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The Enterprise *AID* methodology: Concepts

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Abstract

The Enterprise *AID* – for assessment, improvement, and design – methodology is a systems science-, operational test and evaluation-, and multicriteria decision analysis-based approach to design and deployment of performance measurement systems (PMSs) tailored to specific enterprises pursuing any or all of enterprise assessment, improvement, or design. Its two phases of design and deployment sprang from designers' inductively generated and now prototyped response to a gap they recognized between performance measurement capabilities required by contemporary enterprises and those offered by contemporary PMSs. This paper illustrates key concepts underlying *AID*, while a companion document, *The Enterprise AID methodology: Application*, draws from a prototyping effort to identify value to be gained by stakeholders from PMSs designed and deployed with methodology application.

Keywords: enterprise performance measurement; performance measurement system; systems science; operational test and evaluation; multicriteria decision analysis

1. Introduction

The past two decades have given rise to enterprise performance measurement systems (PMSs) broadly acknowledged to exceed the scope of their predecessors. The new systems, for example, emphasize enterprise features such as customer satisfaction that complement traditional measures like financial performance; but even that enhanced scope retains predecessors' focus on current and generalized performance of generalized enterprises. Few, if any, PMSs seem designed to directly serve the specific measurement needs of specific enterprises, especially when those needs demand future-oriented perspectives. Much might be gained from a methodology with which users can design and deploy enterprise-specific PMSs suited to Table 1-defined purposes of assessment, improvement, or design; and that proposition has prompted two research questions:

Research Question (1). What concepts might be essential to a methodology for the design of PMSs able to

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uniformly address enterprises' assessment-, improvement-, and design-oriented measurement needs?

Research Question (2). What concepts might be essential to a methodology for the deployment of PMSs able to uniformly address enterprises' assessment-, improvement-, and design-oriented measurement needs?

Table 1. Performance Measurement System Purposes

Purpose	Definition
Assessment	Evaluations of current enterprise performance with respect to stakeholder intent.
Improvement	Enhanced performance, likewise with respect to stakeholder intent, generated by evaluations of current enterprise configurations and associated processes versus those of projected alternatives.
Design	Wholly new combinations of enterprise configuration and process generated in response to stakeholder intent.

By adopting the Rouse [1] definition of "enterprise" for that term's prominence in both of research questions (1)-(2), this paper's Sections 2-3 can respectively respond to each:

> *An enterprise is a goal-directed organization of resources – human, information, financial, and physical – and activities, usually of significant operational scope, complication, risk, and duration.*

2. Essential PMS Design Concepts

The research questions prompted an extensive literature review that converged on three disciplines the authors felt essential to any methodology for enterprise PMS design: disciplines of systems science, operational test and evaluation (OT&E), and multicriteria decision analysis (MCDA). Specifically, the review compelled developers to:

- Consider a link to systems science as one essential to the design of systems intended to measure performance of Rouse's [1] goal-directed organizations, or enterprises, that necessarily feature the complexity and related concepts central to systems science [2];
- Recognize the utility to enterprise measurement of OT&E concepts of critical operational issues (COIs), measures of effectiveness (MOEs), and measures of performance (MOPs), as defined by Sproles [3-5] and others [6-10]; and to
- Recognize the criticality of MCDA-related concerns such as utility [11-13] and measurement theory [14] to the validity and usefulness of results achieved with an enterprise PMS.

Figure 1 depicts those three disciplines, select components, and the relationships among all within a methodology the authors were ultimately led to develop and label as Enterprise *AID*, or simply *AID*, for enterprise assessment, improvement, and design. Ensuing subsections more fully explain the importance of each discipline to PMS design.

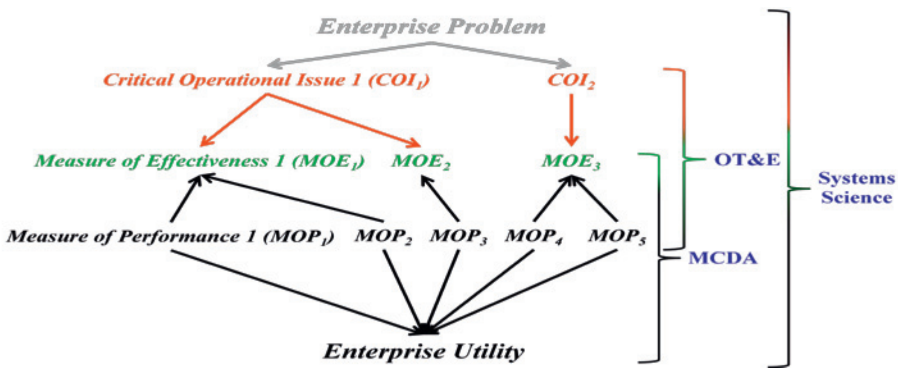

Figure 1. Essential Disciplines and Select Components of a Methodology for Enterprise PMS

2.1. Systems Science Concepts

The literature strongly suggests "enterprises [to] represent complex systems of human endeavor" [10], so *AID* developers desired a methodology for *enterprise* PMS design and deployment that could accommodate the observability, emergence, value system, and other traits long posited to characterize the complex systems [2, 15, 16] that enterprises are. In other words, they wished what ultimately became a methodology to be seen by potential users as a legitimate means to meet measurement needs associated with current or envisioned enterprise performance. Only respect for systems science made possible such a methodology [6], and discipline tenets such as those informally described with Table 2 therefore pervade the whole of *AID*'s PMS design and deployment features.

Table 2. Select Systems Science-derived Concepts Incorporated with Enterprise *AID*

Concept	Description
Systems	Collections of elements that together produce results not obtainable by the elements alone.
Complex Systems	Sets of elements characterized by performance that emerges over time through interactions among the elements and between the system and its operating environment.
Emergence	A feature of systems exhibiting properties meaningful only within the context of the whole system, and not of its components.
Emergent Properties	Properties exhibited only by whole systems and not by any of those systems' components.

2.2. Operational Test and Evaluation Concepts

What later portions of this paper will show to have become an *AID* Phase 1, *PMS Design*, focused on establishing enterprise-specific performance evaluation structures owes extensively to advocates of three OT&E conventions as mechanisms "not the exclusive domain of just the engineering disciplines....[but] equally applicable to all disciplines and...a manifestation of good management practices" [3]. Table 3 displays the conventions of COIs, MOEs, and MOPs together with definitions advanced by prominent contributors [3-5, 7-9] and tailored for *AID* purposes by its developers [6, 10]. Table 3 also makes plain a link between the OT&E concepts upon which *AID* depends and the equally significant systems science concept of emergence; and the table's COI description reference to "problems" hints at a feature of *AID* that has users apply the PMSs they design with it to performance measurement needs expressed as problems they wish resolved or, equivalently, as gains in capability they wish to achieve. Section 2.5 will demonstrate the essential role of problem statements in measuring enterprise performance.

Table 3. OT&E Discipline-derived Concepts of COIs, MOEs, and MOPs [3-10]

Concept	Description
Critical Operational Issues	Essential needs recognized by stakeholders to sufficiently characterize particular problems faced by their enterprises of interest; and needs that therefore must be satisfied for problem resolution. Emergent essentials of capability without which posited problem solutions must be judged as unacceptable on functional grounds.
Measures of Effectiveness	Scales of "goodness" derived by stakeholders from enterprise COIs, preferentially independent of solutions proposed for COI resolution but representing emergent properties inducing rank orderings on solutions proposed to satisfy essential needs.
Measures of Performance	Evaluations of intrinsic properties of solutions proposed to resolve COIs, as measured against MOEs independently established with stakeholder preferences.

2.3. Multicriteria Decision Analysis Concepts

Its facilitated employment by subject matter experts representing user enterprises' possibly diverse interests marks Enterprise *AID*'s Phase 1 as particularly reliant on prominent concerns of the MCDA discipline; and the methodology's pairing of scale of measurement- and utility theory-related concepts therefore rests on a par with the criticality to PMS design of the systems science- and OT&E-derived notions already identified. Moreover; and as

Section 3 will show, those two MCDA concerns figure perhaps most prominently in *AID* processes regarding PMS deployment, once designed.

Gravetter and Wallnau [17] have defined measurement as "assigning individuals or events to categories." Complete category sets determine scales of measurement, and the relationships among distinct categories allow classifications of scale type. Scale types selected for evaluative endeavors should be those offering the empirical operations needed for the efforts, as Stevens [14] recognized with what Table 4 shows to be his four-type classification of increasingly sophisticated nominal, ordinal, interval, and ratio scales. Each of those scales exhibits properties related to basic empirical operations, mathematical group structure, and permissible statistics; and each represents a cumulative capability that includes all properties assigned to preceding scales, and more.

Table 4. Types of Measurement Scales [14]

Scale	Basic Empirical Operations	Mathematical Group Structure	Permissible Statistics
Nominal	Determination of equality	Permutation group, $x' = f(x)$, where $f(x)$ is any one-to-one substitution	Number of cases Mode Contingency correlation
Ordinal	Determination of greater or less	Isotonic group, $x' = f(x)$, where $f(x)$ is any monotonic increasing function	Median Percentiles
Interval	Determination of equality of intervals or differences	General linear group, $x' = ax + b$	Mean Standard deviation Rank-order correlation Product-moment correlation
Ratio	Determination of equality of ratios	Similarity group, $x' = ax$	Coefficient of variation

AID employs interval and ordinal scales. Ordinal scales are sets "of categories that are organized in an ordered sequence" [17] and can represent relative preference between alternatives but not the magnitude of preference. Examples of ordinal scales include those applied to the hardness of minerals or the first, second, and third place finishes of racing results. Interval scales are sets "of ordered categories that are all intervals of exactly the same size. Equal differences between numbers on the scale reflect equal differences in magnitude" [17], and interval scales therefore represent more powerful tools than ordinal scales. Numbers indicate magnitudes of differences between alternatives (as well as rank-ordering) without the use of any zero point. Examples of interval scales include those applied to temperature or calendar time.

Their desire to identify methodology concepts supporting enterprise improvement and design as well as assessment endeavors required *AID* developers to allow for combining multiple and possibly competing MOPs into single values of utility. Figure 1's "Enterprise Utility" therefore acknowledges *AID*'s observance of utility-focused precepts spanning the work of Bernoulli [18] through von Neumann and Morgenstern [11] through Savage [13] and Keeney [12]. The methodology perhaps most notably observes: Savage's extension of the classic utility concept to one allowing subjective evaluations derived from personal preferences; and Keeney's additive "multiattribute utility function" [12] model allowing for functions of three or more weighted attributes and that provides much to *AID*'s measurement protocol.

2.4. Additional Concepts

The inductive effort that generated Enterprise *AID* also led developers to the belief that valid and useful enterprise assessments, improvements, and designs can only be had by smartly eliciting the judgments of persons expert in enterprises' issues of interest. That belief directly highlighted the importance of group decision-making, and it correspondingly mandated concern for the means by which expert groups pursue decision-making processes: means that methodology developers believe must respect a concept of risk and closely aligned elements of fuzzy set theory. The methodology's PMS design processes thus incorporate select elements drawn from the domains of group decision-making, risk, and fuzzy set theory.

The individual expert judgments on which *AID* applications have been designed to depend can promote results of value only if they can be captured in terms of group preferences representing singular, enterprise-level judgments made with a scope of perspective not typically held by individual experts. *AID*'s group decision-making elements therefore rely on popular definitions of consensus like those of Susskind [19] that, while often accompanied by time-consuming deliberations of participating experts, nevertheless afford *AID* the degree of validity its users need to develop PMSs suited to their enterprises' problems, or measurement needs.

The community concerned with risk holds risk-based decision-making as a logical approach to uncertainties commonly faced by enterprises and their stakeholders. That same community moreover asserts risk-related endeavors to be part-and-parcel of all decision processes. Enterprise *AID*, too, adopts a concern for risk on display with, among other of its PMS design processes, an MOE derivation process largely founded on experiences [20, 21] identifying MOEs via conventional risk assessment means. Like the concern for group decision-making, *AID*'s sensitivity to risk assessment-related needs is inextricably linked to contributions also to be gained for its application from fuzzy set theory.

AID supports its concerns for group decision-making and risk with an equal concern for the ambiguities and other "fuzzy" characteristics of cognition and language manifest in human evaluations like the "highly likely" and "significant" characterizations respectively often used to assign probability and consequence values to risk events. The methodology therefore allows users to design enterprise- and problem-specific PMSs for "success" in terms they can readily understand and that support many of *AID*'s Phase 1 processes.

2.5. Concepts Illustration

Space constraints do not allow this paper to fully address the roles played by each of systems science, OT&E, and MCDA in *AID*'s PMS design steps. This section will therefore draw on the methodology's relatively accessible OT&E-derived concepts to represent the broader array of contributions made to PMS design by all of *AID*'s three foundational components.

Critical operational issues constitute sets of necessary and sufficient elements characterizing some enterprise-specific problem demanding the measurement processes that *AID* can provide; and COIs' defined criticality likewise demands that they be universally resolved before enterprise stakeholders can claim resolution of whatever problem they collectively describe. The same definition suggests that determinations of COI resolution be made in strictly binary terms of "yes" or "no," and that in turn makes convenient issues' representation as questions like one Figure 2 depicts as posed by stakeholders of a state health agency, or enterprise:

"Do we offer 'person-centered' service?"

Typically small numbers of COIs to be identified by stakeholders addressing specific problems should each be accompanied by a similarly small number of MOEs [5] that stakeholders use to make the "yes" or "no" determinations demanded by COIs. Recalling their Table 3 definition as emergent properties that induce rank orderings, MOEs are truly the scales of "goodness" defined by Dockery [8] and Sproles [22, 23]. The Figure 1 directional arrows highlight another of MOEs' most profound features by indicating them to be exclusively responsive to the problem from which they derive and wholly unbiased toward the performance measures of any solutions – or, in the case of *AID*'s application domain, particular enterprise configurations or processes – posited to resolve the problem. Effectiveness measures may assume quantitative or qualitative forms and are quite commonly represented as constructs defined as

> *Characteristics that cannot be directly observed and that therefore can only be measured indirectly, often inferred in terms of human behavior* [24-27].

Constructs include characterizations like the Figure 2 "user satisfaction" and "facility management outreach," each a scale of goodness against which stakeholders can gauge their enterprises' performance in terms of intrinsic enterprise features, or MOPs.

Unlike stakeholder perspective-oriented MOEs, strictly enterprise-oriented MOPs should be viewed not as (variable) scales but as precise evaluations of enterprises' measurable outputs, or properties, to be rank-ordered by MOEs. Like their measure of effectiveness counterparts, measures of performance may assume either of qualitative or quantitative forms; and Figure 2 therefore portrays both forms together with representative COIs, MOEs, and the relationships among those and a problem statement representing a state health agency's need to measure its performance in light of a charge to provide "the greatest reasonable degree of mental health services."

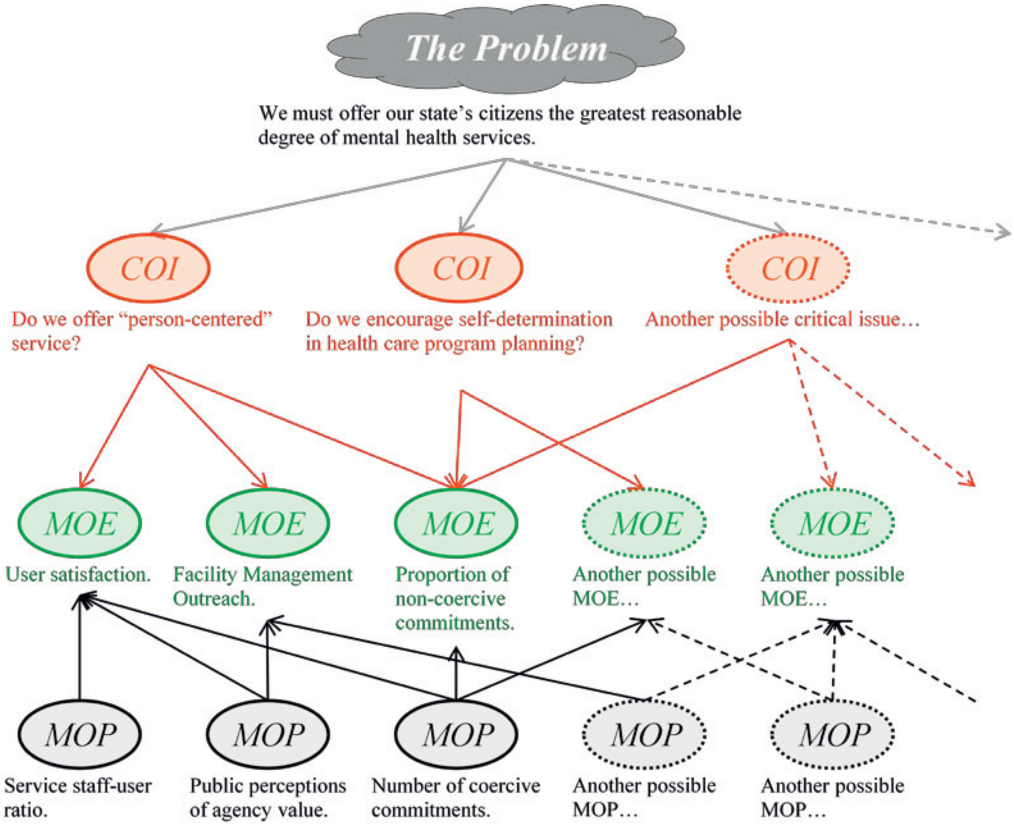

Figure 2. Problem, COI, MOE, and MOP Forms and Relationships

Section 4 will briefly return to the PMS design concepts highlighted throughout the length of this section. It will also note complementary highlights related to PMS deployment that Section 3 will first address in greater detail.

3. Essential PMS Deployment Concepts

Phase 2 of *AID*'s two successive phases focuses on deployment of PMSs designed with Phase 1. Phase 1 guides users through PMS design, and Phase 2 guides them through applications the designs are deliberately structured by users to accommodate. This section will elaborate on *AID*'s MCDA-derived concepts already noted as most prominent to its PMS deployment focus and, in so doing, will also hint at practical concerns that this paper's companion document, *The Enterprise AID methodology: Application*, more rigorously identifies.

3.1. Utility Theory

In support of its enterprise improvement and design capabilities most visible with Phase 2 activities, *AID* requires a mechanism for combining multiple, possibly competing MOPs into the single value of *Enterprise Utility* displayed in Figure 1. The methodology therefore observes Bernoulli's [18] 300 year-old concept of utility maximization as it likewise respects von Neumann and Morgenstern's [11] much more recent formalization of a theory of utility founded on four axioms with which rational decision-makers – such as the enterprise stakeholders represented by expert participants in an *AID* application – can construct utility functions whose maximized values can be said to represent decision-maker preferences. The four axioms are:

- **Completeness.** Given two alternatives, ***A*** and ***B***, a decision-maker either prefers ***A*** to ***B***, prefers ***B*** to ***A***, or is indifferent between ***A*** and ***B***;
- **Transitivity.** If ***A*** is preferred to ***B*** and ***B*** is preferred to ***C***, then ***A*** is preferred to ***C***;
- **Continuity.** If $\boldsymbol{A} < \boldsymbol{B} < \boldsymbol{C}$, then there exists a unique probability, p, such that the following relationship can be constructed: $p\boldsymbol{A} + (1 - p)\boldsymbol{C} = \boldsymbol{B}$; and
- **Independence.** For any $\boldsymbol{A} > \boldsymbol{B}$, $p\boldsymbol{A} + (1 - p)\boldsymbol{C} > p\boldsymbol{B} + (1 - p)\boldsymbol{C}$. That is, introduction of a third alternative does not influence the original preference of one alternative over another.

Even von Neumann and Morgenstern's now-classic work has been augmented. Savage [13] promotes key elements of *AID*'s methodology by extending the utility concept to include subjective evaluations derived from personal preferences and subjective probabilities, where individuals' sense of utility would be subjectively determined as expected values. Keeney [13], too, provides for *AID* premises with an additive "multiattribute utility function" model allowing for functions of three or more weighted "attributes." His model further suggests that values of individual utility functions and incorporated weights be confined to the interval, [0, 1], a characteristic precluding the rather meaningless concern for infinitely good or bad enterprises. Smith and Clark [28] offer one more utility-related feature that *AID* developers have incorporated with their methodology, a requirement that it provide for aggregation and decomposition; in other words, that evaluations of utility of any of an enterprise's subordinate levels mathematically support evaluations of the utility of the entire enterprise.

3.2. Ordinal vs. Cardinal Utility

The Figure 1-depicted *Enterprise Utility* value determined with *AID*'s Phase 2 of PMS deployment must be viewed as an ordinal, never a cardinal, evaluation of the utility of a particular configuration of the particular enterprise of interest. In other words, any *Enterprise Utility* value derived from PMS deployment steps should only imply to interested stakeholders an enterprise worth within the context of a specific current (for assessment purposes) or envisioned (for improvement or design purposes) structure and set of enterprise processes. *Utility* evaluations should never be taken as absolute measures of anything; but any single enterprise's myriad possible configurations, extant or projected, can be compared, and it is precisely such a robustness to temporal concerns that distinguishes *AID* from like-intended methodologies and PMSs. Enterprise *AID* users must simply avoid the temptation to compare distinct enterprises because with the distinctiveness will always come distinct PMS designs rendering any inter-enterprise comparisons as those of "apples and oranges."

3.3. Other MCDA Discipline Concepts

Enterprise *AID* developers acknowledge the merits of MCDA schemes other than those used with Enterprise *AID*. Approaches such as Saaty's [29] analytic hierarchy process, or AHP, for example, have been justifiably popular for decades. However, developers believe that the advantages of an additive utility function typically able to identify the "uniquely 'best all around' alternative in the choice set" [30] – albeit with "a great deal of effort and time" [30] – makes Keeney's [12] additive utility function formulation a best fit for a methodology crafted to provide systemic and meaningful evaluations of enterprise utility.

4. Conclusions

This paper began by citing two research questions focused on the need for a methodology with which stakeholders of any enterprise can design and deploy systems suited to the responsible measurement of enterprise performance. It answered those questions by identifying concepts essential to such a methodology, and it revealed Enterprise *AID* as a particular methodology its developers believe incorporates PMS design and deployment guidance instantiating essential concepts.

Enterprise *AID* represents a temporally robust approach to designing and deploying systems that can meet performance measurement needs specific to enterprises large or small, formal or informal, and most especially, extant or envisioned. In that vein it is rather unique. It comprises concepts logically linked to twin purposes of tailored PMS design and deployment, and it instantiates those concepts in a manner only hinted with the immediately following Figure 3 but wholly the focus of this paper's companion, *The Enterprise AID methodology: Application*.

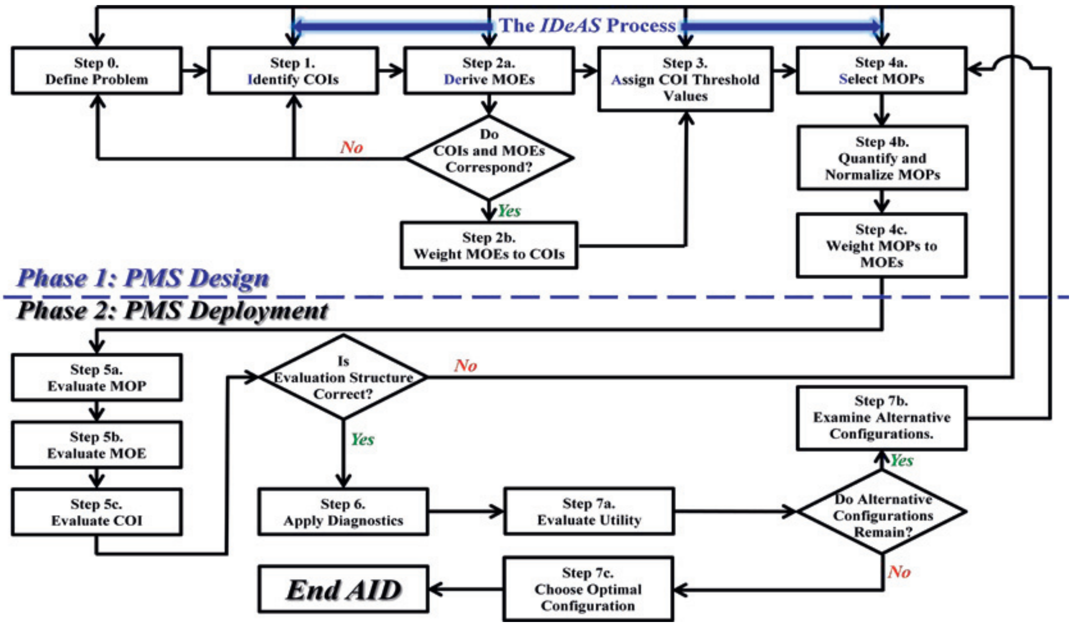

Figure 3. Enterprise *AID* Application Flowchart

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