Proposal for Applying Telematics Concept and Analyzing Economical Model in Site

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Abstract: Nowadays, the dependence of productivity on construction equipment is getting bigger and the mass of equipment cost is increase, those are indirect evidence of important of equipment. But construction field has the characteristic that is the various activities and wide work area. These make many problems in the operating of equipments. These problems bring about diminution of workability and productivity, in result it makes increase of cost and time. Owing to solve the problems, this study introduce of Telematics. This study analyzes process into its work and management for construction equipment using at the land work, and will apply Telematics to the field equipments.

Keywords: Construction equipment, Telematics, Site characteristic, Economical analysis model

1. Introduction

1.1 Background and Object

Today, construction business is considered as a typical 3D industry and shows higher separation rate than other businesses, and at the same time the age of people engaged in construction industry is getting older and older. Accordingly, construction equipments which have been radically introduced since 1980's become substantial element as a supplement for insufficient labor power in construction field and the dependency upon construction equipment at site is getting higher and higher.[1]

Yet the improvement are required because there is limit in making the best use of productivity of construction equipment along with the difficulty in managing process related to construction equipment due to the feature of construction equipment and construction site.

In this study, I would like to examine and analyze the management situation regarding construction equipment at construction site, propose the management concept of construction equipment applied Telematics which can lead to the productivity improvement, enumerate the expected effect and propose improvement plan based upon the existing model taking economic feature into account.

1.2 Scope and Methodology

In this study, I intend to conduct research on the site management of construction equipment and concept of Telematics through literature inquiry, find the problem in managing construction equipment at construction site and factor which influences on productivity, and search for improvement plan for this problem through the interview with site manager and construction equipment operator.

Through this study, I plan to forecast the improvement effect in case of applying Telematics in return for earth work used excavator, dump truck, bulldozer, etc., indicate elements which should be considered for analysis of economic feature and propose improvement plan based upon suitable concept regarding the analysis model of economic feature among the existing researches.

2. Telematics

2.1 Definition of Telematics

Telematics is a composed word of Telecommunication and Informatics and variously defined, but in general it means consolidated service which combines GPS technology, wireless communication technology, system which enables user to have interactive communication, etc., and provides vehicle and driver with diverse information and service.[2]

Recently, Telematics is being brought into relief and mainly used in automobile industry thanks to the Ubiquitous, which is epochal paradigm and the development in wireless and mobile communication technology.

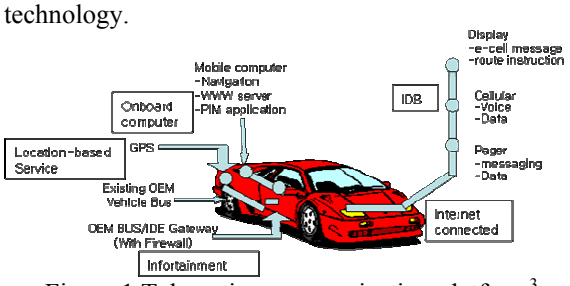

Figure 1 Telematics communication platform[3]

[1] Lee B.N, Woo S.K, A construction site facility labor reduction plan through a productivity enhance, Construction & Economy Research Institute of Korea, 2002.8

[2] Moon H.D, Trends and prospect of world Telematics market, ITFIND, 2003.12

[3] Moon H.D, The penetration strategy according to Telemetics market situation and characteristic, ITFIND

2.2 *Function and Using of Telematics*

The service provided by Telematics technology can be found via the feature of Telematics in automobile industry. Based on its use purpose, Telematics is classified as

1)Service related to traffic information, navigation and operation, etc.

2)Service related to safety, protection, diagnosis, troubleshooting, etc.

3)Service related to entertainment, private information, communication, etc.[4]

Telematics service provides the driver with dealing with car accident, theft, road information, living information, etc. at real-time and can provide tailored service for individual drivers using mobile communication technology and global positioning system by means of terminator installed in vehicle.

Service Type		Fucntions
Traffic Information	Road Service	Traffic information, Navigation,
	Management Service	Self-inspection, Checking reservation , Quality management
Safe, Self-Test,	Office Service	Internet connection, Mobile image meeting, private business conduct, etc.
	Emergency Service	Emergency connection, Medical service, emergency measure, etc.
	m-Commerce Service	Electronic commerce base on mobile network
	Extra Service	Burglary prevention, Remote Control
Entertainment	Delivery service	Information of delivered productivity, Stock management, Customer management
	Entertainment Service	Movies, On-line game, etc.

Table 1 Telematics service[5]

Moreover, it can check the status of major parts and inform repairman of accurate malfunctioning point and reason through the embedded computer.

	USA	W.Europe	Japan
Market characteristic	-Homogeneous market -Large land mass -Spotty wireless coverage -many network operators	-Multiple language -Multiple culture -Inter-country trip -Cell phone & SMS use	-Homogeneous market -Difficult navigation -Long-term ITS Vision -Packed-based cell phone
Focus	-Safety&security -Concierge -Content & LBS	-Safety&security -Mobility portals -Traffic/Routing /Navi	-Navigation -Real-time traffic info. -Mobilit/Travel/ POI
Platform approach	-Embedded solution -simple interface	-Embedded solution -simple interface -Mobile devices	-Navigation system -Coupled with phone adapter -New platforms emerging
Issues	-Driver distraction -Privacy protection	-Fragmented market -Language barriers	-What's next after navigation? -Carwings,G-book?

Table 2 Regional Telematics Difference[6]

Lately more and more local and overseas companies are using Telematics but its applicable method depends on countries. In Korea, there was a service which had similar concept to it through the linkage between communication company and automobile company in the past yet the actual service using the name of Telematics has been provided these days.

2.3 *Forecast of Telemaics*

Telematics is expected to have more features owing to the development in relevant technology. In particular, the rapid development in computer and communication technology and getting cheaper price might be considered as a factor which makes Telematics market active. Eventually, Telematics is expected to grow fast based on many domestic/international factors. Especially since Telematics has been designated as promising industry for next generation recently in Korea, not only aggressive research but also rapid development as to related technology are expected.

Computer H/W & peripherals	Mobile Communication	Multi media Tech.
Micro Processor	GSM, PDC, CDMA, TDMA	Digital Compaction (MPEG)
Memor(Flash)	2.5G/3G Cellular	DSP
CD/DVD	Digital Radio(DAB, DVB, DSR)	3D Acoustic
Speech Recognition	LAN	Display(LCD, HUD)
Speech Convertor	Ku/Ka Satellite	High Speed Data Bus
Access(xDSL, Cable, Wireless)	Bluetooth	Conditional Access
High Speed Internet	WAP/WML	Smart Card
Router		DVD/MP3 Playback

Table 3 Technologies related in Telematics[7]

3. Operation of Construction Equipment in Site

I planned to examine and analyze the process from work order to work completion in finding management problem in construction equipment at construction site. Generalized management process of construction equipment through the interview is as follows.

[4] Kim J.H, Telematics concept and market growth, Korean Information Strategy Development Institution IT FOCUS, 2001. 9

[5] Moon Y.C, Service and Technology in Telematics, Korea IBM, 2002

[6] Phil Magney, Telematics System & Architecture Trend, Telematics Research Group, 2003. 3

[7] Gartner Dataquest, 2000.12

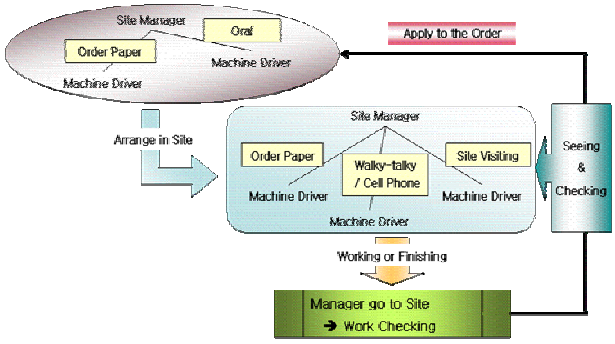

Figure 2 Construction equipment existing operation

It takes more than 1 hour a day on an average for site manager to move for the tasks related to construction equipment like work order, work confirmation, etc. and more than 2 hours to prepare for move and other works related to construction equipment out of entire work hours.

3.1 Characteristic of Construction Site

It is difficult to completely understand site situation because various process are conducted at various external spots in most of construction works. Particular, in case of public work site, the site manage should spend his/her major time moving because the area is broad and he/she must confirm works moving from places to places. This makes his/her time for other works decreased, incidentally provokes expense increase in fuel and maintenance and distracts the problem from being settled fast in case of long distance. In addition, site manager has difficulty in effectively getting information because the works are carried out at many places and this is limitary factor in systemic management of site information.

3.2 Characteristic of Construction Equipment

The space for operating construction equipment is narrow, the impact in using it is directly conveyed to operator's body and this can deteriorate work efficiency. Moreover, most of works are simple and iterative, working site is far from site office or it has the restriction although it is close and this can make the construction equipment operator feel isolated in case of log-term work. Unlike common worker, construction equipment operator is required to do additional process like equipment warming-up, supply to fuel, oil replacement, grease infusion, etc. for maintenance and he/she should check various things while operating devices as a construction equipment operator. This needs additional time than common worker.

3.3 Complex Characteristic

Complex feature of site and equipment related to the management of construction equipment has influence on transmission/modification of work, process status, confirmation of result, etc.

Task	Task Contents	processing method
task ordering	Work scope delivering Changed scope delivering	Tranmit directly (face to face) Using of walkie-talkie or cell phone
task confirming	Work progress checking Work completion checking	Using of walkie-talkie or cell phone Confirming directly (by naked eye)
outbreak dealing	Problem solving (Demend decision of the site manager)	Using of walkie-talkie or cell phone Confirming directly (by naked eye)

Table 4 Work related on construction equipment

In case of face to face meeting for work performance or using communication means like handie talkie, mobile, etc. he/she must stop working due to noise from equipment or restriction in operating it. This means the reduction in working hours and can affect productivity.

3.4 Analysis of Earth-work

Earth works is a general term for work which is dealing with soil such as excavation, load, conveyance, heaping, etc. in construction works and fundamental process in most of construction.

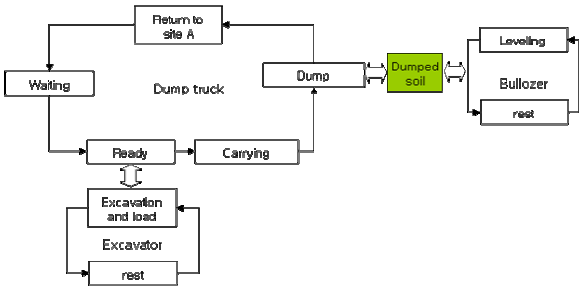

Figure 3 Earth work flow

Thus, price reduction in work can also influence on overall works through productivity improvement in earth works. Equipment related to earth works can be selected considering the rule of equipment combination along with workload, conveyance distance in carrying soil, road status, etc.
In this study, I intend to search for applicable field for Telematics and apply it based on works like excavation by shovel, loading soil, conveying soil by truck, leveling process using bulldogger, etc.

4. Application of Telematics in Site

The work that Telematics can be applied at construction site is a process which can reflect the feature of Telematics, and GPS technology, image/voice data, sensing technology, etc. are applicable, and it can be applied to earth works.

4.1 Using of GPS

In earth works, since dump truck secedes from site and moves for soil delivery, shovel which loads soil and bulldogger which level soil are likely to stop doing process unless the truck reaches working place. It is difficult to find its location while dump truck in the process of move. However in case of GPS installation, it is easy to find the location of truck and this enables user to effectively know control of work speed, addition to further equipment, etc. In case of GPS installation in shovel and bulldogger, it ensures more convenient work process management via the analysis of working pattern of equipment.
In addition, surveying process can be minimized in existing works because leveling status can be known in leveling works through application of GPS technology.

4.2 Using of Various Data

Currently, site order can be classified, which is site manager delivers process order document before the commencement of works and oral order by face to face meeting. Site manger and construction equipment operator should spend more time than common worker for process order because process order must be completed before starting works. According to the information from interview, construction equipment operator spends approximately 30 minutes more than common workers to reach the site and receive works and site manager spends more than 1 hour to be ready for work and move for process order.
In case Telematics is applied, site manager can order works by transferring various data like image, voice, character, etc., which are suitable for each process at site office. It is expected that site manager can reduce move, operator can receive correct process order. In case of problem in works, manager must consume more than 30 minutes to visit site, on the other hand, in case Telematics is applied, site status can be monitored via installed camera in equipment and relevant settlement can be transmitted in many ways.

4.3 Using of Sensing Technology

Construction equipment is required to be continuously managed for effective works. Additional process is needed like warming-up, fuel check, diverse oil check, grease infusion, making management document, etc. On the whole, the construction equipment operator is conducting these process using before/after work, lunchtime, etc. and it takes 1/2~1 hour for them. In comparison with common worker under application of work commencement/completion, decisively it means decrease in working hours or break as compared with common worker because the construction equipment operator should use time except for working hours like break. If Telematics is applied, warming-up using remote control is available via sensing technology and embedded computer in equipment, the equipment itself notifies problem in case of problem after automatic fuel and oil check and can do basic settlement. Equipment check card and history card are handled as a electronic document and pertinent matters can be solved by minimizing construction equipment operator's concern. This is expected to save time for work preparation and equipment maintenance.

4.4 Using of Others

It is hard for construction equipment operator to leave site and handle private things like common worker. In case of using internet connection service provided by Telematics, he/she is forecasted to deal with his/her personal business. If he/she use the existing communication means, he/she should stop working due to its inconvenient operation, on the contrary in case of using voice communication feature of Telematics, he/she is expected to effectively use his/her working hours by minimizing its influence due to communication.
Conclusively, the improvement in productivity and minimization of operation time for equipment will be able to be realized via the application of Telematics through the improvement in working environment for construction equipment operator. At the same time, information created during work process automatically is converted into DB and effective productivity management will be able to come true together with information management through linkage with legacy systems PMIS, KMS in the future.

Before Telematics introduction	After Telematics introduction
A movement and explanation time requirement for the task instruction	The alternate to the transmission of a relation information
The limit for the task explanation of means	Using the various data (voice, video, etc.)
A movement time requirement for the task checking	The monitoring in the spot office

Table 5 The expectation effectiveness(Site manager)

Before Telematics introduction	After Telematics introduction
A time need the maintenance and management the construction equipment	The minimize through the practical use of a sensing technique of the task
Restricted task information transmit	Using the various and efficient data
Efficient utility of a task hour difficulty	Efficient task environment supply
The limit due to a equipment control of the understanding	Smooth understanding supply

Table 6 The expectation effectiveness (Equipment operator)

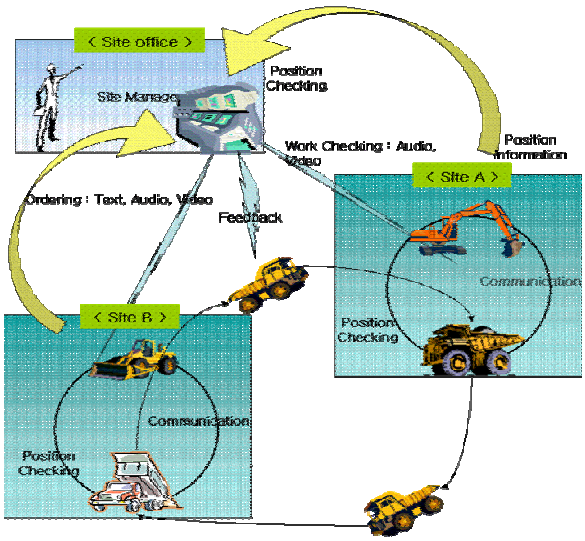

Figure 4. Telematics applied earth work

5. Consideration for Feasibility Analysis of Teleamtics

5.1 Consideration for Feasibility Analysis

The factors which must be considered to improve economic feature in applying Telematics are initial investment cost for system implementation, labor cost reduction owing to system implementation, anticipated cost for productivity improvement due to increased working hours.
Anticipated cost may be vary from what surplus time will be converted into work among the uncertain considered factors for the analysis of economic feature, thus it is difficult to measure the cost correctly because it has not been applied. I deem this problem should be resolved through the constant study in the future.

	Append elements	Utility purpose	note
Construction Equipment	Wireless camera	Site checking	Escaping & sticking /fix cost
	DGPS transmitter & receiver	Equipment position checking Amount of work checking	Escaping & sticking /fix cost
	Terminal unit	-Visualization of work	Escaping & sticking /fix cost
	Modem	Data transmitting and receiving	Escaping & sticking /fix cost
	Sensors	Amount of work sensing Eequipment condition checking	Fix /fix cost
	Input&output equipments	Data input & output	Escaping & sticking /fix cost
Site Office	DB Server	Site DB saving	Fix /fix cost
	Modem	Data transmitting and receiving	Escaping & sticking /fix cost
	System operating software	System operating	Fix cost
	Equipment management program	Equipment management	Fix cost
others	System manager	System management & operating	Labor cost /regular cost
	Cost of communication & data using	Communication line using	Regular cost
	Installation cost	Equipments installation	Fix cost

Table 7 Clear consideration for economical analysis

the charge computation is possible	Foreman cost	The minimize of role of equipment foreman through the central management of equipment
	Assistance cost	The minimize of role of equipment assistance through the equipment management system
	Surveying cost	A charge degrade from the automation and minimize of the survey
	Visiting cost	A vehicle carrying and fuel cost reduction through minimizing of the number to visit the site directly.
the charge computation is impossible	Expectation cost	The expectation cost which minimize of the site visiting and switching other work
	Reduction of equipment management time	The expectation charge from the enlargement of a main task time through the minimize of an equipment officer hour
	Work time increasing	The expectation charge from the enlargement of the task time

Table 8 Vague consideration for economical analysis

5.2 Feasibility Forecasting Model

In order that the application of Telematics to construction site may carry conviction, its economic feasibility should be proved. To analyze economic feature of Teleamtics application, we should prove whether reduction effect cost gained via system introduction within applicable period for application model is bigger than cost invested for model configuration. In this study, I would like to propose analysis model of economic feature which is suitable for Telematics as a reflective model among existing analysis models of economic feature based on economic feasibility analysis model concerning existing Hume pipe laying automation device. [8] Because I consider this is a device for productivity improvement, connects existing equipment with additional equipment, minimizes other processing time and it is similar to the concept of this research. Economic feasibility analysis model regarding Hume pipe laying automation device is as follows.

[8] Kim K.T, Han J.G, Lee J.B, Han C.H, Development of an Economic Feasibility Forecasting Model for Introducing Teleoperated Pipe Manipulator, Architectural Institute of Korea vol 22, 2002. 10

$$I \le \frac{L \times C \times D - (M + O + S)}{1 + i} + \frac{L \times C \times D \times (1 + j) - (M + O + S) \times (1 + \alpha)}{(1 + i)^2} + \cdots\cdots + \frac{L \times C \times D \times (1 + j)^{n-1} - (M + O + S) \times (1 + \alpha)^{n-1}}{(1 + i)^n} = \sum_{k=0}^{n} \frac{L \times C \times D \times (1 + j)^{k-1} - (M + O + S) \times (1 + \alpha)^{k-1}}{(1 + i)^k} = \frac{L \times C \times D}{i - j}\left[1 - \left(\frac{1 + j}{1 + i}\right)^n\right] - \frac{(M + O + S)}{i - \alpha}\left[1 - \left(\frac{1 + \alpha}{1 + i}\right)^n\right] \quad (1)$$

Here is,
I : Initial investment cost for pipe laying automation device
L : Decreased labors to use automation device
C : Labor cost per man
D : No. of work-days per year
M : Maintenance cost of automation device
O : Operation cost of automation device
S : Moving and others cost
i : Interest rate j : Labor cost increase rate
α : Inflation per year
n : Fixed period of automation device

In applying equation(1) to this concept of Telematics, the factor which must be additionally considered is the generated opportunity cost when needed time for existing additional process is converted into other process in case of applying Telematics to construction equipment. The following result can be shown in case of applying this to equation (1)

$$I \le \frac{(L \times C_1 \times D + T \times C_2)}{i - j}\left[1 - \left(\frac{1 + j}{1 + i}\right)^n\right] - \frac{(M + O + S)}{i - \alpha}\left[1 - \left(\frac{1 + \alpha}{1 + i}\right)^n\right] \quad (2)$$

Here is,
I : Initial investment cost for Telematics
L : Decreased labors to use of Telematics
C_1 : Labor cost per man
T : Time of Conversion from original works to other works per day
C_2 : Expectation cost per hour
D : No. of work-days equipments applied Telematics per year
M : Maintenance cost of equipments applied Telematics
O : Operation cost of equipments applied Telematics
S : Moving and others cost
i : Interest rate j : Labor cost increase rate
α : Inflation per year
n : Fixed period of equipments applied Telematics

6. Conclusions and Future Studies

In case of applying Telematics system to construction site, site manager can manage time effectively and overall improvement in productivity is expected to be realized. Moreover, construction equipment operator is forecasted to improve working efficiency and entire productivity based on the improvement in working environment.
In this study, I intended to consider factors in applying Telematics system to the site and examine feasibility analysis model by summarizing the necessary factor in considering economic feature via previous interview with construction site manager and worker.
In case of applying Telematics to the site, site manager is expected to perform confirmation/order of work effectively, reduce the time in moving to the site and shift into other works. At the same time construction equipment operator is forecasted to minimize maintenance of construction equipment, reduce unnecessary time for actual work and use his/her time effectively through overall improvement in working environment.
At the next step, the feasibility consideration in applying Telematics is required in case of applying proposed economic feature model to the site in this study.

Acknowledgement

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