THE EVOLUTION OF SUCCESSFUL C³I SYSTEMS

BY

COMMANDER D. G. THOMSETT, MIMgt, RN(RET)
(*Crew Services Ltd.*)

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ABSTRACT

This article aims to analyse some of the lessons to be learned from successful C³I systems. It sets the scene by defining a successful system as, 'a system widely accepted by its users as meeting their operational needs'. Successful systems serving both strategic and tactical users are briefly described, drawing on common threads in their development history. Contrasts are made with more orthodox procurement practice.

The article urges a pragmatic approach and an acknowledgement of the customers need for flexibility to react to different and rapidly changing operational scenarios by advocating evolutionary procurement, within a framework bounded by clear operational and technological goals. The USN Copernicus initiative is used as an example. The practical problems of managing evolution are discussed, based on DGSW(N) experience gained with the Message Handling systems derived from OPCON and the Ocean Surveillance Information System (OSIS).

The article may well be guilty of over generalizing. It has tried to concentrate on principles and ideas from a management viewpoint rather than become immersed in the equally challenging technology.

Introduction

There is growing evidence that successful CCIS (Command, Control & Information Systems), both in the UK and the US, owe much to following an evolutionary development path. The case for evolutionary development, already made by many in NATO, lies in the argument that there is no practical alternative if capability is to be provided when it is needed. At the same time there are those in the MOD and PE who see problems with this approach.

This article attempts to define a 'successful' system and provides some examples. Following this, the contribution of management, procedural, technological, financial and contractual issues are discussed.

What is a Successful System?—A Definition and Some Examples

A 'successful' system is one widely accepted by the user as meeting his operational needs. In the fast moving world of C³I (Command, Control, Communication & Intelligence) this, by implication, must include the flexibility to respond rapidly to changing operational demands.

Some examples are:

- The Maritime Message Handling System — MHS
- The Air Staff Management Aid — ASMA
- The Joint Operational Tactical System — JOTS
- The Ocean Surveillance Information System — OSIS (Baseline Upgrade)

These systems have all received glowing praise for their contribution to UK Command, Control and Intelligence during the Gulf Operations.

MHS

The Maritime Message Handling System (MHS) has its origins in the OPCON pilot project developed in the mid 70s for the Fleet Headquarters at Northwood to provide automatic signal message preparation and distribution, basic database files for historical data, individual turnover notes and track data display. Today the MHS system is based on a National network of interconnected Tandem Non Stop computers, with over 800 terminals. The system is multi-level secure and accredited to UK level 3, equating to B1 in the US Orange Book terms, and serves both National and NATO users. The system's expansion has been rapid, providing the user with desk top facilities to transmit and receive signals automatically, routed to any destination on the network as well as to interconnected systems. In addition, it provides an effective E Mail facility between individuals directly connected to the system. The inbuilt flexibility of the basic software architecture of the MHS has allowed enhancement and expansion of its capabilities which now include the control of ship/shore/ship communications and an interface capability with X400.

ASMA

Initiated in the mid 70s with the modest aim of providing ADP support to the RAF at HQ Strike Command, ASMA, like MHS, benefited from the formation of strong mixed User and MOD teams working closely with industry on what was seen conveniently at the time as non-operational IT. This simple tote-based system, using flat files under the control of named staff titles, struck an immediate chord with the customers, who found it easy to use and adapt. Senior Commanders were able to browse through files for information from airfield status to manpower availability, and able to query the appropriate staff officer owning the file. It thus provides a vital aid to decision making for the Command. This system has, like MHS and JOTS, migrated and expanded into a wide area network with terminals in operational stations at home and abroad as well as in HM ships.

JOTS

JOTS was introduced some seven years ago by Admiral Tuttle, the US CINCLANTFLEET, as a result of dissatisfaction with his on-board Command System which allowed him to view the tactical picture gathered by his organic sensors, but little else. He was well aware that the Ocean Surveillance Products produced by the US OSIS were in signal form, and that formatted text could be translated by software into geographic positions against a map background. However, the Command System did little to assist him in Flag Support tasks which dealt with the wide area picture. A small high tech company with the right background to investigate the problem was invited to sea. As a result, a prototype system using a PC was produced, with much of the code written on the spot and validated direct with the user.

From this small initiative, the seeds of the US JOTS programme were sown, with the eventual establishment of a common core of software based on UNIX and employing standard off-the-shelf applications from commercial and government sources, capable of being ported to a number of hardware platforms. Today JOTS core software, and a growing library of application programmes, known as the 'Unified Build', are at the heart of most USN C^4I developments, both ashore and afloat. The US term C^4I (Command, Control, *Computers*, Communications & Intelligence) is equivalent to C^3I.

In the UK a derivative of the original JOTS software was ported onto the Link 14 HP 330, and together with some earlier JOTS terminals, now provides a Fleet-wide capability under the umbrella of the Pilot Flag Support System. This innovative system also provides the means whereby terminals from the MHS and the next example, ASMA, have been installed in ships.

OSIS Baseline Upgrade

The genesis of the OSIS OBU has much in common with the UK MHS. Although based on the original OSIS OBS, it was designed to be multi-level secure. It went through the usual agonies experienced by many MLS projects before finally emerging as a successful system. This success was not assured until an evolutionary programme was established late in the development. This placed the customer back in the driving seat. The UK purchase of OSIS OBU has clearly benefited from this change of policy, and the Northwood node commissioned in January 1990 has been particularly successful. The OBU system is now evolving towards a distributed architecture, making use of the JOTS UNIX-based core software and hardware and new role specific UNIX applications, but retaining the hard-won multi-level security message handling software architecture of the current mainframes.

Discussion

Some common threads which are apparent in the developments described, particularly when viewed from a UK perspective, are:

- They all benefited from lessons learned from earlier systems or prototypes.
- All were urgently needed to fulfil a capability gap.
- The user was involved during the development.
- Development was, in practice, evolutionary and primarily driven by user demand. Only after the system had first proved its military worth, was evolution carried on into the Post-Design Stage (PDS) phase.
- MOD approval was generally reactive to user pressure, with these new initiatives often gaining precedence over established items in the CCIS core programme.

It could be argued that this success was achieved to some extent at the expense of the core programme. Even if there is some truth in this, the price of success is small when compared to the price of failure. It is perhaps no accident that all four systems played a significant part in C^3I in the Gulf, and are still migrating under the user's control to meet his operational needs today. By contrast the main planks of the UK defence CCIS programme of ten years ago would certainly not have fulfilled today's user requirements, even if they had entered service as planned.

The Strategy

How then can one learn from, and capitalize, on this success. The US Copernicus concept is recommended as a starting point, not because there is a dearth of strategies in UK and NATO, but because it wraps up the highly complex issues of C^3I, or C^4I as the US now call it, into one cohesive strategy, addressing all the main issues involved in one family of documents. Copernicus provides a total review of US Maritime C^4I requirements into the next century in a rounded approach that applies equal rigour to the technological and procurement issues as well as the operational aims.

A snapshot of the technology issues might include:

(*a*) The technology challenges

- Rapid infusion of standardized building blocks—Using COTS ('Commercial Off The Shelf') where possible but GOTS ('Government Off The Shelf') where necessary.
- Evolutionary logistics.
- Multi-media comms.
- Technology bridges to permit use of existing systems.
- Move towards Open System Standards as they emerge.

(*b*) The procurement goals.

- Incremental development (evolutionary development).
- Move away from formatted messages.
- Adoption of standard Tri-Service Data Management Dictionaries.
- Maximization of Comms assets.

An essential feature of Copernicus is the audit of existing and planned systems. Their capability is judged against a range of criteria to establish their place, if any, in the evolutionary strategy. As shown in TABLE I, these range from the age of the equipment and their upkeep and support costs through to standards, technology and time-scales.

Within the UK there is no such comprehensive single-service or tri-service overview as Copernicus which addresses all aspects of C^3I or C^4I. Although the issues are broadly covered by a raft of recent strategies and studies, most people in the Services, let alone industry, are left confused by an apparent lack of direction and cohesion between individual service plans and confusion between Operational and Non-Operational IT strategies.

TABLE I—*Criteria for US maritime C^4I requirements*

The 'Keep' or 'Cut' decision points for C^4I	*Key Questions*
Procurement	In service date after 1995. Development prior to 1989.
Operational	Does it support high interest/out of area operations?
	Does it conform with tri-service strategy?
Technology	Does it include a high % of pre-1985 technology? Has it a high ILS (Integrated Logistic Support) tail? Does it use COTS?
Manpower	Does the project provide manpower savings?
Costs	Is the Project over budget? Does the Project absorb a disproportionate amount of service/tri-service C^4I funding?

The Requirement

Having identified the need for a co-ordinated UK strategy, along the lines of Copernicus, the problem faced in capturing the requirement needs to be addressed. It is not possible to capture a snapshot of a complex and dynamic system in an Operational Requirement (OR) and expect it to remain conveniently static for a traditional major project life-cycle extending over 15 years. Even if the threat does not change, Command and Control organizations will. The users' exposure to a rapidly increasing diet of timely information, coupled with their expectation that technology will help them in the face of stringent manpower cuts, will surely change the way they do business. It is therefore necessary to convince those approving the OR and the guardians of the single service purse strings, that demands for more and more explicit description of capability with an exhaustive examination of risk and trade-offs against technology and costs at the formative stage is unrealistic. The result serves only to 'ring fence' and over-specify the requirement to a temporal snapshot, ignoring that many of the factors on which judgements were made will change significantly in a relatively short period. More emphasis needs to be given to identifying candidate technologies, such as emerging standards in the dominant commercial environment, COTS and GOTS software, Common Data Dictionaries, and information exchange requirements supported by illustrative architectures.

The aim must be to deploy a minimum capability in the shortest possible time, recognizing the need for an evolutionary programme to develop the system further, once further expenditure is justified by practical experience.

Managing the Development

It is not suggested that *ad hoc* development is substituted for a disciplined approach. By recognizing the need for change and designing for flexibility, a strictly controlled quality development and integration environment is required. There is a nice expression from across the Atlantic, 'test a little, deploy a little', to which one might add 'but know where you are going'. Press only for precise costs for the next stage after the prototype is delivered and demonstrated to the customer as working and fulfilling his needs. It is possible, of course, that the 'prototype' provides all that the user wants.

The recommendations of *Learning from Experience* (Jordan, Lee and Cawsey Report[1]), place stress on the need for strong Project Management and emphasize the important role played by the user and the scientific and engineering staff supporting the Project Manager. The user support nominated must be well trained, not only in warfare and as an operational staff officer, but in at least the principles of Requirements capture and software engineering. He must be part of the Project team and not a 'floating voter'. He will often be the interpreter between the aspirations of the Command and the realities of what can be achieved and when.

Turning to scientific and engineering support, the apparent *de facto* abdication of DRA from this role has allowed Industry a key role as the customer's friend, providing direct support to the Project Manager. Impartiality is strictly observed by maintaining independence from potential bidders. This role helps the partnership with Industry who will, in the age of COTS, more frequently be seen as the system integrator.

The finance and contracts officers should also be seen as an integral part of the Project Manager's team and identify themselves with his objectives by being under the same direct line management. Unfortunately a move still fiercely resisted in some quarters.

The management of evolutionary development at the LTC level appears well suited to the principles of cash budgets introduced by the New Management Strategy. Scrutiny by a Top Level Budget Holder (TLBH), such as C-in-C-Fleet should be mandatory. It is essential that all development takes place within the framework of a cohesive strategy of the Copernicus type. Whilst not advocating that the user becomes the procurement authority, it seems entirely appropriate that the Procurement Executive (PE) becomes accountable to the TLBH for spending that part of NMS funds allocated to the procurement of CCIS equipment.

Customer Acceptance

The development environment described cannot be sustained unaltered throughout the project life. There needs to be a clear milestone which registers the customer's approval and acceptance of the system. Within DGSW(N) an extensive audit is applied to all new ship weapon systems. This has now been extended in a modified form to Shore CCIS. Shortcomings that need to be rectified are noted in the Acceptance document, irrespective of whether they are part of the original requirement or in the contract. This approach provides the essential starting point for continuing the evolution of the system following first deployment. It is contended that a CCIS system will never arrive at Fleet Weapon Acceptance without being based on evolutionary development, so why not plan for it from the beginning?

The Post-Deployment Phase

The Post-Deployment phase of a System, the Post-Design Stage (PDS), is now considered using the example of OSIS OBU and the Message Handling Systems described earlier. DGSW(N) currently handle PDS in a climate where an evolutionary approach, although tacitly accepted, is subject to procurement procedures provided to control random update of materiel rather than phased introduction of system changes.

The traditional approach to PDS has its origins in hardware development. A system's functions were set by the original design specifications and any changes incorporated thereafter normally due to ARM (Availability, Reliability & Maintainability) deficiencies. Funding for PDS is released annually and the equipment remains in service supported as stated in the Upkeep Plan. Assuming that the capability of the system is still required, the PE is responsible for raising the requirement for a replacement system when ARM factors or cost of ownership makes this sensible—providing there is no significant change required to equipment operational capability. This form of replacement still has to retain adequate funding in the appropriate LTC. If significant changes to functionality are required then formal Staff Requirement procedures have to be re-introduced.

Along with other items in the LTCs, PDS funding is subject to scrutiny. In the 'hostile' environment of the annual LTC discussion, it can be considered as a 'soft target' for savings. The case for or against long-term cost-effectiveness or the operational impact of PDS work is not likely to carry much weight, even if available, alongside high profile new development programmes supported by Staff Requirements.

The Evolutionary Approach to CCIS

In traditional developments, the design team moves on once the system is delivered, often irrespective of whether the customer is satisfied or not. The delivered system is based on the terms of a contract expressing a Staff Requirement written years before. Such systems can quickly establish an ill-conceived reputation, irrespective of the fact that the Contractor may well have delivered what was asked for. Inconsistent CDS (Continuing Design Services) funding can result in the need for 'get well' programmes and an unsatisfactory aura of inadequacy pervades the system.

Because CCIS is predominantly based on commercial hardware and software, change is inevitable. Irrespective of the amount of development anticipated for operational enhancements, there will always be changes necessary for purely technical reasons. The need to maintain strict configuration control, both at the user sites and within the design support environment at the reference facility, not least to maintain security accreditation, demands a nucleus of expertise that must be sustained throughout the project's life.

In an evolutionary development at least some of the original design expertise is likely to remain. Individuals in the Company and in MOD identify themselves with successful projects and expanding systems. This has been very evident in the ASMA and OPCON/MHS projects. A similar loyalty is also evident in the OSIS OBU and JOTS programmes.

What marks evolutionary post-design development is the speed of implementation and high customer satisfaction, normally achieved to time and to cost and against a fixed price. It is however very dependent on assured funding which must cover at least a four-year period, with the release of funds being geared to a periodic audit or appraisal of the project to ensure that it conforms with the overall CCIS strategy and is a sound investment. A company that delivers what is required is in a strong and privileged position. If they are sensible about price (long experience with the company and periodic visits by the MOD technical costs team will tell you what is reasonable), then opening the contract to competition is probably not worth it.

It is essential however that the Ministry preserves full rights to exploit the software by making the delivery of an updated data pack available on demand at any time during the project life-cycle. The need to maintain such documentation is of course an essential feature of an MLS system. The commercial right to move the PDS support to another company must be preserved and not given away early in the project development, even when faced perhaps, with a seductive offer of a PV development to reduce price. Attempting to unravel which bit of the software was PV and which was paid for by the MOD years later, is a near impossible task. However, it must be recognized that the use of commercial software may result in the payment of licence fees. This aspect calls for careful management throughout PDS as it is a significant factor in the cost of ownership.

The US position on software ownership is entirely uncompromising. The US Government has full exploitation rights. They have, in fact, changed PDS software contractors for both OSIS OBU and JOTS. However there is an important difference. The US maintain their own reference facilities and do much of the system integration in house, employing a range of specialist contractors to support a small government team. They are therefore less dependent on the original contractor. Current MOD policy which calls for a reduction in MOD staff and facilities is not supportive of such an approach without the use of contractor support.

It is imperative that MOD seriously consider re-instating an 'in-house' capability for System Integration Authority, as few, if any, commercial practices competing for development and production of complex systems have any profit-oriented motivation for the long-term support of their products once an initial sale has been achieved.

Change Procedures

The change procedures used for OSIS and the UK Message Handling system are remarkably similar if terminology is ignored. In the US, all OSIS sites, including the UK, are represented at a bi-annual Fleet Planning meeting at which proposals, from whatever source, are discussed and prioritized. Ultimately the co-ordinated prioritized list is matched against available funds by the Project Manager.

In UK a similar procedure is followed for the MHS with inputs from users at the main sites co-ordinated by C-in-C-Fleet and the PE user application staff. MOD-directed changes, such as the need to interface with a new system or to establish a new node, are funded by individual Staff Requirements but are integrated into the overall programme of work, including those necessary to counter obsolescence in commercial software and hardware and those driven by security. The pace of change is therefore dependent on the total funding available. A fine balance has to be struck, calling for a clear strategy of where the system sits within the framework of Defence-wide CCIS, including the trade-offs to be gained by absorbing the functions performed by other systems in need of replacement.

The need to maintain the system's security accreditation in the face of change is difficult. Procedures have been devised whereby the contractor produces an assessment of each software issue for its security implications. This is then vetted on behalf of the Project by an independent security consultant who has full access to the contractor's site. He then reports to the PM and Communications and Electronic Security Group (CESG) on the scope of any re-evaluation required. A CESG Licensed Evaluation Facility (CLEF) is then employed and their findings used to correct any security shortcomings in order to maintain system Accreditation.

Costs

Maintaining a large CCIS system is expensive. As an example, the MHS costs run into several millions of pounds annually, divided amongst the activities shown in FIG. 1. Of particular interest is the fact that over half of the total £5m is required just to keep the systems running, without any significant changes being made. As already stressed, changes are essential to keep the system up-to-date, irrespective of whether new functionality is added or not.

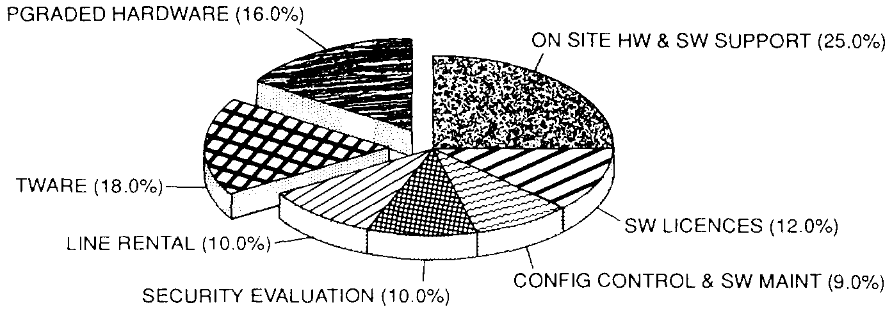

FIG. 1—EVOLUTIONARY POST-DESIGN STAGE—THE COST OF SUPPORT

FIG. 2 is based on figures supplied by Tandem computers and shows how hardware costs are falling—even discounting the commercial pressure on margins. By contrast, significant reductions in software costs even with more flexible hardware and improving software tools, are forseen as unlikely. The strong drive for greater functionality and the need to keep the system security accredited will see to this.

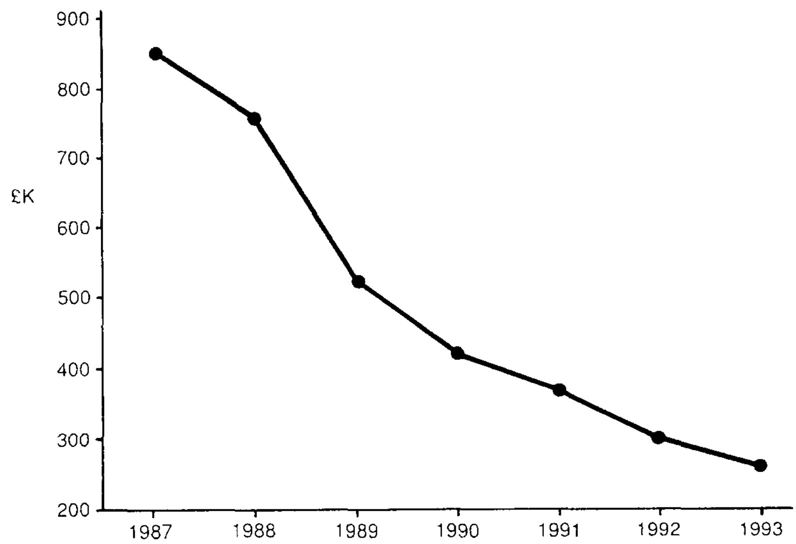

FIG. 2—PRICE TREND FOR SIMILAR CAPACITY AND CAPABILITY HARDWARE

So what are the conditions required to ensure value for money and for the Project Manager to drive down costs? Firstly there has to be a clear MOD agreed policy of the role the system is to fulfil in the overall CCIS Defence architecture for the next ten years. This must be backed up by project audits to refine and justify the broad programme of change for the next four-year period.

Costs can then be driven down by:

(*a*) Ensuring that the Project Manager's PDS contractors support team is the minimum to maintain effective configuration control and support and is able to undertake further development when called on, augmented if necessary.

(*b*) Looking carefully at software licence fees and possibly trade-offs by one off payments, multi-user licence fees and longer period licences.

(*c*) Migrating from dedicated line rental to common bearer system under DFTS (Defence Fixed Telecommunications System).

(*d*) Demanding that the PDS contractor holds competitions for all hardware where possible.

(*e*) Ensuring 'favoured customer' deals are fully exploited using the CCTA (Central Communications Telecommunications Authority) price guide as the starting point if you can. This is much easier if your project is known by Industry to have an assured future.

(*f*) Considering a single source maintenance support contract in collaboration with other projects.

(*g*) Being robust in maintaining the system security state. Ensure in-house staff know and understand the subject. Do not rely on the users' knowledge and the blind application of guidance documents.

(*h*) Considering exposing the PDS contract to competition. Ensure access to an extant data pack to make this possible.

Conclusions

This article may well be guilty of over generalizing. It has tried to concentrate on principles and ideas to provide food for thought and discussion.

It started with a definition for a successful system giving examples of successful CCIS projects in service both in UK and in the US. How they achieved success where others have failed, has been explained. Far from being high risk, the evolutionary path, properly followed, offers the only way of risk containment and is the only cost-effective way to give the user the CCIS he wants when he wants it. More than ever technology provides the tools to achieve this. It is not easy and places the Project Manager and his team in an even more important and accountable role. To answer this challenge the Project Manager needs training and experience, with full control of his resources. He needs well-trained and co-operative users on his team backed up by equally well-trained and motivated Project, Finance and Contracts staff. Given this professional team in house, Industry can be an effective partner. This is no more than is demanded by the business world. Here the successful management of change, with the application of modern IT and effective Project Management, is seen as providing the competitive cutting edge in today's difficult global market.

Reference

1. Jordan, G., Lee, I. and Cawsey, G.: *Learning from experience, a report on the arrangements for managing major projects in the PE*; London, HMSO, 1988.