Industry Sector – Elevators

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1. Executive Summary

This research seminar was originally aimed at developing a framework of implementing knowledge-rich 3-D applications in the Elevator Industry. The idea was to analyze the working of this sector of the building industry, the current business environment and technologies, identifying areas with poor information exchanges, suggesting IT integration options to the same and evaluate the economic feasibility of such a transition.

From the analysis, it was seen that the Elevator Industry is not really fragmented, but controlled by a handful of companies. These are big companies who have invested millions of dollars in research, and by now have highly sophisticated 3-D modeling systems and a computer-based information network. They have also developed web-based monitoring and feedback systems to remotely track installed elevator systems worldwide. Also, there is very little need of data exchange between elevator manufacturers and Building Contractors. As a result, there is not much scope for implementing Information Technology in this sector. The only potential area was information exchange between the General Contractor and the Owner, Architect, Structural Engineer, Sub-Contractors and Elevator Manufacturer.

In conclusion, even though the purpose of the seminar was accomplished as planned, the positive aspect is that the foreseen goal had already been reached.
2. Introduction

Elevators have become an integral part of any building facility over the past few decades. In our everyday life, we depend on them for vertical transportation in offices, schools, public buildings, airports, sub-stations etc. With over 4 million elevators in operation today, it accounts for an important facet of the building industry. To gain some idea of the effect of this one advancement, consider that today, elevators move the equivalent of the world’s population every hours. Thus, it is unarguably an important sector of the building industry and a worthy topic of research.

(Source: http://www.otis.com/cp/subcategorydetails/0,2241,CLI90_RES1_SCM14945,00.html)

This seminar addresses specifically the US Elevator market. 5 major players – Otis, Schindler, Thyssen-Krupp, Kone and Fujitec dominate the elevator market. Each of these has an annual turnover of over a billion dollars and is densely spread out throughout the country. With numerous offices, hundreds of projects running simultaneously and a huge inventory of men, materials and machinery, it makes good sense to have state-of-the-art information trafficking and computerization. Otis is the largest producer of elevators and escalators in the world with an annual sale of $6.3 billion in 2001. They have about 22% of the market share and supply products to 220 countries. Within the US, their business amounts to more than $1.5 billion and they have a workforce of about 9000 people. Otis spent over $100 million on research and development in 2001. This will give an idea of the scale on which each of these 5 giants function.

Another key thing to note here would be that all of these companies also manufacture and install escalators and moving walkways. They also provide service and maintenance for elevators and escalators on a contract basis. Otis alone services about 1.2 million elevators and escalators worldwide.

(Source: http://www.otis.com/cp/subcategorydetails/0,2241,CLI1_RES1_SCM15553,00.html)
3. Objective

This research seminar focuses on the Elevator Industry and its production life-cycle. The goal of this seminar will be to develop in-depth understanding of the management, business and technological aspects of the adoption of information integration technologies in this sector of the building industry. The building industry is assumed to include contractors, architects, structural and M/E engineers, and all the various sub-contracting businesses. The seminar will focus on identifying likely factions of this industry that already use IT and conversion of some others from the use of isolated and largely 2-D applications with minimal data transfer between them, to knowledge-rich 3-D applications, with fully integrated data exchange based on product models.

The steps undertaken towards this goal may be arranged chronologically as:

- Identifying a sector (Elevators) in the Building Industry.
- Background study of this sector – how big is it, is it worldwide, what is its future potential.
- Analyzing the current business environment of this sector and studying the key links of money and data flow.
- Study of the technologies being used and echelon of advancement already achieved on a local and network level.
- Identifying the areas within this sector (if any) those are currently using 2-D applications with limited information flow capabilities.
- Suggest improvements in these areas keeping in mind – feasibility, monetary benefit, time-frame of implementation, likelihood, impact on specific sector and impact on inter-dependent sectors of the building industry.
- Analyze the market situation and conclude whether the sector would easily comply with the transition.
- If yes, then provide a concrete working plan showing capital investments, re-organizations of workforce, change in the mental paradigm and eventually short term and long term benefits.
- If no, then pinpoint the obstacles at the various stages and lack of benefits at the specific points of the supply chain.
Another learning objective I recognize is to develop an understanding of why the construction industry has lagged behind some other industries in adopting Information Technology. The idea is to understand the thinking of professionals in this industry and propose a solution that, if feasible, could bring about a paradigm shift to the working of the industry. In the broader perspective, this seminar encourages you to think beyond the currently used practices and take a bold step into the future.
4. Background – History of Elevators

An elevator is a device for vertical transportation of passengers or freight to different floors or levels, as in a building or a mine. The term elevator generally denotes a unit with automatic safety devices; the very earliest units were called hoists. Elevators consist of a platform or car traveling in vertical guides in a shaft or hoist way, with related hoisting and lowering mechanisms and a source of power. Rudimentary elevators, or hoists, were in use during the middle ages and can be traced back to the third century BC. They were operated by animal and human power or by water-driven mechanisms.

The power elevator debuted mid-19th century in the U.S. as a simple freight hoist operating between just two floors in a New York City building. In 1853, Elisha Graves Otis was at the New York Crystal Palace exposition, demonstrating an elevator with a "safety" to break the cab's fall in case of rope failure, a defining moment in elevator development. By 1857, the country's first Otis passenger elevator was in operation at a New York City department store, and, ten years later, Elisha's sons went on to found Otis Brothers and Company in Yonkers, NY, eventually to achieve mass production of elevators in the thousands. Today, Otis is the world’s largest elevator manufacturer.

In 1889 came the direct-connected geared electric elevator, allowing for the building of significantly taller structures. By 1903, this design had evolved into the gearless traction electric elevator, allowing hundred-plus story buildings to become possible and forever changing the urban landscape. Multi-speed motors replaced the original single-speed models to help with landing-leveling and smoother overall operation. Electromagnet technology replaced manual rope-driven switching and braking. Push-button controls and various complex signal systems modernized the elevator even further and safety became an integral part of the design. The year 1926 saw the birth of the modern elevator in the Woolworth building, then the tallest building in the world. The progress in this field has been astonishing ever since, and today we have intelligent elevator systems that can be remotely tracked for maintenance and rework.

(Source: http://www.columbia-elevator.com/info/history.html)
5. Existing processes and business environment

This sector of the construction industry is dominated by a few giant players who between them control almost 90% of the $4 billion plus US market. Smaller manufacturers are far and few, and would not really make a noticeable difference to the big picture. (Fig. 1) According to the 1997 census, elevator manufacturing resulted in sales of $3.8 billion from over 350,000 establishments and related machinery and equipment in another $4 billion.

(Source: http://www.census.gov/epcd/ec97/industry/E421830.HTM
(http://www.census.gov/epcd/ec97/industry/E333921.HTM)

Otis.................20%
Schindler..........20%
Thyssen-Krupp...20%
Kone..................15%
Fujitec..............15%
Others.................10%
(Approx. % market share in the US)

Source (for logos): Official websites of the respective companies

Fig. 1
After the decision to install an elevator is taken, the following people are involved till the completion stage. The owner makes the decision, and with the help of Architect and Structural Engineer decides the requirements of the building. This information is then passed on to the General Contractor who becomes the liaison between Owner and Elevator manufacturer. In bigger facilities, the General Contractor may also have a Sub-contractor who may refer to an Elevator Consultant. (Fig. 2)

It is a common practice to finalize on the elevator design during the pre-construction stage. This allows the building construction and elevator production to run in parallel. A schematic of the functioning is shown in Fig. 3.
The Owner makes the decision to install an elevator of an array of elevators in the to-be-built facility. This decision is taken prior to commencement of work on the site. For the same, he will hire a General Contractor (GC) to co-ordinate all the work and interact with the Structural Engineer, Electrical Engineer, Elevator Manufacturing Company and other Sub-Contractors. Depending on the budget allocated for elevators, the architect and structural designer will suggest the optimum elevator layout to the owner. The owner will pass this information to the GC who will then prepare a Tender Document to invite bids from various sub-contractors. After the sub-contractors submit their bids, the GC will select the most appropriate ones and award the contract applicable to them. One of the sub-contractors will get in touch with an elevator manufacturing company, like say Otis or Schindler, and place a word order as per requirements supplied.

Manufacturing of elevators again may be broadly classified in 2 types:

- Global giants such as Otis, Schindler, Kone and Thyssen-Krupp
- Small local manufacturers

Of these, the earlier occupy a very large part of the market share and offer the latest in design and safety. They are already using a lot of computer-assisted tools for design, manufacture, assembly, maintenance and rework of elevators.
After the elevator has been manufactured, it may be installed into the building at the appropriate time during its construction schedule. This co-ordination is also the responsibility of the GC who is in contact with the Elevator Contractor. After installation of the system, the GC will obtain a working permit from a Licensing Inspector so that the elevator is now ready for use. (Fig. 4)

In this process, there are 2 key areas where flow of information is enormous and multidirectional:

- General Contractor
- Manufacturing

Thus, it may be a good idea to adopt IT in these sectors. This may result in saving of time, more discreet information flow, and better communication. The long term benefits include a more economical overall process and less rework.
It has been seen that companies today offer fully integrated scheduling, engineering, production and installation under one roof. Once the order has been placed with the elevator company, they have highly sophisticated tools that will schedule the activities, makes designs and 3-D models, manufacture the parts and then hire sub-contractors who will install it on the site. (Fig. 5)
6. Available and suitable information technologies

This section is typically supposed to analyze the available 3-D modeling tools and suggest the appropriate ones for the elevator industry. On studying this sector and talking to several people in the industry, it was found that the elevator industry has already surpassed this stage and has gone ahead to develop tailor-made software and modeling tools as per specific requirements. Most big companies have extensive ongoing research and are heavily investing in adoption of information technology. Also, they have moved to 4-D modeling, wherein they can visualize the elevator model and working at various stages of time. Some of the new technologies implemented by the industry giants are described below.

Otis
The market leader, Otis has successfully implemented high-end graphics and cutting-edge technologies to become #1 in the world. Apart from having developed design and modeling tools, they have also employed IT to predict problems and tackle them at an early stage to save on time later. Avoiding potentially costly elevator problems can be achieved through early planning. Hoist way modeling algorithms allow anticipation of complications that might arise from rope sway - a phenomenon that occurs in high-rise buildings. To facilitate this planning process, Otis has developed a special program called the OTISPLAN®. A design and evaluation tool, it simulates the actual operation of the building's vertical transportation system and proposes the optimal traffic handling solution.

(Source: http://www.otis.com/products/detail/0,1355,CLI90_DSC405_PRD6392_PRT217_PST391_RES1,00.html#CAD)

Another interesting application developed by Otis is their remote monitoring system. Developed to optimize performance and minimize downtime, Remote Elevator Monitoring — REM® — tracks hundreds of system functions on thousands of elevators around the world. The REM system identifies most problems before they occur. REM detects deteriorating components and intermittent anomalies, and notes the small nuisances that might have gone undetected until they caused service disruptions. Intermittent problems are fixed before they annoy the tenants.
A Diagnostic software monitors elevators continuously and sends data to the REM unit located in the machine room.
B The REM unit sends this information to the OTISLINE center.
C Data is categorized by urgency and reviewed by OTISLINE representatives.
D An OTISLINE representative alerts the field mechanic, if necessary.
E The mechanic arrives at the job site with specific information, tools and parts to work on the elevator.

(Source: http://www.otis.com/innovationdetail/0,1416,CLI1_IID805_RES1,00.html)

**Schindler**

Schindler is the second largest elevator manufacturer, and among the leaders in elevator design using computer-based modeling. They are currently working on automation software that will eliminate actual models, and be able to design and simulate elevators using a computer. Some such commercial products available are SchindlerDraw and SchindlerSpec. The best part about these products is that they work online and can be customized as per user requirement.

SchindlerDraw is the industry's first automated, interactive drawing program for hydraulic elevators, escalators and moving walks. The program simplifies drawing time and eliminates time-consuming manual layouts. The drawings are customized to your particular building. No boilerplate drawings here. The final drawing can be viewed, printed and inserted into building layouts and other documents, thereby shortening the approval process. SchindlerDraw works online, or can be downloaded to your computer. It's also available on CD-ROM. SchindlerSpec is an interactive architect's tool that customizes specifications to individual buildings. Like SchindlerDraw, it works online, or can be downloaded to your computer. It is also available on CD-ROM.

(Source: www.schindler.com)
**ThyssenKrupp**

Apart from having developed software and networking for scheduling, production and fabrication, they are now expanding into remote monitoring of elevators. This will enable their engineers to gather information about any elevator installed from their mainframe, which continuously tracks installed elevators worldwide. Thus, the engineer can simply go to any site, obtain relevant data on his laptop or PDA and even compare with similar platforms from their database. Particular progress in this area has been made in Germany, France, Belgium and the USA, where customer-focused service concepts such as Tele-W@tch, POP or TAC20 utilize the internet, e-mail, text messaging and other IT technologies. The Tele-W@tch system records the frequency with which individual elevators are used; customers can view this information on the Internet and use it to plan service call-outs. POP is a service concept, which records all relevant service and repair information and presents it clearly to customers in the form of a service history. In the USA we developed the TAC20 monitoring system for hydraulic elevators, which facility managers and service engineers can use to continuously check the serviceability and technical condition of their installations.


**Fujitec**

Fujitec America, Inc.’s Elevator Monitoring System (EMS™) is a sophisticated state-of-the-art, PC-based system designed as a comprehensive elevator management device. Developed from the highest standards of quality synonymous with the name Fujitec, the Elevator Monitoring System contains distinctive graphical representations, interactive communication features, precise data accumulation capabilities and advanced event logging characteristics to satisfy a wide range of customer monitoring requirements.

(Source: [http://www.fujitecamerica.com/modernization/modernization_main.htm](http://www.fujitecamerica.com/modernization/modernization_main.htm))

An animation of computerized installation of an elevator can be found at the link below. It shows the application of 4-D modeling and emphasizes that the Contractor really need not know detailed specs of the elevator unit.


(All information gathered here is from the respective sites of the elevator companies.)
7. Framework target plan – Assessment of potential benefits

The requirements for different facilities like commercial high-rise buildings, schools, residential buildings, public spaces etc differ greatly. Also, two similar facilities may have vastly different budgets that will result in completely different elevator designs. However, in all the above cases, there still remain a few common aspects:

- Decision by owner for an elevator
- Company designing and manufacturing the elevator
- Contractor supplying and installing the elevator
- Flow of information between owner, architect, general contractor and manufacturer
- Feedback data that may/may not result in changes and thus time loss

Hence, it becomes necessary to identify the key areas of concentrated information exchange and try to increase efficiency by the use of Information Technology, so that the final outcome is a viable combination of time saved and monetary benefit.

The various units involved in the different stages of elevators are as follows:

- Owner
- Architect
- Structural Engineer
- General Contractor
- Sub-contractors
- Manufacturer
- Installer
- License Inspector

(Refer Fig. 6)
The green rectangle, which covers the elevator manufacturer and its various factions, has already adopted IT to a large extent. The blue rectangle has been left behind and may benefit from IT adoption.
8. Assess the expected costs of achieving the plan

Each of the 5 elevator giants has an annual turnover of a few billion US dollars worldwide. Hence, they can almost afford to act as an independent industry sector by themselves. All 5 of them invest heavily in R&D and have their in-house 3-D modeling packages and fully integrated information flow systems.

Compared to most other sectors of the building industry, the elevator industry has seen tremendous progress and sophistication of IT systems. Due to this, no realistic plan can be put in front of this sector for IT adoption.

9. Analysis of the readiness of the Elevator industry for implementation of the framework plan

It is thus seen that the Elevator industry is not really disjointed. This is due to the fact that a few companies have almost complete control the market.

It would be wrong to say that this industry is not ready for integration of IT in the construction stage. In fact, most elevator companies are already using 3-D modeling and other high-end software. The point where information needs to be transferred to the Contractor, they argue that only negligible information flow is sufficient, reason being that the Contractor does not need more details. As a result, the information expressways stay within these companies and they are operating successfully by providing the General Contractor only with the size and shape of the elevator tunnel. The sequence of events goes as follows:

- The General Contractor receives the set of drawing and specs from the Architect.
- The General Contractor (or his Elevator Sub-Contractor) then goes to the elevator manufacturing company and submits the final building requirements.
- The Elevator Company then takes control of the whole project.
The Elevator Company submits only the vertical tunnel dimensions and specs to the Contractor.

Construction of the building progresses as planned, and at the stipulated time, the Elevator Company will bring all the parts on site and assemble them into a ready-to-use elevator.

Elevator is made functional soon after and made available to users as soon as building facility is made open.

Maintenance work may be awarded to the same company, or a local servicing company, depending on terms of contract.

It is seen that the elevator industry was ready for IT adoption some years ago, and by now, has already crossed several milestones of implementation of information-rich networking.

10. A detailed plan for the next incremental step the Elevator industry should take

As per the objectives, this chapter should include an actual feasible plan for implementing IT into the specific industry sector. The plan should provide:

- A timeframe for implementation
- Cost analysis
- Key areas where changes will take place
- Likely benefits

The elevator industry, however, is already beyond this stage and has successfully employed sophisticated IT implementation in its various sub-sectors. Elevator manufacturers are at a point that is way ahead of this seminar and are already reaping the rewards for adoption of 3-D modeling and web-based information flow in their business practices.
Suggesting a detailed plan to them would not be of any use at this point of time. This sector of the building industry functions more like the manufacturing sector, and hence have kept up with the pace of that sector.

However, an interesting point to note here would be that the General Contractor and his associates are not as technology-savvy as yet. They still refer to printouts of AutoCAD and other 2-D drawings. Therefore, it would be a logical decision to experiment on widening the link between the Elevator manufacturer and the General Contractor. The earlier already is using computer-based modeling and information transfer. If they were to communicate this information with the General Contractor via these technologies, then the General Contractor would benefit, and without any substantial additional cost. The key benefits are listed below:

- General Contractor would be able to see how the building would look at the time of installation of elevator.
- If there were any obvious flaws in the building design, they can be taken care of at the starting point itself, thus saving rework.
- By using 4-D modeling, the Contractor can even know how the building is going to shape up at the various stages of construction. This brings to light any deficiencies and shortcomings in the scheduling.
11. Conclusion

From this study, it is clearly seen that the elevator industry is not fragmented at all. A peculiar characteristic of this industry is that majority of the market is controlled by a small group of companies that have expanded their operations and become global giants over the years. In fact, in the US market, 5 major companies control almost 90% of the market of new elevators between them.

The other characteristic of this industry is the nature of information flow between the various segments. The information flow between an elevator manufacturer and the general contractor of a building site is minimal. From the technical specs, the elevator company will only ask for the size of vertical shaft. Then, depending upon the number of floors, traffic of people and arrangement of elevator array, the elevator company will do a start-to-finish job with the elevator production. This includes scheduling, design, engineering, manufacturing, assembly, installation and even servicing of the elevator. This type of business environment had led to the formation of 2 discrete groups – owner, architect, general contractor on one side, and elevator manufacturing company, sub-contractors and suppliers on the other. In spite of being highly interactive factions between themselves, there is very little information flow across the 2 groups. However, this is not perceived as a problem and the industry has readily adopted this setting. Furthermore, there is no need for the elevator manufacturer to furnish detailed information to the building contractor and vice-versa, because their individual design details do not affect the other. The only likely hotspot for IT adoption is around the General Contractor. He shares information with the Owner, Architect, Structural Engineer, Electrical Engineer, Elevator Consultant, Elevator Manufacturer, Sub-Contractors (if any) and the License Inspector. Enhanced data flow here will cut down decision time, make instructions more explicit and reduce the amount of rework required. The Contractor would be able to visualize the building facility at the various stages of construction and make decision changes to correct evident mistakes even before the construction commences.
Thus, in conclusion, it can be said that the Elevator Industry has made tremendous progress in adopting Information Technology and 3-D modeling already. It would be a redundant exercise to try and convince these people to implement IT strategies.

12. Lessons Learnt

This is my first semester of graduate studies at Georgia Tech and in the first 4 months itself; I have been exposed to a plethora of new ideas. I am enrolled in the Construction Engineering and Management group of the School of Civil Engineering. My aptitude to gain awareness in the new technologies in this industry made this seminar an attractive course.

Most importantly, this seminar encouraged me to seek information from the vast ocean of knowledge and be able to compile and relate it to the relevant topic of study. It opened my eyes and literally gave me my first taste of research work, where I would not be spoon-fed by the Professor. We were given a framework and a general plan to go about the research. Having certain people from the Architecture school in the class helped me look at the building industry from an Architect’s point of view.

Another key aspect was the need to get in touch with people from the industry. I learnt to talk to industry professionals, discuss my point of view with them and gather knowledge from them. This has greatly enhanced my communication skills, which I am sure will help me in my career.

Working with Prof. Eastman and Dr. Sacks was indeed a privilege because of the knowledge and insight they provided me with. Coming from a relatively developing country (India), I was not aware of the scope of IT adoption in the building construction industry and its potential to bring about radical changes in the current business environment. This course has given me pretty much all that I expected from it, and I hope I have been able to return the favor by putting together a satisfactory research paper.
References

Some of the information above was obtained via interviews with:

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