Knowledge-Based Condition Survey Inspection Concepts

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Abstract: The U.S. Army's Engineer Research and Development Center—Construction Engineering Research Laboratory has developed a "knowledge-based" approach to planning and conducting routine facility inspections. Rather than simply recording deficiencies on a calendar-based schedule this new approach uses knowledge of facilities to develop and execute a tailored inspection plan for individually defined facility "management units." This knowledge includes measurable attributes such as facility importance, management unit importance, condition (past, present, and predicted future), desired condition thresholds, and expected asset remaining life. Also, recognizing that there are several inspection objectives to be met at different times in a management unit life cycle, different levels of inspections may be used at different times to attain those objectives. The "knowledge-based condition survey inspection (KBCSI)" approach marries all of these elements together to develop inspection plans for a vast array of facility components. The result is more meaningful facility inspection information with less inspection effort compared to traditional calendar-based inspection approaches. This paper discusses the KBCSI approach as applied to building component life cycle management.

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Introduction

Facility inspection is fundamental to a successful asset management program. One of the primary purposes for inspection is to support the calculation of accurate and objective condition assessment metrics. Additionally, inspection must be affordable.

Traditionally, a calendar-based detailed type inspection process where inspectors record deficiencies and estimate the cost for correction has been routinely and periodically conducted by many agencies to satisfy condition assessment requirements. The resulting outcome is typically a "job jar" full of work needs. This is an expensive, labor intensive, and inefficient inspection approach because typically one or more of the following occurs:

- During an inspection cycle, all systems and components in a facility are inspected regardless of condition, condition history, or importance;
- Inspection frequency is based on the available inspection budget often leading to underinspection and missed opportunities for optimal correction decisions;
- Occasionally, overinspection occurs wasting inspection resources; and
- Due to funding delays and constraints, the scope-of-work and cost estimate for corrective actions developed as part of the inspection process are often rendered obsolete due to changed conditions, thus requiring a reassessment at a later time.

This paper introduces a knowledge-based condition survey inspection (KBCSI) planning concept for buildings. These condition survey inspections discussed here are not detailed engineering assessments, preventive maintenance inspections, specialized inspections, or detailed "job plan" inspections. However, they do satisfy the facility management requirements for condition assessment and risk mitigation. The results of these assessments provide decision support for several management activities, including long-range budgeting for sustainment (corrective maintenance), restoration (catastrophic event repair or major repair), or component-section replacement planning. They also help to quickly identify infrastructure components that may require a further detailed technical assessment to diagnose specific problems.

The BUILDER Engineered Management System (EMS) is a building infrastructure asset management system developed by U.S. Army's Engineer Research and Development Center-Construction Engineering Research Laboratory (ERDC-CERL 2004). BUILDER EMS has a variety of features including procedures for creating a building inventory including the appropriate "management units" (discussed in the following), condition survey inspections of those management units, assessment and measurement of component condition through the use of condition indexes (also discussed in the following), and sustainment, repair, and restoration planning. Using robust, self-adjusting, condition prediction models based on measured past inspection results, current and future condition states are estimated and reported in real time. This condition modeling capability helps plan not only current and future work needs, but also current and future condition survey inspection needs.

The primary objectives of BUILDER EMS are to improve facility performance and minimize facility life cycle cost. Cost savings are obtained by (1) reducing inspection costs; and (2) optimizing sustainment, repair, and restoration investments. Inspection costs are reduced by selectively limiting which compo-

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nents get a detailed inspection in a given cycle, based on risk and condition criteria. Sustainment, repair, and restoration cost savings are the result of penalty cost reductions realized by identifying, planning, and executing the right work at the right time.

In the context of this approach, the term "knowledge-based" is used to indicate that knowledge (quantifiable information) about a building's system and component inventory is used to select an appropriate inspection type and schedule throughout a component's life cycle. Thus, inspections are planned and executed based on knowledge and not the calendar.

The inherent variety of building components and materials (each with their own life cycle) drove the development of the KBCSI process. However, since the same basic asset management principles (e.g., inventory and inspection) apply to all infrastructure types a KBCSI approach should have a broad application.

Component-Section Management Units

The overall system inventory describes the components (on a system by system basis) that comprise a particular building. It also defines the type and quantity of every component present. Each component is further divided into one or more management units called "component-sections" based on the presence of different materials or component types. A component example is "exterior wall finish/covering." Part of a building's exterior wall façade may be wood and another part may be masonry. In this case two exterior wall finish/covering component-sections exist because each has its own expected service life, condition degradation rate, and sustainment, restoration, and/or replacement requirements. Component-sections may also be based on building layout and/or functional use. For example, the "interior ceiling" component-section may be defined for each floor of a multistory building even though the material may be identical. It is outside the scope of this paper to describe the inventory process for delineating component-sections, but it is important to understand that the inspection and condition assessment process occurs at the component-section level. This is also the level where most asset management decisions are made, and thus the component-section is also referred to as the management unit.

Condition Indexes

The condition survey inspection directly supports the computation of the condition index (CI) for a component-section (Uzarski et al. 2002). The condition index ranges from 0 to 100 (with 100 denoting a "Defect Free" component) and forms a key condition assessment metric for building asset management. Because the component-section is also the work management unit, the Component-Section Condition Index (CSCI) is the fundamental condition metric. From the CSCI, all subsequent building hierarchy condition indexes are derived. The CSCI is rolled up to the building component condition index (BCCI), the system condition index (SCI), and the building condition index (BCI). The BCIs are averaged for groups of buildings, complexes, or entire portfolios. The CI hierarchy is shown in Fig. 1. Further discussion of the BCI and the actual calculation process are documented elsewhere (Uzarski and Burley 1997).

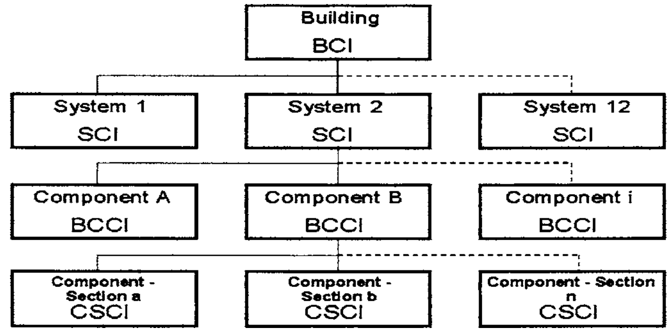

Fig. 1. Condition index hierarchy

Remaining Service and Maintenance Lives

Each component-section within a given building has its own unique life cycle. Each has a finite expected service life at the end of which replacement (or major restoration) is required. Also, most have a maintenance life where sustainment work is periodically recommended or required to correct accumulated degradation. The time to the next maintenance action is the estimated remaining maintenance life (RML). The difference between the current age and the expected service life is the expected remaining service life (RSL). These concepts and their relationship to condition (specifically the CSCI) are shown in Fig. 2. This classical infrastructure deterioration curve illustrates how condition degradation accelerates over time. Overall condition loss begins slowly, but then accelerates as compounding modes of deterioration occur.

Condition assessment is needed to establish and calibrate the predicted condition index versus age curve as illustrated in Fig. 2. From this, the RML and the RSL can be estimated. The curve itself represents a degradation model developed for a generic component-section and estimated service life values serve as an initial "seeding" of the models to give a reasonable estimate of component-section life. As condition data are collected over time through condition surveys, the model is regularly recalibrated to reflect the unique localized component-section life cycle. The expected remaining service life is adjusted based on actual condition measurements to give better estimates as to when a specific component-section must be replaced or rehabilitated.

Determining the time to maintenance is more complex. In this context "maintenance" is a broad term that encompasses corrective repair work associated with reducing or eliminating the distresses (cracks, deterioration, damage, etc.) negatively affecting a component-section. As these distresses accumulate,

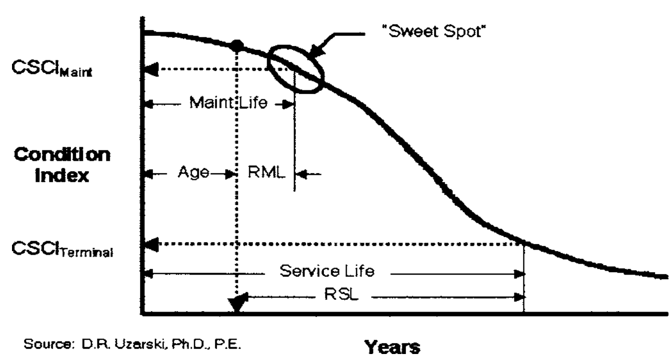

Fig. 2. Component-section life-cycle condition curve

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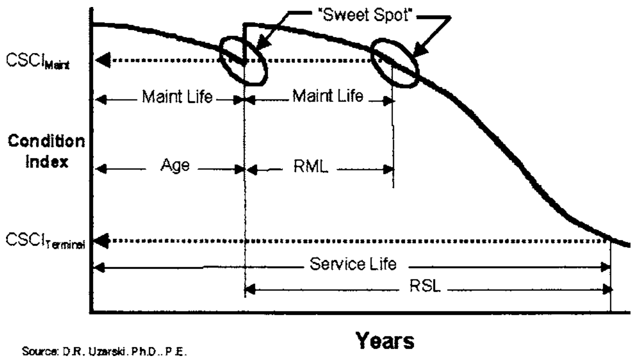

Fig. 3. Component-section life-cycle condition curve after maintenance

the component-section approaches what is referred to as the "sweet spot" (see Fig. 2) for maintenance and repair. The theoretical sweet spot is a narrow range of CSCI values that represent the economically optimum condition where maintenance/repair work should be performed. Performing maintenance work while the condition is in this range minimizes penalty cost incurred from deferring maintenance and results in life-cycle cost savings. In general, the theoretical sweet spot is a CSCI range of 70–80 based on the associated condition index scale. The practicable sweet spot represents a user defined condition standard for triggering work. The standard, which can be different for different component-sections, is a minimum desired condition level needed to support the building mission. This standard is based on desired performance and risk criteria, including building use, building importance, component importance, etc.

When a component-section is replaced, its life-cycle curve essentially resets, using condition and service life information measured over the previous component's life cycle, to predict future deterioration rates and life. When maintenance and/or repair are performed, the life-cycle curve does not reset. Instead, the CSCI experiences a step increase and remaining service life is consequently extended. The service life extension (measured in terms of years) is a function of the extent of the work performed (as represented by CSCI gain) and the age when the work was completed. The maximum CSCI gain from repair is to a value of 100, but the postwork CSCI will be less if not all of the distresses are eliminated, as is often the case. A new maintenance life is also set. Fig. 3 displays these concepts.

Condition Survey Inspection Types

Condition survey inspections encompass three approaches listed in order in the following from the most detailed to the least detailed (and most expensive to least expensive—each of which is less expensive than traditional deficiency-based inspections). These inspection approaches are also described elsewhere in great detail (Uzarski 2004):

- Distress surveys with distress quantities;
- Distress surveys with or without sampling; and
- Direct condition ratings with or without sampling.

The determination of the most appropriate condition survey inspection approach to do is based on the understanding of the differences between them.

Distress Survey with Distress Quantities

The distress survey procedure with distress quantities is the most accurate, objective, and reproducible approach. It provides a record of the type of distresses present (e.g., cracked), their severity levels (e.g., high), and their quantity (e.g., 20 LF) for each subcomponent comprising a component-section. The BCI process utilizes twenty-three distinct distress types with a maximum of three severity levels for each. These are documented elsewhere (Uzarski 2004). Measuring actual distress quantities also provides the most accurate distress density (distress quantity affected divided by the subcomponent amount) and therefore results in the most accurate CSCI. This survey type provides the most comprehensive picture of component-section condition for supporting managerial decisions (discussed in the following). However, this survey is also the most time consuming and expensive of the three approaches to accomplish.

Distress Survey (with or without Sampling)

The distress survey procedure (with or without sampling) is similar to the approach discussed earlier, except the quantities are not normally recorded. Instead, the density is estimated within a predefined range (e.g., 1–5%, 5–10%, etc.). The utility value of the information is less than if the quantities were recorded and the CSCI is slightly less precise, but the process is faster and more economical. Also, sampling of component-section portions is permitted and desired if the component-section is large and/or discontinuous (e.g., interior ceiling in a large office building). Here, the condition is determined for discrete sample portions, and those portions represent the component-section condition as a whole. This introduces sampling error, but further speeds the process and reduces survey effort and costs.

Direct Ratings with or without Sampling

The direct condition rating procedure is a less accurate, but faster method for performing a condition survey. Each component-section is visually evaluated as a whole (not individual subcomponents) against a set of nine different rating criteria, and the appropriate rating is selected. No information is collected regarding distresses, but a CSCI result does. Sampling is permitted and desired if the component-section is large and/or discontinuous.

Condition Survey Inspection Objectives

One of the primary purposes of a condition survey inspection is to support the condition assessment process. This, in turn, supports a range of tactical objectives that include:

1. Determine the quantitative condition of the component-section using the CSCI;
2. Determine the aggregate condition indexes for the building component (BCCI), system (SCI), building (BCI), and higher;
3. Provide a measurable condition history trend;
4. Compute measurable condition deterioration rates,
5. Calibrate life-cycle condition prediction model curves (Fig. 2);
6. Compute (or recompute) the remaining maintenance life from condition model trends based on the established sweet spot;

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Table 1. Condition Survey Inspection Type Matrix by Objective

Objective	Distress w/qty	Distress	Direct
Determine condition of component-section	Best	Better	Good
Determine roll-up condition of system, building, etc.	Best	Better	Good
Provide a condition history	Best	Better	Good
Compute deterioration rates	Best	Better	Limited
Calibrate CSCI prediction curves	Best	Better	Limited
Compute/recompute RML	Best	Better	Limited
Determine broad scope of work for planning	Good	Better	Limited
Establish when cost effective to replace	Better	Good	No
Compute/recompute RSL	Best	Better	Good
Quality control (postwork assessment)	Better	Good	Limited

7. Determine the broad scope of work for planning purposes, including a scoping cost estimate for current or future maintenance or component-section replacement;
8. Determine at what point does replacement become a more viable option than repair;
9. Compute (or recompute) the estimated remaining service life; and
10. Provide a quality control assessment for completed work (postwork assessment).

Note: It is not the purpose of a condition survey inspection to quantify materials and labor requirements for a corrective job plan. Instead, a "just-in-time" (JIT) detailed inspection tied to the work execution schedule is conducted when appropriate to quantify labor and materials. This occurs if and when the work item has a reasonable likelihood to be funded and completed in a given fiscal year. A JIT inspection is not a condition survey inspection and, thus, not discussed in this paper.

Condition Survey Inspection Approach Applications

Table 1 lists the various objectives for doing condition surveys. Also listed are the survey type and how they match up to each objective. As can be seen, the distress survey (with quantities) does the best job of satisfying all objectives. However, inspection costs can be reduced by utilizing the other two less expensive inspection approaches when appropriate to match required CSCI accuracy to the required objective. The appropriate application for each type is elaborated upon in the following.

Various factors need to be considered when selecting the appropriate condition survey inspection type. The first relates to where on the life-cycle curve the component-section is projected to reside during the time of the survey. Fig. 4 displays the general work needs, based on condition, throughout the life cycle of a component-section. Fig. 5 shows the relationship between life-cycle condition and inspection requirements by matching suggested condition survey inspection type to each condition range so that it economically supports planning for that work. A second factor is the general need for CSCI accuracy. The closer the component-section is to the sweet spot for repair, the more precise the CSCI must be to calculate RML. For example, if the RML is believed to be years away, a direct rating may suffice. However, if the RML is believed to be a year or less, and work is required, the distress survey with quantities approach is recommended to ensure the most accurate CSCI and resulting RML. A third factor relates to density accuracy. Sometimes density is easily estimated whereas sometimes it is not. If distress density cannot be estimated within the limits of predefined ranges, distress quantities should be measured or counted, as applicable.

In general, each condition zone indicated in Fig. 5 will have its own condition survey inspection requirements. These are addressed in the following.

Zone 1—"Preventive Maintenance Sustainment" Zone

Zone 1 is the Preventive Maintenance (PM) Sustainment zone. It represents the usually long, steady-state range of the component's life cycle when the condition deteriorates relatively slowly.

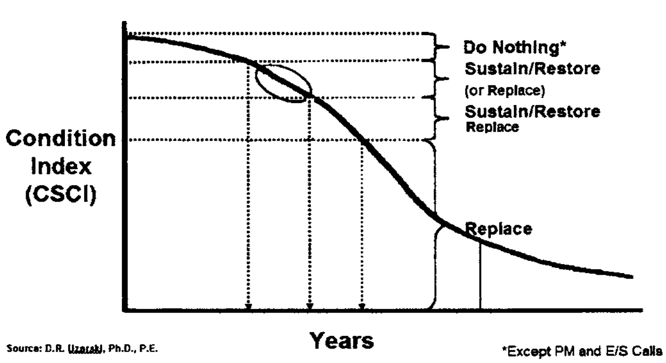

Fig. 4. General sustainment, restoration, and replacement needs based on condition

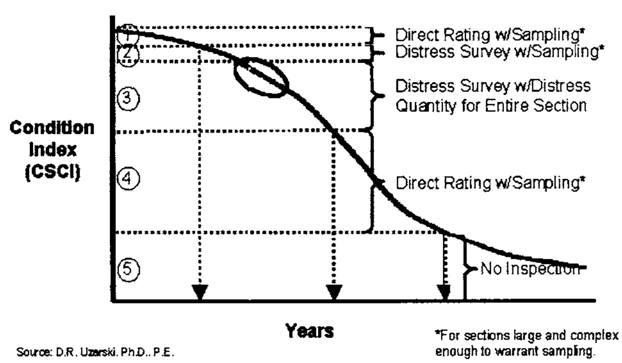

Fig. 5. Suggested condition survey inspection types for specific condition ranges (zones)

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During this time frame, little if any corrective action is needed. Instead, preventive maintenance and/or unplanned emergency service calls may be warranted. However, condition surveys are still needed to satisfy Objectives 1–6 (see Table 1). A quick assessment to ensure uncharacteristically rapid deterioration is not occurring is of particular importance in this zone to mitigate risk of a premature failure. The direct rating procedure satisfies this requirement. Computing the RSL is not of prime consideration here since component-section failure will typically be well into the future. Also, although future work requirements (Objective 7) are generated from these surveys, most often the work is minor and deferrable.

Objective 10, quality control (postwork assessment), is also accomplished in this zone because of the rise in CSCI from the work. If the postwork assessment of the component-section reveals a "defect-free" condition, either the distress survey or the direct rating approach may be used inasmuch as both have a defect-free feature. If the work did not attain a defect-free condition, the distress survey should be done to document the remaining distresses. This survey should be done as soon as practicable after the work is completed.

Zone 2—"Corrective Maintenance Approach" Zone

Zone 2 is the Corrective Maintenance Approach zone. Although no sustainment, restoration, or replacement work (other than preventive maintenance and/or emergency/service calls, if needed) is usually planned for this zone, condition assessment surveys are needed to satisfy objectives 1–7 (see Table 1). However, since the sweet spot is approaching, a greater precision to the condition assessment is needed. Thus, the distress survey is suggested.

The CSCI boundary between Zones 1 and 2 is a function of the beginning of the sweet spot zone (Zone 3, discussed next). That CSCI value, rate of deterioration, and the desired long-range work plan horizon (e.g., 5 years) are used compute the boundary value. For example, if the sweet spot CSCI value is 70, the rate of deterioration is 2 points/year, and the long-range work plan horizon is 5 years (5 year plan), the sweet spot approach zone begins at a CSCI of 80.

Zone 3—"Corrective Maintenance" Zone

Zone 3 is defined by the sweet spot. This is the target zone for completing corrective repair work. User defined standards set the minimum acceptable condition for each component-section in the zone. These standards may be different for unique component-sections in a building portfolio. The zone begins 1 year before the anticipated sweet spot for repair to ensure that the component-section is indeed in the sweet spot zone and to determine the broad scope of work, including a scoping cost estimate so that the prioritized work plan can be established for next year. These are Objectives 6 and 7, respectively. Objectives 1–5 will also be met, but they are of secondary importance at this point. To best meet Objectives 6 and 7 the distress survey with distress quantities is recommended. Sampling can be used for this, but if sampling is performed, 100% of the component-section samples should be inspected. Also, as a result of this survey, if it is determined that not all of the component-section requires work, consideration should be made to split the existing component-section into two or more separate sections.

Sometimes a condition survey inspection may not be necessary in this zone. Depending of the length of time since the last condition survey inspection, the inspection type conducted last, the complexity of the component-section, and the likelihood that the work will be funded *and* executed in the next work cycle it may be preferred to go directly to a JIT detailed inspection for the purpose of creating the job plan.

Fig. 5 shows that this zone extends past the sweet spot. Due to competing priorities, budget constraints, and other factors, the plan may require that some recommended work be deferred. With deferment comes continued degradation that is measured through a distress survey with distress quantities. As degradation progresses, replacement will eventually become the preferred work alternative. Objective 8 addresses this repair versus replacement analysis.

The facility manager (this may be an organizational policy decision) sets the sweet spot CSCI value. It is based on two factors. One is an economic criterion for minimizing the penalty cost that accrues from deferring work. The second is the condition standard at which the component-section should not drop below to ensure that the building mission can be adequately accomplished. The latter often governs with economic penalty measured from that baseline.

The sweet spot need not be the same for all buildings or building component-sections. Building importance is measured by the Mission Dependency Index (MDI) (NFESC 2004) or other means and component importance may be measured by the Component Importance Index (CII) developed by ERDC-CERL (private communication, 2006) or other means. The idea is that the most important or critical inventory will be maintained to a higher level than the least important inventory.

Zone 4—"Missed Opportunity" Zone

Often (and unfortunately) deferral of corrective work will cause the condition of component-sections to degrade well past the sweet spot into the Missed Opportunity Zone. In this zone, component-section service life still remains, but the degradation is such that replacement (or major rehabilitation/reconstruction) is now the best option from an economic perspective. Once in this zone, the primary objective is to determine time until failure (Objective 9), at which point component-section replacement is required. The direct rating with or without sampling satisfies this goal. Since replacement is warranted, there is no longer a need to document distresses in the existing component-section. Objectives 1–5 and 7 are also met.

Zone 5—"Failed" Zone

As the component-section life cycle enters Zone 5, it has passed its expected service life and is considered failed. (Recall, service life is determined from condition assessment, not the calendar.) For all practical purposes immediate replacement is the only viable option (assuming that the component-section is still needed). No further condition surveys are needed. The estimated CSCI value satisfies Objectives 1–3. All of the other objectives either cannot be met or they are meaningless with CSCIs so low.

Exceptions

The above-presented generalized discussion applies to most building component-sections. However, there will be situations and/or component-sections that dictate a different condition sur-

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vey inspection strategy. Four such situations are described in the following. Other specific situational-based possibilities may occur in practice.

Nonmaintainable

Occasionally, a component-section is not maintainable. No intermediate repair options exist to extend service life. In these cases, it will be simply replaced when needed. This generally involves two cases. The first is a run-to-failure option with minimal service disruption due to the failure. This is a low risk situation. Condition survey inspections are not needed in this situation, because the failure of the component itself indicates a work requirement. The other case is a high risk situation because replacement is required prior to failure due to the magnitude of the resulting service disruption. In this case, an inspection may be scheduled at some point prior to the end of the expected service life, and the number of years ahead is based on the tolerable risk of service disruption resulting from the failure. Additional condition survey inspections may be required over time to help mitigate disruption risk.

Catastrophic Event

A catastrophic event, such as storm damage, can alter the life cycle curve for a component-section in an unpredictable way. Often immediately after a catastrophic event, some type of condition survey inspection will be required. The type of inspection will depend of the nature and extent of the damage and the urgency for repairs.

Computerized Maintenance Management System Trend Analysis Trigger

Some organizations or agencies use a Computerized Maintenance Management System (CMMS) for, in part, scheduling and tracking work. Trend data showing an unusually high number of service calls, for example, could indicate an unexpected problem. This could automatically trigger a condition survey inspection to verify component-section condition.

Rapid Rate of Deterioration or Short Service Life

If component-section service life is short and/or deterioration is rapid, Zones 1 and 2 may be compressed and combined with Zone 3 because the sweet spot is rapidly approaching.

Condition Survey Inspection Scheduling

In addition to the appropriate type of condition survey inspection to perform, the KBCSI also addresses the scheduling (by year) of the inspections. Most often in current practice, the frequency of inspections (either "traditional" or condition survey) is set on a fixed schedule. This frequency, which may be 2–3 years, or something else is based on facility importance, available funding, management policy and doctrine, and other factors. Unfortunately, that approach often results in some component-sections being inspected too often, and others not being inspected often enough.

The KBCSI approach abandons that fixed schedule approach in favor of a flexible schedule based on supporting the above-described objectives. The KBCSI approach looks at expected CSCI trends for each component-section and uses that information to compute values for RSL, RML, condition zone location, and rate of deterioration. Those criteria, plus others, are used to determine the recommended subset of component-sections to receive a condition survey inspection in a given year. Providing this additional degree of freedom in inspection scheduling requires an understanding of the criteria involved in determining appropriate frequency. These criteria are listed in the following, followed by an explanation of each:

- Building importance;
- Component-section importance;
- Service life;
- Remaining service life;
- Maintenance life;
- Remaining maintenance life;
- Rate of deterioration;
- Condition zone;
- Condition standards and policies; and
- Maximum time frame between condition surveys.

Building Importance

Logically, the buildings that are most important to an organization's mission should demand to be kept to a higher condition standard than the buildings that are least important. The MDI measures building importance. If a MDI analysis has not been performed, building use can be used as a surrogate metric.

Component-Section Importance

Also, the component-sections that are most important or critical to building performance should be kept to a higher condition standard than those component-sections that are less important. The CII measures this metric.

Service Life

Component-sections with short service lives usually require inspection on a more frequent basis than those with longer lives because more condition change is expected each year as it passes through its life cycle.

Remaining Service Life

The remaining service life metric is most important when a component resides in Zone 4. Here, the component renewal strategy is a replacement at failure, and the RSL can estimate how much service life is remaining before the impending failure.

Maintenance Life

Component-sections with shorter maintenance lives usually need to be inspected on a more frequent basis than those with longer lives because more condition change is expected from year to year. If the inspection frequency is too long, it is possible to slip by the sweet spot between condition surveys and incur penalty costs.

Remaining Maintenance Life

The remaining maintenance life is used to set the timing for condition surveys. Typically, a distress survey with distress quantities would optimally be performed when the RML reaches 1 year.

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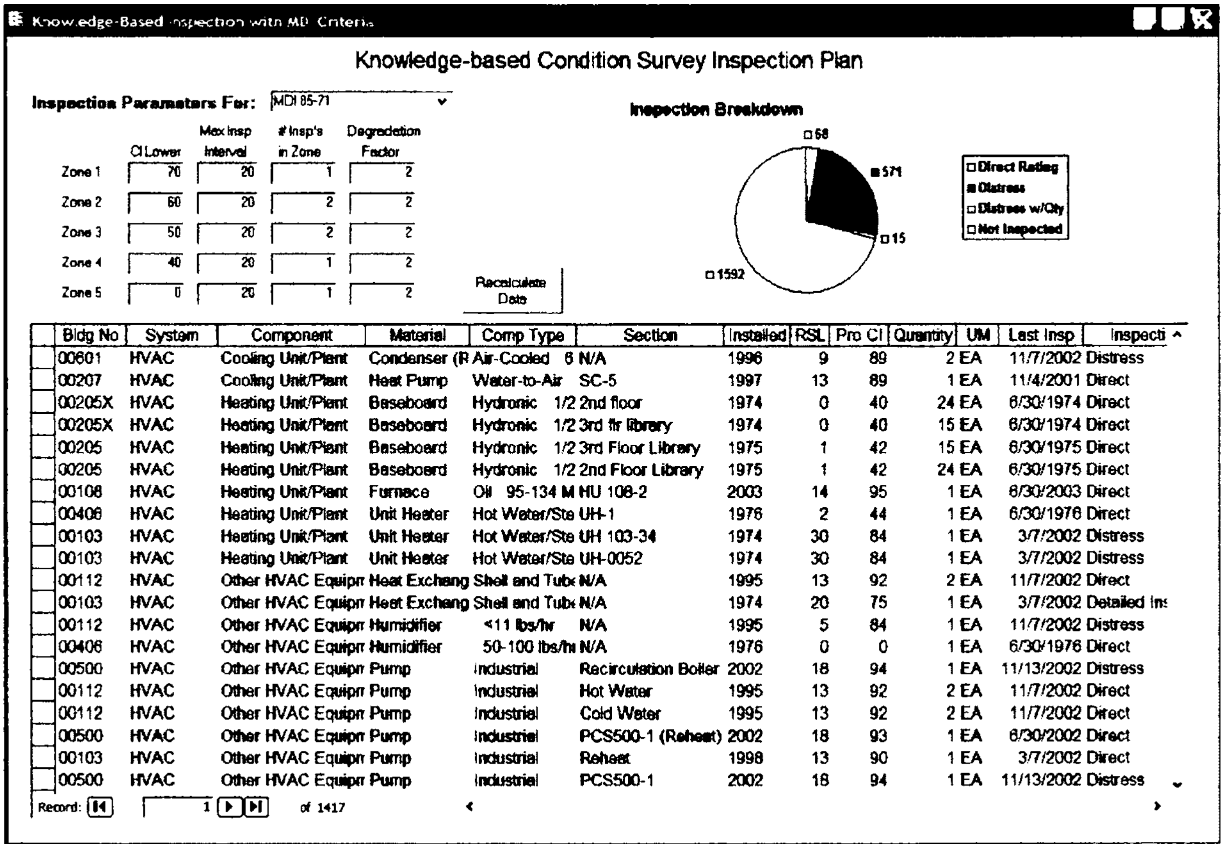

Fig. 6. KBCSI example plan

Rate of Deterioration

In general, component-sections with low deterioration rates do not require inspections as frequently as those with faster deterioration rates. The faster the deterioration rate, the faster condition change is occurring within the component-section. Rapid condition change may be indicative of problems that need to identified through inspection and ultimately corrected in a timely manner. If the deterioration rates are faster than expected for a given service life, condition must be monitored more frequently.

Condition Zone

As discussed previously, the condition zone serves to determine the type of condition survey to perform. It also affects frequency when viewed with RML and RSL.

Condition Standards and Policies

As discussed earlier, the facility manager establishes standards and policies to set minimum condition levels for building component-sections. These, in turn, affect sustainment, repair, and restoration planning. These policies also affect the KBSCI planning process to have the inspection plan in synchronization with the work execution plan.

Maximum Time Frame between Condition Surveys

Applying the above-mentioned criteria may result in several years passing between inspections for specific component-sections. This policy criterion sets a maximum number of years between condition survey inspections.

KBCSI Example

The KBCSI concepts addressed in this paper have been used to develop inspection plans at a number of military installations. Fig. 6 shows a plan for a given year at one such location. In this case the maximum time frame between condition surveys is set at 5 years. The numbers on the pie chart indicate the number of component-sections in each condition survey inspection type category. Note that the vast majority of component-sections require no inspection. A relatively small number require distress survey and a mere few require the more detailed distress survey with quantity. This shows that very few component-sections are at or near the sweet spot. (This mix of condition survey inspection types will vary by year and location depending on the age and condition of the component-sections.) Inspection savings do result (as compared to the traditional deficiency-based approach) from both a deferral of component-sections that do not require an inspection and a reduced inspection effort on those that do. By focusing resources on minimizing risk to mission support, the KBCSI approach eliminates costly inspection tasks that add little value for facility management.

Conclusions

The KBCSI process improves on the traditional program of rigidly scheduled "one size fits all" comprehensive inspections. By reducing inspection frequencies and eliminating inspection tasks that contribute little to facility management, the knowledge-based approach better matches resource investments to mission requirements. The criteria considered in developing an effec-

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tive inspection plan includes facility mission importance, component criticality, time in service, remaining service life, current condition, deterioration rate, and facility performance standards thresholds. Knowledge-based inspection practices enable facility managers to match inspection frequency and level of detail to asset management information and decision support requirements at the various stages in a component-section life cycle. The result is improved facility decision support, more affordable life-cycle management, and improved mission and organizational effectiveness.

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