Condition Assessment in Facility Asset Management

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Those who manage and operate large physical plants, whether public or private, universally confront a conundrum: "How do I satisfy the budgeters that I need certain resources to adequately maintain these facilities, without wasting those same resources on data gathering and analysis to build my case? [1]

Background

Protecting a portfolio of facility assets against the ravages of time and keeping it fit for current use takes significant and continuous investment in repair and renewal of deteriorating components. Proposed expenditures must compete for money that organizations could put to other good uses. When there isn't enough money to go around, many valid and urgent needs remain untended, deterioration worsens, facility condition suffers, and organization performance degrades. Accumulated, deferred investment in repair and renewal creates an ever-accelerating, downward spiral of condition as breakdown maintenance depletes repair and renewal funds.

For the past 50 years, facility professionals, CFO's, governance boards, and legislatures have become increasingly aware of these realities and have been trying to deal with them by adapting a generic business process known as "*Asset Management*" to facility management. A key step in "Facility Asset Management" is the continuous generation of data describing asset inventory, condition, and performance. Such data constitute the process "lifeblood," which feeds analytic tools and creates business intelligence of value to decision makers. The successful application of the generic process to any organization's facility portfolio therefore depends on the accuracy, granularity, and credibility of facility data available to that organization. Unfortunately, quality data comes at a price that few organizations can fully afford, making it necessary, at least until recently, to accept fewer benefits and reduced return on investment in Facility Asset Management that first-rate data could otherwise render.

This chapter examines these issues by providing:

- A generic description of "Asset Management"
- A detailed description of "Facility Asset Management" and the role played by condition assessment
- Comparisons of alternative techniques of building condition assessment, and
- Recommendations to help the reader decide which alternative technique is best for an organization.

Asset Management [2]

"Asset Management" is a broad term often used to signify the management of physical, assets or financial assets. Physical assets encompass two main categories: fixed and non-fixed. Fixed assets include buildings, utilities, pavements, dams, locks, etc and non-fixed assets are rolling stock,

1 Ottoman, G. R., Nixon, W. B., and Lofgren, S. T. (1999). ''Budgeting for Facility Maintenance and Repair. I: Methods and Models.'' Journal of Management in Engineering, ASCE, 15(4), 71-83.

2 Much of this section has been adapted from FHWA (1999). "Asset Management Primer," Federal Highway Administration, Office of Asset Management, Washington, DC.

vessels, automobiles, cranes, etc. This chapter describes the management of only one sub-category of fixed, physical assets: buildings.

The American Public Works Association Asset Management Task Force once proposed to define Asset Management simply as:

> *"…a methodology to efficiently and equitably allocate resources among valid and competing goals and objectives[3]."*

The Institute of Asset Management recognizes that the management of physical assets plays a key role in determining the operational performance and profitability of industries that operate assets as part of their core business, and defines Asset Management as:

> *". . . the art and science of making the right decisions and optimizing these processes (by cross disciplinary collaboration). A common objective is to minimize the whole life cost of assets but there may be other critical factors such as risk or business continuity to be considered objectively in this decision making[4]."*

The Federal Highway Administration (FHWA) elaborates with a widely-known definition:

> *"Asset Management is a systematic process of maintaining, upgrading, and operating physical assets cost-effectively. It combines engineering principles with sound business practice and economic theory, and it provides tools to facilitate a more organized approach to decision making. Thus, Asset Management provides a framework for handling both short- and long-range planning[5]."*

And the Government Accountability Office (GAO) adds:

> *"At its most basic level, Asset Management involves the systematic collection of key data, the application of analytical tools, and the creation of business intelligence (BI), which managers can use to make sound investment decisions about their organization's physical assets[6]."*

The process works as follows: First, performance expectations, consistent with goals, available budgets, and organizational policies, are established and used to guide the analytical process, as well as the decision-making framework. Second, asset inventory and performance data are collected and analyzed. This information provides input on future asset repair / renewal requirements (also called "needs"). Third, analytical tools and reproducible procedures produce viable cost-effective strategies for justifying budgets and allocating funds to satisfy organizational needs and user requirements, using performance expectations as critical inputs. Alternative choices are then evaluated, consistent with long-range plans, policies, and goals. The entire process is reevaluated periodically through performance monitoring and systematic processes[7].

Figure 1 illustrates one well-known generic Asset Management process. The process steps are indicated, as are the relationships among them. Various issues, tools, and/or activities are associated with each step. For example, "Alternatives Evaluation" would include the application of an array of engineering economic analysis (EEA) tools, including benefit/cost analysis, life-cycle cost analysis, and risk analysis.

3 "Asset Management for the Public Works Manager – Findings of the APWA Task Force of Asset Management," August 31, 1998

4 http://theiam.org/what-is-asset-management

5 "Asset Management Primer," U.S. Department of Transportation, Federal Highway Administration, Office of Asset Management, December 1999

6 "Comprehensive Asset Management Has Potential to Help Utilities better Identify Needs and Plan Future Investments," GAO-04-461, December 2004

7 See Footnote 5

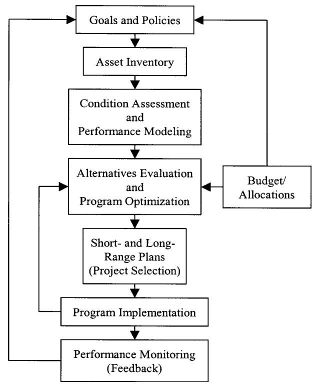

Figure 1 FHWA Generic Asset Management Process

The indicated steps would typically be included in any Asset Management approach, although the specifics would differ to suit a particular organization and asset type. Individual organizations and portfolio managers will define the parameters of their own processes based on organization-specific decision variables, such as policies, goals, asset types and characteristics, budgets, operating procedures, and business practices. Furthermore, any Asset Management process should be flexible enough to respond to changes in any of these variables or factors.

The assets likely to be included in an organization's initial Asset Management implementation efforts will depend on the organization's existing capabilities, particularly in the area of technical, financial, and human resources. What is needed to support the Asset Management approach is a logical sequence of decision steps, constituting a decision framework. The framework is supported by (1) information regarding organizational goals, policies, and budgets, (2) horizontal and vertical organizational integration to implement the decision steps in practice, and (3) technical information to support the decision-making process.

Adapting Asset Management Principals to Facilities Management

The application of asset management principles to Facilities Management (FM) began in the 1960s with comprehensive, annual inspections that produced lists and cost estimates of needed repairs and replacements. The focus of such inspections and information was on maintaining a "job jar" as a tactical, work scheduling tool and the collected data had no clear strategic application. As facility condition assessment evolved, it both contributed to and derived benefit from parallel advances in "Asset Management." The interplay of the two disciplines eventually converged to produce today's "Facility Asset Management."

This still-emerging discipline is a strategic approach to the optimal allocation of capital for the repair, renewal, and modernization of aging buildings, pavements, utilities, and other infrastructure. Like its generic forebear, Facility Asset Management combines engineering and economic principles with business practices, tools, and a framework to facilitate organized, logical, and complementary decision making at strategic, operational, and tactical levels. Figure 2 illustrates a simplified framework with the basic elements of the generic process divided into four facility-specific activities. While Figure 1 presents a clearly divided, sequential flow chart of the process Figure 2 shows a grouping of inter-dependent activities. The "Generic Elements" listed below each activity block in Figure 2 correspond to the boxes in Figure 1.

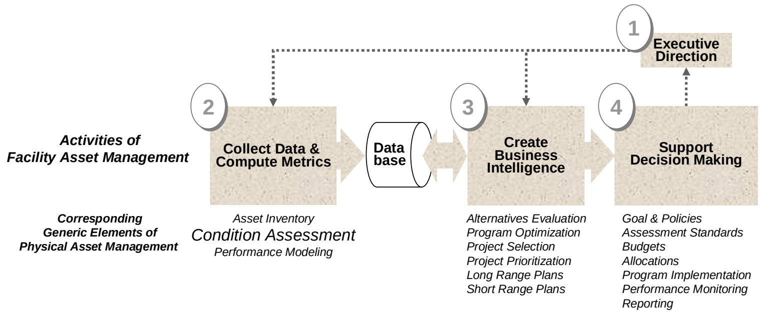

Figure 2 Facility Asset Management Process

The process incorporating "*Facility Asset Management"* goes by a variety of names including: "capital asset management," "facilities capital planning and management," or "capital renewal and deferred maintenance planning." Whatever label is preferred, the promise of this process is that organizations using it will be rewarded with budget success, improved facility conditions and functionality, grateful users and stakeholders, and better mission support.

Advocates also claim that "Facility Asset Management*"* can reduce long-term costs of ownership, prolong facility life, eliminate unforeseen demands on routine operation and maintenance activities and, thus, help optimize return on investment in facility condition and performance.

Phases of the Facility Asset Management Process

Phase 1. Executive Direction

Phase 1 of Facility Asset Management controls the overall rigor, effectiveness, and efficiency of an organization's process by setting goals, policies, and standards that regulate process quality, timeframes, and cost. Executive Direction should be set consciously and deliberately by the organization's management. If management does not fulfill this duty, lower level employees and contractors will gladly substitute their own guides, which are not always in the best interests of the organization.

a *Goals & Policies*

This ever-repeating action establishes goals and policies against which process steps and their outcomes can be measured and adjusted. Such goals and policies are used to guide the collection of data, the computation of metrics, the creation of business intelligence, and the decision-making framework that employs the business intelligence.

b *Standards*

This action represents the creation and deployment of criteria and rules for regulating each process step and work products of process participants.

c *Schedules*

This activity produces the calendar schedules for collecting data and computing metrics, creating various types of business intelligence products, and operating the decision-making framework.

Phase 2. Collect Data & Compute Metrics

The purpose of this phase is to systematically gather data and update metrics about individual facilities, their included systems and components. This information answers the questions:

- What facilities do we have?
- What are their physical characteristics, condition and service utility?

Data and metrics describe the inventory, as well as its condition and performance, and are stored in one or more databases for future re-use in this and subsequent phases.

Phase 3. Create Business Intelligence

Phase 3 systematically answers questions such as:

- What investments are needed in repairs, renewals, and modernizations?
- Which investments should be made with limited funds?
- What are the risks and outcomes of investments made and not made?
- How can those risks be managed with proper investment?

Computer-based parametric models use inventory data and computed metrics from Phase 2 to compute many forms of "Business Intelligence," which can be used by decision makers. Any comprehensive Facility Asset Management software enables a trained analyst to forecast future behavior of metrics, create and rank work packages, and analyze alternative return on investment for individual projects - all based on data collected and metrics computed during Phase 2. Good parametrics also help the analyst develop both short- and long-range repair/replacement scenarios and plans, and many applications also enable analysts to forecast long-term renewal costs of building components over a building's entire lifetime.

Phase 4. Support Decision Making

This phase includes the activities which organizational managers conduct in order to set goals, policies, and standards, create and review budgets, allocate available resources, implement programs and projects, monitor spending and performance, and make reports. Managers work within a defined decision making framework and use business intelligence produced by Phase 3, as well as other sources.

Condition Assessment in Facility Asset Management[8]

In an environment of tightly constrained spending, the decidedly unglamorous business of facility maintenance, operating behind the scenes and producing subtle and distant outcomes, is an easy target for the cost-cutting knife. Defending M&R requirements means building a convincing case. Professional judgment and experience are essential, but lack the definitive edge of a hard, reproducible, computer-generated estimate.[9]

The activity in Figure 2 labeled "Collect Data & Compute Metrics" involves the gathering and treating of data pertaining to three facility-related factors: (1) inventory, (2) condition, and (3) performance. The activity's primary input is the output of the previous process step, "Executive Direction" and its purpose is to generate metrics and other data, which are in turn used in the subsequent process step "Create Business Intelligence." Business intelligence products of Facility Asset Management include reports and projections on inventory, condition, performance, deferred maintenance, repair, and modernization; short- and long-range repair/renewal/modernization plans; funding alternatives, risks and penalty costs attributed to deferring work items and projects; budget requests, fund allocation plans, spending evaluations, detailed project identification, return on investment calculations, project priority ranking lists, and execution plans.

This chapter deals only with the data collection and metrics of Condition Assessment. Data collection and metrics pertaining to Facility Inventory and Performance Monitoring are separate, complex discussions not included in this discussion.

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8 The author is preparing a paper on the fascinating and quickly advancing field of facility performance assessment and its close but contrasting relationship to condition assessment. The remainder of this paper concentrates on just the condition assessment aspects of Facility Asset Management.

9 Ottoman, G. R., Nixon, W. B., and Lofgren, S. T. (1999). ''Budgeting for Facility Maintenance and Repair. I: Methods and Models.'' Journal of Management in Engineering, ASCE, 15(4), 71-83.

Overview of Facility Condition Assessment

There are many different types of facilities, ranging from buildings, bridges, railways and pavements to dams, locks, piers and utility systems. "Central to a comprehensive asset management program is the ability to evaluate and know the condition . . . of all inventoried assets in (an organization's) real property inventory[10]."

Specific, condition assessment technologies have been developed for most of these facility types. For instance, there are at least twenty technical reports that discuss development and provide specifics on using the various condition assessment techniques for a corresponding number of components and groups of related components of the US Army Corps of Engineers Civil Works infrastructure. Due to space limitations, this chapter discusses the one technology of most interest to IFMA readers: Building Condition Assessment.

Building Condition Assessment Methods and Techniques

There are four main types of alternative techniques for accomplishing Building Condition Assessment. All four draw upon building inventory data to varying degrees and supplement the processing of inventory data with various kinds and combinations of on-site visual observations and computerized parametric models[11]. All four techniques produce metrics and other condition-related data, which are used as inputs to the subsequent step in the Building Asset Management process, "Create Business Intelligence."

As shown in Figure 3, each of the four building-related techniques can be classified into one of two main categories: (1) the Monetary Method, and (2) the Engineered Method[12]. It is important to understand the differences between these methods and techniques when choosing what is best for a particular organization.

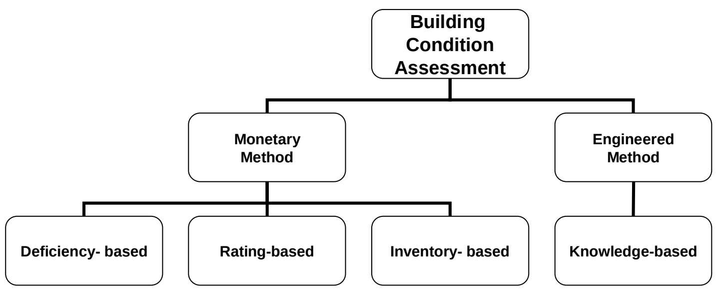

Figure 3 Building Condition Assessment Methods & Techniques

The four techniques are classified according to purpose, type of collected data, and metrics computed. All three techniques of the Monetary Method have one identical objective[13] and use dollar estimates of needed work to compute two, monetary-based metrics called "Backlog" & "Facility Condition Index (FCI)." These three techniques differ only in how the dollar estimates are obtained. The "Deficiency-Based Technique" gets cost estimates from engineers and technicians who conduct detailed visual inspections. The "Rating-Based Technique" taps reports from people who record cursory visual observations. And the "Inventory-Based Technique" employs pre-existing databases of building attributes, usually without any visual input.

10 FRPC Guidance Section 4, "Operations of Real Property Assets"

11 The term "parametric model" as used in this chapter refers to a mathematical equation representing a relationship between a set of measurable factors, (such as component type, age, and time) that defines another variable, such as condition, and determines the component's behavior regarding that variable.

12 Uzarski, Donald R., and Michael N. Grussing. "Building Condition Assessment: Best Practices." Infrastructure Reporting and Asset Management (2008): 147-52.

13 To produce information needed to manage estimated backlog of $Repair

In contrast, the "Knowledge-Based[14] Technique" of the Engineered Method has two additional objectives[15] and works in the opposite sequence, initially computing a Building Condition Index (BCI) series of metrics from which are derived dollar estimates of needed work and several other useful metrics, including the monetary-based condition metrics, Backlog and FCI. The following pages of this chapter define the key difference between the two methods and explain how it drives other significant variances between the four included techniques of building condition assessment.

Origin of the Monetary Method for Building Condition Assessment

The Monetary Method was conceived and developed by the U.S. Navy Bureau of Yards and Docks in the 1960's in an effort to better manage shore base maintenance[16]. After years of refinement and use, the technique was eventually carried by ex-Navy people and a vendor to public higher education in the 1980's. Subsequently, the technique was further refined and successfully marketed by private vendors to other governmental agencies, educational institutions, the health care industry, and large corporations.

Foundation of the Monetary Method: Backlog and FCI

The classic description of the original Monetary Method is contained in a 1991 book[17] written, in part, by the vendor who helped introduce it to public higher education. That book explained a detailed, systematic approach to visual inspection and helped establish the use of Backlog and FCI as the first metrics of building condition assessment. Since then, the definitions of backlog and FCI have evolved in different directions to meet the needs of various organizations, thereby causing inconsistency and inability to compare different organizations in terms of the metrics.

For example, the original published equation for calculating FCI is shown in (1):

$$FCI = \frac{\text{Cost of Deficiencies}}{\text{Current Replacement Value}} \qquad (1)$$

Where:

> Cost of Deficiencies is the total dollar amount to correct existing maintenance and repair deficiencies. The amount does not include any future maintenance and repair or other types of work such as alteration or new construction, and
>
> Current Replacement Value is the amount required to reproduce a building in like kind and materials at one time in accordance with current market prices for materials and labor.

Equation (2) gives a different formula for FCI now sanctioned by a task force comprised of representatives of APPA, IFMA, FFC, and others[18]:

$$FCI = \frac{\text{Deferred Maintenance + Capital Renewal}}{\text{Current Replacement Value}} \qquad (2)$$

Where:

> Deferred Maintenance is "total dollar amount of existing maintenance, repairs (i.e. work to restore damaged or worn-out facility systems or components to normal operating condition) and required replacements (capital renewal), not accomplished when they should have been, not funded in the current fiscal year or otherwise delayed to the future. For calculation of

14 Uzarski, D.R., N.M. Grussing, and J.B. Clayton, "Knowledge-Based Condition Survey Inspection Concepts," ASCE Journal of Infrastructure Systems, (American Society of Civil Engineers), Vol. 13, No. 1, March 2007, pp. 72-79

15 To produce business intelligence needed to minimize life cycle cost and to produce business intelligence needed to manage risk to mission

16 "Facilities Management, NAVFAC MO-321," NAVFAC 025-LP-173-2965, Department of the Navy, 1978

17 AME and Rush, S.C. (1991). Managing the Facilities Portfolio, National Association of College and University Business Officers, Washington, D.C.

18 "Asset Lifecycle Model *for* Total Cost of Ownership Management Framework, Glossary & Definitions," A joint product of APPA, FFC, IFMA, NASFA, and Holder Construction, Inc. 2007

facility condition index (FCI) values, deferred maintenance does not include grandfathered items (e.g., Americans with Disabilities Act compliance), or programmatic requirements (e.g., alterations)," and

Capital Renewal[19] is an exchange of one facility system or component for another that has the same capacity to perform the same function, and

Current Replacement Value: The total expenditure in current dollars required to replace any facility at the institution, inclusive of construction costs, design costs, project management costs and project administrative costs. Construction costs are calculated as replacement in function vs. in-kind.

Yet another equation (3) was adopted by the Federal Real Property Council[20]:

$$FCI = (1 - \$repair\ needs/\$PRV) \times 100 \quad (3)$$

Where:

$repair needs is the amount necessary to ensure that the facility is restored to a condition substantially equivalent to the originally intended and designed capacity, efficiency, or capability, and

PRV is Plant Replacement Value: the cost of replacing an existing facility at today's standards.

Close study of just these three of the many available FCI equations makes it readily apparent why the Government Accountability Office (GAO) recently found that: ". . . condition indexes, which agencies report to FRPP, cannot be compared across agencies because their repair estimates are not comparable. As a result, these condition indexes cannot be used to understand the relative condition or management of agencies' assets. Thus, they should not be used to inform or prioritize funding decisions between agencies[21]." (emphasis added)

Additional factors adding to the confusion over FCI both within and outside the federal government:

- There are multiple ways to calculate CRV and PRV, and some officials don't recognize the difference between the two
- in some circles, FCI is called "Asset Condition Index" (ACI), "Financial Condition Index," or, simply, "Condition Index" (CI),
- The original FCI condition rating system employs a range of values to represent the condition categories of good, fair, and poor. (Good = FCI <.05, Fair = .05< FCI >.10, Poor = .10<FCI).
  - These categories are arbitrary and without any basis in science or economics,
  - Because this scheme is counter-intuitive for some people (low indicator meaning good, high indicator meaning bad), some organizations define their condition index to be the quantity (1 minus FCI) in order to correlate higher values of the metric with better condition and, thus overcoming the counter-intuitive shortcoming of the original FCI equation.
- Recently, certain officials of the Government Accountability Office (GAO) noted that a more appropriate term for FCI would be "Financial Condition Index" in recognition of the fact that FCI indicates only an organizations financial "health" regarding the ability to provide adequate facility services[22].

The Deficiency-Based Technique

19 Minimum dollar threshold levels for capital renewal are set by the building owners/manager, however typically in excess of $5,000 or $10,000.

20 "2010 Guide for Real Property Inventory Reporting," Federal Real Property Council, October 2010

21 "Federal Real Property-An Update of High Risk Issues," GAO-09-801T, July 15, 2009

22"Overcoming Challenges in Federal Facility Investments," ERDC-CERL 4/7/2011, p 6.

This chapter uses, the term “Deficiency-Based Technique” when referring to the refined, now wide-spread practice that evolved from the Navy and was described in the previously-cited 1991 book[23]. The Deficiency-Based Technique has been refined and augmented, and can be described in terms of the progression shown in Figure 4.

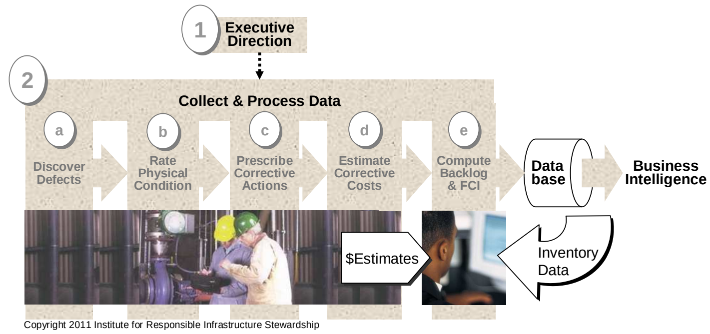

Figure 4 Deficiency-Based Technique Relies on Inspector Opinion

Phases of the Deficiency-Based Technique

Phase 1. Executive Direction

The ultimate purpose of condition assessment in Facility Asset Management is to determine the present condition of an organization’s facility assets and to provide data and metrics for use in subsequent process phases of creating and using business intelligence. Accordingly, Phase 1 of Deficiency-Based Technique sets the goals, policies, and standards that regulate assessment quality and establishes inspection schedules that determine data freshness and process cost.

a Goals & Policies for Data Collection & Metric Computation

Phase 1 begins with an organization’s leaders establishing goals and policies against which data collection standards and schedules can be measured and adjusted. Such goals and policies are also used to guide the computation of Backlog and FCI metrics.

b Standards for Collecting Data and Computing Metrics

This action represents the creation and deployment of criteria and rules for regulating the assessment and work products of Phase 2 participants. Standards determine things such as:

(i) when and how to inspect buildings

(ii) which discovered physical conditions are acceptable and can be ignored vs. which conditions are unacceptable and require correction

(iii) whether an unacceptable condition warrants a repair vs. a replacement; and

(iv) what is the desired accuracy for cost estimates associated with corrective actions?

c Inspection Schedules

In the Deficiency-Based Technique, teams of specially-trained, highly-skilled engineer-inspectors receive schedules that tell them which buildings to tour and comprehensively inspect. Schedules are usually based on a calendar frequency of inspection that management can afford rather than on component need.

Phase 2. Collect Data & Compute Metrics

23 *AME and Rush, S.C. (1991). Managing the Facilities Portfolio, National Association of College and University Business Officers, Washington, D.C.*

The purpose of this phase, as related to Deficiency-Based Technique is to collect and aggregate monetary cost data to system, building, and portfolio levels in order to compute backlog and FCI metrics. Phase 2 of the Deficiency-Based Technique is comprised of the following actions:

2a Identify Defects

Inspectors tour the entirety of each assigned building, observing all systems and components within their own specialty fields (mechanical, electrical, structural, etc.), and looking for the presence of conspicuous defects. A defect is a visual clue (e.g. corrosion) that a building component (e.g. gutter), is deteriorating or even is in potential or actual failure mode. The Deficiency-Based Technique relies on the individual inspector's training, skill, experience, and situational awareness to detect defects, but does not require the inspector to catalog, record, or report the attributes of detected defects, per se. Instead, whenever the inspector detects one or more defects on a particular component he simply initiates the next action of Phase 2.

2b Rate Physical Condition

Deficiency-Based inspectors are not required to rate physical conditions per se. Nonetheless, inspectors view defective components and form opinions regarding which conditions are "acceptable" and which are "below standard." This subjectivity plays a big role in influencing the next steps of prescribing corrective action, and the fact that such ratings are unwritten makes the process opaque and untraceable.

2c Prescribe Corrective Actions

The Deficiency-Based Technique does not require inspectors to formally catalog, record or report defect data or condition ratings. Instead, inspectors use mostly unwritten, heuristic standards and unstructured personal decision-rules to:

(i) decide whether components should be repaired, replaced, or left alone until the next inspection;

(ii) write and report descriptions of needed repair and replacement actions;

(iii) record and report opinions on needed Work Type, Work Quantity, Craft Classification, Urgency, Life/Safety, Funding Source, etc.; and

(iv) predict and report a component's remaining useful life.

2d Estimate Corrective Costs

The Deficiency-Based Technique requires inspectors to estimate, record, and report a cost for each reported corrective action. The accuracy of such estimates varies greatly according to inspector training, skill, experience, and situational awareness as well as the quality assurance processes used by the inspecting organization.

2e Compute Backlog and the FCI

This action is normally performed by automated parametric models designed to support the Deficiency-Based Technique. There are many commercial versions of such software, including Web sites that let clients conveniently access and manipulate their own data. All versions use inspectors' cost estimates to compile and compute the estimated corrective costs in a given system, building, or group of buildings. The various sums are called "deferred maintenance backlogs," Deferred Maintenance & Repair (DM&R)," "Backlogs of Maintenance and Repair (BMAR)," or simply "backlogs" of the respective system, building, or group of buildings. Parametric models also combine backlog data with facility inventory data to compute FCI.

Phase 3. Create Business Intelligence

Deficiency-Based parametric models use backlog, FCI, and facility inventory data to compute many forms of "Business Intelligence" that can, in turn, be used by decision makers. Any Deficiency-Based Technique software worth considering enables the trained analyst to forecast future backlog and FCI; create and rank work packages; and analyze alternative return on investment for individual projects - all based on inspector cost estimates, predictions of Remaining Useful Life (RUL), and selected inventory data.

Good Deficiency-Based Technique software also helps the analyst develop both short- and long-range repair/replacement scenarios and plans. Short range (5 year) “what if” scenarios and work plans are computed by formulas that estimate levels of backlog and FCI based on projected funding levels and indicate necessary funding levels to achieve targeted backlog levels and FCI.

Most Deficiency-Based Technique applications also enable analysts to forecast long-term renewal costs of building components over a building's entire lifetime using a combination of inspector RUL predictions and life-cycle concepts. According to the law of large numbers, projections of this nature are more meaningful for a portfolio as a whole than for any one component or facility.

Dissatisfaction with the Expense of Deficiency-Based Techniques

Despite inspectors' use of hand-held data collection devices, the labor-intensive requirement for comprehensive, annual facility touring and cost estimating by skilled labor make the Deficiency-Based Technique very expensive and time-consuming. Resources are often wasted by inspecting items that don't warrant scrutiny and preparing cost estimates that will never be used. Furthermore, data collected by Deficiency-Based Techniques represent a snapshot in time and therefore provide limited future visibility and quickly grow stale as building components deteriorate through age and wear.

In recent years, organizations that initially employed the Deficiency-Based Technique have made numerous attempts to reduce the inherent expense of obtaining inspector cost estimates in order to produce *Backlog* and *FCI*. Two modified Deficiency-Based techniques have been tried: (1) reducing the frequency of entire building inspections, (2) Scheduling inspection of building systems rather than entire buildings, and (3) surveying a statistical sample of building systems and inferring the results to the entire portfolio.

1. Reducing Frequency of Entire Building Inspections. The first and most common practice used to ease the cost of gathering cost estimates is to reduce the frequency with which individual buildings are inspected. The original Deficiency-Based Technique schedules inspections for entire buildings at yearly intervals. When the reduced frequency technique was devised, a building that normally would be inspected annually might have been inspected only once every 3-5 years. The reduced frequency technique slashes inspection cost, but exacerbates inherent credibility problems of the Backlog and FCI metrics by allowing cost data to stagnate during extended periods of no inspection. The reduced frequency technique also misses opportunities to assess critical components in delayed buildings that need at least partial inspection. Furthermore, extending the inspection cycle to 3-5 years leads to increased breakdowns, negative impact on operations, and, ultimately, the harmful siphoning of funds from proactive stewardship. Cost estimates gathered by the reduced frequency technique are fed into Deficiency-Based Technique parametric models for computing *Backlog* and *FCI*. It is also one of the few building assessment techniques that produce cost information granular enough to create and prioritize actionable work items and projects.
2. Inspecting Systems, not Buildings. This variation of the Deficiency-Based Technique schedules detailed inspections of selected building systems rather than whole buildings. Schedulers identify and tag each system in the inventory according to perceived need for inspection, and then schedule system inspections by frequencies set according to system attributes such as mission criticality, age, condition, and backlog. Reduced frequency system scheduling further slashes inspection cost, but also exacerbates inherent credibility problems of the Backlog and FCI metrics by allowing cost data to stagnate during extended periods of no inspection. The system inspection scheduling practice is an improvement over the reduced frequency, whole building practice because it misses fewer opportunities to assess needy systems and, thus, avoids more breakdowns, negative operational impact, as well as the harmful diversion of funds from proactive stewardship. Cost estimates gathered by the system inspection practice are fed

into Deficiency-Based Technique parametric models for computing building- and portfolio-level *Backlog* and *FCI* metrics. It also produces cost information granular enough to create and prioritize actionable work items and projects.

3. Inspecting a Statistical Sample of Systems. Another technique for lowering the cost of the Deficiency-Based Technique is to limit the number of detailed inspections to statistically-sampled building components and inferring the results to entire portfolios. This method was used in lieu of comprehensive inspection of all buildings for assessing the condition of public higher education facilities in Virginia[24]. It achieved credible results at significantly lower cost compared to the full-blown Deficiency-Based Technique. At the state-wide portfolio level, this sampling technique produced Backlog, FCI, and "what if" funding scenarios. It was not designed to yield any metrics at the institution or building level, but could have if funds had been available for additional sampling.

   Sampling methods such as this cannot produce work items or project details except for the limited number of building components that are actually inspected. A major flaw is that few portfolio owners know enough to care about statistic sampling and, consequently, engage the lowest priced inspection vendor whose low price invariably is based on inadequate sampling. Unsuspecting officials accept the analyses because they're deemed scientific in nature. The officials then unwittingly treat the results of inadequate sampling as though they are "statistically significant" and use the faulty data to support financial decisions.

   This variation of the Deficiency-Based Technique is useful in determining portfolio-level Backlog and FCI metrics, but the portfolio steward must still expend additional resources to acquire data for identifying work items and projects.

Description of the Rating-Based Technique

In other attempts to avoid the expense of the Deficiency-Based Technique, some organizations have tried substituting cursory field observations in place of detailed inspections and feeding subjective ratings of condition into parametric models, which compute estimated costs, Backlog, and FCI. This alternate practice, called the Rating-based Technique, is depicted in Figure 5 below which, for easy comparison, is located adjacent to the Deficiency-Based Technique.

There are two subcategories of the Rating-Based Technique: (1) questionnaires, and (2) visual surveys. Both have been designed to limit expensive data collection and both yield macro indicators of Backlog and FCI without prescribing corrective actions or identifying work items or projects.

Figure 5 Rating-Based Technique - Substitutes Questionnaires or Cursory Observations for Detailed Inspections

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1. Questionnaires

   This subcategory of the Rating -Based Technique uses parametric modeling to produce a high-level, portfolio summary of corrective costs by sending questionnaires to building managers

24 ANADAC, Inc (1993). Facility Condition Assessment of Virginia's Public Higher Education Institutions.

and/or occupants rather than conducting detailed inspections by qualified engineers and technicians. This method is relatively inexpensive but does not render work and project requirements and often relies on untrained people to answer the questions, resulting in inconsistencies between portfolios.

2. Cursory Observations

An example of this practice is the Army Installation Status Report (ISR), where non-technical administrative people use written and pictorial guidance to visually observe and rate the general appearance of building systems and record ratings on an ordinal "Red, Yellow, Green" scale. A parametric model calculates an overall quality rating for each type of building in the portfolio from the distribution of "color" ratings for all buildings within that type group and estimates portfolio-level Backlog and FCI. This method is relatively inexpensive but does not render specific work and project requirements.

The NASA Deferred Maintenance Estimation Methodology is another example of this subcategory of Rating-Based Technique. It also uses a parametric model to compute an overall assessment of the general condition of facilities and a dollar estimate of deferred maintenance costs. It typically begins with a rapid visual inspection of all systems in each building. Trained assessors follow a pro forma that captures consensus impressions of conditions in a numerical rating (1-5) for each system. The ratings are used in conjunction with overall system costs on a square foot basis and percentage of Current Plant Value (CPV) to estimate corrective costs and calculate Backlog and FCI. NASA Headquarters uses cursory observations to determine budget requirements, but the executing NASA centers must still spend considerable resources to acquire data needed to identify and prioritize work items and projects.

In 2006, the Wyoming School Facilities Commission employed the NASA "Shortcut" to identify $331 million in deferred maintenance at a cost of just 17% the estimated cost of the Traditional Method. The technique does not produce details of specific work items or projects[25].

Description of the Inventory-Based Technique

By the early 1990s, dissatisfaction with the cost of Deficiency-Based Techniques, as well as failure of Deficiency-Based and Rating-Based techniques to overcome inherent issues of credibility, led the office of Secretary of Defense (OSD) to seek yet another approach. As a result, a consultant devised a technique that completely eliminates inspectors and observers as sources for portfolio-wide Backlog and FCI estimates. The commercial offspring of this work is called "Whitestone MARS Facility Cost Forecast System" and estimates future funding necessary to restore and maintain buildings by loading parametric models with building system inventory data and no inspection or rating data.

As the main focus of analysis, the models employ building metadata (e.g. type of building and date of construction) to speculate current component age and average service life determined by actuarial practice and use that data to produce portfolio-level estimates of Backlog and FCI. Figure 6 is a graphic comparison of the Inventory-Based Technique with the Deficiency-Based Technique.

25 Thomson, N. and Whittaker, J. "The BMAR Approach to Asset Management." The Military Engineer, January-February 2008, page 62

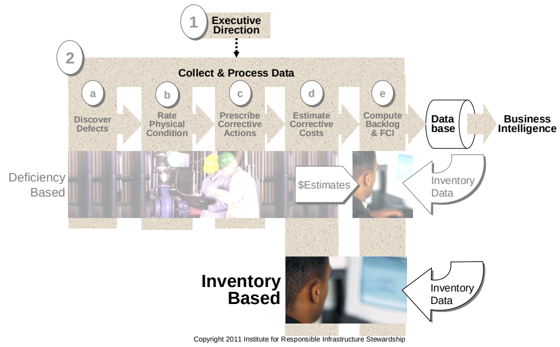

Figure 6 Inventory-Based Technique - Eliminates Inspections, Questionnaires and Field Observations

The reader should note several important similarities and differences between the two techniques.

1. Both compute Backlog and FCI; neither rates physical condition directly.

2. Unlike the Deficiency-Based Technique, the Inventory-Based Technique: ". . . relies on several general assumptions about building configuration, materials, and conditions based on the 'law of averages,' which perform adequately for a large portfolio of buildings as a whole. However, these tools lack the connection to specific real world buildings, their localized conditions, and operating environments, thus preventing the critical transition from budgetary decision making to work plan execution."[26] In other words, the Inventory-Based Technique can be used only on portfolios comprised of many building and yields Backlog and FCI only at the portfolio level and not at the individual building level. Neither does the Inventory-Based Technique identify or price individual work items and projects that constitute the Backlog and FCI.

3. The Inventory-Based Technique is substantially less expensive than the Deficiency-Based Technique; $0.01 - 0.02/square foot for the former and at least $0.15/sf for the latter. Results are more consistent, as well, because the Inventory-Based Technique derives Backlog from stable inventory and statistical data rather than from inconsistent, widely variable cost estimates or condition ratings produced by different inspectors and observers.

4. Both Inventory-Based and Deficiency-Based techniques yield Backlog and its derivative FCI as proxy indicators of physical condition. It is important to note that this practice is widespread despite the fact that there is no scientific study or any data showing Backlog or FCI to be reliable indicators of building condition. On the contrary, as discussed in a subsequent section of this chapter, there is a large body of study and research to resolve the longstanding concerns about the advisability of using Backlog and FCI for assessing physical condition.

A recently created variation of the Inventory-Based Technique is called *"Age-based Scalable modeling*[27]*."* Like the Inventory-Based Technique, it estimates Backlog and a "Theoretical FCI" by entering building system age and standard life expectancy data into parametric models rather than deficiency or rating data. It differs from the basic Inventory-Based Technique in that it employs non-linear deterioration curves and field observations to periodically update system inventory data rather than taking such data at face value from actuarial tables.

It also uses a parametric model to reduce Deficiency-Based inspection frequency and cost by inspecting in a given time period only those building systems meeting pre-set criteria for age and remaining useful life. Data gathered by Deficiency-Based inspections are used to calibrate deterioration curves, which are used to compute repair-need percentage for every building system and building in the portfolio. Like all Rating- and Inventory-Based techniques, *"Age-based Scalable*

26 "Using Performance Metrics for Making Facility Investment Decisions," Marrano, L., US Army Engineer Research & Development Center, Champaign, IL,

27 "Assessing Facility Conditions: A Cost-Effective Strategy," Teicholz, E, & Evans, G., www.graphicsystems.biz

Modeling" does not identify work items and projects, which comprise the Backlog and FCI metric, so portfolio stewards must invest additional resources to acquire such additional detail.

Dissatisfaction with the Monetary Method Spurs Research

In the early 1980's, Navy leaders decided that their Monetary Method was not satisfactory. The organization could not afford comprehensive, annual inspections. Additionally, inspection data were inconsistent, unverifiable, often proved inaccurate, and quickly became outdated. Metrics behaved illogically and didn't withstand budget scrutiny. The Navy learned that, contrary to theory, increased funding promoted significant Backlog growth and reduced funding shrank reported Backlog. This finding was attributed to the subjectivity and non-repeatability of the inspection process. More importantly, actual physical condition of Navy buildings continued to deteriorate despite increased investment in Backlog reduction in doses prescribed by Backlog and FCI hypotheses.

The Navy needed a better technique. It was already reducing frequencies of building inspections only to realize that longer times between inspections increased breakdowns, disrupted building operations, and siphoned money from planned repairs. The Navy also rejected the Rating-Based and Inventory-Based techniques because these approaches could not identify individual work and project requirements.

Consequently, the Navy joined with the Air Force (which was experiencing similar issues) in funding Army research for next-generation building condition assessments. Their goals were to reduce inspection costs; improve credibility of inspections and repair budgets; enable more productive funding allocation and project selection; and allow meaningful tracking of spending impact on mission performance. Another objective of this initiative was to create a condition metric that was so reliable and consistent it could be used to regulate the outsourcing of installation maintenance functions.

The Engineered Method – Product of Published Government Research

Subject matter experts at the U.S. Army Engineered Research and Development Center, Construction Engineering Research Laboratories (ERDC-CERL) took the same scientific approach to re-structuring building condition assessment that they had previously used to develop advanced assessment methods for roofing, pavements, and railway tracks[28]. In keeping with the principles of asset management, they also integrated their re-structured building condition assessment technique into a comprehensive facility asset management process for assessing both building condition and performance, computing metrics, for each and using the metrics to create useful business intelligence[29].

While ERDC-CERL was conducting its research on building condition assessment, a 1998 National Research Council (NRC) report[30] reiterated the many shortcomings of existing federal condition assessment programs and recommended that the programs be re-structured to: (1) optimize available resources, (2) provide timely and accurate data for formulating maintenance and repair budgets, and (3) provide critical information for the ongoing management of facilities.

One year later, ERDC-CERL began publishing its research[31] and the Engineered Method was rated "preferable choice" among 18 alternative methods by a peer-reviewed American Society of Civil Engineers (ASCE) paper[32]. More important, the Army's Engineered Method met the aforementioned

28 e.g. ASTM D6433-03 Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys and ASTM D5340-04e1 Standard Test Method for Airport Pavement Condition Index Surveys.

29 "Building Infrastructure Functional Capacity Measurement Framework," M.N. Grussing, D.R. Uzarski, and L.R. Marrano , Peer Reviewed Journal , 13 Nov 09 , ASCE , Reston, VA 20191-4400 , Report No Journal of Infrastructure Systems Dec 2009 , Vol 15 (4) , pp. 371 -377 , ISBN No 1076-0342

30 Stewardship of Federal Facilities, National Research Council, National Academies Press, 1998, p89 & 96

31 Uzarski, D. R., and Burley, L. A., Jr. (1997). ''Assessing building condition by the use of condition indexes.'' *Infrastructure condition assessment: art, science, and practice, Proc., ASCE Conf.*, ASCE, Reston, Va.

32 Ottoman, Nixon, Lofgren, ASCE, "Journal of Management in Engineering," July/August 1999

Navy and NRC specifications, thereby affording its potential users "considerable savings and benefits in building condition assessment as well as reducing total maintenance and repair costs by nearly half over a 50-year lifecycle"[33].

The Engineered Method for Building Asset Management evolves around a different kind of data that can be gathered at significantly less cost than the Deficiency-Based technique[34] and has been shown by researchers to produces more credible and useable information than produced by the Monetary Method. Federal organizations such as the National Research Council (NRC) and the Federal Facilities Council (FFC) also have recognized this body of research[35] and several federal agencies are currently implementing the Engineering Method as the basis for agency-wide building asset management[36].

Differences between Knowledge-Based and Deficiency-Based Techniques

Figure 7 compares the re-structured, Knowledge-Based building condition assessment technique with the Deficiency-Based Technique. Both techniques employ the same steps in the same order, but, as discussed in several ERDC-CERL papers cited in this chapter, differ significantly in who accomplishes each step and how each step is accomplished.

Specifically, the Knowledge-Based Technique:

1. Capitalizes on inspector skills in identifying problems while eliminating inspector subjectivity in prescribing and estimating the cost of corrective actions;

2. Standardizes the way in which inspectors classify and record identified problems;

3. Replaces inspector subjectivity with transparent, consistent, and auditable parametric models, which are constantly and precisely regulated by Executive Direction;

4. Produces a family of metrics, the BCI (series)[37] that depicts true physical condition, while also yielding more accurate and dependable monetary metrics (Backlog and FCI).

5. Includes an accurate condition prediction tool that can help significantly reduce or eliminate critical breakdowns and bolster credibility of budget requests.

Here's a brief summary of the similarities and differences between Knowledge-Based and Deficiency-Based Techniques:

Phase 1. Executive Direction

Similar to Phase I of the Deficiency-Based Technique, Phase I of the Knowledge-Based Technique controls the overall rigor, effectiveness, and efficiency of an organization's process by setting goals, policies, and standards that regulate assessment quality and by establishing inspection schedules that determine data freshness and process cost. Unlike Phase I of the Deficiency-Based Technique, Phase I of the Knowledge-Based technique requires that the organization's management set Executive Direction consciously, deliberately, and in precise detail. The Knowledge-Base Technique cannot be deployed until management fulfills this obligation. After management sets and deploys the necessary goals, policies, and standards, inspection groups cannot substitute their own assessment goals, policies, and standards.

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33 "Building Component Lifecycle Repair/Replacement Model for Institutional Facility Management," M.N. Grussing and L.R. Marrano , Conference Proceedings - Refereed , 24 Jul 07 , ASCE , Reston, VA, pp. 550 -557 , ISBN No 978-0-7844-0937-4

34 "Knowledge-Based Inspection Capabilities," M.N. Grussing and L.R. Marrano , Miscellaneous Publication , 31 Jan 06 , Report No ERDC/CERL TN-06-1

35 "Key Performance Indicators for Federal Facilities Portfolios: Federal Facilities Council Technical Report Number 147," National Research Council, ISBN: 0-309-54718-0, 2005, p 17

36 As of this writing, the USMC has selected the Engineered Method as its enterprise condition assessment program; the Navy has selected the Engineered Method as its enterprise lifecycle analysis and long range work planning tool, and the Army, USAF, and Defense Logistics Agency are engaged in Engineered Method trials.

37 "Assessing Building Condition by the Use of Condition Indexes." Uzarski, D.R. and L.A. Burley, Proc., Infrastructure Condition Assessment: Art, Science, Practice, ASCE, Boston, MA, 365-374, 1997

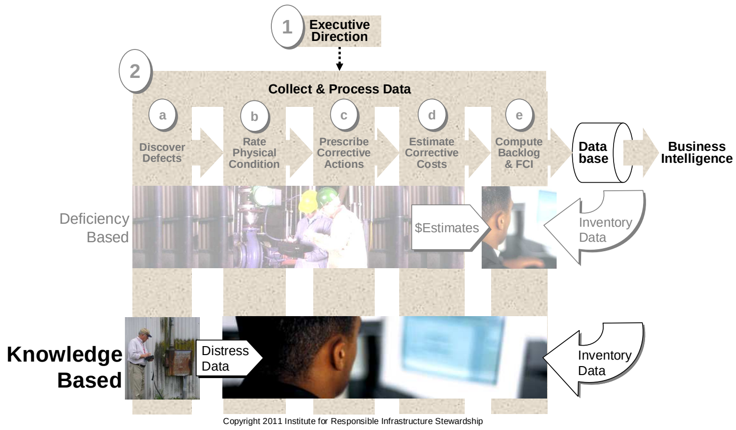

Figure 7 Knowledge-Based Technique - Replaces Inspector Opinion with Management-driven Parametrics

1a Assessment Goals & Policies

The first action of both techniques is to establish goals and policies against which data collection standards and schedules can be measured. Such goals and policies are also used to guide the collection of data as well as the computation of metrics.

1b Standards

Deficiency-Based standard-setting is frequently relegated to technical employees or inspection vendors. The Knowledge-Based Technique requires managers to consciously set these standards.

1c Inspection Schedules

Organizations using the Knowledge-Based Technique do not schedule teams of highly-skilled engineers to tour buildings looking for defects. Instead, they can use trained service technicians and even integrate scheduled distress surveys into technicians' daily preventive maintenance (PM) assignments and service calls. This capability limits the time demand on technicians and further reduces the cost of data collection. In keeping with the cost-cutting goal of its research, ERDC-CERL designed the Knowledge-Base Technique so that trained service technicians can produce distress data as accurately and proficiently as engineers inspecting the same components or pre-determined group of components called a "component section[38]."

Knowledge-Based parametrics, such as physical condition forecasts for specific building components, generate schedules that tell trained technician-inspectors which limited number of selected components to inspect and which of three progressively rigorous inspection types to use on each component. Component selections and inspection types are based on actual need, as determined by forecasted component conditions and standards set by management. Knowledge-Based scheduling skips inspections when not warranted or cost-effective, such as very early or very late in a component's life cycle.

Knowledge-Based parametric models select and schedule the type inspection that is most cost effective for each component's condition as predicted by the models' automatic, condition index updating feature and pre-programmed risk tolerances of the organization's management. The least costly inspection (called Direct Rating) simply tracks a component's general condition, serving as a watchdog until the component's condition indicates that it is time to obtain more granularity by scheduling the second, slightly more detailed type inspection (called Distress Survey). Then, when the second type inspection indicates that the time for component repair or replacement is on the

38 Building component-sections are the "management units" upon which work decisions are made. Examples: a group of four 50 lb/hr central humidifiers, same model and age. A component section's condition establishes work item scope and cost for that section.

planning horizon, the software schedules the third type inspection (Distress Survey with Quantities), which produces actionable work packages and project-level detail sufficient for program planning purposes. When projects become serious candidates for funding, they receive the fourth and most detailed inspection, which becomes the basis for execution planning.

Knowledge-Based inspectors do not tour buildings. Instead, they go directly to the components listed on their schedule and conduct the prescribed type inspection. This “just-in-time” scheduling approach and the use of technician-inspectors rather than engineer-inspectors are major factors in cutting the cost of Knowledge-Based inspections to less than 25% of those required for comprehensive, calendar-derived Deficiency-Based inspections.

Phase 2. Collect and Process Data

2a Identify Defects

Both Deficiency-Based and Knowledge-Based techniques rely on the individual inspector’s training, skill, and experience to initially detect physical defects in building components. But, while the Deficiency-Based inspector does not catalog, record, or report such defects, Knowledge-Based inspectors follow a standard, engineered procedure to perform this task.

The inspector records each distress and tags it with various attributes: component identity, distress type, severity, and density or quantity. He neither formulates nor records any of the opinions or estimates needed to specify a corrective action or to predict remaining useful life. These calculations are done later by the Knowledge-Based parametrics. Consequently, researchers’ field tests and user experience shows that the Knowledge-Based inspection process is quicker and much less costly than Deficiency-Based inspections and data are independent of inspector bias, guesswork, and inconsistency. Limiting inspector participation to Step 2a and 2b and not using inspectors to accomplish the subsequent steps of data processing is another major factor in cutting the cost of Knowledge-Based inspections to 25% of those required for labor-intensive Deficiency-Based inspections.

2b Rate Physical Condition

Inspector opinion of physical condition does not influence Knowledge-Based condition ratings for building components. Instead, a parametric model uses inspector distress data to directly compute a science-based condition index for each *building component section* and subsequently keep each index constantly updated in real time with deterioration projections calibrated with refreshed inspection data. However, whenever an inspected component is free of reportable defects, the Knowledge-Based inspector is trained and required to assign, record, and report one of nine possible, pre-defined “direct condition ratings” for that component.

The parametric model also rolls up refreshed component section condition indexes into a BCI (series) of condition indexes for parent systems, facilities, and portfolios. Army research shows that condition indexes computed and updated in this manner achieve a consistency among inspectors of plus or minus 5 on a scale of 1 to 100 (100 = distress free) regardless of the profession or trade of properly trained inspectors.

2c Prescribe Corrective Actions

Deficiency-Based inspectors use mostly personal opinion to prescribe corrective actions. The Knowledge-Based Technique prescribes impartially and consistently by using a component’s computed condition index and other parametric models regulated by specific, pre-set management preferences and risk tolerances. Individual, prescriptive work items and projects are produced quicker, at much less cost, and independently of inspector bias, guesswork, and inconsistency.

2d Estimate Corrective Costs

The Knowledge-Based Technique minimizes estimating variability by relieving the inspector of estimating duties and relying, instead, on computerized parametric models consisting of, unbiased work scopes, reliable commercial cost data and management-set standards.

2e Compute Backlog & FCI

Both Deficiency- and Engineering-Based techniques compute Backlog and FCI using inspection data. The major difference is that the Engineered Method operates on “distress” data while the Deficiency-Based Technique operates on cost estimates.

Additional Benefits of the Engineered Method

The Engineered Method includes all the functions and yields all the business intelligence produced by the best-in-class techniques of the Monetary Method – plus much more. By capturing and analyzing objective, consistent component “distress” data rather than cost estimates contaminated with subjectivity and variability, the Engineered Method is able to produce many additional, high value business intelligence products that are impossible to duplicate with the Monetary Method. These include:

- Accurate and dependable forecasts of future condition at various funding levels; triggering the creation and prioritization of corrective actions by management-set standards of mission performance and risk tolerance; selection among alternative corrective actions based on ROI; forecasted penalty costs for deferring repairs beyond their most advantageous execution time; Risk Informed Decision Making and Multi Criteria Decision Making; precise analysis of alternative funding scenarios; and creation of actionable short- and long-range capital repair and renewal programs.
- Unlike results turned out by techniques of the Monetary Method, the results of the Engineered Method are scientifically derived from objective, constantly refreshed condition data supplemented with management’s pre-programmed risk tolerances and, therefore, are highly credible and consistent. Minimum cost, need-based inspection schedules are also derived from the same condition data and risk tolerances.

Deciding Which Technique Is Best For Your Organization

Condition assessment can only meet the need if the metric used meets the objective of the user. A single condition assessment procedure, no matter how robust, cannot meet all needs of all users. A particular condition assessment technique should not be denigrated for not meeting an objective it was not designed for[39].

This chapter describes the varied methods, techniques, and practices depicted in Figure 8 and suggests that there is a place in facilities management for each of them.

A facility manager would be well-advised to thoroughly evaluate the applicability of each available practice to his own organization’s particular needs and pocketbook before making a commitment to any one of them. Figure 9 and the following paragraphs provide a starting point for such an evaluation by summarizing the pros and cons of each technique.

Organizations that Should Consider Using the Deficiency-Based Technique

The Deficiency-Based Technique is best for organizations with few buildings to manage and/or those that need and can afford a good tactical system for near-term project-level functions such as: identifying and pricing deficiencies, packaging them into executable projects, and prioritizing the projects; allocating available funds among the current list of backlogged projects; supporting requests for next year’s funding of specific projects; and tracking results of near term spending on individual work items and projects.

Eroded credibility of its primary FCI metric as well as use of “book value” average service life of building components render use of the Deficiency-Based Technique extremely limited for organizations that also need a long range tactical system for project planning or a good strategic

39 *“Condition Assessment Aspects of an Asset Management Program,”* Foltz, SD and McKay, DT, US Army Engineering Research and Development Center, January 2008

system for near-term and long range portfolio-level functions such as: ascertaining current and possible future portfolio condition and preparing portfolio-level budget requests and “what-if” scenarios. One-time, start-up costs for the Deficiency-Based Technique can be expensive, and recurring annual costs of building inspection and data upkeep are very high.

Organizations that Should Consider Using Rating-Based or Inventory-Based Techniques

Rating- and Inventory-Based techniques are best for organizations with large building portfolios and/or those needing only a strategic system for supporting near-term budget requests and funding allocations at the macro-level. Rating- and Inventory-Based techniques do not provide business intelligence at the work item or project level. Questionable credibility of the primary FCI metric renders both techniques limited for ascertaining current portfolio condition and forecasting future conditions. The use of “book value” average service life of building components also reduces credibility of long-range budget requests. On the plus side, there are usually no one-time, start-up costs, and annual costs of building inspection and data upkeep are very low compared to the Deficiency-Based Technique.

Organizations that Should Consider Using the Engineered Method

The Knowledge-Based Technique is best for organizations that need a system for comprehensively and credibly supporting all strategic and tactical functions associated with *building asset management*, both near- and long-term. Annual costs of building inspection and data upkeep for the Deficiency-Based Technique are very low compared to the Deficiency-Based Technique, but there is an initial, one-time investment required to gather and organize detailed component inventory data. Using this technique also requires a solid understanding and thoughtful application of asset management principles.

Deficiency-Based Technique (USAF, DOE, USCG, National Park Service, et al)	
PROS	Generates backlog and FCI for portfolio, facility, and systems
	Identifies and prioritizes work items
CONS	Expensive ($0.15+ /sf)
	Wasteful over-inspection, risky under-inspection
	Inconsistent results, credibility issues
	Unproven condition forecasting
	Expensive COTS software
	Vender lock on COTS software
Rating-Based Technique (Army, NASA, Smithsonian)	
PROS	Generates backlog & FCI for large portfolios
	Affordable (~ $0.02/sf)
	Cost of custom software development by agency consultants
	No vender lock on in-house agency software
CONS	Does not identify or prioritize work items
	Wasteful over-inspection, risky under-inspection
	No condition forecasting
	Inconsistent results, credibility issues
Inventory-Based Technique (OSD – possible transition to Engineered Method, GSA)	
PROS	Generates backlog & FCI for large portfolios
	Affordable (~ $0.02/sf)
	Cost of custom software development by agency consultants
	No vender lock on in-house agency software
CONS	Does not identify or prioritize work items
	No condition forecasting

	Credibility issues
Knowledge-Based Technique (USMC, Navy, and DLA. Army &USAF transitioning)	
PROS	Generates backlog and FCI for portfolio, facility, and systems
	Generates physical condition index for portfolio, facility, & systems
	Affordable (~ $0.02/sf)
	Identifies and prioritizes work items
	Eliminates waste and breakdowns from over- and under-inspection
	Proven & accurate condition forecasting
	Consistent & credible – based on published, peer-reviewed science
	GOTS software free to Federal government agencies
	No vender lock on GOTS software
CONS	Beware of vendors selling counterfeit software

Figure 8: Pros and Cons of Condition Assessment Techniques

APPENDIX A:

FCI and Backlog Technique Critique by the Office of the Secretary of Defense[40]

After 20 years of rigorous testing and development, the Office of Secretary of Defense (OSD) publicly criticized the Backlog metric and its offspring Facility Condition Index (FCI) as ways of assessing facility condition and managing facility repair and renewal requirements. Specifically, the report made the following criticisms:

- **BACKLOG and FCI are too expensive to maintain** – if properly maintained, they require annual condition assessments; however, the cost of performing these assessments is large and installations vary greatly in their methods and completeness.
- **BACKLOG and FCI are inaccurate** – since they are too expensive to maintain, unfunded annual maintenance and repair is often simply compounded and inflated without any reference to actual conditions.
- **BACKLOG and FCI are subjective** – to the extent they are based on actual condition assessments, the assessments themselves are often biased, especially those conducted by facility users rather than by independent teams of engineers not associated with the facility, installation, or major command.
- **BACKLOG and FCI provide only partial coverage** – if they were accurate, they might represent restoration requirements, but they shed no light on annual Sustainment or Modernization requirements.
- **BACKLOG and FCI are not interoperable** – there are no universal standards for computing the metrics – Installations vary greatly in the performance of condition assessments and estimation methods. Therefore, comparative analysis is not possible.
- **BACKLOG and FCI are unverifiable** – to the extent data are collected. The data exist in stand alone, off line systems and are not linked with official real property inventories – so it is impossible to confirm where the backlog exists or even if it does exist. There is no link to funding databases.
- **BACKLOG and FCI are not timely** – the metrics provide only backward-looking snapshots that shed no light on what has been accomplished in the meantime or what the changing needs are in the future.
- **BACKLOG and FCI do not account for all sources of mitigation** – an item in the backlog may be included in a future construction, demolition, or privatization project. Therefore, requirements may be double counted.
- **BACKLOG and FCI perform illogically** – they go up when more funds are available, because facility managers are more likely to identify deficiencies when the probability of obtaining funding increases.
- **BACKLOG and FCI have lost credibility** – they have gone up continuously for at least two decades with little or no impact by resource allocations.

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[40] Report to Congress **Identification of the Requirements to Reduce the Backlog of Maintenance and Repair of Defense Facilities** April 2001 This report responds to Section 374 of H.R. 5408, the Floyd D. Spence National **Defense** Authorization Act for Fiscal Year 2001 (House Report 106-945), enacted into law by Public Law 106-398.