Institutional Metrics for the United States Marine Corps

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Abstract

This paper describes an early-stage investigation into approaches and tools to collect, manage, and deliver institutional metrics to the senior command of the United States Marine Corps. The paper describes how contemporary approaches to institutional metrics and supporting tools from more traditional organizations were adapted to Marine Corps priorities. The study explores current institutional metrics strategies with a particular emphasis on the balanced scorecard approach, deemed most relevant because of its focus on strategic alignment and its applicability to non-commercial organizations. The literature on performance measurement for industry, not-for-profit organizations, and government/military institutions is reviewed along with Marine Corps strategy publications, campaign plans, and other doctrinal documents as the basis for a set of sample metrics to act as a 'strawperson' for further development. The different software metrics tools that may be used to manage the information required to support institutional metrics programs are reviewed as are approaches to managing a successful institutional metrics program.

1. Introduction

The Marine Corps is seeking to implement an information system to support both predefined and *ad hoc* queries related to strategic decision making at the highest levels of command. This effort conforms to the goals expressed in the strategy document *Joint Vision 20-20* [1] in that it recognizes the centrality of information superiority in military activities and acknowledges that superiority is only achieved when information is leveraged into both superior knowledge and superior decisions. The focus of this effort is on acquisition of a "best in class", commercial-off-the-shelf (COTS) decision aid at the lowest possible cost. The purpose of the study reported here is to investigate how models of commercial institutional metrics management - and the COTS software tools available on the market to support metrics capture, management, and delivery - can be adapted to the unique and dynamic requirements of the Marine Corps organization.

Identification of institutional metrics for non-commercial organizations involves reflecting on the high-level mission of the organization and carefully translating this mission into operational measures. In the case of the Marine Corps, this involved a review of published strategy, campaign plans, and other doctrinal documents as the basis of a first-cut metrics model mapped to mission priorities and the capabilities required to fulfill them. This study explored approaches to managing institutional metrics with an emphasis on the balanced scorecard approach [2][3] identified as particularly appropriate because of its focus on strategic alignment of operations and its de-emphasis of the financial measures that form the basis of performance assessment in for-profit organizations. A first-cut metrics framework is identified as a 'strawperson' to exemplify some possible key performance indicators and to act as a baseline for further metrics program requirements analysis. The paper also describes systems development and implementation approaches and the critical project success factors with respect to the unique requirements of the Marine Corps.

2. Institutional Metrics & Decision Making

Institutional metrics are measures of the performance and readiness of an organization relative to its strategic mission as operationalized in concrete mission requirements. In the case of the Marine Corps, the organization's mission derives from its mandate as defined in Title 10 of United States Code and as further elaborated in published strategy, campaign plans, doctrine, and other mission specifications (see www.usmc.mil/marinelink/ind.nsf/publications). The Marine Corps' mission suggests a taxonomy of requirements in seven critical areas including manpower, logistics, infrastructure and installations, command and control, systems (various technologies to include weapons, aircraft, transport, communications, information technology, and a host of others), research and development, and safety.

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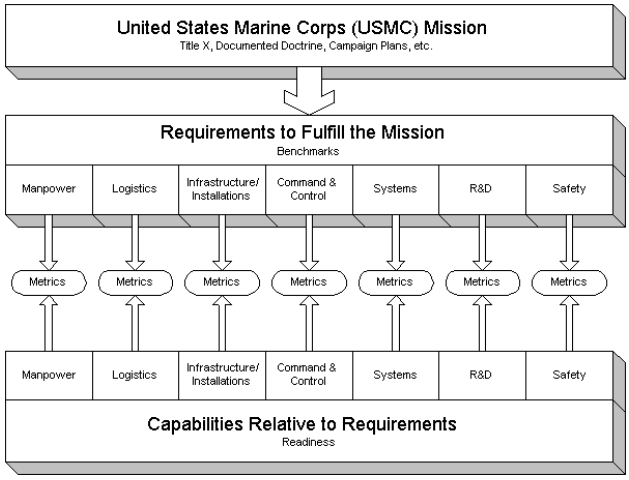

Figure 1. Marine Corps Mission, Requirements, & Capabilities

All of these requirements center on the Marines' ability to carry out scalable operations anywhere in the world at a moment's notice. These requirements are mapped to corresponding operational capabilities, which in aggregate describe overall Marine Corps readiness. Accurate and precise specification of mission requirements combined with accurate and timely measures of the Corps' capabilities would provide senior commanders with an extraordinary management tool. The decision tasks faced by senior commanders in the unique environment of the Marine Corps are inevitably ill-structured, and characterized by high uncertainty and high stress. Decision-making scenarios at Marine Corps command are sometimes reactive in response to domestic and world events (for example, U.S. political reorganizations, regional conflicts) and sometimes proactive, for example, when assessing the impact of new strategic procurements on Marine Corps capabilities.

Relevant decision research ranges from normative, prescriptive approaches described by different versions of expected utility theory to naturalistic, descriptive approaches that describe how 'real-world' decision makers operate in environments characterized by uncertainty. The former are concerned with the creation of optimizing decisions that maximize the utility of available resources given a quantified but narrow range of variables that both directly and indirectly influence the measured outcome of different decisions. Naturalistic approaches, on the other hand, acknowledge the human cognitive dimension of real world decision scenarios and describe a process by which people act to make decisions that are "satisfycing", or good enough [4]. Much contemporary decision research focuses on the adaptive nature of situated human decision making and suggests that how decisions are made is dependent on both the context and scenario, and on the attributes of the individual making the decision [5]. A key challenge in the development, implementation, and use of software decision aids is identifying the system attributes that support identification of the best possible decisions while at the same time achieving broad, adaptive usability given the limitations of human cognition.

3. Metrics Strategies

The Marine Corps is a singular institution with a mission and corresponding metrics distinct from any other organization. This singularity means that many commonly accepted measures of organizational performance are not applicable in their context. Measures based on the overall value-added by an organization, for example, Economic Value Added (EVA) or Market Value Added (MVA) [6] do not map to an organization tasked with an extremely complex mission where the value add is both obvious and difficult to quantify. The approach adopted in this study attempts to adapt and incorporate metrics techniques from all types of organizations - corporate, government and not-for-profit, and military - into an approach suitable to the Marine Corps' unique mission.

Institutional performance measures or metrics may be viewed as assessing some combination of the following factors: effectiveness, the ability to achieve objectives; efficiency, achieving objective with the least possible resources; and economy, acquiring resources at the lowest possible cost [7]. An acknowledged role of institutional metrics is to operationalize institutional vision and strategy into objectives that can be implemented and realized at all levels of the organization [8]. A key challenge in any metrics program is identifying a clear relation between identified metrics, corresponding benchmarks, and the decisions and actions taken to meet specified objectives [7]. Metrics programs have the potential to induce a systemic, self-fulfilling effect in that identification of metrics relative to strategy forces the institution to further clarify and develop the strategy itself. The prescribed organizational change and attendant visibility of a metrics program implementation also acts to help align the different facets of an organization with its explicit strategy. Adoption of an approach to centralized management of institutional metrics typically requires that an organization subject itself to sweeping change; changes that may be especially difficult to implement in institutions with the rich traditions and special budget status of the Marine Corps [9].

Institutional metrics programs should include the identification of relevant benchmarks that decision

makers can use to gauge performance relative to "best practice" values achieved by external referent institutions or deemed achievable by internal analysis. Benchmarks derived from external sources may prove more useful than internally derived measures as they are less likely to be viewed as unrealistic creations of the metrics' designers [8]. External benchmarks are also more likely to suggest prescriptions for action, since they can often be traced to the specific activities that led to their achievement in the source organization.

3.1 Budgeting

Budgeting approaches to performance measurement are among the most widely used assessment systems. Budgets measures are extremely useful in that they distill measurement of an organization's planning and execution processes into a simple statement of the difference between budgeted and actual figures [11]. Though easy to comprehend, budget control mechanisms typically hide or make implicit the organizational priorities and capabilities that they represent. Governmental agencies are typically managed and evaluated based on the effectiveness of their cost controls, the degree to which they comply with regulations bounding their operations, and performance relative to budgets. Historically, this approach provides little incentive for governmental entities to increase performance or reduce spending relative to established budgets since unspent funds may result in reductions in future budgets and are not transferable to other budget line items. More importantly, this measurement approach fails to relate an agency's mission to performance.

3.2 Balanced Scorecard

The Balanced Scorecard (BSC) is a performance measurement system that attempts to relate an organization's mission and strategy to concrete, operationalized metrics [2]. A BSC program involves development of a carefully identified set of performance measures or key performance indicators (KPIs). The approach is designed to provide a means for linking the strategies of diverse operating units across an organization to the organization's overall mission and vision. The structure of the BSC system is shown in the figure below.

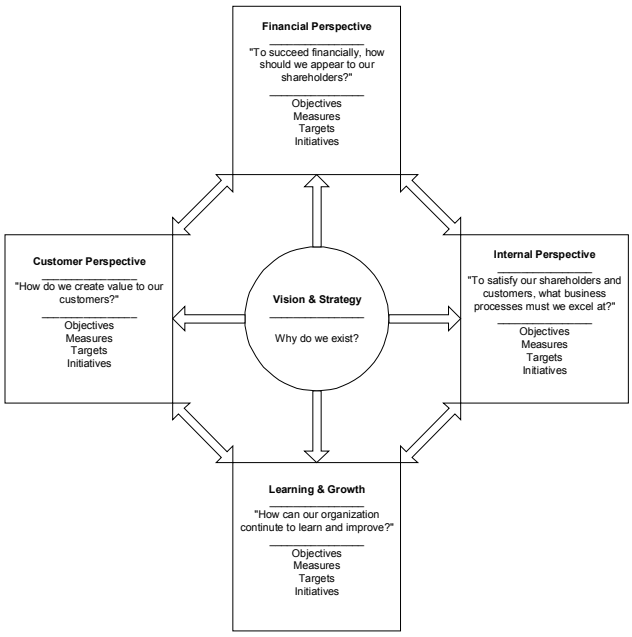

Figure 2. The Balanced Scorecard [13]

Increasingly, analysts and researchers are arguing that although the mission of government agencies differs greatly from profit-oriented organizations, metrics techniques such as the Balanced Scorecard may be usefully adapted to the government domain [12].

The BSC suggests that an institution view performance from four perspectives: financial, customer, internal business processes, learning and growth. The financial perspective uses financial measures to gauge performance against the bottom line, for example, profitability, return on investment, or budget performance. The customer perspective focuses on the organization's perception of customer requirements. Common measures include customer satisfaction, customer creation and retention, market share, and customer service standards. The internal business process perspective focuses on how internal operations can be made more efficient and effective. This perspective includes both internal operations and the innovation processes critical to long-term performance. Some example metrics include product quality, cycle time, costs of production, product development time and percentage of sales from new products. The learning and growth perspective is used to measure and improve an organization's capabilities with regard to its evolving, competitive environment. Some example metrics include employee training and development, employee satisfaction and retention, flow of required information to employees at all levels, and measurable improvement in internal processes. For each of these four perspectives, objectives and measures are centered on the institution's mission and strategy. Targets and initiatives describe the

change strategies designed to move an organization to higher levels of performance.

The BSC system represents perhaps the most popular institutional metrics model in use today. However, the BSC does require substantial customization to be useful in the Marine Corps domain. The internal process and learning and growth perspectives are easily applied to Marine Corps priorities; both are identified in *Joint Vision 20-20* as key components of the Corps strategic direction [1]. The financial perspective has proven to be relatively easy to adapt to public, budget-driven organizations [12]. Though the customer perspective may more complex to adapt to the Marine Corps domain, one approach may be to focus on the needs of warfighters and combat operations as the military's conceptual analog.

The Balanced Scorecard approach is viewed by many analysts and researchers as a stakeholder-oriented measurement program [11]. Measures that align to specific institutional stakeholders are problematic in public institutions as these organizations operate within a complex matrix of stakeholder interests that may act to confuse and conflict the identification of a single set of core metrics [14]. Left alone, this dynamic may result in any number of decoupled metrics sets each serving a different constituency and each aligned with its own version of institutional strategy. While this outcome is in some cases desirable, for example, in highly distributed, federated organizations that value sub-unit autonomy, decisions to create independent metrics programs should be made explicitly to avoid deadlock as differing perspectives conflict, though in some cases such conflict can be leveraged to help balance the actual strategic alignment of stakeholder groups.

The creators of the balanced scorecard approach argue that it is a change program, not a metrics program *per se* [2], and that BSC projects should focus on implementation of a strategy involving dynamic institutional change. Kotter [15] provides a set of high-level actions that need to be taken by leadership to ensure institutional success. First among these is for management to articulate a vision and a strategy relative to institutional objectives. This first step necessarily entails the second, creation of a "guiding coalition" to oversee institutional change. Finally, the management team must work to establish a sense of strategic urgency throughout the institution. Other factors identified as contributing to metrics program success include the following [16].

- Employ a grassroots approach with broad organizational representation and expertise on the team tasked with implementation of the system.
- Use the metrics identification process to relate metrics to desired outcomes *and* incentives.
- Use metrics as a focal management tool and disseminate performance information throughout the organization.
- Work to continuously improve the metrics program and related systems.

3.3 A Framework for Marine Corps Institutional Metrics

Drawing on published Marine Corps strategy, campaign plans, and other doctrine documents, a set of example metrics and metrics categories were identified as examples of the types of measures that might be managed in an institutional metrics tool. These were proposed as a basis for further discussion of Marine requirements. Note that no direct measures of combat operations *effectiveness* are included, the set developed here is representative of the key strategic objective as operational *readiness*. The table that follows provides a representative sample of identified metrics.

Table 1. Sample USMC Institutional Metrics

Metric/ Scorecard Perspective	Description	Measure
Manpower		
Morale *Customer*	A measure of overall Marine morale.	Complex, from surveys, reports
Performance *Learning & Growth*	A measure based on average performance ratings for Marine across the institution.	Complex, from reports
Cost per new recruit *Financial*	Total number of new recruits divided by total recruiting expenditures.	Amounts from systems
Training *Learning & Growth*	A measure of the total hours and costs of training being provided to Marines across the institution.	From reports
Enlistment *Process* *Learning & Growth*	A measure of enlistment/re-enlistment rates.	Quantity, from systems
Recruit quality *Customer*	May include some combination of the range and number of skills and college degrees possessed by new recruits.	Quantity from records

Metric/ Scorecard Perspective	Description	Measure
Logistics		
Readiness *Customer*	A complex measure of the readiness of different logistics capabilities.	Rating, from reports
Confidence *Customer*	A measure of commanders' and warfighters' confidence in logistics capability.	Rating, by survey
Expense ratio *Financial*	This measures the loaded cost of distributing materials based on distribution cost divided by total materials cost.	Amounts, from systems
Asset visibility *Process*	Real-time measures of effective cargo-tracking capabilities including the quantity, location, and condition of all logistics assets anywhere, at any time.	Ratings, from samples
Time Definite Delivery Rate *Process*	Measure predictability of the logistics function relative to field requirements.	Ratings, from reports, surveys
Infrastructure/Installations		
Readiness *Customer*	A complex measure of the readiness of different infrastructure and installation components.	Rating, from reports
Budget conformance *Financial*	The extent to which different installations are operating within budgetary constraints.	Amounts, from systems
Command & Control		
Budget conformance *Financial*	The extent to which different units are operating within budgetary constraints.	Amounts, from systems
Performance *Customer*	A measure of the average performance ratings for Marine commanders across the institution.	Rating, from reports
Aggregate metrics rating *Process*	An aggregate measure of the different institutional metrics that apply to a given command.	Rating, from systems
Measurement *Learning & Growth*	This measures Marine commanders' contribution to the metrics program.	Rating, based on submitted measures
Systems		
Readiness *Customer*	A complex measure of the readiness of different systems.	Rating, from reports
Effectiveness *Customer*	A measure of the perceived effectiveness of different Marine systems.	Rating, from survey
Expenditures *Financial*	A measure of the expenditures for different classes of system.	Amounts, from systems
Research & Development		
User satisfaction *Customer*	Measures the extent to which users of Marine R & D sponsored innovations are satisfied with what is produced.	Rating, from survey
Expenditures *Financial*	A measure of total R & D expenditures.	Amounts, from systems
Cycle time *Process*	The average time needed for a project from initiation to fielded system.	Amount, from reports
Publications *Learning & Growth*	The number of peer-reviewed publication produced as a consequence of Marine Corps funded research.	Amount, from reports
Safety		
Mishap rate *Process*	The total number of accidents resulting in injury and/or damage.	Amount, from reports
Mishap ratio *Process*	The total number of accidents divided by the number of Marines in the reporting unit.	Ratio, from reports
Expenditures *Financial*	A measure of total safety related expenditures.	Amounts, from systems
Risk awareness *Learning & Growth*	A measure of the number of hours spent on safety-related training and awareness programs.	Amount, from reports

4. Software Tools for Institutional Metrics

The alignment of information technology strategy with overall institutional objectives is a critical component of metrics program success. The importance of IT dictates that organizations interleave IT decisions with their planning and decision-making processes at all organizational levels. Strategic IT alignment refers to the extent to which the IT mission, objectives, and plans support and are supported by the organization's mission, objectives, and plans [18]. The strategic alignment model identifies two types of integration: strategic integration and operational integration [19]. Strategic integration deals with the capability of IT functionality to both shape and support business strategy. Operational integration deals with the linkage between organizational infrastructure and processes, and IT infrastructure and processes. One of the key issues with the IT function is the identified time lag between changes in institutional strategy and corresponding changes in IT strategy necessary to realize the new vision and objectives [20]. Keeping pace with institutional change involves adopting an iterative, goal-oriented, and evolutionary approach to IT development and implementation and must include acknowledging that successful IT programs typically involve continuous organizational learning.

Given the variability of decision scenarios; the different individuals involved in the decision process; and the Marine Corps' complex, unique, and dynamic mission, decision aids adopted for the highest levels of command require some essential attributes. These include flexibility in their technical architecture, flexibility in the inscribed model of the information structure supporting decisions, and flexibility in the extent to which they prescribe a particular decision making process. Software packages for online analytic processing (OLAP) are information systems that use operations data generated in transaction and other primary source systems as the basis for high-level performance measures.

A typical OLAP architecture consists of a suite of tools including software components to extract elemental source data from transaction systems (ETL), a data warehouse to manage this elemental data and act as a source for different analytic applications, and the different analytic applications themselves, which might include OLAP 'slice and dice' data visualization tools, ad hoc report writers, algorithmic DSS, what-if analysis tools, data mining programs, and scorecard/dashboard user interfaces. This suite is often augmented with application or domain-specific data marts, which serve as localized data sources for specific applications and which can be relational or multi-dimensional databases.

Selecting an OLAP tool suite requires understanding the tradeoffs inherent in choosing among the different data storage models including the most common method, multidimensional OLAP (MOLAP); OLAP based on relational database technology (ROLAP); less scalable, desktop-based data stores (DOLAP); and hybrid models that combine two or more of these approaches (HOLAP). Multidimensional OLAP data sources are designed by identifying the different measures required by target users and the dimensions across which they might wish to view these measures. For example, a measure such as reenlistment rate might be aggregated by the dimensions rank, years in service, unit, specialty, time, etc. Common OLAP data display tools allow users to analyze data stored using these indexes in a number of different ways including (adapted from [21]):

1. Slice and dice: "How many Lance Corporals in Aviation reenlisted in 2001?"
2. Drill-down and roll-up: "How many Lance Corporals in Aviation reenlisted in March 2001?" or "How many Lance Corporals in Total reenlisted in 2001?"
3. Filter: "How many Lance Corporals in Aviation reenlisted in 2001 excluding Aviation Logistics?"

OLAP also supports time series and trend queries such as "plot Rotary Wing Aircraft (dimension) readiness rates (measure) over the Last 12 Quarters (dimension)".

Implementing a COTS OLAP solution involves consideration of how data will be accessed and analyzed by its target users, the feasibility and costs of capturing the data required to support aggregate metrics, and the overall lifecycle costs of the metrics system. Other high-level meta-criteria to be used in selecting a COTS OLAP and data delivery package in support of the Marine Corps' metrics program are shown in the following table.

Table 2. Marine Corps Metrics System Meta-criteria

Requirement	Rationale
Information Visualization	Given that senior commanders make up the target use population, the system should provide meaningful and easy to comprehend metrics displays. Front-end tools must support creation of easy to use and understand data displays, e.g. dials and gauges that provide a quick look representation of the underlying data.
Balanced Scorecard features	System must go beyond traditional financial measures to link a range of different metrics to overall institutional performance.

Drill-down Capability	System should present initial aggregate metrics values with the ability to drill down into successive levels of detail across important dimensions.
Flexible queries	Users of the metrics system will view the effect of different change programs by performing time increment queries that bound the period in which the program was implemented.
Metrics deltas	System shows how a given program has affected performance over time.
Relations between metrics	This functionality will support what-if type analyses that show the potential impact of a given decision, e.g., a new strategic system, on the different metrics being tracked.
Write-back functionality	Needed to support forecasting and what-if type analyses.
Performance	Excessive query times may have a significant negative impact on the usability of the system, especially given the target use base.
Flexible custom metrics	Given the unique and highly heterogeneous nature of Marine Corps metrics, the system will include the ability to create customizable metrics suites.
Collaboration	The metrics tool should support some degree of collaborative decision making.
Annotation	Users should have the ability to create text annotations or notes related to metrics values.
Security	Given the nature of the data being managed by the system, security will be a key requirement.
Rapid, Evolutionary Development	An initial version of the system must be implementable in a reasonable time frame, e.g., one year. This version, while not capturing a complete picture of the Corps' metrics structure, should provide a system with significant value add to key decision makers and develop momentum for the project.
Integration	The selected COTS package should provide an architecture for integrating a wide range of data sources into a single analyzable data source, or linked set of data sources.

Detailed, independently validated reports of metrics software package functionality are essentially non-existent in the literature, though one for-a-fee industry report does exist, The OLAP Report [22] and appears to be highly respected by both analysts and OLAP users. Related academic literature focuses either on custom decision support system solutions or on the technical details of data warehouse and hypercube implementations. However, high-level COTS OLAP package selection attributes can be derived from a number of sources including industry trade publications, analyst reports, vendor publications and web sites, and usenet news group postings. The review of these eclectic sources resulted in construction of a simple framework to act as a guide producing a short-list of OLAP COTS vendors. Criteria in this framework included feature set, price, performance, ease and cost of development/customization, interoperability, and the existence of working installations in related, for example, Department of Defense, domains.

For each criterion OLAP COTS products were given a simple score of low, medium, or high depending on their degree of fit relative to Marine Corps requirements. The purpose of this analysis was not to select a particular vendor, but to create a short-list of vendors for further review, comparison with meta-criteria requirements, and possible participation in a request-for-quote and/or prototype implementation "bake offs". The framework proved effective in helping to narrow potentially applicable options from a large field of vendors.

5. Implementing a Metrics System

The implementation approach recommended to the Marine Corps involves prototyping an initial OLAP-based system for managing institutional metrics and using this prototype as the baseline for further system evolution. Identifying and attempting to implement a solution approach to a limited set of representative, high-priority metrics system use scenarios will help to crystallize project requirements and project challenges and lead to the level of understanding necessary to craft the most coherent approach to the problem. A 'lightweight' evolutionary prototype also has the potential for rapid successes to help achieve and maintain project momentum. Information technology projects with OLAP and decision support applications reportedly suffer from high failure rates, even relative to other types of complex IT projects [21]. These failures may be a function of the critical need for senior management (or command) involvement and support, the complexity of enterprise performance reporting, and the complexity of the different tools used in this application domain.

Implementing decision aids in support of an institutional metrics program for the Marine Corps presents some special challenges to the identification of an accurate and appropriate set of functional

requirements. New system implementations such as this that are characterized by high levels of uncertainty, risk, and cost suggest a participative, incremental, and scenario-driven approach to requirements determination. Requirements should be derived from observations of the actual decision-making and other use scenarios the system is meant to support. Analysis of scenarios is an effective way to inductively determine how the system will be used, the information that is required to support different decision scenarios, and the range of critical success factors (e.g. timeliness, usability, etc.) most salient in the system use context. Scenario-driven requirements analysis may also help to minimize the 'gold plating' that commonly occurs when systems analysts and developers attempt to identify the most flexible combination of features to support a hypothesized range of use scenarios [23].

The approach developed at the Marine Corps eschews grandiose-scale analysis and planning in favor of short, realistic implementation cycles that minimize complexity and provide end users with working software, albeit of limited scope, in the shortest possible time frame and at the lowest possible cost. The first-cut methodology is presented as an ordered, but iterative, list of tasks, each with a rationale and objective. Where appropriate, specific methods for performing the task are suggested, again with objective and rationale.

1. *Identify Core Use Scenarios* – this task focuses on identification of a core set of use scenarios to be supported by the metrics system. Use of scenarios to drive requirements helps ensure that requirements are firmly rooted in the actual domain of use.

a. Participant Observation – analysts spend as much time as possible 'looking over the shoulders' of senior commanders as they engage in decision-making tasks. This method could be augmented with techniques from protocol analysis [24] whereby decision makers are asked to "think aloud" as they consider a decision scenario. Protocols are recorded and later transcribed for detailed analysis of the information needs of decision makers.

b. Interviews – analysts design and develop an interview guide and engage the target user population in focused interviews to identify key information-seeking and decision-making scenarios.

c. Secondary Analysis – analysts use secondary sources including orders, memos, emails, meeting notes, and other documents to derive use scenarios.

2. *Prioritize Scenarios* – this task involves classifying scenarios according to derived types and developing a prioritized list of the decision scenarios relative to the Marine Corps mission. The first iteration targets a set of closely related, high-priority scenarios to be supported by the first iteration of the system.

3. *Scenario Analysis* – this complex task involves determination of the actual metrics that will be used to support command decision scenarios.

a. Identify Supporting Metrics – perform an iterative analysis of scenarios to extract and validate the metrics that, if available, would contribute to the decision problem represented in each scenario.

b. Identify Metrics Dependencies - A key element of the Marine Corps' metrics vision is construction of a metrics network that will map dependencies between different metrics and incremental resource investments. This project component presents substantial analytic challenges. Construction of such a network will be a complex task and the required relations between a given set of metrics may in fact be situation and context dependent. We have suggested that the Marine Corps take an evolutionary approach to the construction of this network, building dependencies as they become clear in the context of actual system use.

c. Identify Metrics Dimensions – consider the different dimensions across which metrics will need to be analyzed. While it is essential to identify and clarify the different data perspectives required to support system use scenarios, in the interest of prototype simplicity and performance it is important to ensure that initial OLAP data cubes are only indexed by the critical dimensions suggested by the use scenario [21].

d. Identify Elemental Data Underlying Metrics – identify the data needed to meet the requirements of a few important use scenarios. This first set should be relatively easy to source and extract. Successful development of an approach to managing how the data required for institutional metrics will be sourced is one of the critical success factors in a metrics project, and one of the potentially most expensive and time consuming [25].

4. *Paper Prototyping* – Engage OLAP COTS vendors in scenario-based paper-prototyping.

a. Scenario Gap/Fit Analysis – provide vendors with identified critical scenarios (perhaps included in an RFP) and request that each vendor provide a detailed explanation of how their product suite meets each one of them.

b. Storyboard Usability – vendors provide example screen displays with visualizations of the metrics data supporting different use scenarios. These are then validated with actual target users.

5. *Prototype Data Warehouse Design* – Though the traditional approach to OLAP development frequently involves beginning with design and implementation of a data warehouse to act as a primary data source, some suggest that starting from the target users' needs, identifying a data analysis front-end, and sourcing the data required to meet users' needs is a more effective approach [26]. Data warehouse development projects are

extremely involved, especially in cases such as the Marine Corps where the range of potential data sources are highly distributed and heterogeneous. However, a key element of an OLAP-based decision aid is careful modeling of the elemental data that are used in decision making. Proper modeling of this elemental data supports their most flexible recombination in response to all of the dynamic decision scenarios, many that are impossible to predict in advance.

6. *Implementation*

a. Incremental Metric Implementation – Begin with high priority scenarios with the most easily sourced elemental data and begin implementing incremental versions of the metrics system.

b. Training - Lack of adequate training is one of the reasons most frequently cited for poor decision aid user satisfaction and low system usage. Target users should be provided with as much training as is realistic given the constraints of time and attention.

c. Iterative User Trials – At each stage of prototype development, as soon as data visualizations are available, involve target users in usefulness and usability reviews.

7. *Refactoring* – The project team should expect to make mistakes in the course of the implementation effort. It is essential to include in any project plan acknowledged refactoring phases. Refactoring involves the implementation team stepping back from the evolving design and considering ways in which what has been already implemented can be improved.

6. Conclusions

Decision making in complex organizations is often less organized and less rational than many outside observers believe [17]. Tools that can help key decision makers focus and then reflect on how they have structured a problem, generated alternative solutions, and evaluated these alternatives relative to the key criteria or values that underlay the organization's objectives hold a great deal of promise in these complex domains. For highly expert problem solvers, making the elements of a decision explicit and reflecting upon them privately and/or publicly may help to surface factors that are more important to the overall solution than is obvious to any one decision maker [27]. The sense-making affordances provided by relevant, clearly defined, and accessible measures of organizational performance are a key benefit of software tools designed to transform masses of detailed organizational data into strategic indicators for use by decision makers.

Both user and top management involvement have been shown as being crucially important to information systems project success [28]. In institutional metrics projects, the number and diversity of the different decision and information seeking scenarios to be supported by a given system implementation is in inverse relation to the relative success of these projects [29]. This is a function of both their inherent complexity and of the range of different stakeholders whose acceptance and support are required to achieve metrics program adoption and diffusion. Providing training early and often so that users and stakeholders understand how the system realizes performance measurement objectives are both critical components of a successful implementation.

The success of the Marine Corps' metrics system project will ultimately depend on the usefulness and usability of the tool set that is provided to the target users. Measuring the success of decision-aid software implementation involves measuring user satisfaction and perceived benefits of the system [29]. We have recommended a rapid-prototyping approach focused on high-priority scenarios that make use of elemental data that is relatively easy to obtain. The first iteration of this approach will provide the metrics project team with the detailed domain and technical knowledge required to anticipate future critical success factors, as well as help to build organizational momentum around the project.

Acknowledgements

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References

[1] United States Marine Corps, *Joint Vision 20-20*, Washington, D.C, US Government Printing Office, 2000.

[2] R. S. Kaplan and D. P. Norton, "The Balanced Scorecard: Measures that Drive Performance." *Harvard Business Review*, 70(1), pp. 71-79, 1992.

[3] R. Kaplan and D. Norton, *The Balanced Scorecard*, Cambridge, MA, Harvard Business School Press, 1996.

[4] H. A Simon, *Models of Man*, New York, Wiley, 1957.

[5] R. Crozier and R. Ranyard, "Cognitive process models and explanations of decision making," in *Decision Making: Cognitive Models and Explanations*, R. Ranyard, W. R. Crozier, and O. Svenson, Eds. New York: Routledge, pp. 5-20, 1997.

[6] P. A. Dierkas and A. Patel, "What is EVA and How Can It Help Your Company?" *Management Accounting*, November, pp. 52-58, 1997.

[7] D. Otley, "Extending the Boundaries of Management Accounting Research: Developing Systems for Performance Measurement," *British Accounting Review*, vol. 33, pp. 243-261, 2001.

[8] M. Wouters, K. Kees, J. Theeuwes, and K. van Donselaar, "Identification of critical operational performance measures - a research note on a benchmarking study in the transportation and distribution sector," *Management Accounting Research*, vol. 10, pp. 439-452, 1999.

[9] S. J. Simon, "The Art of Military Logistics," *Communications of the ACM*, vol. 44, pp. 62-66, 2001.

[10] A. K. Graham, "Challenge your balanced scorecard." *Credit Union Executive Journal* 41(3), pp. 22-27, 2001.

[11] D. Otley, "Performance management: a framework for management control systems research." *Management Accounting Research*, (10), pp. 363-382, 1999.

[12] D. A. Ellingson and J. R. Wambsganss, "Modifying the Approach to Planning and Evaluation in Governmental Entities: A " Balanced Scorecard" Approach." *Journal of Public Budgeting, Accounting, & Financial Management*, 13(1), pp 103-120, 2001.

[13] R. S. Kaplan and D. P. Norton, "Using the balanced scorecard as a strategic management system." *Harvard Business Review* 76(1), pp. 75-85, 1996.

[14] S. Brignall and S. Modell, "An institutional perspective on performance measurement and management in the 'new public sector'." *Management Accounting Research*, 11, pp. 281-306, 2000.

[15] J. Kotter, (1996). *Leading Change*. Boston, MA, Harvard Business School Press, 1996.

[16] M. L. Frigo and K. R. Krumwiede, "The balanced scorecard: a winning performance measurement system", *Strategic Finance*, pp. 50-54, January, 2000.

[17] R. L. Keeney, "Creativity in Decision Making with Value Focused Thinking." *Sloan Management Review,* Summer, pp. 33-41, 1994.

[18] R. Hirschheim and R. Sabherwal, "Detours in the path toward strategic information systems alignment", *California Management Review*, 44(1), pp. 87-108, 2001.

[19] J. Henderson, J. Thomas, and N. Venkatraman, "Making Sense Of IT: Strategic Alignment and Organizational Context," *Working Paper 3475-92 BPS*, Sloan School of Management, MIT, 1992.

[20] J.T.M. Van der Zee and B. De Jong, "Alignment is not enough: Integrating business and information technology management with the balanced business scorecard", *Journal of Management Information Systems*, 16(2), pp. 137-156, 1999.

[21] H. Hasan and P. Hyland, "Using OLAP and Multidimensional Data for Decision Making," *IEEE IT Professional*, September/October, pp. 44-50, 2001.

[22] N. Pendse, *The OLAP Report*, 2001.
Available at: www.olapreport.com.

[23] B. W. Boehm and P. N. Papaccio, "Understanding and Controlling Software Costs," *IEEE Transactions on Software Engineering,* 14(10), pp. 1462-1477, 1988.

[24] K. A. Ericsson and H. A. Simon, *Protocol analysis: verbal reports as data.* Cambridge, MA, MIT Press, 1993.

[25] Gartner Group, *Gartner Predicts 2002: Business Intelligence & Data Warehousing*, Gartner Group. 2002.
www.gartner.com/1_researchanalysis/focus/bidw_fa.html

[26] L. Abinanti, "Put OLAP to work in your data warehouse." *Management Accounting* 78(4), pp. 54, 1996.

[27] D.A. Schön, *The reflective practitioner : how professionals think in action*, New York: Basic Books, 1983.

[28] M. Alavi and E. A. Joachimsthaler, "Revisiting DSS Implementation Research: A Meta-analysis of the Literature and Suggestions for Researchers," *MIS Quarterly,* 16, 1, pp. 95-116, 1992.

[29] T. Guimaraes, M. Igbaria, and M. Lu, "The determinants of DSS success: an integrated model", *Decision Sciences*, 23, , pp. 409-430, 1992.