BENEFITS OF MOBILE TELEPHONES FOR CONSTRUCTION CONTRACTORS IN THE UNITED KINGDOM

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Mobile telephones have been widely used for communication purposes over the last ten to fifteen years. The construction industry is increasingly using mobile telephones in the day to day execution of construction projects. To date, there is little information in the public domain about the contribution mobile telephones make to project performance. This paper presents findings from research undertaken to quantify the benefits of mobile telephones to construction contractors in the United Kingdom. The research employed a case study research strategy. The case was a large construction contractor (annual turnover in excess of £350m) whose portfolio of work was divided into four main sectors: utility services, highway services, rail services and infrastructure services. Data about mobile telephone call events were carefully collected from inside informants using a survey sheet. The data comprised of three dependent variables: duration of telephone call, cost implications and time implications; and two independent variables: sector and source/destination of call. The data were analysed following standard analysis of variance procedures. The results showed that even though there were variations from sector to sector and source/destination to source/destination, it could generally be said that mobile telephones were of great benefit to the construction contractor (for example the estimated cost saving associated with mobile telephones was over £4,000 per person per week). Although this study was based on one contractor, it is argued that the results provide a good insight into the benefits of mobile telephones for construction contractors in the United Kingdom.

Keywords: communication, contractor, mobile telephone, performance.

INTRODUCTION

The UK has seen tremendous growth of the mobile telephone industry over the last ten to fifteen years leading to increased availability and use of portable mobile telephones in every day life. In 1995 there were 4.5 million mobile telephones in the United Kingdom; in 2000 this had increased to 25 million. With better network coverage, cheaper rental costs, advancing technology and better usability, the mobile telephone industry in 2005 had in the region of 50 million mobile telephones and 40,000 base stations in operation in the United Kingdom (NRPB 2004). The issuing of mobile telephones to employees in the construction industry has become common over the last few years and this has added another cost to the annual budget of every construction company.

The advancement of mobile telephone technology seems to have influenced changes in management styles too. Management styles have changed as reliability on the mobile telephone has affected some of the basic management skills that once involved better planning and more face-to-face communication between stakeholders.

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Increasingly less time is allowed for planning at the start of construction projects and decisions are being made reactively, for example, less thought is being put into material requirements as quantities can be easily changed by one phone call. Some have said that the mobile telephone has removed individual's power of decision making in that it is easier now to ring one's manager than thinking for oneself (personal communication, April 27, 2006).

In light of the above, it is worthwhile addressing the question: How does the use of the mobile telephones affect the implementation of a construction contract? Standard forms of construction contracts have provision for communications to be made for example the ICE Form of Contract Clause 2 (8) (a) requires written instructions to be given by the Engineer or anyone who has been given delegated duties (ICE 1999) . Clause 2 (8) (b) (ICE 1999) allows for oral instructions to be given but demands that such oral instructions to be confirmed in writing as soon as possible. Increasingly, oral instructions are now made by mobile telephone to the contractor who in turn can immediately instruct the sub-contractor to carry out the required task. This process can take a matter of minutes from conception to action while no piece of paper has been exchanged between the contracted parties. This practice tends to go on day after day and the oral instruction is rarely confirmed in writing. This practice can cause extensive problems when the contractor claims for extra money, extension of time or something goes wrong with the new design as there is no paperwork in place as suggested by the contract. This also means that there are no contemporary records kept to refer to for back up information or when dissecting the contract at completion for lessons learnt for future use.

The extent to which mobile telephones are used in the construction industry can be illustrated by the information from the construction company used as a case study in this research. In the interest of anonymity, the company will be referred to as Construction Contractor A (CCA). CCA is a public limited company with an annual turnover in excess of £350m and an average profit margin of 3%. In July 2006, CCA employed 3,200 staff directly and had, in circulation, in the region of 3000 mobile telephones which accounted for an annual bill estimated at £1.2m per year (personal communication, July 24, 2006). This suggests that the company has to complete roughly £40 million worth of work to cover the cost of mobile telephones alone. This equates to about 11% of the company's overall turnover for the year.

Research problem

Some of CCA's senior managers were adamant that the expenditure on mobile telephones in the organization had reached a critical level (personal communication, July 24, 2006). They were pretty sure too that CCA is not alone in this. They believed that many other organizations were facing similar issues. While there may be courses of action to reduce the bill, it was felt that any such reduction should not diminish the need to quantify the benefits that accrue from the use of mobile telephones. Therefore, at least as far as CCA was concerned, it was necessary to quantify the benefits in order to establish whether the cost of mobile telephones was justified. It was felt that this could be done by obtaining and analysing data about mobile telephone call events over a period of time. The main variables considered were: duration, cost implications, time implications, source/destination and company sector involved.

RESEARCH DESIGN

Kervin (1992) provides an excellent framework within which research issues can be addressed. In this framework, research design involves selection of cases, variables and data sources. This framework was employed to develop a plan for gathering data. A summary of this exercise is provided in Tables 1, 2 and 3 below.

Table 1: Selection of cases

Aspect		Choice	Justification
Selection of cases	Unit of analysis	Event – the event was a telephone call made or received by the participants during the study period.	Event characteristics would provide data relating to things like: what the mobile telephones were being used for, to whom the calls were made and duration of calls – all these were important variable that would enable the quantification of benefits to be made.
	Basic design	Non-experimental	The nature of the research problem did not necessitate an experimental design; There were no manipulable independent variables; and There was no comparison group.
	Specific design	Four sub-samples were drawn for the study.	CCA's relevant business was divided into four sectors: Highway Services, Infrastructure Services, Rail Services and Utility Services. It was felt that it was worthwhile to design the research in such a way that any differences between the sectors would be identified.
		The study was cross-sectional	The nature of the problem did not necessitate a repeated-measure design.
	Sample design	A sample was drawn.	The population of events (mobile telephone calls made/received during the construction project) was too large – sampling was the only option.
		The non-probability sample was drawn.	It was not possible to draw a probability sample.
		A large sample, from diverse sectors and individuals within CCA was drawn.	It was important that the sample was as representative as possible

Table 2: Selection of variables

Aspect	Choice	Justification
Selection of variables	Company sector Source/destination Reason Direction Duration Cost implication Time implication	These are important features of the mobile telephone call events that would enable the researcher to quantify the benefits of mobile telephones for the construction contractor.

Table 3: Selection of data sources

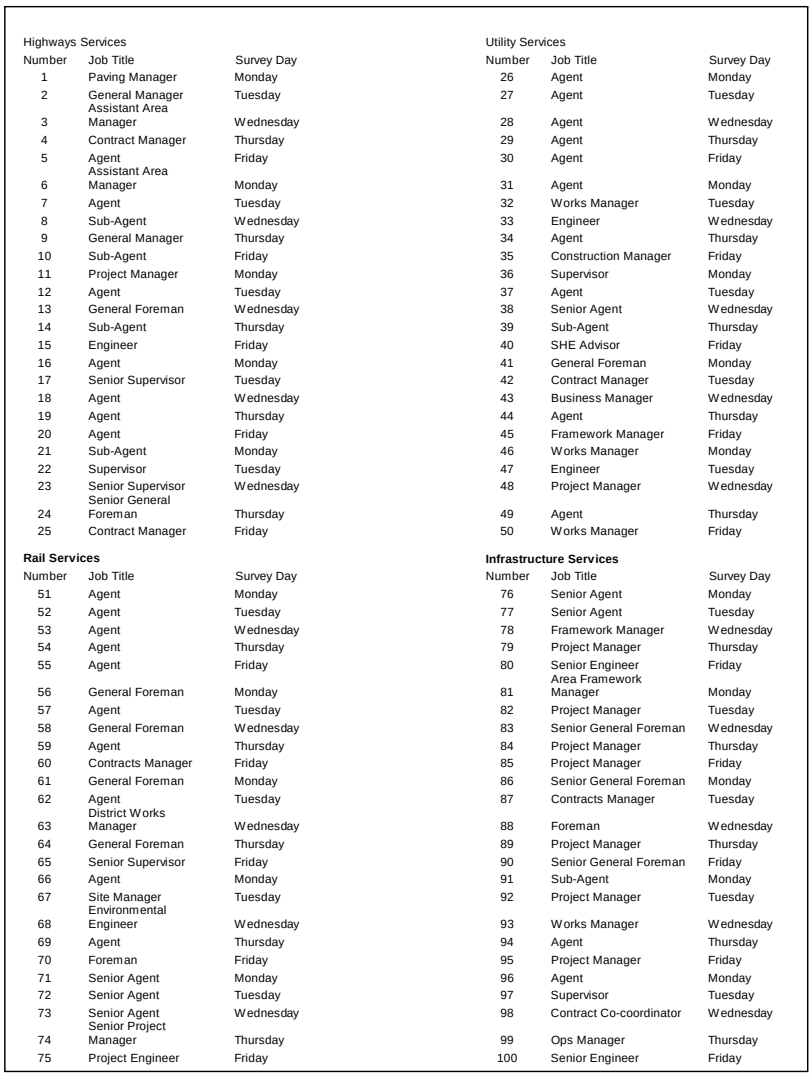
Aspect	Choice	Justification
Selection of data sources	Inside informants – these were professionals in supervisory/managerial positions within the sectors of CCA who were involved in the day-to-day implementation of projects.	With the unit of analysis being the mobile telephone call event, the people best placed to provide the data about the events were those involved directly in the events.

DATA COLLECTION

As indicated in Table 3 above, data about mobile telephone call events were obtained from people who were involved in the calls. The data were collected during a period of three normal and convenient working weeks – each participant would log event details occurring in one complete workday.

Random samples of 25 supervisors/managers from each of the four sectors were drawn. Contact details (e-mail address and mobile telephone number) were obtained from CCA's internal directory. Each individual was assigned a day (Monday, Tuesday, Wednesday, Thursday or Friday) on which they were required to log all their mobile telephone call details. Each individual was asked to identify a convenient day over the three week period (i.e. if one was allocated a Monday, they could choose any one of the three Mondays and log details of mobile telephone calls on this chosen Monday, and so on). This procedure ensured that the resulting data set could be considered to cover the equivalent of a typical working week (Monday – Friday) with minimum inconvenience to the respondents. Because the time period was quite short compared to typical project durations, there was no staff movement (from project to project) which helped to obtain consistent data. At the end of this day-allocation exercise, there were 20 people (5 from each sector) expected to log call details on each day. Figure 1 below summarizes the results of the day-allocation exercise. Figure 1 shows that the targeted participants comprised of a wide variety of supervisory or management professions on a typical construction site.

Each of the targeted individuals was contacted, requested to participate in the survey and provided with the survey form and survey instructions. It was important that the participants were clear and confident that they knew exactly what information was required of them. In order to reach this level of understanding, a Survey Explanation Sheet (SES) was sent to each participant. The SES illustrated what information was appropriate and the type of information that would have been inappropriate or unwanted and unnecessary for the purposes of the research. All this communication occurred via e-mail. It was considered necessary to track the progress of the communication, so delivery and read receipts were requested when the e-mails were sent.



Highways Services

Number	Job Title	Survey Day
1	Paving Manager	Monday
2	General Manager	Tuesday
3	Assistant Area Manager	Wednesday
4	Contract Manager	Thursday
5	Agent	Friday
6	Assistant Area Manager	Monday
7	Agent	Tuesday
8	Sub-Agent	Wednesday
9	General Manager	Thursday
10	Sub-Agent	Friday
11	Project Manager	Monday
12	Agent	Tuesday
13	General Foreman	Wednesday
14	Sub-Agent	Thursday
15	Engineer	Friday
16	Agent	Monday
17	Senior Supervisor	Tuesday
18	Agent	Wednesday
19	Agent	Thursday
20	Agent	Friday
21	Sub-Agent	Monday
22	Supervisor	Tuesday
23	Senior Supervisor	Wednesday
24	Senior General Foreman	Thursday
25	Contract Manager	Friday

Utility Services

Number	Job Title	Survey Day
26	Agent	Monday
27	Agent	Tuesday
28	Agent	Wednesday
29	Agent	Thursday
30	Agent	Friday
31	Agent	Monday
32	Works Manager	Tuesday
33	Engineer	Wednesday
34	Agent	Thursday
35	Construction Manager	Friday
36	Supervisor	Monday
37	Agent	Tuesday
38	Senior Agent	Wednesday
39	Sub-Agent	Thursday
40	SHE Advisor	Friday
41	General Foreman	Monday
42	Contract Manager	Tuesday
43	Business Manager	Wednesday
44	Agent	Thursday
45	Framework Manager	Friday
46	Works Manager	Monday
47	Engineer	Tuesday
48	Project Manager	Wednesday
49	Agent	Thursday
50	Works Manager	Friday

Rail Services

Number	Job Title	Survey Day
51	Agent	Monday
52	Agent	Tuesday
53	Agent	Wednesday
54	Agent	Thursday
55	Agent	Friday
56	General Foreman	Monday
57	Agent	Tuesday
58	General Foreman	Wednesday
59	Agent	Thursday
60	Contracts Manager	Friday
61	General Foreman	Monday
62	Agent	Tuesday
63	District Works Manager	Wednesday
64	General Foreman	Thursday
65	Senior Supervisor	Friday
66	Agent	Monday
67	Site Manager	Tuesday
68	Environmental Engineer	Wednesday
69	Agent	Thursday
70	Foreman	Friday
71	Senior Agent	Monday
72	Senior Agent	Tuesday
73	Senior Agent	Wednesday
74	Senior Project Manager	Thursday
75	Project Engineer	Friday

Infrastructure Services

Number	Job Title	Survey Day
76	Senior Agent	Monday
77	Senior Agent	Tuesday
78	Framework Manager	Wednesday
79	Project Manager	Thursday
80	Senior Engineer	Friday
81	Area Framework Manager	Monday
82	Project Manager	Tuesday
83	Senior General Foreman	Wednesday
84	Project Manager	Thursday
85	Project Manager	Friday
86	Senior General Foreman	Monday
87	Contracts Manager	Tuesday
88	Foreman	Wednesday
89	Project Manager	Thursday
90	Senior General Foreman	Friday
91	Sub-Agent	Monday
92	Project Manager	Tuesday
93	Works Manager	Wednesday
94	Agent	Thursday
95	Project Manager	Friday
96	Agent	Monday
97	Supervisor	Tuesday
98	Contract Co-coordinator	Wednesday
99	Ops Manager	Thursday
100	Senior Engineer	Friday

Figure 1: Results of day- allocation exercise

DATA ANALYSIS

Of the original 100 respondents targeted, 74 returned their survey forms and all together 415 (200 in-coming and 215 out-going) telephone call events were recorded. Tables 4, 5, 6, 7, 8 and 9 below provide a summary of the data received.

Table 4: Data from the rail sector

Day	**No. of respond-ents**	**No. of calls recd**	**No. of calls made**	**Total Duration of calls (mins)**	**Source/ Destination***					**Cost implications**		**Time implications**	
					1	**2**	**3**	**4**	**5**	**Money saved (£)**	**Money lost (£)**	**Time saved (hrs)**	**Time lost (hrs)**
Mon	2	5	4	30	3	5			1	10000		38	
Tues	3	10	8	29	5	9	1	2	1		1500		9
Wed	3	3	5	43	3	5				5500			18
Thu	4	7	9	82	3	8		2	3				
Frid	3	3	4	54		4			3	200	1250		9
Total	15	28	30	238	14	31	1	4	8	15700	2750	38	36

Table 5: Data from the utilities sector

Day	Number of respondents	Number of calls received	Number of calls Made	Total Duration of calls (minutes)	Source/Destination*					Cost implications		Time implications	
					1	2	3	4	5	Money saved (£)	Money lost (£)	Time saved (hrs)	Time lost (hrs)
Mon	3	12	9	108	5	15			1	36500	7400		
Tues	4	17	29	211	18	20	7	1		18300	3000	45	11
Wed	5	16	15	198	7	18	3		3	133250	1680	132	27
Thu	5	11	18	118	4	19	1		5	45440	2519.2	181	9
Fri	3	11	4	61	5	6			4			12	9
Total	20	67	75	696	39	78	11	1	13	233490	14599	370	56

Table 6: Data from the highways sector

Day	Number of respondents	Number of calls received	Number of calls Made	Total Duration of calls (minutes)	Source/Destination*					Cost implications		Time implications	
					1	2	3	4	5	Money saved (£)	Money lost (£)	Time saved (hrs)	Time lost (hrs)
Mon	5	11	14	113	7	8	3		7	3900		10	7
Tues	4	9	7	57	2	12	2			25000	2000		7
Wed	4	6	6	46	1	11				38000	200		5
Thu	3	6	3	25	5	4						18	
Fri	3	13	7	113.5	3	15			2	1275	400		2.75
Total	19	45	37	354.5	18	50	5	0	9	68175	2600	28	21.8

Table 7: Data from the infrastructure sector

Day	Number of respondents	Number of calls received	Number of calls Made	Total Duration of calls (minutes)	Source/Destination*					Cost implications		Time implications	
					1	2	3	4	5	Money saved (£)	Money lost (£)	Time saved (hrs)	Time lost (hrs)
Mon	4	8	12	107	1	11	3		5	6000	1336	35	
Tues	5	21	29	253	5	33	4	4	4	31250	11244	293	10
Wed	4	11	16	165	7	10	9		1	58500	59100	132	261
Thu	4	13	11	132	2	16	1	1	4	32400		192	45
Fri	3	7	5	69	3	4	3		2		5000	127	45
Total	20	60	73	726	18	74	20	5	16	128150	76680	779	361

*1 = client; 2 = staff: head office, project office or subcontractors; 3 = supplier; 4 = designer; and 5 = other.

Table 8: Descriptive statistics (categorized by sector)

Sector	Mean duration of calls (minutes)	Mean of money saved (£)	Mean of money lost (£)	Mean of time saved (hours)	Mean of time lost (hours)
Rail (N=58)	4.10	270.69	47.41	0.66	0.62
Utilities (N=142)	4.90	1644.30	102.81	2.61	0.40
Highways (N=82)	4.32	831.40	31.71	0.34	0.27
Infrastructure (N=133)	5.46	963.53	576.54	5.86	2.71
Total (N=415)	4.85	1073.53	232.84	2.93	1.14

Table 9: Descriptive statistics (categorized by source/destination)

Source/destination of call	Mean duration of calls(minutes)	Mean of money saved (£)	Mean of money lost (£)	Mean of time saved (hours)	Mean of time lost (hours)
Client (N=89)	5.61	1297.47	201.12	2.88	1.00
Staff (N=233)	4.48	1074.85	84.90	2.56	1.31
Supplier (N=37)	4.32	1186.49	1533.24	3.00	0.81
Designer (N=10)	9.00	2900.00	0.00	3.20	4.50
Other (N=46)	4.82	145.65	48.20	4.70	0.13
Total (N=415)	4.85	1073.53	232.84	2.93	1.14

It was important to establish whether the data (for each variable) were parametric or non-parametric. On carrying out the standard normality test (Coleman and Pulford 2006; and Norusis 2005), it was established that the data were non-parametric. Therefore, any tests to determine whether there were differences between groups would have to be non-parametric tests (Coleman and Pulford 2006; and Kinnear and Gray 2006).

To determine if there were differences between the four sectors, a series of Kruskal Wallis tests (Coleman and Pulford 2006; and Kinnear and Gray 2006) were run. The results showed that there were no differences between the sectors as far as 'money saved', 'money lost' and 'time lost'. However there were differences between the sectors as far as 'duration of call' and 'time saved' were concerned. Using the Mann-Whitney U test (Coleman and Pulford 2006; and Kinnear and Gray 2006), it was established that the differences existed as follows:

- For 'duration of call', the pairs of sectors that were different were: rail and infrastructure; and highways and infrastructure.
- For 'time saved', the pairs of sectors that were different were: rail and infrastructure; and highways and infrastructure.

To determine if there were differences between the source/destination categories, a procedure similar to that described in the preceding paragraph was implemented. The results showed that there were no differences between the source/destination categories as far as 'duration of call', 'time saved' and 'time lost' were concerned. However, there were differences between the sectors as far as 'money saved' and 'money lost' were concerned. Using the Mann-Whitney U test (Coleman and Pulford 2006; and Kinnear and Gray 2006), it was established that the differences existed as follows:

- For 'money saved', the pairs of sectors that were different were: designer and staff; and designer and other.
- For 'money lost', the pairs of sectors that were different were: supplier and client and; and supplier and staff.

DISCUSSION

Duration of calls

The average duration across all sectors was 4.85 minutes. While calls to and from the rail, highways and utilities sectors had similar average durations, the duration of calls to and from the rail and highways sectors were significantly shorter than those to and from the infrastructure sector. From the authors' experience (Parcell 2006), the differences may be explained as follows. Rail, highways and utilities schemes involve intensive upfront planning which leads to a good state of readiness and minimizes the

need to communicate whilst on site. For example, the rail sector on the whole has very strict health and safety rules and strict procedures to be followed so there is a huge amount of pre-planning prior to even the smallest of jobs. There is generally very little a manager can do on the day of the job in the rail sector if something has not been planned properly unlike in the infrastructure sector where making a few phone calls can often get over issues and allow the work on site to continue. If a problem arises on a railway scheme, the work generally stops and requires pre-planning for another day. Another possible explanation for the higher durations in the infrastructure sector may be obtained by scrutinizing the direction of the calls. The infrastructure sector has a higher ratio of calls to staff (which include subcontractors, head office, direct employees) and also to suppliers - this suggests that changes were being made while on site and this may have been necessary because of a lower level of planning.

When the duration of calls was analysed for differences between the five source/destination groups, no significant differences were identified. This suggests that calls to and from any of the source/destination categories have, generally, similar durations.

Cost implications

As can be seen from Tables 4, 5, 6 and 7, cost implications were investigated in terms of 'money saved' and 'money lost'. Respondents were asked to provide an estimate of what they felt were consequences of each call in terms of money lost and/or money saved.

The average estimated amount of 'money saved' per call was £1073.65. When 'money saved' was analysed for differences between the four sectors, no significant differences were identified. This suggests that the estimated 'money saved' was independent of the sector – all sectors benefit equally from the use of mobile telephones. When 'money saved' was analysed for differences between the five source/destination groups, significant differences were identified between staff and other; and staff and designer. The difference can be explained as follows. The category for 'other' could include anyone other than the identified four categories such as a statutory undertaker like Transco for example. From the survey sheets, it was clear that savings tended to be from external participants like land owners for instance. The designer has far more control over the project than any external participant and therefore can make decisions that would make radical cost savings – hence the results obtained. The data results also suggest higher cost savings from calls to and from the designer than from calls to and from staff. This difference can be explained as follows. The designer has far more control over the project with regards to cost saving, although the staff can make decisions on certain criteria, if it is a major change to the original design then the designer has the final say.

The average estimated amount of 'money lost' was £232.84. When 'money lost' was analysed for differences between the four sectors, no significant differences were identified. This suggests that the estimated 'money lost' was independent of the sector – all sectors benefit equally from the use of mobile telephones. When 'money lost' was analysed for differences between the five source/destination groups, significant differences were identified between supplier and other, supplier and staff and supplier and client. This difference can be explained as follows. It can be seen from Table 9 above that the estimated money lost was far higher when the calls were to or from the supplier. The survey sheets showed that the majority of the calls were

to, rather than from, the supplier. It may therefore be that they were calls to cancel supplies (and because of rigid terms of sale could not achieve significant cost reductions) or enquire about delays in delivery (which would be confirmed and lead to productivity losses).

When the 'money lost' and 'money saved' are taken together, the average is a net average saving of £ (1073.65 – 232.84) = £ 840.81. When this figure is used to compute the cost saving per respondent, it can be seen that the average net cost saving per respondent per week is: £ ((840.81 × 415) ÷74) = £4715.35 per respondent per week. It is the authors' contention that this figure shows the tremendous cost saving that mobile telephones provide to CCA.

Time implications

As can be seen from Tables 4, 5, 6 and 7, time implications were investigated in terms of 'time saved' and 'time lost'. Respondents were asked to provide an estimate of what they felt were consequences of each call in terms of time lost and/or time saved.

The average 'time lost' was 1.14 hours. When 'time lost' was analysed for differences between the four sectors, no significant differences were identified. A similar result was obtained when the analysis was done for differences between the source/destination categories. This suggests that the estimated 'time lost' was independent of the sector and source/destination – all groups suffer equally from the use of mobile telephones.

The average 'time saved' was 2.93 hours. When 'time saved' was analysed for differences between the four sectors, no significant differences were identified. This suggests that the estimated 'time saved' was independent of the sector – all sectors benefit equally from the use of mobile telephones. When 'time saved' was analysed for differences between the four sectors, significant differences were identified between the rail sector and the infrastructure sector as well as between the highways sector and the infrastructure sector. The explanation for these differences is similar to that provided to explain difference in average durations among the sectors. The differences come about because of more emphasis on pre-planning works in the rail and highways sector with very little room to adjust programmes of work due to the licenses and approvals required as opposed to the infrastructure sector which is more flexible and therefore presents opportunities for saving time.

CONCLUSIONS

The aim of this study was to try to quantify the benefits of mobile telephones in the construction industry. In the case study, it was established that the mobile telephone bill stands at £1.2m. The monetary saving was estimated at over £4000 per person per week. It only takes about 300 people to use mobile telephones over a period of one week (or its equivalent) on normal/typical construction projects to recoup the annual mobile telephone bill. Given the 3000 strong workforce of CCA with mobile telephones, this point of equilibrium is not difficult to achieve. In all probability, it will indeed be exceeded. Furthermore, mobile telephones provided a net time saving across all the telephone events considered. Therefore, for CCA, mobile telephones are of real benefit.

Although this work was undertaken using the case study of CCA, experience (Parcell 2006) suggests that similar issues are faced by other medium to large construction

contractors throughout the UK. The results can therefore, provide useful insight into the industry as a whole.

LESSONS FOR CCA AND THE CONSTRUCTION INDUSTRY IN GENERAL

So what lessons should CCA and the rest of the construction industry learn from this piece of work? In the authors' opinion, this work has shown that mobile telephones provide significant benefits for CCA. The results suggest that, typically, mobile telephones provide cost savings of more than £4000 per person per week. Not withstanding any criticisms about the research design and methods used, this value can be taken as a good estimate of the net monetary benefit.

The data has also shown that in general the four sectors in which CCA's work is organized perform very similarly to one another. Therefore, for CCA; there should be no differences between the sectors when allocating the mobile telephone budget as equal benefit seems to be the case.

From the data and analysis results, advance planning seems to provide the greatest positive impact on both time and cost. It is therefore suggested that improving project planning will reduce the duration and cost of mobile telephone calls.

This research has shown that when mobile telephones are used for business calls only, they are of great benefit. This work does not take into account the possible use of mobile telephones for non-business communication. It may be worthwhile to spend some resources to monitor mobile telephone calls more closely as this could have a significant affect on the annual mobile telephone bill and increase the value of the mobile telephone.

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