EVALUATION OF A GPS SUPPORT SYSTEM FOR FLEET MANAGEMENT CONTROL

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ABSTRACT

Delivery precision and fleet optimisation are highly prioritised within the ready mix concrete industry. Introducing a Global Positioning System (GPS) for logistic steering and planning provides a tool to make improvements on these areas. Such a system is presently under evaluation at a ready mix concrete supplier in Stockholm, Sweden. The system consists of GPS receivers in the trucks that send relevant information via the General Packet Radio Service (GPRS) net to a server.

A direct effect of implementing a GPS system is that the plants and the order central will be able to better control the whereabouts of the concrete trucks. As a result it will be possible to decrease the waste time at the plants. Another result is that the ratio of usage of concrete trucks will increase, leading to cut-downs in the truck fleet. It is further believed that the lead-time at work sites can be reduced as the delivery precision is improved. By eventually letting the contractor be a part of the system the possibilities for a good production planning at the work site will increase and the non-value adding activities will decrease due to reduced waiting time.

The article presents findings from a pilot study in Stockholm, Sweden. An important ambition is to find out if the system gives the expected benefits. The customer value is evaluated through interviews and time measurements.

KEY WORDS

GPS system, Waste time, Fleet optimisation, Non-value adding activities, Pilot Study, Production planning.

INTRODUCTION

In recent years the demands have been increasing on the actors of the building industry to develop the building process in order to improve the productivity and cut costs while maintaining or even increasing the quality. Possible solutions have been debated in several reports and surveys in recent years according to Jonsson (2005). A general hypothesis today is that the degree of industrialization within the building process needs to be increased. Inspiration is often sought in the manufacturing industry, e.g. the concept of lean production as described in Womack, Jones and Roos (1990). An important question is how to adopt the concept in the building industry. In other words what is required to achieve an industrialized process?

Main characteristics of an industrial building process are according to Olofsson et al (2004) and Lessing et al (2005) a higher degree of collaboration between partners, design of standardized solutions and technical concepts, an increased use of pre-manufactured highly processed components, improved effectiveness of the logistics and adoption of information technology. It can thus be concluded that industrialization is not synonymous with the utilisation of pre-manufactured components assembled at the building site, even though the association is common. However, there are increasing concerns within the ready mix concrete industry that market shares will be reduced as large contractors take efforts towards industrialization. The only way of survival is then to join the development according to Emborg (2005).

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A number of developments that will take the in-situ cast concrete in this direction are pointed out in Byfors (1999). Examples are to increase the degree of prefabrication by replacing traditional formworks with non-removable ones in which the reinforcement has been pre-installed, to minimize the reinforcement work at site by adopting the steel fibre concrete technology, to increase the degree of mechanization regarding the handling of concrete at site and to eliminate the compaction work by using self compacting concrete. Some of the suggestions, such as non-removable formworks, steel fibre reinforced and self-compacting concrete, are used successfully today on a regular basis while some are still to come. This means that measures have already been taken to establish a more industrialized process for site-cast concrete.

However, in order to be competitive in the future it is further essential for a ready mix concrete firm to be more cost effective. Considering that transport costs are the most significant after the cost for materials it is realized that rationalizing the transports is a high priority. It is anticipated that the introduction of a new tool for fleet management control based on the Global Positioning System (GPS) will have positive effects. Expected improvements are e.g. that the efficiency of transports increases and that waiting times at the production facilities are reduced. Another expected result is that the waste time at construction sites decreases, as real time information on the whereabouts of the concrete trucks is made available.

A GPS system is at the moment under evaluation at the Swedish ready mix concrete producer Betongindustri AB. The analysis is conducted partly on the basis of data collected from an ongoing pilot study and partly on a theoretical discussion on expected effects when introducing such system in full scale. The ambition is to see whether or not the information flow to the company and from the company to the customers can be improved. Also important is to show that the enhanced information results in improved productivity in the supply chain.

PRESENT SITUATION

ORGANISATION

Betongindustri AB is a ready mix concrete company owned by the international building material conglomerate Heidelberg Cement Group. Betongindustri AB operates a total of 41 plants, serving major parts of the Swedish market with ready mixed concrete. The number of employees is approximately 230 and the yearly turnover is around €50 million.

A business concept of Betongindustri AB is to have production facilities close to the customers, which improves the delivery precision and limits the environmental influence by reducing transportation distances. In the Stockholm area there are a total of seven plants run by Betongindustri AB. A positive effect is of course that it facilitates an optimisation of transports in the region, as each concrete order can be placed on the geographically most favourable production facility. At the same time the planning process gets more complex as the number of plants increase, thus implying that more intelligent systems are required for transport coordination.

About 50 trucks each day are utilised by Betongindustri AB for the distribution of concrete on the Stockholm market. Approximately half of the truck fleet is company owned while the rest is hired from transport logistics firms. Betongindustri AB also runs a fleet of concrete pumps, to be used for in-site transportation of concrete. The motivation for keeping a high degree of concrete trucks and pumps within the company, which is unusual in the ready mix concrete market, is to be able to offer customers the best possible delivery service.

SUPPLY CHAIN

The in-situ placed concrete industry is to a high degree characterised by "pull" behaviour in the sense that the customer controls the delivery chain. This implies that the logistic process of the ready mix concrete producer needs to have a high flexibility. The reason being that concrete is a fresh product that cannot be stored on the construction site. In other words it is necessary for the contractor to be prepared to receive and use the concrete at the moment it arrives at site.

An illustration showing the supply chain that a ready mix concrete company take part in is shown in Figure 1. The first link in the chain is that a customer contacts the order reception, specifying the quality and quantity of concrete to be delivered at a certain place at a certain time. The order reception will check for available resources to meet the specific demands put by the contractor. After acceptance the order is assigned to the most suitable production facility, generally corresponding to the one closest to the site of delivery. The order is further registered in FNG (Fabian Next Generation), the order and invoice system used at Betongindustri AB. A truck-planning list is then established, containing information on the number of trucks as well as to which plant each truck should report the following day. The information on the list is recorded on an answering

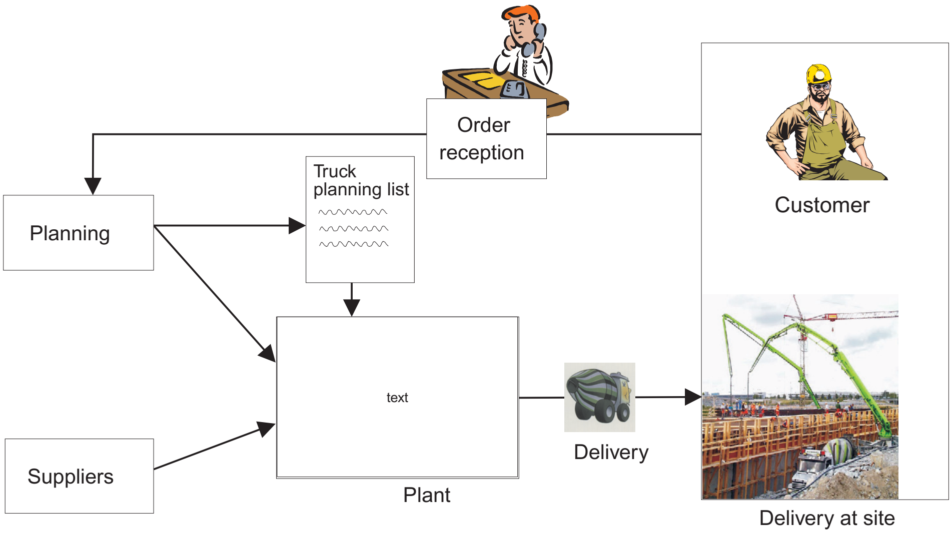

Figure 1: Illustration of a typical regional supply chain for in-situ placed concrete.

machine and made available to the drivers the evening before delivery.

Each production unit then has the responsibility for the local planning, in other words to see that the required materials for the production are available in sufficient amounts and to utilise the designated transport resources as effectively as possible. Regarding the inbound supply of raw materials to the plant it can be said that it mainly consists of large amounts of cement and aggregates, the main constituents of concrete besides water. Moreover there are numerous additives and additions, such as fillers, fibres, plasticisers, air-entraining agents, shrinkage reducers etc, which may be utilized in order to achieve specific qualities of the concrete. The large amount of materials that can be used is one of the reasons as to why there are up to and sometimes even above 200 recipes at a production unit. Depending on the type of concrete produced the time required to mix a batch of concrete is between 5 and 10 minutes.

Upon acceptance the plant manager assigns a specific recipe to the order, after which it can be delivered. The computer system utilized at the plant today is connected to the order system, in which relevant information regarding the deliveries is stored. This means that the time to start mixing a batch of concrete is automatically estimated based on mixing time for the specific type of concrete and the transport time required to the construction site. In case of a delay in a delivery consisting of more than one truck, the computer system will recalculate the initiation time for the next batch so that the delivery interval can be kept.

Important to mention is further that the real time planning of the fleet is manually controlled today, implying that it to a high degree relies on the experience of isolated individuals. Contacts between plant personnel and truck drivers are provided for through radio communication units.

ANALYSIS OF THE LOGISTIC PROCESS

As mentioned previously Betongindustri AB has production facilities at several positions in the Stockholm area. This can be seen as a strategic advantage as compared to most of the competitors, thus implying that transport costs can be reduced as the average distance to the customer decrease. The nearness to construction sites also reduces the sensitivity to traffic disturbances implying that supply safety can be improved. There are furthermore environmental aspects that are worth mentioning in the context.

However, in order to be able to draw full benefit from the situation it is essential to be able to optimize the truck fleet, preferably on a real time basis. This is not possible today, mainly due to the lack of information in the various parts of the supply chain. The nature of the information that is missed as well as a discussion on how a GPS is expected to contribute is provided in the following sections. Most of the information provided in the following sections is based on a previous report of Ögren (2004).

Order reception

As mentioned previously the order reception has the responsibility to assign orders and transport facilities to the plants at least a day in advance. A problem that the planners meet is the daily variations in the demand. The distribution of loads in percent over the day as obtained during the pilot study is shown in Figure 2. Ordered delivery times are compared to actual or measured. It can be seen that the ordered deliveries has a maximum early on and is then successively decreasing during the rest of the day. This means that more trucks are generally required in the morning than later on. Thus in order to be able to fulfill the early transports on time it is necessary to plan for excess capacity during the remaining day, if optimization is only conducted at plant level. However, when comparing with actual delivery times it can be seen that there is rather a lack of capacities early on. Approximately 36 % of the daily deliveries were actually carried out between 6 and 9 am to be compared with the ordered ratio of 45 % during the same period. This means that in average 9 % of the deliveries were postponed, possibly due to a lack of trucks.

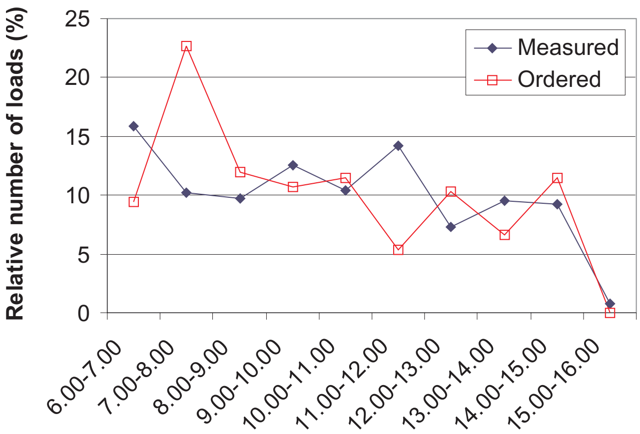

Figure 2: Variation of delivery times over a day evaluated during a four-week period. Ordered times are compared to actual measured delivery times.

The only way of solving this situation is to increase the cooperation between the production units aiming at minimizing the waste time for the trucks. In other words if resources are available at a plant while a lack appears at another trucks should be redirected. This is rarely the case today as the main objective for the plant manager is to first make sure that sufficient resources are available to be able to provide good service to the customers of that specific plant rather than sharing the resources with other plants.

A more advanced system for fleet planning is required in order to steer the transport facilities in real time. The focus must be to take care of the interest of the company as a whole rather than at each plant as an isolated unit. It is anticipated that the GPS system will provide such possibilities, implying that the productivity of the transport fleet can be increased.

The production process

The responsibility of the production unit is to produce and deliver concrete to the customer using the resources made available the day before by the order reception. As a concrete truck is expensive to hire there are rarely excessive trucks available on the plant yard. This implies that the logistic process is extremely sensitive to disturbances. There are further a number of variables that makes the planning at the production unit rather complex.

A transparent overview of the truck fleet is not provided by the present system for information sharing. A consequence is that mixing cannot be initiated until a truck has arrived back to the plant, which results in unnecessary waiting times. The considerable number of concrete recipes available as mentioned previously is another variable that affects the planning. Thus, when a truck returns from a delivery it is necessary to first check if the truck carries any excess concrete. In case of, the truck container needs to be cleaned before the truck is available for a new batch, a process that requires a time of approximately 10 minutes. The exception is when the old concrete is of a similar concrete quality as the new one, in which case it may be possible to fill the truck directly. The solution is clearly a system that gives continuous information on the position, identity and status of trucks.

It is also important to mention the high degree of customer control, which puts high demands on the flexibility of the planning at the production unit. Changes of the specifications of an order, regarding for instance volume or unloading time, can be made just prior to or during a delivery. Today such changes often result in disturbances. The use of a more transparent planning tool would give the plant manager possibility to check for available resources at other plants and thereby minimize the disturbance.

With the present manual communication system it is further not possible to give customers real time information on the exact positions of the trucks. Considering that a contractor relies on high precision in the deliveries of concrete this is a major drawback. In case of adopting a GPS system it will be possible for customers to access the digital map via Internet and check for the positions of the trucks. The waste time at the construction site may then be reduced, as less time will be spent on waiting for the concrete delivery.

CUSTOMER VIEW

When analyzing the efficiency of the logistic process it is further essential to consider the opinion

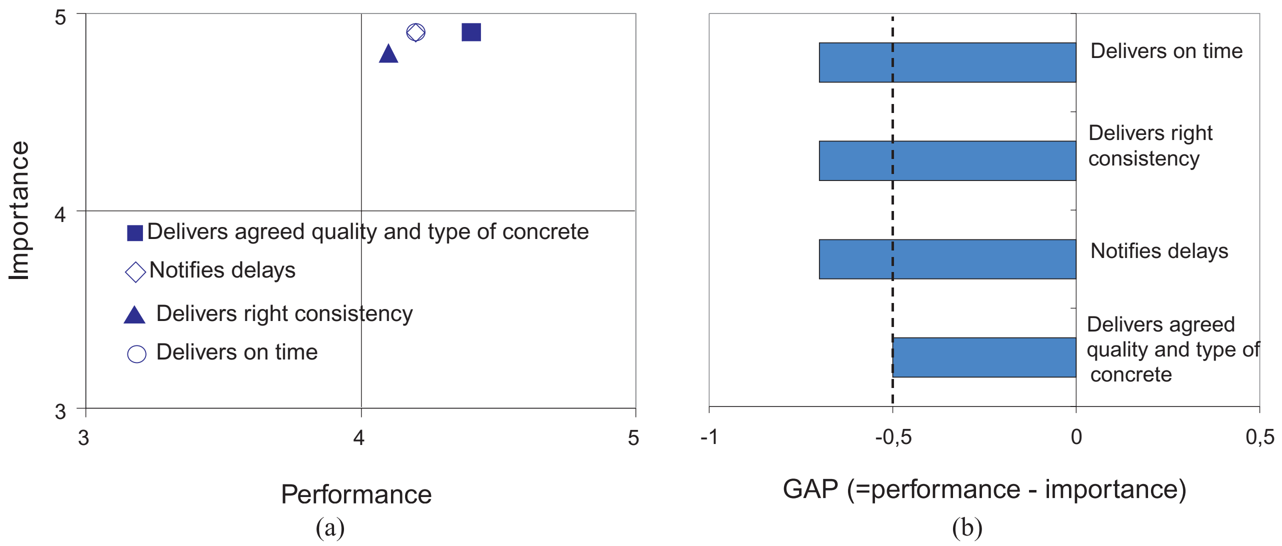

Figure 3: Selected results from a customer survey conducted in 2003.
Performance and importance are shown in (a) while the GAP-values are shown in (b).

of the customers. A customer survey is conducted every other year at Betongindustri AB, in which about 300 customers are asked for opinions on a number of issues. A selection of results from the enquiry conducted in 2003 is shown in Figure 3. Diagram (a) illustrates performance and importance while diagram (b) shows the so-called GAP-values, corresponding to the difference between performance and importance. The GAP-value is a measure on how well the performance of Betongindustri AB coincided with the importance as perceived by the customer. In the context it is important to mention that a GAP-value of between –0,5 and 0,5 is recommended. A value that falls outside the limits simply implies that the service is either unnecessary high or low. Importance-performance analysis has previously been utilized to evaluate the supply chain performance of the transport logistics industry, Lai et al (2003). In the study it was found to be useful for assessing the service effectiveness of transports.

When studying the results shown in (a) Betongindustri AB appears to perform rather well as 4 equals fairly good performance/fairly important and 5 equals very good performance/very important. However, based on the GAP values shown in the other diagram it can be seen that an even higher service degree should be strived for.

To improve the service level on deliveries and consistence is thereby continuously highly prioritised. Nevertheless it has proved to be extremely difficult to improve the GAP-values. One reason is most certainly that the present system for information exchange in the logistic process is not sufficient.

THE GPS SYSTEM

The utilisation of GPS-systems is common in businesses such as grocery and material delivering firms, taxi companies, police and ambulance transport etc. There are further examples of ready mix concrete companies in e.g. France, UK and the US that have introduced such system.

The experience within the building sector in Sweden is more or less restricted to a theoretical evaluation on the utilisation of GPS in different applications, Nilsson et al (2003). A result of the study was that a mobile support system based on GPS was introduced to increase efficiency of asphalt deliveries at the Swedish contractor NCC. For the ready mix concrete industry in Sweden however such systems has not yet been adopted even though several firms are evaluating different possibilities at the moment.

TECHNICAL FUNCTION

The mobile support system under evaluation consists of GPRS-modules and GPS-receivers that are placed in the concrete trucks. The GPS-receiver determines the vehicles position and transmits the information to the receiving unit, e.g. a concrete plant.

MOBILE MAP SUPPORT

Construction sites and plants are symbolized on a digital map transmitted via Internet as zones that are introduced in order to be able to sort out valuable information. When a truck passes a boundary to a zone a message is sent to the receiving computer with information on truck identity and status. Automatic data is then collected regarding transportation time, time of arrival at the construction site, waiting time at the construction site and time for unloading.

Typical status reports are "towards customer", "towards ready mix plant", "towards ready mix plant carrying excessive concrete", "not accessible", "disabled truck" or "available resource". Such information will clearly give the involved personnel a better real time overview of the fleet. An anticipated result is that the planning at plant level becomes better as reliable information is made available on the status of the trucks. It will also be easier for plants to share resources and for the order central to make changes in the fleet in real time when necessary. The statistics regarding the use of the transport fleet will further be more correct in the future. It should be mentioned however that in the pilot study positioning and identity are the only services provided.

ADVANTAGE OF A GPS SYSTEM

The main motivation for introducing so called wireless fleet management solutions is typically to increase the efficiency of a transport fleet and to improve customer satisfaction. For instance, in an internal periodical report Ralph (2003) states that optimisation of delivery efficiency while maintaining a high level of customer service is an expected effect of introducing a satellite-based truck tracking system at the US concrete producer Lehigh. It is expected that the amount of non-productive time spent waiting in the yard or at site can be reduced so that more time is available to actually deliver and pour concrete. The positive effects are believed to come from the fact that more accurate information is made available when and where it is needed. The ability of the system to actually increase productivity has further been verified by the French producer RMC Beton. After introducing a wireless truck tracking system including status reporting a remarkable increase in efficiency of each truck was noticed. Instead of four deliveries a day each truck could take on five.

Thus, more value id added and more relevance is given to the information, factors that will make the company more effective. In order to fully benefit however it is necessary to also include the order and invoice system. Combined with equipment that enables printing and electronic signing at site this would reduce the administration significantly. In the long run it is further likely that a mobile support system is introduced in the whole logistic chain from raw material supplier all the way to the customer.

In Ögren (2004) an analysis has been conducted to estimate the time to recover the investment. It is assumed that the implementation of the system in full scale will result in a reduction of the truck fleet by one truck each month, which is a rather low estimate. This results in an ROI (Return On Investment) time of approximately 10 months. The relevance is further verified by follow-ups conducted by the Canadian firm Ocean Concrete in Vancouver. After one and a half year of using a GPS based system it was concluded that the investment was recovered in only about 13 months as compared to the expected ROI time of 24 months.

PILOT STUDY

The pilot study was conducted at one of the ready mix concrete plants of Betongindustri AB in Stockholm. Six concrete trucks were involved along with a few service vehicles. As mentioned previously the pilot study, which went on for a four-week period, only enclosed positioning and truck identity. Rather than showing the advantages the intent was to verify the function of the system, consisting of software, GPRS modules, GPS receivers and hand computers. Another ambition was that some of the staff should be given the opportunity to evaluate it during a few weeks.

Nevertheless data regarding e.g. usage of the trucks during the evaluation period was actually collected although any major positive effects were not expected at this stage. The intent was rather to show that there are deficiencies in the present system for logistic steering.

GATHERING OF DATA

A substantial amount of information is generated in the GPS-system. Data regarding the position of a truck is gathered every 20 sec. However, only a minimum of the information is relevant. Thus, the zone system as mentioned previously was adopted to be able to sort the data. This means that construction sites and concrete plant have been predefined with a position and a radius on the digital map. Data on times when trucks passes into and out of a zone can then be stored and analysed. Examples of results from such analysis are transportation time, unloading time and time at ready mix concrete plant.

EVALUATION OF DATA

Delivery efficiency

A high degree of usage of the concrete truck fleet is clearly a high priority. Follow-ups conducted in 2003 indicated that the average effective time of a concrete truck, i.e. transport + unloading time, is only just above 4 hours per day. A considerably higher degree of usage was obtained in the pilot study as shown in Figure 4. The reason is however more likely to be due to experienced staff and a favourable order distribution over the day rather than due to the GPS system. In the diagram the average effective time of trucks equipped with GPS is compared to the corresponding time for trucks without GPS at the same plant. In order to be able to make such comparison the data used was collected from the present system, i.e. based on manual registration of times. It should be mentioned that the automatically obtained data from the GPS system gives an average time that is 30 minutes longer. This indicates that the effective time is typically overestimated today.

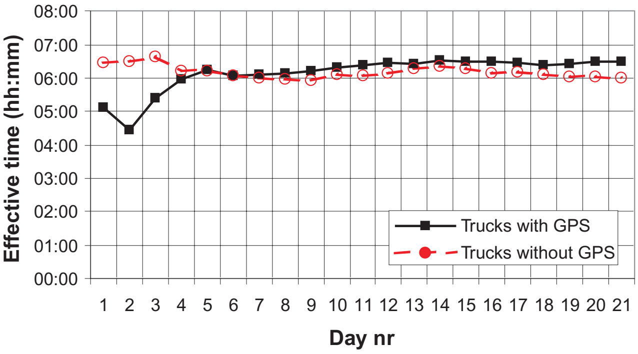

Figure 4: Average effective time, time at site and transport time of the trucks involved in the pilot study.

When studying the results shown in the diagram an average usage of approximately 6:30 hours was obtained for the trucks equipped with GPS at the end of the study as compared to only 6:00 hours for trucks without GPS. This indicates that although not fully implemented the GPS system has contributed to an increased usage.

Waiting times

An expected result of the introduction of a GPS based planning system in full scale is that the waiting times can be minimized. This is mainly due to the more transparent planning provided, which makes it easier to prepare for upcoming loads. Waiting times at the plant for the trucks included in the pilot, i.e. equipped with GPS, were compared to the corresponding times for trucks without GPS at the same plant and during the same period. As in the previous section the comparison was enabled using the existing system for data collection, which means that times registered by the drivers were used. Results showed that the average waiting time for trucks with GPS was 5 minutes shorter, 28 compared to 33 minutes. This is yet another indication that the productivity was in fact slightly increased in the pilot although this was not the prime intent.

Delivery precision

With the term delivery precision the intended interpretation is to which extent a product or service is delivered to the intended customer at the agreed point in time. As Betongindustri AB to a high degree is working with customer order steering such measurement is of great importance. Delivery precision is a parameter that is and will be relatively easy to measure. Today the precision is obtained simply by interpreting noticed time for arrival and departure from the construction site on the invoice. In the future however this kind of information can be achieved directly from the GPS-system, when fully implemented.

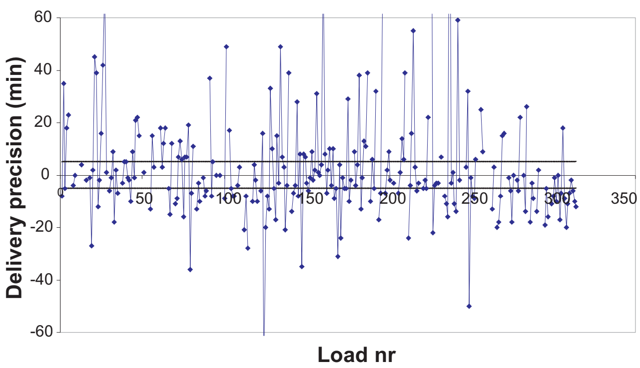

Figure 5: Transportation delays for trucks involved in the pilot study.

Transportation deviations in the pilot study show that there are problems with maintaining agreed delivery times, Figure 5. A positive deviation is a delay while a negative value indicates that the truck arrived early. It is important to note that a deviation does not necessarily imply that the truck arrived at the construction site at the wrong time. Particularly in case of extreme deviations it is more likely that an unregistered agreement has been made between contractor and plant manager.

Nevertheless, rather poor results were obtained in the pilot study. Only about 30 % of the deliveries arrived within the interval set up by Betongindustri AB, i.e. ±5 minutes, compared to an ambition level of 95 %. Approximately half of the remaining 70 % of the trucks was late. Disturbances in deliveries early on in a day are a possible explanation for the delayed loads. This would cause problems even for later deliveries due to reduced transport capacity. Based on evaluations conducted within the study it was also concluded that actual unloading times were in average 10 minutes longer than ordered. This is another reason as to why it is difficult to keep the agreed delivery times for succeeding loads.

Contrary to the results shown in Figure 5 it is a general opinion at Betongindustri AB that the delivery precision is rather good. For instance, in follow ups conducted in recent years the goals have typically been reached, i.e. 95 % within ±5 minutes. It is thus suspected that incorrect data is frequently entered in the present manual system, as was also indicated in section "Delivery Eefficiency". A possible reason is that delivery precision is bonus related.

DISCUSSION AND CONCLUSIONS

Next after cost for raw material the most significant cost for a ready mix concrete firm is the ones associated with transportation. Delivery is further an important part of the product and the associated service. An ambition is to maintain a high degree of service and make it as efficient and cost effective as possible. It is anticipated that this is achieved when introducing a GPS based system for fleet management control.

Expected positive effects are e.g. an increased degree of usage on the trucks and concrete pumps and a higher number of deliveries at the agreed time. The system is further expected to bring more valid information to the customers giving them real time notification on the positions of the trucks. A positive effect is that the customer will be able to see at an early stage if a delivery is delayed. Thereby it is possible to make a change in the planning of the personnel activities. This gives Betongindustri AB a better customer focus and will lead to better productivity at the construction site due to less waiting time. The map system will further aid the drivers in planning the route to the construction site, thus resulting in less transportation time and better delivery efficiency.

Although the intent of the pilot study was more or less to verify the functionality of the soft- and hardware some conclusions can be drawn based on results from the rather limited pilot study. Firstly, it was shown that the efficiency of concrete deliveries was slightly increased, possibly due to the GPS system. The average usage time was approximately 30 minutes higher for trucks with GPS as compared to trucks without. Secondly results showed that waiting times were in average 5 minutes shorter per delivery for trucks equipped with GPS. For a single truck this may not seem much. However, it can result in savings corresponding to one or several trucks considering a fleet of 50 trucks that are delivering up to 5 or 6 deliveries a day.

Important to mention is also the fact that the automatically generated data in the GPS based system is more reliable than the manually obtained as used today. This is important since many decisions are based upon statistics analysed from the data.

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