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Management Issues in the Use of Commercial Components in Military Systems

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SUMMARY

Commercial off the shelf (COTS) products are being used increasingly in military systems, an approach that offers many advantages including lower initial acquisition costs, faster delivery to the front line and ability to utilise the latest advances in technology - a seemingly perfect match to the "faster, better, cheaper" ethos of modern acquisition initiatives. COTS products do, however, bring their own problems, including rapid obsolescence, lack of product control and fixed functionality optimised for the non-military market. In addition to addressing the complex technical issues that the use of COTS products brings, Defence Ministries and Industry will have to adapt their management approach and practices if the full potential of using commercial technology is to be realised, and dangerous pitfalls avoided.

This paper discusses some of the management issues that will have to be addressed and draws a number of lessons relating to the avoidance of obsolescence problems during the in-service life of a system or platform.

BACKGROUND

The use of commercial off the shelf (COTS) components is becoming an increasingly important aspect of the acquisition of military systems, particularly in the areas of information technology and communications. The use of COTS components should offer the potential to harness the rapid technological developments underway in the commercial world and to capitalise on the lower costs delivered by mass-market developments. Over recent years, these potential advantages have led to a view within the defence authorities and in industry that the use of COTS was going to solve many long standing problems in military systems, and would allow more capable systems to be delivered more quickly, at lower cost.

This initial widespread optimism is now being replaced by a realisation that while the use of COTS delivers many advantages, it also brings many difficulties and challenges of its own. These include more rapid product obsolescence, lack of control over product support and difficulty in predicting future developments. Many of these difficulties become most critical after systems have entered service and the obsolescence of their components has started to have a significant effect on support and development.

If these problems with obsolescence in COTS-based systems are to be solved and the attendant risks contained, then changes are required to the management of their acquisition and support. Much work has been directed at the *technical and design issues* relating to the use of COTS products. This paper, however, explores a number of aspects of the through life *management* of COTS-based systems, including initial acquisition, requirements management, managing upgrades, spares support and costing.

The paper focuses on information technology (IT) systems, as it is in this area that the rapid advances in commercial technology produce the greatest obsolescence problem. It is hoped, however, that the paper includes lessons of application in other acquisition domains.

This paper is based on work undertaken by the author for the UK Ministry of Defence (MOD) Defence Procurement Agency (DPA) and Defence Evaluation and Research Agency (DERA) Sea Systems Sector as part of a series of studies aimed at improving the COTS acquisition guidance available to UK MOD staff. The support of all those who contributed to these studies is acknowledged.

Paper presented at the RTO SCI Symposium on "Strategies to Mitigate Obsolescence in Defense Systems Using Commercial Components", held in Budapest, Hungary, 23-25 October 2000, and published in RTO MP-072.

COTS AND COTS-BASED SYSTEMS OVERVIEW

Terminology

Before embarking on a discussion of COTS it is necessary to define exactly what we are talking about, as common terms are often used inconsistently in this field. In this paper "COTS" refers to *commercial* off the shelf items, that is those that are developed for use in the commercial market, available from a catalogue or other description and delivered fully developed and ready for use. The paper does not specifically address other off the shelf acquisitions, such as the use of military systems bought with little modification (sometimes termed Military Off The Shelf, or MOTS) or the use of products developed by government (Government Off The Shelf, or GOTS). However, MOTS and GOTS items share a number of characteristics with COTS, and this article may offer a number of insights of value to those involved in such acquisitions.

Basic Characteristics of COTS Products

The basic characteristics of COTS components stem from the fact that they are developed for commercial, rather than military, purposes and that they are sold in large numbers (sometimes millions). COTS products have been designed to make a profit for the vendor, and not for the convenience of the (minority) military customer. Upgrades and changes are driven by predicted return on investment and not by some altruistic desire to improve or extend a product. The military user generally represents a small minority of the customers of a given COTS product, and military specific features are unlikely to appear high on the list of priorities for the vendor.

It is not the intention of this paper to provide a detailed description of the advantages and disadvantages of using COTS products. However, the following section summarise the main points, to put the management problem in context.

Advantages: The advantages of using COTS products have been advertised widely (possibly too widely). They include the following:

- *Low initial cost, with development costs amortised over many buyers*
- *Availability of established support arrangement, including development tools, vendor support and spare part support*
- *Reduced acquisition times by the use of standard pre-developed components*
- *Ability to capitalise on upgrades in technology developed for the commercial market*
- *Ability to adapt to meet new requirements*
- *Potential for enhanced interoperability*

Disadvantages

The use of COTS products is not all good news. In particular, COTS products suffer from

- *Rapid obsolescence, with support and spares lifetimes driven by commercial markets beyond the control of the defence sector*
- *Lack of product control with changes being made to meet commercial drivers*
- *Lack of Design Detail leading to difficulties in modifications and in safety and security certification.*
- *Mismatch with Military Standards*

COTS-BASED SYSTEMS AND COMPLEXITY

The complexity of developing a COTS based system is often underestimated. It is important to recognise that there is a considerable difference between buying a complete COTS system, sold commercially in the form or configuration that the military will use, and developing a system based on COTS components (referred to as "COTS-based systems" in this article). Lack of recognition of this COTS characteristic has been at the root of many management issues in the development of military COTS based systems.

There has been an impression that COTS-based systems are easy to build, and therefore the use of COTS will automatically reduce design complexity and hence cost, timescales and risks. This feeling has, to some extent, been generated by an incorrect extrapolation from the observed characteristics of complete COTS system purchases. When a *complete* COTS system is purchased, the system design has been carried out by the vendor and its complexity is hidden from the purchaser. Design cost has been amortised over a large number of purchasers, reinforcing the impression that the cost of COTS-based system design is low.

Unfortunately, this assumption is not valid for a typical military COTS-based systems, which will contain a large number of COTS components or products, each of which is *purchased separately from the vendor* and then integrated to form a new system configuration, *never previously developed and unique to this application.* This integration will involve the configuration of individual products to match their environment and typically require the development of custom code to provide interfacing functionality and to meet the specific system requirements.

The unique configuration will also place the individual components in a new environment, never tried before, and this may well expose incompatibilities previously unknown to either the developers or the COTS vendors. The situation is further complicated in most military systems by the need for bespoke applications to meet specific military requirements and the need to incorporate bespoke legacy applications.

As a consequence of these issues, COTS-based systems require at least as much effort in system design as any system based on bespoke components. Indeed, it may be argued that the fixed functionality and performance of the COTS components place *greater* constraints on the design of the system, forcing more iteration between system levels. This design iteration will not cease when the initial design is completed.

In summary, the combination of a unique design, the use of a large number of inflexible components in a new environment and a mix of bespoke and COTS elements, means that, contrary to widely held opinion, large COTS-based systems are inherently complex. Management plans that fail to recognise this complexity are likely to underestimate the effort and time required for system design, both during initial acquisition and during the in service life of a system.

CONTINUOUS DESIGN PROCESS

As the underlying COTS components are replaced by others (as they surely will be), the system configuration or design needs revisiting to address the characteristics and functionality of the new components. In some cases the changes will be minor, for instance when a component is superseded by another without affecting its functionality or interfacing, and the effort required will principally be focussed on configuration management. In other cases, however, the withdrawal of support for a key infrastructure component (such as an operating system or database) may necessitate a major redesign with impact on many other components in the system.

The interrelated nature of IT products can lead to a domino effect, with the change of one component requiring the replacement of many others. For example the change to a new processor could require a new operating system, which may in turn require application programmes to be replaced. It may also require the redesign of bespoke application software developed for the system. The unique nature of a given military system also means that with each change, components may be placed in a new environment, which can expose shortcomings in products not previously uncovered. This will need to be resolved before the system is put into service. Each major increment will, of course, also bring the need for extensive testing and revalidation.

The rapid turnover of COTS products and the consequent changes to the system design and configuration means that *a COTS-based system is in a state of continuous design, throughout its lifetime*. (See Figure 1)

This fact needs to be recognised in the through life management of a COTS-based system, and suitable resources and funding to support the continuous design process must be secured.

MAGNITUDE OF TECHNOLOGY CHANGES

It is readily apparent that the technology on which COTS products are based will change during the lifetime of a typical military system. While it is universally recognised that that changes *will* take place in technology, discussions with a wide range of military projects suggests that the *magnitude* of the changes is often not appreciated or taken into account in project management planning.

To get some idea of the likely impact of technology changes on military systems we need to look forward some twenty five years (at the end of which many systems currently in the concept stage will still be in service). If we look *back* twenty-five years, to 1975, we can see how far commercial information technology has moved. In 1975, there were no desktop computers, no Internet (in the form we would recognise today) and no mobile phones. Object oriented programming was an obscure specialist technique and interfaces were (at best) text based. The microprocessor was in its infancy (the 6 MHz 8080 and 6.4 MHz 6800 were both launched in 1974). Windowed user interfaces, mice, LCD screens, the world wide web, TCP/IP and HTML were still all years in the future. Figure 2 shows some of the key events over the last twenty-five years. In short, we can see that commercial technology has changed beyond all recognition.

It is generally considered that the rate of change of technology has been increasing over this period, and today new concepts and ideas are being introduced at a high rate. (The life of a commercial software product is typically 12 - 18 months before it is replaced by a new version, and some 2-3 years before all support is dropped.) It is against this background that we are asking industry to develop systems that will last for twenty or more years beyond In Service Date (ISD).

Some changes during this time will be predictable. The cost of processing power will continue to fall, bandwidth available to commercial users will expand, and the cost of storage (volatile and non-volatile) will reduce. However, as the last ten or twenty years has shown us, the way in which these developments will be exploited in the commercial world is impossible to predict.

If specific technology trends can't be predicted, those considering the design and implementation of COTS-based systems must consider the *magnitude* of the changes that are likely to take place. In the next 15 years we will see changes as far reaching as: the removal of keyboards and screens as interface devices, the demise of a web based approach or indeed of the internet as we know it, the advent of effectively unlimited bandwidth for commercial users (with the subsequent transformation in commercial system architectures and techniques) or the demise of the concept of a workstation running software. It is not suggested that all (or any) of these specific possibilities will definitely occur, but changes of this magnitude are certain to arise. The challenge to military COTS-based systems designers is to develop architectures and design and management approaches that can deal with this level of innovation during the 25-year life of a typical military project.

The rate of change of technology means that a system will have to deal with more than just component obsolescence during its lifetime. In the typical 25-year life of a system, commercial technology may be expected to have changed beyond recognition. Current standards, design approaches and architectures will have been superseded and forgotten. There is very little scope for assuming that we could continue to use today's hardware and software solutions throughout the life of a military COTS based system. Even though we do not know exactly what the changes will be, we must plan to manage this level of technology change if fatal obsolescence problems are to be avoided.

REQUIREMENTS MANAGEMENT

All studies into the use of COTS in military systems emphasise the need for a suitable process to manage requirements and requirement trade-offs. It is considered, however, that we have yet to see a system or management approach that handles this task satisfactorily.

If a COTS product is to be used in a system, there is very little scope to change its functionality (although many products have parameters and settings that can be changed). When a COTS product is selected, it is highly unlikely that its characteristics will match precisely those of the requirement. This implies that it may be sensible to accept the capability offered by the product despite the fact that it is not precisely what was originally demanded by the user.

As the design becomes more detailed, and different combinations of products are selected, then the match of these to the original specification will need to be assessed. In some cases the advantages (low price, availability, good support) offered by a COTS product will outweigh the fact that it does not match the original requirement. In other cases, there may be a need to select a different product, or use the product and enhance its capability by the use of other products, or by producing some bespoke application code to provide the required functionality. In many cases, of course, a COTS product will have features that were not originally included in the requirement, but which are of value to the customer. Design decisions such as these can only be carried out if the design team has the skills and experience to understand the needs of the user, and the impact of any possible design changes. This will require a very close relationship between the designer/system integrator and the user community.

Trade-offs between cost, risk, availability and functionality will continue throughout the life of the system. As obsolescence forces the change to a component, the selection of its replacement will require the same assessments to be carried out, possibly leading to further agreed changes to the user's expectations/requirement. The timescales of changes will often mean that later fielded systems are different from their predecessors, leading to the potential for a range of different systems in service, each developed during trade-offs for particular systems or batches of systems.

An additional feature of COTS-based systems is that the use of commercial technology should allow the rapid exploitation of advances in the commercial world. This, in turn, means that COTS-based systems offer the chance to enhance the requirement in a cost-effective manner. In particular it should allow military systems to exploit new applications and methods of working in the commercial world. The management of upgrades will need careful control; this is discussed further below.

The aspects discussed above indicate that if the full potential of COTS-based systems are to be exploited, then a close and dynamic relationship is required between end users, procurement staff and industry. This close working relationship will be required throughout the life of the system, as trade-offs and requirement developments are initiated by COTS product changes forced by obsolescence and upgrades. Such relationships are rare, with traditional acquisition approaches often leading to a confrontational relationship, rather than close cooperation.

A key to making sound decisions in this dynamic environment will be a clear understanding by all parties of the way in which commercial technology is advancing. Such knowledge will permit a realistic vision of what is likely to become feasible in the near future and will assist in foreseeing and managing potential obsolescence problems.

In summary, COTS-based systems involve considerable effort to be placed on requirement negotiation and trade-off. This process needs to involve all stakeholders, and many of the detailed decisions will continue to be required beyond Main Gate. Requirements evolution will continue throughout the life of the system, as new products are delivered by developments in technology and old products become unsupportable.

The use of rapidly developing commercial components brings the need for a paradigm shift in requirements management. Conventional tools and methods are inadequate to either capitalise on the huge advantages that COTS products could deliver or to avoid the pitfalls of obsolescence. A much greater emphasis is required on involving all stakeholders and a new approach to requirements management is required, based on continuous requirements evolution. If the full potential of COTS-based systems is to be exploited, then a close and dynamic relationship is required between users, procurement authorities and industry.

COST FORECASTING AND FINANCIAL MANAGEMENT

Successful project management includes a need to predict future costs, and plan future spending and manage the programme to remain within allocated budgets. In the procurement of military systems, it has long been recognised that initial acquisition costs are heavily outweighed by the costs of in service support, and this has recently led to an emphasis on through life or whole life costs.

Unfortunately, however, *accurate prediction of the long-term costs of a complex COTS-based system is not possible*, for a number of reasons. These include:

- A lack of suitable cost models.
- No agreed MOD/industry process for the maintenance and development of COTS-based systems through life, making assessment of through life costs infeasible.
- Volatility and unpredictability of future developments in technology.
- Unpredictability of the direction of future commercial developments and their applicability to military systems.

This poses particular problems in military system acquisition, in which acquisition authorities are expected to provide reliable through life cost estimates early in the programme to support the choice of contractor or solution. There may be reasonable assessments of costs through the initial acquisition of the system but cost estimates beyond this will be subject to significant uncertainty.

It is not possible to accurately predict the through life cost of a COTS based system. This fact needs to be recognised in the planning and funding of systems, and runs counter to most standard defence acquisition strategies. Failure to plan for this uncertainty, and to secure adequate flexibility in funding will delay the introduction of updates, leading to increased problems with obsolescence and support.

SAFETY AND SECURITY MANAGEMENT

The use of COTS products in systems introduces some significant difficulties with regard to system integrity assessments, in particular for safety and security assessment and accreditation. Those problems are caused by a number of factors, including the way that COTS products are developed and controlled, the lack of information and the rapid obsolescence and replacement of products.

The military world has traditionally insisted on systems meeting specific standards regarding product safety. It can generally be assumed that COTS products will not have been designed to meet these specific standards , although in some cases equivalent civil standards will have been addressed. In some cases these standards will be acceptable for use in the military environment, and the explicit requirement to meet a military standard can be waived. If this is not the case, however, the military system procurer may have to gather further evidence or undertake specific tests on the proposed or delivered products to assess their safety. Such tests may not, however, be cheap and gaining assurance that they will remain valid for all deliveries may be difficult. For example the source and chemical make-up of cases and components may change between batches, and toxicity tests undertaken on a sample product may not be representative of all such products. If assurances are required that tests will remain valid, then a manufacturer may have to establish additional procedures or a different product line, in each case this will invite additional costs.

COTS software presents particular difficulty in safety related (or safety critical) systems, because lack of control over the development method and lack of information render standard methods of assessing software quality infeasible. In particular:

- COTS products have already been designed, and so design and coding methods (such as the use of formal methods) can not be influenced.
- Code listings are not generally available for COTS software products, rendering static code analysis impossible.
- COTS products will generally have been designed to less rigid standards than those demanded by, for instance, Def Stan 00-55.
- Large software infrastructure components (such as operating systems) are of a complexity that renders exhaustive testing impossible.

Even if a product had been analysed and accepted, the short lifetime of COTS products can force repeated analysis. Any analysis will take time, and this may introduce delays in re-confirming the safety or security accreditation of the system.

These difficulties can be mitigated by good system design (for instance by partitioning of safety critical elements of a system, or by adding additional safety controls), and by using alternative assessment methods (for example assessing the general quality of a company's software or gathering evidence on the reliability of the COTS software product). The selection of the supplier should include an analysis of his credentials and qualifications in supplying safety critical software. The assessment of the system and the accreditation task itself will be simpler if the supplier has a suitable track record and is familiar with the development and accreditation of safety critical items.

The safety and security accreditation of COTS based systems presents considerable technical, design and management challenges. The difficulties and cost of initial and ongoing system accreditation must be considered in the development of COTS-based systems and in the selection of system contractors. Delays in the introduction of upgrades caused by safety and security issues will increase obsolescence problems.

MANAGEMENT OF SYSTEM UPGRADES

The key to successful ongoing support and improvement of a COTS-based system will be the development of a suitable infrastructure, into which new components and products can be inserted, combined with the development of a suitable management regime. The implementation of an open, flexible infrastructure, capable of adaptation, extension and scaling to counter obsolescence and to provide new functionality and capacity, is not a simple task. Those financing and approving programmes will have to take into account that it is more expensive to develop, implement and maintain such an infrastructure than to develop one that will simply meet the current demands.

Management of upgrades

The terminology relating to system modifications and upgrades is complex, diverse and inconsistent. It is important to distinguish between at least two different categories of system modification. These are:

- Changes driven by obsolescence ("technology refresh")
- Changes to increase capability ("capability upgrades")

Having made that distinction, however, we must recognise that there are limited opportunities for upgrades, and the need for cost effectiveness means that any significant system upgrade event will include elements from *both* of these categories. As the different categories of modification carry different responsibilities for specification and funding, this has the potential to introduce management difficulties.

The management of upgrades in a COTS-based system is a far from simple problem. It involves a wide range of stakeholders with conflicting interests, and successful resolution will require understanding of many viewpoints and interests. There are many tightly interrelated factors to be considered in managing system development and in planning individual upgrade events. These include cost, time required to implement the upgrade, time required for preparation, risk, obsolescence pressures, availability of COTS and legacy components, platform programmes, links with other programmes and specific operational demands. (Figure 3). These various aspects will need to be assessed and traded off in any particular upgrade, and this will require input and understanding by all stakeholders. The complex interrelationship between the various stakeholders will be simplified by clear understanding of their individual aims and responsibilities. Managing the upgrade process will require the co-operation and support of all stakeholders.

A through life view needs to be taken by all parties, and each must have an incentive to act in a manner consistent with getting overall value for money on a through life basis. Amongst other things, this means that:

- Those controlling the finance must recognise that there will often be an up-front cost to keep a system flexible enough to accommodate future (but currently unknown) capability upgrades.
- The acquisition authority must recognise that industry needs to make a profit, and enter into arrangements that allow for this while still ensuring good value for money.
- Industry must be given the incentive to invest in system upgrades and support facilities confident in the belief that these will contribute to increased return at a later date.
- The long term strategy for maintaining and upgrading the system needs to be agreed early in the programme, in order that the through life costs can be realistically estimated and suitable support arrangements put in place.

Management plans must recognise the complexities of managing technology refresh and capability upgrades. Successful management of upgrades will require the cooperation of many stakeholders, often with different and conflicting priorities. Successful management of upgrades will only be possible if there is a close and trusted working relationship between MOD and industry. The confrontational approach that is typical of many current procurements will preclude cost effective management.

CONTRACTOR LOGISTIC SUPPORT

Contractor Logistic Support (CLS) contracts, where the contractor is given the responsibility for supporting a system for a given period, are often seen as a standard solution for reducing risk on acquisition authorities and gaining cost effective support for a system. However, for COTS-based systems, there is a danger that, unless supported by other incentive schemes, the traditional CLS contract can contribute to *increased* obsolescence and higher through life costs.

As has been pointed out, COTS-based systems suffer from rapid obsolescence, leading to the need for continuous technology refresh if they are to remain supportable. If a contractor accepts a firm price CLS contract for, say, the five years following ISD then he will be under an obligation to support the system, and hence it will be in his interests to keep the system free from obsolescence problems during this period. However, he will not wish to spend more money than is necessary to meet his contractual commitments. As the end of the CLS period approaches, the system will be in a state that no further technology refresh is required to maintain the system for the remainder of the period. This point will probably be some three years before the end of the period. The contractor might not, therefore, undertake any work to mitigate against future obsolescence during these three years. The result will be that at the end of the CLS period, the system will be about to become unsupportable.

To avoid this, there is a need to provide the contractor with the incentive to keep the *through life* cost of obsolescence low. A fixed CLS period, with no further obligation or commitment, will only provide an incentive to keep the obsolescence cost low during the contracted period. It is clear that we will have to look at innovative solutions to this problems. These will involve working closely with their suppliers to achieve solutions that are of mutual benefit. For these solutions to be successful through life, the benefits will have to be capable of being shared between government and industry.

The management of CLS for a COTS-based system requires careful consideration, as the conventional "hands off" approach brings particular problems. A closer working relationship, and cost and risk sharing, will be required if a successful support regime is to be maintained.

SPARES SUPPORT AND CONFIGURATION CONTROL

The use of COTS components in a complex system introduces some significant difficulties in the domain of configuration management and spares support. These challenges are a direct result of the fundamental characteristics of COTS products, including:

- short periods of commercial availability,
- interdependence between products (including hardware and software interdependencies)
- the potential supply of compatible COTS components from a number of suppliers.

The principles of configuration management are as (or more) important in COTS-based systems as they are in traditional systems. However the widespread use of COTS products introduces a number of additional complexities to configuration management. These include:

- frequent design changes,
- lack of configuration information for COTS products,
- inter-dependence between hardware and software,
- need to track the installation of new versions even when they appear to be completely interchangeable,
- the many minor changes made to new COTS software products,
- the lack of reliability data.

The short supply lifetime of COTS components and the diversity of configurations make the supply of hardware spares difficult to manage. As new products appear, and old versions are no longer available, there will be a requirement to certify new products for use in a system and manage their supply and availability for the different system configurations in use.

The use of COTS components brings the potential for a configuration explosion, with each installation (and each sub-system within the installation) being significantly different from others. This in turn brings complexities for spares and support management. A balance will have to be struck between containing this diversity and the cost of limiting implementations to a manageable subset of configurations.

Whole life buys (or "Through life buys" or "Lifetime buys") are often proposed as a strategy for dealing with hardware obsolescence. Unfortunately, experience has shown that these are rarely a realistic solution, for a number of reasons:

- *Inter-relationships between software and hardware* - COTS-based systems often exhibit a strong interdependence between their components, and particularly between the software (both infrastructure and application) and the hardware on which it runs. In the commercial world, new processor upgrades are commonplace, and as new software is developed, support for older hardware is often dropped. The consequence of this is that if hardware is not upgraded then in a relatively short timescale, software cannot be upgraded further with a direct effect on the capability of the system to react to new threats and requirements.
- *Loss of ability to exploit new technology* - If the infrastructure hardware and software becomes frozen, then the capacity to modify the system to add new functionality is reduced. Software packages that the users may like incorporated into the system will not be available, because a modern commercial package will expect and require up to date or recent versions of the operating system, processors, peripherals etc.
- *Need for system development support environment* - In the longer term the decision to limit the system to obsolete technology will affect the development environment as well as the system itself. For example, as new software languages are developed, compilers will only be written for newer processors and operating systems. This will further limit the ability to upgrade the system.
- *Difficulty in predicting numbers* - It is difficult to gather or obtain MTBF figures for COTS products, either because the data has not been gathered, or because they have relatively short life histories, or because they have not been used in representative environments. This lack of data, combined with the possibility of the spares being rendered unsuitable by other changes in the system, represents a major risk in costing and undertaking whole life buys of spares.

Spares support for COTS-based system presents a complex management challenge, with the potential for serious configuration management problems. The principles of configuration management are just as important for a COTS-based system as for any other procurement, but the use of COTS products brings the potential for an explosion in system and sub-system configurations. This diversity carries a cost overhead, *and will need to be contained. It is essential that this issues is addressed in other management areas, including technical design, funding and support management. The use of through life buys of spares is rarely an adequate solution to these problems.*

CONCLUSIONS

Military acquisition is moving into new and uncharted waters. The use of COTS products as the basis for military systems brings many advantages, but it also brings many challenges. To meet these challenges will certainly require new technical skills and an understanding of the characteristics of COTS within procurement organisations. However, COTS-based systems also bring management challenges, many of which run counter to current working practices in military acquisition. If we are to rise to these challenges, and harness the potential advantages of COTS, then a change in management culture and philosophy will be required, allowing the introduction of new management approaches, representing and balancing the needs of all stakeholders in government and industry.

BIOGRAPHY

Richard Ellis is a Principal Consultant with Stratum Management Limited and has over 12 years' experience of system acquisition management and research for the UK Ministry of Defence (MOD). He joined the British Royal Navy in 1977, and during a 13 year career as a Weapon Engineer Officer gained a BSc in Electrical Engineering and an MSc in Intelligent Systems. Since leaving the Royal Navy in 1990, he has worked as a technical management consultant with Crew Services Limited and more recently with Stratum. During this time he has supported a wide range of MOD projects, both in the Procurement Executive and Defence Procurement Agency and in the Defence Evaluation and Research Agency. Much of his work in 1998 - 2000 has been in the development of MOD acquisition policy for systems based on Commercial Off The Shelf components. In addition to his work in military procurement, Mr Ellis is also the Director of Advanced Technology for ideadollar.com, an internet based innovation company, and is actively involved in the UK artificial intelligence community.

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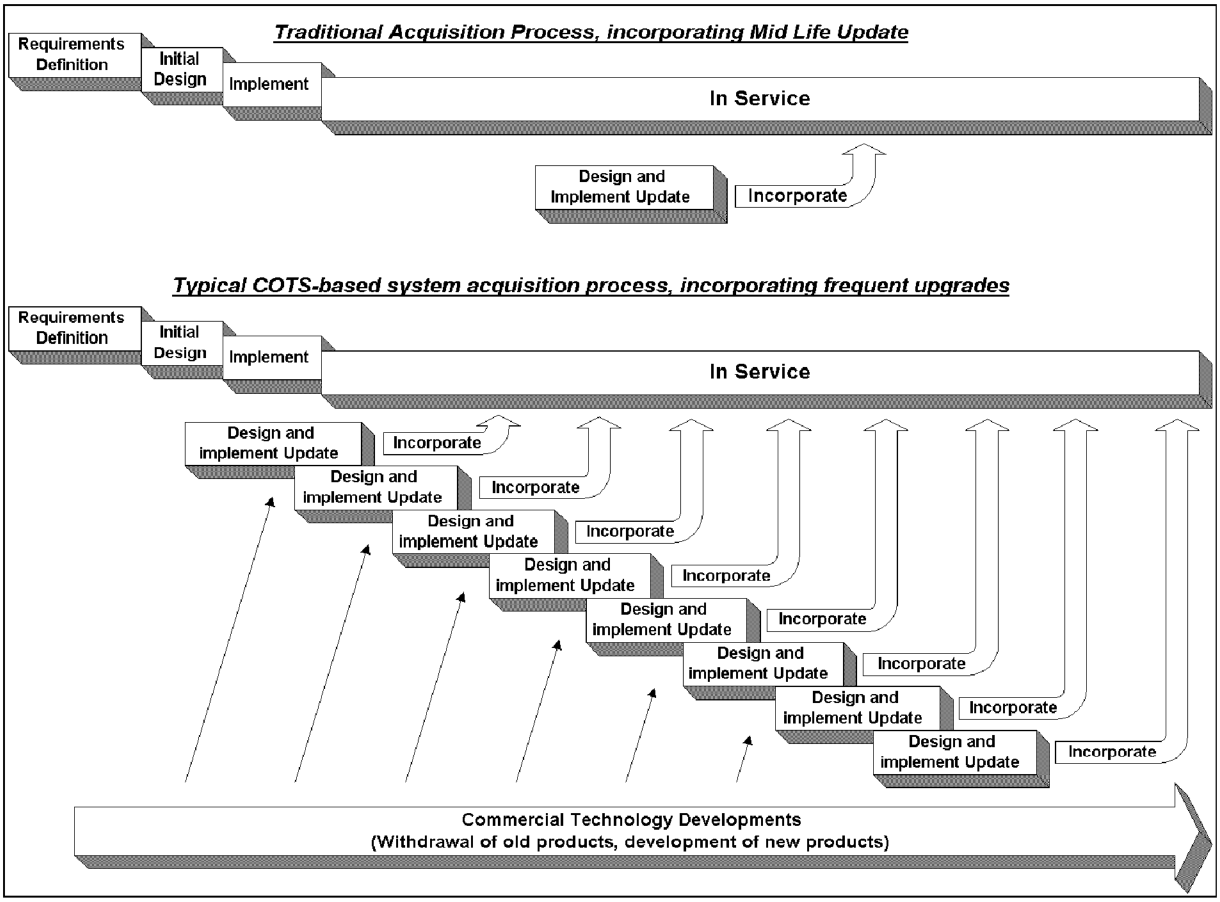

Figure 1 - Comparison of traditional and COTS-based system acquisition lifecycles

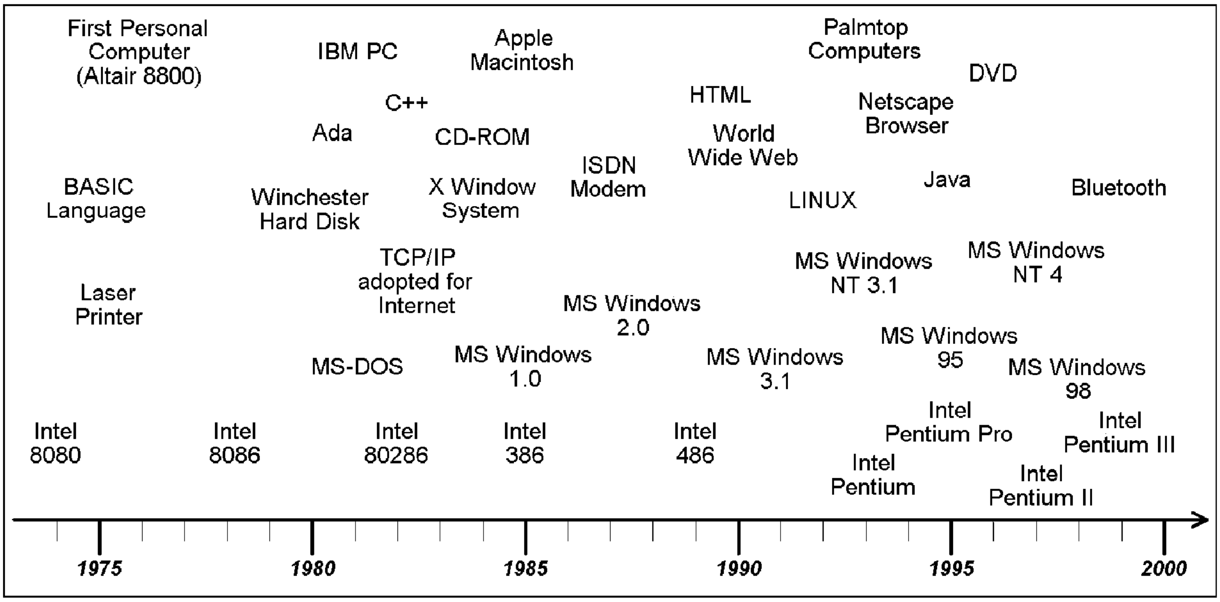

Figure 2 - Selected events in the development of commercial technology

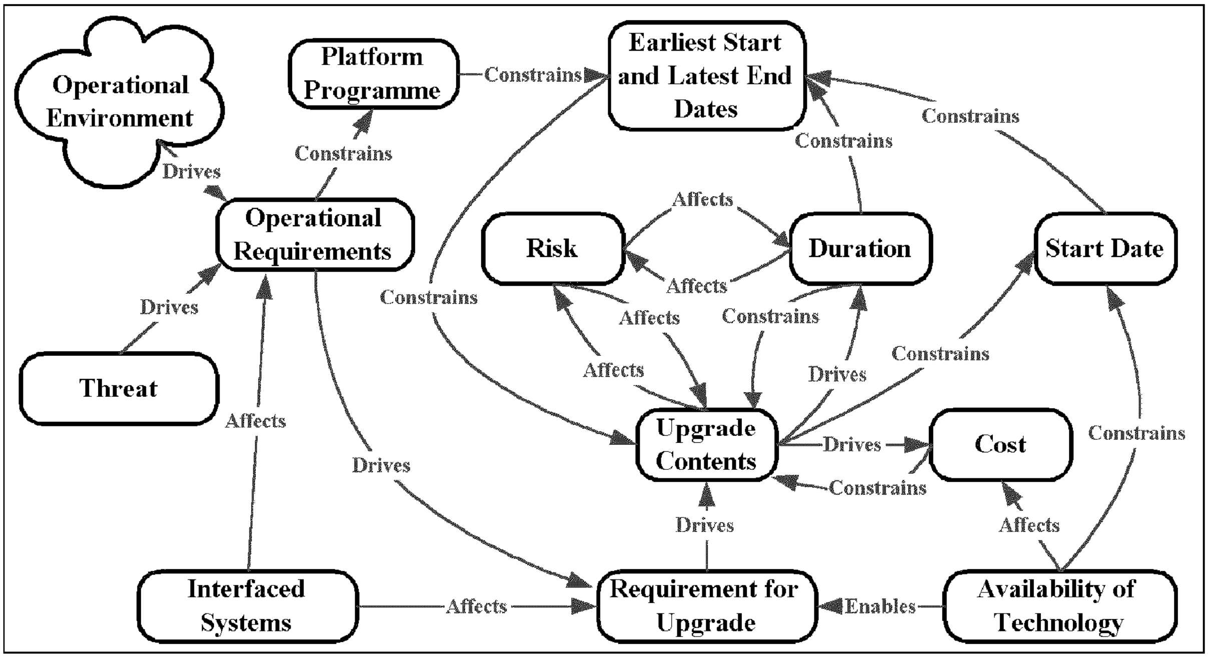

Figure 3 - Influences on system upgrades