A PROCEDURE FOR EVALUATING PERFORMANCE OF MEASURED SURVEY METHODS

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ABSTRACT

There are challenges surrounding the planning of field measured surveys for graphical documentation of heritage buildings. The survey teams' technical know-how of different survey methods is undoubtedly important, but more so is the survey planners' ability to select appropriate survey methods for diverse survey projects. In response to the selection challenge, this paper is aimed at devising a performance-based procedure for evaluating—and ultimately selecting—measured survey methods. Consisting of data collection and data processing function, the devised procedure design builds on performance of survey methods in accuracy, thoroughness, and rate; the contextual conditions of the documentation subject; and the project situation requirements imposed by the purpose of survey, significance of the structure, and urgency of documentation. The procedure's principal merit lies in its potential as a guiding instrument for planning field measured surveys.

1. INTRODUCTION

Those of us who are in the business of heritage documentation wonder at times if the projects we are entrusted with are carried out to our own satisfaction, let alone to the satisfaction of the client. This kind of speculation has undoubtedly invigorated the current wave of re-examining the relationship between providers and users (LeBlanc, 2002; Letellier, 2002), the counterpart players of the documentation undertaking. Of the hoard of motives for re-examining such relationship, two come readily to mind: first, users are entitled to quality products; second, providers are expected to take advantage of professional opportunities.

There are ways to enhance the players' relationship in the documentation undertaking. In measured surveys, the form of documentation of interest for this study, this can be done through improving the decision-making practices of survey method selection. The assumption is that sound decision-making practices lead to "appropriate" method selection. Why and how does a heritage survey team or a governmental documentation program arrive at a decision to use a specific survey method from an array of methods? The scope of this study falls in line with the theme of this method selection.

This study recognizes a decision making process for selecting measured survey methods for heritage buildings. This process builds on three aspects of the documentation situation: a) performance of survey methods in accuracy, thoroughness, and rate; b) the contextual conditions pertaining to the documentation subject, such as complexity of building surfaces; and c) the project requirements emanating from the purpose of survey, significance of the structure, and urgency of documentation. A published paper (Elwazani, 2002) of the author has addressed some features of the method selection process. It specifically investigates the effect of the contextual conditions on the performance of measured survey methods. That study ended with establishing a set of *standards* for evaluating such effect.

Building on the results of the above paper, this study aims at devising a *procedure* for evaluating the performance of measured survey methods—into which the developed performance standards are integrated.

The undertaking involves laying out the basis for the procedure and describing the procedure's data collection and data processing functions. Accordingly, the rest of this paper discussion is organized under the following headings:

- Basis for the procedure
- The procedure's data collection function
- The procedure's data processing function

2. BASIS FOR THE PROCEDURE

As a background for this study, this section draws heavily on the results of the previous paper. However, this discussion goes beyond that and presents new information needed to pave the way for the procedure's data collection and data processing functions. The discussion here is organized under the subheadings "Survey Project Situation" and "Performance Standards".

2.1 Survey Project Situation

2.1.1 Basic Elements. A field measured survey project has the following interrelated elements:

- o Survey subject: A building in its entirety is the documentation subject. However, because field survey activities proceed from one building part to another, say from front elevation to the next, building "part" is the survey operational subject in planning the procedure.

- o Significance of building: Significance criteria and the level of significance (based on such criteria) are schemes instituted by the jurisdiction (city, county, province, and so forth) in which the survey subject lies. However, in planning the procedure, the levels of building significance have been normalized as follows:
  - Primary
  - Secondary
  - Tertiary
- o Purposes of surveys: Purposes are classified as preservation, rehabilitation, restoration, and archival. These are well established purposes with differentiated implications on the required accuracy, thoroughness, and rate of survey projects. Explanation of preservation, rehabilitation, and restoration draws on the Secretary of the Interior's Standards for the Treatment of Historic Properties (U.S. Department of the Interior).
  - Preservation: "the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property."
  - Rehabilitation: "the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values."
  - Restoration: "the act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time by means of the removal of features from other periods in its history and reconstruction of missing features from the restoration period."
  - Archival: The archival purpose embodies the process of developing records of heritage buildings for use by future generations and for study ends.
- o Survey methods: From several measured survey methods, only three are appropriated: hand measurement (HM), estimation practices (EP), and site rectified photography (RP). Appropriation is aimed at usefulness of a reduced number of methods with distinct, but comparable characteristics.
- o Method technical performance: Technical performance has the attributes of accuracy, thoroughness, and rate. These are defined as follows (Elwazani, 2002):
  - " 'Accuracy connotes the degree of the conformity of measurements to their true value.' "
  - "Thoroughness is a degree of method capacity for recording survey information with abundance and ease."
  - "Rate performance is the pace at which a survey is driven to completion."

2.1.2 Performance Types and Relationships. The technical performance types and their inter-relationships are explained below:

- o Performance types include optimal, actual, absolute, and required. All four types apply to accuracy, thoroughness, and rate.
- o A method has an optimal performance and an actual performance.
- o Optimal performance requires the most conducive contextual conditions (factors) at the time of survey. Thus it is rarely possible because the "most conducive" mode of all contextual conditions is hardly obtainable.
- o Actual performance ensues from reducing optimal performance by the (reducing) effect of contextual factors.
- o Absolute performance is a concept that applies to a performance attribute in the first place and it is universal in its relatedness to methods. The value of absolute performance in accuracy, thoroughness, or rate is 100%. The concept is universal because it does not depend on the type or number of methods under consideration. Absolute performance, say in accuracy, is a reference for determining accuracy optimal performances of methods.
- o The effect of "contextual factors" should be quantified to arrive at the actual performance.
- o Required performance is a project characteristic. A survey project dictates a required accuracy, a required thoroughness, and a required rate depending on such factors as purpose of the survey, significance of the subject, and urgency for the survey.
- o A project required performances influence the acceptability of a method's respective actual performances, and, subsequently, the suitability of the method for the project.

2.2 Performance Standards

2.2.1 Methods Optimal Performances. A method optimal performance obtains only in the hypothetical case where all (thirteen) contextual conditions act at "most conducive" mode. A method may perform optimally under one or more contextual conditions and non-optimally under others. Optimal performance values are established with a reference to absolute performance value in the attribute. For example, the rectified photography accuracy optimal performance of 90% means it equates to 90% of the absolute accuracy—the accuracy that is attributed to some method, which may or may not be in the population of methods under consideration (this could be stereo-photogrammetry). Methods' optimal performances are listed below.

Survey Method	Accuracy	Thoroughness	Rate
Hand measuring	80	80	70
Estimation practices	70	70	100
Rectified photography	90	100	80

2.2.2 Standards for Measuring the Effect of Contextual Factors. In order to arrive at the actual performance of methods, the effect of the 13 contextual factors on the accuracy, thoroughness, and rate performance of methods needs to be evaluated. This proceeds as follows:

(1) Recall the contextual factors
There are three categories of factors:
- Building factors: height, size, condition, complexity, concealment level
- Site factors: size of property and surroundings, topography, obstructions
- Climatic factors: temperature, humidity, wind, precipitation, daylight

(2) Breakdown individual factors into classes

For each factor, and based on anticipated effect, three classes are considered. To illustrate, consider the factor "complexity of building part surfaces: a measure of how much the building part surfaces depart from that of a plain and smooth surface," labeled as BF4 in the previous study. The classes under this factor include the following:
Class 1: Plain surface
Class 2: Somewhat complex surface
Class 3: Complex surface

(3) Devise reference standards
For each set of standards (say accuracy), assess comparatively the effect of all contextual factors on the performance of the three methods. Building on the results of the previous work, the effect of surface complexity will be as listed below. The numbers refer to rankings of methods, with "1" indicating the method is performing the best, or stated otherwise, the effect of the contextual factor is the least.

Class	Method		
	HM	EP	RP
Class 1: Plain surface	0	0	0
Class 2: Somewhat complex surface	2	3	1
Class 3: Complex surface	2	3	1

Three sets of standards will result:
- Standards for assessing effect on accuracy
- Standards for assessing effect on thoroughness
- Standards for assessing effect on rate

3. THE PROCEDURE'S DATA COLLECTION FUNCTION

The procedure's data collection function deals with collecting data about purpose of survey, significance of survey subject, urgency of survey, and contextual factors. Data collection efforts about the first three facets are geared to answer the following:
- For purpose of survey: whether the purpose is restoration, rehabilitation, preservation, or archival
- For significance of survey subject: whether the subject is of primary, secondary, or tertiary significance
- For urgency of survey: whether urgency level is intense, medium, or light

The data collection effort about the (thirteen) contextual factors requires first hand, field examination of the building and its site, as well as access to climatic and weather prediction information. Here, the data collection effort is geared towards determining the "contextual severity" for each factor. For example, the effort involving the BF4 "complexity of building part surfaces" will end up with determining that the surface under consideration is either a) plain surface, b) somewhat complex surface, or c) complex surface. Let's assume that the BF4 has been determined as Class 3: "complex surface." This fact will be checked against the established performance standards to locate the performance comparative rankings of the methods in the accuracy, thoroughness, and rate attributes. Method rankings emanating from the BF4 scenario above will be as follows:

Performance	Performance Rank		
	HM	EP	RP
Accuracy	2	3	1
Thoroughness	2	3	1
Rate	3	1	2

Because there are thirteen contextual factors, the checking process will result in
- Thirteen accuracy comparative rankings of methods
- Thirteen thoroughness comparative rankings of methods
- Thirteen rate comparative rankings of methods

Table 1 illustrates a hypothetical itemization of the thirteen accuracy comparative rankings of methods. Similar itemizations can be completed for thoroughness comparative rankings and rate comparative rankings.

Factor and Class	HM Rank	EP Rank	RP Rank
Building Factors			
BF1, Height: C2	3	2	1
BF2, Size: C3	1	3	1
BF3, Condition: C2	3	1	1
BF4, Complexity: C3	2	3	1
BF5, Concealment: C2	1	2	3
Site Factors			
SF1, Size: C2	1	2	3
SF2, Topography: C3	1	2	3
SF3, Obstructions: C2	1	2	3
Climatic Factors			
CF1, Temperature: C3	3	2	1
CF2, Humidity: C3	3	2	1
CF3, Wind: C2	3	2	1
CF4, Precipitation: C2	2	3	1
CF5, Daylight: C2	1	2	3
Summation of Actual Rankings	**25**	**27**	**24**

Table 1: Hypothetical itemization of the thirteen accuracy comparative rankings of methods

4. THE PROCEDURE'S DATA PROCESSING FUNCTION

The procedure's design handles data processing function under the following areas:
- Actual performances
- Required performances
- Actual performances versus required performances
- Method selection

4.1 Actual Performances

4.1.1 Assess Actual Performances. The steps below apply to finding the actual performance of each method in accuracy, thoroughness, and rate—in three separate procedures. I will discuss the accuracy actual performance assessment procedure only; thoroughness and rate performance procedures are similar. Simple tabulations support the discussion as needed.

(1) Obtain S, the summation of maximum (theoretical) rankings. This is the hypothetical case when a method is ranked third (last) in the 13 contextual factors. S will then be 39 (3x13). There is only one universal S (39) in the data processing function.

(2) Obtain X1, the summation of actual rankings for each method. This is the "summation of actual rankings" in the last row of Table 1.

X1 for HM	X1 for EP	X1 for RP
25	27	24

(3) Obtain X2, the difference of the summation of maximum rankings (S) and the summation of actual rankings (X1) for each method. For example, for HM, the difference is 39-25 = 14.

X2 for HM	X2 for EP	X2 for RP
39-25 =14	39-27 = 12	39-24 = 15

(4) Obtain X3, the ratio of X2 to S. For example, for HM, the ratio is 14 to 39 = 0.359.

X3 for HM	X3 for EP	X3 for RP
14/39 = 0.359	12/39 = 0.307	15/39 = 0.385

(5) Obtain Pa, actual performance of each method. Actual performance is the product of X3 and method optimal performance, Po. According to 2.2 Performance Standards, accuracy optimal performances for HM, EP, and RP are 0.80, 0.70, and 0.90 respectively. To obtain Pa for HM, for example, it would be (0.359) x (0.80) = 0.2872

Pa for HM	Pa for EP	Pa for RP
0.359x0.80 = 0.2872	0.307x0.70 = 0.2149	0.385x0.90 = 0.3465

The decimal figures for the actual performance of the three methods represent—directly, not inversely—the relative accuracy of the three methods.

(6) Transform the relative actual accuracies of the three methods for meaningful comparison. In other words, relate these accuracies to some sort of accuracy scale.

a. Isolate the highest of the three relative accuracies; this is the RP accuracy of 0.3465
b. Employ the "highest relative accuracy" (0.3465) to find the "absolute" accuracy.

Since the "highest relative accuracy" (0.3465) has been established as 90% of absolute accuracy, the absolute accuracy in decimal terms will be:
(100/90)x(0.3465)=0.3850

c. Express each method "relative accuracy" in terms of absolute accuracy—to find Pa:
   - For HM, accuracy Pa: (0.2872/0.3850)x(100)=74.597%
   - For EP, accuracy Pa: (0.2249/0.3850)x(100)=58.415%
   - For RP, accuracy Pa: (0.3465/0.3850)x(100)=90.000%

Pa for HM	Pa for EP	Pa for RP
74.597%	58.415%	90.000%

The percentage expressions above are the results of the actual accuracy assessment procedure. Once the actual thoroughness assessment procedure and actual rate assessment procedure have been completed (as mentioned above, they are not part of the discussion), the results of the three sub-procedures can then be listed as follows.

Method	Actual Accuracy Performance	Actual Thoroughness Performance	Actual Rate Performance
HM	74.597%		
EP	58.415%		
RP	90.000%		

4.1.2 Classify Actual Performance into Levels. An actual performance level scale will result. This scale equally applies to the three attributes of performance: accuracy, thoroughness, and rate.

Level	Description
Level 1	High, ≥ 80%
Level 2	Medium, ≥ 60% to < 80%
Level 3	Low, < 60%

4.2 Required Performances

At this juncture, the survey project's required performances need to be determined.

4.2.1 Establish Level Scales for Required Performances. This involves establishing level scales for the following:

- Required accuracy
- Required thoroughness
- Required rate

Required performance for a survey project is a function of the purpose of survey, significance of the structure, and the urgency level of survey. Recalled from 2.1: Survey Project Situation, these facets are as follows:

- Survey purposes: restoration, rehabilitation, preservation, and archival
- Significance of the structure: primary, secondary, and tertiary significance
- Urgency level: intense urgency, medium urgency, and light urgency

The level scale for any required performance consists of:

- Level 1 (L1), high performance
- Level 2 (L2), medium performance
- Level 3 (L3), low performance

4.2.2 Assess Required Accuracy and Required Thoroughness. Required accuracy and required significance are assessed simultaneously by correlating both purpose of documentation and significance of the structure as shown below. For example, documenting a primary significance structure slated for restoration requires L1 accuracy and L1 thoroughness.

Level of Significance	Purpose of Documentation			
	Restor.	Rehab.	Preser.	Arch.
Primary	L1	L2	L1	L1
Secondary	L1	L2	L2	L2
Tertiary	L2	L3	L3	L3

Restor. = Restoration; Rehab. = Rehabilitation;
Preser. = Preservation; Arch. = Archival

4.2.3 Assess Required Rate. Rate expresses the speed of survey operations. The more urgent the need for documentation, the higher the level of required performance:

- Intense urgency requires Level 1 rate of survey
- Moderate urgency requires Level 2 rate of survey
- Light urgency accepts Level 3 rate of survey

4.3 Actual Performances versus Required Performances

At this point, we have outlined how to obtain the following:

- The actual performance of each method in the accuracy, thoroughness, and rate attributes
- The required performance of the project in the accuracy, thoroughness, and rate attributes

Proceed as follows:
(1) Match actual performances of methods with the required performances of the project. A matching matrix would look like the following.

Method	Accuracy		Thoroughness		Rate	
	Act.	Req.	Act.	Req.	Act.	Req.
HM						
EP						
RP						

Act. = Actual; Req. = Required.

(2) Determine what methods would satisfy individual required performances. Building on the results of the above step, a plausible determination scenario would look like this:

Required Performance	Satisfying Methods
Accuracy	HM, RP
Thoroughness	RP
Rate	EP, RP

4.4 Methods Selection

Determine what methods would independently satisfy the entire set of performance factors. Referring to the preceding scenario, it is obvious that rectified photography (RP) is the only method that would, by itself, satisfy the entire set of required performances—for this part of survey subject.

5. CONCLUSIONS

A previous paper (Elwazani, 2002) investigated the effect of the contextual conditions on the performance of measured survey methods and ended with establishing a set of standards for evaluating such effect. The purpose of this paper was to devise a procedure for evaluating the performance of measured survey methods—into which the developed performance standards are integrated. To such end, this paper laid out a basis for the procedure and described the procedure's data collection and data processing functions.

The data collection function accounts for data about the main aspects of the survey project, including the purpose of survey, significance of the survey subject, urgency of survey, and contextual conditions. The data about the latter describes the conditions of the 13 building, site, and climatic factors. In types and extent of data, this function is designed to commensurately feed the "processing" steps in the subsequent data processing function.

The data processing function is geared to produce actual performances of methods in accuracy, thoroughness, and rate, and then to compare actual performances with the project required performances. To produce the actual performances, the function begins with the methods performance values obtained from the developed performance standards. The function then makes use of the available optimal performances and absolute performance values by means of a series of simple equations to produce the actual performances.

The remaining steps of the data processing function evaluate the survey project's required performances before comparing them with the actual performances. These steps establish level scales for required performances in accuracy, thoroughness, and rate attributes and then, in a special assessment technique, show how these required performances can be determined. Once the required performances are in hand, steps for deciding upon appropriate methods follow.

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