Use of ASCE 38-02 and Subsurface Utility Engineering for Better Design, Cost Savings and Damage Prevention.

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Abstract: CI/ASCE 38-02 applies to projects where existing utilities will be impacted and requires that the project approach used by engineers be modified in order to conform to the standard.
The ASCE Standard 38-02 "Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data" provides much useful information. However, in order for the standard to realize its full potential, owners, designers and contractors must know how to best use the information provided. Intelligent use of the standard and appropriate incorporation of subsurface utility engineering (SUE) services will result in better designs and enhance damage prevention efforts. This paper/presentation will review the Standard Guideline and then proceed to discuss how to incorporate it and SUE services into an airport project. Also addressed will be maximizing the benefits of CI/ASCE 38-02 and Safety concerns.

Forward: In late 2002 CI/ASCE 38-02 was published. It's referred to as a "Standard" since it was prepared under the ASCE consensus process making it the first nationally recognized publication covering aspects of Subsurface Utility Engineering.

The following items are discussed in this paper:

- Basic Concept and Goals of the Standard
- Review of the Standard-"What does it say?"
- Review of SUE field techniques.
- How to incorporate the Standard into an airport project.
- Maximizing the Benefit of the standard and "The 100% guarantee".
- Safety Concerns
- Conclusions

Basic Concept and Goals of the Standard

Concept: Current practice by designers with regard to existing utilities is to place a note on the construction documents such as:
Utility information has been obtained from available records. The actual locations may differ. Contractor to verify all utility locations. Any utilities damaged shall be repaired by the contractor.
The basis of CI/ASCE 38-02 is that designers state on the drawings, according to

best professional judgment, how good the utility information is deemed to be. How good the utility information is, prior to ASCE 38-02, was purely subjective. CI/ASCE 38-02 provides a clear definition for the “Quality” of the Utility information being presented on a drawing. It’s important to note that “Quality” or “Quality Level of information” as used in the standard refers to how the utility information was collected and depicted. It does not refer to quality of work or professionalism (which should always be of the highest level). The standard refers to four quality levels (D,C,B & A) which should be referenced when depicting utilities on design and construction documents. This information indicates to all involved in a project how their roles may be affected by existing utilities and what risks they are likely to be burdened with as the project proceeds.

Goal: The following is a goal of the ASCE standard and also of the aspects of SUE not yet covered by the standard.
To manage the risks with respect to overall project costs and safety associated with existing utilities in a coordinated and complete fashion.

Review of the CI/ASCE 38-02 standard
The standard is a comprehensive document and should be reviewed in its entirety. A significant amount of the information is also contained in Appendix A-F and should also be reviewed.
The major technical portions of the standard are as follows:

1. Definitions: Some of the more important definitions are as follows:

Subsurface Utility Engineering (SUE): “A branch of engineering practice that involves managing certain risks associated with *utility mapping at appropriate quality levels*, utility coordination, utility relocation design and coordination, utility condition assessment, *communication of utility data to concerned parties*, utility relocation cost estimates, implementation of utility accommodation policies and utility design.” In general the portions of SUE covered by the standard are in italics. The object of this paper is also to cover some of the remainder.
Note: This definition recognizes SUE as “a branch of engineering practice”. Based on this the standard requires that SUE documents be certified by a registered professional. The tasks listed above not in italics require certification by a registered professional engineer.

Designating: “The process of using a surface geophysical method, or methods, to interpret the presence of a subsurface utility and to mark its approximate horizontal position (its designation) on the ground surface.” It should be noted that the mark on the ground is not the final product. The marks should be survey located, reduced onto the contract documents and reviewed by a competent professional.
Locating: “The process of exposing and recording the precise vertical and horizontal location of a utility. “ Exposure is typically done using vacuum excavation techniques.

2. Collection and Depiction tasks and their assignment. This section assigns tasks to the project engineer and to the project owner. The following is a shortened version.

The Project Engineer Should: (with respect to Utilities and the standard) advise the owner, educate the owner, recommend a scope, discuss deliverable formatting, discuss incorporation of SUE into the design process, prepare utility drawings, review plans/designs with the owner and make recommendations for further investigation work.
The Project (Airport) Owner Should: (with respect to Utilities and the standard) specify the scope, assist with obtaining records, review the information with contractors and other end users, notify the engineer of suspected deficiencies discovered during construction, furnish information to utility owners and other involved parties.

3. Quality levels for Utilities. The following are not the exact definitions provided in the standard but rather a more descriptive definition of each quality level:

QUALITY LEVEL D: "QL D". Utility information plotted on the drawings based solely on record information, individual recollections or the existence of utility service. Information other than horizontal location information may also be obtained from records. It is my personal opinion that all information shown (other than at test hole locations, see QL A below), with reference to a utilities size, capacity, material composition, condition or service status shall be considered QL D even though the utility may be plotted and labeled as QL C or QL B.

QUALITY LEVEL C: "QL C". Utility information obtained as above for quality level D, plotted to correlate with surface utility features which have been field verified, survey located and accurately reduced onto the design/construction documents. Included in this category are utility depictions, which in the professional opinion of the subsurface utility engineer represent the most probable approximate horizontal location, type and/or existence of a utility. Aerial utility information may also be included in this category. It should be noted that utilities, which are, typically non-linear (e.g. direct buried telephone) could be shown as QL D even if correlated to surface utility features.

QUALITY LEVEL B: "QL B". Utility information derived by establishing the surface horizontal location of a utility using electronic methods (Designation). Said information is subsequently field survey located and accurately reduced onto the design/construction documents.

QUAILITY LEVEL A: "QL A". Utility information which has been visually verified, survey located (both horizontally and vertically) and accurately reduced onto the design/construction documents. This Information is typically shown on a test hole data table or exploration hole log.

4. Deliverables Formatting. This section covers various ways to depict utilities on plans without prescribing the actual format of the deliverables. Methods such as line code and style, labeling, symbol embedding, color, line weight, layer or level and accompanying text are discussed. The important point to note is that the quality level of the utility shown shall be clearly indicated. The standard states that with respect to advanced CADD programs (using 3-D views) "quality of vertical information is not addressed". This may seem like a strange statement but it can be explained as follows. Quality level A data is 3-dimensional and is point data rather than linear data. On the other hand for quality levels B,C & D the data is linear but only 2-dimensional. This may lead to problems and/or confusion when imported using the above mentioned software. It is probably safer to represent the data in the host drafting software environment only.

5. Costs and benefits. The standard provides some basic information on costs such as indicating that costs for providing services typically range from 0.5% to 1% of the Design/Construction budget. A study prepared by Purdue University for the Federal Highway Administration (Publication No. FHWA-IF-00-014) provides more specific information on costs verses benefits.
It should be noted that the study was based on the implementation of Subsurface Utility Engineering Services (SUE) which are only partially covered by the standard.
"*A savings of $4.62 for every $1.00 spent on SUE was quantified from a total of 71 projects. These projects had a combined construction value in excess of $1 billion. The costs of obtaining Quality Level "B" (QL B) and Quality Level "A" data on these 71 projects was less than 0.5% of the total construction costs, and resulted in savings of 1.9% percent over traditional Quality Level C (QL C) and/or Quality Level D (QL D) data. Qualitative savings were non-measurable, but it is clear that those savings are also significant and may be many times more valuable than quantifiable savings.*
The figure $4.62 is somewhat less than the $7.00 to $10.00(Previous Virginia DOT study), $18.00 to $1.00(Previous Maryland DOT study), and $10.00 to $1.00(Society of American Value Engineers) returns on investment that were previously reported in the literature. However, the quantity of studied projects is much higher; the projects are more random in nature; and no qualatative costs were included in the total. Indeed, one individual project had a $206.00 to $1.00 return on investment (North Carolina DOT). Only 3 of 71 projects had a negative return on investment."

Review of SUE field techniques. (Quality Level B)

ASCE 38-02 has an extensive listing of techniques for electronically detecting underground utilities which is part of the process for certifying utility data as "Quality Level B". The methods described are as follows:
Electromagnetic Pipe and Cable Locators, Terrain Conductivity, Resistivity Methods, Metal Detectors, Ground Penetrating Radar, Optical Methods, Infrared (Thermal) Methods, X-Ray Methods (Penetrating Radiation),

Total Field Measurements, Gradiometric Measurements, Acoustic Emission, Micro gravitational Techniques, Isotopic (Radiometric) Techniques, Chemical Techniques, Borehole Geophysics and Geophysical Diffraction Tomography

While all the above methods are valid, many have limitations based on cost, site conditions, limited application and current state of development. Based on a survey of Subsurface Utility Engineering Professionals it appears that at least 70% of Quality Level B data is generated using Electromagnetic Pipe and Cable Locators with other methods being used to either verify the information or for situations where Electromagnetic Pipe and Cable Locators yield poor or no results. For this reason only a description of Electromagnetic Pipe and Cable Locators is provided.

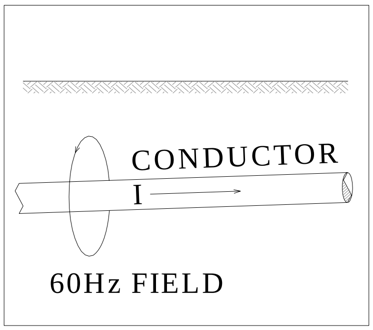


Figure 1.1
Ambient Energy Field

The following is not a comprehensive discussion but rather a brief overview.

Electromagnetic and Radiofrequency line locators operate by locating either a background signal (an ambient energy field, see Figure 1.1) or by locating a signal introduced into the utility line using a transmitter (an applied energy field).

An applied energy can be introduced by placing a transmitter that emits a varying magnetic field in close proximity to a utility.

This induces a varying current in the utility which in turn has a unique varying magnetic field which can be designated (See Figure 1.2 Indirect Induction).

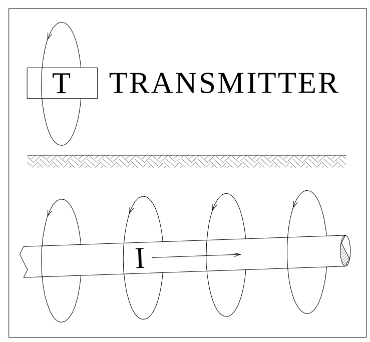


Figure 1.2
Indirect Induction

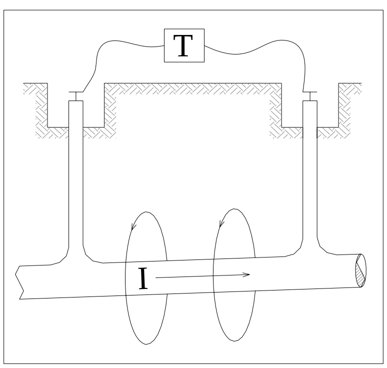


Figure 1.3
Direct Induction

A signal can also be introduced into using Direct Induction (or Direct Connection). This is a preferred method when possible because interferences from other utilities or subsurface features are minimized (see figure 1.3).

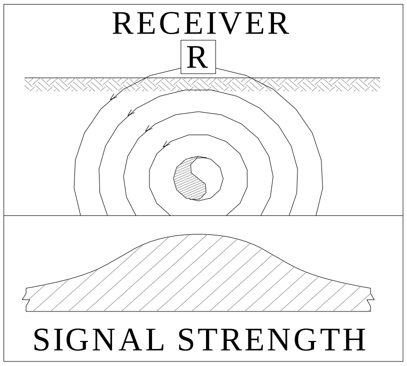


Figure 1.4
Utility Designation

The signal carried by the utility line can be located horizontally on the surface using a receiver. The receiver is moved across the estimated location of the utility line. The location of the highest signal strength is marked as the approximate horizontal location of the utility. The receiver is then rotated until the highest signal strength is achieved. This will give the approximate orientation of the utility (See Figure 1.4).

The approximate vertical locations can be estimated using the above techniques. In some situations, however, errors can be introduced that render the vertical location no better than good judgment would predict. In addition, errors can occur in situations when lines are running one on top of the other. What results is a combined field, which would indicate a single utility with greater depth than the actual depth (See Figure 1.5). Conversely, the presence of a conductor above the utility being traced could lead to a shallower depth than actual. Situations such as these make the determination of vertical location with these techniques unreliable. The best way to determine the vertical location is to exposure using minimally intrusive methods.

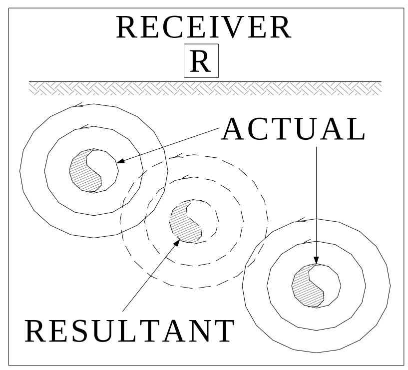


Figure 1.5
Possible Inaccuracies

Figure 1.6 Photograph of Field Proceedure

Review of SUE field techniques. (Quality Level A)
CI/ASCE 38-02 does not specifically discuss the methods used to obtain quality level A information. What is stated is that "Exposure and survey of the utility at each specific location where quality level A date is obtained is currently necessary". As discussed above this is because, to date, depth can not be reliably determined electronically. Exposure of the utility is by non-intrusive methods such as hand excavation or typically for SUE firms Vacuum Excavation. Survey is by usual field survey methods.

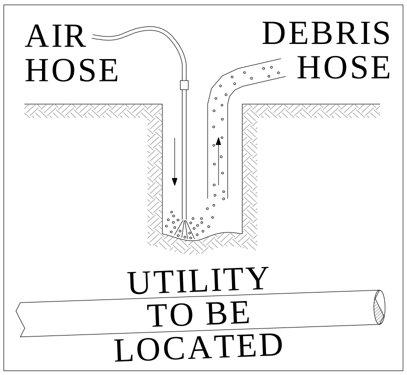


Figure 2.1
Utility Locating

Non-destructive Air-Vacuum Excavation: Non-destructive Air-Vacuum Excavation is used to expose utilities so that information can be obtained. The process involves removing the surface material over approximately a 12in x 12in area at the electronically determined approximate horizontal location. The air-vacuum process then proceeds with the simultaneous action of compressed air-jets to loosen soil and vacuum extraction of the resulting debris. The process continues until the utility is uncovered (See Figure 2.1).

It should be noted that certain soil conditions may warrant the use of water jets in place of air jets however it is outlawed in certain areas due to potential corrosion and damage. The following information can typically be recorded: utility, material, size, depth, condition, location (x, y, and z), orientation, roadway section materials and depths, soil type and water table. Air-vacuum excavation can be used to obtain soil samples from utility line trenches without risking damage to the utility which can be very useful as contaminants frequently move along utility line trenches.

Fig 2.2 Field Procedure

Fig 2.4 Utilities in a Test Hole

Incorporating CI/ASCE 38-02 into the Design Process.

Process using an example project. In very general terms quality level D data is used for planning, quality level C data is used for conceptual design, quality level B data is used for preliminary design and quality level A data is used for final design. The example below is somewhat of an oversimplification. The Subsurface Utility Engineer will take into consideration such things as importance of a utility, age of a utility, ease of relocation, cost of relocation, delays caused by relocations and safety issues relating to relocation. The following example however illustrates some basic concepts. Typically a base topographic plan is prepared using conventional survey methods and/or aerial mapping. Available utility record information is then added to the drawings. This corresponds to quality level D information or quality level C information if correlated to surface utility features (see Fig 3.1).

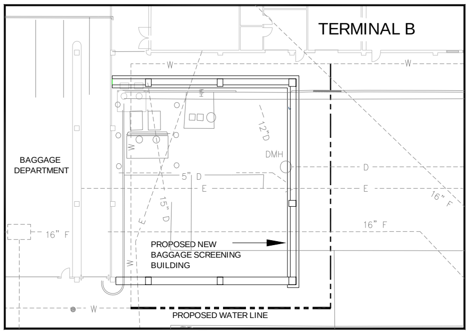


Fig 3.1 Quality Level D & C

The existing utilities are electronically located and the results plotted on the base plans (see Fig 3.2).

The location of the preliminary alignment is revised to avoid conflicts with existing utilities where possible. In this example the original horizontal alignment would have unnecessarily impacted several underground utilities and utility structures.

Based on the revised alignment and the existing utilities, locations are chosen where exact horizontal and vertical information will be determined.

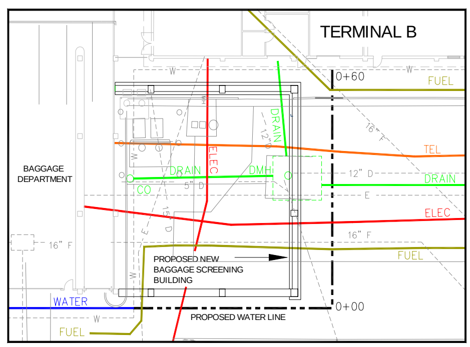
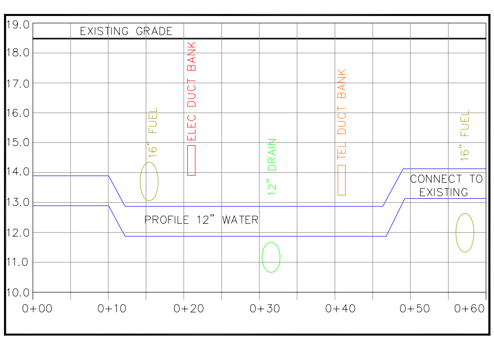


Fig 3.2 Quality Level B

When the quality level A data is obtained it is plotted on a profile showing exact utility locations and sizes (see Fig 3.3).



Now that the exact horizontal and vertical location has been established the proposed utility line can now be designed to minimize the impact on existing facilities. Where relocations are required, informed decisions can be made as to how this can be achieved.

Fig 3.3 Quality Level A

Maximizing the Benefit of the standard.

A typical project involves improvements to the existing areas which have, over time, had various utilities placed in and crossing them. Subsurface Utility Engineering is implemented on a project for several reasons as follows:

1. To determine what existing utilities exist and their specific location.
2. To determine how the existing utilities will be impacted by the proposed improvements.
3. To determine what measures can be taken if any to limit the impact and thereby reduce design and construction costs, construction delays and risk of damage during construction.

The above are achieved as follows:

1. Generation of Subsurface Utility Engineering deliverables which depict the existing utilities at Specific Quality Levels (see quality level index above).
2. Comparing the SUE deliverables with the proposed work to determine impacts and generate a utility impact statement, spreadsheet or matrix.
3. Determine what measures need to be taken to avoid or mitigate project impacts.
4. Where deemed cost effective, modify the design drawings to reduce impacts. Where impacts are unavoidable, the design drawing should indicate how they are to be dealt with by the contractor. In addition, the pay item list / cost estimate should include items to deal with relocations or protection of existing utilities. Relocations "By Others" should be indicated on the drawings with a schedule and proposed location so as to ensure relocated utilities are not damaged during construction or cause project delays.
5. Incorporate the SUE deliverables into the construction documents (to supercede other utility plans) for use by the contractor in determining the bid and to reduce the likelihood of damage during construction.

"The 100% guarantee"

Frequently the question of who is liable if a utility is missed or not documented on the SUE deliverables arises. This is a valid question but could also be asked in the following format. "Can a 100% guarantee be provided as to the location of underground utilities for a particular area"? This question needs to be addressed in the context of risk management and cost benefit ratio. The simple answer is "yes, a Subsurface Utility Engineering provider can provide a 100% guarantee and be held liable for anything found that's not shown on the SUE deliverable".

The question now becomes how much it is going to cost. Going back to the definitions of quality level, a 100% guarantee or full acceptance of liability comes only when quality level A information is requested and provided. Quality level A information can only be obtained by, referring back to the standard, "Exposure and survey of the utility at each specific location".

So providing a 100% guarantee for a particular area requires exposure of the entire area using non-intrusive methods. This leads to costs far above the potential savings and reduced risk of damage. Exposure is also necessary to prove the non-existence of utilities for example at proposed boring locations, using vacuum excavation to ensure that utilities are not damaged.

Safety Concerns.
OSHA requires that the primary method of achieving safety is to “engineer a solution”. When viewed in the context of proposed construction the design should recognize the existing utilities. In essence design around the existing utilities.
The following example illustrates a potential problem that could have been avoided through the application of the above recommendations and CI/ASCE 38-02.

A subcontractor tasked with relocating site utilities requested that existing utilities be located. A SUE crew performed this work and a drawing was prepared for the subcontractor. The general contractor was not provided with this information. When on-site performing additional work the SUE crew observed a pile driving crew working in close proximity (on top of the main electric feed to the facility). The work was stopped in time to prevent damage to the facility.

Fig 4.1 Pile Driven within 1’ of Utility

Fig 4.1 Next pile Locations

In reviewing the situation it is difficult to assess blame on any one entity. However using the above recommendations and CI/ASCE 38-02 the designer should have reviewed the existing facilities, notified the owner, with the owners agreement mapped the utility at an appropriate quality level and in this case made a decision to either relocate the utility or redesign the pile group.

Conclusions.
Significant cost savings and prevention of damage to utilities will result from appropriately managing the risks on a project. Subsurface Utility Engineering, as a branch of engineering practice provides a means to manage these risks.
At each stage of a project the risks, impacts and costs should all be assessed and the optimum solution determined. A qualified Subsurface Utility Engineer, as defined by ASCE 38-02 can be of great assistance in this process.
When assessing costs, consideration should be given to indirect costs not directly attributable to the project and costs to entities other than the project owner.
Damage prevention measures can only happen when the risks are fully understood and accounted for.