Information systems case study

Education

Difficulties arising from dysfunctional information systems in manufacturing SMEs ± case studies J. G. Thoburn Coventry University, UK S. Arunachalam Coventry University, UK A. Gunasekaran University of Massachusetts, North Dartmouth, Massachusetts, USA Keywords Information systems, Agile production, Small-to-medium-sized enterprises Introduction Today, manufacturing organisations are increasingly required to be highly optimised.

Abstract The ability to respond swiftly and effectively The necessity of maintaining optito produce new products and services has mal operations and becoming an agile and responsive enterprise is become not so much a method of gaining competitive advantage, but more a means of becoming increasingly important to survive in the global market. survival. Many companies have seen the need Consequently, all resources in the to adopt a whole range of practices that reduce companies need to be effectively inputs and waste, and allow greater responmarshalled.

Traditionally SMEs siveness to customer needs and the markethave concentrated on the 4Ms ±money, materials, machine and place. In reaction to changing requirements manpower but have often neand conditions, manufacturing paradigms glected the effective management continue to be defined. It is possible to identify of information, which many authors suggest is at the heart of two trends: those addressing predominantly any agile organisation.

The effect the relationships required in local and global is inadequate or fragmented infor- trading environments such as that described mation systems (IS) that do not by Porter (1996) and those systems focusing on

address the demands of operational or the wider strategic needs organisational structures within an enterof the company. The study reprise such as business process re-engineering ported here examines the diversi(Hammer and Champy, 1993).

Arguably, the ties of problems that occur in agile manufacturing paradigm combines both. three different companies and, Changes in informationtechnologyand compares their systems to the communications in the last two decades have ideals of agile manufacturing. further shifted the balance towards the customer. There has been a huge growth in the number of computers in use, putting huge power on the desktop, at ever-decreasing hardware cost.

The arrival of the Internet and the expansion of the free market in telecommunications present the option of simple and low costcommunication. Now it has become easy for all players in the supply chain, or even individual consumers, to measure specification, price and supply performance against their needs. They can purchase goods that precisely meet their requirements from anywhere in the world, bypassing any perceived shortcomings of their local marketplace.

In response to the need for agility or the requirements to link different parts of the International Journal of Agile organisation or elements of a supply chain Management Systems 1/2 [1999] 116±126 effectively, systems are emerging that may # MCB University Press fundamentally change the organisation of [ISSN 1465-4652] manufacturing. In order that they might [116] achieve this, companies must clearly understand and organise their information resources at the earliest possible stage in their development.

It is clear that only those enterprises that are able to respond to market demands with minimum delay will survive. Kidd (1996) argues: The agility that arises can be used for competitive advantage, by being able to respond rapidly to changes occurring in the marketenvironmentand through the ability to use and exploit a fundamental resource, knowledge. People need to be brought together, in dynamic teams formed around clearly defined market opportunities, so that it becomes possible to level one another's knowledge. Through this process is sought the transformation of knowledge into new products and services.

High reaction flexibility will be no more than a qualifier in the future, just as high quality is today. This flexibility cannot be realised by high-tech equipment alone. Human creativity and organisational ability, if necessary supported by advanced computer based tools, will be the basis for survival and success strategies. This paper describes studies over a period of 15 months, of three companies, and analyses how far they are away from possessing the ability to become agile, by examining the areas that were dysfunctional.

It explores the importance of information management and appraises information systems in place in these companies. It discusses the need for a more structured and holistic approach to transferring information in its various forms to the different areas of an organisation, aiming to give optimal access to information while eliminating wasteful duplication as well as generating and testing new knowledge about the firm's changing requirements. Information defined The term information is widely and often

inaccurately used. Many authors agree that J. G. Thoburn, S. Arunachalam and A.

Gunasekaran Difficulties arising from dysfunctional information systems in manufacturing SMEs ± case studies International Journal of Agile Management Systems 1/2 [1999] 116±126 there are three elemental types: data, information and knowledge. However, this paper argues that there is a fourth, intelligence, which is distinct from the others. All but data require an understanding of the socially defined context ± where the information, knowledge and intelligence came from, the assumptions surrounding them, and their importance and limitations. Each of them may be defined as follows: .

Data: a series of observations, measurements or facts. . Information: information is data organised into meaningful patterns by means of the application of knowledge. The act of organising data into information can itself generate knowledge, when a person reads, understands, interprets and applies the information in a specific work situation. . Knowledge: the intellectual capital resident within an organisation. The facts, experiences or competencies known by a person or group of people, or held within an organisation, gained by individual or shared experiences, training oreducation. Intelligence: what a company needs to know about its competitive, economic, technical and industry environment to enable it to anticipate change and formulate strategies to best provide for the needs of the marketplace and its specific customers. Yet many aspects of a company's IS are based, not around formal or technology based solutions, but rather on informal or human oriented systems. Mintzberg (1997)

examined a wide range of managerial work, predominantly in large organisations. He reported that managers, while 40 percent of their time was devoted to gaining and sharing information, usually used informal systems centred on people.

Nevertheless, he concluded that: the job of managing is fundamentally one of processing information. that managing a company was essentially a matter of control. However, this implies a rigidity of framework and formality that does not fit well with today's organisation, and certainly does not promote agility. Flatter, less hierarchical business systems localise control and make it difficult for management to achieve enterprise-wide regulation. Smith (1984) however, believed that the vitality of living systems was not a matter of control, but rather of dynamic connectedness.

Veryard (1994) argues that: systems are a dynamic interplay between adaptation and non-adaptation. This is precisely what is required in agile organisations, where there remains the need for stability andaccountability, in an environment of necessary and perhaps rapid change. Dynamic connectedness in an agile organisation is provided by the flows of formal and informal information. Veryard further suggests that: the future belongs to symbiosis ± external integration in pursuit of common business aims. The authors' research and experience shows that informal systems are equally important in every part of the organisation.

This appears to be especially true in smaller organisations, where they have less developed formal systems, or formal systems are not performing optimally. In order to better understand and integrate the IS, the vital role of informal systems must be taken into account. The need for information

systems in SMEs to successfully communicate and control For the better part of this century, classical management writers such as Henri Fayol (1949) and Gulick and Urwick (1937) taught This is evidenced in those extended enterprises now reported to be emerging.

If this biological view is pursued, it can be seen that biological organisms, especially human ones, achieve precisely the continuous adaptation that is described in the agile paradigm. The most successful individuals are able to blend information from their external environment, with knowledge of their own capabilities, using formal and informal systems, whilst retaining information and knowledge in memory. There is constant building and retention of knowledge, with competencies taught by example as well as by the formal methods to be found in education and training.

Concurrently, many of the control and co-ordination systems, even those learned, become largely autonomic, permitting more effective processing of environmental and circumstantial changes. Such systems may be clearly observed at work in individuals when they are, for example, driving a vehicle. Failureto function effectively in those circumstances leads to severe consequences. Also, by combining with other individuals, capabilities may be extended to be far more than the sum of the parts.

Accordingly, biological systems may provide useful models for what may be expected to occur in manufacturing organisations of the future. With biological organisms, the need for adaptive ISs is most profound in growth and early learning stages, or in times of a significantly changing environment. Failure to adapt and learn from conditions [117] J. G. Thoburn, S. Arunachalam and A. Gunasekaran Difficulties arising from dysfunctional

information systems in manufacturing SMEs ± case studies International Journal of Agile Management Systems 1/2 [1999] 116±126 ay lead to survival difficulties. Similarly, small or growing companies, or those adapting to rapidly changing market conditions will require a dynamically linked IS that binds together all parts of the enterprise, and allows it to adapt to its external environment. This may be very different to the rather rigid systems of the past, operating on pre-defined rules and algorithms. Yet it must be within the reach of the smallest company functioning at low resource levels, which may well preclude expensive and complex IT based systems.

Information management differences between large companies and SMEs The EC and the UK Government's Department of Trade and Industry have identified SMEs as critical to future economic growth and job creation within the European Union. They form large and important sectors in most industrialised countries, especially in Europe and the USA. Yet significant differences exist between the management of SMEs and larger companies, where much of the research in this field is concentrated.

Just as a small fishing boat and a passenger liner may share the same ocean, so SMEs share the global trading environment with large organisations, and are no less susceptible to environmental effects. Indeed it may be argued that just like the smaller vessel, they are much less able to ride out the storms of uncertainty and rapid change, because of their lower resource base. As a result, they must be more, not less vigilant and adaptive than their larger counterparts, with intelligence systems able to influence their strategy and knowledge base much quicker.

The Society of Practitioners of Insolvency in the UK concluded (SPI, 1998) from their 1998 survey that many companies, mostly SMEs, fail from lack of information ± with loss of market being the single most important factor. Case studies Research took place in three companies over a period of three months with Company A, and more than six months each for Companies B and C, when one of the authors was in daily attendance. The companies were self-selected for study. Full access was allowed to every part of the business, its operations, management and financial systems, and to all employees.

Research took the form ofobservation, participatoryethnographicand action research. Questioning of employees used unstructured or semi-structured interviews. [118] Company A was part of a large international group, operating in a number of countries and in every major geographical area in the world, with a group turnover at the time of the study around ? 1 billion. The group consisted in total of eleven divisions each producing a different product. The division studied was located in France, and had approximately 200 employees. The company has been established a number of years and operates under an ISO 002 based system, as well as a number of other quality assurance regimes. The organisation manufactured a variety of special, large-scale products for the oil field, nuclear and defences industries worldwide. These complex products were produced individually to specific customer requirements. Lead times on nuclear products ranged from one to two years, and for the others, from six to 12 months. The products were manufactured as individual one-off specials, in a job-shop operation. The

company was divided into seven departments, three by product sector, and the remainder by function.

One of the latter was the information technology department. Unlike other departments, although it had a functioning office in the French division it was not a part of the local company; IT was attached directly to the parent company in Germany. Its responsibilities encompassed the development and operation of the main computer and software systems used on the site for production management, purchasing, sales, production costing, and time and attendance systems. The department had additional responsibilities for networks and PCs which variously ran under MsDOS, Windows and Macintosh formats.

Where information transfer took place between departments, it was almost entirely carried out manually, transferring information to paper, and then manually transferring it to the next system. No section used the same nomenclature or data dictionary for parts and components. The organisational design was partly hierarchical and partly a matrix structure, and used a predominantly formal communications network. There were a substantial number of formal and informal meetings, through which much of the departmental and inter-departmental co-ordination was attempted.

All formal systems describing the company's operation and administration were well documented. Each department, though relatively autonomous, seemed to be run with apparent efficiency. The operations and production management elements were especially highly developed, Company A J. G. Thoburn, S. Arunachalam and A. Gunasekaran Difficulties arising from dysfunctional information systems in manufacturing SMEs ± case studies

International Journal of Agile Management Systems 1/2 [1999] 116±126 and had been subjected to repeated internal scrutiny as well as by local universities.

Despite this, the company experienced considerable difficulties in meeting quoted leadtimes. Those lead-times were already longer than their major competitors, and the company was also losing price-competitiveness. As much as 50 percent over-run on lead times was common, and substantial underachievement of possible turnover, and erosion of market share resulted. Otherwise the company and its products enjoyed a long-standing high reputation, though the managers believed that without this, considerably greater erosion of market would have occurred.

Their major competitors, predominantly Japanese and American, through price, technical improvements, and a significantly better responsiveness and delivery performance, were nevertheless making increasing gains at the company's expense. The company was a self-contained profit centre, a division of a larger group that trades throughout the UK. There were approximately 25 employees on the site, though there were wide fluctuations in the total due to a self-imposed seasonality in turnover. Certain support services such as accounting and human resources management were provided from the central holding company.

Otherwise the company was responsible for all aspects of its operations. The company was engaged in metal finishing to the engineering industry and as a first tier supplier to several Original Equipment Manufacturers (OEMs). It had two production lines and operated under an ISO 9002 system. The formal IS of the company revolved around the sales order processing (SOP)

system operated from group headquarters and accessed remotely over a fixed link. SOP formed part of a non-standard accounting system, originally written for another group company operating in a non-manufacturing sector.

The system itself was user unfriendly and slow, and no intuitive use was possible. At the start of the study only one person, the production supervisor, had any training in SOP. However, that training gave even him only limited knowledge of the system. Cryptic codes and generic descriptions entered by him into SOP made it impossible for others to distinguish between one product and another, and the division could not operate in his absence. Product and process knowledge was almost wholly vested in the production supervisor's head.

There was no formal planning or production scheduling system, and no collection system for information concerning production times and material usage. Inter- Company B nal and external rejects were not generally noted or analysed. The company had three stand-alone personal computers, two of them extremely outdated. The central management-accountant exercised the most stringent control, and the company was expected to make bottom-line operating profits each month. The whole operational objectives became focused only upon this, and ignored other fundamentals.

To reduce costs, ``non-essential'' spending such as machine maintenance, healthand safety, training, housekeeping and sales were ruthlessly cut. Those ``savings'' often represented all of the profits made by the division. The lack of an IS significantly increased the time spent preparing reports, reduced their accuracy and eroded local management time. At the start of the study, new management was installed in the company. Several

initiatives aimed at improving operating performance were considered. The absence of any suitable or appropriate IS soon emerged.

In some cases, lack of coherent historical information prevented the justification of proposed initiatives, while the effectiveness of others could not be judged within the imposed monthly timescale. Machine and process measurement systems were designed and put into place. They quickly showed that processes were incapable. Similarly, measures of rejects and returns showed that external rejects were in excess of 30 percent while internal rejects were almost 60 percent. An analysis indicated the causes of the problems, and allowed them to be addressed.

Reject rates fell to less than 1 percent within a few weeks. However the centre continued to rigorously apply the accountant's previous control measures. A monthly operating profit remained a continuous and absolute requirement even though large backlogs of rejects, and uncoated, badly corroded customer parts required processing, and machines needed to be brought to reliable operating condition. Consequently, employee training was vetoed, and workforce stabilisation measures overturned. In a climate previously dominated by dismissals and redundancy, the workforce actively delayed the implementation of an IS.

After some time, substantial employee involvement began to overcome this barrier, and they became enthusiastic participants in data collection and process improvement. Customer confidence began to return and the customer base marginally improved. However, the new IS also begun to uncover previous managerial shortcomings, especially at group level. In response, draconian short-term financial measures were applied [119] J. G.

Thoburn, S. Arunachalam and A. Gunasekaran Difficulties arising from dysfunctional information systems in manufacturing SMEs ± case studies International Journal of Agile Management Systems 1/2 [1999] 116±126 rom the centre, and initiatives overruled. The workforce was further reduced, and training programmes cancelled. Workforce morale and customer confidence fell sharply. The division has now closed. Company C was a private limited company, whose directors were its owner-managers. There were approximately 60 employees, with recruitment rising because of rapid growth and expansion. The company was in its third year of trading. The company operated under a newly introduced ISO 9002 based system. The company had two product lines. The first produced simple, low volume components for the automotive sector.

The second built components for the machine tool industry. The operations involved in both of these activities were largely manual. The second group of products were much more complex ± many containing more than one thousand sub-components. A number of variants of each were produced, and all work was carried out by hand. Much of the information within the company was held on personal computers. The internal system was networked into three sections; operations management (OM), purchasing and administration. OM includes quality assurance and control (QA), and a computer aided design (CAD) station.

Each section was independent of the others. Employees were inadequately trained in the use of software and frequent problems arose through their lack of understanding of the packages in use. There was considerable duplication of data entry, with employees in each of the sections entering and extracting

information in an unstructured manner. Where information transfer took place between sections, it was almost entirely carried out manually, transferring information to paper, and then manually transferring it to the next system. No section used the same nomenclature or data dictionary for parts and components.

Manufacturers' references and descriptions were entered in a casual and unstructured way, making cross-referencing impossible. The data structure of each system was entirely different, and there were further large differences even within systems. CAD and QA were not integrated into the OM system. Consequently, internal systems were largely unsynchronised. As they grew in size, so the problems that they created were progressively magnified. Build and wiring order was an important factor, particularly in the case of control cabinets. It could significantly affect productivity, quality and finished appearance.

Company C Consequently, the order and format of cutting and build lists were central to production aims. Despite this, methods of list production failed to recognise this. It was difficult to derive build-order from examination of design information alone. Product variants caused additional difficulties and required translation by unskilled production operatives. As a result, operatives frequently transferred build instructions onto handwritten sheets and maintained unofficial work instruction systems. There was no formal method of transferring or retaining their build-order knowledge.

Comparative attributes, and a summary of the most significant problems arising from the collection and use of information, knowledge and data for each of the three companies are shown in Table I. Identified success factors/

dysfunctional areas In order to more accurately compare and analyse the areas of dysfunction in each of the companies it is necessary to use an objective measure. Bailey and Pearson (1983) have produced one of the most definitive and widely used lists of factors that identify the success factors in ISs. Li (1997) added a further seven factors.

These 46 elements have been used to form a matrix, shown in Table II, against which the ISs of thecase studycompanies can be compared. However we have made minor modifications to some of the original criteria to widen references from a computer based information system (CBIS) to simply information system (IS). A hash (#) is shown in the description in these cases. A seven-point scale has been used to describe the degree of success or dysfunction of the IS when first observed. The scale used is as follows: 0 Not applicable 1 Significantly unsuccessful or dysfunctional 2

Moderately unsuccessful or dysfunctional 3 Broadly neutral ± neither successful nor unsuccessful 4 Moderately successful 5 Significantly successful X No information available. Discussion and analysis The companies studied were self-selected, with the only common factor being that they were experiencing operational difficulties which extended to their trading environment in one form or another. There was nothing to suggest that they were other than typical of [120] J. G. Thoburn, S. Arunachalam and A. Gunasekaran Difficulties arising from dysfunctional information systems in manufacturing SMEs ± case studies

International Journal of Agile Management Systems 1/2 [1999] 116±126 Table I Company attributes Company B UK Manufacturing General engineering Throughout UK Yes Yes 25 Very high Low ? 170k ? 40 million

Low Hierarchical High Very low Central Mixed, central file server, local PCs High Low Very low Yes No Very low Manual Management accountant Very high Yes Medium High Very Low Yes Yes Low Directors High Yes Company C UK Manufacturing Automotive/machine tools English Midlands No N/A 60 Fairly high Low ? 1. 8 million ? 1. million Both high and low Team based Low Medium Local owner/directors Local PCs Characteristic Company A Country of operation Type of company Sales sector Sales area Part of a group High degree of central control Approximate number of employees on site Employee turnover rate General level of employee skills Approximate site sales turnover Approximate group sales turnover Product complexity Organisational structure Organisational formality Degree of manufacturing sophistication Origin of principal control Type of information system

Degree of manual systems Degree of computerisation Degree of IS training Islands of information Local networking Degree of IS integration Transfer between systems Provider of IT support Informal information systems External audit systems (e. g. ISO 9002) France Manufacturing Nuclear engineering/oil and gas production Worldwide Yes No 180 Low Very high ? 12 million ? 900 million High Hierarchical/matrix High Very high Local Mixed, central mainframe (financial), local mainframe and PCs Low High Medium Yes Some Low Manual IT department Medium Yes 121] (continued) J. G. Thoburn, S. Arunachalam and A. Gunasekaran Difficulties arising from dysfunctional information systems in manufacturing SMEs ± case studies International Journal of Agile Management Systems 1/2 [1999] 116±126 [122] Table I Company B . . . . . Characteristic Company A Company C Principal symptoms . . . . . Poor lead time performance Higher prices than

competitors Loss of market share Serious loss of available turnover through lower throughput times . .

Poor quality performance Poor lead time performance Extremely small customer base offering low value work Low profitability High degree of seasonality Poor quality performance Poor lead time performance Poor cash flow Frequent stoppages due to material shortages High degree of duplication and wasted effort Principal causes . . . . . Failures in communication in verbal systems ± formal and informal Need to manually transfer data between separate IT systems leading to delays and inaccuracy Poor communication with suppliers and failure to keep adequate ata on vendor performance Lack of unified IT and IS strategy . . . . . Lack of any formal operations management and scheduling system Failure to keep manufacturing performance records Control using inappropriate measurements Failure to monitor customers' records and address reasons for erosion of customer base Failure to understand market conditions Failure to understand employment market Self-imposed seasonality High staff turnover and absenteeim Constant loss of skills and competencies Lack of skills sharing Poor training Inappropriate SOP system

Information systems unable to cope with rates of growth Unstructured data gathering Inappropriate transfer of information to factory floor leading to proliferation of informal systems Failure to feed back information and knowledge from production Failure to understand employment market Limited knowledge base and deliberate limiting of skills base Lack of understanding of quality failures Lack of appropriate IT training Inappropriate IT systems Ad-hoc IT systems leading to Lack of unified IT and IS strategy

J. G. Thoburn, S. Arunachalam and A. Gunasekaran Difficulties arising from dysfunctional information systems in manufacturing SMEs ± case studies International Journal of Agile Management Systems 1/2 [1999] 116±126 Table II Success factors and dysfunctional areas Factor no. 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 Description factor Top management involvement Competition between computer based information system (CBIS) and non-CBIS units Allocation priorities for IS resources (#) Chargeback method of payment for services Relationship between users and the CBIS staff Communications between users and the CBIS staff Technical competence of the CBIS staff Attitude of the CBIS staff Scheduling of CBIS products and services Time required for systems development Processing of requests for system changes Vendor's maintenance support Response/turnaround time Means of input/output with CBIS centre Convenience of access Accuracy of output Timeliness of output Precision of output Reliability of output Currency of output Completeness of output Format of output Features of computer language used Volume of output Realisation of user requirements Correction of errors Security of data and models Documentation of systems and procedures User's expectation of computer-based support User's understanding of the systems Perceived utility (worth vs. ost) User's confidence in the systems User's participation Personal control over the IS (#) Training provided to users Job effects of computer-based support Organisational position of the IS unit (#) Flexibility of the systems Integration of the systems User's attitude toward the IS (#) Clarity of output Instructiveness of output Support of productivity tools Productivity improved by the IS (#) Efficiency of the systems Effectiveness of

the systems A 3 2 3 X 4 4 4 3 3 3 2 X 4 4 4 3 2 3 3 2 4 4 4 2 4 4 4 5 4 4 4 4 4 4 4 4 4 2 2 4 4 4 4 4 3 3 Company B 1 1 1 2 1 1 2 1 1 1 1 1 3 2 1 1 1 2 1 1 1 1 2 1 1 3 1 1 1 1 2 1 1 1 1 4 1 1 1 2 2 1 1 1 1 C 2 3 2 0 4 2 2 2 2 2 3 1 2 3 4 2 2 2 2 2 2 2 3 2 2 2 1 2 4 2 3 3 4 4 1 2 5 4 2 4 3 3 2 2 2 2 companies of their size or sector. The studies aimed to determine the extent of use of ISs, report effectiveness and what contribution, if any, their systems had to the areas of dysfunction. They were intended to be preliminary studies from which initial conclusions could be drawn, with reference to published work. By spending a considerable amount of time in each company, and becoming involved with various aspects of their operations, and interacting with employees at all levels in each company, there is a high level of confidence that the systems observed were unaffected by short term experimental bias.

Company A, with the highest turnover and backed by a large multi-national parent company was the most resource rich [123] J. G. Thoburn, S. Arunachalam and A. Gunasekaran Difficulties arising from dysfunctional information systems in manufacturing SMEs ± case studies International Journal of Agile Management Systems 1/2 [1999] 116±126 company. It possessed a highly sophisticated and well-designed production and operations management system, backed by logistics, quality and design departments each equally efficient in their own right. The IS appears from Table II to perform reasonably well. Yet consistently it was unable to meet promised lead times, often by a substantial margin.

It was found that the purchasing department was at the centre of many of the problems, with poor communication with suppliers, and adversarial purchasing based principally on price. The consequence was many late

deliveries and variable quality. Yet the true cause of the problems was not discovered to be there. The principal means of information transfer between different sections of the company's IT system was manual. Because of incompatible systems, even at PC level, where both Apple and MsDOS based systems were employed, communication was impossible. Each department's system had grown on an ad hoc basis to fulfil its own needs, without reference to others. Each data transfer took place using printed information, usually in the form of schedules, which was translated, then re-entered manually.

There were often delays, some considerable, while this process took place. Subtle yet cumulative changes of data and information took place because of translation errors. This had the effect of de-synchronising the whole system. But the most significant effects on leadtime were not to be found in the IT system, but rather in verbal communication systems. A large number of formal and informal meetings were held to exchange information often in response to increasing delays against the planned schedule. In response to pressure, the spokespersons from individual departments often gave incorrect answers, sometimes inadvertently because of the cumulative errors or delays in information transfer.

Other times, errors were deliberate, where attempts were apparently made to save face, or under pressure from a senior manager or colleagues, to agree to plans that they knew to be unrealistic. Different participants often repeated this process in turn during a meeting. Accordingly, this information was recorded and became crystallised into the formal system with the result that delays were progressively magnified. Thus it was lack of true dynamic

connectedness of the system that created the problems that led to continual poor lead-time performance. In contrast, the IS in Company B was not only seriously deficient and absent in many places, but was dysfunctional in every area where it did exist. IT systems were limited, unfriendly and uncoordinated, with training and documentation absent.

In the wider system information, and particularly feedback, was deliberately withheld, and knowledge generation stifled in response to the corporateculture. The annual haemorrhage of accumulated skills combined with the lack of training and poor human resources policies substantially added to the problem. Inappropriate measurement and control of the feedback systems that did exist reinforced this culture, and the problems that were occurring. Because of poor management techniques, both internal and external intelligence was ignored for considerable periods of time. At the times attention was placed upon this aspect, the system was incapable of multiple focus, and one set of problems was replaced with another.

The response of senior group managers was particularly interesting. As IS was put in place or repaired, long-accumulated problems began to emerge which pointed to previous management failures. Their immediate response was to try to dismantle newly implanted systems, and halt knowledge generation and dissemination, and return to the previous culture. Once they took these steps, failure was inevitable. In Company C, the problems were quite different. There was a clear belief in the ability of computers to solve problems by their mere presence. Yet the growth and structure in their IS was wholly unplanned and uncoordinated, and was incapable of supporting the rapid growth of the organisation.

There was substantial redundancy and duplication of software systems, and poor understanding of their capabilities that led to the disablement of important reporting and control facilities. Poor system management and training allowed proliferation of duplicated files, and it was often difficult to determine the correct version of any instruction. As a consequence, a considerably higher level of employee time was expended than necessary, substantially increasing costs. Poor data gathering, knowledge management and information generation techniques exacerbated these problems, and informal systems proliferated. Yet simple trial measures to return acquired manufacturing process and merge formal and informal systems, improved quality, productivity and worker-satisfaction.

Information systems in an agile company should contribute to responsiveness as well as to overall corporate and organisational aims (Burgess, 1994; Goldman and Nagel, 1993; Kidd, 1994). There are a number of broadly accepted principles of the agilemanufacturing paradigm that provide the [124] J. G. Thoburn, S. Arunachalam and A. Gunasekaran Difficulties arising from dysfunctional information systems in manufacturing SMEs ± case studies International Journal of Agile Management Systems 1/2 [1999] 116±126 basis for a rapid and flexible response to changing trading conditions. That is to say there is emphasis on strategies (Goldman et al. , 1995), technologies, systems (Cho et al. , 1996; Gillenwater et al. , 1995) and people (Goldman et al. , 1995; Kidd, 1994).

In many cases, many authors have placed great emphasis on the technological capabilities of the organisation (Adamides, 1996; Medhat and Rook, 1997; Merat et al. , 1997). Such resources may not be available to

smaller companies. Does this necessarily mean that small companies may not be agile. This would be directly contradictory to the long held view that the strength of smaller companies is their inherent flexibility and responsiveness. Nevertheless, from the comparisons shown in Table III it is possible to conclude from this study that the more dysfunctional, and less dynamically connected the IS, the less able the company is to achieve agile outcomes, flexibility and responsiveness, in the broadest sense of its definition (Gehani, 1995; Kidd, 1996). Conclusion and implications

In this section consideration is given to three broad issues arising from the case studies: potential implications of the results; preliminary conclusions; and plans for further work. The studies found broadly in line with previous work, though we have suggested that the normal three-part definition of information of data, information and knowledge be extended to include a fourth, intelligence. We have further observed the fundamental importance of informal systems particularly in the case of the two smaller companies B and C. Here personnel at every operational level relied heavily on informal information, and constructed their own systems, either to protect their position, or to operate more effectively.

We have also propounded the biological view that human behavioural systems in particular provide a useful view of how responsive organisations should behave if flexibility and responsiveness is the desired outcome. This paper then considered the companies against the background of agile manufacturing and compared their actual performance to the ideals of the paradigm. It can be concluded that in every case in this study, the more dysfunctional and less dynamically connected the IS, the less able the

company is to be agile in the broadest sense of its definition. However current tools and techniques of evaluation and design of ISs are far less well

Table III Comparative performance against agility principles Company A Strategy Agile principles Technology Systems Lack of direct integration of IT systems and connectedness of IT and people-centred systems Absent, deficient or dysfunctional. Without effective coordination or integration People Flexibility Outcomes Responsiveness Low Good strategic Good to awareness excellent Low People highly trained, valued and rewarded but failure in communications in people-centred systems People poorly valued and rewarded. No training and deliberate withholding of knowledge in response to company culture Poor B Poor strategic Badly provided, maintained and awareness ± understood with lack of internal and external intelligence Poor C Strategy held in individuals at board level

Limited, uncoordinated and unplanned. Computers seen as an answer by simply being present Uncoordinated and incapable of adapting to rapidly increasing demand Poor HR policies Rapidly decreasing leading to staff shortages and low reputation. Poor knowledge management Rapidly decreasing [125] J. G. Thoburn, S. Arunachalam and A. Gunasekaran Difficulties arising from dysfunctional information systems in manufacturing SMEs ± case studies International Journal of Agile Management Systems 1/2 [1999] 116±126 suited to the needs of many companies (Sauer and Lau, 1997), SMEs in particular, and the achievement of their strategic, commercial and operationalgoals.

This suggests that a new and simpler technique is required that aims to lay down the foundation for an IS at an early stage in the development of a

company. This system must be capable of being applied by non-specialist managers in circumstances where there may be a mix of information technology and manual systems. Nevertheless it must be one that incorporates the four elements of information that have been defined in this paper. Work to devise such an audit and planning tool, together with a methodology for its application, is currently being undertaken. References Adamides, E. D. (1996), ``Responsibility-based manufacturing'', International Journal of Advanced Manufacturing Technology, Vol. 11 No. 6, pp. 439-48. Bailey, J. E. and Pearson, S. W. 1983), ``Development of a tool for measuring and analysing computer user satisfaction'', ManagementScience, Vol. 29 No. 5, May, pp. 519-29. Burgess, T. F. (1994), ``Making the leap to agility: defining and achieving agile manufacturing through business process redesign and business network redesign'', International Journal of Operations and Production Management, Vol. 14 No. 11, pp. 23-34. Cho, H. , Jung, MY. and Kim, M. (1996), ``Enabling technologies of agile manufacturing and its related activities in Korea'', Computers and Industrial Engineering, Vol. 30 No. 3, pp. 323-34. Fayol, H. (1949) General and Industrial Management, Pitman, London. Gehani, R. R. 1995), ``Time-based management of technology: a taxonomic integration of tactical strategic roles'', International Journal of Operations and Production Management, Vol. 15 No. 2, pp. 19-35. Gillenwater, E. L. , Conlon, S. and Hwang, C. (1995), ``Distributed manufacturing support systems ± the integration of distributed group support systems with manufacturing support systems'', Omega ± International Journal of Management Science, Vol. 23 No. 6, pp. 653-65. Goldman, S. L. and Nagel, R. N. (1993), ``Management, technology and agility: the emergence of a new era in manufacturing'', International Journal

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