adaptability. It is thanks to this adaptability that values coming from historical and cultural traditions of different epochs have been reassembled in a mosaic, diffused and transmitted inside the social system and the relations of the productive world.

If Japan assumed the western model of doing technology its possible evolutions would inevitably imply a great involvement of their cultural traditions. The final outcome might consist in the discovery of the same problems and polemics that characterize in Western culture the relationship between tradition and scientific–technological progress. The Japanese productive world remains, in this sense, at the periphery of culture, which does not feel either the need of it or its crucial relevance for the future. Thus instrumentality in the end prevails without jeopardizing the cultural models that are, and remain, extraneous to it, differently from what occurred and occurs in Europe.

For Japan, presumably the problem of the two souls, as we know it, is of no relevance. It is, however, also important for the international relations which Japan has developed, to wonder for how long this will be true, and what syntheses Japanese culture will turn to when it has to deal with the consequences of the diffusion of a technology that until now has been, so to speak, bracketed, as pure instrumentality.

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Effects of CSCW on Organizations

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Abstract: We consider the potential impact of Computer Supported Cooperative Work, with special reference to large technically advanced projects involving several organizations. It is vital that such projects are managed efficiently, without delays, since a product that reaches the market a few months earlier than its competitors enjoys a great advantage. Traditional methods of coordinating large projects, based on hierarchical communication, tend to produce delays, since technicians at remote sites are obliged to solve coordination problems by passing them up the hierachy. It would be better if such problems were solved by improvising conferences among the technicians; Computer Supported Cooperative Work will provide the technical means of implementing this heterarchical style of management without losing control of the project. The use of computers as a social medium raises methodological and ethical issues which are discussed in the final section.

Key words: Computer Supported Cooperative Work; Organizations; Project management; Heterachy; Coordinator

Introduction

The term 'cooperative work' applies to any situation in which people act together to achieve shared goals. The people who are collaborating may be located in the same building, so that they can meet face to face. Alternatively, they may be located in different buildings, cities, or countries, perhaps because they belong to separate organizations. The emerging field of Computer Supported Cooperative Work (CSCW) aims to facilitate collaboration in all these contexts, by transforming the computer from a tool that supports solitary work into a tool that supports group work.

As its name suggests, CSCW has two main concerns: first (CS) it studies appropriate hardware/software support (here there are links with Computer Science and Artificial Intelligence); second (CW) it studies how people work together in organizations (here there are links with Sociology, Psychology, and Management Science). This division reflects a general conviction that effective computer support must be based on careful study of how people collaborate at work: initially, at least, the technology must respond to existing organizational structures and procedures. However, even the earliest experiments with electronic networks have shown that there will be a reciprocal influence of the technology on social relationships (Sproull and Keisler, 1991a). In this article we discuss the way in which CSCW technology might change the organization of work during the 1990s, focussing in particular on the coordination of large complex projects in areas of rapid technological advance.

Computer Supported Cooperative Work

The concept of computer supported cooperative work (CSCW) was pioneered by Engelbart (Engelbart and English, 1968), who demonstrated as early as 1968 a prototype called NLS/Augment. Developed at the Stanford Research Institute during the period 1963–76, this system allowed office workers to communicate either by exchanging documents or by interacting in real time through a shared window.

Until 1980 interest in CSCW was limited to a few visionaries like Engelbart, but thereafter the field expanded rapidly. The first workshop was held at MIT in 1984, and major conferences followed in 1986, 1988, 1990, and 1992 (Greif, 1988; Bikson, 1990; Mantel and Baecker, 1992). These conferences attracted researchers from a wide range of disciplines including computer science, artificial intelligence, psychology, sociology, and management science. Towards the end of the 1980s a centre for Coordination Science was established at MIT, and some early CSCW products began to reach the market. Many of these products are cited in the December 1988 issue of *Byte*, which features a special report on Groupware. Two journals dedicated to CSCW appeared during 1990–91: *Information Systems Research* and *Journal of Organizational Computing*.

All CSCW systems are based on networks which link together the personal computers of the participants. People who work in the same office can be connected cheaply by a *local area network* (LAN); workers at remote locations are connected

by a *wide area network* (WAN). Communication may be *synchronous* or *asynchronous*. In the case of synchronous communication, there is no perceptible gap between the production of a message and its reception; with asynchronous communication the message is first composed, then sent, then read at leisure.

Synchronous communication over a LAN is a feature of many office automation systems. Typically it is based on a *shared window* which can be viewed and modified by two or more users at separate terminals, according to the principle of WYSIWIS (what you see is what I see). Each user can display the shared window, along with further private windows which vary from one terminal to another. The person holding the floor can write into the shared window, the results being immediately visible to the other participants. A more ambitious objective is *teleconferencing* over a WAN. For example, the experimental system MERMAID (Watabe et al., 1990) allows people working in different cities to converse through an audio-visual link. Each participant is filmed and may appear in windows on other workstations. The audio link allows more than two participants to take part in the conversation, and provides a sound quality far superior to telephone.

Although technically feasible, a high-quality audio-visual link is at present too expensive for most applications. Consequently, systems requiring communication at a distance typically employ electronic mail in preference to an audio-visual link. Asynchronous communication is obviously slower yet it has some compensating advantages: sender and receiver can communicate even if they work at different times; if the material is complex there is no pressure to respond overhastily; in group discussions people who are usually too slow or too timid to capture the floor have a chance to contribute. It is safe to assume that for the next few years nearly all CSCW applications will be based on electronic mail.

Why should people prefer electronic mail to traditional methods of communication like telephone calls and letters sent by ordinary post? The postal service may suffice for non-urgent messages but for many purposes it is simply too slow: some email users refer to it as "snail mail" (Sproull and Keisler, 1991b). Philipp and Young (1987) found that as many as 70% of telephone calls failed to reach the intended party. Moreover, even if the call goes through, the receiver often has to interrupt another activity at an inconvenient moment. Subordinates are reluctant to communicate by telephone with superiors, who may resent the interruption, or may be protected by secretaries who cannot be trusted to transmit the message accurately.

As well as electronic mail, CSCW systems should provide facilities for document management. Very large libraries of documents must be organized for efficient access and maintenance. Documents may have multiple authors and complex rules of access. When a document has several authors it will typically exist in multiple versions, as successive drafts are bounced back and forth for revision and for the insertion of new material. For cooperative writing, coauthors often need to make comments on the original draft, or perhaps even comments on each other's comments.

To facilitate the organization of email documents, the Information Lens system (Malone et al., 1987) permits authors to create *semi-structured messages*, which are frame-like objects with slots for time, place, speaker, topic, as well as fields containing normal free text. By exploiting information in fixed format, the system can sort messages into folders by such criteria as sender, date, location, topic. Semi-structured messages are also used in The Coordinator (Winograd and Flores, 1986; Winograd,

1988), which associates each message with a speech act category (e.g. request, proposal, or promise). The system has a repertory of networks which indicate the paths that a conversation may follow: for instance, if Mary sends John a question, John is expected to provide an answer. On noting that the question has been asked, the system is able to infer that an answer should be provided, and to add this to John's list of current commitments.

The organization of documents into a logical structure is especially important for complex technical discussions. When people take technical decisions on their own, or in face-to-face conversation with colleagues, the rationale underlying the decision is usually recorded only partially, if at all, and may soon be forgotten. To avoid losing valuable information in this way, some researchers have suggested special formats by which the rationale can be coded. Probably the most popular such format is IBIS, which stands for Issue Based Information System. The IBIS method distinguishes three types of contribution to a discussion: *issues* (which state questions or problems), *positions* (which state possible resolutions of issues), and *arguments* (which justify or criticize positions). Conklin et al. (1988) have developed a groupware system called gIBIS (graphical IBIS) which enables users to create, through a graphical interface, a hypertext with nodes and links corresponding to IBIS concepts. Tools of this kind may prove useful in organizing complex asynchronous discussions.

More sophisticated CSCW systems will incorporate AI technologies such as intelligent agents (Bond and Gasser, 1988) and knowledge bases. An experimental office information system called COKES (Kaye et al.,1987) provides each user with a computerized assistant to which certain tasks can be delegated. Thus if Mary wants to fix a meeting with John by the end of the week, she can delegate this job to her computerized assistant, which will get in contact with John's assistant, compare their forthcoming commitments, determine a convenient time, and add the new appointment to both agendas. Another experimental program called CALLISTO (Rathi et al., 1986) includes an expert system which can apply expertise on project management in order to support planning and negotiation.

In this paper we are specifically interested in CSCW systems that support collaboration among organizations in complex projects. From the sketch given in this section we can identify some features that such a system would require. At each site, people will have access to terminals which are connected by a local area network. These local networks will be linked by a wide area network for transmitting documents and other data. For the next few years, the cost of transmitting voice and video film will probably be too high for most applications; we therefore assume that remote communication will be asynchronous. Users will be able to create documents, usually in a partially structured format, which will either be sent as messages or will be linked to a communal plan, report, or discussion. The system for managing documents must include facilities for efficient access, versioning, commenting, confidentiality, and security.

Managing Complex Projects

There are strong grounds for thinking that CSCW will become a key technology during the 1990s. Numerous studies have reported a movement towards greater

flexibility in organizing work. Members of a project team no longer work in the same office, during the same hours, under strict centralized control. There is a worldwide trend (especially marked in Europe) towards the formation of joint ventures and consortia for large-scale technical projects. As a result, individuals and groups from different organizations, often located in different countries, may have to collaborate intensively, exchanging messages not just occasionally but almost every day.

If a project is badly coordinated, delivery of the final product will be delayed. In domains of slow technological evolution such delays may do little damage; however, in domains of rapid technical advance, where novel products appear often, any company which reaches the market a few months after its competitors will obtain a drastically reduced share. This phenomenon has been called 'time-based competition'. Because of time-based competition, it is vital that projects at the leading edge of technology should be managed effectively.

However, precisely for projects of this type, traditional methods of management often work poorly. Advanced technological projects typically present problems of *unpredictability* (the product specification and work plan cannot be stated definitively at the outset) and *contemporaneity* (many interdependent subtasks are performed in parallel). As a result, unexpected problems repeatedly occur which call for rapid modifications in the product specifications or work plan. The traditional management hierarchy is too slow to cope with this kind of complexity. What seems to be needed is a heterarchical style of management, in which some decisions are taken through conferences among technicians rather than being passed up to a higher level.

The problems of managing a complex construction project have been illustrated by Amadio and Fassina (1993). During 1985 the Italian state railway decided to build a new high-speed train, the ETR 500, capable of running at over 300 km/h on a straight track. The work was subcontracted to a group of four companies, one of which was made responsible for coordination. This system did not work properly since the coordinator was assigned two conflicting roles. The project went out of control by mid-1988 when the first prototype was almost completed and the construction of the two complete convoys had just started. At this point the railway called in an external consultant in project management.

The difficulty of coordinating this project was due to a combination of factors. Although a prototype of the train had been built, the complete product required further innovations, so the design and the work plan could not be fully specified in advance. The work was distributed among four constructor companies which were market competitors, so that their loyalties were sometimes divided. Technicians were reluctant to report delays, or to give realistic estimates, through fear that their company would lose credibility. When decisions required consultation between technicians from different companies, the relevant people were either not in touch, or uncertain of their powers and duties, or uncertain whether or how their decision should be communicated to others. Decisions were taken without their underlying rationale being recorded or even discussed.

The following example illustrates the kind of situation that typically leads to delay. Rossi works at a factory in Naples, producing a motor; Bianchi works for a different company in Milan, producing the framework into which the motor and other components should be assembled. Since the exact shape of the motor could

not be specified in advance, Bianchi cannot build and test the relevant part of the framework until Rossi finishes the motor and sends it to Milan. Owing to a defect in his original design, Rossi is obliged to modify the form of the motor and to deliver it two weeks late. He might report this problem to his project manager so that it could be raised next week at a meeting of the coordinating committee; however, the matter could be sorted out better and more quickly by getting directly in touch with Bianchi. Ideally the conversation might proceed thus:

Rossi: I've had to modify the motor. There will be a delay of two weeks.

Bianchi: But that means I can't finish the framework.

Rossi: Can't you use the two weeks to do something else?

Bianchi: No, I can't fit the wiring and other attachments until I know the shape of the motor. Can you build a maquette which simulates the motor and send me that?

Rossi: Yes, but it will delay me another three days.

Bianchi: Never mind, the priority now is to build the framework.

This hypothetical conversation can occur only if some conditions are satisfied. First, Rossi must realize that the delay in delivering the motor raises a coordination problem, which can and should be resolved by consulting another technician – i.e. through lateral rather than vertical consultation. Next, he needs an effective means of getting in touch with Bianchi and exchanging messages. If it turns out that other people are directly influenced by the decision, they should be brought into the conference: for instance, Verdi, the person responsible for testing the mechanical properties of the motor, might object to the extra three-day delay due to constructing the maquette.

In summary, delays are often due to unforseen problems over details which should be resolved by impromptu conferences among the relevant technicians. If such problems are passed up to higher administrative levels, decisions that could have been reached in hours may take weeks. However, the partial devolution of management responsibility to technicians raises some new problems. They need information on how their tasks are connected to other (possibly remote) activities in the project, clarification of their rights and duties when unforseen issues arise, and efficient tools for arranging conferences and for recording and explaining their decisions. We argue that CSCW will provide the technical means of realizing heterarchy effectively, and hence encourage a shift away from hierarchical structures and procedures in organizations.

Supporting Devolution in Organizations

The heterarchical style of management has been called "the networked organization" (Malone and Rockart, 1991) or "ad-hocracy" (Toffler, 1971). A shift from hierarchy to adhocracy does not imply that all conventional methods of project management will be abandoned. Construction projects will still require a consistent, detailed specification of the product, even if this specification is often modified as the work progresses. All projects will still require a work plan, probably defined by the usual PERT/CPM methods, even if this work plan too will be updated to accommodate unforseen delays or changes in design. What will change is the way in which these

documents are maintained: dictation from above will be replaced by consensus among lower-level staff with direct knowledge of the problem.

Compared with hierarchy, adhocracy places a far greater burden on coordination, and hence on the communication and storage of information. If all decisions are made by a single person, or by a compact team, there may be no need to record in detail the underlying reasons, or to make all this information generally available. But if decisions are devolved to impromptu groups of technicians, solutions and their rationale must be recorded; otherwise inconsistencies will remain undetected, and solutions that have been refuted by one group may be considered and even adopted by another. CSCW makes large-scale heterarchy possible because it supports the storage and communication of massive amounts of information at low cost; it can also organize and filter this information so that individual workers are not overwhelmed.

Especially in the early stages, people will need guidance on their new rights and responsibilities. This guidance should be supplied by a person or team with the special role of *coordinator*. If the project involves several companies (as in the case described above), the coordinators should be impartial outsiders loyal to the whole project. When a technician encounters a problem, e.g., the delay in finishing the motor, he/she will inform a coordinator, who will help to organize a conference among the relevant parties. If necessary the coordinator will supervise the conference in order to give procedural advice.

In defining the role of coordinator it is important to note that the person who runs a conference need not be the same as the person who has decisional power. In many cases these roles can usefully be dissociated: the coordinator runs the meeting, using expertise in methodology; decisions about the problem domain are made by the whole group, or by a manager, or by the person with most technical competence. For complex technical discussions among representatives from several organizations, there are obvious reasons why the meeting should be chaired by an external facilitator rather than by a manager or technical expert, who may be seen as favouring the interests of his/her own organization rather than the interests of the whole project.

A CSCW system for coordinating complex projects will provide tools for the coordinator as well as for managers and technicians. We list below some examples of services that such a system might provide.

1. Dramatis Personae

The coordinator needs to record some stable information about the people participating in the project: name, company, address, telephone number, position within company, position within project, skills required for project, other skills, other responsibilities. The value of such a database would be augmented by a tool that helps the coordinator to find a person or team to perform an urgent task. Given a specification of the skills required, and the deadline, the system could search the data intelligently and assemble a suitable team, taking account not only of ability but also of other commitments.

A simpler version of this tool would be useful for all users, not just for the coordinator. Often people are blocked for hours or days because they need a simple item of information but do not know whom to ask. If participants are encouraged to provide detailed profiles of their knowledge and skills, a simple expert system could

ask a few questions about the problem and then provide a list of people to ask (taking into account not only knowledge but also availability and level of responsibility – small queries should not be addressed to top management no matter how well they know the topic). Such a facility would be especially useful in projects involving several organizations, since it would facilitate unpredictable contacts across companies.

2. Where is Everybody?

People move around. To find a key person at short notice, the coordinator might maintain a constantly fluctuating record of where people are. For instance: today Mary is in her office, or visiting John, or working at home, or on holiday. People could be obliged to report their plans on request (perhaps every week), but allowed to report much more often if they wish. A simple expert system could use information about a person's plans, habits, duties, in order to suggest where to find him/her. For instance: "According to the work plan, X should spend this week doing task Y. Most of task Y is carried out at location Z, which can be reached by telephone 02-12345 or fax 02-12346."

3. Work Plan

The coordinator should keep a definitive version of the work plan. If a delay or change of plan is reported, the coordinator needs to determine the consequences for the whole project. Normal project management software will suffice for this purpose, provided that it is adapted for cooperative use. For instance, one might allow each team to alter those details of the work plan that fall within its responsibility; or one might allow a team to explore the global consequences of several alternative local modifications so that it can judge which is best.

4. Confidentiality

Since part of the coordinator's job is to disseminate information, the database should specify what each person is obliged to know, allowed to know, and forbidden to know. (Presumably this will be done through general assertions such as "people of category X are forbidden access to information of category Y". Given a formal specification of the content and purpose of each document, the system should be able to apply its knowledge about confidentiality and interests in order to distribute the document automatically to the appropriate people – or at least to prepare a mailing list which the coordinator can correct. This facility would save the coordinator some boring work of compiling lists by hand. It might also prevent mistakes, for instance by reminding the coordinator that X should be informed of all decisions about topic Y. Perhaps all communications (not just those sent or received by the coordinator) should be checked to ensure that they do not violate confidentiality regulations.

5. Progress Reports

As explained above, the coordinator will need tools for designing report forms, ensuring that they are sent to the right people for compilation, collating the results,

assessing reliability, comparing reports both with one another and with the work plan, and preparing global progress reports for the consortium directors. Many of these documents will have to be integrated into a database representing the history of the project.

In summary, we have examined the potential of CSCW technology for facilitating collaboration within and among organizations engaged in complex projects. In projects at the frontier of technology the management of time is crucial, since the first effective product to reach the market takes the lion's share. Conventional hierarchical methods of management work well when the product design and the work plan can be specified definitively at the start. However, for technically advanced projects, modifications in the design have to be made repeatedly, and the time needed to complete each subtask cannot be precisely estimated in advance. Such projects could be coordinated more efficiently by a heterarchical style of management (adhocracy). To make adhocracy work, people must receive guidance on their new powers and duties, and must be equipped with tools for storing, searching, and communicating vast amounts of information. The emerging technology of CSCW will provide these tools, and hence may provoke changes in organizational structures and procedures. If these changes occur, many decisions will be devolved to groups of relevant technicians, and fixed organizational structures will be replaced by temporary groupings, perhaps spanning several organizations, which are constituted to tackle a particular problem and then dissolve a few days later when the problem is solved.

Methodological and Social Issues

At present the field of CSCW has not advanced beyond the stage of early exploration. Many ingenious tools have been conceived in research laboratories and tried out in experimental systems, but as yet there are few established issues and even fewer definite conclusions. The methods used in CSCW research are inherited from software engineering and behavioural science. In any branch of computer science, new tools and architectures arise from improvements in hardware, experiences with existing tools, as well as the intuition and common sense of the researcher. User reaction to CSCW systems are assessed by controlled studies using the empirical techniques of psychology and sociology.

A recurrent theme in CSCW discussion is the need for a consolidated theoretical framework for communication and coordination. Through lack of such a framework the field can seem little more than a hodgepodge of tools and observations, often interesting but seldom fitting together so that one result builds on another. Malone and Crowston (1990) outline a potential discipline which they call 'coordination theory', based around the concept of *interdependency*: they view coordination as the act of managing interdependencies between the activities performed to achieve a goal. Kuutti and Arvonen (1992) propose a somewhat different framework based on 'activity theory', a school of thought which originated in the Soviet Union but has spread to western social science. (An activity consists fundamentally of the manipulation of an *object* by a *community* of *subjects*, relationships between subject, object, and community are mediated by further factors which are subject to historical

evolution – in particular by *tools*, which mediate the relation between subject and object, and by *rules*, which mediate the relation between subject and community.) Since neither of these approaches has been elaborated in convincing detail, most researchers continue to ignore them and to rely instead on intuition and common sense.

In addition to a unifying theoretical background, the field of CSCW needs a methodology for developing large-scale applications. As Martin and Oswald (1993) point out, the crucial step in designing a CSCW application is the modelling of the relevant cooperative enterprise. This step often receives little attention, either because designers are unsure how to set about it, or because they are already biassed towards a particular technical solution. Having defined the problem, possible solutions should include sociological as well as technical elements: in other words, the solution lies not merely in a new software system, but in a set of work procedures which exploit (among other things) the facilities of the new system. Martin and Oswald propose some concepts and methods for modelling cooperative enterprises, but again this is an area where no consensus has yet been established.

The advent of CSCW raises important social and ethical issues, which have been discussed especially by Sproull and Kiesler (1991b). Although new technologies are usually introduced for reasons of efficiency, they also have social and psychological effects which are harder to forsee and often more important. In the case of CSCW some insights have already emerged from studies of organizations that make extensive use of electronic mail.

First of all, it has been found that in computerized meetings there is a more even distribution of influence. When people meet face to face, only one person can speak at a time; as a result, the meeting is usually dominated by a few high-status participants, objections tend not to be raised, and decisions are reached relatively quickly. Since computerized conferences are asynchronous, everybody has a chance to present a point of view, and it is harder for high-status participants to control the direction of the discussion. Apart from asynchrony, a crucial property of electronic mail is that *messages are decontextualized.* At a face-to-face meeting, contributions are interpreted in relation to contextual features like the way people dress, how they are seated, their gestures and tone of voice, their age, sex, and height; in a computerized meeting all these contextual features disappear and only the text survives. The sentence pronounced in a deep confident voice by the tall elegantly dressed man seated in the leather chair at the head of the table does not seem so impressive when displayed without context on a screen. In groups that communicate through electronic mail, reputations are founded more on the content of contributions and less on physical appearance and social confidence.

The danger of decontextualization is that people are less constrained by rules of conduct. Appropriate behaviour depends on the physical and social environment: we behave differently in church than in a restaurant or the office. When people communicate over computer networks they lack the conditioning of a familiar context, and tend as a result to indulge in bursts of extravagant self-expression that have been called 'flaming'. Sproull and Kiesler (1991b, p. 50) cite an example in which a junior employee distributed an obscene and threatening complaint to three hundred colleagues, including the vice-president, because somebody had moved his motorcycle: it is hard to believe that this employee would have stood up and delivered the same

complaint at a general assembly. Similarly, in computerized conferences, acrimonious disputes tend to develop over minor points, so that consensus is hard to achieve and meetings tend to take longer.

Flaming may be due in part to an attempt to compensate for the absence of gesture and tone of voice by putting more emotion into the words themselves. There is also evidence that people take email messages less seriously as commitments: group decision made through computer conferences are riskier than decisions made at face-to-face meetings. Initially this is puzzling because almost all users realize that their email messages are stored on disk; subjectively however the message seems ephemeral, a temporary apparition on the screen, and the possible effects on receivers seem less important as they are not directly perceived.

Flaming and irresponsibility will probably diminish as the technology allows messages to be embodied in a richer context, and as rules of conduct are developed and consolidated (already etiquette is a major topic in network discussions). The world of information is becoming for many people as important as the world of physical objects, yet we have scarcely begun to develop the framework of laws, conventions, and values, that this new environment requires. Kumon (1992) has speculated that persuasion and inducement through telecommunications will become the predominant motivations in the next phase of civilisation. Early civilisation was based on military power, wielded by nations of states competing for prestige; during the second phase, the predominant form of power was economic, as industrial enterprises used exchange and exploitation to complete for wealth; in the third phase, so-called 'intelpreneurs' will share information and ideas, competing not for money but for reputation as a source of wisdom. A similar view has been proposed by Toffler (1990), who also distinguishes between three kinds of power ('muscle, money and mind') and identifies a shift, already underway, in favour of power based on cultural influence.

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Learning from the Japanese Vision: A British Consultant's Personal Perspective*

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Introduction

The first part considers the decline of the UK whose industrial base is in almost a terminal state. The Tory idea of free markets for UK, and industrial activity is forcing it ever down. The second part deals with the Japanese vision and operational innovation. The third is my own industrial activity and my personal motivation.

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