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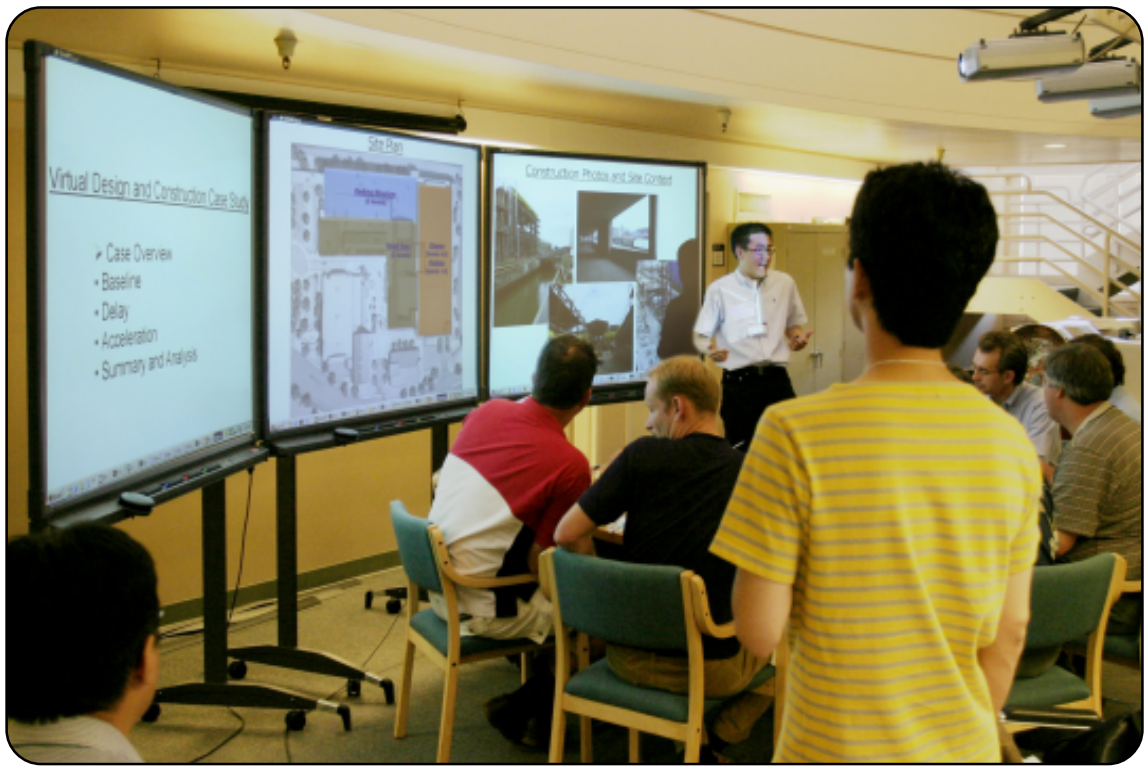

Tapio Koivu, Tuomo Laine, Veijo Iivonen &
Dan Gonzales

Options for the Finnish FM/AEC software packages for market entry in the U.S.

VTT TIEDOTTEITA – RESEARCH NOTES 2211

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Executive summary

This report describes results of a project executed cooperatively by Technical Research Center of Finland (VTT) and the Finland Trade Center (Finpro). The aim of the study has been to find out the opportunities for a group of Finnish Facility Management, Architectural, Engineering and Construction (FM/AEC) industry software vendors to launch business in the United States.

The report gives an overview of the industry, discusses the roles of different disciplines and value chains. It identifies high-tech offices and manufacturing facilities, pulp, paper and power plants, concept construction and public sector facility owners as potential market segments and discusses their maturity and readiness to partner with the Finnish vendors. An overview of the U.S. vendor market is also given as well as descriptions of major competitors and their products.

A suggestion of how the Finnish software products can interoperate is also given in the report. The basic argument is that competitive advantage can be built on openness of the Finnish products. The Finnish products, Tocoman's TCM-software for quantity take-off, cost estimating and control, DynaProject for scheduling by DSS, EcoProp by VTT, xEngineer by Tekla, Optimize.net by Rapal, ModelServer by Eurostep and ModelChecker by Solibri can be made to support the business processes of U.S. customers in open, modular and interoperable way. Finnish references of how these software packages can add value together exist today.

The conclusion states that the market is not mature yet and that technology is not completely mature either, the most likely option to succeed is to form a combination of consulting service and software sales. The customers are not IT-savvy and they will be requiring education, training and consulting in order to exploit the potential. At this point, the breakthrough still awaits itself. The consulting offers a step that does not exclude the formation of a more traditional software vendor business later. The consulting also allows a time frame for the much-needed further development of the software, especially interoperability features and model server concept as well as for producing actual proof in real construction projects.

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1. Introduction

1.1 VERA program and Finnish FM/AEC Software

Finland has gained a reputation of being in the forefront in applying IT to Facilities Management, Architectural, Engineering and Construction disciplines. Finland is technologically more advanced in the area of interoperability and standardization in this segment than the U.S. Mostly this is due to investment programs in technological development work over the last two decades. Especially during the last six years the Finnish facility management, architectural, engineering and construction industry (FM/AEC) has had the opportunity to develop tools under VERA-technology program (Information Networking in the Construction Process) administrated by the Technology Agency of Finland (Tekes). The vision of the program was centered on the integration of all FM/AEC information throughout the lifecycle of projects using information-modeling standards. Furthermore, the vision was not at the level of individual companies, but rather on the integration of companies spanning the lifecycle of projects and throughout the industry as a whole – at the level of networks of companies. Achieving such system in technological innovation has been a great challenge, but the potential benefits of the target technologies can only be realized if they attain such widespread use. The program ran for six years. The overall volume of the program was 47 million euros, of which 22 million euros were funded by the Finnish government through Tekes.

The program was evaluated during its last months. The results and conclusions of the evaluation pointed out that the program placed a high emphasis on an international focus. There were several aspects to this: the program established Finland's reputation as a world leader in this area of technology and helped to create international business opportunities for Finnish technology companies. Prof. Martin Fischer and Prof. Froese stated at the final seminar of the program in Helsinki that Finland is the leading country in the area of information technology in FM/AEC industry. Perhaps the most important international aspect is that the technological vision is based on the creation of standards for exchanging project information, and this is necessarily an international task. Support and input from the VERA program had a significant positive impact on the progress of the International Alliance for Interoperability's IFCs [Uusikylä et al., 2003].

Furthermore, the evaluation states that Vera-sponsored work is already beginning to create an industry for Finnish companies to offer IT tools and services to international markets [Uusikylä et al., 2003]. This report and project can be seen as an additional step towards internationalization of the results of VERA.

1.2 Aim of this study

This study has been initialized by Technical Research Center of Finland together with its partners both in Finland and abroad. Technology agency of Finland has sponsored this project as well as the participating companies. The project aims at finding out whether there is an opportunity to combine Finnish FM/AEC software packages to add value to the potential customers in the U.S. The sub-aims of the project are to

- Produce a market analysis on the current and future customer expectations, emerging trends, and competition,
- Search for potential partners in the U.S.
- Analyze the Finnish joint software offering,
- Analyze the level of commitment of the Finnish companies towards a joint effort in the U.S., and
- Produce alternative strategic options for further steps.

The project will deliver a preliminary description of the joint offering, a report on the market potential and trends as well as on the alternatives. For the participating companies, this project helps in opening an alternative for exporting software as well as a more detailed picture of the possibilities or issues in launching software business in the U.S. in this particular industry.

The readers of this report are expected to be primarily the managers and decision-makers of the companies interested in a market entry to the U.S. Some of the companies are listed in this report but the writers do not wish to make the conclusions and recommendations exclusive for any potential partner in an endeavor to enter the U.S. market with this group. Also, this report is meant to help in potential negotiations with venture capitalists or other interested partners and investors.

1.3 Execution & acknowledgements

This project owes its origin to discussion during the VERA evaluation process between Prof. Thomas Froese, University of British Columbia and Mr. Arto Kiviniemi, the program manager of VERA. Prof. Froese commented on the Finnish possibilities during the early spring of 2002 and suggested that a joint effort of the companies might lower the threshold for internationalization for the Finnish companies. After exploring this idea, a proposal to launch a project was discussed with the Tekes. A project team was formed during the fall of 2002 and the project launched with a market study before Christmas 2002. The results of the project were presented in a workshop arranged for potential exporting software vendors in Helsinki, May 15th, 2003.

The project was executed as a joint effort between the Technical Research Center of Finland, (VTT) Silicon Valley, The Finland Trade Center (Finpro), Palo Alto and Design Village, Oakland. The project manager was Dr. Tapio Koivu, VTT Silicon Valley, Mr. Tuomo Laine (Finpro, Helsinki) was responsible for the contacts and project management in Finland, Mr. Veijo Iivonen (Finpro, Palo Alto) has written the majority of the market analysis, Mr. Dan Gonzales (Design Village, Oakland) has provided the team insights about the value chains in the U.S. as well as future trends in technology and Mr. Kim Hurtta (Finpro, Helsinki) has assisted in analyzing the Finnish software offering.

Mr. Esko Enkovaara, CEO of Tocoman Oy, chaired the steering group of the project. The members of the group were Mr. Risto Räty and Mr. Ragnar Wessman, Tekla Oyj, Mr. Heikki Kulusjärvi, Solibri Oy, Mr. Olli Seppänen, DSS Oy, Mr. Leo Torvikoski, Eurostep Oy, Mr. Matti Martola and Mr. Mitro Mero, Rapal Oy, Mr. Arto Kiviniemi, VTT and Mr. Reijo Kangas, Tekes. The steering group has provided the project team invaluable insights both on the technology and business development issues. The awareness and knowledge of the steering group of the U.S. market is also very high. This has given the project a sound basis for making a successful attempt in starting a possible joint effort to actually launch business in the U.S.

2. Software markets

2.1 Overview of the industry

The United States is the largest single construction market of the world with more than a quarter of the global construction activity. According to the U.S. Census Bureau the total annual construction put in place has exceeded USD 800 billion in recent year with 2002 being the top year with a total estimated (preliminary) construction value of USD 846 billion. The U.S. construction industry is also significant as an employer with 6.7 million people in its payroll.

The construction industry is divided into three main segments: general building contractors, heavy construction contractors and special trade constructors – which typically serve as subcontractors. Major members at the top of the construction value chain are the architecture and engineering companies – and naturally the property owners.

The construction industry can be broken down also by end product, i.e. type of building/object to be constructed. In 2001 (Fig. 1), residential construction – including single and multifamily housing – was by far the largest construction segment with 46 percent of the total. Private non-residential construction, which covers commercial and industrial construction, accounted for nearly a quarter (24 percent) of the overall construction business.

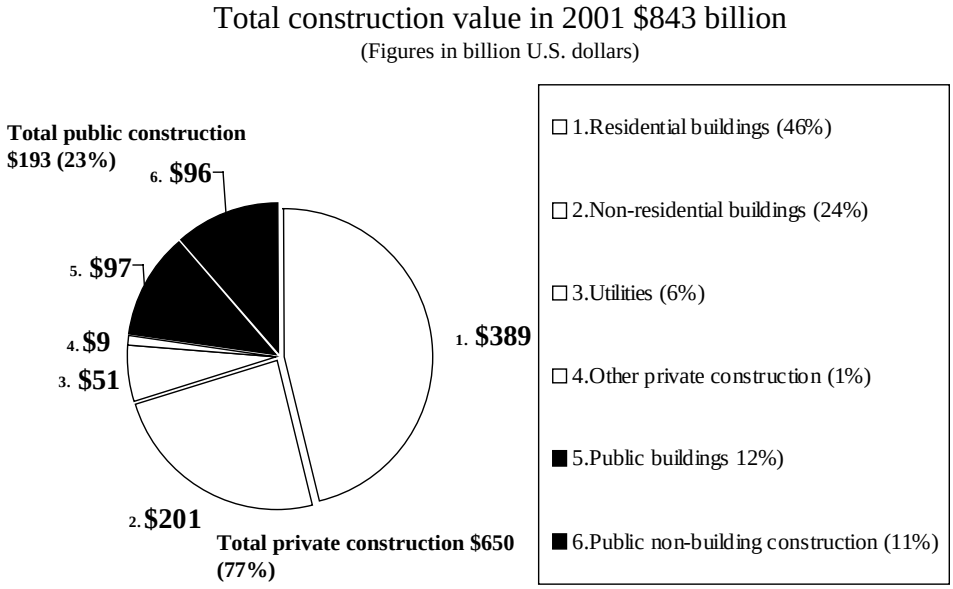

Figure 1. Annual value of construction put in place in the U.S. [U.S. Census Bureau, 2002].

Over three quarters (77 percent) of all construction is done for private entities, and the remaining 23 percent are public construction. Non-residential building construction (Fig. 2) totaled USD 298 billion (35 percent of all construction) in 2001. Two-thirds of that activity was privately funded, and the main private construction segment was commercial construction with an annual put-in-place value of USD 127 billion.

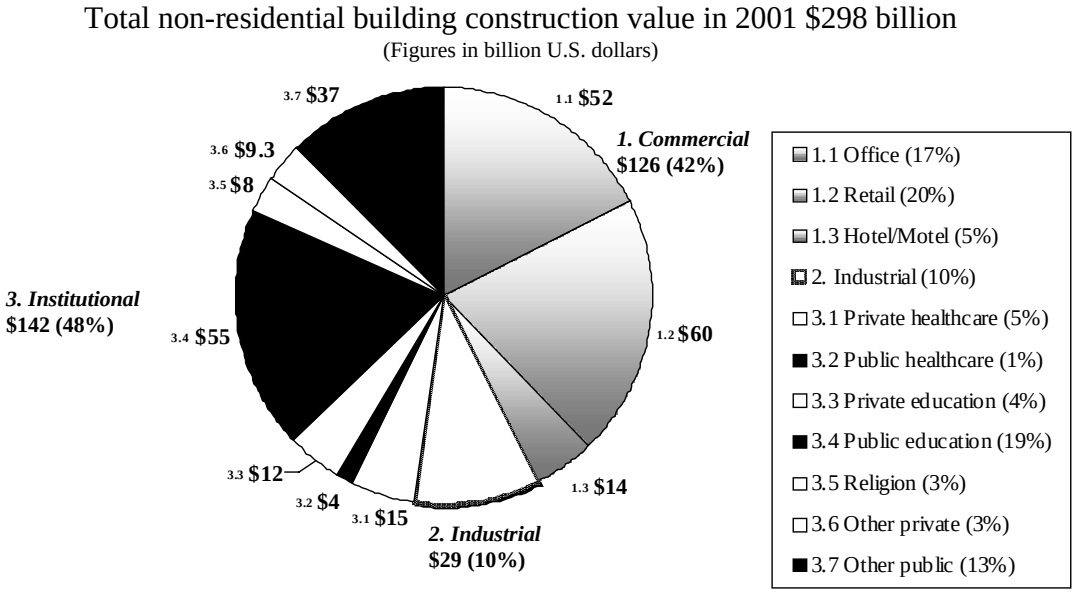

Figure 2. Breakdown of non-residential building [U.S. Census Bureau, 2002].

The commercial segment can be broken down to sub-categories in 2001 as follows: retail – USD 60 billion; office – USD 52 billion; and hospitality – USD 14 billion. The industrial construction – covering both manufacturing and process industries – had a combined value of USD 29 billion in 2001.

After the rapid growth in until 2000 the construction activity has stagnated in recent years. While residential construction has continued its growth, industrial and particularly commercial construction have fallen back. On the other hand, increasing public construction has compensated the losses in the private sector. Due to unstable circumstances and only slowly recovering U.S. economy, the construction sector does not appear to see any rapid boost in business.

Due to geographical factors and the large number of major construction companies the U.S. construction industry is quite fragmented: even the largest contractor covers only 1 percent of the domestic construction business. On the other hand, the largest 400 contractors account for nearly one quarter (contract value) of all construction – leaving to remainder to approx. 225,000 smaller construction firms.

It should be noted that the two most-quoted sources of construction statistics calculate their figures differently: while McGraw–Hill monitors construction starts and contract values, the U.S Commerce Department's data are based on the construction put in place figures (which are significantly higher than those of McGraw–Hill).

According to an Informationweek study the overall IT budget (including hardware, software, services and personnel) of an average construction and engineering company was 3 percent of the annual revenues, which was slightly less than the average of all industries. The construction and engineering companies spent only 9 percent of their IT budget for new products and technology which was the least of all industries. The IT expenditure in the U.S. construction industry corresponds to 0.3 percent of the companies' annual revenues. Although most construction companies consider IT improvement initiatives, many contractors still indicate that they have not implemented these strategies. This puts particularly smaller companies at disadvantage when their larger competitors have sooner adopted advanced IT tools. Based on Finpro's interviews, companies with annual revenues above USD 100 million appear to be more receptive to the latest IT trends than their smaller competitors.

In another study by the Constructech magazine in 2002 among construction contractors about their "technology" spending it turned out that they were spending on the average 0.35 percent of their revenues to IT.

The Real Estate industry has a significant impact on national and global economy, so the economical importance of the industry is not to be underestimated. The market for office buildings, retail malls, apartment buildings and warehouses is today estimated to an amount of $4 trillion. The Federal Reserve Board has estimated land values to $4.4 trillion and building values at $9 trillion. This $13.4 trillion of Real Estate value represents two thirds of the total $20 trillion in overall assets for the United States economy. Real Estate also accounts for three-fourths of the capital consumption allowances of the economy. The sector generates over $300 billion in interest payments, which represents some two-thirds of the interest paid by American businesses. Mortgage debt of $4.3 trillion represents some 46 percent of the economy's $9.3 trillion private non-financial debt.

2.2 About disciplines

There are approximately 27,000 architectural firms in the United States with an average of 6 employees each. A vast majority of the firms employ 1 to 5 people. The estimated number of more sizeable architecture companies with at least 20 employees is around 1700, but companies with a staff of 500 or more number only 40.

The American Council of Engineering Companies (ACEC) has more than 5800 engineering firms as their members. Nearly 2800 of them are involved in structural design and about 950 in structural building design.

About 200 of largest building contractors with more than 500 employees report commercial and institutional construction as their specialty, whereas there are just over 60 large contractors (with 500 or more employees) who specialize in manufacturing and industrial building construction.

According to ENR the 400 largest U.S. construction contractors in 2001 can be broken down by their annual revenues as follows:

Revenues USD/a	Number of contractors
Over 2 billion	17
1 to 2 billion	29
500 million to 1 billion	32
400 to 500 million	19
300 to 400 million	34
200 to 300 million	86
150 to 200 million	90
109 to 150 million	94.

Currently, primarily contractors above USD 100 million in their annual revenues are sufficiently enlightened to be in the position to effectively adopt 3D modeling and sophisticated collaboration methods.

While there are overall some 380,000 subcontractors in the U.S., only a small percentage of them are significant enough and equipped with compatible CAD and collaboration tools. On the other hand, in recent years many advanced subcontractors have made the more rapid technology investments than the traditional general contractors.

Various building products are manufactured by approx. 160,000 firms but only a few thousand of them can be considered significant. The entire supplier network covers over 250,000 entities but a vast majority of them are very small firms.

Significant property owners number over 10,000 including those of commercial, industries and public buildings. These owners employ more than 130,000 facility managers. The real estate business is very fragmented. The top 5 companies have a market share of about 11%. The largest is CB Richard Ellis with a market share of about 5%. There are about 125,000 real estate brokers in the U.S. 12,500 are employed by the top 5 companies. The number of real estate transactions is approximately 65,000 per

year. Of those 75% are under one million USD and 85% under 3 million. Among the largest are:

- CB Richard Ellis
- Jones Lang LaSalle
- Cushman Wakefield
- TrammellCrowCompany.

The role of corporate end users is growing. The trend is towards more flexible use of workspace and also flexibility in contracts. Some very large corporate owners outsource majority of their facility management functions (SUN, CISCO); some have stronger in-house FM professionals (IBM).

2.3 Examples of interesting segments

The various FM/AEC software products from Finnish vendors – due to their advanced features – are more applicable in certain construction segments which may involve a complex project, challenging design, fast-paced project delivery, tight budget, design-build method, or all of the above. These segments include high-tech office buildings; high-tech manufacturing facilities; pulp, paper and power plants; and special chain or other buildings where “repeat” or “concept” construction methods can be applied.

2.3.1 High-tech office buildings

The office building market – valued at USD 52 billion in 2001 – can be broken down into three categories or classes – based on the amenities and prestige they provide to their tenants. While classes B and C are medium- and lower-cost, respectively, class A features state-of-the-art automation, communication and security systems; prime location; and top-quality materials.

Many of those high-end buildings can be called “smart” or “intelligent” with a wealth of higher technology. In an intelligent building the following functions are emphasized: 1. Energy efficiency; 2. Life safety systems; 3. Telecommunications systems; and 4. Workplace automation. Ideally all those functions would be integrated into one computer system and all the hardware and a single supplier would furnish software.

The number of class A buildings and their total floor area vary naturally by city and specific location. Downtown areas of major cities as well as new satellite business centers have the largest concentration of class A buildings. E.g. in the extended downtown of Chicago 47 percent of commercial floor space is in class A buildings. In

the long run, new office construction produces proportionally more class A buildings than their current share on the market is. Still the truly “intelligent” buildings account for less than 2 percent of all new office buildings.

Thanks to the proliferation of sophisticated communication and personnel identification systems there is “pressure” to add new advanced features to the office building already at the construction phase. As a result, the buildings become gradually more intelligent and are more complex to design and construct. At the same time, property owners and the construction industry feverishly try to curtail construction costs – in part through implementing modern IT in the project work.

All the leading commercial office building contractors are technology-savvy and are seeking the best IT tools to keep abreast with competition.

2.3.2 High-tech manufacturing facilities

The industrial construction in the U.S. has been continuously declining from USD 40 billion in 1998 to USD 29 billion in 2001, and the preliminary figures for 2002 are even lower. Electronics manufacturing is one of the slumping industrial segments due to the overcapacity created in the 1990’s. The majority of vanished construction business can be attributed to inactivity of large-scale production and assembly plant construction, in part because manufacturing is transferred to overseas locations with cheaper labor. Still, smaller and medium-size manufacturing facilities are constructed – although at somewhat cautious pace. Long-term outlook for high-tech manufacturing – including biotechnology – is quite promising.

Many manufacturing facilities are very demanding to design and construct involving a lot of diversified subcontractors in the project team. Combined with expedited schedule good management and collaboration tools are necessary. As many high-tech manufacturing plants are expensive investments the contractors are motivated to acquire the best-performing tools – often price-independently. It is a challenging segment for software vendors, and due to the potential rewards most of them are looking seriously into it.

2.3.3 Pulp, paper and power plants

The global pulp and paper industries have over decades benefited from Finnish innovation and technical know-how. Finnish consultants and machinery manufacturers have greatly contributed to the current state of the forest industries. Therefore, Finnish AEC software offerings may have a slight advantage in mill (building) project

applications. Especially, if construction team members include Finnish companies, implementation of Finnish software in a paper mill project could be accomplished. U.S. or international power generation plant projects may similarly be applicable. Generally, these customer groups are profit-driven, and they view state-of-the-art project tools favorably. As the projects involve also mechanical engineering seamless integration with other software products may be necessary.

The pulp and paper industry in the U.S. comprising approx. 500 paper and fewer than 40 pulp mills in operation is suffering a long-lasting investment drought, and totally new mills have not been constructed in the past ten years. The biggest projects concern mill (or machine) remodeling, where there is a limited amount actual building construction. The top ten U.S. contractors specializing in pulp and paper had a combined project value of only USD 1.0 billion in 2001.

Currently, the limited new-construction activity takes places primarily in newer and growing markets, i.e. forest-rich developing countries and selected emerging markets. Currently, there are fewer than ten “greenfield” pulp or paper mill projects going on worldwide. All other pulp and paper construction involves rebuilding or expansion only. If collaborating with American contractors, the options are limited to half a dozen companies.

The U.S. power generation industry sees considerably more construction activity than the forest industries. According to the Energy Information Administration there are (1998/2000 status) a total of 14,600 power generation plants in the U.S. About 9350 (64 percent) of them are owned by electric utilities whereas the rest is owned predominantly private non-utility entities. The largest segment potentially applicable to Finnish construction offering, thanks to their large unit size, is the coal-fired power plant industry comprising nearly 1400 plants. Wood and waste burners represent another prospect with a current count of approx. 970 units, but they are much smaller and may not often present construction challenges.

Power plant construction remains quite active, and currently about 180 plant projects – out of which half are utility-owned – each year are completed. Out of those 85 percent use gas or petroleum fuels and are much smaller than coal power plants. Thus, they are less demanding construction-wise. The remaining 15 percent of annual power projects include coal, wood and waste as well as a variety of renewable energies as an energy source. It should be noted that in temperate weather zones power plant construction involves relative little building construction since the process equipment is primarily under open sky.

The multidiscipline engineering/contracting companies responsible for pulp and paper mill as well as power plant projects already have the “best” design systems for process and mechanical design. On the other hand, structural design and erection of buildings are carried out with less sophisticated IT tools. Although intra-company collaboration works satisfactorily, there is still a lot of room for improvement on the construction side.

2.3.4 Concept building construction

A relatively large share of new construction involves identical or resembling building parts or sections or even entire buildings that have similar designs. By applying the Finnish software offering to such design and construction significant savings may result. From hospitals and biotechnology factories to chain stores, malls and hotels the project duration can be shortened when unnecessary repetitive work is eliminated.

While there are no statistics about concept construction, some interviews conducted by Finpro have resulted in tentative indications of interest in streamlining “repeat” building projects. Particularly in retail construction fast tracking is desirable, and large owners may find the Finnish approach highly useful. Examples of concept builders in this sense these might be

- Large hospital owner-operators. For example, Kaiser Permanante, one of the largest hospital owners, plans to build 21 new hospitals in the state of California by the year 2013 based on a unified design concept. The main goals are to reduce the time used in the approval process by State authorities and optimize the construction process.
- Fast food chains. Although business is claimed to have slowed down its expansion, the industry builds, owns and operates thousands of restaurants based on unified concepts and conceptualized designs. The same applies to, for example, car rental agencies.
- Shopping mall or outlet store owners and operators. Most shopping malls follow similar types of designs. Concept building is very much applicable for these as well.

2.3.5 Public sector customers and other building owners

The private sector in the U.S. has been somewhat hesitant in investing in full-scale projects where the entire range of building life cycle functions is incorporated in the same model. The private sector typically seeks the lowest possible cost and does not focus on the long-term benefits of model-based facility management. The federal government, specifically its General Services Administration (GSA), on the other hand, has taken initiative to investigate – and also implement – computer-integrated facility

management (CIFM). The goal is to achieve responsible asset management on any major construction or renovation project.

Although still in its early stages, the CIFM program aims at lowering design and construction as well as major repair and alterations costs through the use of electronic, intelligent, and easily accessible building and site plans. They will also help the owner market, lease and dispose of GSA properties. One of the concurrent goals is to provide federal employees with quality work environments.

The U.S. Coast Guard at its expansive Charleston, South Carolina, facilities, launched the first full-scale federal project applying object-based models. "The Charleston Regional Strategic Plan" involves intelligent object-oriented 3D CAD models built by Graphisoft's ArchiCAD and coupled with Geographic Information System (GIS) tools to describe their geographical relationships. The overall objective of the project is to create a results-based decision-making system, which will help the Coast Guard efficiently manage and maintain its assets through their life cycles. The existing models will be continuously enhanced when new data becomes available. Currently the models concentrate on physical data, but to become working tools for integrated decision-making the models require non-physical attributes, such as cost and time, as well.

The Charleston project due to be finalized by summer 2003 is called a "prototype" but plans exist to extend similar projects to other locations. The Coast Guard is not committed to any specific software vendor and will select future providers based on the performance and interoperability of their products. This means compliance with the International Alliance of Interoperability (IAI) and its Industry Foundation Classes standard IFC. The Coast Guard is looking forward to enhancing their current models and would welcome potential input from Finnish vendors.

The federal government and its various departments and agencies could offer interesting real-life prototyping opportunities for Finnish vendors, which could become valuable stepping stones in the endeavors to enter also the commercial construction software market in the U.S. Such opportunities may develop also at the U.S. Army Corps of Engineers, U.S. Navy, DOE (Department of Energy), FEMA (Federal Emergency Management Agency), DHS (Department of Homeland Security), VA (Veterans Administration), and NASA (National Space Agency).

In addition to federal (and possible state) end-users the local county and city governments could offer intriguing piloting opportunities for Finnish FM/AEC Cost-conscious counties and cities may find viable application areas in their hospital and school projects.

Owners can be segmented also by their likelihood to press innovation. Many technologists and observers have noted that “Owners drive the system”. It is also true that most owners do not have justification to risk disruption in construction performance while chasing what look to be very incremental improvements. However, there are segments that are exceptions. Figure 3 proposes a methodology for identifying the segments of owner types who are likely to be interested in innovations that reduce their cost significantly.

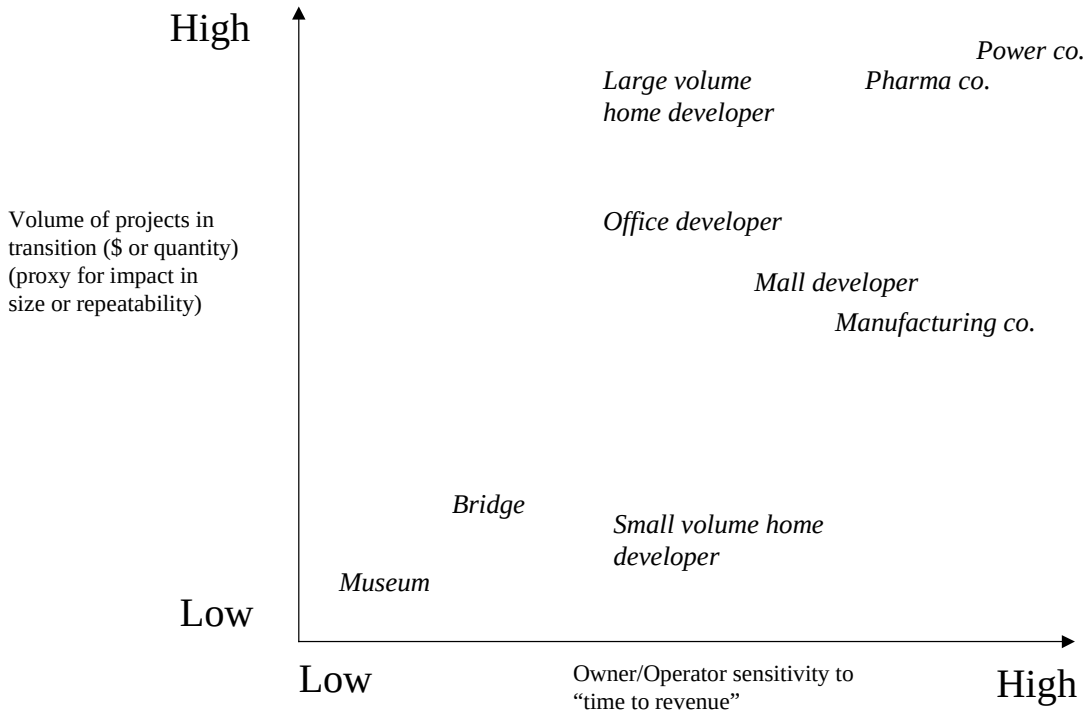

Figure 3. Market segmentation by owner types. Owners likely to be interested in innovation for economic reasons will be those who have a high volume of projects (either in size or quantity) and who can quantify “time to revenue” and hence quantify the cost benefits of acceleration gained by innovation [After Porter, M., 1995 by Macomber, 2003].

In addition to the public owners, large corporates have been active in finding out ways how to optimize the use of their facilities as workplaces. Corporate end users are more and more interested in developing tools for creating ”agile workplaces”. For example, one large high-tech company is trying find out ways how to make better use of its offices in certain large metropolitan areas by minimizing commuting distances for the company’s workers. The corporate real estate service functions in this sense are rather advanced, but at the same time, they do not typically use information produced by the actual construction process. The division to disciplines seems to step in much stronger than in Finland.

2.4 Overview of vendor business

The U.S. construction market with its all segments is served by at least 600 software vendors. Despite the large number of players on the market only a handful in each application category are significant companies. Only a few real estate, facilities management or construction-specific vendors exceed USD 100 million in their annual sales. An average established software vendor serving the construction industry has its yearly revenues in the USD 5 to 10 million range.

Software products used by the construction industry can be divided into the following main categories:

- job costing/accounting/payroll
- CAD
- estimating
- project management
- project collaboration
- scheduling
- ERP.

Table 1 lists the leading facilities management and construction-related software and related services providers in the order of their annual revenues.

Microsoft is also a significant player with its MSExcel, MSProject and Microsoft Visio offerings. Leading ERP vendors serving the construction industry include SAP, Oracle, J.D. Edwards, PeopleSoft, Deltek and Geac.

Due to the very diversified IT needs of the industry, the overall annual FM/AEC software sales are very difficult to measure. Based on Daratech Inc. [2001] global estimate, USD 1.8 billion for 2001, the U.S. construction CAD software sales and services (estimated at more than a quarter of global sales) could have reached USD 500 million that year. According to our calculations (based on the Daratech information and average technology spending by the construction industry) AEC project management software sales reached USD 150 million. In our estimate, the total software expenditure by the U.S. AEC industry reached or exceeded USD 1.2 billion in 2001.

Most construction and business software is available both as a product and through hosted services, which can be offered directly by the vendor or a third party (Application Service Provider, ASP). Approx. 2/3 of U.S. construction companies use – or have used – hosted services to satisfy at least part of their software needs. ASPs or vendor-operated services are particularly handy when the company does not have a

large IT staff of their own. ASPs are also flexible in situations where the contractor needs a project-based tool on a temporary basis.

Although a wide variety of software for each application is available, 2 to 3 percent of end-users choose to develop some of their software in house.

Table 1. Leading construction related software vendors.

Company/Location	Since	Revenue [m$]	Employees	Main products
Autodesk Inc, San Rafael, CA	1982	947	3400	CAD, collaboration, FM software
Archibus	1982	261	?	FM software
Bentley Systems, Exton, PA	1984	206	1200	CAD, FM
Solid Works, Concord, MA	1993	114	260	CAD
Primavera Systems Inc, Bala Cynwyd, PA	1983	82	425	Project management and collaboration
Timberline Software corp. Beaverton, OR	1971	57	500	Accounting, job costing, estimating software
Meridian Project Systems, Folsom, CA	1993	14	168	Project management software
Research Engineers International, Yorba Linda, CA	1981	18	60	Structural Design Software
Citadon Inc, San Francisco, CA	2001	10	80	Collaboration tools
Nemetschek North America Inc., Columbia, MD	1985	10 (est.)	85	CAD
RAM International, Inc., St.Louis. MI	1982	10	18	Structural Design software
Emerging Solutions, Inc. (Constructware), Alpharetta, GA	1995	9	80	Project management and collaboration software
U.S. Cost, Inc., Atlanta, GA	1983	9	80	Estimating software
Management Computer Controls, Inc., Memphis, TN	1965	5	40	Estimating software
Global Software, Inc., Raleigh, NC	1981	5	40	Accounting software
Graphisoft U.S., Inc., Newton, MA	1984	3	20	CAD (and FM) software
Building Systems Design, Inc., Atlanta, GA	1983	2.5	18	Estimating software
WinEstimator, Inc., Kent, WA	1992	2.5	25	Cost accounting and estimating software

3. Industry value chains

3.1 Fragmented markets & different value chains

The way the industry value chains are set up varies from large, international large engineering projects running several years to building of homes. There are no ”general contractors” in the USA in the same way one would find in Finland. Even the very general companies, such as Turner, Webcor or Kellogg’s do try not focus on all possible market segments and thus have aligned their way of working according to the processes most suitable in the segments in question. However, if one looks at the classification according to the contract forms, one finds some coherent and very commonly used, universal ways of classifying the deliveries, such as

- Design-Bid-Build
- Construction Management
- Construction Management (CM) at Risk
- Design-Build
- Build – Own – Operate
- Contractor Pre-selected.

The Real Estate and Facilities Management (RE and FM) sectors have far more fragmented and less established business processes compared to the delivery methods in architectural, engineering and construction sector. Furthermore, typical deliveries in these sectors are changing due to the changes in corporate real estate management approaches. More and more companies are outsourcing their FM functions. Information on the typical value chains in also very hard to find. This is why the chapter mainly deals with typical deliveries of construction projects.

3.2 Design-Bid-Build

In this traditional method of project delivery, a design team of architects and engineers is hired to work with an owner to develop plans for a building to fit the goals, budget and aspirations of the owner. Based on completed construction plans, a contractor is selected through a bidding process to build the building for a set price. During the construction period, the architect works to see that the contractor builds according to the plans and specifications, and that the owner meets financial and other obligations to the contractor.

Design-Bid-Build is an effective project delivery system that, for many years, has helped public owners achieve quality in the design and construction of public projects. The architect is typically selected at the onset of the project based on qualifications and

experience, and represents the owner's interests during both design and construction, delivering professional service as the owner's "agent". The building contractor that is successful in bidding will then contract with the owner as a "vendor" to construct the specified design for the lowest responsible price.

Advantages of Design-Bid-Build

1. Contractors bid competitively based on complete design documents to maximize the built product for the price.
2. The owner selects the architect based on qualifications or ability. The architect's role is that of owner's advocate.
3. The architect is active in construction administration so design intentions are followed.
4. Design and construction roles are clearly defined, and responsibilities and liabilities clear.
5. Owner is an active participant in design process.

Disadvantages of Design-Bid-Build

1. Design-Bid-Build construction phases are sequential and may require more time.
2. Owner is at risk for final construction cost. Actual construction costs are not known until design and bidding is complete.

3.3 Construction Management

Some owners or public agencies planning construction of complex projects may not have resources in-house to manage planning, design and construction of a major building project. To support this need, Construction Management services can be provided in two different ways to an owner.

In one form of Construction Management, the owner contracts separately with an architect, a Construction Manager as Agent (CM-Agent) and – through a competitive bid process – one or more prime contractors. The CM-Agent provides early cost estimating, scheduling and assistance to the owner throughout the bidding and construction phases of the project. Additional cost control and condensed scheduling are the two main benefits of this method. The CM-Agent approach can be beneficial for large, complex projects where construction alternatives and solutions can positively impact the overall budget. The Construction Manager-Agent performs as an additional representative of the owner's interests.

Advantages of Construction Manager-Agent

1. CM-Agent with construction expertise gives the owner an agent, in addition to the architect, to supervise the project, reducing the owner's management burden in large or complicated projects.
2. CM-Agent's project scheduling and capability to competitively fast track some items may speed process and save owner money.
3. CM-Agent's cost estimating and construction expertise at design phase assists in monitoring construction costs.

Disadvantages of Construction Manager-Agent

1. CM-Agent is added cost. Owner is at risk for final construction cost; actual construction costs are not known until design is complete.
2. Multiple prime contracts increase paperwork and administrative time, and increase potential for construction disputes and claims.
3. CM-Agent typically has less clout to resolve design-construction issues than a general contractor and serves only as a mediator.

In the second form of Construction Management, the owner contracts separately with an architect and a Construction Manager at Risk or Construction Manager as Contractor (CM-Contractor). In this vendor form, the construction manager is "at risk" since he provides both contractor services and construction management services for the project. Construction Contractor services are provided to the owner based on a guaranteed maximum price, fixed price, cost plus or other means of defining a contract. This creates a major conflict of interest since the CM is no longer acting as an agent providing professional services to the owner, but now is a vendor delivering a contractually defined product to the owner for a price.

Advantages of Construction Manager as Contractor (vendor)

1. Architect still acts as agent protecting owner's interest and architect's early involvement with owner addresses building quality and function.
2. Early cost commitment gives owner project cost security.
3. At Risk entity is responsible for managing construction process and has more clout with subcontractors.
4. CM-Contractor can reduce owner's burden in management of large or complicated projects.
5. CM-Contractor reviews project for constructability, cost and schedule, potentially reducing change orders and delays.
6. Fast tracking and multiple prime contracts may speed construction.

Disadvantages of Construction Manager as Contractor (vendor)

1. Management role of CM-Contractor is added cost.
2. CM-Contractor may provide less building than a bid approach to protect margin of profit. Major conflict of interest with role as both construction manager and contractor.

3.4 Design-Build

In the Design-Build delivery approach, the owner contracts with a single entity for both design and construction. The owner has one contract assigning single point responsibility for the project. The Design-Build entity may be a single organization with both architectural and construction staffs, or a construction organization that hires or affiliates with an architect as part of a Design-Build team. The design-build entity usually proposes the design and construction price simultaneously, and the construction commitment is made. Design and construction may or may not be fast-tracked.

According to the Design-Build Institute of America, the share of Design-Build of the market penetration of major project delivery systems was at 35% in 2000. The share of Design-Build is expected to equal the share of Design-Bid-Build contracts in the year 2005 (45% share for both). The share of Construction Management (at risk) seems to remain at 9–10% in the future as well.

In a Design-Build delivery system, the architect is part of the Design-Build entity and not the agent of the owner. Thus, uniquely in the Design-Build system, there is no one in an agency relationship with the owner who is obligated to work in the owner's best interests. The design-build team is placed in a vendor relationship with the ultimate end user groups and public owner. When dealing with public sector building projects where much involvement, interaction and negotiation between agencies, officials and constituent communities is expected or required, a vendor led project delivery process may minimize the opportunities for user involvement. The design-build entity is focused on the delivery of a contractually defined product. Since single point responsibility leaves no independent agent representing the owner's interests, the owner will often be required to engage an administrative architect to assist in defining the building program, writing performance requirements, selecting the design-build entity and administering the design-build contract for the owner. The owner will often also hire a separate construction management entity to monitor its interests. Without early additional program/design/specification development, the owner is likely to get less building for the price.

Advantages of Design-Build

1. Generally fastest project delivery system.
2. Single entity responsible for design and construction.
3. Early cost and scheduling commitment.
4. Conflicts between project professionals internalized; may not involve owner

Disadvantages of Design-Build

1. Design-Builder may provide less building than a bid approach to protect margin of profit. Construction costs are non-competitive.
2. Involvement of owner is generally limited to early stages of project.
3. Hidden reductions in quality are possible when design builder determines cost-savings and design changes. Short-term construction savings may outweigh life-cycle costs.
4. Construction documents not complete when cost commitment made. Disagreements about quality and design intentions may arise later.
5. Major conflict of interest with role as designer and contractor.
6. No objective agent to represent owner's interests.

3.5 Contractor Pre-Selection

Contractor Pre-Selection has evolved from Design-Build in order to obtain the benefits of an independent designer shortened schedule and early cost commitment. The owner holds separate contracts with the architect, who functions as an independent owner's agent, and with the contractor, with whom he negotiates a construction price. Final construction cost may be negotiated to provide for bids from subcontractors, with cost savings going partially to the owner. The owner/user is involved in programming and design decisions. A construction manager may be added to the team if required.

Advantages of Contractor Pre-Selection

1. Provides early cost and scheduling benefits and saves time.
2. Architect acts as agent protecting owner's interest.
3. Architect's involvement with owner addresses building quality and function.

Disadvantages of Contractor Pre-Selection

1. Without competitive bidding from the contractor, owner may not obtain lowest construction price, but this can be mitigated by mandatory subcontractor bidding.

3.6 Use of tools

3.6.1 The industry approach is conservative

The use of different software tools varies by the discipline, size of the company and by how advanced the company is with its use of IT: The only really cross-cutting tools are very generic, such as regular office tools or at the most advanced projects, collaboration tools. Furthermore, unlike in many other industries, new breakthrough software innovations by entrepreneurial firms have largely been absent. Although the software industry in general (in the ”good times”) was able to attract venture capital in bundles, the CAD and other construction-specific software vendors did not make headlines. (A major exception was the e-procurement and online collaboration arena, which overheated and received collectively more than USD 2.5 billion of venture funding. Only a fraction of those 250 companies are still in business.)

The relative quietness in R&D and the subsequent absence of new products by newcomers can be attributed to the following facts:

1. Primarily the top vendors, who also have been hatching most of the new hit products, have adequately served the traditional construction industry.
2. Thus far, there has not been enough incentive for the entrepreneurs and their financiers to aggressively tackle the market.

Although the total number of FM/AEC companies is significant, the majority of them are not particularly IT-savvy. Until now, only the larger architecture, engineering and construction companies have heavily invested in IT. To be on the safe side, they rather select proven software from a familiar vendor. As the end-users have been so conservative, small software developers have not seen enough demand for their new products, if any. The situation is somewhat different with accounting, estimating and other non-FM/AEC software vendors, whose core products after customization are often used in numerous industries.

The IT spending by an average AEC company is trailing the average IT expenditures of all industries. Even in the case of most compelling applications – whether they are sophisticated CAD, project management or collaboration tools with adequate compatibility become usable and reliable – the end-users are very slow in joining the IT bandwagon. When the anticipated online collaboration revolution occurs, it will likely be lead through the muscle of the current top vendors, because they are influential and have the necessary development funding at their disposal.

3.6.2 How software is bought and implemented

The variety of ways companies buy and implement software is very large. However, some categorization can be made to help understand the different roles in very typical transactions. Figure 4 tries to outline some of the most typical sales channels for FM/AEC software. Especially in the case of collaboration tools, an Application Service Provider (ASP) sells the software over the Internet. The interactions between vendor and customer can take place directly, but this is most often not the case. The vendors very typically have dealers or local sales representatives who act as channels. The customer may interact with a Value-Add Re-seller (VAR), who helps the customer in implementing the software for customer's processes. Very often the FM/AEC industry customers also require the use of System Integrators (SI). These, as well as value-add resellers can represent more than one vendor. Both get paid also for consulting or programming services besides sales.

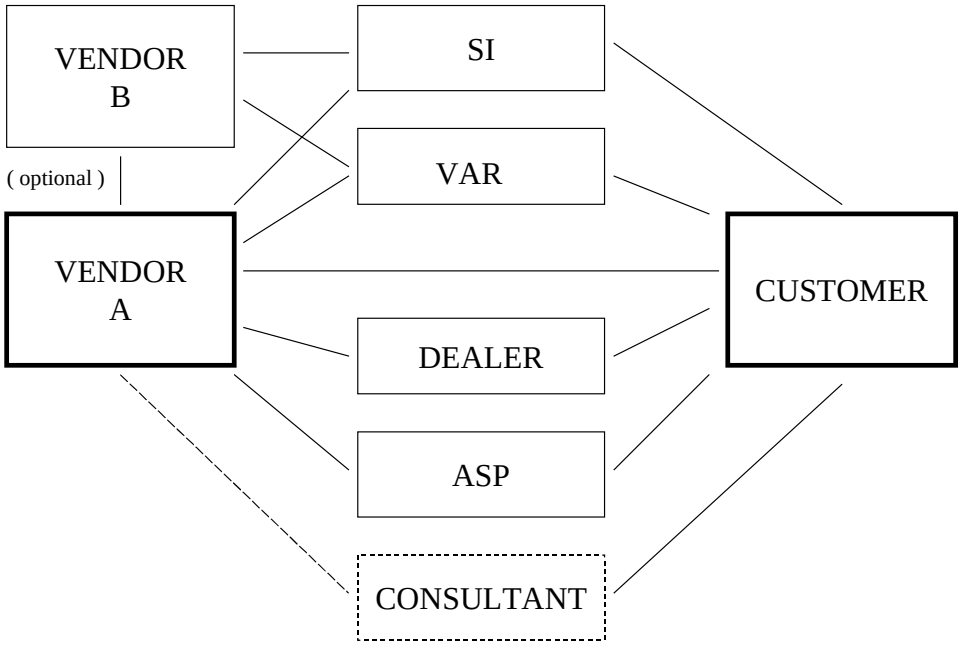

Figure 4. Options for software sales channels.

3.6.3 Modeling

For modeling, larger architecture companies have first-class 2D and 3D design software. 3D design systems are widely used by large companies. 3D tools are common also in mid-size and even smaller firms but 2D tools are often enough for basic design. 3D format is mainly used to visualize complex designs and demonstrate the results to customers and project team members.

Strictly architectural companies seldom assume a leading role in a design-build project. Thus, they would not create a 3D model to be a basis for a collaborative effort.

The larger and more multi-disciplined an engineering company is the more likely it has 3D engineering tools from some of the leading vendors. For structural design tasks, approx. one fifth of the design work is performed in three-dimensional format. For most building projects 2D design suffices. It is less common to use a 3D model for conventional building design, whereas challenging shapes and structures see more 3D design. The simple reason not to use 3D is its extra cost and the little value it adds. One exception to the rule is the modeling of prestigious, historical buildings during their restoration. Although 3D tools exist, the designers mostly leave them idle. In fact, the variety of 3D software products at an engineering or architectural company can include even up to 20 different packages, and each engineer can have the tool of his/her choice.

The owner as the coordinating party in a design-build project can hire an architectural or engineering company. In such a situation the company seeks a construction contractor to partner in the project. Although an inter-company collaboration through a 3D model would be ideal it typically does not happen in the reality.

Among the main participants in the construction value chain the largest contractors, often also furnished with architectural and engineering design capabilities, are technologically best equipped to manage design-build projects. They also are the main drivers of design-build projects. Their intra-company online communications can be top-of-line, and they can also adjust to the IT requirements of the most demanding owners. However, even in such construction conglomerates the models created by their architects and those required by the various engineering disciplines do not fully support each other. Generally, the large contractors are quite satisfied with the state of their in-house collaboration: geographically dispersed team members are served well and various engineering disciplines can partially utilize the 3D designs of the others. Seamless online sharing of 3D models with external parties, however, can be very cumbersome.

The specialty contractors – such as electrical, HVAC, masonry and woodwork – and their respective design tools and means of communication can constitute serious

hurdles, if the entire project team were to utilize and contribute to the common collaboration platform. The majority of the contractors are small independent firms with only limited IT capabilities, and they would probably be the last in the value chain to implement state-of-the-art IT technologies. On the other hand, many larger specialty contractors, such piping installers, with experience on large industrial projects already are way ahead of average construction companies as far as 3D software is concerned.

The nature of building owners and their IT capabilities vary extensively. Companies commissioning only occasional or more basic construction projects are still operating with basic design (if any) and project management tools. On the other hand, owners of sophisticated industrial complexes; high-tech manufacturing plants or a large number of high-scale commercial properties could use very advanced software. They commonly insist on using a specific 3D design program as well as other relevant project tools, and these issues are discussed already in the pre-planning phase of the project. Because of the importance such high-value projects, contractors naturally comply. Should the required tools not be readily available with the contractor, they could be used through a hosted service.

The Construction Financial Management Association (CFMA) conducted an ”Information Technology Survey for the Construction Industry” in 2002. One of the target groups interviewed in the survey included 505 general contractors (out of which 410 were general building contractors, 51 involved in non-residential construction, 26 in industrial and warehouse buildings and 17 in residential buildings. One company was an operative builder. Companies with a minimum of USD 26 million accounted for 62 percent of those interviewed. The use of various software products in six application areas was inquired. The below tables summarize the findings of the study.

In the CAD software category Autodesk’s AutoCAD was by a large margin the dominating product, see Table 2. MicroStation by Bentley placed a clear second and was more popular among larger users compared to the smaller ones. It was noteworthy that 8 to 27 percent of contractors in various size categories did not use CAD software at all.

Table 2. CAD/drafting software used by U.S. general contractors [CFMA, 2002].

	Contractor revenues/a		
Software (vendor)	USD 26–100 million	USD 101–250 million	Over USD 250 million
AutoCAD(Autodesk)	60%	70%	77%
MicroStation(Bentley)	3%	5%	9%
CADSoft Build	1%	1%	4%
QuickPen	3%	4%	0%
Other	1%	0%	0%
None used	27%	14%	8%

Some technology oriented and advanced companies or groups of companies have started to develop their core processes to be better adaptable for interoperable use of modeling tools. The processes to be developed are to support the concept of virtual building. Example of how the Virtual Builders Round Table[1] has been approaching the use of models is shown in Figure 5. The example shown is not current practice. It shows, however, the direction where the development of processes is heading.

DPR Inc. constitutes also a prime example of a company that invests in new tools to create a sustainable competitive advantage. The company has 14 offices nationwide. It has been in business for 14 years and ranks 14th on the Engineering News Record Top 400 companies listing in 2001. In that year, it built over 1.8 billion USD worth of construction in a number of different market sectors. DPR's main market sectors are in commercial building segments, such as telecom, biophram and microelectonics plants and offices, health care facilities, entertainment and other commercial buildings. DPR has been one of the leaders in implementing 4D CAD and modeling. DPR has incorporated 4D in over 12 projects in the past 3 years. The use of 4D includes

- Logistics planning,
- Safety,
- Construction sequencing,
- Trade coordination,
- Constructability and
- Project team visualization.

Most of the projects used AutoCAD's Architectural Desktop as a modeler. Recently on a proposal that DPR was not awarded the project, DPR explored the use of ArchiCAD to create a 3D model for the project. Using ArchiCAD's Plan to Model software a 3D model was created from the architect's and structural engineer's 2D drawings in approximately 40 hours. The ArchiCAD model was checked for inconsistencies using the Solibri Model Checker. A preliminary cost estimate was created from the model using Timberline and a specialized cost database. While the project did not go forward, DPR considered the modeling a success and is interested in exploring the exchange of model information through the use of IFCs.

[1] A consortium of companies lead by DPR Inc. in California.

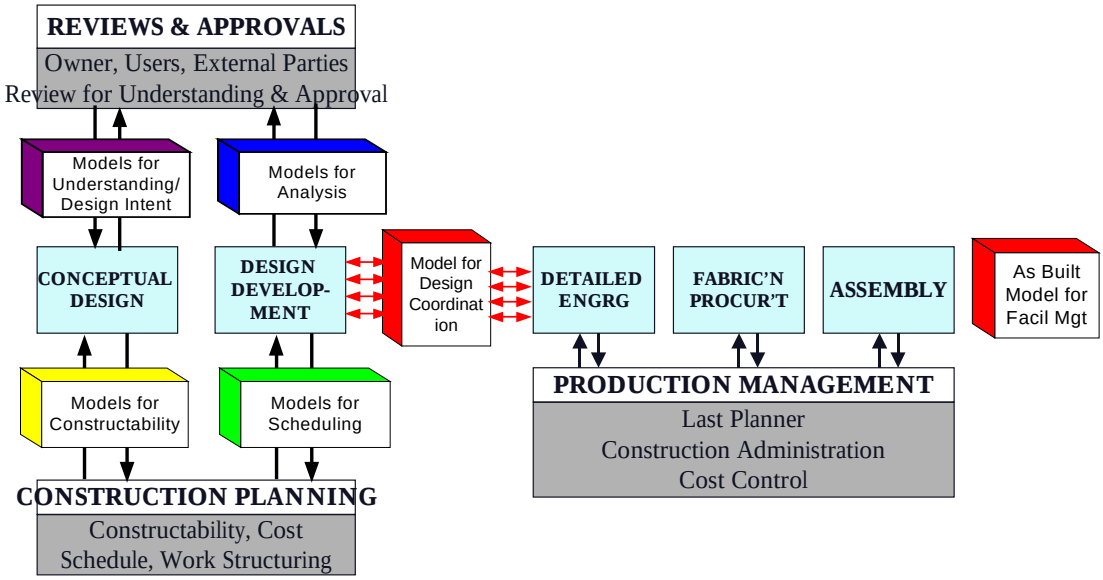

Figure 5. Use of object-based model during the life cycle of a construction project.

3.6.4 Estimating, job costing, accounting

Microsoft Excel was the most popular estimating tool even in the largest-companies group with a 33-percent share. Out of the dedicated estimating offerings Precision Collection by Timberline was the most common – not far behind Excel. Up to 5 percent of estimating software were the result of companies' own development (see Table 3).

Table 3. Estimating software used by U.S. general contractors [CFMA, 2002].

	Contractor revenues/a		
Software (vendor)	USD 26–100 million	USD 101–250 million	Over USD 250 million
Microsoft Excel	30%	26%	33%
Precision Collection (Timberline)	25%	30%	26%
ICE-2000 (MC2)	7%	10%	11%
Heavy Bid (HCSS)	3%	2%	6%
Developed in house	1%	4%	5%
Perfect Project (Emque)	3%	3%	0%

Timberline was at the top of the chart in the job costing, accounting and payroll software group (see Table 4). While it was the undisputed leader among the mid-size companies its popularity declined toward larger contractors. In the group of the largest companies CGC's Construction Management System was number one followed by Timberline, mPower and J.D. Edwards' World Software.

Table 4. Job costing/accounting/payroll software used by U.S. general contractors [CFMA, 2002].

	Contractor revenues/a		
Software (vendor)	USD 26–100 million	USD 101–250 million	Over USD 250 million
Gold Collection (Timberline)	42%	38%	16%
Construction Mgmt. System (CGC)	4%	12%	29%
mPower (Computer Methods)	2%	8%	16%
World Software (J.D. Edwards)	1%	4%	13%
Viewpoint (Bidtek)	6%	3%	4%
COINS (Shaker)	3%	5%	4%

3.6.5 Project Management and collaboration tools

All mid-size and large contractors as project management software solidly favored primavera whereas Prolog Manager by MPS was strong only in companies with annual revenues of more than USD 100 million. A third popular product worth mentioning in this application was Constructware. A fair amount of project management products are created in house, and quite a large share of companies especially in the mid-size group gets along without any project management software at all. (See Table 5.)

Table 5. Project management software used by U.S. general contractors [CFMA, 2002].

Software (vendor)	Contractor revenues/a		
	USD 26–100 million	USD 101–250 million	Over USD 250 million
Primavera Expedition	30%	27%	25%
Prolog Manager(MPS)	1%	26%	27%
Constructware	4%	17%	13%
Primavera Enterprise	4%	5%	6%
Developed in house	2%	3%	8%
None used	21%	4%	3%

Project collaboration through software is the more common the larger the contractor is. The study very dramatically showed that as many as 73 percent of mid-size companies does not use collaboration software. It was absent also in 30 percent of the larger companies and in 12 percent of the largest companies. Constructware has the most users in the two larger company categories but Meridian's Project Talk dominated among the largest companies. Also BuildPoint and Buzzsaw had respectable shares with the largest companies, who also developed 12 percent of their project collaboration tools on their own. (See Table 6.)

Owners with regular high-value projects occurring frequently are very savvy with IT tools for design, project management, and gradually also for collaboration. Those owners dictate which software to use in a construction project. To be competitive the responsible project contractor will accommodate and purchase the required tools or use them through an ASP. Still, in the majority of current construction projects the architects, engineers and contractors use software tools to their liking.

Table 6. Project collaboration software used by U.S. general contractors [CFMA, 2002]

Software (vendor)	Contractor revenues/a		
	USD 26–100 million	USD 101–250 million	Over USD 250 million
Constructware	5%	30%	16%
Meridian Project Talk	5%	2%	24%
BuildPoint	4%	7%	10%
Buzzsaw (Autodesk)	3%	5%	10%
Developed in house	0%	2%	12%
None used	73%	30%	12%

3.6.6 Scheduling

The mostly used project scheduling software was provided by Primavera and Microsoft Project placed second (see Table 7). The combined showing of two Primavera offerings resulted in 57 to 71 percent shares in the various size groups.

Table 7. Project scheduling software used by U.S. general contractors [CFMA, 2002].

Software (vendor)	Contractor revenues/a		
	USD 26–100 million	USD 101–250 million	Over USD 250 million
SureTrak (Primavera)	37%	36%	39%
Microsoft Project	37%	31%	23%
Project Planner (Primavera)	15%	16%	14%
Primavera Enterprise	5%	13%	18%
Construction Mgmt. System (CGC)	0%	2%	1%
None used	2%	0%	1%

3.6.7 Real Estate, Facilities management, work place management

The first multiple integrated Facility Management applications entered the market around 1990. At this time several types of Facility Management systems were connected together to form effective applications.

Under the impact of the recent Internet development most Facility Management applications tend to go towards systems using the Internet for communication. These systems are mostly used as an information source, but in recent years systems to be used with all activities that have to do with the running facilities have been designed. Many of the system developers offer different levels of complexity through their applications, e.g. Archibus that builds systems for both small and large companies with single- or multiple user systems[3].

Transaction systems for the Real Estate industry have improved during the last years, however this area is not yet fully developed. Today, most of the systems in this area offer different kinds of information services or act as a regular marketplace where customers can even make a deal. The service can either be open for everyone or function as a service to which the users have to subscribe.

[2] ibid

[3] http://www.archibus.com

Planning

The first step of commercial Real Estate is the planning phase. It is difficult and demanding to develop these kinds of systems because of the complexity of the planning analysis. Therefore only a few actors have been identified on the market.

3.6.8 Interoperability

Interoperability has been a subject for research and development for the last two decades in the FM/AEC industry. Despite several attempts, the major breakthrough, especially in the U.S., awaits itself. While the major members of the value chain, architects, engineers and contractors – as well as advanced owners – have sophisticated design software solutions per se; those products do not communicate well with each other. Although file sharing through electronic means is relatively common each project team member has to convert their 3D design drawings (if any) into 2D to transfer them electronically to another project participant. The recipient, in turn, has to create their own model (2D or 3D) to meet their specific requirements. While 3D data sharing between the main design tools is not possible, it is practical to use a 2D format for the transfer. Even if the 2D transfer is a smooth process, the viewing tools at the receiving end are not perfect.

Architects were historically the early adapters of 3D-design software. Along with technological advancements those graphical software solutions have become capable of producing impressive visualizations of the design projects. However, architectural software has traditionally been limited to graphics – lacking the intelligence to incorporate product data, or at least share it with other applications. This is one of the current inhibitors at the beginning of the value chain to slow down the further development of interoperability.

A typical construction contractor (or an AEC or EC company) has a large number of more or less disparate software solutions to handle the various back office functions as well as the more project-specific duties such as design, project management, estimating and scheduling. Typically there is little or at least insufficient interaction between programs dealing with physical (i.e. CAD) and non-physical (such as expenses) attributes. Integrating these two computing areas under the same umbrella would create a construction-specific “light” Enterprise Resource Planning (ERP) solution, which could result in significant cost savings within a construction company and particularly in project work. The major CAD solutions providers, such as Autodesk and Bentley, are seeking to expand beyond the traditional design business by developing their existing products toward that goal. That accomplished, they would be able to enter more

strategic partnerships with their customers. As a possible “by-product”, an all-inclusive property life cycle management solution could be developed for the most advanced property owners.

Some well-known ERP vendors already serving the construction industry may have similar plans to expand their back-office solutions to include the 3D design capabilities.

James O’Connor has evaluated some of the most used standards for system interfaces. Table 8 summarizes the comparison between the Steel Supply Chain Information (CIS), the aecXML, IFC, National CAD standard (NCS) and the Bulk Material ID code and Information standards. Interestingly enough, O’Connor also ranks the usefulness of the standards by the following weighed factors:

- Breath of scope,
- Progress in development cycle,
- Prospect for timely completion,
- Breath of input and acceptance,
- Opportunity for interface with other standards, and
- Implementation cost & difficulty.

The standard ranking the highest according to this study was the aecXML standard.

Table 8. Characterization of different standards [O'Connor & Hubers, 2003].

	Scope & Noteworthy Exclusions	History	Support & Implementation	Shortcomings	Future
CIS	Steel supply chain data pertaining to detailing, scheduling, tendering, ordering, purchasing, payment of primary and secondary steel members; Excludes non-steel components: concrete, masonry, timber, glass, HVAC, windows, doors, and machining/fabrication NC parameters;	Began in 1987 as CIMsteel project; CIS 1 released in 1995; Related development as AP 230 begun but stopped in 1998; CIS 2 begun in 1997 and was completed in 2000;	Initially involved 70 organizations from 10 European countries; Integraph and AceCad Implemented CIS 1; AISC has endorsed the use of CIS2-compliant software; Many pilot implementations underway;	See scope exclusion; Exclusion of Machining/fabrication NC parameters Particularly limiting;	Compatibility with STEP may resurface;
AecXML	An interoperable computer language similar to HTML; A framework for structuring text based material for efficient exchange over the Internet; Information exchanges addressed: RFP, RFQ, PO, RFI, drawings, specs, addenda, change orders, contracts, supplier catalogs, cost estimates, schedules, cost reports, and more;	Initiated by Bentley Systems in 1999; Merged with IAI efforts in 2000; Several data schemas available	Bentley, Autodesk, Primavera, Timberline, Meridian Systems, among other web portals; GSA has implemented on several projects; Several web-based portals are compatible;	Autodesk initially slow to join; Industry participation less than that needed; Dot Coms interested but can offer little financial support; Little compatibility with other industries;	ifcXML efforts underway for compatibility with IFC; full versions for IFC 2.0 and 2x already available
NCS National CAD Standard	Integration of three CAD standards; DOD, AIA, and CSI; Includes drawing set organization; schedule structuring; layering guidelines for different disciplines, systems, and status; drafting conventions; terms, abbreviations, symbols, and notations; code conventions; plotting guidelines, and color coding; Emphasis has been on 2D;	Began in 1994 with leadership by National Institute of Building Sciences; First version published in 1999; Second version completed in 2001;	AIA, CSI, GSA, National Institute of Building Sciences, Sheet Metal and Air Conditioning Constructor' National Assoc., U.S. Coast Guard; GSA and Intel require implementation on many projects;	Less participation by infrastructure and industrial sectors; Layering for these sectors need work;	Version 3.0 is near completion, with greater participation from facility managers and the industrial sector and some emphasis on 3D CAD; Integration with other standards, such as aecXML, IFC, libraries, etc.;
IFC	Industry Foundation Classes; Object model contains representations of physical elements in a building, such as beams, slabs, walls, doors, windows, electrical fixtures, furniture; Also addresses O/ M process Information: facility management, building services requirements, cost schedules;	Industry Alliance for Interoperability began in 1994 with 12 companies brought together by Autodesk; First version released in 1996; Version 2.0 released in 1999; Version 2.x released in 2000;	Participation is very international; IFC-compliant software is emerging from Autodesk, Bentley Systems, Graphisoft, Microsoft, NEC, Nemetschek, Primavera, Timberline, U.S. DOE, Public Works Canada, among others; Large number (30+) of certified commercial software products for versions 1.5.1, 2.0 and 2x.	Perceived domination by Autodesk slowed adoption in early phases; Development funding continues to be challenge: standard is large and expensive to implement, especially for small companies; Tools set software helps with implementation;	Extension 2x2 will be published in May 2003
CIMIS	Supports exchange of descriptive information for buying and managing bulk material, including common identifiers and standard descriptions for commodity materials utilized in construction, operations, and maintenance;	Began in late 1980's by CII and Constr. Industry Action Group then merged with API effort; 2000 version included piping, fittings, flanges, nipples, and gate valves; Very compatible with many legacy systems; Contains 2.3 millions entries;	American Suppliers Assoc., API Data Exchange Comm., PVF Roundtable, Trade Service Corp.; Little implementation thus far; Hope that web portals will facilitate usage;	Piping limitation limits benefits; Needs to be expanded to include structural, electrical and instrumentation commodities;	Continued growth and diversification of commodities included in system;

4. Finnish software offering

4.1 Overview of the Finnish companies and their products

The offering that this project covers is comprised of requirement management, modeling (model server), structural analysis, estimating and project management and scheduling. Figure 6 illustrates the space and functions that the tools cover.

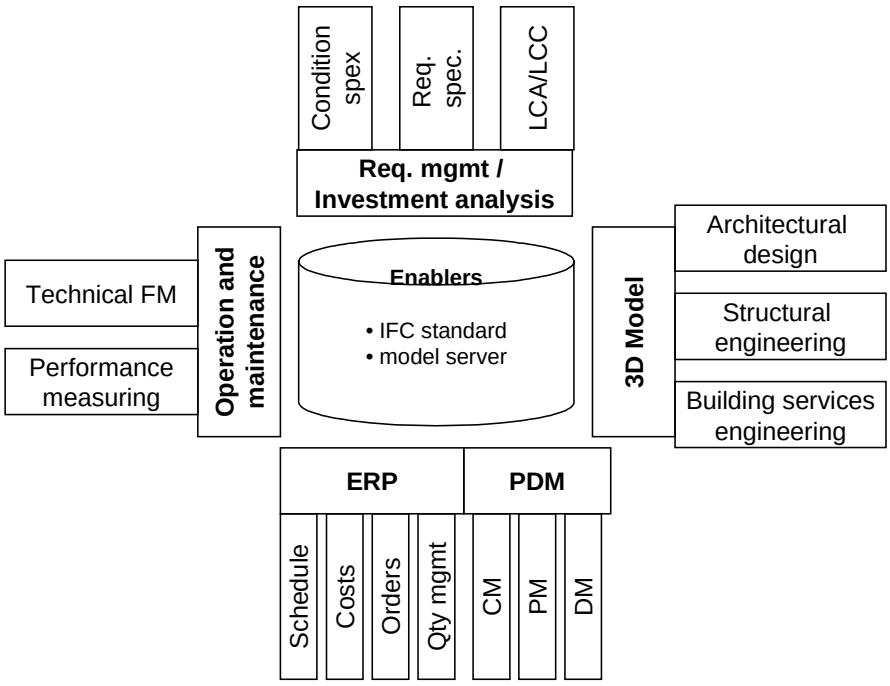

Figure 6. The framework for the Finnish FM/AEC offering.

The noteworthy aspect of the figure is that the tools are divided into enablers of interoperability and actual tools. The most important enabler of interoperability for the software is the Industry Foundation Classes (IFC) standard. This standard is taken as one of the cornerstones of the offering but not in an exclusive way. For example, aecXML can be used as well. Another important enabler is the model server technology represented by Eurostep. This approach is rather novel and can be considered as a future option for building competitive advantage for the offering.

4.2 Tocoman

Business definition / vision

The business of Tocoman is to offer innovative world class construction economist and quantity management services. These are implemented both as software tools and expert services.

Company phase (personnel, revenue)

Tocoman is has a history of developing information services and software applications for the building cluster since 1989. Today the company is active in Finland, UK and Sweden, but the aim is to increase the international presence. With about 50 employees Tocoman creates revenue of over 4 m€.

Products

TCM software and service concept include; integrated quantity take-off, cost estimation and data warehouse system. The new element and the competitive advantage that Tocoman has are the product data management functionality of buildings. This includes configuration management and related cost information. The offering can be described as Engine – Production – Consulting.

Customers and customer benefits

The customers for the Tocoman services are on one hand the owners of the buildings and on the other hand the construction companies. The best environment for Tocoman is the mass-customization where the role PDM and Configuration management becomes especially important. Improved building product and cost information improves the profitability of the construction companies.

Standards and interoperability

The IFC compatibility has been implemented through the ArchiCAD interface. The upcoming versions of the TCM products will be implemented according to the .Net architecture. Interfaces to scheduling and resourcing are under development.

4.3 DSS

Business definition / vision

DSS Oy is a software company specializing in building and earth-moving programs. The software focuses on project control. DSS Oy aims at becoming an internationally important producer of software for the construction industry.

Company phase (personnel, revenue)

Company was established in 2000 and presently employs about 10 persons. DSS Oy is in the commercialization phase and has some 20 companies and organizations piloting its software products.

Products (Technology)

DYNAProject is an intelligent scheduling system for the planning and control of building projects. Resource-based schedules use default or standard labor productivity figures. Risk analysis helps in testing for feasibility and sensitivity to disturbances.

Customers and customer benefits

The primary customers of DYNAproject are the construction companies of various sizes. Also the investors, project management and construction management companies can benefit of the product. DYNAproject enhances the scheduling, resource planning and control process of a building project.

Standards and interoperability

Typically the program reads the data (bills of quantities) in an Excel file. Interfaces to TCM and other object-based modeling software are under development.

4.4 Eurostep Oy

Business definition / vision

Eurostep is a consulting company specializing in information management. The Eurostep Group has presence in Finland, Germany, Sweden, UK and the U.S. The company sees that model servers enable product data management throughout building's life cycle, and they will be one of the leading service providers in this field. Eurostep will work on creating alliances with application vendors with the goal to,

together with partners, offer a suite of software products designed for the production use of the Eurostep Model Server for IFC.

Company phase

The Group has altogether 45 employees. The network is a spin-off of Digital's product modeling unit, and it has focus on STEP technologies. The group's managing director is in Sweden.

Products

The company specializes in product data management throughout the lifecycle of buildings. Its products include e.g. IFC Toolboxes and ES Model Servers. The Eurostep Model Server for IFC is targeting to enable the IFC information sharing paradigm, where software applications (like CAD, project management, cost calculations, etc) can access and update IFC models. The "Share-A-Space" is a design collaboration tool for several industries (like automotive and aerospace).

Customers and customer benefits

The Building Industry is one of the focus areas in the Nordic Countries. Design-build contractors are customers of the Eurostep as well as AEC/FM application vendors in the construction industry. Outside AEC/FM industry Eurostep is working e.g. in the area of automotive, and aerospace industries in participating in the development of standards, like ISO STEP, and Product Life-Cycle Support (PLCS), development of customer solutions, tools and applications to support product data management and life-cycle support.

Support, tools and expert services in the development process. Improved interoperability between various applications with the IFC Toolbox and EMS ModelServer. Improved collaboration in the design process. Better re-use of information which is based on standards.

Standards and interoperability

The Eurostep Model Server for IFC is fully conforming to the IFC standard. Other important standards used include EXPRESS, P21, UML, XML and SQL. Model Server implementation is utilizing technologies like Java, VRML, SOAP and Active-X.

4.5 Solibri – ModelChecker

Business definition / vision

The business of Solibri is “design spell checking”. The main product of Solibri is the ModelChecker, a program that checks the consistency of a building information model according to user specific, pre-set rules.

Company phase (personnel, revenue)

Solibri was established in 1999. Its personnel total 8 employees. The company is in the commercialization phase, where product benefits can be demonstrated, but the customer base is very limited. Early adopters are using the Model Checker.

Products (Technology)

The current product version is 1.6, which includes the Constraint Set Manager. The prerequisite for Model Checker has been that the Object Technology CAD-systems take over the market from document-based CAD systems. Today most CAD-systems are object technology, but still many user companies do design from a document perspective, which makes it more difficult to

Customers and customer benefits

Customers could include architects, construction companies as well as companies active in the facility management. Most potential customers are the construction companies, who can benefit directly from more correct models giving better cost estimates. The engineering companies and architects are not that interested because it is difficult to get a better price for better quality design (billable hours are their business).

Increasing the accuracy of time, cost and material estimates done based on the building model, by identifying design errors early in the process. Leverage of best practices by adding company-specific constraints etc. In a broader perspective Model Checker is helping to reduce the high costs caused by ineffective communication in the building process.

Standards and interoperability

Solibri Model Checker complies with and is certified to IFC 2.x. There is also a direct link between Model Checker and ArchiCAD.

4.6 Tekla – Xengineering & Xsteel

Business definition

Tekla Corporation supplies versatile model-based software. Its products and services are used in building and construction, energy sales and distribution, and public infrastructure. Tekla Building & Construction is concentrating on developing products for the structural engineering industry. Solutions cover the whole construction process, from the design to production.

Company phase

Tekla Corporation was established in 1966. Tekla's net sales in 2002 were over 40 M€ and it employs over 400 people. Currently Tekla has offices in 12 countries and its products are found in over 50 countries. Its shares are quoted in the Helsinki Stock Exchange.

Products (Technology)

Xsteel is a 3D modeling system for creating all types of steel structures. It creates an intelligent steel model, which can be shared throughout the design, fabrication and erection processes. Xengineer is the latest application in this field. With Xengineer the project specialist is able to model the complete building structure of their projects. Xengineer's multi-user mode allows several users to simultaneously access the same single product model.

Customers and customer benefits

Consulting engineers, project designers and steel and concrete manufacturers are Tekla's customers. In contrast to older 2D systems intelligent 3D technology results in remarkable gains in efficiency and accuracy and results in increasing overall productivity. Clients have been able to demonstrate an average of over 10% saving of tender returns against cost plans over a period of 5 years.

Standards and interoperability

Tekla has not yet applied for IFC certification. If and when it becomes necessary, Tekla is ready to certify its products.

4.7 Rapal – Optimaze.net

Business definition / vision

The business of Rapal is to provide services for the management processes of facility- and building property. The Vision of Rapal is to be the domestically leading and internationally recognized expert in investment and use economics of built environment.

Company phase (personnel, revenue)

Rapal is a company with a profitable history of over ten years. Rapal revenue in 2002 amounted to 2.2 M€ and the end-year head count to 20 employees. The property management services have been in the portfolio since 1995.

Products

Rapal's main services include space and occupancy cost management system and services for the property owners and users. These can be divided into three parts: consulting in the area of Corporate Real Estate (CRE), software tools for managing the use and the costs of real estate, and expert services related to implementation and use of the software system.

Customers and customer benefits

The potential customers of Rapal's space and occupancy cost management tools consists of the Corporate Real Estate function of companies and organizations managing and using office premises with above 100 workstations or an organization situated in more than one location, managing portfolio of any kind of facilities more than 200,000 sqft. Better utilization of the individual building or a building pool. Strategic costs measurement and utilization of the office space. Connecting the floor plan to the cost centers and accounting systems.

Standards and interoperability

The role of IFC standardization is limited. XML interfaces to other applications (like HR- and financial applications) are in use. .Net architecture will be used in upcoming versions.

Future plans

Rapal has taken a careful approach to international business development. Nordic Countries and EU are most interesting, but the U.S. has a special interest for competitive benchmarking.

4.8 VTT – EcoProP

Business definition / vision

VTT (Technical Research Center of Finland) is a government owned, not-for-profit research organization. The Ministry of Trade and Industry owns it. The mission of VTT is to provide applied, techno-economical research and development services to the Finnish industries. The vision of VTT is to improve the competitiveness of the industry and other business sectors through creating and applying technology. This will create welfare to the nation as a whole.

Company phase (personnel, revenue)

It has approx. 3000 employees and annual turnover of 250 m€. VTT has been in operation since 1942.

Products (Technology)

VTT is not primarily a software developer. Despite this and to a limited extent, VTT can be involved in commercializing its research results. EcoProP is an example of this activity. The product has been developed throughout the years in different research projects and has been piloted in a number of construction projects. EcoProP is a tool for the systematic management of building project requirements. EcoProp comprises a database of performance requirements and an easy-to-use interface to the database. There are a number of requirement definition sets that correspond to the possible requirements of different building project types. This application has been primarily designed for the building and construction domain but it can also be used in other domains by adding new requirement definition sets. The user can select from one to five pre-set performance levels for each requirement and add own requirements as well. EcoProp can be used to manage performance requirements for new building projects as well as for the evaluation of performance levels of existing buildings.

Customers and customer benefits

The customers are typically design team members who want to discuss with the user or/and owner the criteria of the project. Typically architects or design-build contractors use the tool to help fulfilling the customer expectations by describing the properties of the final product using a hierarchy of performance requirements and different performance levels. The technical solution can then be designed based on the specified requirements. EcoProp can also estimate life-cycle costs associated with different alternative solutions.

Standards and interoperability

A demo version of IFC interface has been produced. However, the IFC standard as such at the moment has not defined the ways performance requirements can be modeled. The developers EcoProp have produced the demo based on IFC standard extension.

Future plans & product roadmap

The current commercial version has been developed in co-operation with Eurostep. The tool is being adapted by an Australian partner to fit the requirements of the Pacific Rim market. The US market is being approached as an independent package as well. These efforts require localization by producing requirement definitions sets according to the U.S. practice.

4.9 Finnish references

There are several case examples of the Finnish construction projects that can be considered as references and proof of the benefits of this technology. YIT, which is the largest FM/AEC company in Finland, has probably the most extensive tools in day-to-day use in terms of coverage of their project activities, see for example, [Backas, 2002]. The company toolset comprises of

- Cove, a unique tool developed for construction companies and general contractors, to enable integration between a product model and company's know-how, e.g. cost structures, approved structural solutions and consumption figures. Cove calculates key figures and it checks whether the building is modeled and designed correctly. Cove has also sophisticated 4D features, which combine schedules with building parts, and thus can be used effectively for visualization. Cove also includes Solibri Model Checker. Cove has been used in production since 1998. It has had IFC 2.0 certificate since spring 2001 and IFC 2.x 1st step since October 2002.
- Tarmo, a cost estimation software fully integrated with Cove system and therefore also with the product model. Tarmo helps in making the most of the model-based

design. Tarmo manages a project database. One can integrate a schedule with product model data. This helps in logistics planning and provides high quality data to supply management and reporting systems. Tarmo has been used in production since 2000.

- Face3D is an application that is used to model existing buildings by measuring the actual parameters with a laser tracker. Face3D is targeted at companies, specializing in design, renovation and maintenance. Face3D functions as an individual program at the measuring phase of, for instance a renovation project. After importing the information and data to a database, it is used as an add-on program through ArchiCad. Face3D has been used in production since 1998.
- Toha is a procurement management software application. It is able to combine several project procurements. It also enables the user to utilize locations and schedule so that the delivery can be fast-tracked according to requirements of building sites. YIT has been widely utilizing Toha since the winter of 2003.

The company states that there are principally two important advantages. The first one is that YIT's Cove system can provide much more reliable information for the customer's decision making than ever before. Another advantage is that one can manage the construction knowledge throughout the entire construction process. This is possible when the computer is not only able to produce but also to interpret information, such as a design solution. Savings are based on the following five facts:

- Fast budget price. Model based system provides a unique way to obtain budget price from the first sketches in just a few hours. Despite the sketches, the level of detail is as accurate as it is in the bidding phase, where the final cost estimation is needed.
- Analysis. The design solution is analyzed according to company's know-how and the company's know-how is utilized before the construction starts.
- Alternatives. Several different design solutions can be compared rapidly, due to quick modeling and bidding process, and therefore the best design solution can be reached.
- Cutting down repeated work, overlapping activities, and redoing. In the traditional construction process, quantities are measured by hand four to seven times during the construction project. Now, computer handles this automatically.
- Reducing tendering time 50 to 80 percent. YIT's experience is that the time used for tendering has reduced form 3 weeks to 7–8 days since this system has been introduced. In the briefing phase bidding time can be cut even to a few hours. Thus, more emphasis can be put into design and construction quality, which gives a clear competitive advantage for the construction company.

The current state of YIT's development process is shown in Figure 7. Similar cases have been produced with the tools referred to in this report.

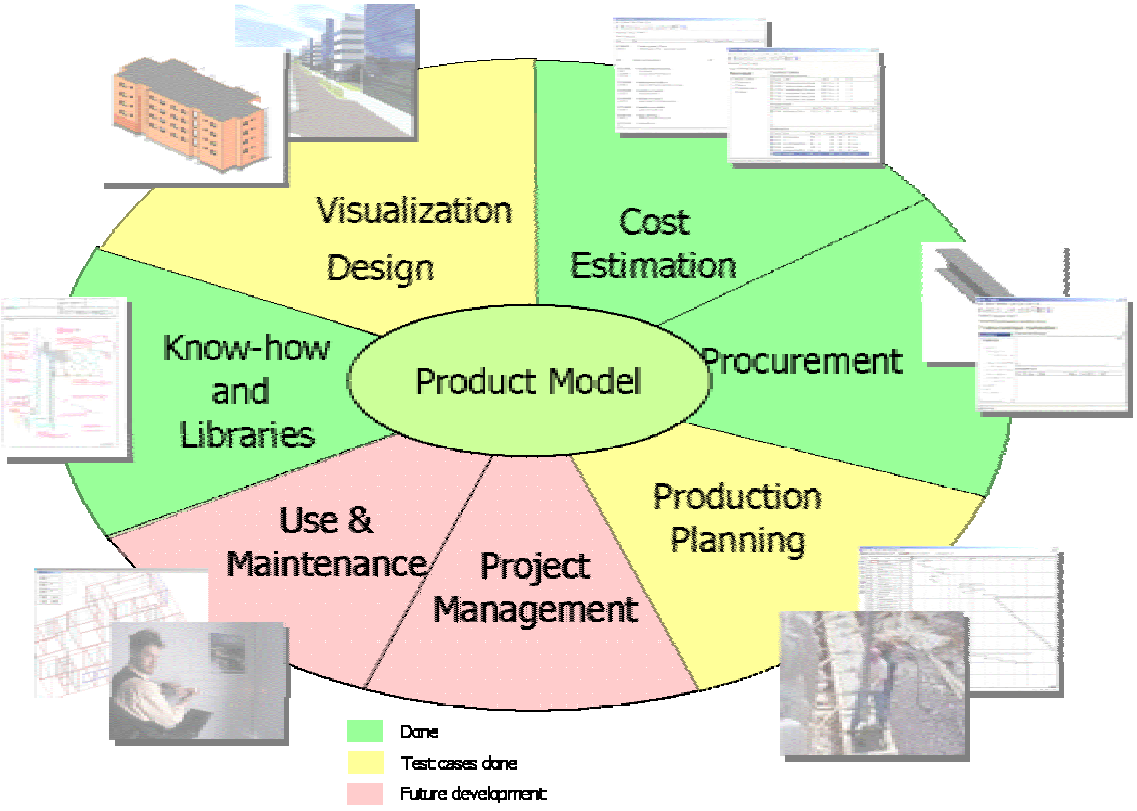

Figure 7. The state of YIT's IT development.

5. Combining Finnish Technology

5.1 About the differences between U.S. and Finland

The U.S. and Finnish construction markets differ radically by size and by use of software. The size of the Finnish market is just a fraction of the U.S. market. Most of the Finnish construction professionals – especially when it comes to the use of innovative software – know each other. Their backgrounds are also very homogenous compared to their counterparts in the U.S. This gives the Finns the advantage of a small and homogenous market: Adoption of any new technology can happen very rapidly, if the key players commit to the new way of working. Then again, this limits variation in innovation and may rule out some advanced practices. Either despite or due to this, the leap in the adoption of the technologies is significant. Figure 8 gives an estimate of how different areas might be at a more advanced level in terms or adaptation in Finland in the U.S. The approximation is subjective and based on interviews and estimates such as the VERA technology program evaluation by Froese [Uusikylä et al., 2003].

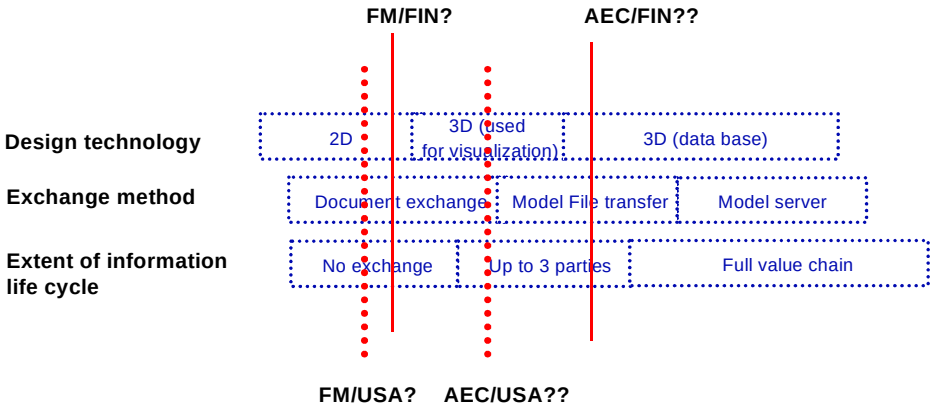

Figure 8. An estimation of differences between technology adoption in Finland and the U.S.

One of the most significant differences between the markets can be found in the area of interoperability. The American software vendors do not believe that the market is capable of producing a feasible, industry-wide standard for data interchange and thus enabling true interoperability between software packages of different vendors. The standardization efforts are said not to move agilely enough to meet the needs of the industry. The Europeans have a longer tradition in standardization. The Finns especially have a good track record of producing industry-wide standards, such as the GSM for mobile telecommunication. The GSM standard is a prime example how a new market opened up for a range of new services, such as SMS messaging. This approach has not really worked in the U.S.

The same analogy works in construction as well. The large U.S. vendors, such as Autodesk and Bentley, primarily act as if their strategy is to be the ”Microsoft” of the industry, to produce the best product and data exchange format available and to outperform competitors and to become the ”de facto” standard of the construction industry. So far, Autodesk has been rather close to reaching this situation.

In Finland, the vision for information technology development in the FM/AEC industry has been to enable value-added management of building product information[4] by different, interoperable software packages throughout the life cycle of the building [Karstila & Seren, 2002, p. 4].

Owning or management of building stock has become globally a more professional discipline. The building owners operate in more and more integrated ways with the construction industry professionals. In Finland, these two professions are seen as being a part of one and the same industry cluster. This can also be sensed in the ways information is used: product information can be passed from the construction industry professionals to the maintenance organization.

One of the most critical issues in using tools is the ownership of the model and other data. In Finland, it is less likely that litigation related to the use of building product models would occur compared to that of the U.S. market. The Finnish legal system is based upon legal codes rather than the common law system. These codes include statutory safeguards and other provisions that allow abbreviated documents. In common law jurisdictions such as the U.S., certain protections provided by the code-based legal systems are not present. As a result of this difference, legal documentation in the U.S., whether it is of a contract or joint venture agreement, tends to be extremely long compared to those for similar transactions in Finland. The Finns, conditioned by business atmosphere in Finland, insist that U.S. documentation be abbreviated. By not focusing on appropriate legal provisions to treat matters such as indemnification, termination, exit strategy limitation of liability and other issues, many Finnish companies have been exposed to often-significant liability [Jacobsen, 2001, p. 182].

Also, the most valuable assets of a high tech company often are its intellectual property. Intellectual property can advance company’s strategic position and secure its competitive edge in a swiftly changing global environment. Establishing protection for intellectual property in Finland and Europe does not mean that the company can feel secure in the U.S. [Jacobsen, 2001, p. 173]. Software is most often protected by other means than patents.

[4] As opposed to 2D drawings.

5.2 Creating an integrated but open family of features

5.2.1 Value proposition vs. maturity of the market and companies

The key issue in making a successful market entry in the U.S. is how the software packages can be combined in a way that meets the emerging market expectations and delivers proven added value. The hypothesis of this project is that combination of such software packages, a family of Finnish FM/AEC tools, can be created. The value proposition of the Finnish product family is based on the open, interoperable use of information throughout the life cycle of a building. The recorded estimates give an overall cost saving of 4% of project contract price and overall time saving of 5–10% depending on the reference project.

The objective of this initiative has been to put together a group of companies that together can offer something that none of them could deliver by themselves. The idea has been that together the companies can aggregate enough power, funding and publicity to break the suspicion of the U.S. building sector. The hypothesis since the beginning of the project has been that better information management covering the building life cycle will increase the productivity of the sector, and that the group of vendors can gain competitive advantage based on this.

The companies contacted and considered for this project have been selected to fit into this framework and together cover the areas shown in section 4. Also the assumed openness and interoperability with other vendors have affected the choices, as well as the size and resources of each company in order to participate in international business development.

Basically the authors see four groups among the Finnish FM/AEC software companies. Some of the companies are presenting very new innovative approaches, which have not yet been accepted by the mass market. These companies are in a situation where further product development, productification and close co-operation with pilot customers is crucial. However, as these companies often represent the newest technology and way of thinking they can bring a lot of value to the concept.

The second group of products is fairly young products, which still need to find their place in the market. These companies have successful commercial deals and reference customers show the value of the offering. The shown value should be utilized to open up new sales channels both in the home market and internationally. In this project these companies will be particularly valuable in showing success of the new way of thinking and presenting positive customer testimonials.

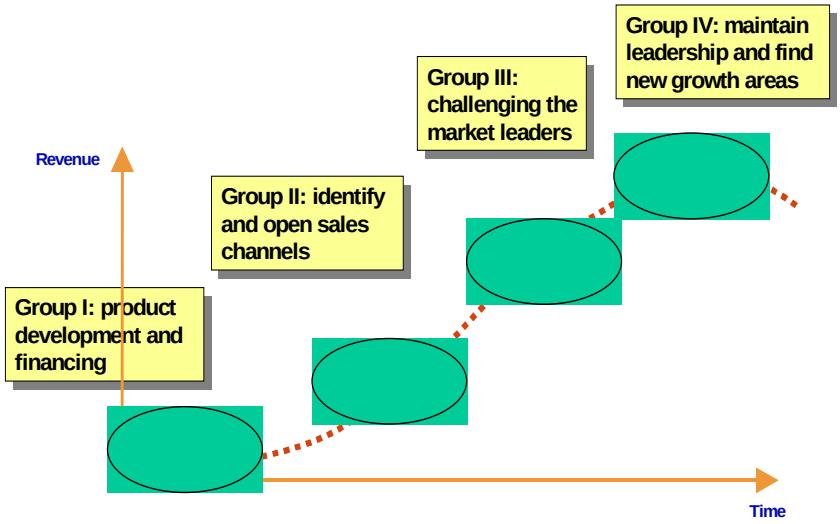

Figure 9. Product maturity: Different challenges.

The third group of companies are those which have an established market for the products and are recognized as a major player by its customer segment. The company is internationally recognized and has an international sales channel. The recognition and presence of the company will be a valuable asset when presenting and launching the concept on the U.S. market.

The fourth group is the established market leaders. Market leadership is often a matter of definition, but in the group of companies discussed above only one could be positioned in this group (Tekla). The value of this group for the concept is the same as of the third group.

The fact that the technology and companies are on different levels of maturity has to be taken into account when forming a possible venture or business entity. The more mature companies may have the resources and power to support the entry operations, whereas the small, younger companies can be agile and faster to adapt turbulent environments. These are factors that need to be taken into consideration in the contractual arrangements.

5.3 Data flow enabled with existing tools

The joint effort to launch a concept for the U.S. market cannot be primarily dependent on how the companies operate in Finland. The primary factor is the way the core of the products value to the projects and how this new technology is better than its competitors. In

this respect the real core of the offering is the capability of performing data interchange in ways that eliminate most of the non-value-adding work typical of the current use of tools.

The data flow enabled by the Finnish family of products covers some of the essential parts of the value chain. This is illustrated in Figure 10. The way the software packages interact as shown in the Figure has not been tested in its totality in actual projects. However, parts of the flow are available and have been used in projects. Some of the data interchange needs more development work should the package enter market as one functional software tool.

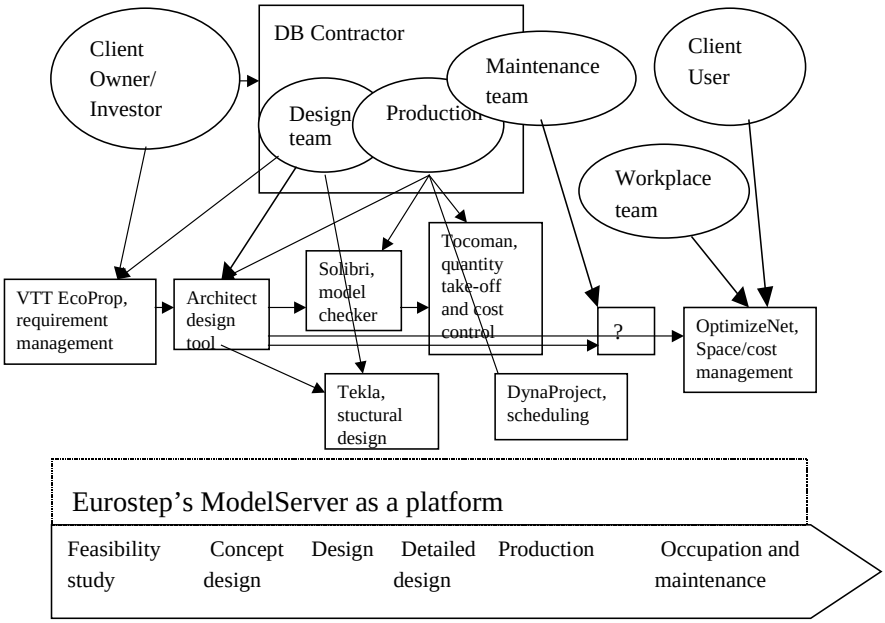

Figure 10. The value chain and the Finnish software family.

Using the EcoProp tool for setting performance requirements of a building can cover the first step along the value chain. The software produces a project brief, which can be used as a guideline for design. The resulting performance requirements can be used as input for establishing constraints for the Model Checker. This is typically done in cooperation between the architect and user/owner. From this point on the work is passed on to the design team.

To create some added value compared to the current practice, the design process itself should be based on a 3D model. The initial model must be created by architectural software in a format, which can be used in other design and analyses tasks. In the figure

above, xEngineer is utilizing data from the initial model. In reality the process is not linear, but iterative transferring data between applications, and the role of model server solutions as the central information storage for all applications is crucial.

The resulting model can be checked against any constraints set by the design team with Solibri's Model Checker. The constraints can help the design team to verify the design, or the contractor can make checks to improve constructability. This makes the model more coherent.

The checked model can be used for quantity take-off by using Tocoman's TCM software. The TCM connector tools can be used to assign quantity/cost structures to the objects of the product model. Based on the structure quantities can be calculated using item and resource pricing. The construction team typically executes this. The TCM software package allows also the construction team to draft a target budget and control the accumulation of actual costs easily at any stage during the project.

The quantities can be transferred to the scheduling tool, the DynaProject module. It can produce a line-of-balance schedule. The construction team can do this work.

As the 3D model is updated during construction, it evolves into an "as is" model. This can be used as direct input to the Optimaze.net module. The model is used for space management (office buildings only). The user can utilize this data by connecting the use of space and the costs generated by its use. Optimaze.net helps the facility owner also in finding ways to use the space better in terms of financial criteria, added value to the core business of the owner/user, customer and employee satisfaction and flexibility against changes.

Table 9 shows the new features that the potential collaboration of Finnish vendors might offer compared to the current offering.

Table 9. GAP analysis of features offered.

Part of the value chain	Features available now	New features offered
Intent/Brief	No unified approach to producing a design brief	Performance approach, specific emphasis on sustainability
Design	Proprietary 3D models, .dwg data transfer, limited data transfer within the project team	True IFC compliance Link from architect's 3D to structural design
Construction	Some file transfer available from 3D models to quantity take-off	True data transfer from product model to both quantity take-offs, cost estimates as well as scheduling
FM/Operations	File transfer from 2D models to FM management tools (for example, Bricsnet)	True as-built information, improved maintenance process, more efficient spatial and property management

5.4 Main technical obstacles

The main technical obstacles related to developing the joint offering are related to interoperability. Solibri Model Checker, Eurostep's Model Server and Tocoman's products have IFC interfaces. DynaProject, EcoProp and Optimize.net do not offer this feature in as a complete form as the other packages, although they are fully capable of implementing these features. However, the interoperability has not been tested in real construction projects so that the test would cover all the modules or products listed in this report. Tests between two or even three packages can be found.

Localizing the modules is a task that does not necessarily need much new actual development work apart from EcoProp. However, resources for this task are often underestimated or overlooked. Especially with regards to the group effort, the localizing might have special demands such as the possible handling of Requests for Information (RFIs) in an interoperable manner. The Finnish way of managing projects does not have to tackle this problem at all.

6. Major Competitors

6.1 About competition

The United States FM/AEC software market is dominated by relatively few large vendors. Although each main application typically is served by 15 to 20 recognized software brands, most of them have been in the shadow of a market leaders or – at best – by a trio of the most popular products.

By and large, the U.S. construction and facility management branch enjoys relatively good design, financial and project management tools. The software may lack the ultimate sophistication, but the users – the FM/AEC industry – get by when considering their current requirement level. One of the biggest shortcomings is the wide-ranged incompatibility between many leading software products inhibiting – or at least slowing down – the endeavors toward seamless all-inclusive building information modeling.

The software vendors have been rather slow in committing to industry-wide interoperability efforts by making their products compliant. Whether it is IFC or aecXML – or anything else the industry will be able to agree upon – most vendors state that their products “will be ready” when there is an adequate number of followers across the industry.

6.2 Leading software vendors

There are a few large software companies in the U.S. whose product portfolio covers many design or project-related applications. Those companies include the design powerhouses Autodesk and Bentley, the accounting and cost management specialist Timberline, and by far the largest FM solutions provider, Archibus. In addition, there are several other vendors who have sought-after products or modules in two or three application categories.

Thanks to their extensive presence in the market and product development resources these companies are in the best position to be key players in model-based collaboration technologies – if they choose so. They are active in the international standardization efforts aiming at interoperability, but smooth collaboration – due to competitive reasons and uncertainty of future formats – has not materialized thus far.

Autodesk, Inc.

The company is the globally leading provider of CAD software. Primarily architects and engineers to design, draft, and model products and buildings use its flagship AutoCAD product. Besides building AEC, Autodesk's customers include civil engineering, manufacturing, utilities, and media and entertainment. International customers account for about two-thirds of sales. Autodesk continues to focus on leveraging its products online, targeting the manufacturing and construction industries.

The AutoCAD software is Autodesk’s core CAD tool used independently and in conjunction with other specific applications in fields ranging from construction and manufacturing to process plant design and mapping. Professionals utilize AutoCAD for design, modeling, drafting, rendering and facility management tasks.

AutoCAD is the technology foundation for thousands of third-party design solutions serving a number of industries including various specialty applications within the construction industry.

Bentley Systems, Inc.

Bentley's CAD software is used to design and build large-scale projects such as airports, transit and utilities systems, manufacturing plants, and all types of buildings. Bentley tends to be favored by larger architectural and engineering companies, who apply Bentley's MicroStation platform software to more demanding projects (whereas Autodesk’s design tools are used more evenly across the board for any kind of projects).

Bentley’s software is available on both a perpetual license and subscription basis and lets architects, engineers, builders, and property owners collaborate over the Web to develop and maintain their projects. The company also provides content management applications as well as consulting, integration, and training services. Design systems maker Intergraph owns about one-third of the company.

Bentley’s products are IFC 2x-compliant, and Bentley was also the initiator of the aecXML format. Bentley probably also has the most feature-filled integrated software system in its TriForma for the FM/AEC industries.

Timberline Software Corp.

Timberline Software Corp. develops, markets, and supports accounting, cost estimating and service management software applications primarily for the construction and real estate industries. More than 25,000 construction and property management customers

use Timberline's Windows-based industry-leading products. The company's Gold Collection accounting suite offers a set of tools targeted toward property managers and contracting firms (while its Precision Collection helps residential contractors estimate costs and bid for jobs). Other applications automate procurement, production management, and service management functions. The company also offers support services such as training and consulting.

The company's operations are divided into two main segments: software products and software services. Timberline has three main software product lines: Accounting (composed of construction, property management and service management software), Estimating and Project Management. The Estimating software applications allow estimators to compile bids on construction projects based on certain parameters such as the architectural design, building materials required and labor costs. The project management software is fully integrated with the accounting and estimating software applications.

One of the newest components of Timberline Estimating is CAD Integrator, which incorporates support for the IFC standard. Timberline CAD Integrator imports the IFC data, and Timberline Estimating takes it, creates a working file, generates a takeoff and an estimate, and writes the cost estimate back to the IFC file. No additional measuring, digitizing, or manual takeoff is needed for the IFC objects. If the design changes, a new estimate can be generated in minutes. Timberline’s products have a 28-percent market share construction industry’s accounting software category and 13 percent of the cost estimating market.

Primavera Systems, Inc.

Primavera Systems serves up project management software used in all sorts of projects, including buildings and infrastructure projects. Primavera’s products have been used in many high-profile projects around the world. Primavera's applications analyze risk, assign resources, track tasks, schedule contractors, and keep expense records and time sheets for projects of all sizes. For the past 20 years, Primavera has become widely known as the leading provider of comprehensive project management, control and execution software. In fact, it is estimated that projects totaling more than 4 trillion in value have been managed with Primavera products.

Archibus, Inc.

Archibus is the best-known global provider of facilities management and infrastructure management solutions and services. Archibus is an add-on program to AutoCAD for facility management applications and it has by far the largest market share in the facility management software market. Archibus/FM has over 100,000 enterprise system users

worldwide, managing over 1.4 million buildings and nearly 1.5 billion square meters. Available in more than 100 countries, Archibus/FM is supported through a global network of over 1600 business partners.

The Archibus/FM solution enables organizations to make informed strategic and business decisions that optimize ROI, lower asset life cycle costs, and increase enterprise-wide productivity and profitability. Organizations of all sizes, spanning the financial, educational, governmental, healthcare, and manufacturing industries, use Archibus/FM to deliver timely, relevant facilities information as part of their strategic business plans.

6.3 Architectural design

CAD software market is clearly dominated by two domestic leaders, Autodesk, Inc. and Bentley Systems, both of them offering a wealth of FM/AEC solutions. Primarily three European vendors, Dassault Systemes SA, Graphisoft NV and Nemetschek AG enrich the available product assortment.

Autodesk, Inc.

The AutoCAD software is Autodesk's core CAD tool used independently and in conjunction with other specific applications in fields ranging from construction and manufacturing to process plant design and mapping. AutoCAD is utilized for design, modeling, drafting, rendering and facility management tasks. AutoCAD is the technology foundation for thousands of third-party design solutions serving a number of industries including various specialty applications within the construction industry.

Autodesk Architectural Desktop (ADT) is a design and documentation software that provides the benefits of building information modeling on the AutoCAD platform. Supporting the architectural design process from conceptual design to design development, through construction documentation, ADT features industry-specific 2-D production drafting functionality and integrated and accessible 3-D design options and all of AutoCAD's functionality. Users benefit from simplified mass modeling, intelligent building components, style definitions and layer management according to industry standards. Speculations exist that ADT may eventually by phased out.

Autodesk's Revit 5 features a building design and documentation system by the newly acquired Revit Technology Corporation. Revit is a parametric building modeler, which has gained recognition thanks to its user-friendliness. Unlike Autodesk's "own" ADT, Revit automatically coordinates all design information making changes quick and easy,

and enabling high-quality documentation. The Revit product line appears to compete nearly head to head with ADT. Its primary target user group consists of designers who are not familiar with and do not want to switch to ADT and the traditional AutoCAD environment.

Bentley Systems, Inc.

MicroStation TriForma 3D is a modeling software for architectural and engineering design. MicroStation TriForma provides the building and plant industry with a common technology platform and consistent user interface for architectural and engineering design. The 3D solids modeling software provides a set of tools designed to address object management, modeling and drafting, visualization, drawing and report extraction and interference review. MicroStation TriForma improves communication and coordination by laying the foundation for a suite of specific applications that address the needs of the many disciplines involved in a building project; including solutions for architectural, structural, mechanical, and electrical raceway design.

Bentley Model Streaming allows the user to interact with high-quality 3D models via a standard Web browser. Models can contain important attribute information from the original design application that describes each component. Unlike desktop applications that require an entire model to be loaded locally, Bentley Model Streaming provides access to the model from a server through a Web browser. No pre-installation of client side software is required, and there is no waiting for entire models to load before beginning the review of large 3D models.

Bentley Architecture can automate the architectural design and production process, from conceptual design to construction documentation. Bentley Architecture features an intuitive user interface, powerful tools and libraries of standard components to support architects throughout the design, documentation and construction process. The flexibility of Bentley Architecture lets the user leverage many international and regional industry standards, or easily customize and expand these standards to meet any specific needs.

Recognized foreign-based technology leaders having foothold in the U.S. include the following companies:

Nementschek and VectorWorks

VectorWorks Architect by German Nementschek AG has a multitude of features to streamline the design and production process. From project setup to programming, schematic design development and construction documents, architect lets the designer work faster and smarter with fewer errors. Nemetschek acquired VectorWorks to

become their U.S. subsidiary. Nemetschek has its own 3D modeling system, Allplan, but it is not widely marketed in the U.S.

Graphisoft U.S., Inc.

Graphisoft is based in Hungary but has established a subsidiary in the U.S. as well. Its flagship product, ArchiCAD is an advanced building information modeling system. During the design process this building information authoring tool creates a central database of 3D model data. All necessary information, such as complete plans, sections and elevations, architectural and construction details, bills of material, window/door/finish schedules, renderings, animations and virtual reality scenes to describe the design, can be extracted from the model. ArchiCAD automatically creates all the project documentation eliminating most repetitive drafting work. The Virtual Building approach also enables further changes at any time maintaining the integrity of all project documents. The Virtual Building approach gives the user a competitive edge by integrating the design into the Building Information Solution. With ArchiCAD the user can access the right representation of the building of for each design phase, and for all of the different partners involved in the project. Project team members can receive the building data in electronic format, regardless of which CAD platform they are on, make changes and return the file for further work without any loss of the Virtual Building data in the process. Comprehensive schedules and bills of materials are available for builders and subcontractors, as well as drawings of scale-sensitive details. Builders can plan tasks, create time-based animations and document any phase of a building's construction or demolition. Finally, developers can use the photo-realistic renderings for a sales brochure.

Dassault Systemes SA

The flagship CAD software of Dassault Systemes, CATIA, is primarily used in highly complex mechanical design as well as many other non-construction applications. Typically a select group of major engineering companies involved in demanding industrial projects are CATIA users as are few large architectural firms. The CATIA model is considered the most robust in the architectural and engineering sectors.

6.4 Structural design

Research Engineers International (REI)

STAAD.Pro is a structural engineering software product for 3D model generation, analysis and multi-material design. It combines visualization tools, analysis and design

facilities and seamless integration to several other modeling and design software products. The software is suitable for static or dynamic analysis of steel, concrete, aluminum or timber buildings, stadiums or any other simple or complex structure.

Design Data, Inc.

SDS/2 by Design Data features engineering design and analysis modules (also a detailing module exists) for engineering companies involved with steel. Structural engineers can create a model that does not need any exporting, translating, or other file manipulation to communicate with their partners.

RAM International

RAM Advanse is a tool for 2D or 3D finite element analysis and design, fully equipped with an analytical engine and OpenGL based graphics. RAM Advanse's intuitive and powerful modeling tools get complex models built quickly.

Autodesk

AutoCAD, thanks to its versatility and long reach in engineering, is a development platform to numerous structural design software packages by small independent vendors.

Bentley Systems, Inc.

Bentley Structural optimizes MicroStation TriForma for structural design and construction documentation. The software features an intuitive user interface, powerful tools and a host of standard components that support structural engineers and designers in the design and documentation of a wide range of structural systems. In addition, Bentley's MIDAS/GENw features a comprehensive structural systems analysis tool that is fully integrated with Bentley Structural to provide coordinated structural design and documentation.

6.5 Other design functions

Autodesk, Inc.

With Autodesk ADT technology built in, Autodesk Building Systems is a stand-alone application that integrates mechanical, electrical, and plumbing functionality for the design and documentation of building systems. Autodesk Building Systems provides

engineering-specific design features for increased productivity and accuracy; building information modeling technology for easy coordination of construction documents and project data; and extensive content libraries and content-creation tools. Autodesk Building Systems integrates three modules – mechanical, electrical, and plumbing – with features that are common to all three, as well as distinct features specific to each discipline. Autodesk Building Systems provides a variety of tools created specifically for mechanical design of piping and ductwork.

The HVAC design arena has only few additional discipline-oriented software vendors – with products based on AutoCAD – but they do not have industry-wide dominance.

Bentley Systems, Inc.

Bentley HVAC is a tool for mechanical engineers and designers who desire a product that offers a choice in workflow and intuitive operation. Bentley HVAC offers a fully integrated, comprehensive solution for the design and documentation of building environmental systems. Powerful tools and a number of standard components support engineers in the design and documentation of air systems.

6.6 Project management/collaboration

Autodesk, Inc.

Autodesk's Buzzsaw is an online collaboration and project management service for building professionals. Buzzsaw offers services that streamline numerous aspects of the building process from design to construction, and from bidding to buying keeping the project teams connected throughout the project life cycle. Currently a unit of Autodesk, Buzzsaw has experienced hard times in recent years but appears to be slowly recovering.

Bentley Systems, Inc.

Bentley ProjectWise is a content management solution for engineering offices. Users can consolidate decentralized engineering content into a single presentation to ensure that all project team members have access to the right data when they need it. ProjectWise is designed to handle MicroStation DGN and AutoCAD DWG files, as well as other business file formats. This three-tier solution leverages existing network infrastructures and provides a common platform for the management of content created by Bentley's portfolio of engineering applications. Related project documents, such as those created by Microsoft Office XP, can also be stored, viewed and annotated within

the Bentley ProjectWise environment. This allows the creation and management of project content throughout the design and construction process, as well as the reuse of that content during the operational life time of the built asset.

Bentley Project Hosting features Internet-based project Web site. Project Hosting combines project scheduling, file sharing, discussion groups and security features to create a single point of entry for project management. It is accessible from an Internet browser without complicated plug-ins or client-side software, making it always available for project collaboration.

Timberline Software Corp.

Project Management tools address and combine Timberline's core specialties under one management umbrella. With all the facts in one central database, and easy-to-customize inquiries and reports the project team members are constantly abreast with real-time project status. Further capabilities include management of change orders, comparison of actual costs against budgets, streamlining RFIs[5], submittals and other documentation, and improved workflow – including the approval process – between project managers and accounting. Integration of construction estimating, accounting, and project management enables the retrieval of all facts in a timely manner.

Meridian Project Systems

Prolog Application Suite by Meriadan Project Systems is a knowledge management system for the FM/AEC industries. It is an integrated project management solution to manage projects from a corporate and collaborative perspective. With the Prolog Application Suite, the project participants can manage project collaboration workflow using Prolog Web site; perform robust project management with Prolog Manager; manage resources and schedules with Prolog Scheduler; and enter field information in handheld personal computers using Prolog Pocket. Both documents and data can be managed, creating one central database for all project information**.** Further, the system can procure materials and services, manage project budgets, and contracts, track project control data and documents, track schedules and resources, collaborate with your project team through the Internet and analyze corporate information from multiple projects and locations.

ProjectTalk is a full-featured online collaboration and project management solution to which users subscribe and access via the Internet. Companies involved in development,

[5] Request for information

planning, engineering, design, procurement, construction and management of facilities use ProjectTalk. This online service brings together the necessary products and services for program and project management. Thanks to ProjectTalk projects can be managed more efficiently and operational savings can be realized. ProjectTalk.com offers three major areas of value: applications, eCommerce, and industry information.

Primavera Systems, Inc.

P3e/c for Construction (P3e/c) is a tailored solution for the specific needs of the construction industry. It empowers engineering and construction professionals to mitigate project risk through powerful schedule analysis, accurate cost forecasting and streamlined coordination among designers, contractors, and owners. P3e/c provides centralized access to all project information by multiple users at the same time. It is an integrated solution with web-enabled, client/server, and desktop software that provides role-specific capabilities to satisfy each team member's needs, responsibilities and skills. P3e/c simplifies contractor schedule integration, enhances collaboration, and has the versatility to support teams who manage single projects or complex programs.

Primavera Expedition is a contract management and project control solution for architecture, engineering, and construction projects. Expedition facilitates carrying out construction projects successfully to an on-time and on-budget completion. Expedition includes an extensive logging system to record every type of project communication, including transmittal letters, RFIs, notices, meeting minutes, phone records, notepads, project letters and correspondence.

Primavera Project Planner (P3) features a solution to control large and complex projects. Project professionals in the engineering, construction, architecture, and utilities industries especially favor it. P3 is the recognized standard for high-performance project management software and is designed to handle highly sophisticated and multifaceted projects.

PrimeContract is an online collaboration and project execution solutions for engineering-construction projects. PrimeContract helps owners and their contractors to speed project team communication, simplifying online construction contract payment negotiations, and expediting the review and approval of design specifications and construction drawings. Project owners and contractors can use project workflow templates to track project milestones, generate and route project documents, and create task lists online in a secure environment. With PrimeContract Collaboration, project teams can host threaded discussions, post industry and project news, and broadcast events. Real time information with e-mail notification provides the most accurate and up-to-date project data to each member of the project team regardless time and location.

SureTrak Project Manager is a scaled-down project management software for small to medium sized projects. It is a combination of ease-of-use, power and affordability, and it is ideal for resource planning and control medium-size contractors. SureTrak is easy to learn how to use, and it is especially beneficial to professionals who only have limited time to update and manage their projects.

Citadon, Inc.

Citadon CW is an enterprise collaboration solution that can be customized and configured to meet the unique needs of each customer. Collaboration technology is offered to design, construction and facility management companies, and a special emphasis is on complex capital projects. Citadon CW also supports integration with other enterprise applications through comprehensive XML-based APIs. Citadon CW can be deployed as a managed and hosted service through Citadon or installed at a third party data center on customer-provided hardware. Citadon has recently performed below expectations.

Emerging Solutions, Inc.

Constructware features collaboration solutions to construction-related companies that help them achieve business success by increasing productivity, improving risk management and reducing costs. Constructware's enterprise-wide project management solution designed for the Internet. The system is mainly intended for general contractors, architects and owners; Constructware enables companies to manage their projects throughout the entire life cycle, from pre-bid to completion.

6.7 Project management estimating/accounting/scheduling

These software categories may include as many as 200 software products used by FM/AEC companies. For the estimating and scheduling functions Microsoft's products (MS Excel and MS Project, respectively) have up to 30 percent market share. Most estimating, accounting and scheduling (point) software vendors target at multiple industries.

Timberline Software Corp.

Timberline Office is an integrated software package including Timberline's proven accounting, estimating, procurement and project management functions. (Timberline has renamed its Precision Collection and Gold Collection suites.)

Timberline Estimating encompasses the whole estimating process, from conceptual estimate to final bill of materials. According to Timberline, the software reduces estimating time by 50% or more. Timberline Estimating offers fast and accurate takeoff tools, a variety of ways to view and analyze the estimate, presentation-quality reports, and more. Estimating comes in basic, standard, and extended editions. Among its many modules are CAD Integrator, Commercial Construction Knowledgebase, Digitizer, Model Estimating (starting from the concept), Prebuilt Databases, Scheduling Integrator, and Viewer.

With the Timberline CAD Integrator, no custom interface is required to transfer information from CAD drawings into a Timberline estimate. Estimates are generated directly from any IFC-compliant CAD software smoothly and accurately. Eliminating manual and digitizer takeoff results in increased speed and improved productivity.

Quick project schedules are enabled thorough the use of Scheduling Integrator to connect Timberline's Estimating to industry-standard scheduling software such as Primavera or Microsoft Project for Windows. Scheduling Integrator gives the contractor instant access to labor and equipment details, material items, productivity factors, and estimator notes.

The Timberline Accounting is complete accounting software to automate, streamline and extend cost control. Whether it's payroll and job costing, to profit analysis and variance tracking, the system provides the answers. An adaptable General Ledger lets the user track multiple divisions, regions, and the entire company. Each operation can be analyzed independently, or the entire company as a whole. Want details? From payroll and job costing, to receivables and cash flow, Timberline Accounting automatically tracks the facts.

Bentley Systems, Inc.

Bentley Schedule Simulator visually simulates the construction process by integrating detailed 3D models with critical scheduling and planning information. Bentley Schedule Simulator visually simulates the construction process by integrating detailed 3D models with critical scheduling and planning information. This can provide project managers with actual vs. planned construction comparisons, analysis of constructability issues, improved design and procurement strategies, and exploration of alternative dispute resolutions.

Management Computer Controls, Inc.

According to MCC, ICE 2000 is the richest, deepest solution ever developed for contractors. Using MS Office 2000 look-and-feel plus time-proven knowledge bases, ICE 2000 gives the contractor a versatile solution for concrete, masonry, drywall, civil, pipe, mechanical as well as electrical estimates. ICE 2000 reduces time spent in takeoff: Using a single entry form manual scrolling through a large number of items is eliminated. Only components needed are selected, and ICE 2000 generates the specified items. Revolutionary Estimating Wizards allow the user to create detailed conceptual estimates with ICE 2000. Using a typical office building as an example, the Estimating Wizards will automatically generate a detailed estimate based on building parameters. With Estimating Wizards, standardization within the estimating department is promoted while increasing productivity and profits. ICE 2000's takeoff screen provides instant calculations with live results.

Areas, perimeters, lengths and counts using on-screen graphics with colors are quickly and accurately digitized. ICE 2000 stores these graphics along with the estimate making possible job backtracking easy and effortless. Finally, takeoff graphics for presentations to clients or to management can be printed. ICE 2000 allows the user to set up project schedules, resources, activities and durations by linking with major systems like Primavera P3 and Expedition, and MPS Prolog Manager. Thus, exporting, translating and importing information or re-keying data, such as resources, durations and dollars, are eliminated. ICE 2000 offers completely open data and works seamlessly with MS Office.

Building Systems Design

BSD CostLink is an estimating software for architectural, engineering and construction management companies. It is designed to appeal to architects, engineers, and other design professionals for whom cost estimating is important but not the primary job function. Its simple and intuitive interface overlays a fast and powerful computational engine and flexible reporting capabilities. On the other hand, BSD CostLink/CM is a detailed cost estimating system for professionals needing to produce detailed estimates for feasibility, projections, or bids.

U.S. Cost, Inc.

SuccessEstimator is an estimating system with fully extensible parametric modeling capabilities. The program features takeoff from on-screen images or paper-based drawings to any application including SuccessEstimator and all Microsoft Office Excel and Word. It is also compatible with many competitors’ cost estimating applications.

SuccessEstimator links also to two other applications for increased efficiency. With a click of the mouse, complete P3-based schedules from SuccessEstimator cost estimate information can be created. It works equally effortlessly with Microsoft Project schedules.

WinEstimator, Inc.

WinEst estimating program is designed with the combined effort of construction professionals and software experts. WinEst can be integrated with project workflow processes to transform estimates into budgets automatically. The Takeoff Pro software option module, used in conjunction with WinEst and a compatible digitizer, gives the estimator unparalleled speed and accuracy. Takeoff Pro simplifies your estimating takeoff process, while making it faster and reducing errors. Using this unique Windows interface, takeoff quantities can automatically be entered into the estimate by measuring from the blueprints. The takeoffs are represented visually on screen to ensure the completeness of the measurements.

The leading providers of ERP and diversified financial solutions targeted at the FM/AEC branch include J.D. Edwards & Company, Deltek Systems, Inc. and Geac Computer Corp. Ltd. In addition, giant enterprise solutions providers, first and foremost SAP, Oracle Corp. and Peoplesoft, Inc., have packages that are customized – primarily for larger – engineering and construction companies.

6.8 Real Estate, FM and workplace management

Many of the top FM companies render services that include developing, deploying and integrating business-to-business facility management solutions including maintenance management, document management, space management, and lease management primarily focused on the FM industry. They serve as integrators a large number of small and medium-size vendors, whose offerings often include also non-FM products. Some of the leading system integrators appear more dominant than the majority of the vendors they are working with. The most notable software provider strictly devoted to facility and infrastructure management is Archibus.

Archibus, Inc.

Archibus/FM is a suite of applications that addresses the various aspects of facilities and infrastructure management. The Archibus/FM solution enables organizations to make informed strategic and business decisions that optimize ROI, lower asset life cycle costs, and increase enterprise-wide productivity and profitability. Organizations of all

sizes, spanning the financial, educational, governmental, healthcare, and manufacturing industries, use Archibus/FM to deliver timely, relevant facilities information as part of their strategic business plans. The system is fully integrated with AutoCAD, ensuring that changes made to drawings are simultaneously reflected in the Archibus/FM database. It also supports well-established database platforms, including native Oracle, Microsoft SQL Server, and Sybase. Archibus/FM offers a variety of product options to accommodate different needs – from single users within a department to worldwide access over the Internet. The solution's flexible, modular structure lets the user assemble the required combination of applications depending on the specific needs. Archibus/FM can be integrated with leading ERP systems such as SAP, Oracle and Peoplesoft.

Aperture Technologies, Inc.

Aperture offers a platform for creating visual facility management applications based on CAD drawings. Aperture is noted for its ease of use and customization. Aperture is used by architects and facility managers to track space, personnel, furniture, equipment, etc. It includes a large number of pre-defined reports that can be used for dynamic presentations. The database is flexible and can access information in other databases as well as referencing existing CAD files.

Drawbase Software

ArchiFM is a next generation facilities management software. Drawbase is a U.S. subsidiary of Graphisoft concentrating on offering FM solutions based on ArchiFM. The program is a natural addition to the ArchiCAD design tool to leverage the sophisticated 3D model by building designers for the rest of the property’s life cycle. Architects, interior designers and engineers as well as contractors, marketing and sales personnel, and building managers and owners can add an extract information to and from the 3D database for the building's renovation, maintenance and operation, even demolition.

SAP

Founded in 1972 in Germany, SAP is recognized as one of the leading companies in providing collaborative e-business solutions for all types of industries. It employs over 23,700 people in more than 50 countries and is the world's third-largest independent software supplier. SAP’s standardized platform MySAP can by customization be used in different business areas. Except for being used in the planning phase for financial planning, it can also be applied in shared services through financial reporting and accounting. Because of the open architecture of the platform, there are a large number

of users in many industries, also in the FM/AEC area. However, SAP does not see small businesses within FM/AEC industry as a primary target.

Peregrine

Peregrine Systems Inc. was founded in 1981. They currently have 3000 employees located in 80 global offices, and its customers include 92 percent of the Fortune 50 companies. The revenue of fiscal year 2001 was $565 million, which is an increase from the $35 million in revenue at the 1997 IPO.

Like in the SAP case, its product AssetCenter is an open platform suitable for many branches in financial planning. They also have a lifecycle e-procurement system called Get-Resources for evaluation of the total lifecycle costs of an investment, but the product still seems to be in the development phase.

JD Edwards

Growing from being an accounting firm back in 1977 to the software platform company of today, JD Edwards now has 5000 employees and $1 billion in revenue in fiscal year 2000. Unlike its competitors, J.D. Edwards focus on smaller customers, and today it has 6000 clients like schools and national parks. J.D. Edwards' financial planning and budgeting tools are tailor-made solutions that can be integrated in its business platform OneWorld.

There are a few more companies on the planning market worth mentioning. In the Management area it is Facility Information System Inc, in the Facilities Master Planning area it is Aperture technologies Inc. and finally in the Performance Measurement area it is Cognosand Businessobject.

The companies that provide information services dominate the transaction area. Their service is a subscription for which the customer pays a monthly fee with a size relative to the size of the customer. Under this section are not only facilities transactions included but also deals concerning contracts and leasing agreements.

CoStar

The major player in the information service field is CoStar, basically dominating the transactions market with more than 60% of leasing and sales transactions in year 2000. Its service consists of an information database in which information about commercial facilities is gathered. Today CoStar has a research staff consisting of over 700 researchers, each and one of them responsible for their particular geographical area. The

goal of CoStar is to have the database updated at least every 30 days and its philosophy is “every building, every detail”. There are however some difficulties with this and it are common that the information found in the database is incorrect.

CoStar Exchange is an electronic marketplace where commercial properties can be bought and sold online. The deal however is still made by the broker who uses this service as a tool. CoStar has today no intention to take the place of the brokers.

Netstruxr

Netstruxr was founded in 1999 supported by venture capital. Today it is backed up by major Fortune 50 corporations such as Bank of America and Prudential and has its headquarters in San Francisco. The goal of the company is to provide a platform originating from its present marketplace SPACEdirect that will serve the entire supply chain in Real Estate.

LoopNet / PropertyFirst

LoopNet was founded in 1995. The company's merge with PropertyFirst was completed in July 2001. Both companies supply web-based listing services for the Real Estate industry and they merged to save money through synergy effects. Today LoopNet and PropertyFirst work together under the name LoopNet. The advantage of the company is the possibility for customers to get property loans approved online within 48 hours. LoopNet does not have any researchers like CoStar and completely depend on the brokers’ information, which may present problems. At the time of the writing of this report, the company has not been profitable.

FacilityPro

FacilityPro was established in 1998, has 70 employees and focus on the procurement market. Today it serves more than 4000 facilities. It provides a sourcing solution and e-procurement technology combined with special sourcing programs to organizations that own, manage and maintain commercial facilities. Its e-Procurement-platform lets the customers control the purchasing process, from sourcing through back-end accounting. Its largest customer is Cushman & Wakefield, which also is the major owner.

Bricsnet

Founded in 1986, Bricsnet provides three different applications. Two of them fall under the Project and Construction Management section, but because of their Building and Operations system we have chosen to sort the company under Facilities Management.

The system, an ASP application called Building Center, takes data collected in the building process and uses it in the Facility Management process. In 1999 Bricsnet went public and today they cooperate with Octane. Bricsnet's customers include some of the world's leading companies e.g. Bank of America, Cisco, Oracle, 3Com, Hilton Hotels, CB Richard Ellis and Tesoro Oil Company.

WorkplaceIQ

WorkplaceIQ, formerly known as Vicusoft, was founded in 1991. It develops a solution for the management, planning and maintenance of Real Estate assets and it is involved in two major joint ventures: A development cooperation with Microsoft and Oracle and, in this case more interesting, another one with Project Octane. The joint venture with Octane is developing a platform for linear transactions for Real Estate services. Apart from its transaction application, WorkplaceIQ is also in progress of developing Portfolio Management, Lease and Contract Management and Project Management applications that will be released in the future. In total, WorkplaceIQ had $24 million of external investments in 2000 of which Octane companies represented $10 million. The customers, except for the Project Octane members, are about 100 corporations and American government organizations, including e.g. Cisco Systems.

SiteStuff – Procurement Marketplace

The marketplaces trading products and contracts for running facilities represent another type of Facility Management applications. Since the Project Octane companies bought $30 million shares in the company, SiteStuff is considered to have the best success potential. Based on the Ariba Marketplace and Ariba Dynamic Trade platforms the system will enable SiteStuff users to review customer catalogs and to do more sophisticated online procurement as reverse auctions (including request for quotes) and bid/ask exchanges.

7. Strategic Options for Market Entry

7.1 Entering the markets

Making a successful market entry to the U.S. has been tried by dozens of Finnish software companies. According to Finland's Ministry of Trade and Industry's statistic from 1996, only 10–20% of Finnish entries to the USA were successful. This rate is lower than the rate of success for raw start-ups in the U.S. [Jacobsen, 2001]. There are numerous reasons why the rate of success has been this low. Common factor of these reasons seems to be that Finns systematically underestimate the level of commitment in terms of time, money and knowledge needed. Here are some examples of useful tips:

- Investigate the market; figure out your position and role among competitors.
- Keep your product offering simple, yet well-defined stating and quantifying benefits clearly (customers are not ready for quick, dramatic changes in their habits)
- Make your product flawless, free of any glitches; experiments should be done before market entry – not in the U.S.
- Reserve ample time for product localization and customization and utilize local expertise.
- Existing references are crucial; it is difficult to secure the first customer for critical application software.
- Evaluate very carefully various partnering options or other mode of operation.
- Consider hiring (or working together with) local sales force who is familiar with the market and customers.
- Learn the needs and practices of the industry and your intended customers.
- Make your product compatible with leading existing products on the market. Develop user-friendly interface.
- Pay attention to adequate training and customer support.
- React promptly to prospective customers' inquiries and emergencies.
- Budget adequate funds for U.S. operations.
- Start early but wisely.

Although these tips seem very generic and simplistic, they do apply also to the effort of trying to enter with a joint family of products. Sharing the risk with other companies may have its pluses but the downsides of a joint effort might be

- lack of clear leadership,
- lack of clarity on partnership structure and ways to share the business responsibilities,
- unclear incentives for partners,
- risks related to the maturity of the products of the partners, and
- dependency on single exit (one company leaves the group and this kills the effort).

All of the factors related to the entry of either a single company or a group need to be addressed before launching even an effort to prepare for a market entry to the USA. The alternative options for the group to enter the market try to reflect the risks mentioned above.

7.2 Key issue: The maturity of the market

It seems that a new market is slowly emerging for services and software enabling the use of 3D object oriented product information. How fast this market is emerging and whether companies are ready to invest in technologies such as 3D and 4D or interoperable use of different software packages is still a question mark. The most popular way of structuring the technology adaptation is by Geoffrey Moore. He structures the phenomena with the help of a bell-curve shown in Figure 11.

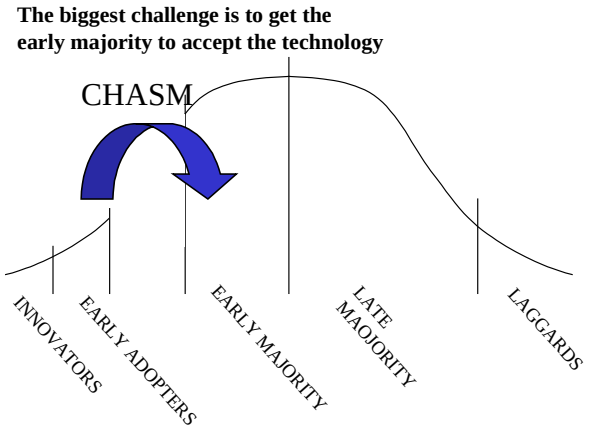

Figure 11. Crossing the Chasm [Moore, 1999].

Froese [2002] referred to this curve in his evaluation of Finnish technologies. He stated that in Finland, the use of 3D object-oriented software has reached the early adopters but the chasm has not yet been crossed even in Finland. In the U.S., the picture is even less optimistic; at the moment the innovators have had their first attempts to use the technology.

In a recent key note address, Mr. George Macomber, the CEO of Building Vision Inc. [Macomber, 2003] stated that there are four major methodologies that promise true innovation in construction: supply chain optimization, knowledge management, 3D design and wrap-up economic models. According to Macomber, these technologies are likely to be adopted by new innovators and not by established firms.

According to Macomber, the life cycle information management concept is treated like the search for the Holy Grail – the recognition of its value will drive lost of additional innovation and services. Furthermore, Macomber uses a model to consider the generic income statement of a typical construction manager[6]. The model can be used to test the sensitivity of how much economic impact an innovation must have in order to show return on investment. The model shows that the major drivers of profitability for this firm are

1. Top line revenue and
2. Cost of work.

To a lesser extent, the magnitude of general and administrative expenses also influences profitability. An investment must make a major impact on the top line or on the cost line AND it must allow the benefits to accrue to the construction management firm, not to the owner, in order to justify its adoption. This is why for most firms, IT investment is only done to maintain sales and cost parity with other firms; it is very hard to build sustainable advantage. However, innovations that can provide major – not incremental – benefits in these areas will be the ones that get traction in the market place.

Within the context discussed above, there is a vast range of technology strategies in the industry. For any reasonable discussion of innovation and the drivers of innovation, analysts must consider: What is the firm trying to do in its overall strategy? To help the firm with its internal cost structure or to help the firm to compete in the open market against competitors; and whether the idea is to support competition in the traditional manner the firm has always pursued, or whether the idea is to change the nature of the competition of the industry.

The key issue addressed in this chapter, the maturity of the market, does not give a very optimistic picture of the readiness of the market and the attitude of potential customers. However, the question of whether 3D design will make its breakthrough is no longer valid, the valid question is to ask when will this happen and who will have the benefit of the technology. This creates the challenge to look outside the traditional market segments and look for something that is emerging. It also creates the challenge of timing: when does the product need to be out not to loose the traction and on the other hand, not to stumble on the first glitches it will have anyway.

The next sections will cover four alternatives for launching a joint FM/AEC software business in the U.S:

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[6] Based on Macomber's experience as a CEO of a ENR 200 firm.

1. A complete “off-the-shelf” software package (equivalent to packages such as AutoCAD with its extensions) and a U.S. based company jointly owned by Finnish/European partners as a vendor,
2. A modular family of tools combined with a consulting service, Finnish based companies providing the software and a local partner/company providing as localizer and ”front-end” consultant,
3. Joint venture for marketing, a U.S.-based sales office run by cost-share basis by either a Finnish or U.S. partner,
4. Licensing of the package, selling rights to a local vendor/consultant.

The way to launch any Finnish based efforts in the U.S. might not finally be any of the above, possibly a combination of two of the above or one of the choices with revisions. It should be noted that the intention of this project is to give a realistic picture of the opportunities, not a complete business plan to follow. Starting up a company with, for example, venture funding from local sources requires local presence, evidence from initial customer pilots and a number of other items in place before.

7.3 Finnish based interoperable and open software package

The first alternative discussed in this report is the option of producing an independent software package of Finnish components. This alternative is the riskiest but also the one with the largest revenue potential should the new market emerge to a scale where the position of the existing vendors can be threatened. This alternative requires more resources than the other options.

The basic theory behind this model is that the Finnish companies launch a joint project to fully integrate the software packages for the U.S. market. The project aims at a package as comprehensive as possible with the intent to compete head-on with major vendors such as Autodesk.

The product will rely on an IFC-based data structure and, optimally in a “model server” environment or platform. The core of the product has to be a true, object-oriented, database and 4D-software package. Modular packages can be added to this core allowing different versions. The versions vary according to users or user groups, such as the design team, the construction manager or a limited package for the owner/user organization.

This model is also the one that costs the most. The items needed to consider in budgeting at the initial stage are:

- The cost of initiating a joint business plan (likely 50–100,000 €),

- The cost of product development (likely to be equivalent to programming a small software package from scratch), employing/assigning programmers and engineers,
- The cost of launching business (likely equivalent to a small start-up).

After these stages one must be able to show revenue to cover the costs of technical support, sales, administration, legal costs, etc. Reaching this stage depends naturally on the joint business plan, typically at this market situation; it takes at least 3 years to generate revenue from a sustaining customer base.

The funding for the product development can probably come from public sources (Tekes, Ministry of Trade and Industry's funds for exports, etc.). The funding for the business development either needs to come from the pockets of the joining partners or from outside venture funds or companies. Some public money for the business development can be available, but to a limited extent.

This option requires partnering outside the existing six companies. The core 3D modeling tool is missing at the moment, and a way to set up a partnership covering this can be very challenging. The core technology provider will probably require a lot in return of the technologies, if the partner is already an established player in the U.S. On the other hand, partnering with a company that is entering the market and is approximately at the same level as the Finnish companies might offer benefits for both parties, such as wider offering and more features than the competition. The most potential partner is Graphisoft and its ArchiCAD as the core. Also, U.S. or other non-Finnish companies that enter the joint efforts as partners and share the cost can be considered, such as CommonPoint Inc., a company commercializing 4D software developed at Stanford University.

The steps toward market entry following this option might include:

1. Ensuring commitments of the partners, agreeing on the exit possibilities,
2. Drafting a joint product development plan and a joint business strategy,
3. Finding funding for the product development,
4. Developing the joint software with partners,
5. Conducting a feasibility study of the available forms of business options in the US, negotiations with partners and seed funders,
6. Localizing the software package,
7. Trials with reference projects in the U.S.,
8. Creating visibility,
9. Opening of an office/business in the U.S. and
10. Recruiting sales force.

This option relies on the belief that the market will grow and the software package will be able to gain a significant market share due to its technical superiority, open approach to data exchange and careful timing to enter the market. The rewards are high but so are the risks.

7.4 Consulting service for sustainable development

This option might be called a watered-down version of the previous one. The thinking behind this option is that the market is not mature enough for the level of sophistication of the software. This is why consulting is needed to help the companies implement the tools, and to get measured benefits from the use of the tools.

The way the joint consulting/toolbox service might work is that, for example, a design-build contractor can buy a service for modeling its project. With the service, he can buy an option to purchase the software and related training for his personnel. The software tools are modular and openly integrated (IFC-compatible) so that the customer does not have to commit to the whole package. The learning in the customer organizations can be taken in steps. This model also allows tailoring of the products according to customer's needs, even profiling the end product according to the brand the customer wants.

This model costs much less than the previous one. The items needed to consider in budgeting at the initial stage are:

- The cost of initiating a joint implementation strategy (likely at 30–50,000 €),
- Product development and localizing of software (likely at 100–300,000 €),
- The cost of productizing the service and toolset offering including the execution of pilot or reference projects (likely at 100–300,000 €),
- The cost of forming partnerships with non-Finnish partners (approx. 30,000 €)
- The cost of initializing office/presence in the U.S. (at 200–300,000 €).

After the initial phase, the strategy might need to be revised depending on the market situation. It is probable, that the consulting service is not a sustaining model, since the companies mature to use the technology by themselves very fast. However, this option should be expected to cover the initial costs and give a limited eventual profit.

Some of the funding can come from public sources (Tekes, Ministry of Trade and Industry's funds for exports, etc.). For example, LIKSA funding can be used for the first phase to create the joint implementation strategy. The "export ring" funding possibility is worth exploring for this option.

This option requires partnering outside the existing six companies both to expand the technology and to productize the consulting offering. It applies to the core 3D modeling tool as in the previous section.

The partner for the consulting should know the potential of the technology, be able to use it and train customers and be able to sell and create a brand for the family of products. The consulting can work as a Finnish–American team in the U.S.

The steps toward market entry following this option might include:
1. Ensuring commitments of the partners, agreeing on the exit possibilities,
2. Drafting a joint business strategy,
3. Finding funding for the initial stages,
4. Localizing software,
5. Productizing the service offering, partnership agreements,
6. Trials with reference projects in the U.S.,
7. Training/recruiting consultants,
8. Opening of an office/business in the U.S.,
9. Revising the strategy.

The execution of this option is likely take less time than the first one. The first reference projects might be launched within 3–9 months after the funding is secured.

This option lets the partnership await the actual change in the business paradigm. The costs of entry are much lower than in the previous option. This most probably means that, for example, venture capital is not needed or is probably not even relevant. Naturally, the rewards are also much more modest.

7.5 Joint venture for marketing

This option relies on the possibility that the software packages represented by the Finnish companies can be sold in the U.S. through a joint, locally established sales channel. The software products are developed in Finland. The localization of the software does not take customer requirements in to consideration in as large extent as the previous options. In this option, the belief for the market's technology adaptation can be ambivalent; if the market picks up, the products might sell and create a moderate additional income. If they do not, the loss is not that significant.

This option might need partnering with a local software vendor or marketing agency. The best way is to create initiatives as well as sanctions for the partners to ensure

commitment to selling the products. The mere representation (i.e. answering the phone should someone inquire the products) is good for nothing.

In this model, the product development is executed in the partnering organizations without the need to coordinate. The extra cost for the companies is generated from the initialization of the marketing/sales channel and from the localization of the software modules.

The steps toward a market entry following this option might include:
1. Ensuring commitments of the partners, agreeing on the exit possibilities,
2. Devising the sales channel, choosing partners/business model,
3. Localizing software.

This alternative can be very low-cost, however, the reaction of the market is unknown. How the sales channel and the agreements and contracts are set up form a critical success factor for this model. The possible rewards of this model are not likely to be more than moderate.

7.6 Licensing through local partner

Licensing of one common product, technology or other Intellectual Property Rights (IPR) based on a joint concept is not really a relevant option at this point. This would require that the group had a common IPR base and that is not really the case as of yet. One alternative is to negotiate licensing contracts with a possible vendor as one group of companies and share the expenses due to negotiation and setting up of contracts.

This option might prove to be the least costly, but on the other hand, the trade-off is that someone else is doing the actual business.

Steps needed for realizing this option might include:
1. Negotiations with potential exploiters,
2. Drafting of contracts,
3. Giving support in localizing the software or localizing by the partners (depending on the contract) and
4. Follow-up/control of the contract terms.

This model is probably the easiest to enter, depending naturally on the availability or willingness of local partners. The return might turn out to be negligent and in some cases this model has not really produced results unless the local partners are obliged to sell in order to earn any revenue. Also, the differences in the maturity of the Finnish companies and products make the joint effort somewhat impaired.

8. Conclusions

8.1 Maturity of the market and segmentation

The conclusions of the project were discussed in the final seminar of the project. The seminar focused on markets, narrowing down the most probable segments, outlining the offering, channels and action items.

The markets are very large and segmented. Seemingly, the software market is very slow at the moment. The most feasible course of action is to identify segments where the number of early adopters is large. The discussions on the markets concluded that

- The overall market is not ready yet for launching full-scale software business. However, the building information model thinking is emerging and there are companies that are seeking solutions for competitive advantage.
- Timing of the emergence is very difficult to predict. The most optimistic estimates of when revenue from actual sales of products based on the new technology might be generated is three years.
- There are a few vendors as well as contractors or facility owners that are ready to partner with right now.
- The most interesting segment seems to be design-build contractors, especially contractors who provide concept buildings. The share of design-build contracts seems be rising and the fact that the liability is in concentrated to one party. The concept building offers a possibility to mass customization; therefore the process changes are most likely to happen in this segment.
- The role of owners is diminishing and the corporate end-users are becoming more and more aware of the possibilities. Large Real Estate companies are also becoming more influential. Large public owners were identified as the second probable segment. However, it was identified, that the purchasing procedures in these organizations might be bureaucratic and slow.

8.2 Technology, offering and competition

The overall view of the software offering is that it is really technologically more advanced in many ways than the competition in the U.S. Also, the proof of having successful implementations in Finland is also available.

The market does not believe in standardization in the same way in the U.S. as in Europe. Ways to reach agreements with two parties or to create even project specific ways to interoperate are of interest to the business community. Large vendors want to

become dominant despite the fact that their customers do not want the proprietary data exchange format to be used. The lack of standard is a constant item for discussion.

The integration of software is not merely a question of technology or standards. Processes and practices need to be re-engineered and most of the industry is reluctant to move ahead with this work. The U.S. market is also particularly difficult due to the liability issues. For example, the steel structure design, manufacturing and assembly process is clearly behind the processes in Finland.

The seminar concluded in the following in regards to the Finnish offering:

- The offering cannot be based on the IFC standards alone. Open interfaces as competitive advantage can be addressed otherwise.
- Offering at its initial phase cannot be based on technologies that are immature in Finland.
- It was agreed that the offering be divided into two separate ”camps”; one directed for design-build contractors and one for real estate companies. The approach and added value for companies can be based on shorter chains of information exchange.
- The group should seek for references of Finnish construction projects that have successfully used the information exchange even partly.

The competition is relying on different arguments in Finland than in the U.S. The major players rely on the fact that their customers still mostly use 2D in design. Integration seems not to be their primary focus. The conclusions on the competitiveness of the offering concluded that technologically the Finnish offering has features that are superior in terms of supporting the process integration. Also, Finnish software seems to take sustainability and environmental issues into consideration in a way that might attract U.S. customers.

8.3 The probable option

As a conclusion, Table 10 summarizes some pros and cons of each option laid out in the previous section.

Table 10. Summary of entry options.

Option	Pros	Cons
Common Software package	▪ Revenue and expansion potential (up to tens of millions of $ per annum) ▪ Control remains in the hands of the partners	▪ High market risk, first sale difficult to make ▪ High initial investment or need for funds
Combination of consultation service and software sales	▪ Reasonable costs in relation to the risk ▪ Stepwise approach easiest to apply, allows time for market and technology to mature	▪ Difficult to set up the partnership with all the stakeholders involved ▪ Relatively low growth potential (up to millions of dollars per annum)
Joint marketing venture	▪ Small initial investment ▪ Easy to manage relative to joint development efforts	▪ Relatively low growth potential ▪ Local partners control unless sales office established
Licensing	▪ Very low initial investment ▪ Very low risk (if contracts made well)	▪ Totally controlled by local partners ▪ Narrow revenue potential (up to a million USD)

Given the fact that the market is not mature yet and that technology is not completely mature either, the most likely option to succeed is to form a combination of consulting service and software sales. The customers are not IT-savvy and they will be requiring education, training and consulting in order to exploit the potential. At this point, the breakthrough still awaits itself. The consulting offers a step that does not exclude the formation of a more traditional software vendor business later. The consulting also allows a time frame for the much-needed further development of the software, especially interoperability features and model server concept as well as for producing actual proof in real construction projects.

8.4 Risks, pitfalls and how to avoid them

One of the most difficult pitfalls is the lack of legislation around the use of product modeling or other FM/AEC software. The fear of litigation can inhibit any business in the U.S., not only the software business. Normally, this issues emerges later before the market entry. However, in this project one needs to address the lack of clear IPR legislation of the product models produced by either architects or contractors. If this is not in place, the threshold for a buyer of software grows higher.

Technologies that the Finnish software products are based on might be very advanced and are liable to attract attention. However, the competitor's products are adapted to the local markets, their sales are used to the American market environments and business models. The fact that an approach from Europe is offered is bound to encounter cultural barriers. To avoid this, the team of people operating with local customers has to be mostly local. Also, marketing and argumenting the benefits, the European references won't carry beyond the first enthusiastic technology friendly adopters.

The best way to avoid the pitfalls is to use a step-wise approach:

- Aim for a realistic but challenging goal and market entry.
- Identify realistic sub-goals on the way to this main goal.
- Make a new decision on committing after a step has been reached.

8.5 Recommendations

As the interviews and the signals from the companies indicate that the market for modeling tools is truly emerging. For the last several years the academia in the U.S. has no longer considered the area as a technological challenge but a challenge of market adoption. Now groups of companies are forming communities of interest, such as the Virtual Builders Round Table, to discuss the user experiences and to speed up the adoption. The conclusion from this is to take steps to prepare for the market emergence, get close to the communities and help companies in their processes of adoption.

The role of reference projects cannot be emphasized enough. If the group of Finnish vendors decides to enter the market by establishing a consulting or software –based entity, one of the first crucial milestones of this is to complete real construction project cases, where the tools will be used. To get a start on reference projects, proof from earlier projects in Finland is essential.

One of the steps towards a successful entry is to find partners for the consulting. It is essential that the partners are local, know the business in the U.S. and have an extensive contact network, visibility as well as the right competence. Assigning a Finn to work with the team in the U.S. to liase with the companies in Finland is strongly recommended. The actual product development should be executed in Finland.

Although the concept for consulting is not probable to create an entity that will grow and attract venture funding, approaching venture capitalists at this point for seed funding should be considered.

- The interfaces for the Finnish toolset are not fully available yet. True interoperability can be marketed only after the tools really have been tested in real projects together.
- Localization of the programs is not started yet.

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Title

Options for the Finnish FM/AEC software packages for market entry in the U.S.

Abstract

The report describes results of a project executed cooperatively by Technical Research Center of Finland (VTT) and the Finland Trade Center (Finpro). The aim of the study has been to find out the opportunities for a group of Finnish Facility Management, Architectural, Engineering and Construction (FM/AEC) industry software vendors to launch business in the United States.

The report gives an overview of the industry, discusses the roles of different disciplines and value chains. It identifies high-tech offices and manufacturing facilities, pulp, paper and power plants, concept construction and public sector facility owners as potential market segments and discusses their maturity and readiness to partner with the Finnish vendors. An overview of the U.S. vendor market is also given as well as descriptions of major competitors and their products.

A suggestion of how the Finnish software products can interoperate is also given in the report. The basic argument is that competitive advantage can be built on openness of the Finnish products. The Finnish products, Tocoman's TCM-software for quantity take-off, cost estimating and control, DynaProject for scheduling by DSS, EcoProp by VTT, xEngineer by Tekla, Optimize.net by Rapal, ModelServer by Eurostep and ModelChecker by Solibri can be made to support the business processes of U.S. customers in open, modular and interoperable way. Finnish references of how these software packages can add value together exist today.

The conclusion states that the market is not mature yet and that technology is not completely mature either, the most likely option to succeed is to form a combination of consulting service and software sales. The customers are not IT-savvy and they will be requiring education, training and consulting in order to exploit the potential. At this point, the breakthrough still awaits itself. The consulting offers a step that does not exclude the formation of a more traditional software vendor business later. The consulting also allows a time frame for the much-needed further development of the software, especially interoperability features and model server concept as well as for producing actual proof in real construction projects.

Keywords

software, computer programs, Finland, market entry, US, United States, vendor market, overview, evaluation, facilities management, construction, engineering, architechture, market study

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“Options for the Finnish FM/AEC software packages for market entry in the U.S.” is a report on a market study that aims at identifying the market potential for a joint software offering of a number of Finnish Facility Management, Architectural, Engineering and Constuction specific vendors. The report gives an overview of the software market in this segment. Also the preliminary joint concept is outlined. The report concludes in recommendations on what to consider when entering the U.S. market and gives options on some possible ways of structuring joint business of the vendors.

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