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Integrated Approaches in Economics of Contracting and Knowledge Management

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Abstract

Knowledge management (KM) in the space sector is a particularly interesting study owing to the specific characteristics of lack of patenting and recording of information associated with security considerations, as well as the sectoral age pyramid and the obsolescence of equipment that results in significant KM transaction costs and loss of information. Coupled with the custom-made nature that is typical of space projects, the analysis in this paper focuses on contractual mechanisms that incorporate transfer of KM within and beyond a project's life-cycle and the implications for specific types of contracts that are typically used -mostly in procurement. This leads to incentives for contractors to enhance also inter-firm transfer of knowledge and develop the management tools that will sustain virtual skills of past project teams. The paper shows that this approach can result in significant benefits for all stakeholders, despite challenges associated with potential transaction costs in contracting and lack of standards and relevant experience in usage of such mechanisms. Finally, a critique of the industry tradition of cost and performance assessments prior to end of lifetime is emerging.

Keywords

economics of procurement, contracting, knowledge management, space

1. Introduction

The economics literature on knowledge management and innovation draws heavily upon Arrow's seminal paper in 1962 on inventive activity and the creation of knowledge under conditions of imperfect information (Arrow, 1962). The issues of moral hazard and adverse selection are discussed along with the under-allocation of resources in research owing to (amongst other things) the challenge of appropriating knowledge, creating disincentives for enterprises within a free-market economy. While Arrow recognizes the significant efficiency benefits arising within a competitive market structure, he also acknowledges how “non-profit” seeking institutions are best placed to pursue the creation of knowledge associated with invention in the face of appropriation challenges, with prominent examples universities and the government. With regards to the later, the significance of cost-plus contractual arrangements is emphasized when the government is issuing relevant contracts for the creation of knowledge and invention:

“A second example is the cost-plus contract in one of its various forms. When production costs on military items are highly uncertain, the military establishment will pay, not a fixed unit price, but the cost of production plus an amount which today is usually a fixed fee. Such a contract could be regarded as a combination of a fixed-price contract with an insurance against costs. The insurance premium could be regarded as the difference between the fixed price the government would be willing to pay and the fixed fee. Cost-plus contracts are necessitated by the inability or unwillingness of firms to bear the risks. The government has superior risk bearing ability and so the burden is shifted to it. It is then enabled to buy from firms on the basis of their productive efficiency rather than their risk bearing ability, which may be only imperfectly correlated. But cost-plus contracts notoriously have their adverse allocative effects. This somewhat lengthy digression on the theory of risk bearing seemed necessitated by the paucity of literature on the subject. The main conclusions to be drawn are the following: (1) the economic system has devices for shifting risks, but they are limited and imperfect; hence, one would expect an underinvestment in risky activities; (2) it is undoubtedly worthwhile to enlarge the variety of such devices, but the moral factor creates a limit to their potential (Ibid, pp. 613-614)”.

The importance of cost-plus contracts issued by the military is highlighted, and further elaborated upon by the less-acknowledged follow-up commentary by Hitch. Hitch using examples from the military/space industry (Atlas and Titan program) focuses on the challenges of the applicable mechanisms and the incentive implications of using the ‘new’ cost-plus contracting policy by the military:

“Nevertheless, the new policy appears far from ideal. The aircraft companies risk nothing (even the cost of preparing designs is usually reimbursed). Because of the great uncertainties involved in any major development, it is hard to make a wise selection at the design stage. Companies have a natural tendency to be optimistic in estimating performance, cost, and availability at this stage—sometimes much more so than at other stages as Klein and Marshall and Meckling have shown. Arid the Air Force has a natural tendency to favor the more optimistic proposals. As a result, the specifications in the development contract are sometimes unrealistic to the point of causing inordinate delay. Moreover, once the winner has been selected, there is no more competition. The company may put its best team on the development for the sake of patriotism or its own long term reputation, but the powerful incentive of competition is lacking. Partly for this reason the Air Force, locked to a sole source with a cost-plus contract, has to exercise a kind and degree of control during the development process that is inconsistent with management prerogatives as they are understood and practiced in other parts of the

free enterprise economy. I believe the inefficiencies resulting from these policies and procedures are serious, and worthy of much more attention by economists. It does no good simply to inveigh against the iniquities of cost-plus contracting and government risk bearing when we are unable to propose a practical alternative. Perhaps part of the answer lies in some form of risk sharing. What is badly needed here is an economics invention or, more probably, several of them. The government is going to be in the business of supporting research and development on a large scale for a long time, and it is important that it use policies that take advantage of the incentives present in the economy" (Hitch, 1962).

Since then a substantial spectrum of literature has sprung out of the economics discipline, largely focused on procurement and contracting (Laffont & Tirole, 1993), as well as, on knowledge management, where the relevant literature has mushroomed in the direction of enhancing the role innovation and knowledge creation plays in the economic development and efficiency in filling in the gaps identified. The approach taken in this paper is to synthesize a project management (PM), knowledge management (KM) and economics of contracting (EC) approach that examines the knowledge-related market failure within a total life cycle contractual perspective. In that respect, research-oriented contracts can potentially act as a KM mechanism within an integrated, systematic approach that ensures not only the efficiency on the creation of the invention, but also of the often-overlooked knowledge creation and sharing in the process of doing so. The rest of the papers is structured as follow: the next section presents a discussion on the KM in the space sector with references to the KM background literature and the applied efforts, initiatives and characteristics found primarily in the space agencies; this is followed by the contracting mechanisms and characteristics of the space sector and their links with PM that address cost and time overruns within a life-cycle approach; this is followed by examining the question of potential mechanisms and challenges in imbedding knowledge management within such a life-cycle framework.

2. Knowledge Management and the Space Sector

- The purpose of KM according to Despres, Charles and Chauvel (2000) is to enhance organizational performance. This is achieved by using different forms of knowledge following a process of specific design of tools, processes, systems and culture that capture and share knowledge necessary for decision-making.
- Other scholars refer to a set of management activities, aimed at designing and influencing processes of knowledge creation and integration including processes of sharing knowledge (Foss & Mahnke, 2003).

The treatment of knowledge as an asset and a valuable resource has been researched and modeled in economic theory from early on in the form of embodied and disembodied technological progress. Technology has been considered as an important element of economic development and the knowledge-creation has been seen as a centerpiece of economic progress even within a macroeconomic perspective (Romer, 1992).

The challenges associated with management of knowledge and its implications have drawn a wide spectrum of analysis within an interdisciplinary context. Knowledge is seen as an asset, yet its value is not given, and processing and integration is important in exploiting its potential, much like rough diamonds. Reference Bartholomaei (2005), based on Cowan, David and Foray (2000) classifies knowledge according to three different formats, namely tacit knowledge that is best described by using the example of the basketball player that scores, but can hardly explain how it is done; codified knowledge, which is reproduced easily and recorded and the intermediate unarticulated knowledge. Arguably, unarticulated knowledge could potentially be codified (at least in part), but there may exist tacit elements that would result in loss of information.

Analysis of properties, problems and tools of different knowledge types.

Table 1. Classification of Different Knowledge Types

	Codified Knowledge the "known knowns"	Unarticulated knowledge the "known unknowns"	Tacit knowledge the "unknown unknowns"
Economic properties	Non-rival good, Quasi equals information, Easy to store & transmit, Needs codebook	Potential value if known how to articulate & cost of articulation is clear	Idiosyncratic to owner or community Economic value rather difficult to access
Problem areas	• Codebook – transformation & appropriation • More codified knowledge is not always positive but equals information "flux"/overload, • Owner/Context specific – for interpretation and usage as well as creation • Most information/knowledge cannot/will not be used	• Codebook is displaced or needs to be invented/created, • At what cost? • Potential trouble with languages • Political reasons for "unarticulated" states • If articulated, might lose history, hierarchy and tradition	• No quality assessment/measurement possible • Misuse with "all or nothing" meaning of concept, • What cannot be articulated can not be known to exist (for self and others), • Neglects business interests and potential economic benefits • Difficult to make decisions on possible transition to other knowledge type • Forecloses any further exploration in direction of codification
Tools of knowledge creation	Portals and Databases, WWW, books, networks	Inscription tools (recording of film and sound), Human mind and group/community interaction	Human mind and group/community interaction

Source: Bartholomaei (2005).

Knowledge management can thus be seen as the process of using procedures and techniques to optimize objectives using an organization's tacit, unarticulated and codified know-how (see also Teece, 2000). Creation, integration and sharing of knowledge are subjects that have received significant attention by the literature, given the multidisciplinary potential of the subject and its significance. The significance of knowledge and ideas for the economic development is as important as their usage and diffusion within a production process:

"Acceptance of and competition among new ideas is what allows organizations and their nations to remain on the creating rather than on the destructing end of Schumpeter's (1942) 'perennial gale of creative destruction', and the widespread diffusion of these ideas is what fosters the development of what Quinn, Anderson & Finkelstein (1996) call know why (system understanding and trained intuition) instead of only know what (cognitive knowledge) and know how (advanced skills) (Cummings, 2003).

It is also important to understand and appreciate that knowledge can be embedded in products and physical hardware. The process of extracting knowledge and codifying it is sometimes not very different to an archaeological process, given that specificity of knowledge may affect its transferability. Reverse-engineering of products for example does not directly lead to knowledge regarding production process of the whole, or parts of an asset. The transfer of technology regarding ex-Soviet space hardware that has been purchased by western firms (RD180 engines and other) following the collapse of the Soviet Union is expected to have resulted in challenges associated with the hardware necessary for mass-production and quality controls embodied in the production process that are harder to transfer; not too dissimilar to the electronics industry experiences with regards to processes and knowledge diffusion in miniaturization (Prahalad, 1993; Leonard-Barton, 1988).

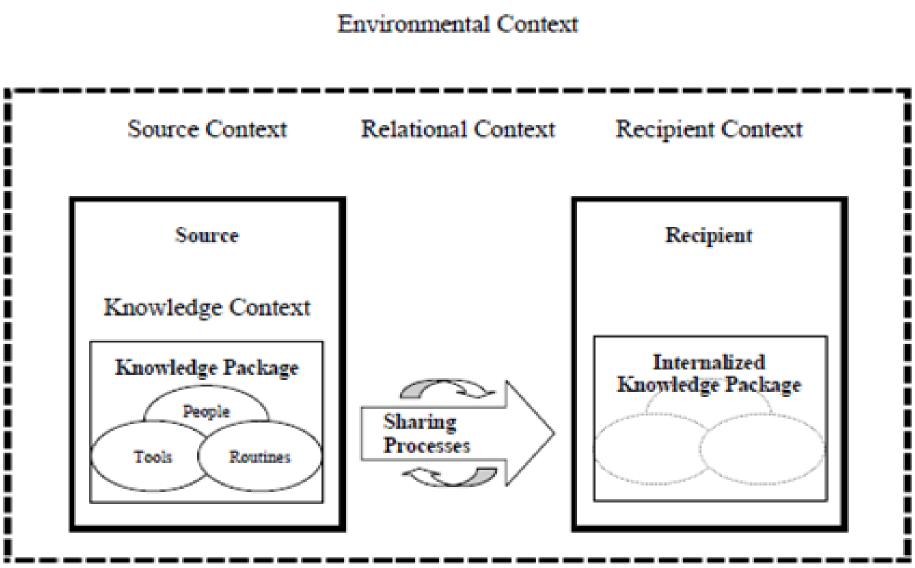

Figure 1. Knowledge Sharing Process

Source: Cummings (2003).

Knowledge sharing then is affected by several factors, such as distance and mediums of sharing, pointing to physical presence coupled with reconstruction and adaptation as an optimal means to transfer and utilize knowledge, as opposed to recording-based impersonal approaches (Athanassiou & Nigh, 2000; Davenport & Prusak, 1998). Culture, harmonious relationships between recipient and source and the strategic intentions are also of importance (Hamel, 1991; Yeung, Ulrich, Nason, & von Glinow, 1999; Arrow, 1971). This is of particular importance in sectors where national security considerations exist in cross-national exchanges.

2.1 Space Sector Characteristics

The space sector is subject to some idiosyncratic characteristics associated with it origins, of particular relevance to the KM theme. The cold war requirements and the space race that accompanied it from the late 1940s up until the collapse of the Soviet Union led to the development and flourishing of the space industries within key space-faring nations. The centrally-controlled governmental requirements led to an erratic development path of the industries and technologies, but also of the -often overlooked- relevant workforce that generated and became the depository of tacit knowledge. The urgent nature within which specific space programs contributed to this “race” placed a low priority the management of knowledge generated. To this contributed the security constraints and characteristics associated with any race and military framework that it is “the relevant position that matters”; hence no significant patents that would identify classified information would be submitted, neither were resources devoted to recording information and knowledge that would have to be cumbrously classified. Coupled with a low-risk tolerance sector and team-requirements that led to an aging workforce in the space sector, this resulted to the process of codifying knowledge of early programs increasingly resembling archaeological methodologies of ancient technologies.

The atypical profile of the workforce stocks and flows that are reflected in the pre and post-cold war era, as well as the wide spectrum of customized space programs through time are key factors resulting in challenges for trans-generational sharing of knowledge and processes of personal communication and engagement in the diffusion. Reconstruction and adaptation is thus frequently not an option, nor is physical presence.

Such codifications take the form of interviews as well as summaries from interviews that can then be edited and given different classification levels contributing to the creation and dissemination of valuable knowledge and lessons learned. Several initiatives are undertaken around the world in trying to preserve knowledge of the early space programs, not only for historical purposes, but also owing to the unique nature of space projects, allowing the repetition of tasks such as landing on the moon again without the need to “reinvent the wheel”. Obsolescence is of particular importance not only for the military, but most importantly for the space sector, where ‘one-off’ projects do not exist in the prototype phase but constitute the final “production run”. The UK’s effective withdrawal from major space civilian programs, including efforts for reusable launch vehicles (e.g., HOTOL) has led to past knowledge that has not been continued and developed, similar to several US and Russian early efforts.

British Library's series of oral recordings online regarding a number of issues, including space-related themes with numerous interviews on past UK space activities (Bob Parkinson; Roy Gibson and others interviewed under "oral history of British science" (Note 1).

A number of KM programs have sprung out trying to codify knowledge and close the gap developing as an aging generation of space engineers and managers is been replaced by a younger workforce that has no experience in discontinued past programs (De Long, 2004; Liebowitz, 2004).

NASA follows a multi-dimensional KM strategy both with regards to knowledge distribution as well as obsolescence and lessons learned approach in an evolutionary approach (Figure 2, Holm, 2010) (Note 2).

NASA's decentralization organizational approach results in centre-specific policies and implementations (General Accounting Office (GAO), 2002) intended to complement integrated approaches (NASA Engineering Network: NEN/ Office of the Chief Engineer, that shares best practices and integrates information from industry, academia, government and NASA; Holm, 2010; Holm et al., 2002). Centre-specific activities are more customized, for example, Goddard space centre maintains the office of chief knowledge officer with usage of case studies methodology (mostly publicly available on-line) along with workshops and other communication and information dissemination mechanisms.

ESA is undertaking a KM holistic approach with emphasis on workshops and information distribution tools. The undertaking of an end-to-end KM approach results in systemic challenges given the multinational nature of the European space environment (Figure 3). The European Space Technology Requirements Database (ESTER) is a key element of the end-to-end process (E2E), as the main knowledge depository.

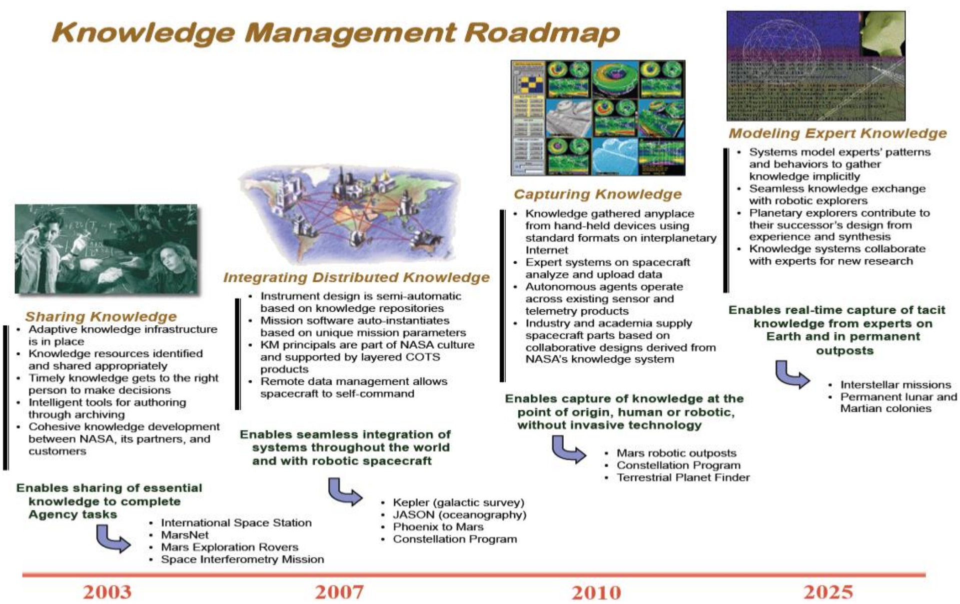

Figure 2. NASA Knowledge Management Roadmap

Source: Holm (2010).

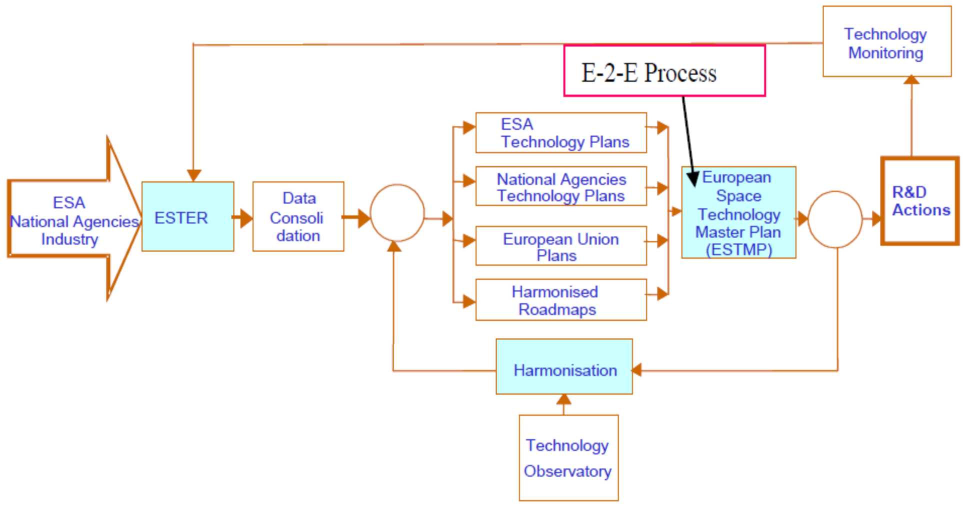

Figure 3. Knowledge Management and R&D in European Space Activities

Source: adapted from Guglielmi and Westman (2010).

Challenges owing to the intergovernmental nature and political background lead to difficulties in adopting and implementing standards in data formats and lessons learned implementation owing to divergence in cultural work environments.

It must be noted that the (electronic) codified storage of information entails increasing risks of security and dissemination of critical technologies and methods that are of crucial importance for the sector. Another point of caution relates to the objectivity of information: protagonists that are silent or have left would not necessarily share perspectives and approaches recorded with conclusions based upon such 'holy grail' inputs. This processing is critical in transforming data and information into knowledge. Furthermore, this processing becomes critical given the opaque nature of the industry, as opposed to more commercial and transparent sectors (Zeckhauser & Pound, 1990).

In conclusion, a security-sensitive environment coupled with intergenerational gaps in workforce and wide spectrum of space programs leads to significant challenges in codifying knowledge, sharing knowledge and integrating it in the space sector. KM efforts are largely focused on codifying information via reports on historical specific programs and also interviewing but are largely of an ad-hoc nature and do not always share standards. Networks and electronic means are also widely used, but mostly focusing on obsolescence, rather than strategically developing a standardized approach.

3. Knowledge Management in a Total Life Cycle Framework

Project management is increasingly concerned with the life-cycle costs (LCC) of projects and operations, given the obsolescence considerations and maintenance of operations cost. This allows the accurate costing for the lifetime of the project to take place, as it examines the expected duration of the project and assesses the risks throughout R&D, operations and disposal, for example of satellites. In this section, the contractual framework that encapsulate this approach is presented and analyzed with regards to the efforts to not only accurately depict the life-cycle information necessary for the appraisal of program, but also to imbed KM elements that are sometimes as much the focus of a strategic approach in the space sector, as experienced during the early days of space programs in the cold war.

3.1 Space Sector Contracts and Total Life Cycle

The procurement processes in the military and space sectors share some characteristics. An important one is the dual role of the space agency with regards to the appropriations process; namely that as implied by Arrow (1962), prior to the awarding of the contract the space agency's objectives are in-line with the industry's objectives to lock-in the funding bodies and accept undervaluation of costs. It is however expected that following the awarding the space agency will subsequently monitor costs and rent to the industry (Zervos, 2008). The several choices the space agency is confronted with in the procurement of space assets are multi-dimensional extending to the type of contract used, the (un)competitive nature of the awarding process and many other choices that can influence efficiency (Zervos, 2011).

The type of contract employed has profound implications for KM: a low-monitoring requirement contract for off-the-shelf items would be a low-value candidate for a KM approach during its drafting. In contrast, a riskier cost-plus contract would be expected to result in a higher stock of new knowledge both with regards to the product deliverables and the managing process. One would thus expect cost-plus type of contracts to be better candidates for applying a KM approach to their deliverables and drafting. In terms of the efficiency implications, the profit of the firm from a space project can be formulated as follows (Sandler & Hartley, 1995):

$$\Pi = \Pi e + s(Ce - Co) \quad (1)$$

Π = realized profitability by contractor

Πe = estimated profitability of contractor

Ce = estimated costs of contracted space project

Co = actual costs of space project

s = sharing coefficient. It reflects the rate at which the difference between estimated costs and realized costs is spread between the agency and the contractor. The value of s is between zero (cost-plus) and one (fixed price; $0 \leq s \geq 1$).

Given a positive relationship between the sharing ratio and effort, when the government pays the full excess costs, and allows the firm to make no more than the expected profit ($s = 0$) the firm has very little incentive to exert effort to diminish actual costs (note the Average Cost -AC- implications in Figure 4).

The cost plus fixed fee (CPFF) type of contracts employed by NASA are thus perceived as resulting in minimum cost risk, while maximum cost risk (and minimum profit control) is expected by firm fixed price (FFP) type of contracts. In between those extremes lie the cases of cost-plus award fee, cost-plus incentive fee and others.

One important note is that reality is often different to the theoretical approach when dealing with contract types in the space and military sector procurement. ESA for example exhibits a preference for fixed price contracts, as opposed to cost-plus. This can be partly attributed to the intergovernmental nature of ESA and the requirement that the industry of contributing nations is expected to receive contracts of analogous size to the national contributions. Thus, it is highly challenging to monitor cost-plus contracts and relevant performances across national industries and agreeing on performance incentives and penalties on a continuous basis. ESA is using FFP type of contracts, cost-reimbursement (or cost-plus) and a novel "ceiling price to be converted to firm-fixed-price" (CP-FFP), where the initial period is similar to a cost-plus with a maximum price and once information becomes available the contract evolves into an FFP. This hybrid type is aimed at avoiding the frequent usage of FFP contracts being altered following engineering notes so as to accommodate information that was unknown at the beginning given the high degree of technological novelty of several programs (Zervos, 2011).

The use of cost-plus contracts is widely applied in the US by NASA and the DoD that experience less organizational and political constraints in monitoring and assessing high-technology projects. The intergovernmental nature of ESA does however offer the advantage of implicit controls as several partners/stakeholders share information within an opaque, yet 'peer reviewing' framework. NASA's extended usage of cost-plus is often seen as endemic to cost-overruns:

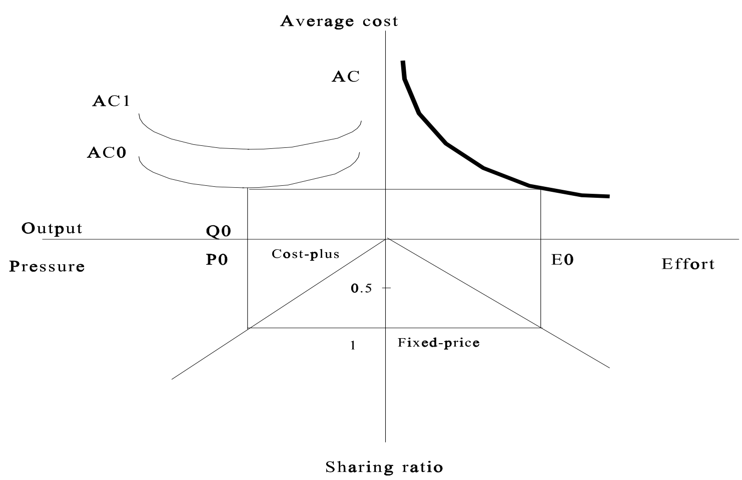

Figure 4. Contract Types, Effort and Cost

Source: Sandler and Hartley (1995).

"A cost-plus contract typically allows for the contractor to spend a proportion above the expected value, but on this overrun there is no profit, hence no incentive for such overruns. However, when successfully negotiated if a contract does not 'lock' in terms of its funding profile by full commitment of the funding authority, then the contractor effectively is facing an annual re-negotiation process for each incremental funding period. In effect, the cost-overruns become part of next period's profile and thus are never treated as overruns. The overrun is real in terms of the overall project, but has little impact

on the contractor's profitability, or incentives. The same can be said about ESA's contract with ceiling price to be converted into fixed price (CP-FP). To illustrate this, what would be considered contract overruns under a well-defined, cost-plus, or fixed-price contract at the signing of the contract, become 'additional information' leading to a de-facto re-drafting of the contract terms. For NASA, this takes place on an annual basis, for ESA's CP-FP contracts this institutionally is supposed to happen once" (Zervos, 2011).

In effect the labelling of contracts as "fixed price", or even "cost-plus" is often inconsistent with the completion path of the project (especially in view of contract change notices- CCN), in effect constituting a "set of renegotiated cost-plus" contracts (Zervos, 2011).

The applicability of in-essence cost-plus mechanisms for distributing risk during the early stages of a project (where the risks are high) to the government is thus subject to different types of contracts and mechanisms but appears to suffer from the same problems and imperfections identified since Section 1.

Thus, there is substantive scope for the application of KM and assessment not only in individual contracts but also as a mechanism of integrating assessment and knowledge from a string of relevant contractual arrangements. Cost-plus and CP-FP are thus expected to generate more information sharing and increase the KM exposure of the recipient agency (as opposed to the fixed-price contracts, where limited exchange of information is expected through the program).

To complement ESA's informal "peer-review" mechanism, the position of ESA Inspector general can be seen as resulting to knowledge creation and assessment of specific contractual performances (Dubock, 2011). In the US the performance of cost-plus contracts for the acquisition phase (not for operations) is formally assessed during the length of the contract by formalized Earned Value Method Systems (EVMS), which assesses and evaluates program performance, but also by GAO and other organizations in an ad-hoc manner (Note 3). Overall though, no integrated KM approach exists to ensure a life-long approach.

"For more than a decade, GAO had identified NASA's contract management as a high-risk area. NASA had been unable to collect, maintain, and report the full cost of its programs and projects. Because of persistent cost growth in a number of NASA's programs, GAO was asked to assess 27 programs—10 in detail. GAO found that only 3 of the 10 had provided a complete breakdown of the work to be performed Underestimating full life-cycle costs creates the risk that a program may be underfunded and subject to major cost overruns" (GAO, 2004).

The EVMS has grown out of the need to monitor and evaluate cost-plus type of contracts by evaluating actual and budgeted costs along with monetary estimates of actual work completed at a point in time/milestone during the duration of the program. This can then be used to forecast the costs and value schedules for the remaining of the program.

EVMS results in sharing of information and generation of information in a structured manner, but mostly until the delivery. EVMS is resource-intensive (Zervos, 2011; Zervos, 2011) and thus embedding a cost-overrun focus, as opposed to a wider KM approach.

Figure V shows schematically challenges associated with the EVMS approach. At time T1 the work value completed (a) is lower than work budgeted (b). In contrast, actual cost (c) is higher than cost budgeted (b). It is therefore (re)estimated at T1 that the initial contract box ToTpBaC will expand outwards to ToECBTd. The cost overrun is illustrated by the difference between ECB and BaC, while the time overrun is the difference between Td and Tp.

It must be noted that if actual work completed incorporates elements that are not part of the original package, this value is not depicted by the “Actual work value” scheme. Thus, at time of completion (Td) actual work value will be defined by information and benchmark at initial time (To). In contrast, ‘Actual cost’ includes in a more realistic manner all costs incorporated. This creates an unbalance, especially if the benchmark of the project changes as the technology matures and the risks diminish, but such changes are not incorporated in the “Actual work value”. This would require a “revised work value” benchmarked against the project at T1, rather than To. The “revised work value” in Figure 5 is higher at time of completion (Td), than actual work value, or budgeted work value set at time To. The knowledge gathered up to point T1 allows the extrapolation and re-forecasting of the actual work value path and actual cost and time-to-completion estimates to be undertaken. This de-facto leads to some lessons learned internalized within the forecasts at time T1, but otherwise a limited KM approach is undertaken, and no specific policies accompany the relevant contractual relationships.

Thus, sharing of knowledge is limited and specifically focusing on the issue of cost-overrun and until the completion of the acquisition. This could be enlarged to provide the right mechanisms (if not incentives) either embedded within contracts or embedded within EVMS-type approaches that will widen the scope of managing and sharing information across the principal and the agent of a contract.

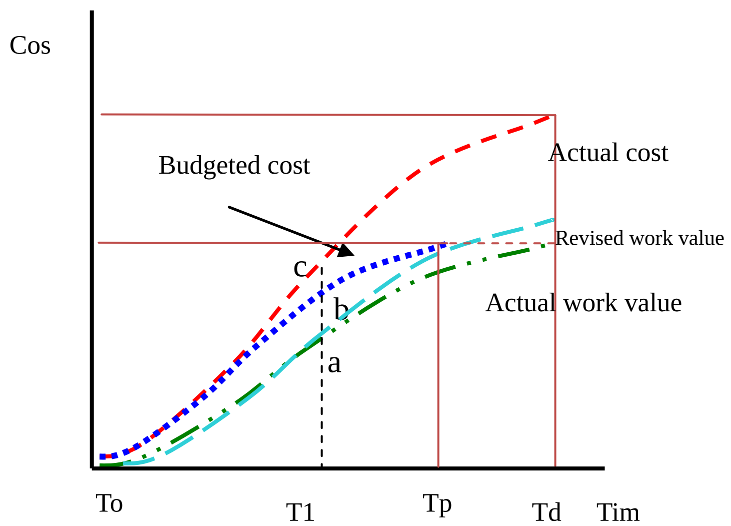

Figure 5. Earned Value Method with Revisions

Notes. Budget at Completion (BaC) = expected completion budget at time To; Estimated Completion Budget (ECB) = estimated budget at time T1; To = starting time of project; T1 = current time; Td = expected completion time at T1; Tp = expected completion time at To.

The KM in the post-acquisition (operations) phase is detached and can thus follow different methods and approaches as opposed to the situation under EVMS (Price & Coolahan, 2011).

Overall, the use of Life Cycle Costing is seen as an approach allowing better and more accurate management and decision-making regarding contracts; in its application, the cost overruns can be estimated along with time overruns for specific programs, extending beyond the acquisition phase and relevant contractual termination. In practice what seems to be lacking is an equal weight of the literature to the actual benefits of a program as the specifications have often been altered along with other significant variables such as the actual lifetime, which in general is longer than expected. This balancing of cost and benefit overruns within a life cycle framework can thus be an element of Total Life Cycle approach alongside an imbedded KM approach.

Schematically then, TLC is comprised of 3-dimensions: project management, knowledge management and economics of contracting that are, however not mutually exclusive. KM in particular needs to be imbedded in contracting/monitoring elements of PM (in particular CP and CP-FP) to allow for exploitation of knowledge and optimization beyond specific programs (Figure 6).

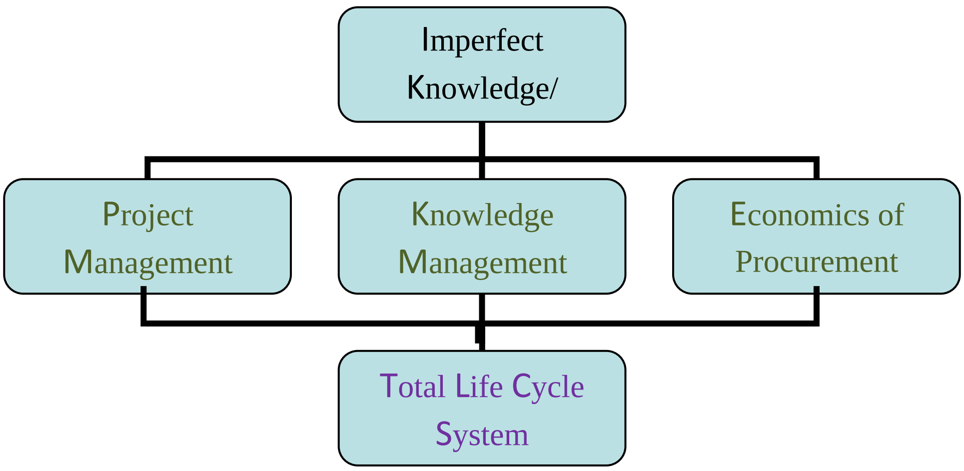

Figure 6. Total Life Cycle System Concept

4. Challenges in Imbeding Lessons Learned

Historically, patents and relevant knowledge stemming from ESA programs, owing to the intergovernmental nature of the agency remained with the contracting firms, unlike the case where the contracting agent is a national space agency with more scope for developing patent depositories. The management of relevant knowledge and patents towards diffusion and commercialization is becoming an increasingly important subject, given the economic returns expected (Note 4).

An obvious embedding challenge is how by externalizing the appropriability of information could potentially result in disincentives for firms to follow high-risk approaches, or codify knowledge beyond the level required, at the extreme impacting on contract bidding considerations. Given the inability to enforce an appropriability-based regulatory framework, owing to national security considerations, there is resulting lack of trade with firms acting as gate-keepers of relevant technologies (Zervos & Swann, 2009). Thus, in international and/or collaborative programs in the absence of a reliable property-allocation mechanism KM sharing tools must be carefully developed to avoid disincentives for bidding in commercial and civil programs.

Beyond that, a balanced KM approach within a TLC System would incorporate lessons learned and processes frequently controversial and from multiple sources analysed by agencies within an objectivity framework, rather than an open-ended interviewing one. This would then utilize appropriate mechanism, such as GAO-style “independent” reviews complementing EVMS monitoring and documentation furthering KM recording and assessment of information towards cross-verification to account for multiple “truths” within an imperfect organizational scheme. The result would point towards embodied KM processes within government contracts and relevant procedures for developing research outputs.

5. Conclusions

In summary, KM is a subject of several dimensions, particularly when applied to the space sector. Contractual process and operations can contribute significantly within this framework and be further utilized. In this respect, ESA’s approach is to either use fixed-price contracts that are subsequently evolving via in-course change notes, and/or use CP-FP. The multi-national nature of such programs lends itself to “peer-review” mechanisms as monitoring tools that is coupled with the presence of ESA’s Inspector General. In the US, (examples of NASA, DoD) the use of cost-plus is subject to monitoring via EVMS and accountability institutions at a federal level. What is lacking is the matching of actual value to expected value and life-cycle benefits in an analogous manner that EVMS treats cost and time overruns for the acquisition phase. Regarding the all-important KM approach, this is reduced to ad-hoc approaches that are potentially suffering from lack of multiple-sourcing of information and no formal mechanisms to embed KM elements within contracts. This results in the key KM elements in contracting existing with regards to cost-plus type of contracts, where monitoring exists, but not for the life-cycle of the project. Further research is required towards furthering mechanisms that can enhance KM via reviewing of information from acquisition and operations/disposal phases towards lessons learned within a total life-cycle system (TLC-S), while ensuring that this does not jeopardize incentives of firms for sharing information.

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Notes

Note 1. Online at: http://www.sounds.bl.uk/Oral-history/Eminent-scientists

Note 2. See online depository of relevant information: http://www.hq.nasa.gov/office/hqlibrary/ppm/ppm51.htm

Note 3. See for example: GAO report on DoD selected space systems online at: http://www.gao.gov/new.items/d1055.pdf; Rand report on 35 main weapons systems, online at: http://www.rand.org/publications/randreview/issues/spring2009/cost1.html

Note 4. Economic return studies from ESA contracts have focused on the returns of knowledge diffusion within firms as well as on spin-offs creation and relevant benefits (OECD, 2011).