FEASIBILITY STUDY OF FIELD FORCE AUTOMATION IN THE SWEDISH CONSTRUCTION SECTOR

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SUMMARY*: Field Force Automation (FFA) is a generic term for mobile applications used in real-time support of orders, scheduling, supervising and reporting in the field. The result from in-depth interviews with people in the construction, the facility management and the supply industry is presented with the purpose to answer the following questions. (1) Where can FFA system be applied in the construction sector? (2) What is the economic impact of FFA systems? (3) How should FFA systems be introduced in specific operations? According to the results from interviews and ROI estimates, FFA can significantly increase the productivity of many construction related field operations through real time planning support, work allocation and follow-up provided that the technical solutions are adapted to the end user. The benefits are reduced lead times, more efficient use of resources in the field and enhanced quality of work.*

KEYWORDS: *field force automation, mobile communication, building services, construction, concrete delivery, return on investment.*

1. BACKGROUND

Today's workforce is becoming increasingly mobile and clients are searching for real-time applications that can be accessed utilizing mobile enterprise technology from a variety of devices. The vision for the mobile workforce is to become a "Virtual Node" of their enterprise. In a market segment analysis, Jeff Heenan-Jalil (2002), indicated that transportation and construction are among the most field service intense sectors.

According to the Swedish Construction Federation (2001), approximately a quarter of a million workers are involved in construction activities in Sweden. Activities characterized by a dynamic flow of materials and information. Field operations are often complex and hard to manage. Unforeseen events, delays in material deliveries to the site reduce the efficiency of the operation.

Field Force Automation (FFA) is a generic term for mobile field services applications used for real time support of orders, scheduling, supervising and reporting in the field. During 2002-03 a feasibility study was conducted in Sweden where the scope was to give people in the construction industry knowledge of FFA system and its possibilities to enhance fieldwork operations (Nilsson, et al, 2003). The aim has been to investigate the applicability of FFA in construction, and to estimate the economic impact in specific operations.

This paper describes the result from the field surveys and workshops with employees and managers who are active in different branches in the construction industry ranging from production of civil engineering construction to delivery of building material and building services. Economic models, added value and return on investment estimations (ROI) on company level are presented as well as the necessary prerequisites for the introduction of FFA system.

2. FIELD FORCE AUTOMATION

2.1 System architecture

A FFA system consists of a number of components to give real time support of dynamic fieldwork operations like scheduling, allocation, dispatch, reports and follow-ups, see Fig. 1.

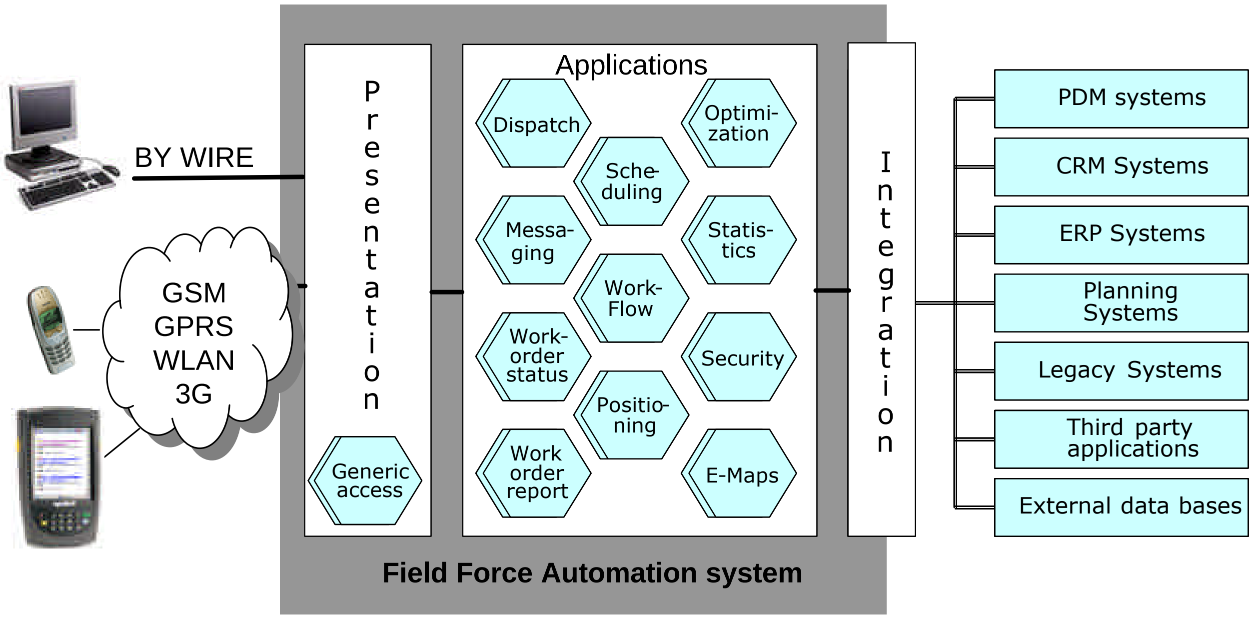

FIG. 1: FFA system architecture.

Generic access: Access independent of hardware platform and network, i.e. from mobile phones, hand terminals over wireless network (GSM, GPRS, 3G or WLAN) to Internet connected terminals.

Dispatch, work order status and messaging services: Dispatch of work orders can be distributed by the work planner (top-down) or received on request from the field worker (bottom-up). Work orders can be accepted, rejected and their status (accepted, rejected, started, interrupted and finished) including cause can be monitored. Messaging services for instant messages and e-mails are also available.

Work order reports and workflow: Possibility to send work order reports to the office for inspection, attest and invoice handling. Use of electronic signatures reduces the paper handling and increases the efficiency. Limitation of the field device requires carefully designed work order report user interface.

Positioning and E-Maps: Services based on GSM or GPS to track the geographic location of workers or workspace. The positioning information can also be used to optimise transport routes and lead times. Positioning is also beneficial for the security of sole workers. In case the user wants to protect the integrity of the staff, the position of the field worker is not presented on the electronic map in the system.

Optimisation and Statistics: Optimisation algorithms can be used for decision support of scheduling and rescheduling, allocation of resources, minimize transports etc in real time. Statistics is an important tool in analyses of lead times and utilization of resources.

Security: To protect the FFA system from unauthorized use, conventional login procedures with usernames and password can be combined with the mobile subscriber's connection number and/or the IP number of the Internet terminal. Electronic certificates and encrypted data can be used to protect the information flow over the network.

2.2 Terminals

The field terminals should resist tough environments, have long battery life to ensure full working days operation and equipped with necessary features such as network connection, bar code scanner to support the application. Access to network and field application governs the type of terminals to be used. Simple applications can be managed by mobile phones using SMS and/or voice recognition access. Managing work orders requires hand terminals with network access. More advanced hand terminals are often equipped with a mobile phone.

2.3 Integration

For efficient workflow the FFA system should be integrated with the company IT environment. For example master schedules activities can be decomposed for operation and follow-up in the FFA system on a daily basis. Handling of work reports, deliveries and invoices require integration with business (ERP) systems. Telematics systems like alarms from sensors can directly generate work orders for maintenance. In sales force automation access to the company's customer relation database (CRM) is important. Positioning services require integration with external map databases.

2.4 System functionality

The FFA application must be designed for the specific operation. The FFA application described here contains an operator interface and the hand terminal interface for the field worker. The system contains orders, activities and resources. When an order is assigned to a resource an activity is created. Different symbols show the state of the activity: accepted, rejected, started, interrupted and finished. Fig. 2 shows an example of an operators interface designed specifically for a concrete supplier.

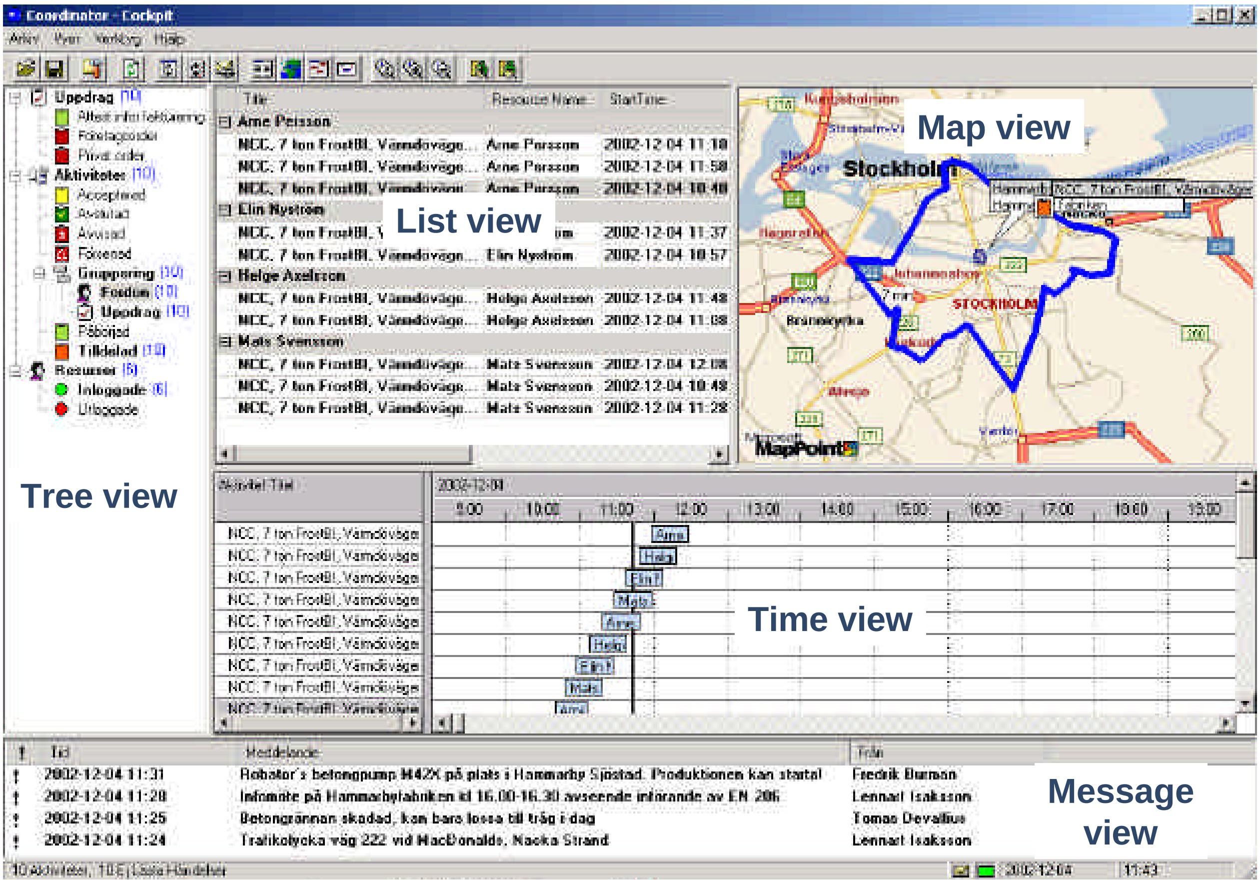

FIG. 2: isMobile Blå Coordinator™ FFA system operator interface, see explanation below.

The system operator interface is divided in five different fields:

- Tree view; orders, activities and resources can be grouped hierarchically;
- List view; orders, activities and resources can be listed according their status. The example in Fig. 2 shows the orders accepted for each resource (truck driver);
- Time view; shows activities and resources in time. New orders can be dragged into the time view for automatic scheduling;
- Map view; shows the location of resources (plant and truck mixers) and delivery sites;
- Message view; shows a log of all messages distributed in the FFA systems

The interface for the field worker/truck driver needs to be designed carefully. It should be simple and intuitive since many field workers in the building sector are in general inexperienced of using IT. Fig. 3 shows the hand terminals interface for (1) list of orders, (2) order in detail and (3) work report for concrete delivery.

FIG. 3: Field worker interface for concrete delivery. (1) List of accepted (yellow) and assigned (red) tasks, (2) order in more detail and (3) work report upon completed task.

The status for an ass ignment can be *assigned* by the operator (red), *accepted* (yellow) by the field worker and *commenced* (green). The accepted status is to confirm that the field worker is able to commence with the assigned task. The work report includes all necessary information for invoicing.

3. FEASIBILITY STUDY IN THE SWEDISH CONSTRUCTION SECTOR

3.1 Introduction

The construction industry is field intense sector with a dynamic flow of information and goods. The design and production phases can be characterized by information flow, field production, transport of equipment and material. The flow of information is intense between contractors, subcontractors and consultants, head office and building site. In the service phase the property manager shall maintain the building throughout its service life. Most of these activities are carried out in the field with support from head office of contractor, subcontractors and suppliers.

A number of pilot studies were carried out in the Performance project (Nilsson et al 2003). The result was based on field surveys, workshops and in-depth interviews with field workers and manager in specific areas in the Swedish construction industry. The benefits of FFA systems were analysed and categorized. Estimates of benefits and costs were quantified in ROI calculations.

3.2 The return on investments - ROI

Before any system is introduced in an enterprise, the objectives/goals should be made clear. This is also true for FFA systems. The objectives can be expressed in economical terms, such as increased turnover and cutting of costs, or in measures of quality, such as increased precision of delivery to site or added customer value.

The economical value of the investment is often estimated using ROI calculation where the condition for the specific business is accounted for. Investment costs and costs of operation are compared with the savings and increased turnover, see example in Fig. 4. The costs of FFA system are operational costs such as software license and support fees and investments in hand terminals, development costs for specific customer applications, start-up cost such as training of staff and integration of the FFA system in the IT environment of the company. Investments are normally depreciated over three years. If the costs are easy to define the benefits are much harder to estimate. How much will the paperwork decrease in accounting when work orders and work reports are sent electronically?

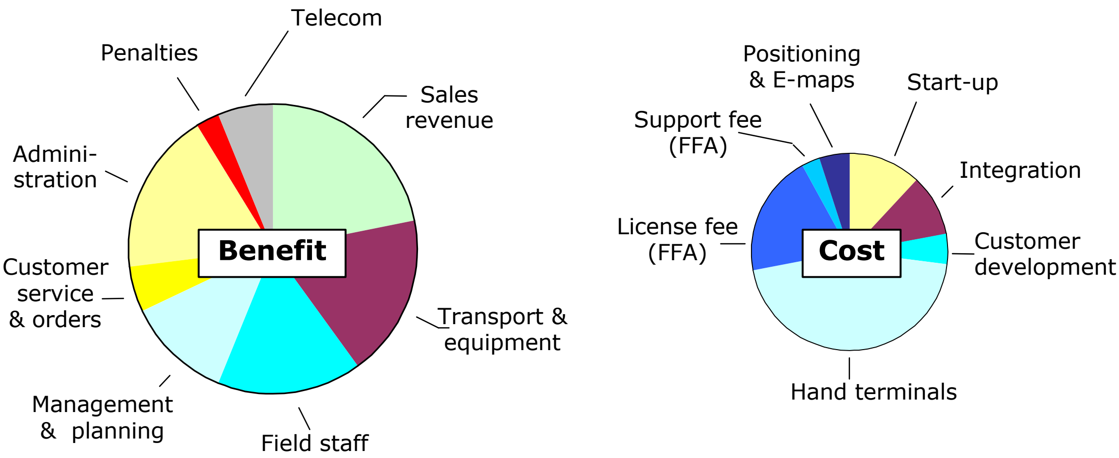

FIG. 4: Example of ROI analyses of value added and additional cost, (the size of circles is proportional to the total value).

The amount of chargeable time increases for the field staff. Unnecessary travels to head office to pick up orders and leave reports are avoided. How will this affect the sales revenue? Can more efficient use of the vehicle fleet lead to better precision in the deliveries and thus avoid penalties or can it be used to increase sale figures? Communication can also be more cost-efficient compared to traditional use of mobile phones. Make realistic assumptions about the increases in revenues and savings. The FFA system per se will not make wonders. The effect comes from the possibility to cut lead-times, create better workflows, use resources more efficiently and increase the value for the customers.

3.2.1 Installations and building services

Building services are characterized by many small and short operative and maintenance assignments often spread over a large geographical area. The field-staff works in ambulatory units that carry out several assignments each day. Every morning each unit is assigned the assignments of the day. In case of emergency, the work orders for assignments are dispatched via the mobile phone to the concerned field worker. Table 1 shows some of the identified problems in the business today and proposed solutions for field staff working with installations and building services.

The following estimations were based on interviews with field staff and management in order to calculate the benefits. Each field worker has on average 0.6 assignment/working day. The time spent on administration of work orders and invoices can be reduced with ~15 minutes/assignment. Planning and follow-up reports of the field activities takes a lot of time. This time can be reduced with ~2 hours/month and field worker. Travel time including the time spent at the office to get new work orders or job descriptions can be reduced by ~30 minutes/field worker each day. This time can also be used to increase the sales. To get the total savings/year the staff are assumed to work 20 days/per month, 11 month/year at a cost of 200 SEK/hour for administration, 250 SEK/hour for field workers and 350 SEK/hour for supervisors. The earnings for the service company is estimated to 50 SEK/hour field work.

TABLE 1: Identified problems and solutions in building services

Category	**Problems**	**FFA Solution**
Management & planning	Low quality of analysis and follow-up. Several incompatible systems used. Low quality in planning and use of resources. Emergency assignments interfere with the daily plans and operations.	Follow-up of work reports, statistics and integration with ERP system. Optimisation based on position and/or skills gives better use of resources. Automatic rescheduling handles emergency assignments.
Field staff	Field staff must travel to office at least twice a day to receive/leave work orders/reports. Job descriptions left behind leads to more travels. Field staff cannot take new assignments if assignments of the day are executed.	Work order/reports/descriptions are sent over the network to the field staff. The field staff can send request for new assignments based on skills and/or interest. Self-control of the assignments boosts motivation.
Administration	Large number of work reports to handle. Work reports get lost or are not complete. Long lead-time between reporting and invoicing.	Electronic work reports, signatures would significantly facilitate the invoice handling and reduce overhead.

The result from a ROI analysis of a building service unit with a turnover of 70 MSEK is shown in table 2. The unit consists of 70 field workers, 7 administrators and 9 supervisors. The unit handles 800 work orders/month. The investments have been depreciated over three years at an interest rate of 5% to get the annual cost. The pay-off is mainly in more efficient use of the field staff. The released capacity can also be used to increase the number assignments.

TABLE 2: Return on investment (ROI) for a typical buildings service unit with 70 field workers.

Cost	Investments (kSEK)	Year (kSEK)
License fee, FFA system	900	-330
Customer development	700	-257
E-maps		-75
Hand terminals including GPS, 20 kSEK/each	1 400	-514
Start-up, education (5 kSEK/field worker)	350	-129
Integration	400	-147
SUM	3 750	**-1 452**
Benefits	Savings (hours)	Year (kSEK)
Administration: work orders and billing	9 240	462
Management: Planning & Follow up	1 540	539
Field worker: Less travels	7 700	1 925
Sales: Increased revenue[1)]	7 700	385
SUM	26 180	**3 311**
RESULT		**1 859**

[1)] The increased revenue has been based on the fact that the hours saved in travel time can be used to increase earnings made on new orders.

In Fig. 5 the cost and benefits are shown as a function of the number of field workers in the company. The estimated size of operation for implementing a FFA system in a building service or installation business activity is ~ 20 field workers.

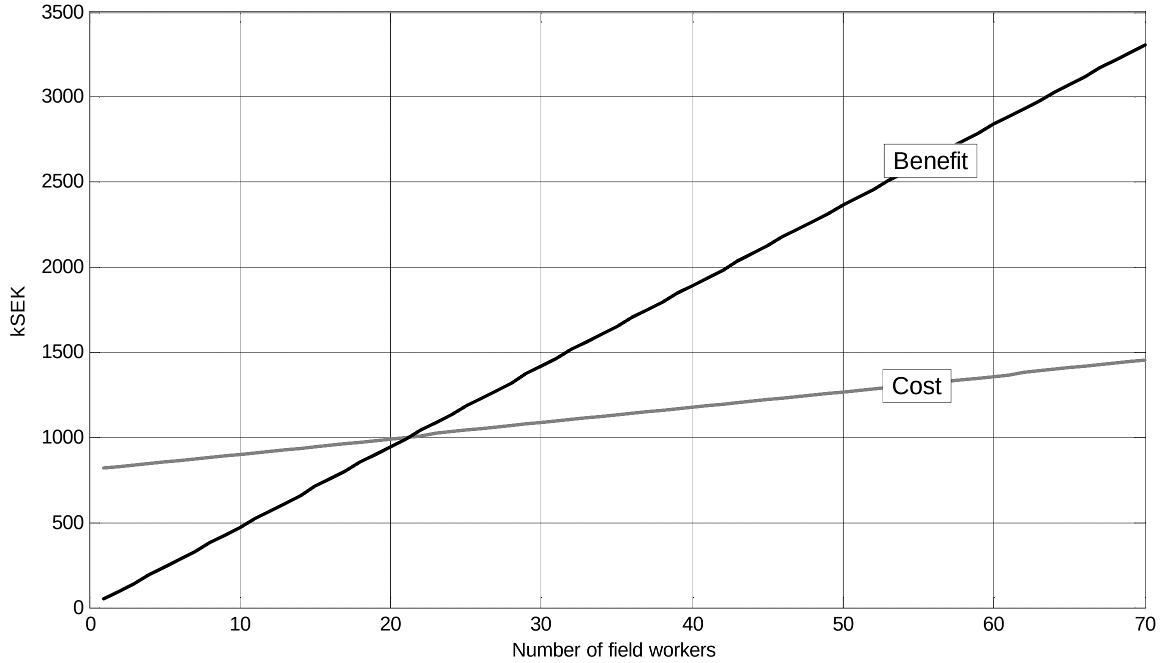

FIG. 5. Cost and benefits of an FFA system in building service as a function of the number of field workers.

3.2.2 FFA in a road construction project

Civil engineering construction works are often spread over a large area, such as road works, foundation works and bridge construction. Large quantities of materials, excavated material, filling material, concrete etc, are transported to and from the construction site. The construction work is highly mechanized using diggers, excavators and trucks. Table 3 shows identified problems and corresponding solutions using FFA systems in a typical road construction project. Estimated benefits and costs are based on a project engaging on average 20 field workers using 12 trucks over a period of 30 months, see Fig. 6.

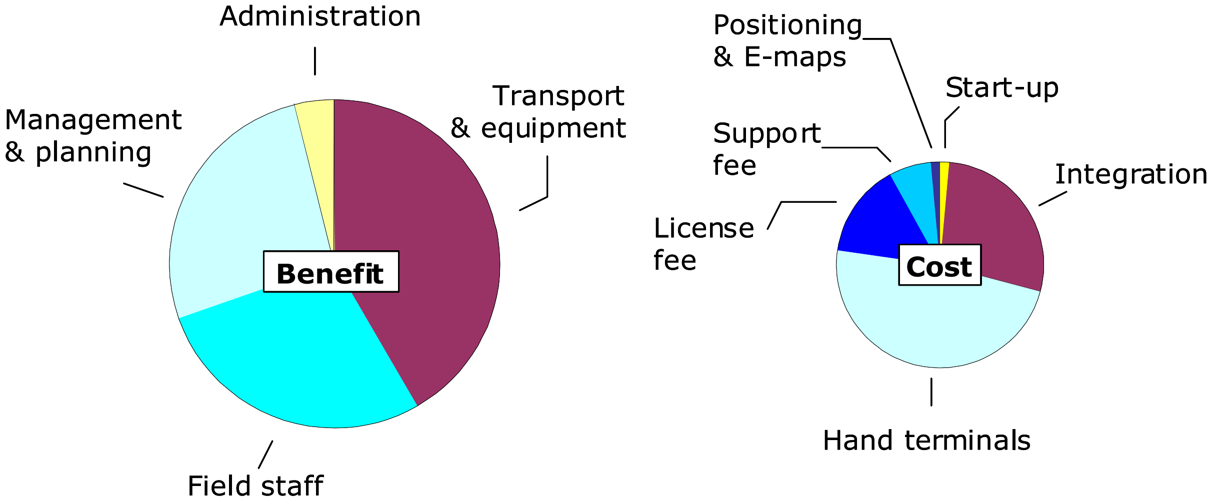

FIG. 6: Estimated ROI for the road construction project. The estimated added value is twice the additional cost per year.

TABLE 3: Identified problems and FFA solutions for road construction.

Category	**Identified problem**	**FFA Solution**
Management & planning	The main contractor has often frequent and extensive meetings with subcontractors and the client to resolve coordination issues.	Generated follow-up reports can automatically be sent to all actors. Better tools for the daily planning and operations reduce the need for meetings.
Transport & equipment	Since the equipments are often spread over a large area it is difficult to make use of available resources. Problem receiving and taking deliveries to right location since no specific delivery address exist on the site.	Positioning and state of equipment and field staff. Use of resources can be based on availability and location. Positioning and external notification of incoming deliveries including the name of the orderer and date of order.
Administration	Paper based work reports, delivery consignments notes get lost or the signature of the receiver is illegible. This creates problems for the accounting department.	Electronic consignment notes, work reports, signatures and bills would significantly facilitate the administration, such as attest of bills and invoices.
Field staff	Coordination of daily operation. Location of staff in space and time.	Login and positioning makes the field staff located and online during work hours.

3.2.3 FFA for ready-mixed concrete delivery

The pilot study concentrated on the business operation of a relatively large ready-mixed concrete company in Stockholm where 10 of its 23 plants are located. The company's delivers 300-500 ready-mixed concrete loads every 24 hours.

Since transport of ready-mixed concrete from the plant to the construction site is time-critical, the goal is to achieve a delivery precision of 5 minutes to customer. The company delivers over 200 different ready-mixed qualities, which makes the operation and logistics even more complex since the mixer needs to be cleaned before a new quality can be transported. Table 4 summarizes the identified problems and solutions and Fig. 7 shows the estimated ROI calculation. One reason for the surprisingly high estimated pay-off is the volume of transports. Rescheduling in real-time gives also the possibility to take orders on short notice and increase the sales revenue.

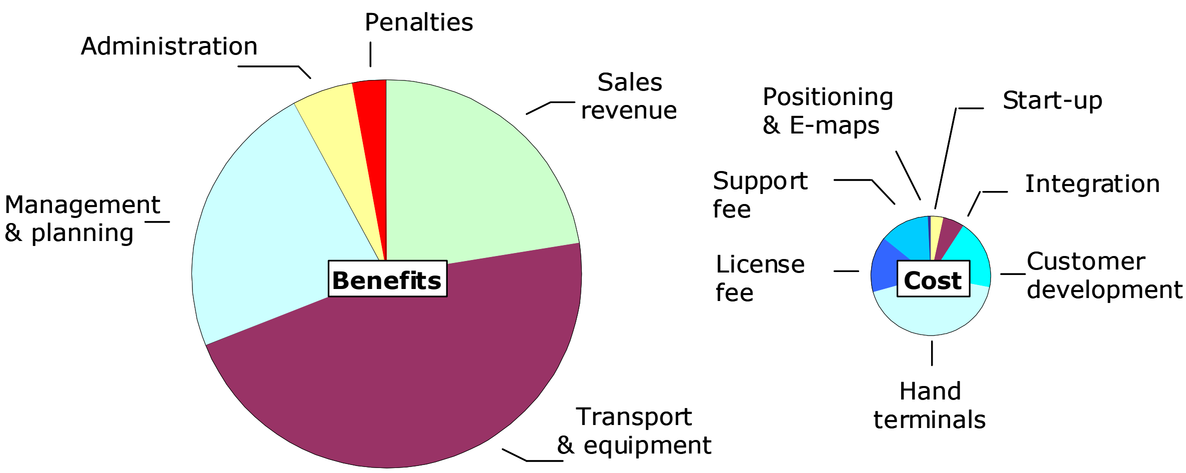

FIG. 7: Estimated ROI for concrete delivery. The value added is ~4.5 times the additional cost per year.

TABLE 4: Identified problems and solutions for concrete delivery.

Category	**Problem**	**FFA Solution**
Management & planning	Planning is complex and often unforeseen events occur that overthrow the daily delivery plan.	Dynamic rescheduling using optimisations makes better use of resources.
Sales revenue	Orders with short notice cannot be accepted. Rescheduling cannot be made quickly enough.	Quick decision can be made using optimisations and dynamic rescheduling.
Transport & equipment	Backup transport capacity is needed to meet the delivery precision. Difficult to start ready-mix production “just in time”. Arrival time of mixer truck to the plant is not known in advance.	Positioning and notification of incoming mixer trucks cut lead-times and reduce the need for backup capacity.
	Traffic jams in rush hours delay the transports. Penalty fees for delayed transport. Address of delivery hard to find.	Electronic maps and positioning and information of traffic jams give the opportunity to optimise transport routes.
Administration	Work report gets lost or is not complete. Disputes with customer for chargeable time for unload at the site. New EN norm requires the time for unload of concrete to be registered.	Electronic work reports, signatures and automatic timestamp of unloading would significantly facilitate the invoice handling. This would fulfil the EN 206 requirement.

4. DISCUSSION

Building services is one of the most promising sectors where FFA systems can make operations more efficient. Manual handling of many small assignments distributed over wide geographical areas are time consuming. Electronic distribution of work orders, reports and bills give a large effect on the profitability. Positioning and real-time planning gives the manager the possibility to handle urgent tasks more efficiently. It also provides security benefits for the field workers.

The potential is also high to make transports of materials and equipment more efficient and precise. Orders given with short notice create complicated logistics and special demands on flexibility. Furthermore, the quality of e.g. concrete and asphalt is dependent on the time of delivery. FFA systems offer dynamic handling of transport, planning and operation, route optimisation and dispatch of orders.

In building and civil engineering construction the coordination of operations and deliveries to the building site are complicated. Contracts are often established with a number of actors and suppliers such as installations engineers, painters, concrete suppliers, etc to do the actual work. The main contractor’s main schedule, describes the activities, lead times and dependencies between these activities. Due to the circumstances when the schedule was made many unforeseen events happens daily that influence the production negatively. FFA systems can effectively reduce the effect of these events providing functions for operational coordination in real time. Schedules can be redesigned with optimisation support on daily basis. It can also provide efficient flow of work orders and work reports. Work orders can be distributed automatically, immediately or on request from the fieldworker. The latter defines a pull system where the operation is controlled by the fieldworker. However, interaction between the FFA systems of main contractor – subcontractors – suppliers is a condition for real-time planning and management of operations on the building site using available personal, resources and deliveries in an optimal way. Subcontractors and suppliers can at the same time make their own operations more efficient by allocating their own workers and resources to the building operations and sites where they are best used and closest located.

Fig. 8 shows a construction scenario using FFA systems. The main contractor workforce carries out most of the fieldwork except HVAC installations. Three actors are involved in the process, the main contractor, the subcontractor responsible for HVAC installations and the concrete supplier. The main contractor decomposes the activities in the main schedule for operations into the main contractors FFA system. The detailing of the HVAC activity is the responsibility of the subcontractor. Only the dependencies to the other activities need to be resolved in the main contractors FFA system.

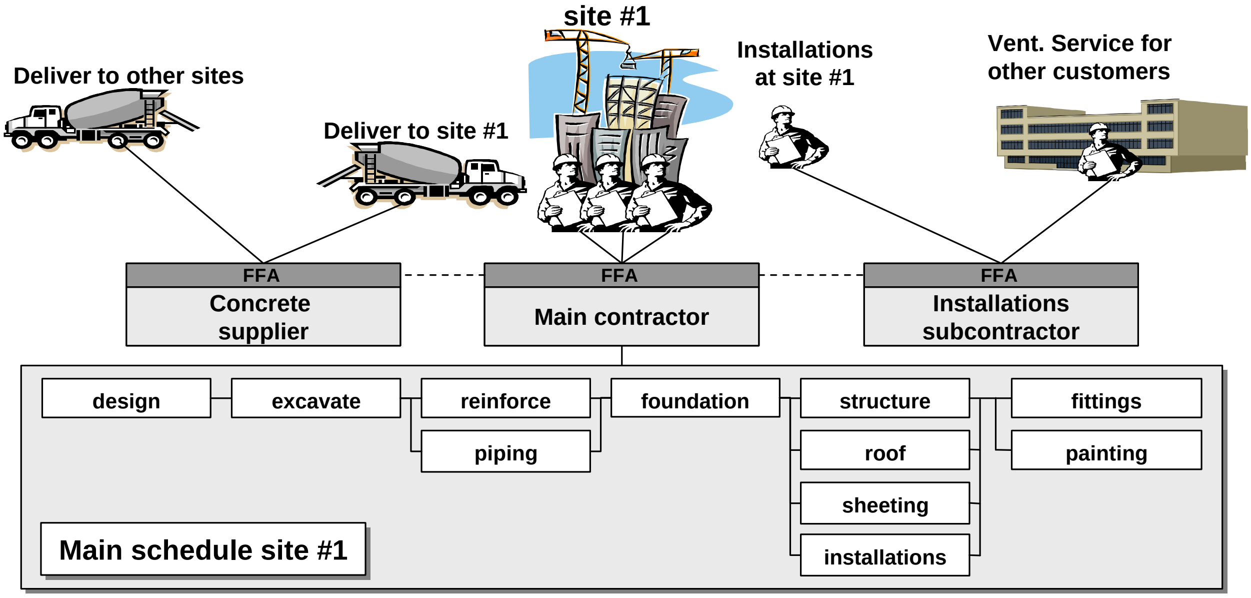

FIG. 8: A scenario using communicating FFA systems on a building site.

The installation subcontractor decomposes the planned HVAC installation work into his own FFA system together with other planned activities such as service of customers' ventilation systems etc. The concrete deliveries to the site are scheduled into the concrete supplier FFA system. Furthermore, the three FFA systems can communicate and calls and requests for work orders can be delivered from one system to the other. The main contractors can now reschedule unforeseen events in the FFA system. Effects on dependent activities will be notified to the suppliers'/subcontractors' FFA systems. Each actor is responsible to reschedule his own resources and workforce in an optimal way. For example a delay in the construction process causes the installation activity to be postponed. The concerned installation workforce can in the mean time be rescheduled to do services on a client's ventilation system. Actions can also be triggered on request. Instead of making detailed plans of concrete deliveries to the site, deliveries can be requested on short notice based on rough schedules and estimated volumes. The concrete supplier FFA system gets a request from the main contractor FFA system to deliver concrete. The supplier accepts the delivery and schedules the transport at requested time and date in the FFA systems operational planning application.

FFA systems are not the only possible mobile service at the building site in the future. Other applications will also be available to enhance communication and distribution of digital information and to make the construction work more effective. Especially when the whole building process becomes digital and product model oriented, the mobile technology will be the link to realise the design of the construction, (Rebolj et al, 2004).

However, a vital condition is that the technical solutions are adapted to the end user. The construction sector has special demands on durability, user interface and simple operation in harsh environments. Furthermore, the introduction of FFA systems in day-to-day operation should be well planned and implemented in small steps. Otherwise the promised rationalization can be lost. Also, to make use of the full potential, standards should be applied for information transactions. Especially in a sector that consists of many subcontractors and suppliers to allow for seamless exchange of invoices, dispatch notes between different types of IT systems.

The take-up of mobile technology and FFA systems in particular has already started in Sweden in sectors like transportation and supply chain management, (Heijden and Valiente, 2002). When will the construction industry begin?

5. CONCLUSION

FFA can give a significantly increase the productivity through planning support, work allocation and follow-up. Integration of FFA system with company business support systems, like ERP and construction planning creates a supporting environment *to reduce lead times, more efficient use of resources* in the field and to *enhance quality of work.* In many cases the investment in FFA systems can be justified through more efficient handling of field operations in the company. Other operations require cooperation between companies and actors to get return on investments. FFA systems can also be the operational field interface to more advanced planning methods and control in the future such as the last planner system of production, (Ballard, 2000), 4D modelling, (Koh and Fischer , 2000, Rönneblad and Olofsson, 2002 and Jongeling et al, 2004) and systems based on the principles of lean construction, (Fischer and Haddad, 2004).

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