginning, but later this task was assumed by our US sales engineer. This joint effort led to cooperation with GNS.

Trus Joist was the only LVL manufacturer in the USA to have concentrated its production and operations on the West Coast, but had also begun to market scaffold planks on the East Coast. This provided an opportunity for the Finnish Master Plank LVL manufacturer to export the product to the East Coast. Master Plank's competitive advantages included:

1. Shipping charges from Helsinki to the US East Coast were less expensive (only 12% of the product price) than land carriage across the US continent.
2. The USD/FIM exchange rate was favourable during the market launch phase.

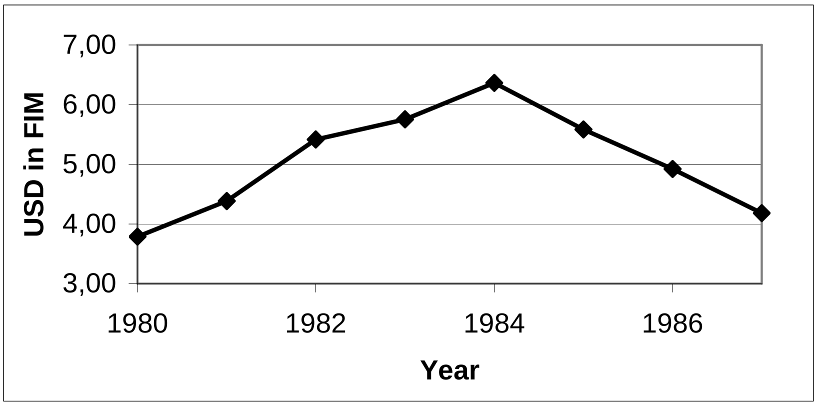


Figure 76. USD/FIM exhange rate fluctuations during the development process from 1975 to 1987 (Bank of Finland)

Until the beginning of 1984, exports to the USA relied exclusively on scaffold planks. In 1984 the first major break-through was achieved in LVL manufacture at Lohja when a large Master Plank order for scaffold planks was received, and GNS started marketing LVL for structural uses. For a while, the US market accounted for over 50% of the total sales volume, which allowed more flexibility for launch efforts in other markets.

In 1986 GNS started up its own production line and consequently limited considerably its purchases from the Lohja mill. In the same year, Redland Corporation withdrew from the wood business and sold GNS to MiTek Industries Inc., which already owned GNS's competitor Hydro-Nail. MiTek Wood Products, Inc. (MiTek) was established to continue the nail plate and Gang-Lam business.

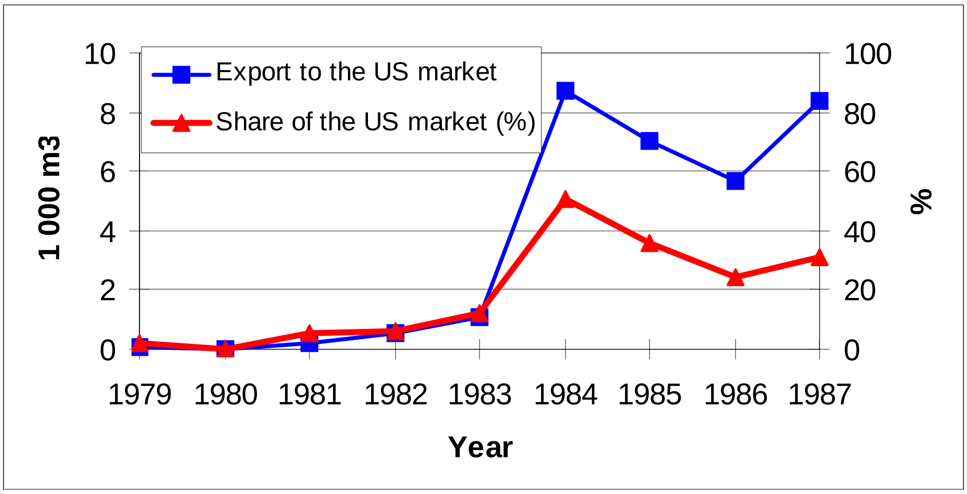


Figure 77. Sales of LVL to the US market. The product was made at Lohja under the trade names Master Plank® and Gang-Lam®.

Type approval as a scaffold plank

In the USA the use of scaffold planks was controlled by the US Department of Labor, Occupational Safety and Health Administration (OSHA). MCL ordered comparative testing in spring 1981 from North Carolina State University (Pearson 1981). The test results were sufficiently similar to the results obtained by VTT. Subsequently, in September 1981 OSHA stated that "if the laminated planking is manufactured under adequate quality control and is properly installed, used, and maintained, it would meet the intent of 29 CFR 1926.451 (a) (10)". Consequently, the authority type approval for Master Plank required only that the status of VTT be established as an authorised third party in the USA.

However, using Master Plank in shipyards required certain additional fire resistance properties. A specific fire retardant impregnation had already been devised for sawn timber. This technique permitted ignition sensitivity to be reduced, but this caused a reduction in strength properties. The tests required for this purpose were carried out for Master Plank Spruce Planks. The test report (Pearson 1982), however, confirmed that Master Plank met these requirements.

The next phase in the fire resistance type approval was the flame spread rating test, required in the ASTM E-84-81 and known as the Tunnel Test. Master Plank was confirmed to meet the specified requirements in the test report (Caldarola and Lomash 1983).

Passing these fire resistance tests successfully opened an outlet for the product in the demanding and highly esteemed scaffold market segment in shipyards.

Type approval for structural use

When the cooperation with GNS was launched, there was a need to test Master Plank in a testing laboratory in the USA. The strength property tests were carried out by the North Carolina State University. The test report (Pearson 1983) was evaluated by Sheppard Engineering, Inc. (Mansfield 1984). The most important type approvals were achieved in various parts of the USA. They had all become valid by June 1985. In Table 20, the technical data of Master Plank with those of Micro=Lam and glulam.

Table 20. Relation of Master Plank (Kerto-LVL), Micro=Lam and highest grade Glulam compared with some technical properties (MiTek Wood Products 1988, Mansfield 1984 and AITC 1985).

	Master Plank/Micro=Lam 1.8E	Master Plank/Glulam
Bending	1.00	1.17
Tension	1.24	1.86
Compression	0.89	1.09
Shear	0.88	2.78
Modulus of elasticity	1.00	1.11

The table shows that the Master Plank's tensile strength in the grain direction is significantly higher than that of Micro=Lam. The difference is possibly due to a different joint structure. The Finnish product had scarf-jointed veneers, whereas the veneers in the American product had overlapping joints. The scarf joint technique is more efficient than overlapping.

5.7 Assessment of process concepts selected in the industrial stage

Business idea and stratified product in domestic market

In Finland the following changes and improvements were made in the Kerto-LVL business idea during the industrial stage:

- The target group was significantly expanded, as instead of targeting only selected companies that were Visionaries in their own particular field, Kerto-LVL was now sold to all companies within selected end use segments (differentiation).
- Two SBAs were identified, with their own specific product requirements.
- The sales and distribution of the product were moved closer to the customers into 17 Metsäliitto Mk units. More than half of these kept standard products in stock, and consequently operated in a distribution market.
- An extensive authority approval was obtained for the product's high technical strength values.
- The product became more stratified.
- The benefit for the end user extended from a mere price advantage to a more rational operating practice.
- The marketing resourcing was increased in Finland and developed to function at a professional level.

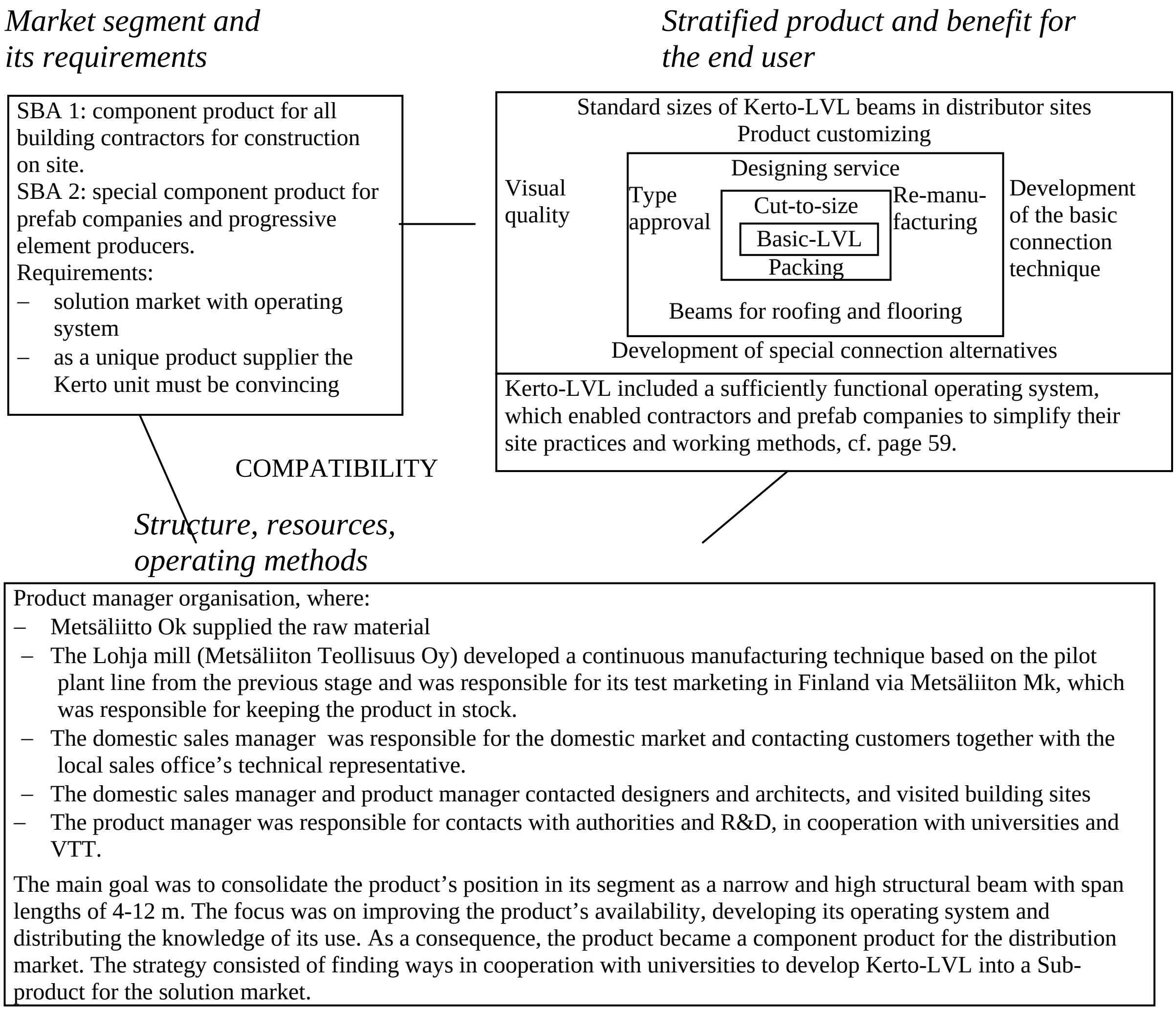


Figure 78. Product stratification increased in the domestic market during the industrial stage in 1981-1987.

Business idea in export markets

In export markets the procedures were mostly similar to those in the domestic market during the pilot plant stage. The only difference to the previous stage was that Kerto-LVL was now a technically advanced industrial product, with the following characteristics:

– The target group consisted of selected companies (*visionaries*) in selected narrow end use segments (Focused differentiation; Table 7).
– The marketing was carried out according to an SBA division in Europe and in the USA.
– In European sales and distribution the traditional operating practice based on importers was abandoned in favour of a solution market approach with integrated services.
– The product's high technical strength values did not all receive authority approval.
– The stratification exceeded the domestic level already at the beginning of the industrial stage

– The benefit for the customer grew from an immediate price advantage to overall competitive strength.
– The main customer relationships developed into partnerships by the end of the industrial stage.

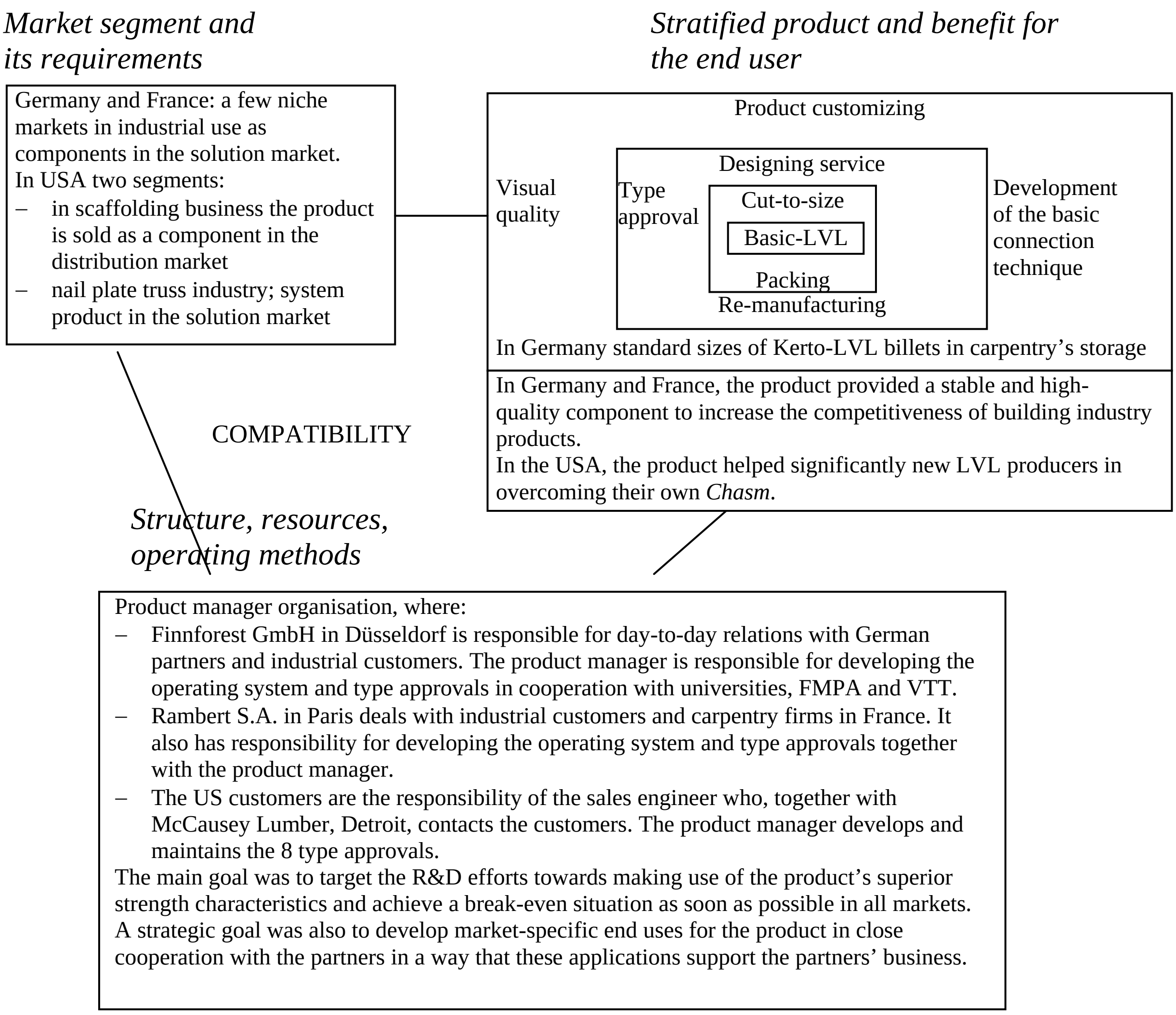


Figure 79. Kerto-LVL's product stratification had to be increased right after the launch of product exports in the industrial stage 1981-1987.

<u>*100% product and operating system*</u>

The main proof of the Kerto team's competence in mastering the *100% product* and *operating system* concepts was achieved when three Finnish export companies adopted Kerto-LVL as a load-bearing structure in their prefabricated elements. In addition, the product's *operating system* was extended in the domestic market, and at the same time the *100% product* concept was expanded with the following developments:

- Increased use as beams and, more importantly, as panels in several applications, which required the visual quality to fulfil certain minimum criteria. For this purpose, separate face veneer sorting had to be implemented, cf. Oulu Dome on page 122. This requirement had a decisive impact on the investment decision in 1986, when a sorting line was devised in the jet dryer.
- The jointing technology had to be developed at the very least to the same level as in other wood products.
- The availability of the product had to be improved by means of different intermediate storage facilities, so that the position as a unique supplier would not constitute a critical drawback for the use of the product.
- The Kerto-team succeeded in developing the operating system into such a simplified form that the designers considered it worthwhile to adhere to it.

In export markets, the Kerto team could build *100% product*s for a narrow market segment where immediate type approvals were not required; “HHW-200” and “La Finlandaise” for concrete shuttering and the “Master Plank” for scaffolding. Their use did not require a highly developed *operating system*. When their volumes achieved sufficient levels, they secured a cashflow in the German, French and US markets. This allowed the team to concentrate on type approvals for structural uses, and on designing an *operating system* for more demanding product segments.

Value chain

In Finland it was crucial to link *technology push* to *market pull*, to produce an interaction as presented in Table 21 below:

Table 21. Interaction of technology push and market pull in the domestic market.

Technology Push		Market Pull
Kerto-LVL characteristic bending strength increased: $f_{bk} = 39\ N/mm^2 \rightarrow f_{bk} = 48\ N/mm^2$ (+23%) (in the highest category ***f_{bk} = 40 N/mm^2***)	→	Export projects to Russia → long series
launch of the new production technology → positive gross margin since 1983 → labour input 10 h/m^3 → 7.5 h/m^3 → development of the operating system for Kerto-LVL	→	Kerto-LVL achieved a branded product position as a roofing material in kindergartens and schools
R&D projects on connection technology	→	Oulu-Dome project
Investment in the new production line in 1986		

The Kerto-LVL unit had achieved both the position of a *customized product* and *component* producer. Apart from a few test projects, the next, sub-product producer level was not achieved. A transfer in the *value chain* would have required a clear change in the operating practice and establishing of a re-manufacturing plant to assume the position between primary industry and main contractor. However, Metsäliitto was not prepared to do this.

The *value chain* concept played a central role in launching the exports successfully. The practice of working together with the customer to achieve a *market pull* effect could be used in a similar way in Germany, France and the USA for a selected customer group:

- In Germany, Finnforest GmbH achieved a functioning business and a positive cashflow as a result of its cooperation with HHW. As a cost-effective re-manufacturer, HHW could use Kerto-LVL to develop its own form beam into a competitive component product for a solution market dominated by large companies (Doka, Peri, Paschal etc), which operated on a turn-key basis.
- In the same way, in France, Rambert first generated a positive cash flow with the Kerto-LVL industrial component. After that, they started working to create an operating system for the French market. Rambert therefore moved from a traditional importer to *sub-product* producer (re-manufacturer), while in a way outsourcing the handling of the product and the *sub-product* installation.

- In USA, McCausey secured its cashflow with the scaffold plank business before moving on to developing technical uses for the product (page 137).

Product platform

In the 1980s, the trust and confidence in the development potential of the new product was called into question within the Metsäliitto organisation. The projects were time-consuming and nearly all products were speciality products, whose order volumes remained rather small, with the exception of the projects in the Soviet Union. In Europe, there did not seem to be any foreseeable demand for a traditional production based on large volumes, which would have enabled a long-term planning of budgets and resourcing, in a similar way as in plywood production. Also, the failure of the Silko project was still fresh in mind, and affected the confidence in new projects; see Appendix II. In this situation, the CEO Ebbe Sommar assumed a central role in offering determined support to the project, which turned out to be decisive for the continuation of the project. Jyrki Kettunen in the R&D department likewise strongly supported the Kerto-LVL development effort. As seen in chapter 5.1, the product's development role according to its market position was assigned the highest category, "leader".

Partnering

In Finland the credibility of the product was strong enough. However, the problem of having to rely on a unique supplier persisted, especially when the product was available only from Metsäliitto Mk. Therefore the mill continued to sell the products to a few main customers directly. The need for developing partner relationships in the domestic market was not considered as critical as during the pilot plant stage.

In Germany the initial challenge was to convince the industrial customers of the Kerto unit's delivery capacity. It took several test series and personal visits before they were ready to take the risk and rely on one supplier in their business development. HHW went as far as establishing a type approval, which was based uniquely on the use of Kerto-LVL. In France, Ricard opted for a similar situation with "La Finlandaise". In the industrial components segment the Kerto unit's operations were based on limited problem solving. If it succeeded well enough, a normal supplier-customer relationship could follow. It did not, however, lead to a partnering situation in which the participants would have developed things together.

To be able to develop a market-specific operating system in export markets, interactive cooperation with Merk and Barkmann in Germany and with Rambert in France became an absolute necessity. In addition to good personal relationships, it was essential to provide clear evidence of our willingness to take their ideas into account when developing the product further. In this way, our R&D supported their business directly. Without such reciprocity the build-up of confidence on a personal level would have been insufficient, as the situation could be characterised as an asymmetric technology partnership. In this way, we were following the operation strategy illustrated in Figure 7 on page 8 (see also Christensen 1995, xii Innovators Dilemma and Table 10 on page 54).

The US situation did not require similar procedures for developing an operating system as in Germany and France. Instead, the cooperation with GNS demanded a functioning partner relationship with the Kerto-LVL unit and Jim Gilleran from McCausey, to enable him to bring our ideas forward with the GNS local representatives.

When assessing the partnership from a theoretical perspective, the statement by Blomqvist (2002, 271) *"A shared vision is the most critical antecedent to individual-based fast trust in asymmetric technology partnership formation"* applies well to the relationship between each of the three partners; Merk, Barkmann and Rambert; and the Kerto-team. They all had a goal for our mutual benefit, but the partners did not yet have much to give to each other.

R&D portfolio

In the domestic market, two SBA's were identified for the product for the first time after a type approval was awarded in 1984. In exports, selling the product for industrial use in the concrete shuttering industry succeeded faster than selling it for project use within the construction industry. The contacts and knowledge from the company's own plywood industry helped in achieving this.

Within the market-product matrix, the aim was to operate actively in the known-known to Metsäliitto square by developing further the use of Kerto-LVL as a multifunctional beam. As the product's use expanded, its SBA position changed from a *customized product* in the solution market (SBA 2) to a *component product* in the distribution market (SBA 1). Simultaneously, the Kerto unit had moved to the new-new to Metsäliitto square after carrying out the development project for the solid I-beam (Maxi-I) as a *customized product* and to the new-new to the world square when the so-called MKD technology (spike plate) was introduced in the Oulu Dome project as a *customized product* (Seppälä 1988) as well. Their commercialization did not succeed, even though calculations had shown their potential. Their business operations were not compatible with the Kerto-LVL unit's own operations, which were centred on component production, but would have required instead their own re-manufacturers and a transfer towards *sub-product* business.

In the product – technology matrix Kerto-LVL was as a beam product "known to Metsäliitto". The technology was also supposed to be "known to Metsäliitto", but instead the aim in production technology development was higher and consequently Kerto-LVL occupied the "new to Metsäliitto" square.

The Kerto-LVL-Q slab was developed to function as a web in massive Maxi-I beam. Its manufacturing technique was based on the technology used for the basic LVL, but as a product its position was in the "new to the world" square (Kairi and Lehtonen 1983).

In the panel industry the Kerto-LVL unit was developing new technology together with Raute. A concrete outcome was a common project where Raute sold the LVL line equipment to GNS (USA), and Kerto-LVL provided the start-up of this new line.

Markets	Product		
	Known to Metsäliitto	New to Metsäliitto	New to the world
Known to Metsäliitto	Component product	Customized product/ Industrial	
New to Metsäliitto		Customized product/ Maxi-I	
New to the world			Customized product/ Oulu Dome

Figure 80. Kerto-LVL was positioned in the "known-known to Metsäliitto" square as a basic beam in the domestic market and in the "known-new to Metsäliitto" square as an industrial component for export. The large size I-beam acted as a customized product in the domestic market. The new jointing technique (MKD) used in Kerto-LVL was "new-new to the world".

Techno-logy	Product		
	Known to Metsäliitto	New to Metsäliitto	New to the world
Known to Metsäliitto			
New to Metsäliitto	Kerto-LVL		Kerto-LVL-Q
New to the world			

Figure 81. The position of Kerto-LVL as a beam product should have been "known to Metsäliitto", but in practice the technology was "new". The production technique of Kerto-LVL-Q was even"new to the world" during the industrial stage 1981-1987

<u>*Key technology model*</u>

During the industrial stage the key technology model was not yet known as a development tool in its own right, but without knowing it we started to look for theoretical information according to the model:

- when developing the solid Maxi-I beam together with the HUT research group in the Laboratory of Structural Engineering and Building Physics directed by Pekka Kanerva in 1983
- when searching for a new jointing technique for the Oulu-Dome structures in 1984.

As a result:

- Theory formation was from the technology point of view focused and goal-oriented to enable the new I-beam and the MKD connection to function technically.
- The development of business idea did not produce a theory which would have served as a basis for the transfer from a *component product* level to the*sub-product* level and further into the *solution market* level.

<u>*Innovation structure*</u>

The product's industrial manufacture made it possible to develop its structure by scarf-jointing consecutive veneers instead of butt-jointing (Pilot plant) or overlapping (Micro-Lam). Its quality level rose significantly when the veneer material was homogenized by mixing the veneers before gluing. Kerto-LVL was thus developed into an industrial product, and its marketing knowledge was raised to a professional level. In addition, the necessary basis was created for exporting the product.

During the industrial stage, the innovation structure reached its final level. Its functionality can, however, be criticized for focusing the interaction on *needs and changes in needs*. Throughout this stage, the Kerto unit and Raute as a *developer* had so many technical development needs that they had to be prioritized. The development of an *operating system* for marketing the product also tied up a lot of resources. For this reason, the Kerto-team, as the *utilizing* counterpart, needed more resources than had been anticipated in the strategic planning phase. From a *research* point of view, *needs and changes in needs* presented two problems: On the one hand, it was necessary to gather real-time information on the winning properties of Kerto-LVL compared to other materials, and to develop them further; on the other hand, the issue of product approvals required further research to determine which ones needed to be met. These needs became more acute when the operations became export-focused.

From a technical viewpoint:

- *Research* counterparts were the following research institutes, in addition to HUT and VTT: FMPA and Universität Karlsruhe in Germany, CTB in France and North Carolina State University in the USA.
- For the product and production, *developers* were the Kerto-LVL unit and Raute. For product applications, the Kerto-LVL unit and HUT/LSEBP assumed the developer function.
- *Utilization* and *end use* of the product were the Kerto production unit’s concerns as manufacturer of the new product and user of the new technology.
- *Business* was relevant to Raute, because in the 1980s it was the only manufacturer of LVL production equipment with considerable experience.

From the business point of view:

- *Research* responsibility was transferred from researchers to the Kerto team, when a sales engineer was appointed to complement the team.
- *Developers* were responsible for marketing in their own areas; Sales managers and Finnforest GmbH in Germany. My task as product manager was to coordinate the actions.

- *Utilizing* counterparts were the Kerto-LVL unit and Metsäliitto Mk as they stocked the product. In Germany and France there were some manufacturers of industrial components, and MCL in the USA.
- *End users* were large end users as well as building contractors and their building sites. In export markets, manufacturers of industrial special components, Merk, Barkmann and Rambert acted as end users.
- *Business* was under my responsibility, but local marketing managers and professionals from Finnforest GmbH were also involved.

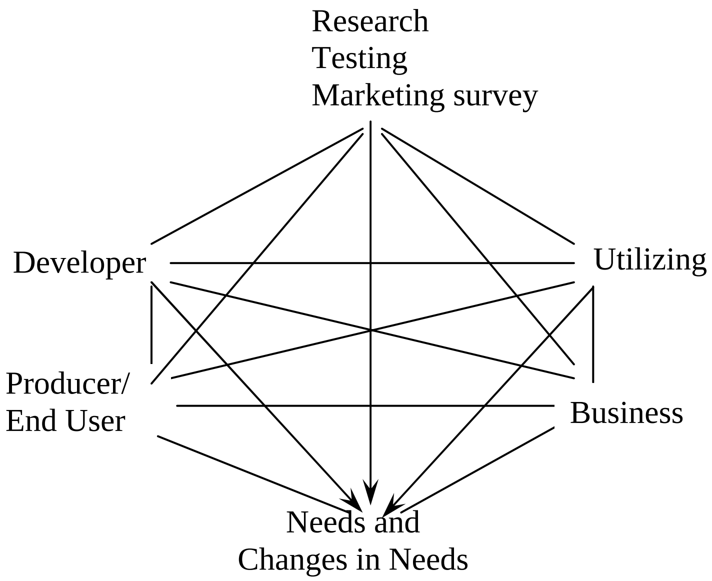


Figure 82. During the industrial stage, the innovation structure was completed, but its different operators were not in balance, because the development resources were tied up by the ”needs and changes in needs”.

6 BREAKTHROUGH OF KERTO-LVL FROM 1987 TO 1997

During the 1990s, efforts were aimed at achieving a final breakthrough for the product. During this period, type approvals were completed in the main markets. Product marketing required development of a functional *operating system* as presented in chapter 3.5.3. From 1993 onwards, there were sufficient resources available for this and the operations were professionally organised.

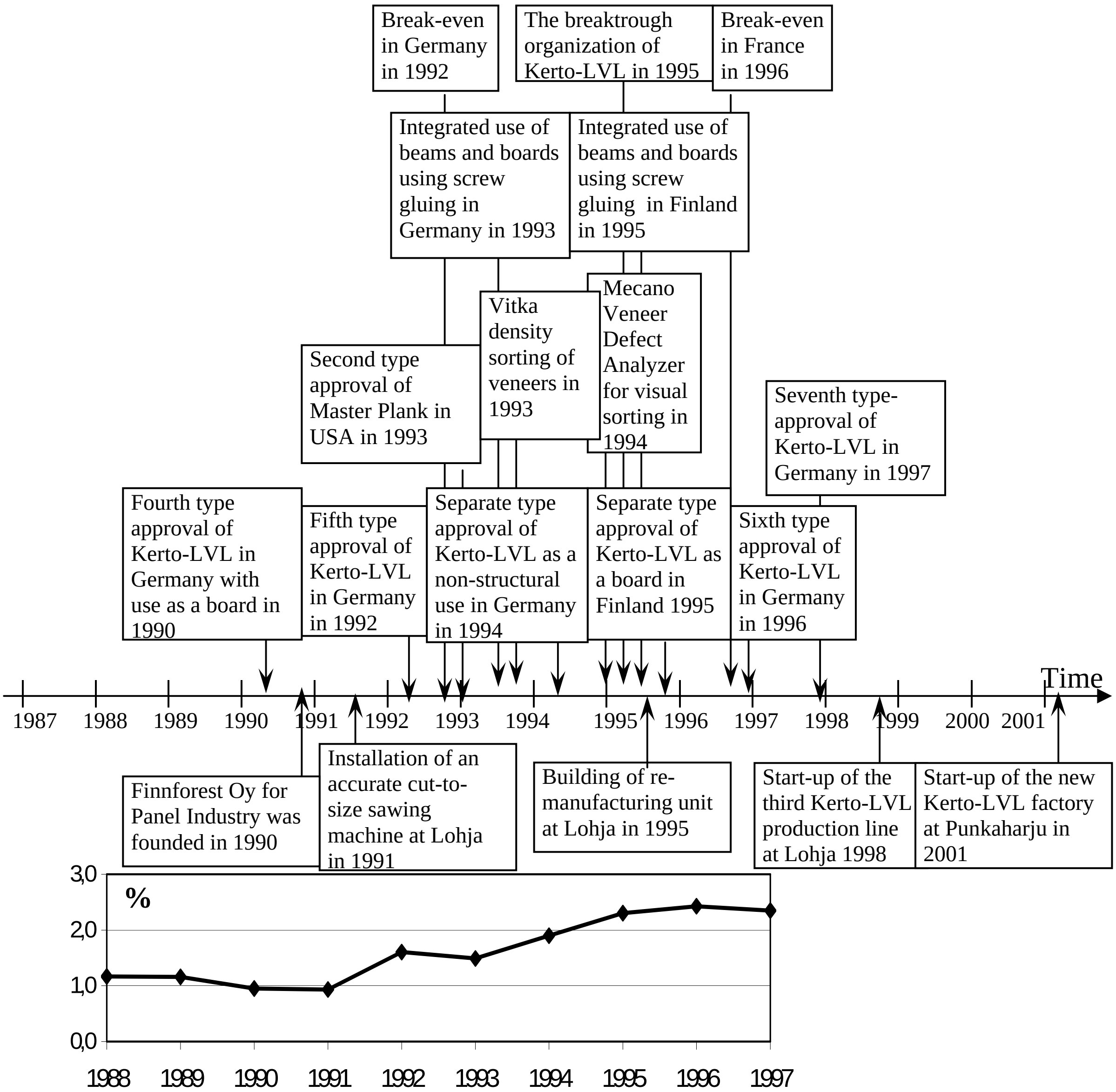


Figure 83. Main steps of Kerto-LVL development starting from 1988 until the breakthrough in 1997. At the bottom, the relative R&D cost as a percentage of Kerto-LVL turnover (source: Finnforest).

During this stage, the investment in R&D doubled in terms of relative cost. The absolute growth was even higher, when in 1997 the sums invested increased 5-fold in comparison to 1987.

The final breakthrough of the product was achieved when an investment was made in the third production line and in the modernisation of the existing production unit in spring 1997. This was followed by a reinvestment in the new Kerto-LVL factory at Punkaharju (2000) only two years after the start-up of the third line at Lohja. The result was a capacity increase of 70%. This chapter will outline the factors that led to the breakthrough.

6.1 Metsä-Serla and Finnforest as a platform for Kerto-LVL

Following the merger between Metsäliiton Teollisuus Oy and G. A. Serlachius at the beginning of 1987, the name of the company was changed to Metsä-Serla Oy. At the end of 1990, the panel industry division, including the Kerto-LVL unit, founded its own subsidiary company, Finnforest. The new company started to expand in the plywood business and entered the wholesale business (trading) by making acquisitions. The plywood production was also part of the strategic focus areas and was developed actively. In the Kerto unit we concentrated on improving production efficiency and on cost savings (Annual Report 1992, 4-9). In 1994 over half of the Finnforest’s net sales came from wholesale operations (Annual report 1994, 31). One basic strategy in the panel industry was standardising products, with the aim of ensuring large volume sales. The rate of change had become considerable compared to the previous situation. The mobility of the head office reflects this. In 1992 the office transferred from Finland to Düsseldorf, in 1996 to London and in 1998 back to Finland, to Espoo (Annual reports 1992, 1996 and 1998).

Following the founding of the new company, R&D functions were decentralised from the corporate level to product units. Consequently, the Kerto-LVL unit was independently responsible for its product development.

6.2 Development of the business

As a consequence of the strategic change, the product manager organisation was gradually transformed into a conventional line organisation. The former manager of the Serlachius IKI laminate unit was appointed mill manager for Kerto-LVL. A marketing manager was appointed in 1991: an export specialist with a degree in commerce, who had earned his credentials in consumer goods in Germany. From my position as a product manager I was transferred to production manager and R&D manager in the Kerto-LVL unit at the beginning of 1991. Two years later I was appointed full-time R&D manager for Kerto-LVL.

In April 1992, a new mill manager was appointed for the Kerto-LVL production unit and in the following year a new marketing manager. This became the key organisation, which achieved the final breakthrough for the product at the end of 1997.

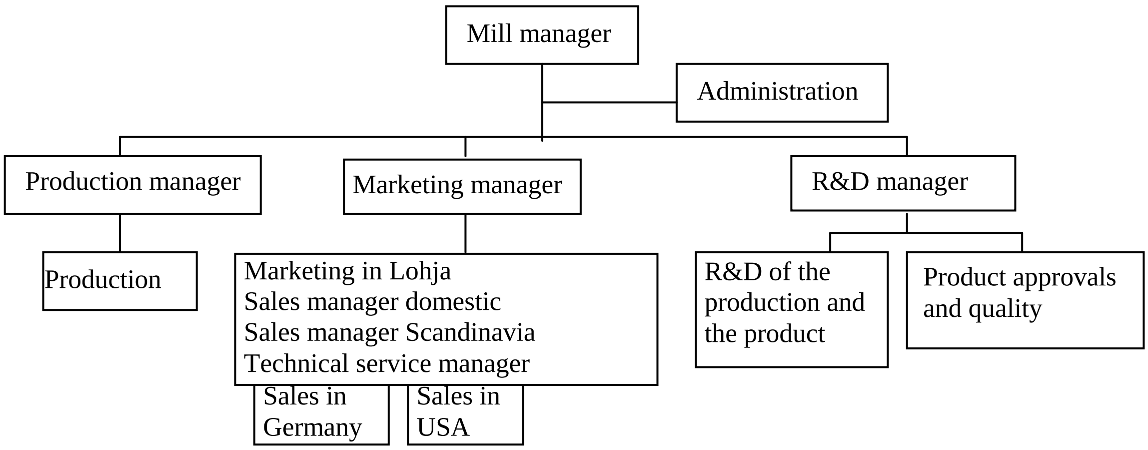


Figure 84. Kerto-LVL organisation in 1993-1997. In 1990, the US market sales manager moved from Lohja to the USA to work in the local sales office. Similarly, a German sales manager was recruited in 1995 for the German market to lead an independent sales office.

<u>*Strategies*</u>

In 1990, a first strategic action plan was devised for the Kerto-LVL business within the product line organisation. The following three main targets were identified:

- Selling the current Lohja mill's capacity (50,000 m^3/a) to European markets.
- Exploiting fully the emerging and expanding market for LVL in the USA.
- Achieving significant growth by expanding the current operations to include wooden supports, mainly glulam.

The idea was to utilize the *market pull* in the USA to achieve a full production line capacity, which meant three shifts seven days a week. The number of working days would thus come up to 355 annually. With a view to European market volume increases, the focus was on Germany.

Due to personnel changes, a new strategy was devised for 1993 – 1996. It consisted of four main objectives:

- Making a profit from using the entire capacity of the Lohja Kerto-LVL unit
- Expanding the customer-orientated product family and increasing product related services
- Improving profitability and ensuring competitiveness by maintaining the quality of operations
- Entering the US market aggressively

The main difference to the previous strategy was that it had a more marketing-orientated focus. It included strengthening the distribution network in several countries, with the aim of achieving a substantial increase in the number of distribution points and the ways in which to supply them by creating technical product concepts. The general idea was to make Kerto-LVL a branded product.

With this approach, a customer focus could be achieved by taking advantage of the results of the R&D carried out by partners with Kerto-LVL and its derivatives. Developments concerning glulam were not taken into consideration as of yet.

The strategy was next reviewed in 1996 following the appointment of a new managing director. Two strategy alternatives emerged:

- The European strategy consisted of operating within the limits of the available 60,000 m^3/a capacity, and pulling out of the US market as soon as sufficient sales volumes would be achieved in Europe.
- In the global strategy, the capacity would be increased by 40,000 m^3/a through the establishment of a third production line at the Lohja mill. By the time the new line's start-up would be completed, the US market would have re-emerged as a viable option. In other areas, this strategy alternative was similar to the previous one.

Calculations showed that the global strategy would give better results than operating in Europe alone. Also, a 80% increase in turnover would indicate a final breakthrough for Kerto-LVL within the standard products market as well as a clear willingness by the owners to invest in a spearhead product. In this strategy, the use of wood would increase by 100,000 m^3/a, which would increase the owners' stumpage earnings and bring about a higher added value for solid spruce logs as compared to sawn timber or spruce plywood. The global strategy would also offer more alternatives for developing business operations, enabling the unit to grow into a significantly sized business.

During 1996 a new manager was appointed for the company's Building Product Division, which included the Kerto-LVL unit. He was convinced of the compatibility of the Kerto-LVL global strategy with Metsäliitto Group's overall strategy. There was, however, also a different view of the investment goals within the panel industry: the previous managing director had supported the standard product strategy described in chapter 6.1. Despite the difference in opinions, the new manager began to actively promote the Kerto-LVL total investment to Finnforest's board of directors. The parent company approved this idea, and a positive decision was achieved in spring 1997.

Marketing segments

The division of the Kerto-LVL markets into segments and its impact on strategy became the subject of internal discussions from 1989 onwards. Consequently, in Finland and in Europe the markets were divided into the following segments in 1993 (adapted from Jalasjoki et al. 1992). These were given the following targets on the basis of sales promotion methods, service levels and technical support required by end use applications situated at different levels of the product chain:

- **Standard products** are delivered in truck loads to distributors/sellers either as standard-measure beams or as large-size slabs according to the possibilities available for handling the products. Larger standard length series could be dealt with by the distributors as direct deliveries from mill to customer. The use of the product is so straightforward that its preliminary sizing can be based on product manuals prepared by the supplier. These, however, need constant updating. The supplier is required to provide continuous technical support to designers and user support to builders, and by means of persistent efforts in marketing consolidate the product's position as a beam with span lengths of 4-12 m, and as a panel with its own span length and widths of 600-1,800 mm.

- **A component product's** specification can be determined according to customer or project requirements. In industrial use its development path (process) has been relatively short, i.e. a so-called ”trouble shooting” phase. Deliveries are made either via a distributor or as direct deliveries without intermediaries. When component products are used in construction, the local supplier cuts the product to size and does his own notching according to the designer's instructions. Products are delivered directly to the site. The designers do not always possess sufficient knowledge of the use of the product, which means that the supplier has to actively maintain contact with them to ensure that the product is being used competitively. Special requirements are usually placed on logistics management. The product's price level is usually significantly higher than that of a basic product, the extra price being due to cutting to dimensions, extra phases required by processing and selection of face veneers.

- **Customised sub-products** are supplied by a separate re-manufacturer, which uses Kerto-LVL as a load-bearing structure or more often as a three-hinged frame or similar main load-bearing structure. As a supplier of customised sub-products, the re-manufacturer is responsible for the design of the product, as well as its manufacture, delivery and installation. Typical end uses are frame structures in residential houses and halls. This is a growing trend in the construction industry. The customer, i.e. the re-manufacturer, wants to get the material supplier involved in designing solutions for their particular problems and in applying for authority approvals. The desired result of this cooperation is a computer-aided sizing tool, which enables the re-manufacturer to react quickly to enquiries from the market. The material supplier gets its customers engaged with the Kerto-LVL product, which is either a standard product or a custom solution, whereas the joints and the computer-based designs are always standard solutions.
- As part of an **integrated system solution,** Kerto-LVL becomes included in the entire construction process. This means that the supplier has to be capable not only of participating in projects targeted at solving individual problems, but also of co-operating in the development of the construction process, construction capacity and profitability with the integrated system supplier. In this marketing segment, the suppliers are provided with the opportunity to develop optimal solutions for their products with regard to the market perspective, and direct their investments over a longer time-scale.

The above division was established in order to make it possible for the Kerto-LVL unit as a material supplier operating in a changing market situation to react to R&D issues in an efficient and organised manner. Market segmentation would also determine to what extent responsibility for Kerto-LVL R&D should be allocated to country-specific divisions, and which part of the development that should be carried out at Lohja.

Investments, development of the production process and basic product

The most significant investments affecting production and marketing of Kerto-LVL were:

- Extension of the storage facility in autumn 1989
- Implementation of a precision saw in 1991
- "Vitka" veneer density sorting pilot unit in 1991 and production prototype in 1992
- Investment in a re-manufacturing unit in autumn 1995
- Decision on a third Kerto-LVL production line on April 2, 1997.

The extension of the storage facility was intended to be carried out during the construction of the second line, but the investment was postponed, because the storage was not immediately required to serve the US deliveries, which had been growing since 1987 and 1988 due to the implementation of standardised dimensions. As the focus moved to Europe, the order size decreased, whereas the range of dimensions increased substantially. As a consequence, there was a growing need for more space for handling and storing products.

In Western European markets, demand for large-sized slabs was rising strongly in the early 1990s, after product approval was obtained for the Kerto-LVL-Q slab. Since high dimensional precision was required for large-sized panels, a *special portal sawing unit* was installed. It provided for longitudinal, transversal and diagonal sawing up to 1.85x18 m^2 dimensions. This permitted the sawing of beams to a tapered form, re-manufacturing of notches at the ends of beams or cutting them into specified angles.

The *"Vitka" veneer density sorting unit* was installed to improve the characteristic properties of Kerto-LVL. This was clearly a development project. An essential improvement in the product's characteristic properties was achieved when an on-line surface density measuring device was developed in cooperation with the Radio Laboratory of Helsinki University of Technology (HUT). The operating principle of the device was based on the technology developed by Vainikainen et al. (1987). A licence was sold to Metriguard Inc, in the USA, which released a commercial version of the device (Logan 2000).

Thanks to the “Vitka“ technology it was possible to develop a third Kerto-LVL product application, Kerto®-LVL-T, the so-called Kerto-post. Lighter veneers and veneers with knots could be used to manufacture Kerto-posts, because the critical properties of the product for its use as a post were length stability and longitudinal compression strength. The new product met these requirements easily. Otherwise, during the last decade the product itself and the production technology did not change significantly from those developed in the 1980s.

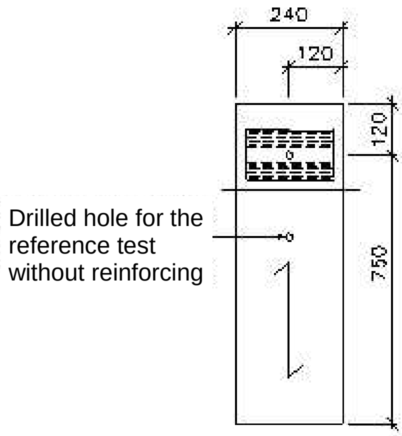
The need to process the product further into components as close as possible to the basic production was growing constantly throughout the 1990s. For this purpose, an old particleboard plant was converted into a *re-manufacturing unit*. In this unit it was possible to saw and sand large panels into dimensions with tight tolerances. For the purpose of re-gluing beams, especially large-section columns, a tailor-made gluing line was installed. A CNC controlled re-manufacturing unit was acquired to provide for dimensional machining and the manufacturing of notches and holes.

Development of product applications

When previously the target had been to exploit to the full the product’s superior technical properties, now it became more important to concentrate on immediate end-use applications. The use of *nail plates as a reinforcement* was a good way to improve the product’s weaker characteristics; in this case, the tensile strength perpendicular to the grain direction.

This joining technique had been developed in the late 1980s as a corner joint in three-hinged frames (Kevarinmäki 1995) and had been patented (Kairi 1994). Nail plates are utilised to increase the capacity of the bolt joints by improving the Kerto- LVL members embedding strength and by preventing them from failing in tensions perpendicular to the grain in the joint area. Nail plates were pressed into both surfaces of the LVL. The nominal thickness of the plates used varied between 1.1 and 2.5 mm. Once the nail plates were in place, the next manufacturing phase involved drilling holes for bolts in the unpunched area. The reason why this phase was so late in the process was that it enabled the exact location tolerances for the holes to be determined. The diameter of the holes in the LVL member was a maximum of 0.5 mm greater than the diameter of the smooth shank of the bolt.

Since one opportunity for the new application was seen in the German market, a decision was made to apply for a specific type approval in Germany. Blaß et al. (2001) have tested a 2 mm nail plate as a reinforcing element in Kerto-LVL-S. The embedding strength of the steel plate $f_{h,t,k}$ was 500 N/mm^2.



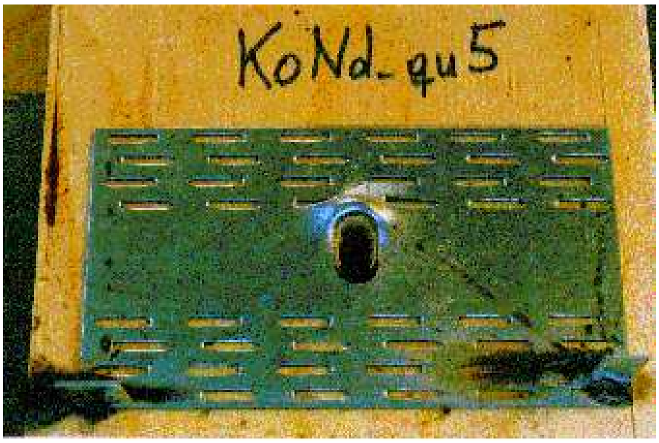
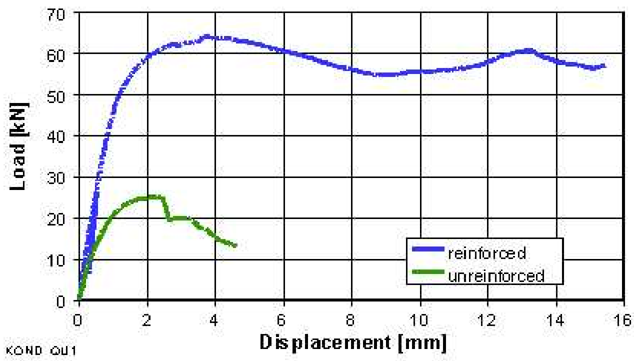


Figure 85. Tension test with reinforced and unreinforced Kerto-LVL-S, t_2 was 45 mm, two steel outer members t_1 on both sides of the Kerto-LVL-S were 20 mm, and the dowel d was 16 mm by diameter. Reinforcements were made on both sides of Kerto-LVL using a 2 mm thick MiTek nail plate (Blaß et al. 2001).



The new joining technology was mainly used in Finland. The most important project using this technology was the multi-storey house project in Ylöjärvi, see Figure 90 on page 163.

6.3 Breakthrough for Kerto-LVL

Following the changes in the organisation, as well as strongly increased demand, in spring 1997 a decision was made to modernise the production in line with the global strategy. Apart from the jet dryer and two previous production lines, all the functions and facilities were modernised, including the following improvements:

- Log handling and debarking were modernised
- The number of log soaking tanks was increased
- A new log cutting and peeling line was installed and old machines were sold

– A new jet dryer and subsequently a veneer sorting line were purchased
– A new gluing line with a capacity of 40,000 m^3/a was purchased along with handling equipment
– A new storage facility was built and the existing storage facility was extended
– A new office was built

The new manufacturing facility was working at full capacity by the end of 1998, and from then onwards the capacity of the entire Kerto-LVL business unit was increased to exceed 100,000 m^3/a.

6.4 Domestic market

Marketing and product

During the 1990s, Kerto-LVL established its position as a load-bearing structure in construction projects and as a component for the construction industry, and its distribution was extended to all main building material outlets throughout Finland. Its volumes had increased substantially by 1997, enabling a shift in its marketing from a *customized product* and *component product* level to the *standard product* level.

On the other hand, we also continued to develop the use of Kerto-LVL in the solution market in close cooperation with house and element factories and by participating in special projects. The newly started cooperation with Tapani Tuominen from SPU Systems Oy (SPU) introduced us to the *sub-product* business as SPU was at the time practically the only wood industry business operating in this area.

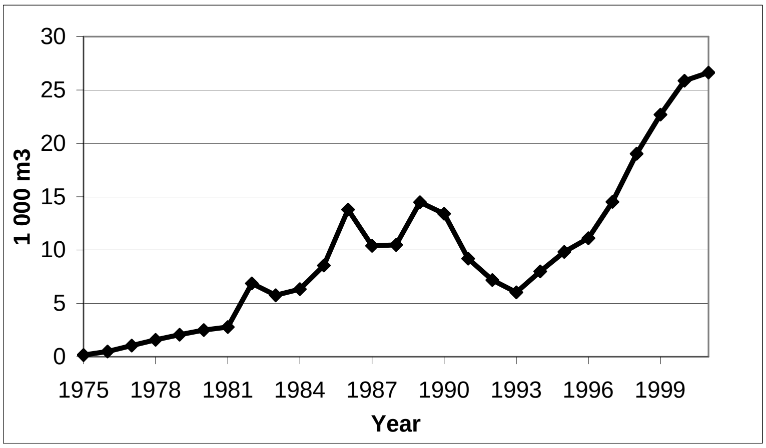


Figure 86. Domestic sales of Kerto-LVL (source: Finnforest).

In Finland the boom in the construction market in 1989 increased the volume momentarily before the economic recession in 1991. The Kerto-LVL production survived the recession in 1993 by extending the distribution network. By the end of 1997 it comprised over 100 retail outlets. Over 50 of these outlets kept a stock of standard cross sections and lengths. At the same time, there had been a substantial increase in technical services.

The following table shows the development of the segmentation on the domestic market, which had been achieved by 1997.

Table 22. Uses and segmentation of Kerto-LVL as a product by 1997 in the domestic market. The boundary between distribution and solution markets is marked with a dashed line.

Segment	Product and services	Customer	Distribution	Designing	Joints
Standard product	- Standard size Kerto-LVL-S roof beams and Kerto-LVL-T columns for one-family houses and terraced houses. -Ready cut to customer's length and size roof rafters, beams and columns for halls, terraced houses, school buildings and kindergartens.	Self-builders and SME contractors SME contractors	Local distributor's storage. Through local distributor as a factory delivery (distribution market)	Producer has calculated the essential loads and presented them as a table, as well as prepared instructions for use and installation i.e. *operating system*	Nails, bolts and screws are used. Joints are simple. Steel plates and mount hangers are used for assembly
Component product	-Ready cut-to-size components for roof rafters, Kerto-LVL-S beams and Kerto-LVL-T columns with holes, notches and machined components for halls, terraced houses, school buildings and kindergartens.	Building contractors	Via local distributor as a factory delivery (distribution market)	*Operating system* is sufficiently inclusive	Nails, bolts and screws are used. Steel plates and mount hangers are used for assembly
Customized product		Prefab companies Manufacturers of customised sub-products, Industrial customers	Selected companies direct from factory (solution market)	Producer contacts directly customer or customer's designer	
Sub-product	Main load-bearing structures; I-joists, box beams, trusses and solid columns for special projects	Nation-wide building contractors	Selected companies direct from factory (solution market)	Producer's R&D manager contacts directly customer and customer's designer	Nails, bolts, dowels, screws, gluing using particular screw gluing technique. Steel plates and mount hangers are used for assembly
Integrated system solution	Do not exist yet	-	-	-	-

Figure 87 shows an example of a project where Kerto-LVL was used as a component product. The beams were cut and both ends were beveled to customer dimensions at the mill using a CNC controlled robot.

Figure 87. Typical use of Kerto-LVL as a ready-made roof joist component in terraced houses (source Finnforest).

Competitors

There were no new I-beam manufacturers trying to enter the market, so the Titaniitti fibre web I-beam remained the only alternative product, in a similar way as in the 1980s. However, it did not compete with Kerto-LVL, since its manufacturer Pyhännän Rakennustuote used it solely as a structural component in the company's own prefabricated houses.

Instead, nail plate trusses were the competition in the component and also customised sub-products market. The shape and profile of the roof structure were based on architectural principles. The designer or the main contractor chose the lowest-cost solution. If there was a need to make use of the immediate space under the roof, Kerto-LVL was a relatively competitive beam solution, but if the under-roof space was not needed, then the nail plate truss had become a less costly option.

Organization of marketing

At the beginning of the 1990s, following the merger, the Metsä-Serla Mk (former Metsäliiton Mk, see Appendix II) distribution company was sold as a result of proprietary arrangements to another company, Starckjohann Oy. At the same time, there was pressure to extend the distribution network, so that other timber distributors on a national scale would distribute and stock standard length products. At the end of 1993, the distribution network was expanded decisively, and despite the bleak economic outlook domestic sales took an upward turn, and the product became widely accepted by the construction industry.

The domestic market sales manager operated more or less independently after the transfer to the production line organisation in the late 1980s. Starting in 1988 he was assisted by a sales engineer.

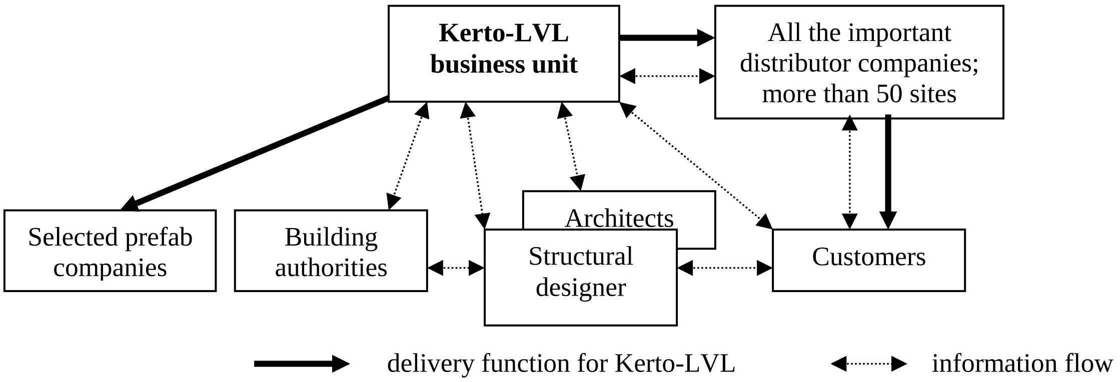


Figure 88. Domestic Kerto-LVL marketing organization since 1993 (source: Finnforest).

<u>*Type approval*</u>

Since 1984 no changes have been made in the type approval for the basic Kerto-LVL product which would have an impact on its structural dimensions (Type approvals 1989, 1994 and 1995a). In 1995 the use of Kerto-LVL-Q (Type approval 1995b) as a panel and Kerto-LVL-T (Type approval 1995c) were both awarded separate type approvals with their own technical values.

<u>*Development of the use of product solutions*</u>

The following pictures show an example of a project involving a customised sub-product. On the left is the end of a truss with grooves for two 12 mm steel plates. The steel plates connect the upper and lower flanges of a truss on top of the post (see small circle).

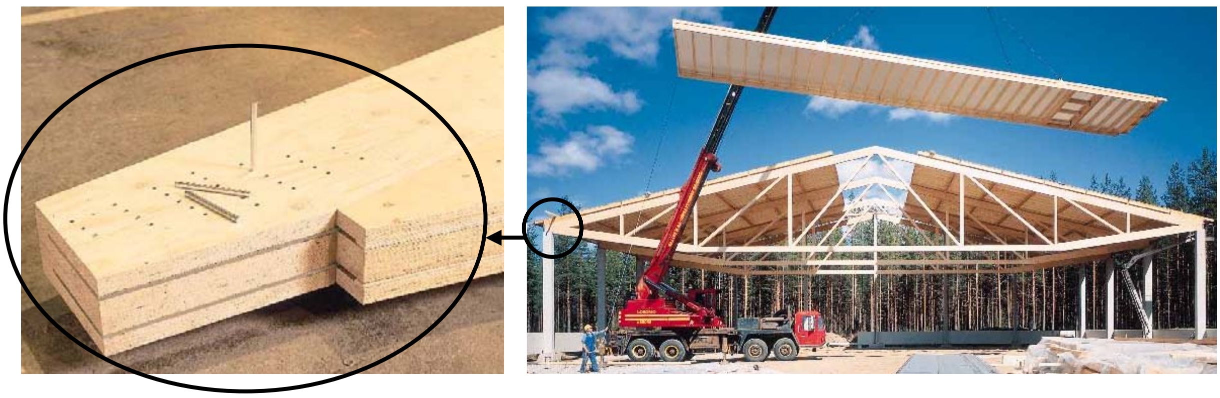


Figure 89. Kurikka Ice Stadium was built as a customised sub-product project. On the left: the end of a truss involving two 12 mm thick steel plates and ø 12 mm dowels. The truss span length was 38 m and its height 4.1 m. The large sized roof elements were supplied by SPU.

The machining grooves were filled with plywood chips to improve the fire resistance properties. Precision drilling of holes that allowed the placing of dowels through two pre-perforated steel plates required the use of an industrial CNC controlled machining unit. For logistical reasons the trusses were assembled on site 2-4 weeks after machining the holes.

In 1995 a significant pilot project was carried out by the Kerto unit in cooperation with the building company Oy Skanska Ab, HUT and TUT to develop customised sub-products for the skeleton and floor elements in multi-storey houses at the home exhibition in Ylöjärvi. There was also close cooperation with local authorities regarding building regulations. The houses were the first timber framed multi-storey houses built in Finland, and worldwide the first construction project where nail plate reinforcement was used as a jointing technique.

Figure 90. Finland's first modern timber framed multi-storey houses were built in Ylöjärvi in 1995 (source: Finnforest).

The Kerto business unit was capable of carrying out this project independently after a re-manufacturing facility was built on the premises that had previously been used by the particle board factory. The construction work was based on a post and element system, using screw glued ribbed components in floors.

The post and element system was built using steel and wood bolted joints where the joint area was reinforced with a special nail plate, see page 158.

Wooden floor elements were developed specifically for this project's requirements. Their model was the ribbed panel used by Merk, cf. Figure 93. They had long spans with a maximum of 7m. This requirement was clearly more challenging than what had been customary in the wood construction industry. Deflection of the floors constituted a critical characteristic in the design of the floor elements. A functioning solution was achieved by structurally gluing a ripped element with a Kerto-LVL-Q panel on top of Kerto-LVL-S beams.

6.5 German market

Marketing

During the 1990s Germany became, after Finland, the second largest market for Kerto-LVL in terms of volume and value. The actual breakthrough in the German market had not happened until after 1990, when a type approval had been achieved for panel use and for dowels as connectors. As a consequence of these developments, the focus moved finally from industrial customers to *sub-product* producers operating on a partnering basis, such as Merk and Barkmann.

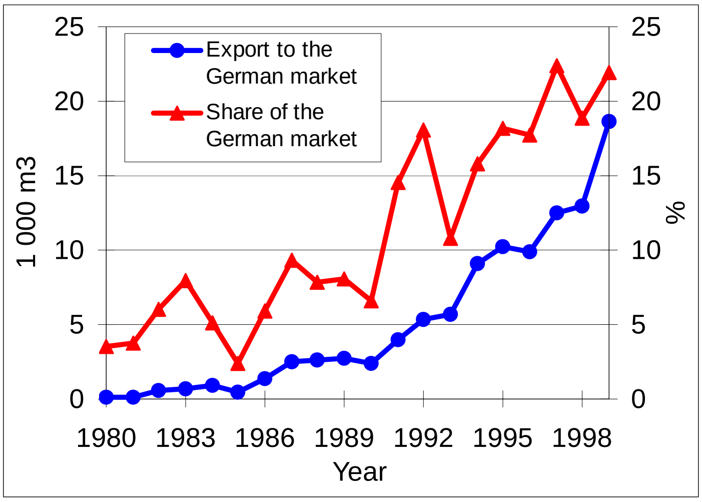


Figure 91. Kerto-LVL sales volume development in Germany (source: Finnforest).

<u>*Partnering*</u>

Both Merk and Barkmann started developing a local distribution function. Merk was faced with difficulties as it was considered too powerful an operator in the southern German market. Merk also developed more complicated solutions than Barkmann, allowing it to control its market position better, cf. figures 93 and 94. The situation improved over time. Barkmann founded Finnholz GmbH, a company specialising in buying and distributing products. Finnholz's cooperation with carpentry firms in northeastern Germany was a success right from the beginning. Both Merk and Finnholz offered technical user support for the product. This proved to be a critical requirement for selling the product.

Competitors in *southern Germany* were unable to work out how Merk's tender could be modified in order to make it suit their products, but instead had to devise or have somebody devise for them an entire plan for an alternative solution. Compared to its competitors, Merk benefited from having a highly competent and cost-effective in-house design department, with a very efficient operating method: The designers first negotiated directly with the buyer's designers at the project tender phase, and later, when the project was being implemented, served as a link to the manufacturing mill. This operating method provided the Merk team with an opportunity for cumulative learning and build-up of competence in the area of wood construction, which benefited the company in carrying out demanding construction projects.

Merk had opted for a strategy that brought success against the competition, but this also meant taking two significant risks. The first risk was related to how customers would react when they do not receive competing tenders which permit easy comparison of tender contents. This problem could be dealt with by active sales efforts. The managing director took an active role in convincing the customers of the fact that for the same price or slightly more, they would receive a higher-quality solution than stated in the original tender. The second risk was related to the fact that Merk was not in possession of a written exclusive distribution agreement for Kerto-LVL products; the cooperation was entirely based on mutual trust between individual professionals. The proposal for a written partnership agreement made by the lawyer of Metsäliitto was too complicated. Merk preferred to continue the operations on an open basis. Results proved that the above risks were worth taking, even though a volume increase did not occur until the beginning of the 1990s; see the preceding figure. The turnover had increased 2.5-fold by 1997, in a period of ten years. As a consequence of the success in partnering, Merk Holzbau GmbH became part of Finnforest through a mutually agreed acquisition in 2004.

Subsequently, Barkmann developed some hall system solutions into marketable products in cooperation with designer partner Peter Wildner. When a couple of new hall projects were won during 1988 and 1989, the decision was made to change the strategy and operating method. Barkmann's aim was to use the Kerto-LVL product to stand out amongst other carpentry companies in the area. He opted to develop hall solutions for small industries and farming on a *sub-product* basis, since Kerto-LVL started competing successfully with steel components after resistance to corrosion, in addition to load-bearing capacity, became a competitive factor. During this stage the turnover grew to EUR 7.5 million/a, with Kerto-LVL accounting for more than 40 % of the turnover.

Also Barkmann preferred to continue operations on an open basis without a written partnership agreement. As long as the cooperation would benefit all participants and a win-win situation would prevail, a legally binding agreement was not seen as a necessity. The cooperation was based on personal relationships and mutual trust between the partner's and product supplier's key personnel.

Product

During the 1990s, the Kerto-LVL-Q panel with cross veneers accounted for approximately 80% of the Kerto-LVL products used in construction and in industry. The beam use of Kerto-LVL-S was less frequent. Some companies, Barkmann in particular, looked into developing uses for Kerto-LVL-T as a post in demanding wall structures.

Some examples of niche usages for Kerto-LVL are the following:

- A Kerto-LVL billet can be split diagonally to obtain optimum sized components for portal frames with minimum wastage. In northeastern Germany there was clear demand for wood framed storage halls and riding maneges. Barkmann, supported by Finnforest GmbH developed together with its designer partner Wildner a specific operating system for a number of hall structures in 1987-1989. Subsequently, Barkmann developed the system further into a so-called *100% product*, see next figure.
- Design office Dröge and Finnforest GmbH developed together an operating system for a floor panel made from Kerto-LVL-Q with a width of 600, 900 or 1,800 mm and a length of 6-12 m. Its primary use as a structural plate was integrated with other new operational functions, including bracing the total building, fire resistance rating and a visual surface material. Due to logistical deficiencies between the building sites and the supplier, the product in this form did not reach the level of becoming a *100% product*. The distribution organisation would have required tens of partners with storage capacity, throughout the country.
- A new application was devised on the basis of panel use; ribbed elements were manufactured by gluing a Kerto-LVL-Q panel on top of Kerto-LVL-S or glulam beams. In this way it was possible to manufacture ribbed panels or box components. Merk

developed the operating system for ribbed panels into a customised sub-product and a *100% product* for themselves.

- Reinforcement of old joists in floors using Kerto-LVL is a simple and economical solution when renovating old buildings. Finnforest GmbH ordered preliminary plans for this technique, which had been thoroughly tested by Barkmann. The operating system level and the definition of a *100% product* could be achieved, see Appendix IV. However, projects were often small and dispersed across the country, which created logistical problems on top of the challenge of promoting the new usage. Therefore, as seen above with floor panels, the organisation of the product's distribution would have required having tens of partners with storage capacity, throughout the country.
- Vacuum-impregnated Kerto-LVL is a competitive material for noise barriers and external walls. Merk has actively developed a technical and commercial offering for this usage application, achieving the level of a *100% product* for the customer.

Figure 92. Warehouse in Lengerich Germany with a span of 18 m, made by Barkmann Holzbau GmbH.

Figure 93. Roof construction of School Nord in Aichach Germany made by Merk Holzbau GmbH. The roof elements are screw glued using Kerto-LVL-Q as a panel and Kerto-LVL-S as ribs with spacing of 600 mm.

Table 23. Use and segmentation of Kerto-LVL as a product from 1988 to 1997 in the German market.

Segment	Product and services	Customer	Distri-bution	Designing	Joints
Component product	-Standard size boards of Kerto-LVL-S and -Q. Quicker deliveries from distributors' warehouses when compared to delivering products from Finland. -Standard size Kerto-LVL-T posts and beams	Merk and Barkmann as Partners and their own partner companies as well. Barkmann	Partners: Merk and Finnholz Finnholz	Producer has applied for an extensive type approval from the DIBt. Partners provide technical support and practical advice	Nails, bolts and screws are used. Joints are simple. Steel plates and mount hangers are used for assembly
Customized product	Customised Kerto-LVL applications into sub-products, semi-manufactured products for further processing in partners' factories	Construction industry, prefab industry, carpentry industry, joiners providing stands for exhibitions.	Deliveries to selected companies directly from the factory or via partners' factories	Producer contacts directly with customer or customer's designer	Nails, bolts, screws and gluing are used. Steel plates and mount hangers are used for assembly
Sub-product	Partners have developed house and hall concepts. Implementation is carried out close to the customer's site and therefore delivery time does not pose a problem	Various main contractors and builders	-Partners: Merk and Finnholz	-Partners support project architects and designers -information on R&D requirements became immediately available to the producer	Nails, bolts, screws and gluing are used. Steel plates and mount hangers are used for assemblage
Integrated system solution	Noise barrier walls and glass faces of buildings	Towns and municipa-lities	Merk	Merk: one-off projects in terms of design, but with the operating method becoming standard	All kinds of connections

In Germany it was possible to build a brand image for Kerto-LVL as a modern engineered wood (EW) product, enabling a carpentry firm at SME level to position itself as an entirely modern business and to compete with steel on an equal, if not better, footing. This concept permitted Barkmann to profitably increase its turnover three-fold in 10 years.

Competitors

Three-layer board is the most significant competitor to the Kerto-LVL-Q panel. It is a structural board manufactured by gluing crosswise 3 or 5 plies of timber using light-colour glue. The raw material is side board obtained as a by-product when sawing structural timber, so-called "Kantholz". Its uses are somewhat limited by the fact that its maximum length falls between 6-9 m, depending on the manufacturer, and due to the use of multi-opening hot press.

The volumes for three-layer board were growing strongly in the late 1990s. Its benefits compared to Kerto-LVL-Q were:

- better visual appearance
- wider size board
- several manufacturers in southern Germany and in Austria, 6 of which had had their products type approved for structural use
- the price level as a standard dimension and visual basic quality board were at the same level with Kerto-LVL-Q
- the total volume as a technical product was 20,000 m^3/a, which could be easily increased to the level of 150,000 m^3/a

In contrast, Kerto-LVL-Q had the following benefits:

- higher strength values in longitudinal direction
- wider selection of board thicknesses
- non-limited board length
- vacuum impregnation of the product is possible

In addition, Trus Joist got type approval for its main product Micro-Lam as well as for I-Joist. However, they did not pose a threat to Kerto-LVL, because the operating system on which their use was based was incompatible with building methods used in Germany.

Organization

In autumn 1986 Finnforest GmbH recruited one more sales professional to join the team. The operations were decentralised in the summer of 1988 when one of the sales staff moved to the south of the country and founded Finnforest GmbH Süd. The office was a sub-tenant in Merk’s premises. The reasons for the move were:

1. Primarily, market presence; the plywood industry’s new customers were located in southern Germany.
2. Secondly, Finnforest wanted to support Merk’s supply service, when the company began to stock the product on their premises to provide cut-to-size service.

In 1992 Finnforest founded Interpan GmbH to take charge of the development of trading partnerships. The company was based in Düsseldorf, and subsequently the main office’s operations were transferred to the same premises. The Kerto-LVL business activities were also integrated with Interpan's operations. At the same time, Finnforest GmbH, which had been operating since 1976, was closed down. During the next three years, a new team was trained to take charge of the technical marketing and partnering services. As operations became profitable, Finnforest GmbH was re-established in 1995, now as a Kerto-LVL unit. In this way it was possible to restart systematic technical and commercial marketing of the product. The unit consisted of the following professionals:

– Kerto manager for Germany; sales in western and northern Germany
– Technical service manager; type approvals, customer service
– Office engineer; technical assistant
– Sales engineer south; Nürnberg
– Sales engineer east; Berlin
– Office assistant
– Office assistant

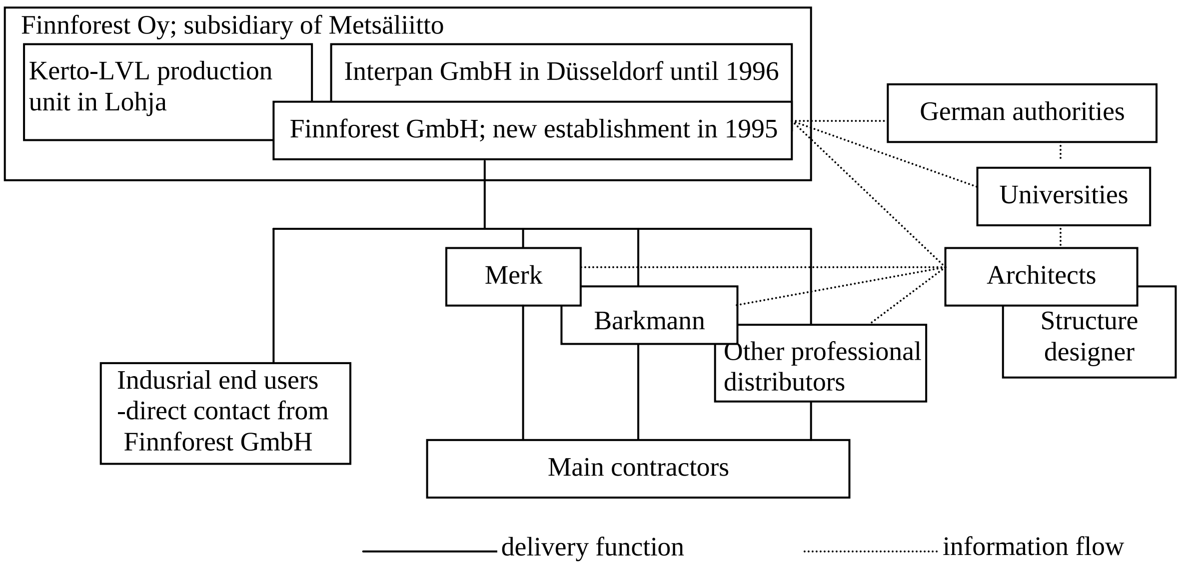


Figure 94. Kerto-LVL marketing organization in Germany in 1992-1997.

<u>*Type approval*</u>

Despite the fact that the product's strength properties according to the 1986 type approval were at current levels, there were several limitations concerning e.g. the connection technique and re-gluing. There was also pressure to use the product as a structural board, as more in-depth market analyses became available. According to German practice, every new usage or application involving the use of a type-approved product required a separate test and approval procedure for the property in question. Therefore, the next application for type approval was made to contain an extensive selection of separate properties that the partners and end users considered important for the product's use. The fourth type approval was awarded in spring 1990 (DIBt 1990) as a result of four years of persistent efforts. The use of dowels as connectors and the use of Kerto-LVL-Q as structural board got an approval for the first time. This led to a steady long-term increase in volume.

However, immediately after the fourth type approval became applicable, it was found to have inconsistencies concerning technical values in different cross-sections. An application for an additional type approval was submitted immediately and awarded two years later (DIBt 1992).

When the type approval had to be renewed in 1996, additions were related to extending the uses of the product (DIBt 1996), e.g. stipulations for curved sub-products. In 1997 characteristic values according to DIN ENV-1995-1-1 (1995 version) were added to the type approval. These were stipulated in the European Eurocode 5 (DIBt 1997). An application was made for a specific type approval for Kerto-LVL-T as a post and beam product, in a similar way as in Finland. It was awarded in 1994 (DIBt 1994).

6.6 French market

Market and products

As noted in section 5.5.1, Rambert - a private plywood product importer - was chosen as the sole representative of Kerto-LVL in France. In the late 1980s, on the basis of experience gained from the German market, together with sales engineer Patrick Moreau, I focused on (1) agricultural hall structures as the main field of application for the product. Thus, by 1990 Rambert had evolved from a traditional importer and merchant into a partner with a role in R&D. They outsourced the re-manufacturing functions to regional carpentry companies. By the end of 1991, the "Client de Kerto" sales network consisted of 12 members, see Appendix V. They were provided with a product catalogue similar to those used in the mail-order business. It contained detailed dimensional drawings for portal frames, with varying values for spacing, column height, rafter spans, inclination of the roof, wind load and roof rack load. The drawings included the dimensions of secondary joists and the wind bracing needed in halls, when its overall length varied. The carpentry firms were left with the responsibility to provide marketing for the product concept in their respective regions. The carpentry firms could offer a project including either:

– only the ready-to-assemble components, which a customer, i.e. self-builder then installed according to the instructions provided by the carpentry firm,
– framed, secondary or wind bracing structures ready assembled, with the builder taking care of the roofing and the construction of walls, or
– delivery of the entire building on a turnkey basis.

Figure 95. Warehouse in France made by Cordonnier S.A. with Kerto-LVL portal frame and Nordex I-joist (source: Finnforest).

The division into *standard products, component products and sub-products* reflected to a large extent the division used in the German market. The main difference was that Rambert had developed a (2) “Nouveau Espace” redevelopment concept, which developed into a product, which was positioned between a customised sub-product and an integrated system solution. The idea was to provide more loft-space when the roofing was installed using nail plate trusses. The projects were most often delivered according to the turn-key principle; see Appendix V.

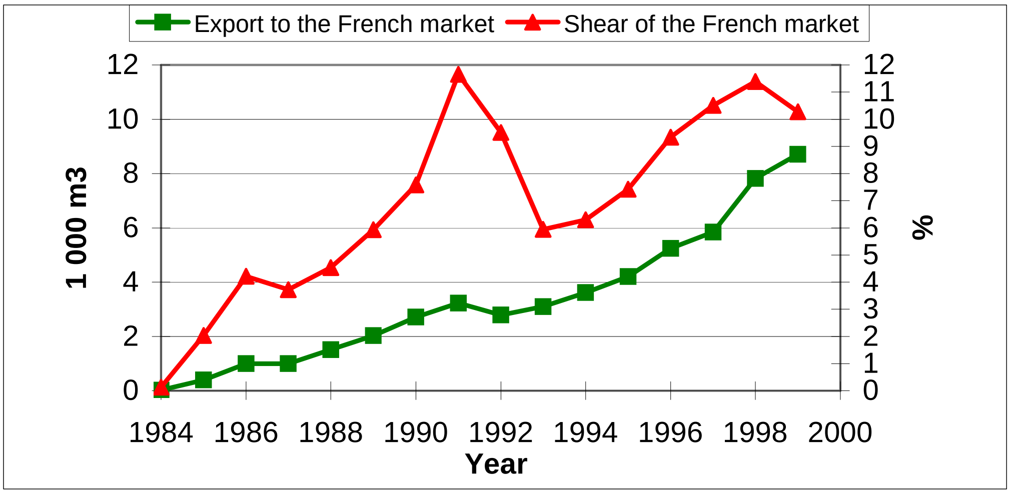


Figure 96. Development of Kerto-LVL exports to France (source:Finnforest)

<u>*Competitors*</u>

I-beams could compete in a niche with 4–6 m span lengths, between sawn timber and Kerto-LVL-S, where they faced no particular competition as a main load-bearing structure. In 1998 the annual sales volume of I-beams had increased to over 1 million lineal metres (Moreau 1999). At present Kerto-LVL-Q has no competitors in the structural panel market.

<u>*Type approval*</u>

At the beginning of the 1990s, the sizing of the product was based on the 1982 strength tests and on a statement issued by the research institute, which had changed its name into Centre Technique du Bois et de L'Ameublement (CTBA). In addition, it was stated that the strength calculations for Kerto-LVL-Q panel needed to consider the cross veneer as a so-called zero veneer, void of any bending capacity along the length of the face veneer grain direction.

For the purpose of sizing joints, wood-to-wood tensile strength tests were carried out by the CTBA with nails, bolts and dowels. The results met the requirements of the norms that were valid at the time (Crubile 1989). Additionally, it was found that the breaking loads achieved with Kerto-LVL-Q using bolt joints were 33–40% higher and using doweled joints 23–45% higher than with Kerto-LVL-S (Koponen and Kanerva 1992). Both of the above joint methods exceeded the requirements of the Eurocode 5 draft (1990) by 25–33%.

During 1996 insurance companies that had provided insurance for new buildings began to question the statements issued by the CTBA for Kerto-LVL. Their argument was the increase of volume to a level, which in their opinion required at the very least a country-specific product standard, in a similar way that had been done with sawn timber and glulam. This requirement, along with the European Construction Products Directive (CPD) and the obligation of CE marking, led to the decision to start working towards a harmonised European Norm for LVL in general.

Partnering and acquisition

The Kerto-LVL cooperation with Rambert was successful throughout the 1990s. Rambert's turnover increasing to EUR 16 million/a by 1997. However, maybe more important was the change in the company's strategy, which helped it achieve a better competitive position in the market compared with the other importers. Finnforest considered Rambert's original activity, plywood imports, as well-suited for the strategy of expanding trading partnerships. Consequently, in 1997 Rambert S.A. was acquired as part of Finnforest's European distribution network (Finnforest annual report 1997, 3).

6.7 US market

Marketing

At the beginning of the 1990s, there had been plans to enter the US market aggressively, but towards the end of the decade the market was viewed more as a strategic option to balance seasonal variations and to facilitate the start-up of new capacity. On November 1, 1990, Finnforest and MCL founded jointly an organisation of experts, Mc Causey Wood Products Inc. (MWP) based in Miami, Florida, to take charge of Master Plank technical sales operations. After various developments, the new organisation moved to MCL's premises in Detroit on April 1, 1992. At the same time, it became 100% Finnforest-owned. The connection with Georgia Pacific Inc. (GP) initiated in the late 1980s, led in 1992 to a promising supply relationship. MWP became the supplier for GP on the East Coast, whilst two other suppliers operated on the West Coast. In 1993 GP was the Kerto-LVL business unit's largest individual customer, with the US sales volume rising to over 60% of the unit's total sales. This enabled the Kerto unit to operate at full capacity, i.e. 3 shifts per day 7 days a week. Following the introduction of the new working time arrangement, the 5-shift system used in the pulp and paper industry in general had to be modified to suit the mechanical wood products industry. A significant increase in volume supported the decision to build a third production line at the Lohja mill.

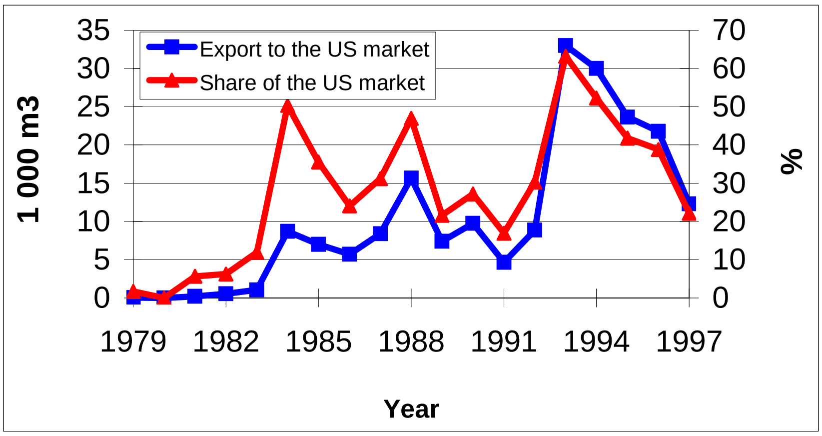


Figure 97. Master Plank (Kerto-LVL) exports from Finland to the USA during the development process from 1975 to 1997 (source: Finnforest).

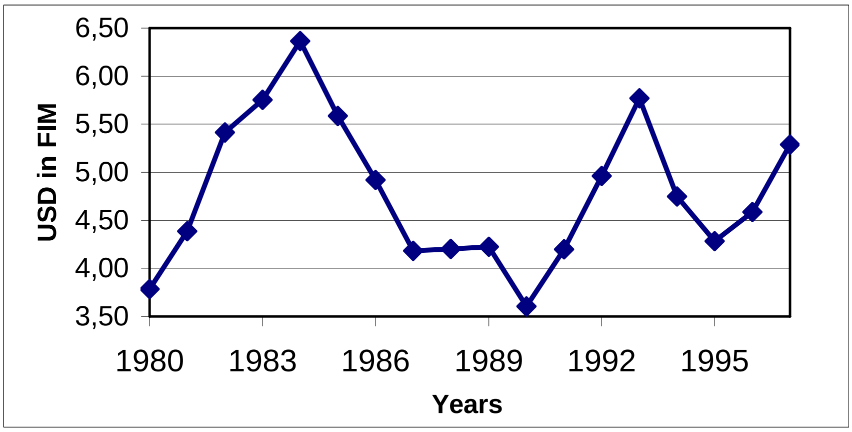


Figure 98. USD/FIM exhange rate fluctuations during the development process from 1975 to 1997 (Bank of Finland).

Competition

In the late 1980s, following the entry of several LVL manufacturers into the market, such as Tecton, American Laminators, and later Boise Cascade and Willamette, LVL developed from a *customized product* and *component* marketed to a small number of suppliers into commodity product.

In general, LVL volumes in the USA have depended on business activity in the building sector. As noted above, the main use for LVL had been for flanges in I-beams, which had accounted for over 50% of the LVL volume used in the USA. As a flange material in I-beams, LVL served as a substitute for sawn timber. The I-beam as a product was a substitute for 2”x10” solid timber. In addition, supporting beams were always needed for the top of windows and doors. Previously, steel beams had often had to be used for this purpose, cf. Appendix III.

Price was virtually the only competitive factor at the beginning of the 1990s. Trus Joist was the only producer with a different approach. Trus Joist began as the first producer to develop an “Engineered Wood Products” (EW Products) concept for the building industry. The EW products consisted of Micro=Lam LVL, TJI wooden I-shaped joists and open web trusses, including a service for architects, shop drawings and installation information for contractors. Thus, Trus Joist changed its operating method clearly towards becoming a supplier of customised *sub-products*, cf. Appendix III.

GP complemented its product range with G-P Lam® LVL, Wood I Beam™ joists and glulam beams, which meant that GP had its own EW product concept to compete with Trus Joist. However, they did not come close to Trus Joist, and their focus was on distribution markets. GP had, however, the most extensive distribution network for wooden building products in the USA, with 139 distribution centres, 22 of which were located on the East Coast at close distance from harbours.

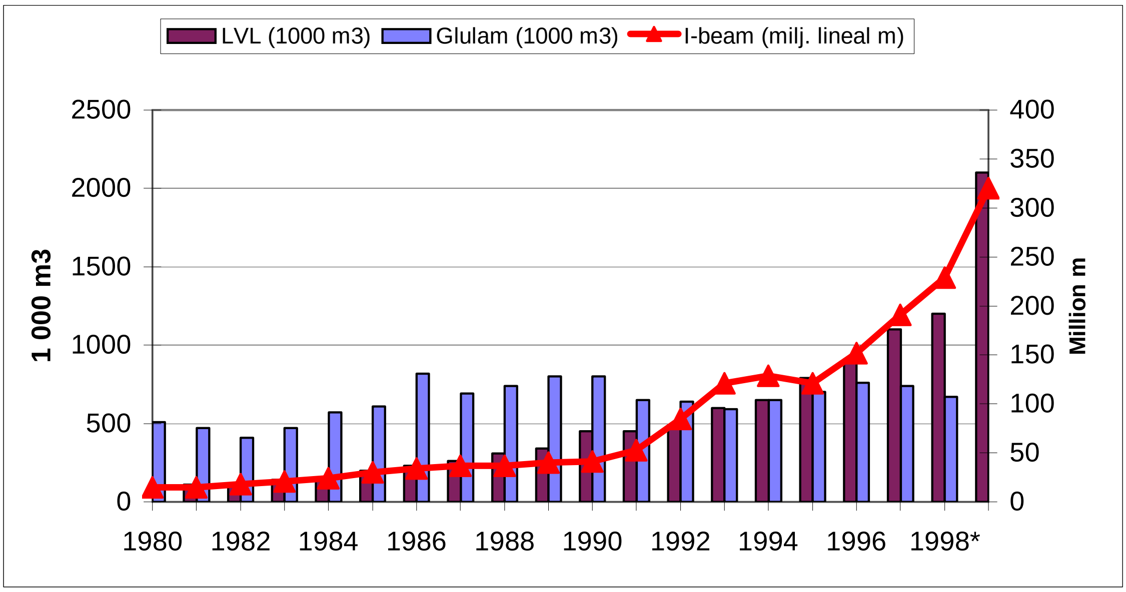


Figure 99. Development of glulam, LVL and I-beam sales in the USA (source: APA-EWP, Timwood research).

Type approval and standardization of LVL

The new ASTM-norm D5456 for LVL was published in 1993 (ASTM 1993) and revised in 1998 (ASTM 1998). The tests that were carried out assigned the same sizing values to Master Plank as in the previous norm. As a standardised product, it occupies an equal position with other similar LVL products (ICBO 1997, SBCCI 1995 and BOCA 1993).

6.8 Assessment of selected process concepts in the breakthrough stage

At the beginning of the 1990s, the Kerto-LVL unit concentrated more intensively on the panel industry than during the industrial stage. Its growth as a unit was clearly overshadowed by plywood and trading, where the strategy involved a rapid increase in standard products. During 1996 and 1997 a clear strategic change took place in Finnforest's operations, which was favourably reflected in the position of Kerto-LVL. In the product life cycle, the product could now permanently move from the *early market* stage to the *mainstream market* stage. The *Chasm* had been overcome in all areas, and in the company's strategy Kerto-LVL became a spearhead product.

During this stage the main focus was on linking R&D and business into an interactive operating practice. This enabled us to build profitable partnerships in exports.

Business idea and stratified product

The product's stratification was increased by the entry of two new product structures into the market:

- The Kerto-LVL-Q panel achieved significant demand in Finland, Germany and France. It was possible to build a specific market for the panel application. The large panel size and solid thickness could be utilised in various types of elements or in *sub-products* for the construction industry.
- Kerto-LVL-T found its own niche market in Finland and in Germany. It was a production-orientated, so-called *platform product* (Ulrich and Eppinger 1995, 20) which, after slight customisation, offered a clearly higher-quality solution than sawn timber. Therefore, Kerto-LVL and sawn timber did not serve as direct substitutes for each other (page 157).

Domestic market

Kerto-LVL expanded from *customized* and *component products* to form an entire product family. It became:

- A *standard product* for the *distribution market* in 1993, when its distribution was extended to over 50 outlets and its *operating system*, created for standard beams, was generally approved by the designers. Also, distributors became more interested in keeping the product in stock when Kerto-LVL-T entered the market.
- A *sub-product* for the *solution market*, when the Kerto team participated in special projects; e.g. in building multi-storey houses at Ylöjärvi, Finland.
- As a unique LVL product in the market, Kerto-LVL became a product leader in selected segments. At the same time, the threshold for market entry for new competing LVL manufacturers became significantly higher.

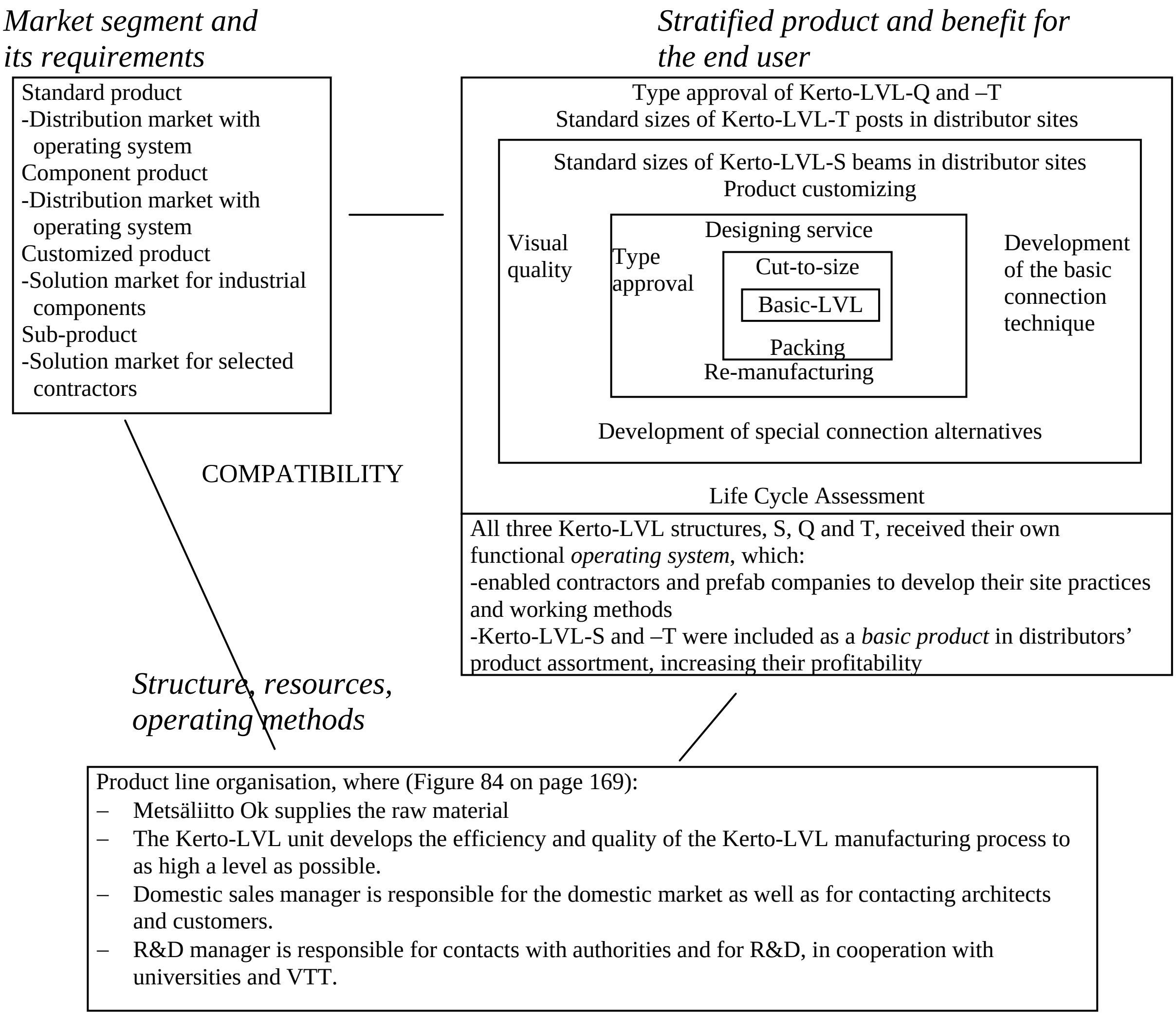


Figure 100. Kerto-LVL business idea at the domestic market breakthrough stage.

Export market

The choice made during the previous stage to enter into cooperation with selected *visionaries* was functional, but at the same time demanding. Entering the market was a slow process, which depended on customers' plans and schedules. The following table illustrates the business idea from the manufacturer's perspective (Finnforest), on the one hand, and from the partners' perspective, on the other:

Market segment and its requirements

-Re-manufacturers and EWP visionaries: Merk and Barkmann in Germany, and Rambert in France purchased and stocked the product, which was specified to their requirements.
-In Germany and France a few niche markets in industrial use as components for the solution market.
-In USA MWP supplies to:
- scaffolding business as a component for the distribution market
- EWP business on the East Coast on distribution market

Stratified product and benefit for the end user

Product customizing

Visual quality sorting

Type approval

Cut-to-size

Basic-LVL

Packing

Re-manufacturing

Development of the basic connection technique

Standard sizes of Kerto-LVL billets in partner's storage

The partners in Germany and in France developed new individual business activities on the basis of the new operating systems that they had created for themselves.
In the USA the product essentially helped new companies entering the EWP business overcome their own *Chasm*.

COMPATIBILITY

Structure, resources, operating methods

Product line organisation, where:
- Finnforest GmbH in Cologne was responsible for day-to-day relations with German partners and industrial customers. The technical service manager was responsible for developing the operating system and type approvals in cooperation with universities, FMPA and DIBt.
- Rambert S.A.in Paris dealt with industrial customers and carpentry firms in France. It also had the responsibility for developing the operating system and type approvals together with the R&D manager.
- In the USA MWP's (Finnforest Oyj) sales engineer was responsible for customer contacts.

The main goal was to target the R&D efforts towards utilising the different product variations that could be made from the basic product, on the basis of its superior strength characteristics, and as soon as possible achieve a break-even situation in Germany and in France. A strategic goal was also to develop market-specific end uses for the product in close cooperation with the partners in a way that these applications support the partners' business activity.

Figure 101. Kerto-LVL business idea from Finnforest's perspective in export markets since 1995 in the breakthrough stage.

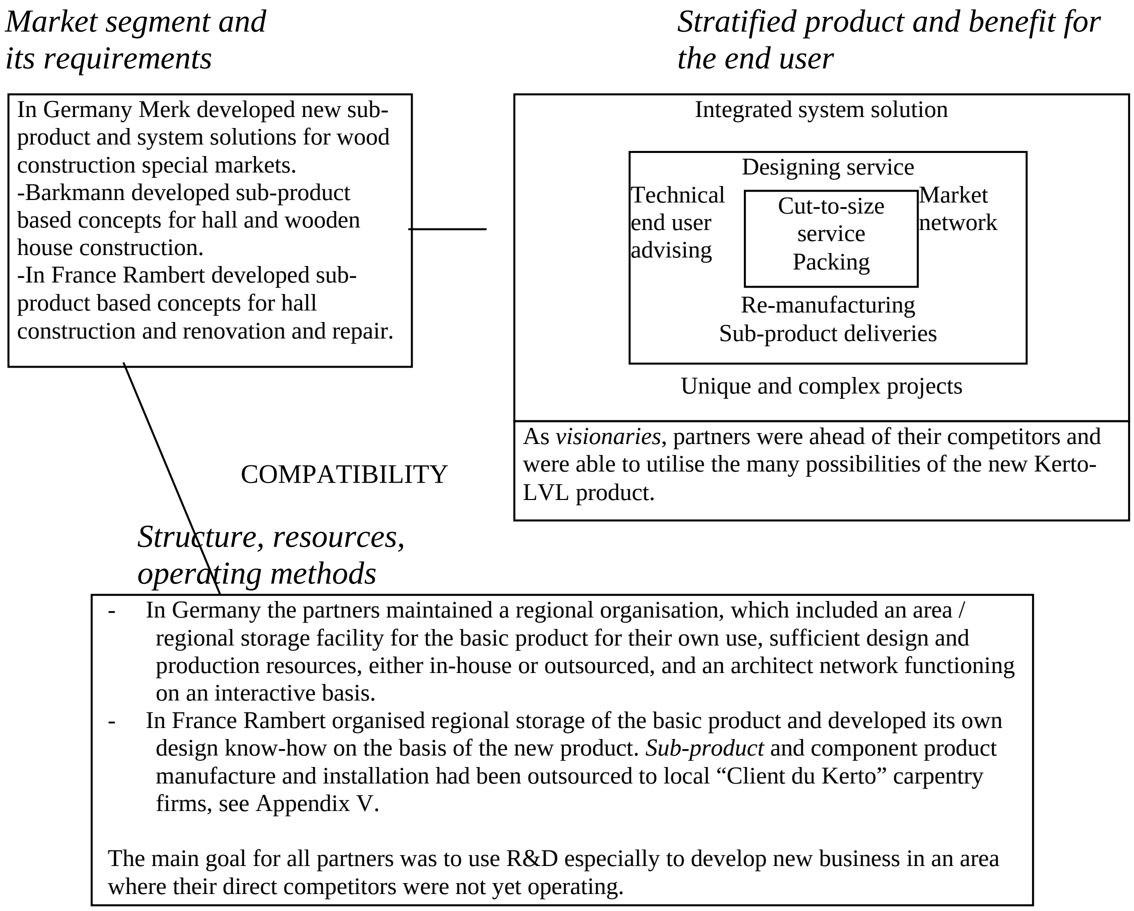


Figure 102. Kerto-LVL business idea from partners’ perspective in Germany and France during the breakthrough stage.

<u>*100% product and operating system*</u>

In Finland a sufficiently user-friendly design tool had been designed for Kerto-LVL, i.e. the *operating system*, and it was published in the sector manuals (RIL 144-1983, 180; RIL 162-1987, 221-224 and RIL 120-1991, 150). From the designers’ and building contractors’ point of view, Kerto-LVL proved to be a product which was technically as easy to use as a load-bearing structural beam such as traditional sawn timber or glulam. The only difference was the specific span range. As the product family expanded to include the Kerto-LVL-Q panel and a slender Kerto-LVL-T post, designers accepted their *operating system*s quickly as extensions to the beam product’s systems.

Even though Kerto-LVL had only one supplier, the problem with delivery times caused by seasonal variations had been satisfactorily resolved during 1993 as a result of cooperation with several distribution companies. They kept Kerto-LVL in stock as a *standard product* in their premises across Finland, making it a *100% product*.

In Germany our partners, acting as *visionaries*, could use Kerto-LVL as a new product before it had become a *100% product* for the local carpentry companies. They completed it to suit their needs, allowing them to develop new business opportunities on the basis of the characteristics of Kerto-LVL. When operating as distributors in their area, they also provided the necessary technical guidance, turning Kerto-LVL into a *100% product* for the local carpentry companies. As a result of joint efforts, the product could be cost-effectively developed for the *distribution market* on a win-win basis, and the *value chain* concept could be refined to eliminate any “rejection” in the export market.

In France Rambert, as our *visionary* partner, managed to develop for itself in a couple of years a *sub-product* for the *solution market*, providing the local carpentry companies with a more advanced business. The resulting hall concept, including an *operating system*, thus became a *100% product* for the local companies. The volumes showed good growth throughout the 1990s.

Value chain

In Finland, the Kerto-LVL unit’s business was still concentrated on the two lowest levels of the *value chain*, i.e. those of a basic material and component supplier. A re-manufacturing hall would have provided a reasonable opportunity to develop *sub-product* manufacture. However, it was considered to interfere too much with the firmly established production process. The hall was used in Finland to some extent in large experimental building projects. A decision was taken instead to operate in *sub-product* projects via external subcontractors. This indicates that in Finland the strategic business segmentation was not yet functioning during the 1990s according to the division illustrated above.

In export markets, *technology push* and *market pull* were acting interactively, as seen previously in the domestic market. Whereas the main domestic customers were building contractors and element manufacturers, in Germany and France the focus was on cooperation with partners. As re-manufacturers, their position in the *value chain* was as sub-product suppliers. The idea was to provide them with an opportunity to try out and develop different sub-product concepts. To be able to meet the Kerto-LVL product specifications they required, the Kerto-LVL factory purchased re-manufacturing equipment. The following table shows the *value chain* principle at the breakthrough stage. It was an important factor in the *key technology model*, as seen later in this study. It also offered important support to the exchange of knowledge and also *tacit knowledge* and experience between markets, ensuring that new information acquired in one country could be immediately put to use in on-going projects in another country.

Table 24. Interaction of technology push and market pull in export markets

Technology Push		Market Pull
Product assortment was extended: Kerto-LVL-Q panel Kerto-LVL-T with lower technical values for posts (Vitka sorting according to veneer density)	→	Partners built their own product families → development of business idea was based on the sub-product segment
Investment in a precision sawing machine.	→	Partners in Germany and in France developed for themselves a building application for hall construction (Figure 92 and Figure 95)
Investment in a further processing unit at Lohja with sanding and re-gluing.		
Transfer of screw gluing technology to Finland	←	Merk developed screw gluing technology (Figure 93)
Development of nail plate reinforcing technique for Kerto-LVL (Figure 85)	→	Multi-storey houses in Finland (Figure 90)

<u>Product platform</u>

Kerto-LVL's position was initially weakened by the merger of Metsäliitto and Serlachius and by the establishment of Finnforest in 1990. It was no longer in a "leading" position among the products and business operations being developed in the company, in the way it had been during the previous stage (chapter 5.1). As Kerto-LVL volumes were only experiencing limited growth, its development did not directly support the expansion strategy that had been chosen for the panel industry. In marketing, the worst crisis and credibility problem emerged in 1990–1993. The turning-point came during 1993 when Kerto-LVL exports began to increase first in the USA and in 1994 in Europe, whereas in the domestic market the product range expanded into an entire product family. Introducing a *standard product* into the *distribution market* and the steady volume growth that followed were clearly a success, consequently boosting the management's confidence in the product.

In the domestic market the emphasis on volume and the fact that product specialisation issues were set aside led to a situation where Finnforest's top management preferred to select *standard* and *component products* as market segments for Kerto-LVL. The attention paid to the *customized product* segment was more or less limited to maintaining the product's image. In the re-manufacturing investment, in 1995, the main focus was on the *component product* segment, which served both domestic and export marketing. Finding a suitable domestic sub-product supplier and developing continuous cooperation based on partnering would have tied up too many of the company's own resources, so this development option was not taken. Cooperation with selected companies in the sector, such as SPU, was seen as sufficient.

The new management, who had promoted rapid growth at the beginning of the breakthrough stage, regarded the slow growth of sales volumes and turnover in exports of Kerto-LVL as a problem. We were also criticised for depending too heavily on *partnering*. In the management's opinion, this restricted our possibilities of expanding distribution to retailers in Germany and France, in contrast to the domestic market. The situation gradually took a positive turn after the *partners* began to operate as resellers, keeping Kerto-LVL in stock. They purchased large standard-size slabs and cut them into *component products* according to the customer's needs. This supported Finnforest's expansion strategy. Afterwards, the partners' own main activity within the *customized product* segment was their own business.

Once R&D operations had been decentralised to unit level, the Kerto unit's development actions no longer received the entire Group's support. In addition, the transfer to the line organisation was completed by 1991, and as a consequence the strategic role of R&D became for a moment less of a priority. During 1993 the Kerto unit's organisation was modified to re-establish the active role of R&D operations in business development. The cooperation with the *partners* was so successful that the *product platform* for Kerto-LVL was extended to encompass the partner companies as well.

The target of "entering the US market aggressively" in the 1993 strategy was not met, which reflected negatively on other expansion plans. A new strategy was not devised until after changes had been implemented in the organisation in 1996. As explained in chapter 6.2, the manager of the Building Products Division had confidence in the competitiveness of Kerto-LVL and managed to get the decisive investment decision approved.

Partnering

In Finland SPU acted in practice as the only *sub-product supplier* for Kerto-LVL in the timber construction sector. The Kerto unit worked in close cooperation with SPU, but as they used Kerto-LVL in a traditional way as a load-bearing beam in roof elements, a conventional supplier – customer relationship was sufficient. A more advanced partnership, such as the ones established in Germany or France, was not necessary.

To develop the business operations described above in export markets, it was of decisive importance to establish personal trust and functioning relationships between the Kerto-LVL manufacturer, Finnforest and its partners. These relationships served as a basis for the win-win situation described above, where participants carried out mutually benefical development work both together and independently. Figure 103 illustrates this partnership model where the partners' business ideas are shown as mutually inclusive when the cooperation has evolved into an authentic partnering relationship.

Partnering was not included as a concept in the company *vision* during the pilot plant or industrial stage. At the time, we only talked about long-term customer relationships. The situation did not change until the beginning of the breakthrough stage, when all the essential product approvals had been won in both Germany and France. The approvals were obtained through joint efforts with the *partner* candidates, which finally opened the path for exporting the product. Subsequently, the potential partners saw the opportunity to build themselves a business on the basis of Kerto-LVL, but they first wanted Finnforest to show a positive attitude to *Partnering*. The Kerto-team was able to coordinate operations on a strategic level via the available plywood marketing network; however, at the market opening phase the daily local issues related to the product's use and logistics posed a problem. The *partners* could solve these issues better than we, and the Kerto-team offered them the opportunity to become specialists in their own particular field. Once *partnering* had established itself as an operating practice, the company as a whole benefited from an extension to its *product platform* and its own *value chain*.

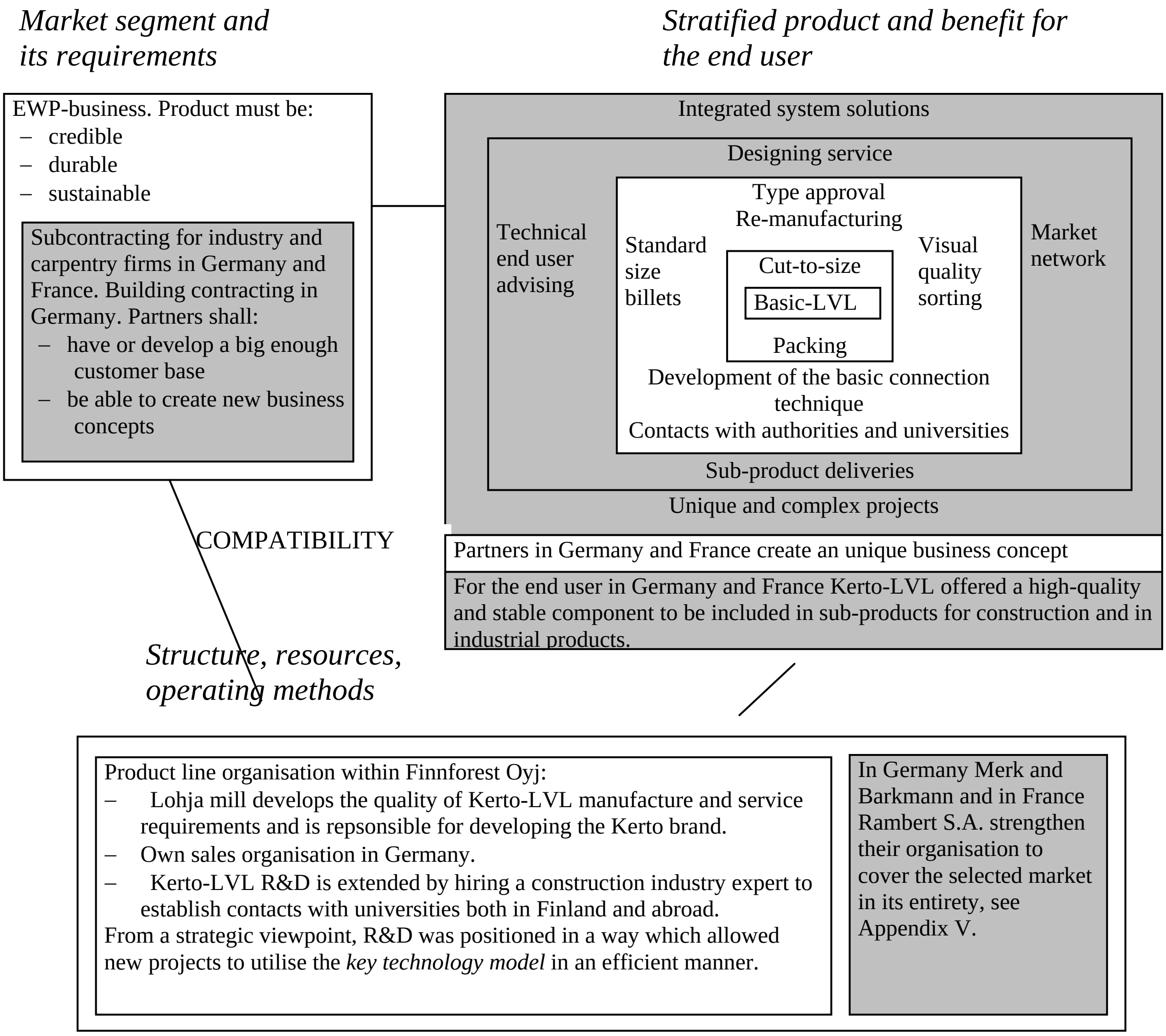


Figure 103. Kerto-LVL business idea in the late 1990s, where the business ideas of both Finnforest (white background) and German and French partners (shaded background) have been combined and superimposed. Product stratification has increased in comparison to previous stages.

The partners took a considerable risk when starting to develop a business activity for themselves based on Kerto-LVL in the early 1990s. Since then they have become leading EWP companies in their area. For Merk the role of Kerto-LVL was important and for Barkmann it was crucial. By changing their operating practices these companies were able to develop into competitive and modern pioneers in timber construction in Germany. For Rambert the change meant a transfer from a mere distributor of capital goods to becoming a *sub-product* supplier. Manufacture and installation of the product were outsourced by training local carpentry firms to assume these roles, as explained in chapter 6.6.

For Kerto-team the certain *Partners'* exclusively was also a considerable risk. On the one hand the growth of the product's volume is maybe not developing according to the planning. On the other hand if the product's applications are positioned mainly in the *solution market*, the product's *operating system* is under processing so that only the *partner* is in a position to supply the *100% product* for the end users. This was the case with Kerto-LVL in Germany and France before it finally was at the Breakthrough stage in each market.

Table 25. Share of Kerto-LVL in partners' business in 1997.

	Merk Holzbau GmbH	Barkmann Holzbau GmbH	Rambert S.A.
Turnover (million €)	25	7.5	16
Share of Kerto-LVL in the turnover (%)	over 20	over 40	over 20

R&D portfolio

Despite focusing business operations on the standard product and component supplier levels as described above, the Kerto unit also developed its ability to enter new business areas. This can be seen below in the R&D porfolio. In the "known – known" square of the market-product matrix, the *operating system* was expanded. The distribution channel extended into the distribution market and the volumes increased for Kerto-LVL as a *standard* and *component product*. In the "new – new to Metsäliitto" square, *customized products*, such as solid Kerto trusses, were developed using steel plates and dowels. In the "new – new to the world" square, *sub-products* were developed in cooperation with partners, for example screw glued ribbed structural elements in cooperation with Merk. They were used in the first multi-storey houses in Finland together with a new jointing technique as well as in sports hall structures in Germany. The idea was to develop an integrated use for the new structure, in which the ribbed elements worked not only as the load-bearing structure but also as a continuous slab to brace the entire structure. In addition, when used as a roof structure they worked well as an acoustic and visual exposed surface.

Correspondingly in the technology – product matrix, in the "known – known to Metsäliitto" square, the component manufacturing technique was developed further using the precision saw and sanding machine in the re-manufacturing hall; in the "new – new to Metsäliitto" square, a CNC-controlled machining technique was developed and in the "new – new to world” square, the Vitka measuring and sorting technique was developed to enhance the product’s strength values management.

Markets	Product		
	Known to Metsäliitto	New to Metsäliitto	New to the world
Known to Metsäliitto	Standard and component products		
New to Metsäliitto		Customized products	
New to the world			Sub-products and turnkey products

Figure 104. Kerto-LVL’s market position was expanded into a product family.

Techno-logy	Product		
	Known to Metsäliitto	New to Metsäliitto	New to the world
Known to Metsäliitto	Kerto-LVL		
New to Metsäliitto		Machining technique for components	
New to the world			Measuring and sorting technique for production

Figure 105. The technological development of Kerto-LVL was carried out at three levels.

The Kerto unit had developed LVL equipment technology together with Raute since the late 1970s. However, Raute’s LVL business did not begin to materialise until the 1990s. Raute’s direct and indirect wholesale price-indexed turnover until 2002 has been nearly 150 million EUR in total (Raute, Appendix VI).

Key technology model

The management of the ongoing PMT and PLT technology programmes in the early 1990s was based on a *key technology model* (Klus and Hirvensalo 1997, 34-39). Their example inspired us to apply the model to the development of Kerto-LVL. A concrete example was the *multi-storey house* project in Ylöjärvi (Figure 90), during which the following techniques were transferred and developed further:

- the screw gluing technique was transferred based on technology developed by our German partner Merk.
- the jointing technique was developed in cooperation with research group in HUT/LSEBP (Kevarinmäki et al. 1995).
- construction capacity and properties of a real-size modular element, e.g. soundproofing and floor vibration, were developed with building contractor Skanska and a research group in TUT/LSE (Keronen and Kylliäinen 1997).

In addition, the Kerto team played an active role in directing the SPT research projects. For Kerto-LVL, Cost C1 “semi-rigid connections” became one of the most important projects; see Figures 85 and 90.

Innovation structure

During the breakthrough stage, the Kerto team and the partners established an interactive relationship, in which both operated on an equal footing. In Germany and France, the partners developed *100% products*, with integrated services, and consequently positioned themselves strategically into an appropriate level in the *value chain*. During the previous stage, the Kerto unit’s resources were not sufficient to manage “needs and changes in needs” in the innovation structure. This was a major improvement. Partners had by now acquired a sufficient technical knowledge. By becoming *developers* and *utilizing* counterparts in the innovation chain, they recognised and solved locally development tasks that resulted from “needs and changes in needs”, and thus eased significantly the Kerto team’s workload. All the aspects of the innovation structure were now in balanced interaction, and the Kerto team moved within the innovation process into new fields that had been identified in the R&D portfolio. The following developments had been made in the innovation structure:

From a technical point of view:

- *Research* counterparts were still HUT/LSEBP, VTT, FMPA, Universität Karlsruhe, CTB and North Carolina State University. HUT/Laboratory of Radio Technology became involved as a new participant.
- *Developers* were still the Kerto-LVL unit and Raute from a production and product point of view. The Kerto-LVL unit, HUT/LSEBP and TUT/LSE were the developers in product applications.
- *Utilization* and *end use* of the product were the Kerto production unit’s concerns as manufacturer of the new product and as user of the new technology.
- *Business* was relevant to Raute, because in the 1980s it was the only manufacturer of LVL production equipment with considerable experience.

From a business point of view:

- *Research* was still the Kerto team’s responsibility.

- *Developers* and *utilizing* counterparts were the Finnforest team in Finland, Merk and Barkmann in Germany, Rambert in France and MCL in the USA. My task as product manager was to coordinate the actions.
- *End users* were large prefabricated house manufacturers and building contractors. In export markets manufacturers of industrial components, Merk and Barkmann themselves as well as the customers of Merk, Barkmann, Rambert and MCL acted as end users.
- *Business* was the sales manager's responsibility, but local marketing managers from Finnforest were also involved.

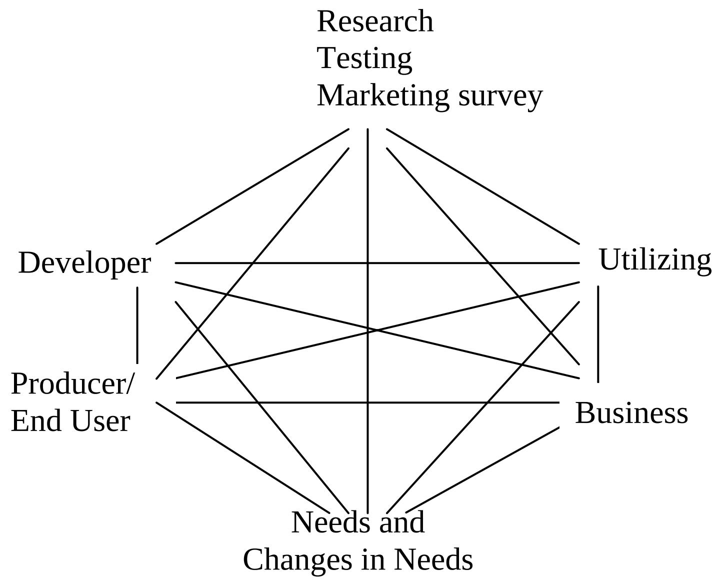


Figure 106. In the breakthrough stage the innovation structure is complete and in balance.

It was decisive for Kerto-LVL's success that the partners took a strategic role in *developing* and *utilizing* the product. As a consequence, strategies became interactive and guided by *market pull*.

7 CONCLUSIONS AND DISCUSSION

In chapter 3.8 I presented the hypotheses and findings developed in this study. To explain these hypotheses I presented a number of concepts at the beginning of chapter 3. In chapters 4, 5 and 6, I presented the three implementation stages of the Kerto-LVL innovation process: the pilot plant stage, industrial stage and breakthrough stage. At the end of each chapter, I reviewed the development of the selected concepts. In the present chapter I shall draw a parallel between the concepts and hypotheses and show the results as a summary. When going through the literature, I noticed that a lot of research has been made on R&D activities and business development, whereas few studies concentrate on the immediate interactions between these two fields. The table below presents a summary of the hypotheses with their corresponding concepts.

Table 26. Summary of the essential concepts in relation to the hypotheses of this study.

		Business				Development		
		Business idea - Strafied product - 100% product - Operating System	Value chain	Product platform	Partnering	R&D portfolio	Key Technology Model	Innovation structure
Prerequisites	1.Hypothesis; *Commitment* as a dynamically changing process.	x	x	x	x			
	2.Hypothesis; Starting the Change in Operating practice.	x	x	x	x		x	
	3.Hypothesis; Autonomy requirement for a developing business idea	x	x	x	x		x	
Structure	4.Hypothesis; Formation of innovation structure and partnership	x	x	x	x	x	x	x
	5.Hypothesis; Partnering leads to a merging of business ideas and strategies on *Solution market.*	x	x	x	x	x	x	x
	6.Hypothesis; Contents of the *100% product* and its *Operating System*	x	x	x	x	x	x	x

<u>*1st hypothesis; Commitment* as a dynamically changing process</u>

Commencing the development of a new product and overcoming the ***Chasm*** *requires a* ***commitment****, consisting of the following factors:*

- ***Product platform****, which serves as the basis and the environment. It gives a new industrial process enough support to enter into an immediate development path. The constituent* *parts of the process need to be compatible with the raw materials and technologies that the company uses. For the purposes of commercialisation, the **product platform** must offer sufficient and functioning contacts to potential market areas in a way that enables the developing company to make use of the new product's properties throughout the **value chain**.*

– ***Visions** regarding the potential of the business which is being developed, the **business idea**, the necessary changes to the **value chain** as well as the potential **partners**. Furthermore, the process should state clear **targets** for the product's technical properties and make an estimate of necessary investments.*

– ***Resourcing** the development, which involves assigning key persons to take charge of the process, and providing the necessary financing.*

*Maintaining the **commitment** and ensuring the necessary investment requires **project milestones** to be met in order to maintain the management's trust.*

Linking *commitment* both to business and/or R&D is in general a common idea. The leading idea of the current hypothesis is therefore widely known, as well as being a prerequisite for the development process resulting in a new product. Hornby (2000, 242) defines commitment as follows: "*Commitment is agreeing to use money, time or people in order to achieve something*". A company's *commitment* is usually stated in the introduction to its Annual Report or in descriptions of different kinds of quality systems (Finnforest Annual Report 2002, 4; BrandTech 2002/2003, 4). Their approach is business-focused, but they also emphasize R&D. However, business and R&D are connected to *commitment* as separate elements, whereas my objective is to link them together and put them in interaction. To better evaluate the success of the interactive process I decided to divide *commitment* further into:

– *Product platform,* which permitted me to evaluate the suitability of the product for a development path based on current operations

– *Vision* to realize the viability of R&D ideas

In addition, *resourcing* is needed to back the operations, and finally, regular *evidence* is necessary to prove the operability of the plans as well as the credibility of the progress that has been made.

Resources can be defined according to Kotler (2003, 67) as follows: "*to carry out its business processes, a company needs resources – labour, materials, machines, information and energy*". The *product platform* consists partly of the same elements, but in this study *resources* are seen as comprising both intellectual and economic investment in technology and business. The significance of investments is emphasized when a new product's R&D

process is carried out in parallel with the business development. Stages where development process resources benefited from a significant investment from management were of vital importance and clearly promoted Kerto-LVL.

The following concepts illustrate how *commitment* changed and evolved during the development process:
In the early stages of Kerto-LVL development, the environment, i.e. its *product platform* as defined in chapter 3.5.6 was sufficient for other areas except for commercialisation. Metsäliitto did not possess sufficient experience of how to market a structural wood product. To allow *commitment* to develop, the *product platform* for Kerto-LVL had to be expanded. The operational management supported this action, and it was carried out during the pilot plant stage by re-organising the operations to function on a product manager basis instead of relying on a traditional divisional organisation. This created the necessary framework for establishing direct contacts throughout the network. Consequently, technical issues and marketing related questions could be discussed with parties with immediate responsibility in different positions in the *value chain*.

The *vision* of the *business idea* developed and became better defined throughout the development process. At first it was dominated by the owners' interest; the opportunity to get a higher price for their raw material - solid timber logs. During the early stages of the development, the project group saw Kerto-LVL as a *standard product* acting as a substitute for traditional structural timber on the *distribution market*. During the pilot plant stage it was positioned as a *customized product*, and it gradually developed into an entire product family. It was not until the breakthrough stage that one of the products became a *standard product* on the *distribution market* in Finland. These developments are illustrated in the figure below.

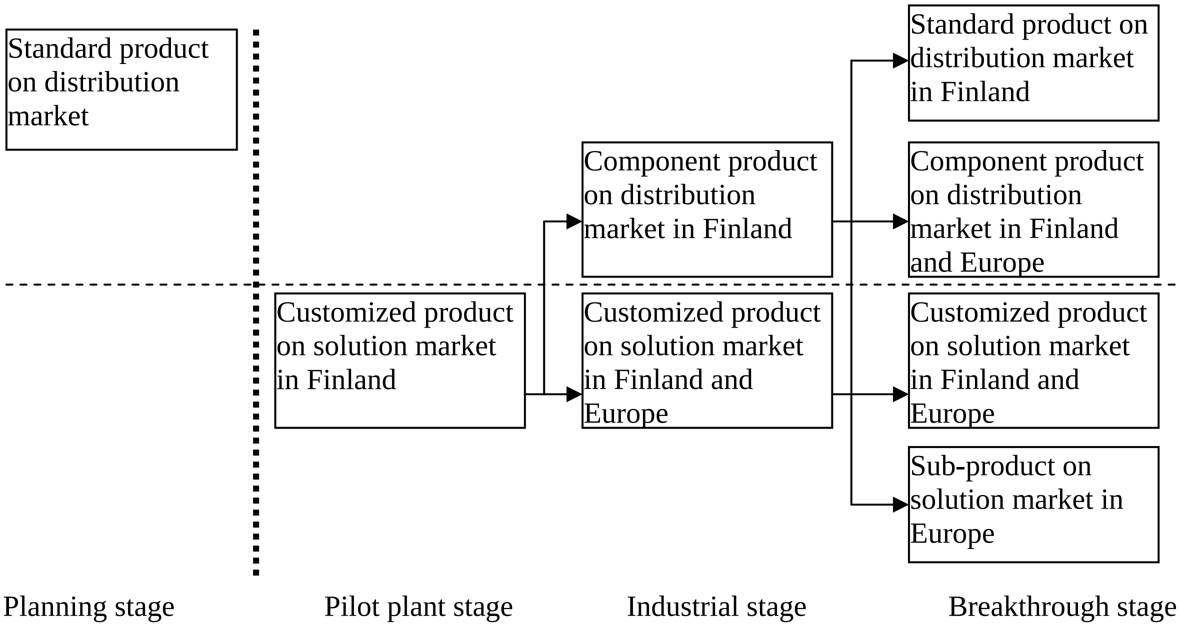


Figure 107. Vision of the Kerto-LVL business idea developed through various stages to form a product family. The standard product on distribution market level (on the left) was not achieved in Finland until the breakthrough stage.

By implementing at each stage a limited *vision* for a *business idea* as seen in the assessment section of chapters 4 to 6, a positive cash flow could be created to secure the development operations; during the breakthrough stage also a clearly positive profit level was achieved. It essentially strengthened the *commitment*. Even though increasing the capacity was viewed with caution at the beginning of the Industrial stage, the selected investment level proved to be a wise decision with regard to the product's market *potential*.

A *vision* of a *value chain* began to manifest itself at the end of the pilot plant stage. During the industrial stage it was further reinforced as we could now supply a more developed product, which was based on the *product platform*, for Finnish export projects. Also in the US market the *value chain vision* worked well enough with GNS, who took charge of the commercialisation part of the *product platform*. As a consequence, the management gave its support to the Kerto team's operations.

At the early stages of a development process an R&D *partnership* is seldom available; instead operations are based on good long-term customer relationships. In certain cases, joint efforts in R&D with such customers lead to a *partnership*. *Partnerships* of this kind began to establish themselves at the beginning of the breakthrough stage, when all the essential product approvals had been won both in the French and German markets in cooperation with the potential *partners*. When the potential partners saw the opportunities available for constructing their businesses on the basis of Kerto-LVL, they required Finnforest to demonstrate a positive attitude to *partnership*. It was indeed possible to coordinate the operations on a strategic level via the existing plywood marketing network. However, handling the product's day-to-day practical and logistical issues locally constituted a problem during the market opening phase. It was found that the Kerto team could deal with these issues better by negotiating with *partners* directly, instead of relying on the plywood marketing network, which in the early days of Kerto-LVL exports had been crucial in providing necessary contacts.

As a result of the fact that *partnership* had become generally accepted as the operating practice, both the *product platform* for the entire company and the *value chain* for Kerto-LVL were extended.

Promoting a new product which was not a direct substitute for a product already in the market required developing an *operating system*. This was time consuming, but without it we could not have met the marketing *targets* and, consequently, achieved the marketing *evidence* and *commitment.* When a realistic *target* had been set for developing the product and technology, these, together with the selected *vision,* constituted sufficient *evidence* of the viability of the project. As a consequence, the management became convinced that the Kerto team had a clear opinion on how to expand the business idea.

Dividing *commitment* into its constituents has permitted us to understand it better. In addition, the continuous *evidence* gained from the development process illustrates its dynamic nature. The combination of concepts I have used in this study illustrates better the issues that are relevant when launching a development process or one of its phases, than each one of these concepts separately. The selected aspects can vary from product to product and case to case. It can be assumed, however, that the same principle applies to other basic industry products.

2nd Hypothesis; Starting the change in operating practice

*To bring about a **change** in a network, the companies who actively participate in it must simultaneously visualise and identify their own **commitment** and also the opportunities arising from changes in the **value chain** as a whole. For a **change** to be implemented, there must be a shared **commitment** among the key persons as well as an application of the **key technology model.***

Hirvensalo et al. (2002, 37) position the basic industry in relation to the trade and end-product companies as shown in the figure below. Basic industry by definition has no immediate contact with the market, and therefore a simultaneous change is nearly impossible.

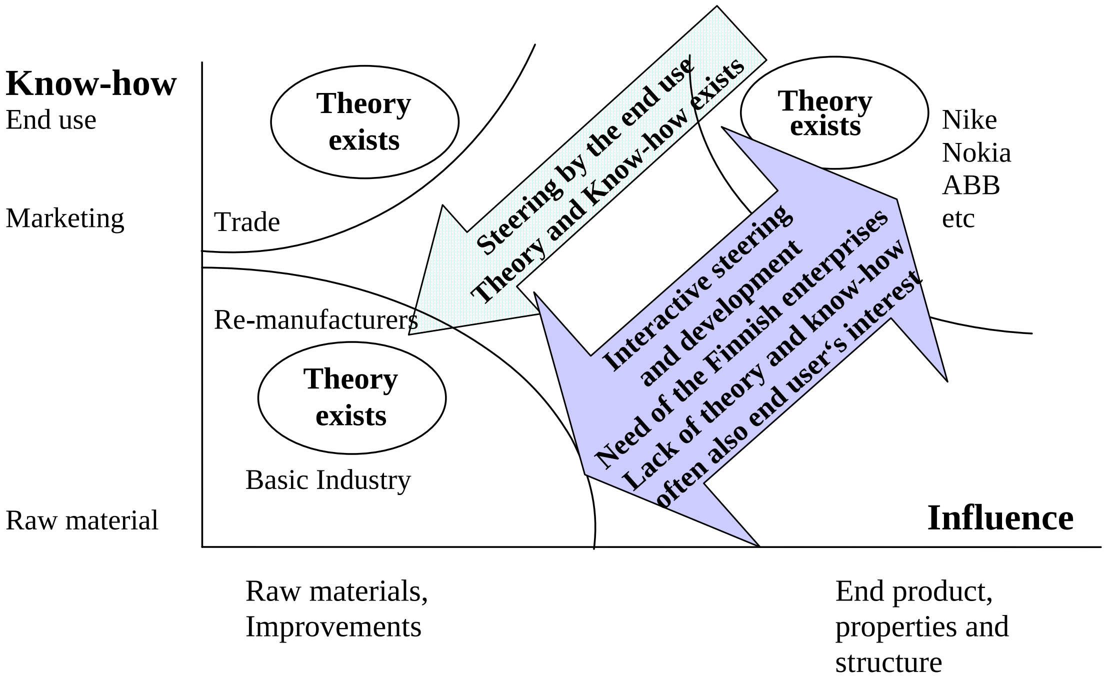


Figure 108. Networking and lack of know-how between wood products industry, trade and end use companies. (Hirvensalo et al. 2002, s. 37)

The present study emphasizes the view on the interactivity of a development process as shown in Figure 108. At the same time, the 5th hypothesis highlights the process-like character of the change and the shared *commitment* that is necessary to realize the change. In this way, it complements the static structure of the *value chain* given in literature (Porter 1985, 51-82). This consists of a number of activities which are carried out in a one-way structure in order to design, manufacture, market, deliver and support a product.

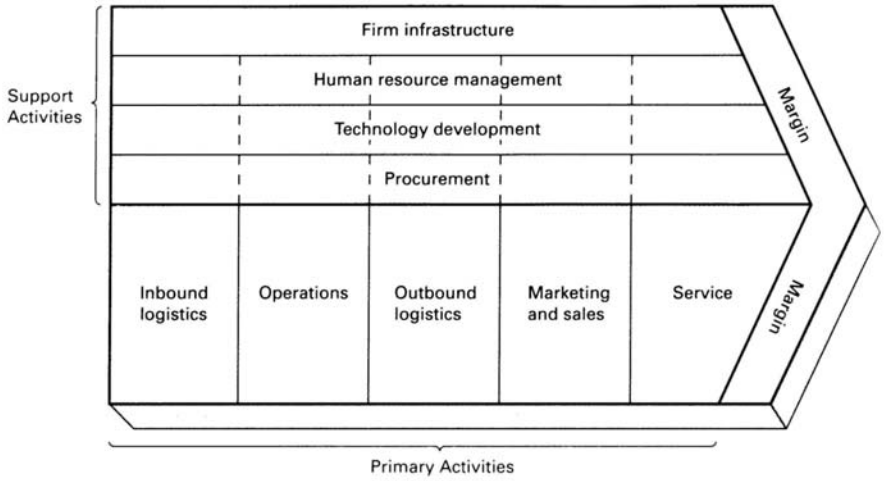
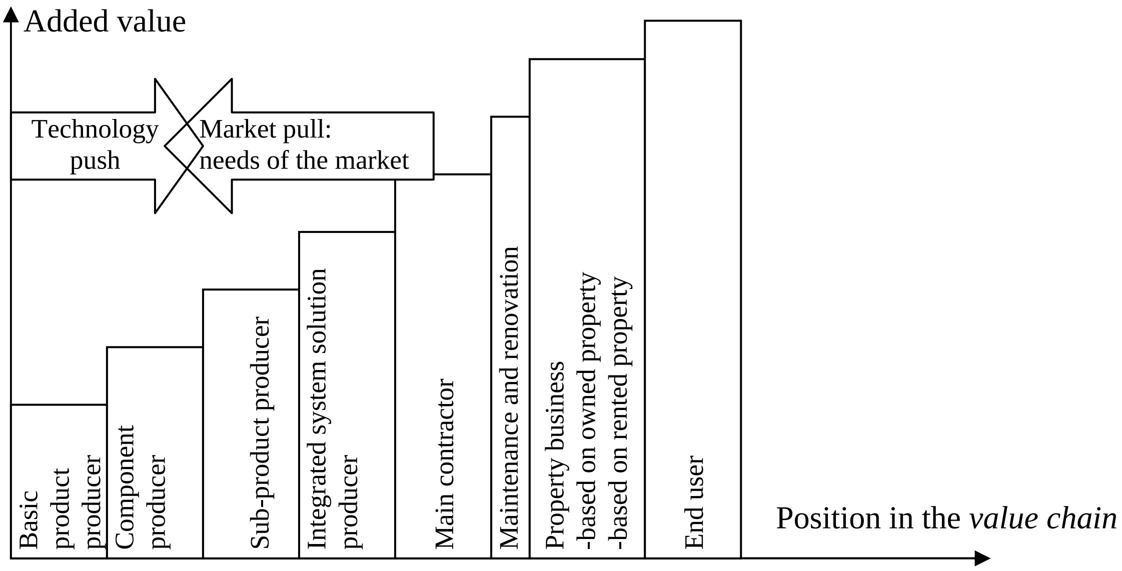


Figure 109. Porter's value chain model (1985, 55).

Mali et al. (1986, 70) and Jumppanen (2003) in particular view the *value chain* dynamically, taking into account the operational change. The idea is to describe the possibilities available for a company to move towards end use in the *value chain*. In the context of Kerto-LVL, this would mean a transfer from the material and component supplier level to *sub-product* level in a way that permits avoiding market disruption caused by a newcomer with a different concept entering the market. The dynamic nature of the *value chain* can be seen in the interaction between the *technology push* and *market pull* (see figure below):



Technology Push	Market Pull
Technical product development of the basic producer; Phase 1	Partner 1 builds his own product; Application 1
Investment of the basic producer in new production technology	Partner 1 builds his own sub-product; Application 2
Technical product development of the basic producer; Phase 2	Partner 2 builds his own product; Application 3
Investment of the basic producer in a further processing unit	Partner 2 builds his own sub-product; Application 4
Transfer of technology to the basic producer; Phase 3	Etc

Figure 110. Management/control of the change in the value chain using the interaction between technology push and market pull.

In my view, when proceeding according to the 2nd hypothesis, the biggest challenge lies in the need for both the manufacturer of the product and the partner to be simultenously capable of changing their operations. It is therefore necessary to identify clearly enough the *value chain* and the impact of the required change on both participants. In order to achieve the situation described in the 2nd hypothesis, the product, its production technology and profitable business need to be developed together to form a functioning entity. This requires close interaction between these activities as well as between the company's own and customer network's R&D. Special attention has to be paid to:

- Technology
  - Developing the production technology together with the product technology

- Integrating the product quality development into on-line production operations so that the authorities (third party) become convinced of the company’s quality control procedures and of the competence of those responsible for quality control.

- Business
  - Development of the business on a win-win principle
  - Developing the product and the integrated services
- Change of the process
  - Necessary improvements to the company’s own operating practices in both:
    - Production and sales
    - Organisation
  - Changes in customer’s operating practices

The 2nd hypothesis began to manifest itself during the pilot plant stage, when the Kerto unit was given permission by the company’ management to try to market the product independently. This could be done without applying a *key technology model*, because at that point the operations were still small-scale and the number of participants in the *change* remained small. The *change* was dramatic as such, because by modifying the operating practice it touched on the distribution organisations’ power structures. Technically, the *change* was not significant since the Kerto-LVL beam was similar to large-size timber and glulam. As the manufacturer of the product, the Kerto unit had to realize the customers’, i.e. building contractors’ need to get a *100% product* ; it was also vital to realize that our *customized beam* was an even more advanced *stratified product* than glulam. A shared *commitment* was achieved on the basis of the *value chain* with selected building contractors. It gave an important benefit to the customers, as the structures became simpler and the overall cost was reduced compared with the previous situation. The Kerto unit assumed the demanding position as the only supplier of the product. This is why we had to concentrate our efforts on establishing *individual-based trust* with the customer, meaning that each project had to be seen through to the end as a one-to-one service.

During the industrial stage, the Kerto unit began to develop cooperation with other Finnish companies in their export projects to the Soviet Union. The SBA was *customized components* in prefabricated elements and the change in operations provided the participants with a clear benefit. In comparison to the previous stage, the change in our operations was significantly deeper. The end users and us as the manufacturers were now mutually dependent on each other. It was crucial for us to gain a better control of the process to ensure that the product tolerances and delivery deadlines were met. The customers were required to modify their operating practice from traditional project-based operations towards process production characterised by an increased performance rate.

When exporting to new markets we found active partners and subsequently began to develop both the product and the business together. We identified a simultaneous *commitment* as seen in the 1st hypothesis, as well as an opportunity for change within the *value chain*. As a result of the cooperation, also the Kerto-LVL *product platform* expanded, when *partners* took charge of the local development work related to the *operation system* and *R&D portfolio.*

As the product's requirements increased, there was a need to start research for solving the newly found practical issues. This led to the application of the *key technology model*. An adequately focused R&D could ensure the development of necessary know-how for the new product.

In Finland the exploitation of the *key technology model* began intuitively during the industrial stage. After finalising the solid Maxi-I beam, we developed, together with HUT/LSEBP and Oulu university researchers, the technical structures for the Oulu Dome. In the breaktrough stage the utilisation of the *key technology model* had become systematical, and it was applied to the multi-storey house project in Ylöjärvi. It created a basis for developing *sub-product* applications into business activity. Further examples include the Sibelius Hall, Pohjola Stadium, Savonlinna Hall and Finnforest Modular Office (FMO). Systematic utilisation of the *key technology model* requires that all key participants in the *value chain* become involved in the development process. Without this happening, it is not possible to establish in the chosen segment a functioning *business idea* and *value chain* as well as a sufficient know-how.

<u>3rd Hypothesis; Autonomy requirement for a developing business idea</u>

If a company perceives a new need within the existing market or, alternatively a whole new market, and provided that the necessary business idea significantly differs from that used to guide its previous activity, the development and implementation of a new business idea require an autonomous business unit. The business unit then takes responsibility for R&D and business.

Norman (1975, 211) presents the concept of the appendix syndrome, which is closely linked to the obstacles inherent in both a cognitive and power system. When a company's new spearhead products support its existing business idea, they receive all the support they need. However, if the products drift too far from the company's core business and start living their own life, they might form a threat to the existing operations and the company's identity. A continuous independent development loses the company's power structures' support and the new operations are no longer allocated sufficient resources. As a result, growth stagnates. Kettunen (2002, 67) states the following example related to the Metsäliitto Saima parquet: "*From a managerial perspective it was important to notice that this kind of project, which differs from its other operations, is to be separated from them, preferably into its own risk company.*" The parquet business was sold off in the early 1990s because it was growing too slowly, see Appendix II. According to Kettunen (2005), the reason why companies are reluctant to accept this autonomous business unit principle is related to power politics.

In the context of this study, Metsäliitto assigned responsibility for R&D and business development to the Kerto team at the pilot plant stage, see chapter 4.4.2 and page 104. The industrial stage brought hardly any change to this. The development of the *business idea*, and of the concepts closely connected to it, the *stratified product*, *100% product* and *operating system*, progressed significantly during both of these stages. This independence decreased in the early 1990s as the product approached the breakthrough stage, as a consequence of the Kerto team's closer connection to the new company, Finnforest. Finnforest had at first concentrated on the plywood industry but now became more involved in Kerto-LVL. This reflected directly on Kerto-LVL by slowing down the development of its *business idea*. The situation was further complicated by the Kerto unit's own organisational changes during the same period.

Based on the assessments of the Kerto-LVL development process in chapters 4, 5 ja 6, Table 57 below summarizes the main arguments of the 3rd hypothesis.

Table 27. The need for an autonomous business unit (3rd hypothesis).

	Existing *business idea* with an established market	New business idea
Value chain	Improving competitiveness by efficiency enhancements at different positions in the *value chain*.	Developing the operations into an interactive relationship between different participants in the *value chain* on a *technology push* and *market pull effect* principle, see previous figure.
Partnership	Importance of building on existing customer relationships and developing them further. The client informs the manufacturer of their particular development needs.	Flexible *partnerships* based on individual trust. In chosen segments, *partners* participate in the developent processes involved with creating a new *business idea*.
Product platform	A controlled change in a market situation is handled within the existing operator network.	*Product platform* is expanded and completed in cooperation with the *partners*.
Key technology model	Multiphase development projects implemented by the R&D staff, e.g. Cagan and Vogel (2002, 112).	Interactive development processes according to a *key technology model*, e.g. *sub-product* applications in 2nd hypothesis.

4th hypothesis; Formation of innovation structure and partnership

The formation of an innovation structure and partnership is a coalescent process.

The basis for this hypothesis comes from the market-product matrix of the company's R&D portfolio. In my view, a new product is initially positioned in the "new-new" square as shown in pilot stage in the next figure. That is when the product is on the demanding *solution market*. The manufacturer is still capable of completing the *innovation structure*, but it is no longer possible to bring it into balance. Some procedures within the development process remain unfinished, or the focus is on the wrong priorities. A *partnering*-based cooperation is one functioning solution to this situation.

The market-product matrix of the *R&D portfolio* illustrates the development need for/within a new product's *innovation structure*, cf. chapter 3.7:

a) At the beginning of the pilot stage, the innovation structure is completed to establish a functioning *value chain* for the new product. At the current stage it does not include all the activities as yet, (N) is lacking.

b) At the beginning of the industrial stage, when partnering remains unaccomplished, the focus of operations is on *technology push*. Penetrating the market requires a *100% product* and a completed *innovation structure*, even without a perfect balance.

c) At the Breakthrough stage, creating a balance in a new product's *innovation structure* requires essential development needs to be identified in cooperation with the partners, based on the *market pull* effect.

	Pilot stage			Industrial stage			Breakthrough stage		
Product	Market			Market			Market		
	KE	NE	NW	KE	NE	NW	KE	NE	NW
KE							x		
NE		x			x				
NW			(x)						

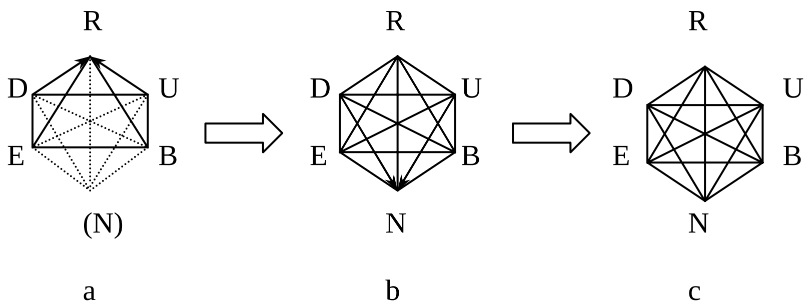


Figure 111. Market-product matrix of the R&D portfolio and the stages in the formation of a new product's innovation structure, when Figure 39 and Figure 44 have been combined.

KE= Known to the enterprise, *R= Research* *N= Needs and changes in needs*
NE= New to the enterprise, *U= Utilizing* *E= End user*
NW= New to the world *B= Business* *D= Development*

The *innovation structure* is a result of the various stages of a development process. The results of the development work, the benefits to be gained, and necessary changes to the *value chain* are discovered during the development process and creates a basis for a truly interactive partner relationship. The purpose of an evolving partnering relationship is to develop together a balanced innovation structure. The development process generates added value for the whole delivery chain and creates a positive win-win situation between all participants.

From the 4th hypothesis follows:

A *partnership* between companies that operate in different positions in the *value chain* is a mutual selection process based on equality. Blomqvist (2002, 246) observes that in the ICT sector "*a shared vision is an important source of commitment and trust*" and further that "*a* *shared vision commits the partners to do the extra mile to reach the goals of the partnership*". Maintaining an efficient *partnership* is so demanding for both that a company cannot have more than a very limited number of active *partners* at any one time. That is also why initially the build-up of an *innovation structure* for a particular product segment is at the same time a *partner* selection process. If this process is successful, the outcome is also a shared *commitment.*

This allows the partners to form an ideal *innovation structure*:

– a shared *R&D-portfolio*
– the location of development needs
– application areas for know-how
– sources for know-how
– a shared key technology model
– a shared *stratified* and *100% product* including its *operating system*
– the new *value chain*

Since both the manufacturer of the product and the *partners* are required to change their operating practices, the manufacturer as the larger company may have an opportunity to work as the leader in implementing the change. The manufacturer has a considerable interest in the outcome and can therefore become the driving force in building the cooperation between the participants.

A *partnering* relationship, on the one hand, and a developed *innovation structure,* on the other, make it possible to add characteristics and services to the product at the appropriate time, when the customer is ready to utilise them. This leads to a *stratified product.* Correspondingly the operators of the innovation structure (architects, designers, carpenter, etc.) learn quicker to make use of the product's characteristics if they become involved in the *100% product*'s development.

When the company operates on several markets, in order to improve efficiency, the business idea needs to view the development of the organisation and operating practices in a way which enables a systematical information transfer between markets. This requires a continuous interaction at the practical level between user, sales operation, R&D and production. A mere information transfer for the purpose of product improvement is not sufficient, but *tacit knowledge* has to be transferred as well.

5th hypothesis; Partnering leads to a merging of the business ideas and strategies on the solution market

As it develops, partnering leads to a reconciliation of company strategies and a merging of business ideas in selected product segments on the solution market.

Building a *partnering* relationship in the *solution market* requires that the *producer* gives its new *partner* in a new market an opportunity to profit from the results of the *producer*'s development work relating to the new product. The *partner*'s local competitors will, however, see the situation as restraining competition, as the *producer* will not give them access to the same information that the *partner* has.

The product's position in the market influences the structure of the partnership and how it operates. According to Winter (2005), in order to start exports to Germany in particular it is sensible for the *producer* to allocate a competent local *partner* an exclusive right to sell the product for a certain period of time, the length of which should be kept open for negotiation even during the current contract. After that, the distribution of the product should be passed on to the trade sellers, to ensure its general availability. This is crucial in building industry projects, because the initiative for using a new product often comes from the designer, who cannot favour one particular supplier.

In my opinion, Winter's comment is very important. As soon the product's *operating system* is functioning widely enough and the main part of the product's applications move clearly from the *solution market* to the *distribution market,* the general availability must be organized by the *producer*. This is what happened to Kerto-LVL in Finland at the end of the industrial stage and to *component products* in France at the end of the breakthrough stage. In Germany, the transfer began likewise at the end of the breakthrough stage, although the process was significantly slower because the more complicated building regulations compared with Finland and France.

In the context of Kerto-LVL, the development process *partners*' own business began to develop significantly thanks to close cooperation with us, allowing them to become specialists in their chosen Kerto-LVL product applications. The most R&D-oriented participants in the innovation structure form a basis for product development and assume a fundamental role in the *partnership*. Partnering aims to locate and develop the added value contained in the end-use applications; the benefits from this added value are distributed between the partners (win-win principle). As a consequence, the company's *product platform* becomes essentially wider; see 1st hypothesis.

It follows from the 4th and 5th hypotheses that the *partners* also benefit from combining their *R&D portfolios* and *value chain* according to Figure 110.

6th hypothesis; Contents of the 100% product and its operating system

The contents of the 100% product and its operating system evolve as a function of the market development stage.

The next figure illustrates the stages involved in interactive development between a raw material and a *100% product*. The arrow named "actions" illustrates the iterativity of the process.

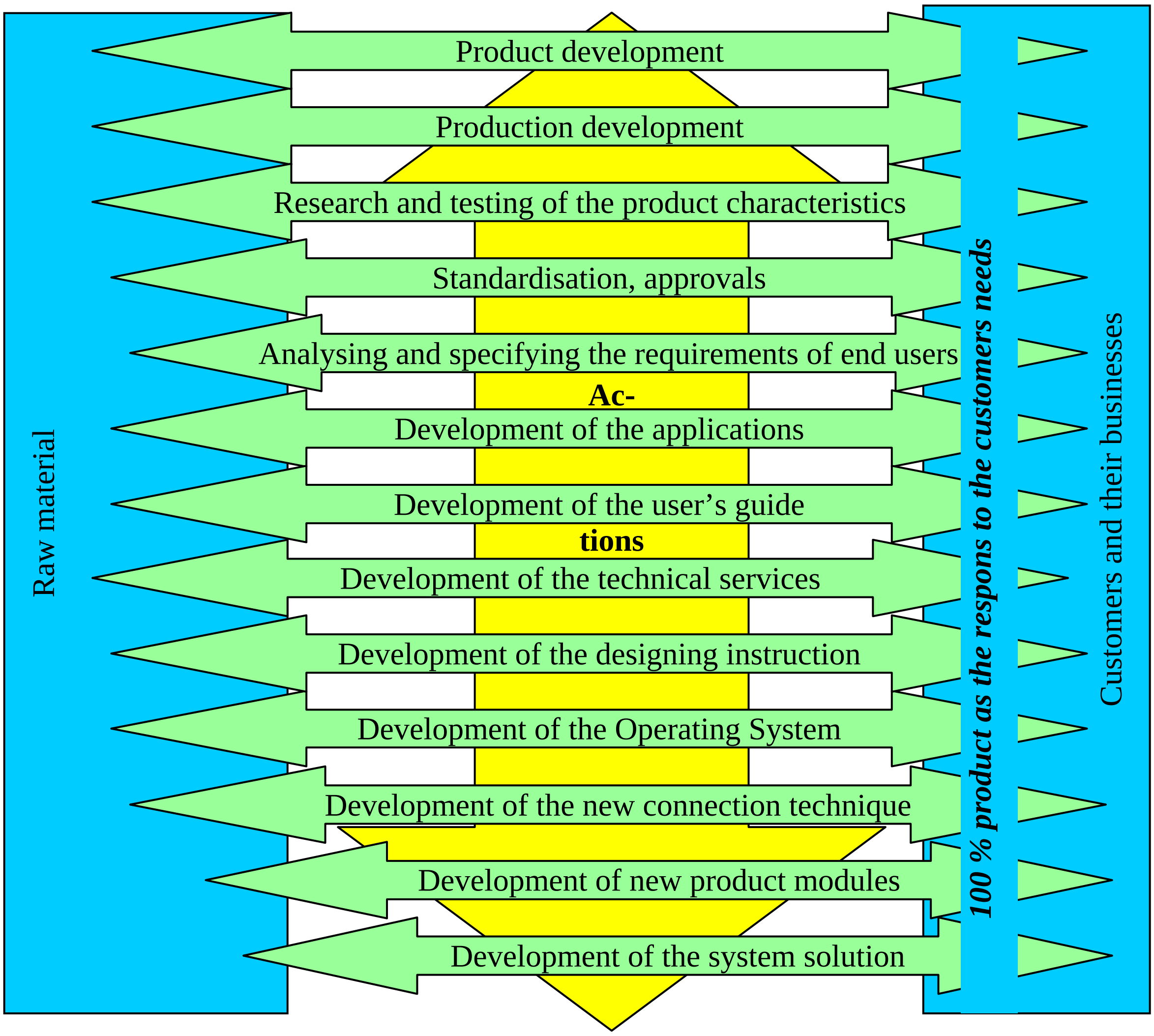


Figure 112. Interaction between raw material and customer businesses that lead to a 100% product.

The following table illustrates the contents of the *100% product* and *operating system* at different stages of a product's development. Simultaneously, the product expanded into a product family according to Figure 107.

Moore (1995, 155-156) refers to an equivalent development process, when the product overcomes the *Chasm*: "*there is still some tailoring to be done, but there is no new design work*." And further: "*Once the whole product (=100% product) gets sucked into the tornado, however, the marketplace applies stronger and stronger pressure to standardize the solution even further, pushing ever closer to commodity-level simplicity and cost to support ever-broader, ever-cheaper distribution*". The development process in the hypothesis thus acquires dynamism. The equivalent situation happened with Kerto-LVL, see next table.

Table 28. Development of a new structural 100% product and its operating system's contents described as a function of its development stage

Stage of the market development	Development of the *100% product*'s contents	Development of the *operating system*'s contents
Pilot plant stage	-The customer is largely unaware of the product, its use and the impact of its use on their existing operating practice -The producer has no prior knowledge of how to apply the product for an industrial customer's needs -The solution to the customer's current problem is sought together, by defining the product in a way that is convenient for both the producer and the customer. -The producer implements the agreed changes and add-ons to the product and modifies their own operation practice to ensure the manufacture and delivery of the newly defined product. -The customer modifies its operating practice in a way to achieve the benefit from using the product that was set as a target. -*100% product* is brought together as a result of these joint efforts.	-As an official document, authority approval is available for the basic product. -*Operating system* mostly consists of one-to-one technical and economic advice provided for the end user and their entire network (architects, technical designers and the authorities responsible for quality control and approvals) -On the basis of this experience, a user's guide for the product is developed cumulatively.
Industrial stage	As a result of prior experience, the product has become sufficiently reliable to extend its availability to larger-scale projects. The producer and customer modify their operating practices so that they become compatible with the ways to use the product. It is crucial to: -Achieve a common agreement on the product specification -Manage the product's quality -Manage delivery times An expanding customer base changes their operating practices as they can now simplify their site practices and working methods. -Product's distribution becomes viable -Designers master the product's applications	One-to-one service is no longer the main form of service: it is mainly targeted at demanding specialist projects. The operating system becomes increasingly automated: -Documented selection tables with instructions for user guides are available on-line, in sector manuals and training course materials. -Instructions regarding current and new technical use applications. -Instructions regarding integrated services required for the product.
Break-through stage	-Customers' product-related know-how increases -Part of the product-related services are transferred to the customer's organisation and part of them are assigned to other service providers within the network (architects, designers etc.). -Product-related customer-specific services are no longer needed. This happens in particular with customers using standard products, and simultaneously the product's position changes from the *solution* to the *distribution market*. -*Partners* develop together with their own network different degrees of readiness for re-manufactured products or solutions with all the needed information on how to design, assemble in the factory and erect on the building site. -In order to expand the end uses for the product a *key technology model* is designed using added technology.	-Services for existing products have become automated. They are now partly based on self-service and on-line design tools. -*Partners*' and customers' know-how on how to use the product develops into an expanding *operating system*.

<u>*Ideas for further discussion*</u>

Taking into account the previous hypotheses does not guarantee that a new wood product's R&D project will succeed in reaching the breakthrough stage. It is clear that a highly structured process is needed to develop a new product and achieve its breakthrough. In the early phases of the development process there are many open questions. If a functioning theory-based plan is not available, the operations should be carried out in stages; see chapter 4.3.1. Klus and Hirvensalo have reached the same conclusion (1997, 48-49): *A parallel and interactive development of the theory and its commercial application is the most effective approach, especially when dealing with such a heterogeneous material as wood*. From this we can draw the following conclusion: If the product, production technology and the market are all new to the company responsible for the R&D project, the company has to support the innovation process with a theory, which combines *business idea*, *innovation structure* and the application of the *key technology model,* cf page 9. The development work carried out in Kerto-LVL illustrates this kind of interactive process constisting of many stages.

When looking for an analogous situation in other products' development processes, it is important to take into account, amongst other characteristics, the length of the development process and the product's lifecycle, as well as sector-specific differences. In the concrete industry, for instance, Ductal® concrete by Lafarge is largely a similar product to Kerto-LVL in terms of its time cycle; however, the implementation models are completely different in these two products.

The long-term primary goal of product development in the concrete industry is to reduce the amount of water required for plasticizing. This has been done by replacing water with various chemicals, while ensuring that the product's strength development is not affected (Penttala 2005). In 1991 Bouygues drew up the preliminary ideas for such superplasticizers (Maître 2003). The actual development project was carried out by Lafarge in 1995-2000. More than 10 external laboratories were involved in Europe and North America (public, universities, private sector). Even though the aim was to realize the project on the basis of the *market pull* principle, the following figure by Maître in my opinion describes the project on the basis of the *technology push* principle. The material supplier also managed the R&D process. In the case of Kerto-LVL, this was not possible for the reasons shown in this study.

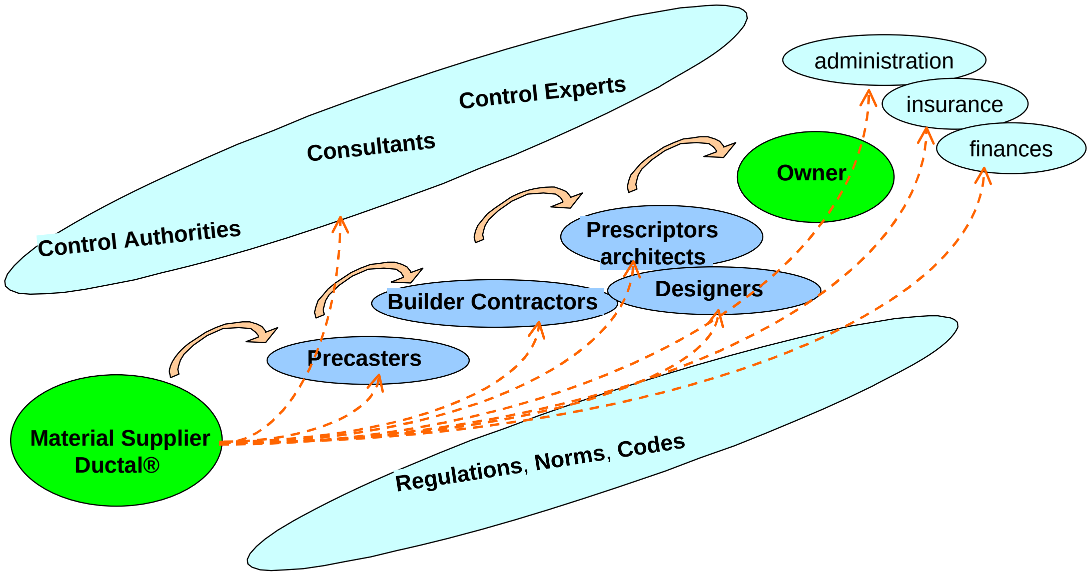


Figure 113. Development of the Ductal® concrete as a product for the market according to Maître (2003) "A huge effort of promotion to accelerate the development".

As a conclusion, it can be stated that no universal instructions can be given on how to carry out a product's R&D process and how to guide the interaction with the business. It is essential to analyse the stages and the needs of a new process as shown in this study and to identify the crucial factors. Kerto-LVL provides an example of how this was done in the wood products industry. The concepts presented in this study need to be analysed, understood and applied in terms of sector-specific circumstances.

8. SUMMARY

In this study I have examined the problems and successes involved in the development of a wood products industry innovation, Kerto-LVL, starting from the product idea and proceeding through various phases until its breakthrough in international markets. The main research question in this study is: How to develop a new structural product in the wood products industry if it is not just an improvement or substitute for an existing one, and what kind of interactions between business and R&D are necessary for the cooperation to function smoothly and lead to a profitable business. In the early stages of the development process, a product is in the *solution market*. My aim is also to bring forward new views of the central position of R&D in the business development for a new product.

The method used in this study is action research, concentrating on one product and its business development as a case study. The reason for opting for this method is that I was personally involved in the process as a member of the development team for most of the product's entire 25-year history. The team solved several problematic situations during the development of Kerto-LVL, using available research information supported by literature searches. Several concepts were selected to describe the position of Kerto-LVL in the market and a number of systematic tests were made on the technology and the product itself. The team solved some of the problems without giving more thought to the theoretical implications behind them. For the present study, I selected from these concepts the ones that I considered to be most relevant for describing the various development stages of Kerto-LVL. To explain the interaction between R&D and business development I defined a number of hypotheses. With a single case study it is only possible to induce hypotheses and demonstrate the product development process, so the validity of these hypotheses in other R&D processes could not be tested within the scope of this study. Other models also work, but they are not examined in depth here. In my opinion, the Kerto-LVL case provides a well-defined and documented context in which to evaluate the research question.

I have divided the development process into three stages: the pilot plant, industrial and breakthrough stage, which illustrate the focus of the Kerto team's operations during certain periods. At the end of each chapter describing a particular stage, I have evaluated how the content of the selected concepts developed during this time. As a result, six hypotheses emerge. Hypotheses 1 to 3 define the prerequisites for a successful development process at a general level and hypotheses 4 to 6 describe the structure of the operations themselves:

1 *Commitment* as a dynamically changing process.
2 Starting the change in operating practice.
3 Autonomy requirement for a developing business idea.
4 Formation of *innovation structure* and *partnership.*
5 *Partnering* leading to a merging of business ideas and strategies in the *solution market.*
6 Contents of the *100% product* and its *operating system.*

The prerequisite hypotheses were extended from the definitions given in existing literature on business development and R&D. This was necessary because the precise interaction *between* R&D and business has not been analysed in previous research. Hypotheses 4 to 6 significantly add to the understanding of the interactive relationship between *innovation structure* and *partnership*, set up to develop a new product.

As well as the hypotheses, in this study I have also developed the content of the selected concepts further to describe in greater detail the dynamic change that is closely linked to a new wood product's development process. Understanding these concepts is crucial for the development teams to get their priorities right during the project stages.

The study revealed that the interaction between R&D and business can accelerate the product's penetration in the market and consequently result in increased growth in profits. An operating method using a *key technology model* will further increase the efficiency of operations. The development of a new wood product is such a complex process that priority must be given to creating controlled and balanced interaction between the different areas of the operator network. The manufacturer of the product, R&D units and the customer need to work together to create a connection between the *technology push* and the *market pull* shown in conclusion of the 2nd hypothesis. Moving up to a higher position in the *value chain* requires more and more market input and most often higher *value chain, partnerships* and expertise.

In my opinion, further research is needed to gain a better understanding of the interdependence between the given concepts at different stages of the development process. The *key technology model* showed its profit-creating capacity and performance, and therefore offers a lot of potential for further research.

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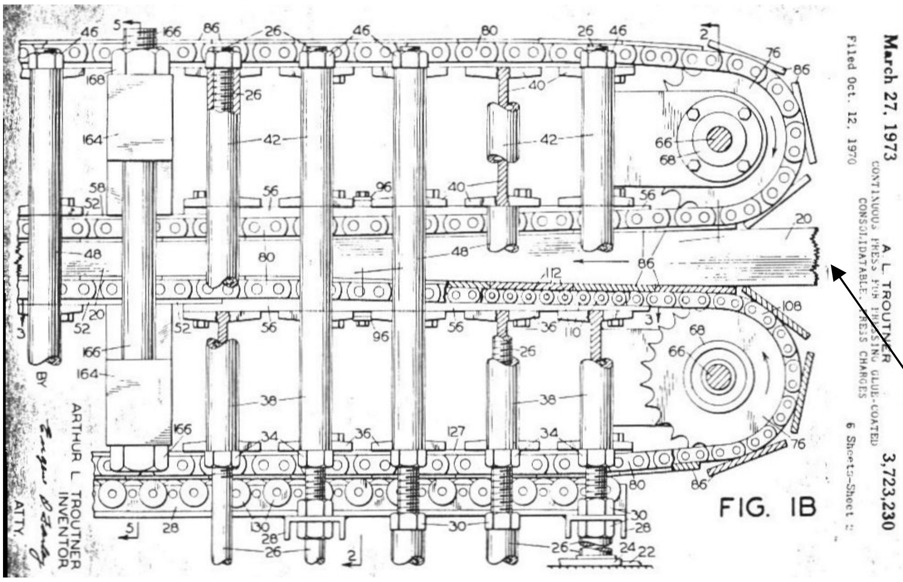
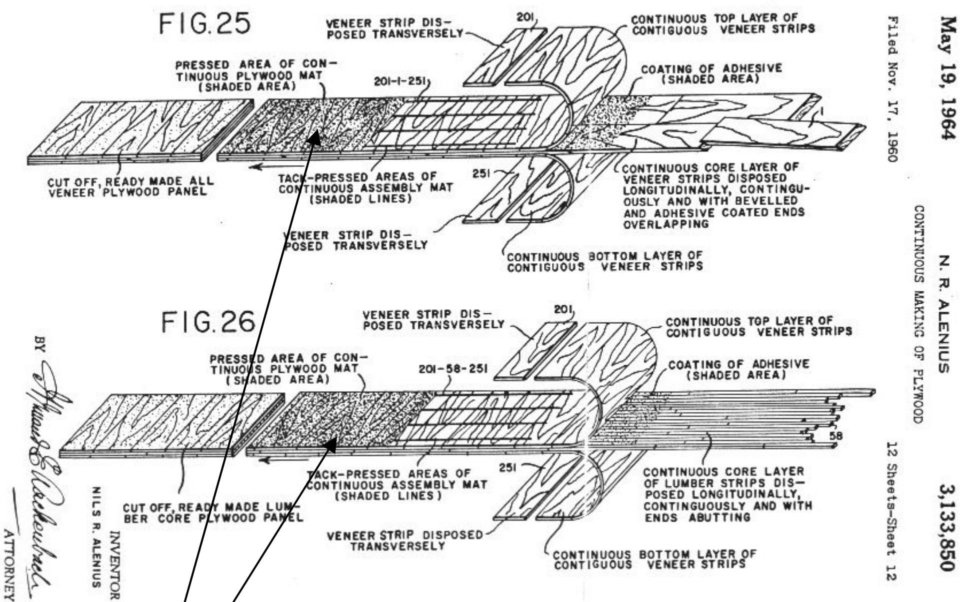
APPENDIX I Micro-Lam-LVL process and ANRA line of Alenius



Idea of Trus Joist – line patented by Troutner in 1973. Lay upped and glued LVL billet is moving into the hot press with 300 mm (12”) steps pulled with chain into the tapering space between hot plates



Idea of Anra line patented by Alenius in 1964. Lay up position is on the right hand side. The glued billet is fed as a continuous panel with constant speed. The wheeled hot press moves with the billet (shaded area) and is pressing that at a temperature of 125 ˚C. When the glue bond is cured, the hot will be opened and returned backwards for its own length (about 10 m) to get a new glued billet. The hot press is functioning stepwise with length of the hot press so that there is no disturbing discontinuity in the billet.

APPENDIX II Metsäliitto as a business enterprise; R&D in Metsäliitto

Table 29. Summary of R&D projects carried out within the Metsäliitto panel industry in the 1970's (Kettunen 2002, 43 and 65-71) (Lehtonen 2003).

Project	Aim/Objective	Result	Start
Improving the cha-racteristics of particle boards	Reducing formaldehyde in urea glue and switching to a formaldehyde-free glue Strength improvement by orientation of chips Alkyd primer coated particle board	A reduction of the formaldehyde content was achieved in cooperation with the glue suppliers. New formaldehyde-free glue was too expensive for the markets Proportion of sanding dust as panel material increased, reducing the price of the panel. Furniture manufacturers were not willing to pay the extra cost. Development investment which brought a significant competitive advantage	1973-1977
Kerto-LVL	Develop a structural material which would replace sawn timber. The aim was to obtain a higher strength capacity from the same log material as compared to glulam. A higher value would be thus achieved from the wood material used.	Demanded 25 years of goal oriented efforts in development. New basic industry product. Constitutes a basis for the corporation's EWP business (engineered wood products).	1973
Silko board	Development of a 3-ply composite panel overlaid on both sides with thin hardboard facing panels and with a particle board core. A higher quality panel to replace block board.	Delay in start-up due to problems relating to production technology and to product quality. The market situation changed in the meantime, and as a consequence the product was never marketed. The importance of reporting was understood through this lesson. In the subsequent years the component selection within the automated process was carried out in-house.	1973
Karatex glue	Replace half of the phenol resin used in gluing of plywood with wood lignin.	The Karatex glue had a longer curing time and required a higher pressing temperature than a conventional phenol resin glue. After the 1974 oil crisis the phenol price fell, and at the same time R&D in glue progressed significantly. The glue project was terminated, but a new technology, the ultra filtering technique, was adopted (by 1999 the use of this method was 1,000 times more than in the 1970's).	1975
Finflake	Testing through a pilot stage of a new construction board in order to develop a competing product to conifer plywood, by utilizing Silko mill's empty premises and parts of its equipment.	Within the corporation, Savon Sellu needed birch as a raw material. Finflake was challenged by cheap North American conifer plywood. The type approval procedure was slow. The product was ahead of its time, given that the current production volume exceeds 2 million m^3/a.	1976
Saima parquet	To replace the closed block board production line, a new production line based on birch veneer was established at the block board plant in Lappeenranta.	Radically different to the rest of the corporation's business. Knowledge of the consumer market was insufficient. Transfer to Suolahti was a bad solution. Project was cancelled: "We've got this equipment, go find a product for it."	1977
Fire resistant particle board "Palo-Ilves"	The manufacture of particle board using an adhesive with high hygroscopic water content, which allows slowing down the temperature rise in case of fire.	By means of a relatively small investment, the service life of the Hämeenlinna particle board plant could be extended by several years. Successful product development within the company for the first time through a purely theoretical concept.	1977

Over the years, Metsäliitto Cooperative has maintained its dual role: it acts as a wood procurement organisation for the Metsäliitto Group's mills, and, through its subsidiaries, it is engaged in the whole range of forest industry activities (www.metsaliitto.com). Below is shown the development of the organization in Kerto-LVL's point of view (Kivelä 2005). Metsäliiton Myyntikonttorit (MK) Oy and later on Metsä-Serla Myyntikonttorit and Rakentajan Starckjohann Oy were for sale of mechanical wood products in Finland.

Metsäliitto Cooperative: Parent company	Purchasing company for the raw material Investment operations	
Metsäliiton Teollisuus Oy		
Pulp, paper and board industry	Mechanical wood industry	Metsäliiton Myyntikonttorit (Mk) Oy sales company

Metsäliitto Group's organization in 1974 (see also Zetterberg 1983, 235).

Metsä-Serla Oy		
Pulp, paper and board industry	Mechanical wood industry	Metsä-Serla Myyntikonttorit (Mk) Oy sales company

Merger between Metsäliitto and Serlachius in 1987.

Metsä-Serla Oy		
Metsä-Serla Oy for pulp, paper, board and saw mill industry	Finnforest Oy for wood-based panel industry	Metsä-Serla Myyntikonttorit (Mk) Oy sales company

Forming Finnforest Oy in 1990.

Metsäliitto Cooperative: Parent company	Purchasing company for the raw material Investment operations	
Metsä-Serla Oy for pulp, paper, board and saw mill industry	Finnforest Oy for wood-based	25 % share of Rakentajan Starckjohann Oy sales company

Forming Metsäliitto Group organization again. Rakentajan Metsä-Serla was sold to Rakentajan Starckjohann in which Metsäliitto became a part owner in 1991.

Metsäliitto Cooperative: Parent company	Purchasing company for the raw material Investment operations
Metsä-Serla Oy for pulp, paper, board and saw mill industry	Finnforest Oy for wood-based panel industry

Metsäliitto's part of Rakentajan Starckjohann was sold off in its entirety in 1993.

Metsäliitto Cooperative: Parent company	Purchasing company for the raw material Investment operations
Metsä-Serla Oy for pulp, paper and board industry	Finnforest Oyj for mechanical wood industry

Forming Finnforest Public limited company (Plc) in 1999 (see also Finnforest annual report 1999).

APPENDIX III LVL in the US

<u>Roofing system of Gang-Nail</u>

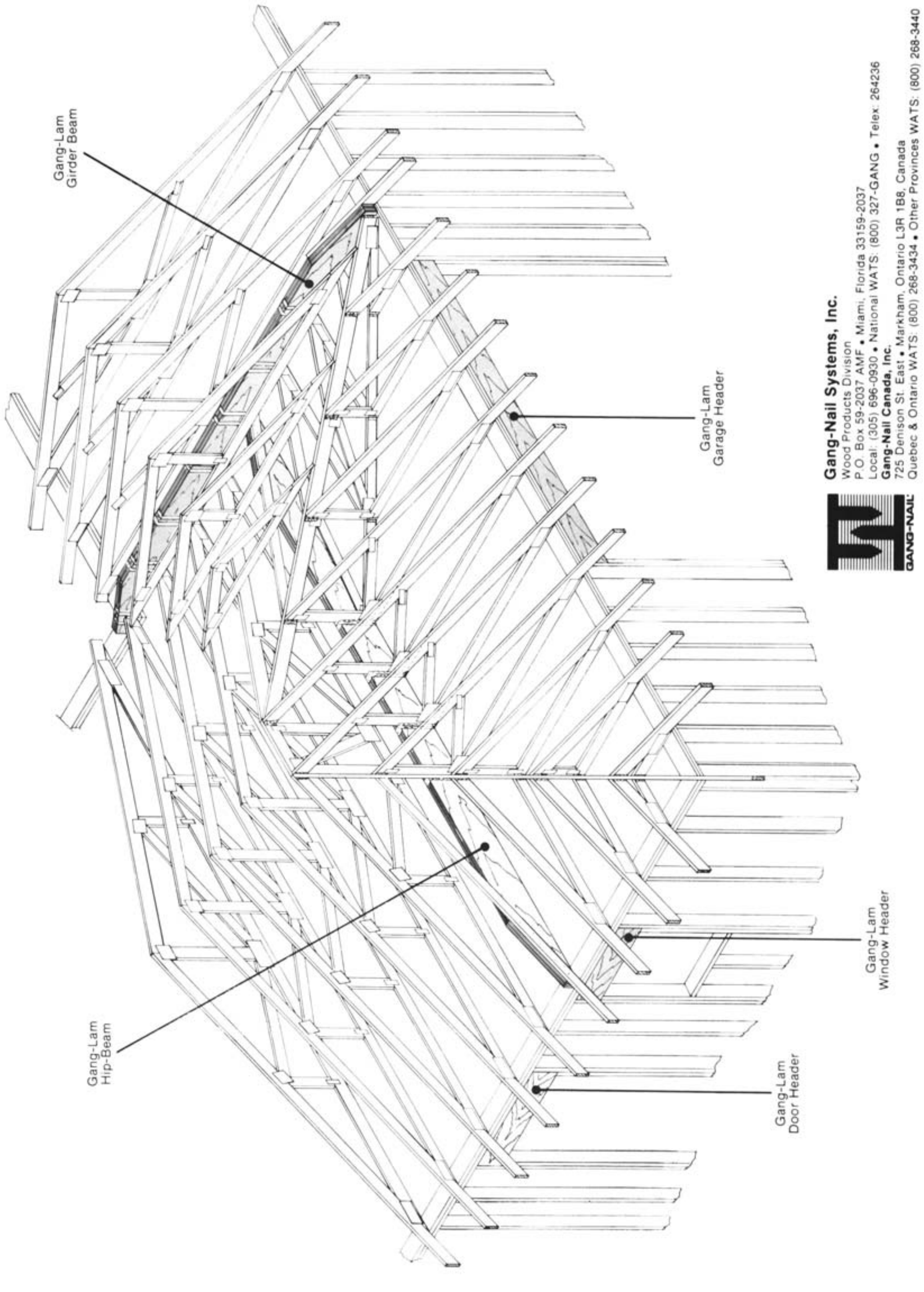


Figure 114. Roofing concept with LVL in the middle of the 1980s in the US.

Idea of the Louisiana-Pacific EW Product concept in 1992.

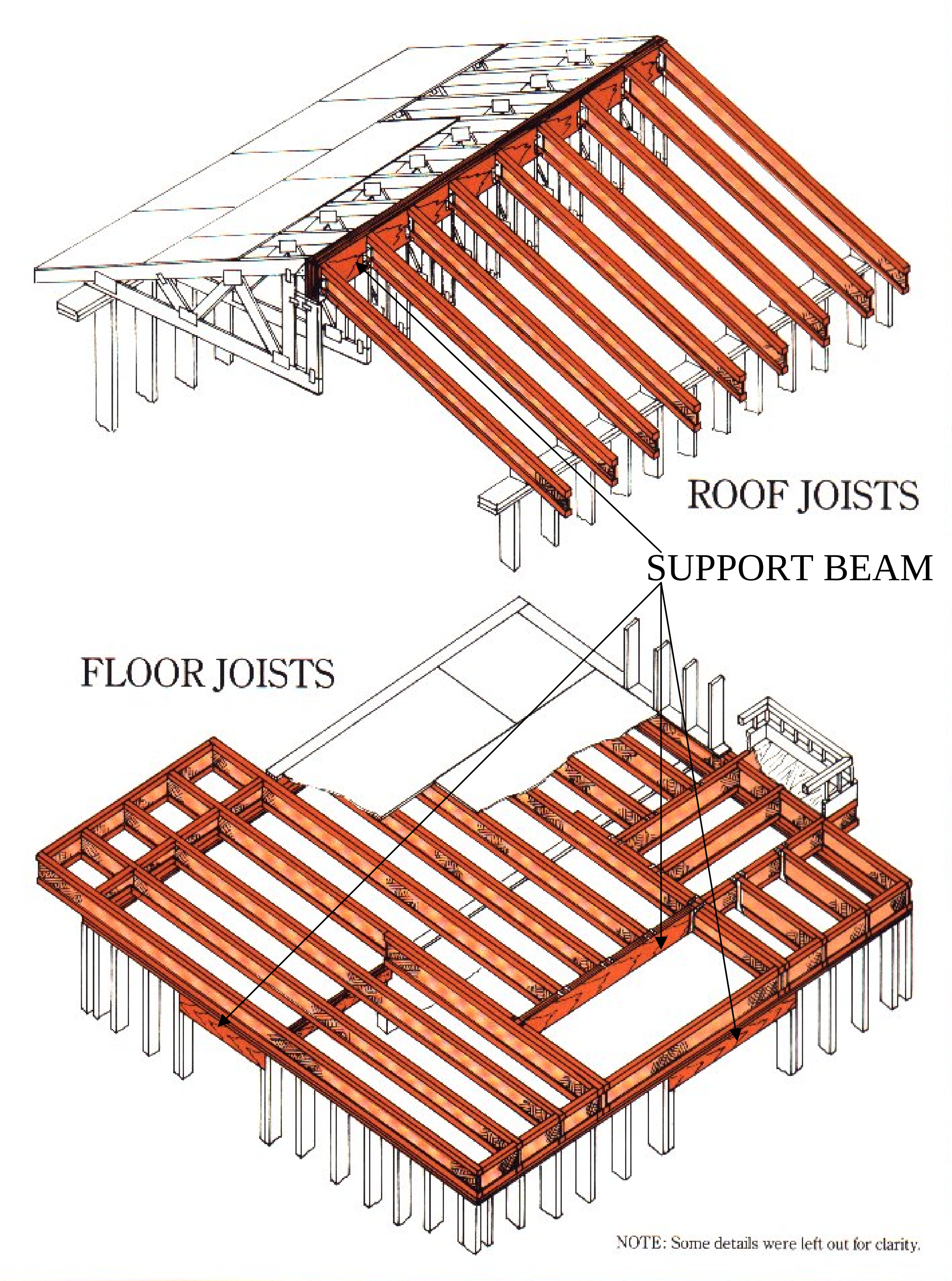


Figure 115. LVL was first used in the US in house building as a support beam and for the upper and lower flanges of I-joists (source: Lousiana-Pacific leaflet 1992)

LVL distribution strategies in USA

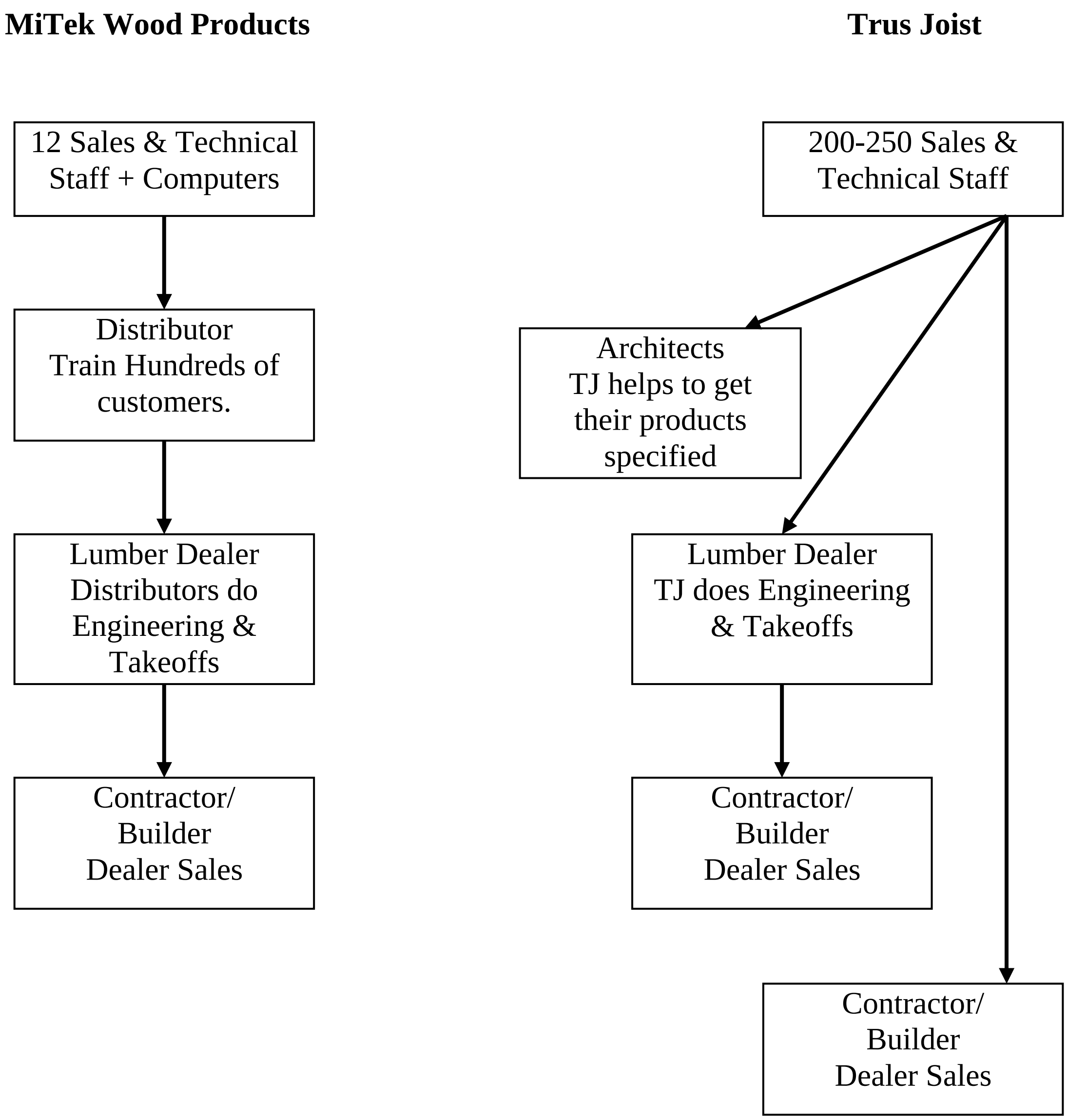
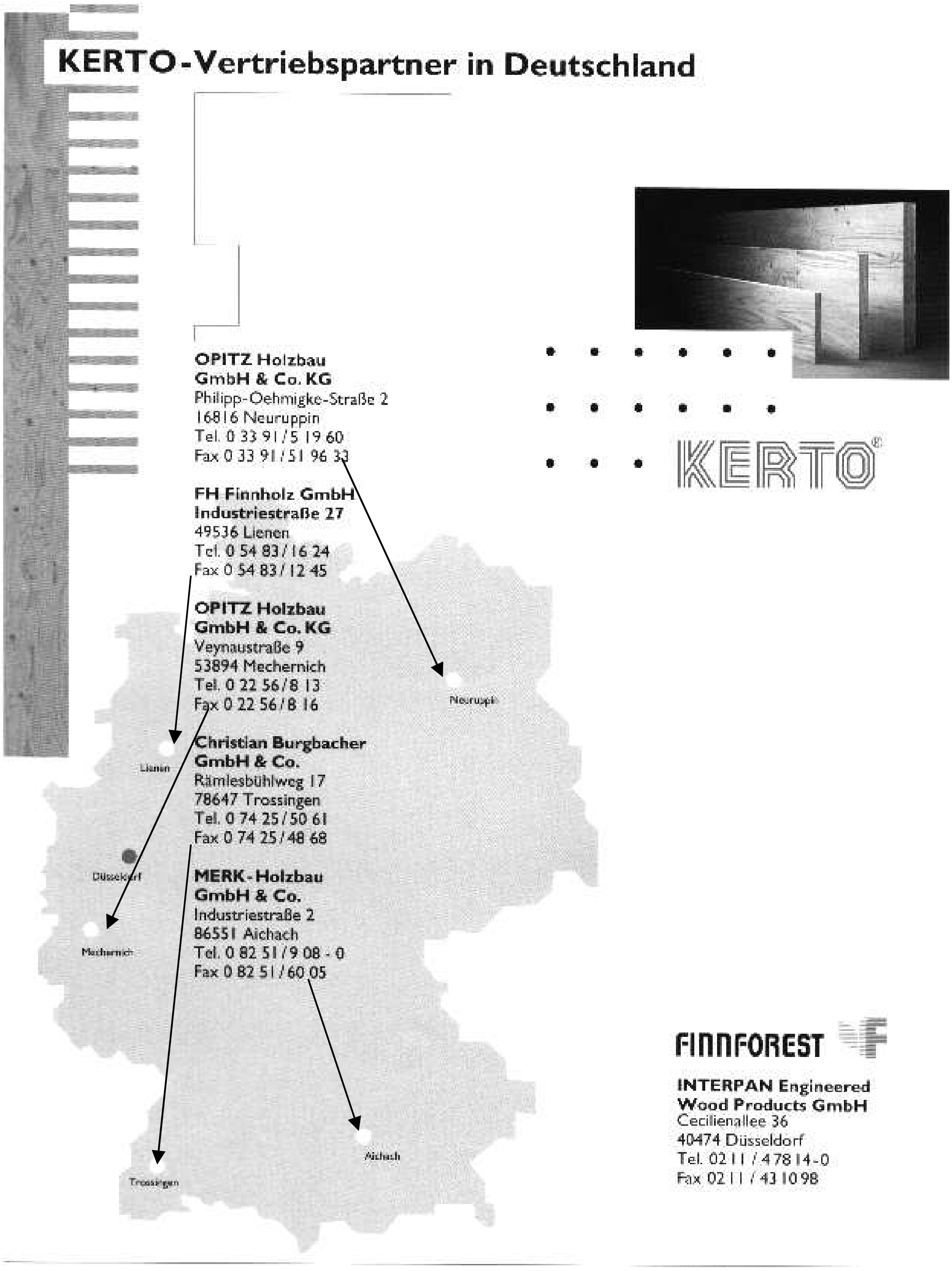


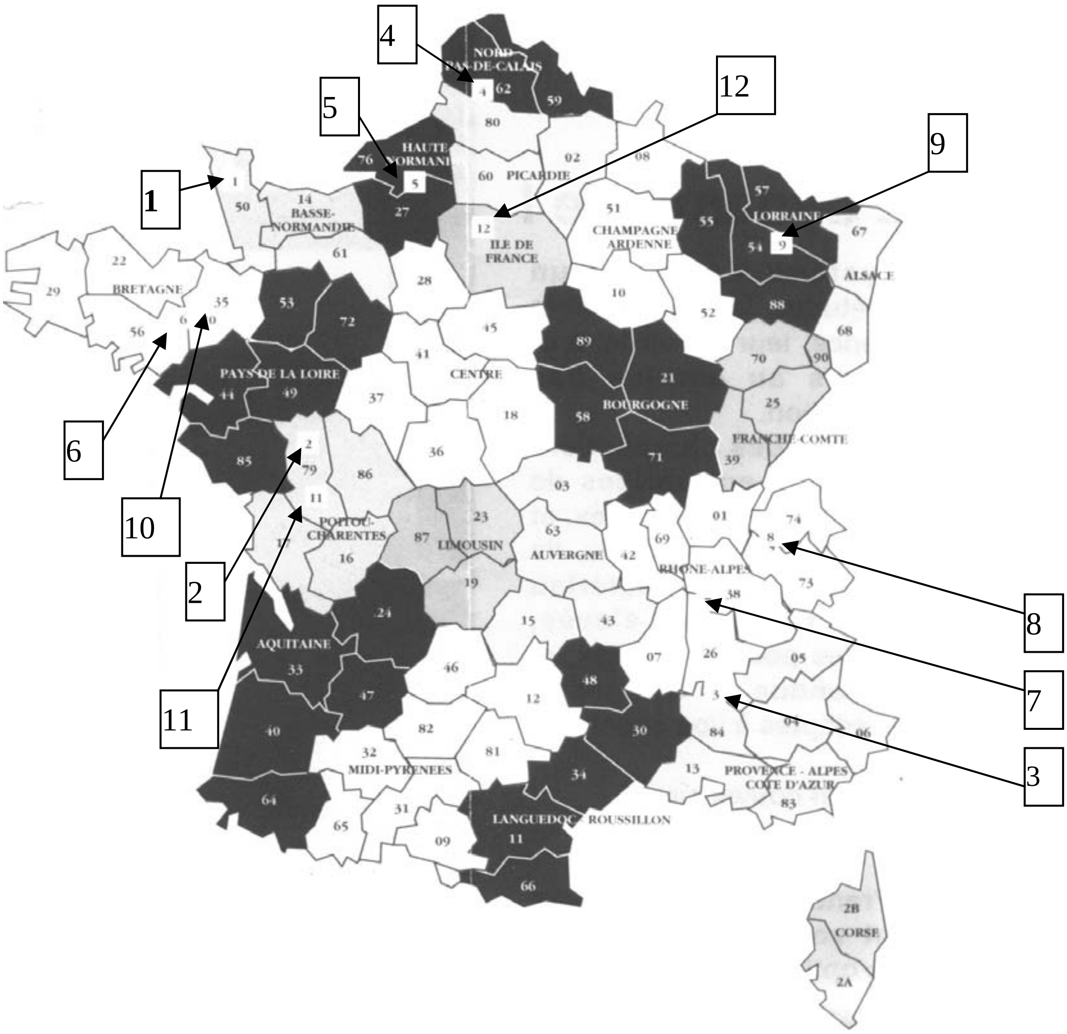
Figure 116. In the USA, Trus Joist was already at the end 1980s a sub-product supplier, while MiTek (since June 07th 1990 Lousiana-Pacific) operated in the traditional distribution market (source: MWP).

APPENDIX IV Kerto in Germany in 1997



APPENDIX V Kerto-LVL in France

<u>Les Charpentiers de Kerto Lamibois in France</u>



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Le Mont-Saint-hilaire
Petitville
B.P. 409
50500 CARENTAN
Tél. : 33 42 33 13
Fax : 33 71 18 30

2 - CMB
Rue de Lattre
Z.I. - B.P. 36
79700 MAULEON
Tél. : 49 81 80 99
Fax : 49 81 84 65

3 - LES CHARPENTIERS DE LA DRÔME
Zone Artisanale
26200 SAINT-DONAT
Tél. : 75 45 21 09
Fax : 75 45 01 39

4 - COQUART
Beauvoir Wavans
62390 AUXI-LE-CHATEAU
Tél. : 21 41 08 62
Fax : 21 03 02 84

5 - CORDONNIER
28, rue du Moulin Bleu
B.P. 32
76270 NEUFCHATEL-EN-BRAY
Tél. : 35 93 01 75
Fax : 35 94 20 73

6 - DUBOIS
Z.A. des Rosaies
35550 SIXT-SUR-AFF
Tél. : 99 70 08 13
Fax : 99 70 08 14

7 - LABAT
71 Chemin des Meunières
38260 LA COTE SAINT-ANDRÉ
Tél. : 74 20 40 32
Fax : 74 20 30 62

8 - LABAT ET SIERRA
La Balme de Sillingy
74330 LA BALME-DE-SILLINGY
Tél. : 50 68 70 61
Fax : 50 77 71 11

9 - MARTIN
Z.I. de la Croix de Metz
54200 TOUL
Tél : 83 43 09 28
Fax : 64 33 96 42

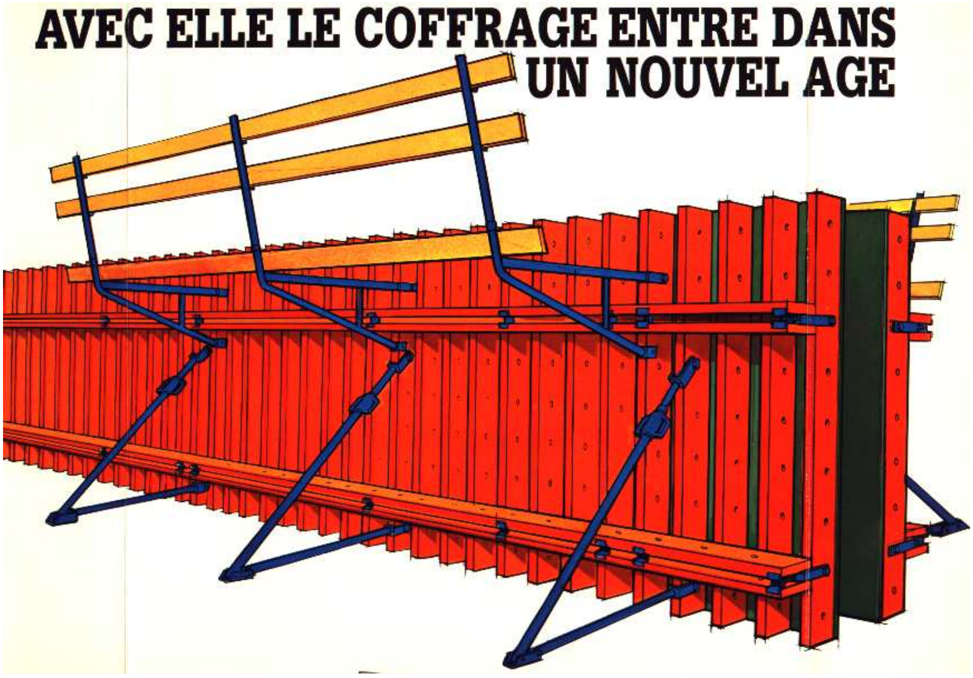
10 - MASSON
Z.I. de Beaucé
Route de Paris
35133 FOUGÈRE CEDEX
Tél. : 99 99 44 56
Fax : 99 94 36 49

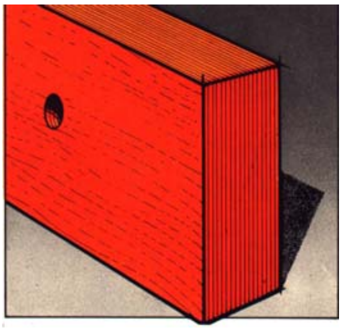
11 - MORISSET et Fils
Route de Bressuire
79430 LA CHAPELLE-SAINT-LAURENT
Tél. : 49 72 00 39
Fax : 49 72 50 25

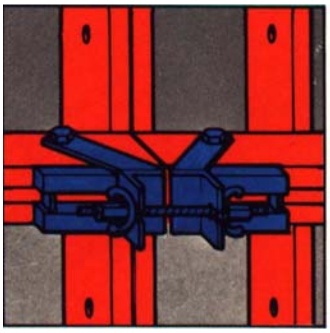
12 - PARIS CHARPENTE
25, rue Cuvier
93100 MONTREUIL
Tél. : 48 59 00 40
Fax : 48 59 80 79

source: Rambert S.A. folder at the Batimat exhibition 12. – 19.11.1991

<u>*La Finlandaise®*</u>







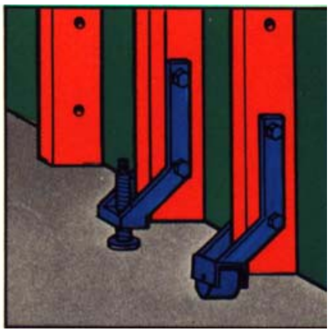


Figure 117. La Finlandaise® concrete forming system developed by Coffrages Ricard. Kerto-LVL cross-section was 51x150 mm with ø 25 mm holes c/c 300 mm. Steel accessories were developed for all necessary details (source: Ricard leaflet 1983).

Nouveau Espace

The idea is to build more space on the roof. The old nail plate trusses are reinforced so that required diagonals and verticals can be cut out.

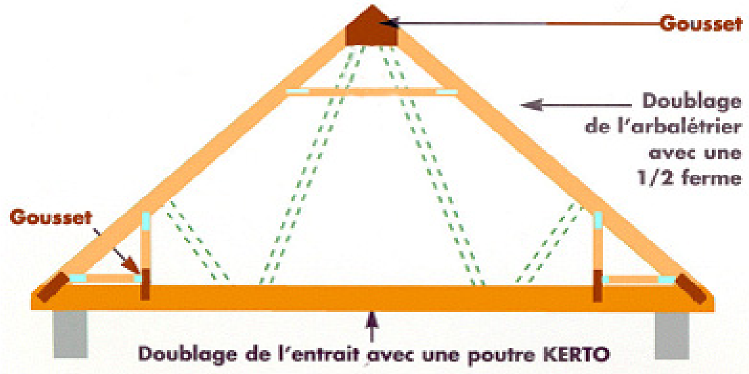


Figure 118. "Noveau Espace" (source: Rambert S.A.)

APPENDIX VI LVL production lines delivered by Raute Wood

No.	Customer	Year	Capacity m^3/a	Line type	Press size	Trade mark Wood species
1 x)	I.P.L Mount Gambier Australia	1976 (1986)	5,000	1-opening Manual lay-up	1,4 x 7 m 4 x 22 ft	Radiata Pine Pinus radiata
2	FINNFOREST OY Lohja Finland	1980	20,000	1-opening Automatic lay-up	1,95 x 17 m 6 x 55 ft	Kerto LVL Norwegian Spruce Picea abies
3	LOUISIANA-PACIFIC (originally Gang-Nail Systems, Inc.) Wilmington, NC USA	1985	20,000	1-opening Automatic lay-up	1,4 x 24,8 m 4 x 80 ft	Gang-Lam Southern Yellow Pine Pinus palustris
4	FINNFOREST OY Lohja Finland	1986	31,000	2-openings Automatic lay-up	1,95 x 14,3 m 6 x 46 ft	Kerto LVL Norwegian Spruce Picea abies
5	LOUISIANA-PACIFIC Wilmington, NC USA	1988	34,000	2-openings Automatic lay-up	1,4 x 24,8 m 4 x 80 ft	Gang-Lam Southern Yellow Pine Pinus palustris
6 x)	BOISE CASCADE CORP. White City, OR USA	1989		1-opening cold press	1,4 x 20,4 m 4 x 67 ft	Versa-Lam Douglas Fir Pseudotsuga menziesii
7	KEYO Co. Kisarazu Japan	1990	20,000	2-openings Automatic lay-up	1,4 x 16,4 m 4 x 53 ft	Keylam Various species
8	TEMBEC Ville Marie, Quebec Canada	1990	20,000	1-opening Automatic lay-up	1,4 x 24,8 m 4 x 80 ft	TemLam Aspen Populus tremuloides
9	LOUISIANA-PACIFIC Fernley, NV USA	1992	34,000	1-opening RF-heated press	1,4 x 20,1 m 4 x 65 ft	Gang-Lam Southern Yellow Pine & Douglas Fir
10 x)	JUKEN NISSHO LTD Gisborne New Zealand	1993	36,000	Automatic lay-up & pre-pressing line		Radiata Pine Pinus radiata
11	LOUISIANA-PACIFIC Fernley, NV USA	1994	34,000	2-openings Automatic lay-up	1,4 x 21,2 m 4 x 68 ft	Gang-Lam Southern Yellow Pine Pinus palustris
12	LOUISIANA-PACIFIC Wilmington, NC USA	1994	34,000	2-openings Automatic lay-up	1,4 x 24,8 m 4 x 80 ft	Gang-Lam Southern Yellow Pine Pinus palustris
13	GEORGIA PACIFIC Roxboro, NC USA	1995	30,000	1-opening Automatic lay-up	1,95 x 30,9 m 6 x 100 ft	G-P Lam Southern Yellow Pine Pinus palustris
14	BOISE CASCADE CORP. Alexandria, LA USA	1995		High capacity lay-up line		Versa-Lam Southern Yellow Pine Pinus palustris
15	WILLAMETTE INDUSTRIES, INC. Millersburg, OR USA	1995	34,000	1-opening RF-heated press	1,4 x 24,8 m 4 x 80 ft	StrucLam Douglas Fir
16	SURYA DUMAI GROUP Perawang Indonesia	1997	72,000	2 x 2-openings Automatic lay-up	2 x 1,95 x 18,8 m 6 x 62 ft	Fixture LVL Mixed trop. HW Plantation species
18	FINNFOREST OY Lohja Finland	1998	44,300	2-openings Automatic lay-up	1,95 x 18,8 m 6 x 62 ft	Kerto LVL Norwegian Spruce Picea abies

19	KEYTEC Co., LTD Kisarazu Japan	1998	48,300	24-openings Two lay-up & pre-pressing lines	1,4 x 6,2 m 4 x 20 ft	Keylam Various softwood species
20	WILLAMETTE INDUSTRIES, INC. Simbsboro, LA USA	1998	74,300	3-openings Merger lay-up	1,4 x 24,8 m 4 x 80 ft	StrucLam Douglas Fir
21	EVANS FOREST PRODUCTS Golden, BC Canada	1998	45,000	2-openings Automatic lay-up	1.4 x 24.8 m 4 x 80 ft	Douglas Fir
22	GEORGIA PACIFIC Roxboro, NC USA	1999	45,000	2-openings Automatic lay-up	1.4 x 24.96 m 4 x 81.9 ft	G-P Lam Southern Yellow Pine Pinus palustris
23	ROSEBURG FOREST PRODUCTS Roseburg, OR USA	2000	187,000	8-openings Two merger lay-up lines	1.35 x 27.4 m 4 x 90 ft	Douglas Fir
24	FINNFOREST OYJ Punkaharju Finland	2001	83,600	8x8 ft 2-openings Automatic lay-up	2.65 x 24.9 m 8 x 80 ft	Kerto-LVL Picea Abies Pinus Silvestris
25	LVL UGRA Nyagan, Khanty Mansisk Russia	2002	37,980	2-openings Automatic lay-up	1.95 x 18.8 m 6 x 62 ft	Pine Pinus Silvestris
Total capacity (installed + ordered)		1,067,460 m3/a				

x) Pressing line not included

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