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# Selection method for COTS systems

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**Abstract**

Historically, organizations developed their information systems in-house. Today, a large portion of information systems development is based on the acquisition of pre-made information systems, so-called commercially off-the-shelf (COTS) systems. This approach for developing information systems requires new skills and methods supporting the process of evaluating and selecting information systems. This paper presents a method for selecting COTS systems. The method includes the following phases: problem framing, requirements and appraisal, and selection of systems. The idea and distinguishing feature behind the method is that improved understanding of organizational 'ends' or goals should govern the selection of a COTS system. This can also be expressed as a match or fit between 'ends' (e.g. improved organizational effectiveness) and 'means' (e.g. implementing COTS systems). This way of approaching the selection of COTS systems as viewing them as a 'means' to reach organizational 'ends' is different from the mainstream views of information systems development, namely the view that sees information systems development as a problem-solving process, and the underlying ontological view in other COTS selection methods, which focus on selection of functionality not reaching organizational ends.


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*Keywords:* COTS systems; competing values framework

## 1. Introduction

A few decades ago in-house development was the only option. There were no information systems (IS) to be bought off the shelf or in the Cloud. However, since that time in-house development has become relatively less common. Today, organizations may select and implement Commercially Off The Shelf (COTS) systems for many reasons, including technical (replacement of old and outdated IS) [1, 2]; integration of disparate IS [2]; business,


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such as changes of production mode (make-to-order versus make-to-stoke) [3]; organizational (new organizational structure) [4], strategic reasons, such as to gain competitive advantage [1, 5], and due to difficulties with in-house development.

The above-mentioned reasons for selecting COTS systems are chiefly based on economic and/or administrative rationality [6-8]. However, there are other rationalities governing the selection of COTS systems, including institutional and individual rationalities. For instance, an organization might select a COTS system if their competitors are perceived as gaining competitive advantage through that COTS system or if a COTS system has become de facto standard in an industry [5, 9]. These types of environmental pressure are referred to as institutional isomorphism [10-12]. Individuals on the other hand, such as senior managers, might also select or argue for a certain system based on rationalities other than economic and administrative. For instance, favouring a friend who works for a vendor, a power struggle within a firm, owning shares in a vendor firm, and previous employments (cf. the motivation behind Scientific Management [13] and Weber's key characteristics of a bureaucracy [8]). Afterwards, the selections are a often justified through economic or administrative rationalities [14], e.g. managers might use statements like "It is a strategic solution" to justify the selection [5] or create a business case that shows positive benefits.

From a traditional rational perspective, organizations and their members should behave systematically and rationally and identify the problems they want to solve, which formulates as a requirements specification. If not they behave dysfunctionally. The specification is the starting point of an *ex ante* evaluation and selection of a solution. In a perfect world, the solution ought to match the requirements, i.e. there is a fit between solution and requirements. However, the solution to the identified problems seldom has a 100% fit. So either the problem domain or the solution domain has to be changed or modified. Changes of the problem domain, e.g. organization and business, refer to changing management, continuous improvement or business process re-engineering. Changes in COTS system, i.e. the solution domain, are labelled as configuration and customization.

Behaviour that is governed by institutional or individual rationalities is frequently difficult to anticipate and control, and therefore difficult to support through formalized methods. Therefore, from a method engineering perspective it has to be assumed that managers behave at least in a bounded rationalistic [7] or incremental [15] manner. Thus, a critical management task becomes understanding, assessing, and evaluating COTS systems for 'rational' and systematic-behaving managers who try to select and implement a COTS system, in the most appropriate way. However, there are few methods supporting the process of selecting COTS systems and the few that exist are inappropriate for the selection of complex IS [16]. This constitutes our design setting or beginning of our method development. The perspective of this paper is to support the selection of a system by improving the understanding of what 'ends' or goals are desired and what 'means' a COTS system supports.

The paper is organized as follows: The next section reviews the limited literature on the selection of COTS systems. The subsequent section discusses how to develop methods and the underlying design theory. In the fourth section the COTS selection method is presented. The paper is then concluded with a discussion and conclusion.

## 2. Research on selection of COTS systems

Largely, previous research on the selection of COTS system is implicitly or explicitly based on experiences from the selection of Enterprise Resource Planning ERP systems. The academic research on COTS systems selection has mostly been concerned with critical success factors and organizational issues [17-25] – for instance, how firm size and the structure of the team affects the selection of ERP systems [24], investigating decision styles during the evaluation, selection, and implementation of ERP systems [20], the use of cost benefit analysis (CBA), e.g. NPV (net present value), IRR (internal rate of return), and payback time, in a large manufacturing firm [26], and how option-pricing models explain replacement decisions between SAP R/2 and SAP R/3 platforms [23].

There are also some specific COTS selection methods in the literature. For instance, SHERPA systematic help for ERP acquisitions) [27] includes five phases: decision to acquire; search systems; get more information; demonstration of systems; and final decision. To gather user requirements SHERPA uses natural language and formal language for modelling the application domain. Other methods for the selecting of an ERP system are based on business process re-engineering (BPR) aims and include the following phases: 1) transformation of management environment; 2) recognize the current mechanism of business operations; 3) confirm mismatches between the

environmental transformation and current business operations; and 4) set necessary action aims (BPR aims) to resolve the mismatches. There are some critic of these methods [28], namely that ERP system implementations are difficult to align to requirements because of the low level at which ERP systems functionality is described. Organizations think in terms of their goals and objectives instead of functionality. They propose a mapping technique to match organizational goals with ERP functionality descriptions. These descriptions can be used to match functionality with organizational goals when selecting a system. To select a system organizations have to describe all the desired functionality. The proposed technique is inspired by scenario techniques from requirements engineering. An iterative selection framework is present in the ERPS (ERP systems selection) framework. This method includes three phases: 1) business vision; 2) requirements, desire to change, and constraints; and 3) ERP selection and evaluation. The method is a synthesized product inspired by the Information System Development ISD literature [21]. A different approach is a procurement-oriented requirements engineering (PORE) model for matching COTS functionality with user requirements [29]. One of the more comprehensive methods for COTS selection is the SIV-method [30]. This contains three phases (selection, configuration, and implementation) with a number of work tasks and documentation forms. The method has been developed as a joint effort between researchers and professional software acquirers in Sweden [30]. The method builds on the ISAC method [31].

To conclude the literature review on the selection of COTS systems, research has generally focused on 1. functionality, i.e. the 'means' not the 'ends'; one notable exception is [28] the goal-oriented method; 2. a simplistic view of management behaviour; and 3. a lack of an underlying design theory. Furthermore, most research is not focused on methods but on the process of selecting ERP systems, with a particular emphasis on evaluating the functionality of the system [16] in relation to what it is supposed to support. The presented methods are based on a strict rational view of human behaviour. What these have in common are the three phases: problem-framing phase; requirements/appraisal phase; and selection phase. There is a need for more research on the selection of IS and in particular conceptual ideas that could affect practice [16]. The gap we attempt to fill is to suggest a 'means'-oriented selection approach and how to incorporate a design theory in the development.

## 3. Development of ISD methods

The aim of this paper is to develop and present a method for selecting COTS systems. Thus, critical questions for this paper are: How can selection methods be designed? What level of analysis (organizational/management/business/ group) should be applied in the design? What theories (organizational/management/information) or frameworks can be used in the development? How should a method be evaluated? We will return to evaluation of the method in the discussion section.

Regarding the first question. As developers of methods we do, nevertheless, need to consider the constituents of methods. A method is a guideline for work [30, 32, 33]. Its character is prescriptive. A method should tell us what to do in different situations in order to reach certain goals (ends). Methods include representational guidelines as well as procedural guidelines [34]. Many times the procedure and notation are tightly coupled together. Modelling is about asking questions and documenting answers in different models. General concepts are used when asking questions and are also part of the semantics of the notation. The concepts can therefore be regarded as the glue between procedure and notation. All methods are based on some implicit or explicit perspective, which includes values, principles and categories. Methods also consist of framework and co-operation procedures. The perspective influences the categories that are reflected in the questions and answers. In this paper, perspective, i.e. what ends to achieve, and framework, i.e. what aspects to focus on, are put in the foreground. In a process of justification there is a need to perform different grounding processes, such as [35]:

- Internal grounding, in which the method's coherency and consistency was checked. This was supported by meta-modelling. This meta-modelling included modelling of different parts of the method such as procedural rules, model types, concepts and values.
- Theoretical grounding in which conceptual grounding and value grounding were performed. We also performed explanatory grounding where other theories about change work were used as a basis for justification.
- Empirical grounding, which meant that we conceptualized observations and conducted interviews in order

to investigate the effects of the method in use.

In general, the writings on IS development recommend that users should be involved in the design process (this refers to the traditional 'building IS from scratch' paradigm) and it is also common in the development of ISD methods [30]. This is motivated by the assumption that the users know best and user participation increases acceptance. However, a problem encountered in ISD is that the users often have limited time for participating in the process, which also applies to the development of methods. Some ideas of how to develop new methods are provided [36], which concludes that new methods can be based on theories.

The second question concerns the level of analysis addressed by the method. Based on the complexity of COTS systems, the conclusion made is that the most appropriate level of analysis for COTS systems is organizational. Another argument for applying an organizational level is that decisions made regarding COTS systems are made by top managers.

The third question raised what theoretical frame of reference or conceptual framework should be used in building a selection method. According to Fitzgerald [36] new methods can be designed on current management and organizational theories. Two examples of how theories can be used in the development of ISD are the critical success factors method (CSF) and MultiView. MultiView builds on work done by socio-technical research [37]. The CSF method can be used to identify executives' information needs [38], its focus being primarily on identifying information needs. Although it can be useful, it does have limitations. Since CSF to a large extent focuses on information needs, it is not complete in generating suggestions for what goals an organization and its managers seek for the IS, which this paper aims at. The approach taken in the development of the selection method was to review some of the descriptive and prescriptive management and organizational literature. The review should point to what 'ends', i.e. goals and values in the method's perspective, an organization could have.

The design theory and model applied builds on the work of Robert Quinn and associates on the competing values framework (CVF). The CVF is a broad framework developed to understand the constructs of organizational effectiveness [39, 40]. The CVF assumes that organizations are purposeful systems that exist to achieve certain goals or ends, the existence of simultaneous and conflicting goals, and that organizations must pay attention to all goals at the same time in order to be effective and efficient. CVF also addresses three fundamental paradoxes found in the organizational literature: flexibility and spontaneity versus stability and predictability (related to organizational structure); internal versus external (related to organizational focus); and means vs. ends. These paradoxes reflect the underlying competing value dimensions [41].

By considering different value dimensions in the underlying perspective of the method proposed in this paper we come to the following conclusion. The first value dimension is focus: internal focus puts emphasis on well-being in the organization while external focus addresses the environment. Structure is the second value dimension: stability refers to the need of top management to control, and flexibility refers to adaptation and change. The last value dimension is means versus ends [40]. Using the two first value dimensions, four organizational models emerge, including the human relations model (HR), the open systems model (OS), the internal process model (IP), and the rational goal model (RG), with its own means and ends. Based on the four organizational models (HR, OS, IP, and RG) and the competing values dimensions, four organizational effectiveness constructs can be defined. The HR model focuses on internal flexibility and stresses human resource development. The OS model focuses on external flexibility and suggests readiness and flexibility as the reasons by which growth may be gained. The IP model focuses on internal stability and uses information management, information processing, and communication to develop stability and control. The RG model is characterized by a focus on external control and relies on planning and goal setting to gain productivity [41]. A critical point to note is that while different organizational models reflect different effectiveness criteria, they are not dichotomic. Effectiveness may require that organizations are both flexible and stable and have a synchronous internal and external focus [39]. The models reflect opposing views of organizational effectiveness simultaneously.

## 4. The ends driven selection approach

The point of departure in developing the method has been that managers apply different rationales (economic, institutional, and individual) and therefore are not always systematic. This is one of the criticisms of the reviewed

selection methods, but also serves as motivation for the use of CVF, which includes dichotomized values. The reviewed methods are also presented as deterministic step-by-step guides for 'successful' selection and implementation of solutions. People do not act in this way; they pick and choose steps as they feel. A point to make is that the method with its guidelines should not be viewed as an isolated project. The overall context of the method is that it should be viewed as an integral part of an ongoing evaluation of a firm's current and future state with or without IS.

The presentation of the method in the subsequent section is not a step-by-step procedure, but illustrated as a number of phases, i.e. areas on which to focus pinpointed as a part of the framework, addressing: 1) problem framing; 2) requirements and appraisal; 3) and selection of solution.

*Problem-framing phase*

Based on the assumption that organizational behaviour is at least bounded rationally it is possible to specify some general organizational requirements in the problem domain. The subsequent list represents some requirements that pertain to the context of the problem domain (i.e. what problems a sought solution should solve):

- The need for the problem to actually involve a real problem (cf. e.g. the Y2K problem).
- The need to be able to define the type of problems (strategic, organizational, business, IS, or technical) under investigation.
- The need to define what type of solution an organization is looking for (e.g. IS, organizational change, business process re-engineering, training etc.) and to seek alternative solutions to IS that might be better and/or cheaper.
- The need to know that IS is a solution to the problems (the only problems that require IS solutions are IS problems).
- The need to know that a COTS system is the right solution to the problems.

The preceding requirements are not confined to all organizations and all problems. It is not possible to meet all requirements for all situations either. To make this even more difficult the empirical and conceptual IS research on the fit between solution and problem is scarce. There are schemas for matching different IS applications to hierarchical levels and functional areas in all IS textbooks. However, they seldom address what problems an IS solves. An exception is [2], who discusses new business demands, such as 'presenting one face to the customer', 'availability to promise' and having 'global inventory visibility', that IS can be a solution for. Means to distil the coveted ends may be brainstorming techniques such as rich pictures proposed by Checkland and Holwell [42]. However, to be able to select a specific solution, the above requirements are not enough. They have to be more specific, which the next phase addresses.

*Requirements and appraisal phase*

The second phase (requirements and appraisal phase) consists of gathering specific organizational requirements, i.e. achievement level/goals/ends, and evaluation of solutions. The level of impact of a COTS system motivates the level of analysis, i.e. organizational effectiveness. It is important to stress that requirements should focus on the 'ends', which the solution should be the means to, not the functionality of the solution; for instance, an 'end-driven' requirement specification focuses on the performance improvements achieved through improved control, whereas a functional requirements specification attempts to specify functionality that has to be included, e.g. cost center controlling. The guidelines do not specify where to start – assessing requirements or evaluation of solution. It is the evaluators' choice, dependent on contextual circumstances.

*Assessing requirements*

To assess the current and future requirements, different instruments can be applied [39-41]. These instruments make it possible to assess what 'ends' managers perceive as important. For instance, the 'competing values

organizational effectiveness instrument' [41] measures perceptions of organizational performance. Based on the CVF it is possible to outline four broad organizational requirements:

- Human resource model's (COTS-HR) requirement focuses on internal flexibility to develop employee cohesion and morale. It stresses human resource development, participation, empowerment, team building, trust building, conflict management, internal communication, feedback to individuals and groups, and development of individual plans and management skills [41].
- Open system model's (COTS-OS) requirement focuses on external flexibility and suggests readiness and flexibility to provide the means for organizational growth. Important issues are acquisition resources, supports of interaction with the environment, identification of major trends, facilitation of organizational change, research and development, problem identification, influence on the environment, and maintenance of external legitimacy [41].
- Internal process model's (COTS-IP) requirement focuses on internal stability and uses information management, information processing, and communication to develop stability and control. This is done by collecting data (mainly internal quantitative information used to check organizational performance), enhancing the understanding of activities, ensuring that standards, goals, and rules are met, maintaining organizational structure and workflow, coordinating activities, and collecting and distributing information internally [41].
- Rational goal model's (COTS-RG) requirement is characterized by a focus on external control and relies on planning and goal setting to gain productivity. This includes clarification of expectations, goals and purposes through planning and goal setting, definition of problems, generation and evaluation of alternatives, generation of rules and policies, evaluation of performance, decision support, and quality control, motivation of organizational members to enhance productivity, sales support, and maximization of profit [41].

The purpose of this phase is to derive different perceptions and requirements of what is important for stakeholders. This phase can take place several times in an iterative process, since an organization can re-evaluate its requirements based on the preceding result.

*Appraisal of COTS systems*

The purpose of an *ex ante* evaluation of COTS systems is to assess which ends a system supports. These guidelines relate to the actual solution. Using the CVF it is possible to identify four ideal COTS subtypes: they are COTS-HR, COTS-OS, COTS-IP, and COTS-RG. A COTS system may include parts and characteristics of the four subsystems. The following step in the appraisal of COTS systems is to map the functionality (i.e. the means) of COTS systems into the four COTS subtypes; some functionality is applicable to more than one COTS subtype. The aim of mapping the functionality of a COTS system is to derive the 'means' of the functionality, i.e. what support a COTS system provides. The four COTS subtypes and their supporting COTS functionality are described below.

COTS-HR is the first subtype and it supports an organization in the human resource development. COTS-HR functionality and features of importance are chiefly e-mail, voicemail, and videoconferencing and these capabilities overcome distance and time. A COTS human resource module also provides functionality for individual planning and training. COTS-HR seldom provide support for team building, building trust and morale, developing management skills, and conflict management.

COTS-OS is the second subtype and it has an external focus and an emphasis on structural flexibility. This supports an organization in identifying problems and possibilities by supporting environmental scanning, issue tracking, and issue probing. Environmental scanning may be quantitatively or qualitatively oriented and may include industry and economic trends, legislative issues, competitor activities, new product and process development, patents, and allocation of scarce resources. By tradition, COTS systems are considered having a weak support for COTS-OS. Hence, in terms of structural flexibility, COTS systems have a reputation for inflexibility, at least when installed. The definition of the OS model is that it seems very difficult to formalize these processes and support them through a COTS system. This is one of the weakest points of COTS systems.

COTS-IP is the third subtype and it has an internal, control, and stable structure emphasis. It supports the internal process model. From an organizational performance perspective, the objectives are to provide user-friendly support for auditing and control through formalization and standardization. COTS systems replace traditional legacy systems, such as accounting systems and production systems. Capabilities supporting this include controlling, investment controlling, material management (stock inventory), plant maintenance, production planning and control, financial accounting, project systems, workflow, and master data.

COTS-RG is the last subtype and has an external focus and stable structure. This subtype supports managers in organizations, by providing 'means' for primary activities, such as production planning sales and distribution, and logistics. Capabilities and features found in traditional decision support systems, such as goal setting, forecasting, simulations, and sensitivity analyses, are available in some COTS. Other COTS capabilities include sales and distribution, quality management, materials management (procurement).

The evaluation of COTS systems' functionality and the assessment of requirements make it possible to map requirements with support from the COTS system.

*Selection phase*

The final phase addressed is the actual selection of a system or solution. The assumptions made are that the problems in the problem-framing phase may be solved with COTS systems and that there is to some degree a match between organizational requirements and the evaluated COTS a system from *Requirements and appraisal phase*. For instance, if an organizations' requirement relates mainly to an IP-model and RG-model and the evaluated system fulfils those requirements it is possible that this is the 'right' solution. However, if an organization on the other hand has requirement problems related to an OS-model and HR-model in the CVF, our suggestion is that the organization should seek solutions other than COTS systems.

The actual decision on a solution should involve the fulfilment of the following two requirements based on a cost benefits analysis:

- Degree of match between requirements and solution – does the system give support to the desired ends? and
- A cost and benefit evaluation between the potential benefits of desired ends and cost for acquiring the means.

The above sections have presented the method for selecting COTS systems based on organizational requirements and the potential contribution of the solution. The method is conceptual, focusing on aspects of the framework connected to values and goals in the framework.

## 5. Discussion

The presented selection approach is conceptual and has not yet been practically validated. It should so far be seen as theoretically and internally justified (c.f. section 3). By this we mean that the framework and perspective are congruent and that the perspective and resulting framework are theoretically derived.

Validation of ISD methods is, however, often limited [30]. For instance, Rolland & Prakash [28] validate their framework through comparing characteristics in scenario-based approaches from requirements engineering to evaluate whether their framework provides better alignment to organizational requirements than traditional functional approaches. Illa et al. [27] validate their method through a comparison of requirement engineering methods and especially those for COTS, e.g. Maiden & Ncube [29]. Finally, Nilsson [30] used three types of validation, including eight cases, expert panels, and literature.

We propose that the COTS method differs in relation to the reviewed methods in the sense that the proposed method emphasizes the underlying framework, i.e. has a theoretical ground. The potential contribution of CVF in the case of selecting a COTS system is mainly related to the focus on ends, i.e. instead of focusing on the functionality of the systems. This might resolve one problem common in most requirements specification, namely organizations' tendency '…to focus on the solution, in large part because it is easier to notice a pattern in the systems that we build than it is to see the pattern in the problems we are solving that lead to the patterns in our solutions to them' [Ralph Johnson in Jackson, p. 243] [43]. Organizational ends are related to the patterns in the problem, whereas other

selection methods focus on the patterns in the systems, i.e. the functionality. By matching the problems identified in the problem-framing phase and the support provided by the system identified during appraisal of the COTS system, it can be possible to better understand the problem sought to be solved by the selected system. A problem is conceived as a deviation to desired goal.

## 6. Conclusion

The presented method has in this paper been theoretically and conceptually validated, i.e. theoretically and internally grounded. The steps and iteration of steps in the method, i.e. problem phase, requirements and appraisal phase, and selection phase, are common in most methods [28-30]. The part of the methods that distinguishes the method is the explicit view of the role of COTS systems, i.e. to support organizational goals – not to support functionality. The underlying conceptual framework is the CVF, which represents values, goals and concepts that help organizations to understand their own current and future situation. It is, though, necessary in future work to also justify the method empirically.

The selection and acquisition of COTS (or any business system) is often perceived as an investment and thereby viewed as an expense [21], based on some economic model [26]). Organizations are therefore measuring their IS selections in economic terms if they evaluate their IS investments [44]. This paper has presented a COTS selection method as an end-driven selection method, which complements the traditional models, based on an economic and rational view of managers, and emphasizes the selection of functionality, used to select COTS systems. The method is conceptual and its theoretical foundation is the CVF by Quinn and associates [39-41]. The development builds upon ideas from design science and the need for method development pointed out by Beach et al. [16]. The use of the method supports the selection by improving the understanding of both the management and organizational requirements and what ends a system can provide means for. The first phase of the method is problem framing with the explicit goal of evaluating whether COTS systems are a solution to current and future problems. The second phase supports the appraisal of a specific solution and the requirements specification of the system. The final phase is the actual selection of a COTS system.

The development of the method builds on knowledge and experiences reported in IS writings – for example, information systems failure, top-management support, relationship between designers, system and user, evaluation, and continuous improvement. The framework has thereby positioned itself against the technical orientation in some COTS systems' implementation methods. However, this is not a criticism of those methods. The goal has merely been to point out some shortcomings. The proposed method has several characteristics making it useful and to be validated as a practical method. It relates to a critical construct, i.e. organizational effectiveness. It has a paradox and complexity perspective, which has been pointed out as necessary in IS research and practice [45]. The overall contingency approach makes it possible to evaluate and select COTS systems in context. Hence, the method stresses that not all COTS systems are equally effective in a specific context.

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