



IEEE Guide for Collecting and Managing Transmission Line Inspection and Maintenance Data

STANDARDS

IEEE Power and Energy Society

Developed by the
Transmission and Distribution Committee

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IEEE Guide for Collecting and Managing Transmission Line Inspection and Maintenance Data

Developed by the

Transmission and Distribution Committee
of the
IEEE Power and Energy Society

Approved 20 May 2024

IEEE SA Standards Board

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Abstract: Reference information to assist electric utilities and their contractors with the development of computer-based means for collecting and managing transmission line inspection and maintenance data and associated asset information is provided. A high-level overview is provided in this guide for key principles and considerations learned through experience that help ensure common pitfalls are avoided and enhance the usability of systems and collected data. It is not intended to provide an exhaustive discussion of the many details and specifics accounted for when designing and developing a system including data requirements for an individual utility's application and needs.

Keywords: AI, analytics, artificial intelligence, asset management, automated, compliance, data, database, data science, defect reporting, electric, electronic, field/virtual inspection, geographic information systems, GIS, IEEE 1808™, lines, machine learning, maintenance, ML, regulations, risk, transmission

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Introduction

This introduction is not part of IEEE Std 1808-2024, IEEE Guide for Collecting and Managing Transmission Line Inspection and Maintenance Data.

In 2009 the Management of Existing Overhead Transmission Lines Working Group organized a Task Force to develop this guide. In 2021 a second Task Force was organized to update the guide. The guide was developed and updated for the following reasons:

- Regulations regarding inspection and maintenance continue to increase.
- Demonstrable evidence of maintenance effectiveness is needed to justify budgets.
- Access to previously unconsidered data sources offers new data acquisition and analysis opportunities.
- New state-of-the-art technologies in data processing [both for hardware and software, especially artificial intelligence (AI) and machine learning (ML) techniques] offer new efficiency opportunities.
- Asset management business models and analytics require meaningful information to succeed.
- Automated data management systems facilitate increased knowledge transfer among personnel.
- The industry could benefit from guidelines when developing, enhancing or reviewing their automated collection and management systems for transmission line inspection and maintenance data.

The purpose of the guide is to provide easy-to-use reference information that serves as a framework and roadmap for designing efficient and effective systems to facilitate and/or enhance the following:

- Collection of inspection and maintenance data for overhead transmission lines
- Field and office usability (both for processing and visualization)
- Data integrity in each phase of data management
- Compatibility with geographic information systems (GIS) and enterprise solutions
- Data exchange with other systems and users
- System expansion and modification
- Transferability of data (from one system to another, i.e., due to system upgrade or implementation of a new system)
- Data analysis and analytics
- Risk assessment
- Application of AI and ML tools
- Reporting
- Security
- Flexibility to adapt to system and regulatory changes

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1. Overview

1.1 Scope

This guide provides reference information to assist electric utilities and their contractors with the development of computer-based means for collecting and managing transmission line inspection and maintenance data and associated asset information including transmission line inventory data. It provides a high-level overview of key principles and considerations learned through experience that ~~helps to~~ ~~will help~~ ensure common pitfalls are avoided and ~~enhances~~ ~~enhance~~ the usability of systems. It is not intended to provide an exhaustive discussion of the many details and specifics that ~~should~~ ~~must~~ be accounted for when designing and developing a system for an individual utility's application and needs.

1.2 Purpose

The ~~purpose of the~~ guide ~~provides~~ ~~is to provide~~ easy-to-use reference information that ~~serves~~ ~~will serve~~ as a framework and roadmap for designing efficient and effective systems ~~to that will~~ facilitate and/or enhance the following:

- Data collection
- Field and office usability [\(both for processing and visualization\)](#)
- Data integrity [in each phase of data management](#)
- Compatibility with geographic information systems (GIS) and enterprise solutions
- Data exchange with other systems and users
- System expansion and modification
- Transferability of data (from one system to another, i.e., due to system upgrade or implementation of a new system)
- [Risk assessment](#)
- Data analysis [and analytics](#)
- [Application of artificial intelligence \(AI\) and machine learning \(ML\) tools](#)
- Reporting
- Security
- Flexibility to adapt to system and regulatory changes

1.3 Word usage

[The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted \(*shall equals is required to*\).^{6,7}](#)

⁶ [The use of the word *must* is deprecated when stating mandatory requirements; *must* is used only to describe unavoidable situations.](#)

⁷ [The use of *will* is deprecated when stating mandatory requirements; *will* is only used in statements of fact.](#)

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should equals is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may equals is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can equals is able to*).

1.4 General

The blackout of August 2003 brought to light the urgent need ~~urgency~~ to address the reliability and resilience ~~availability~~ of the transmission grid in North America, and the impacts continuous aging of infrastructure, risks, and other maintenance-related issues are having on performance. For these reasons, coupled with financial pressures to do more with less ~~. Aging of the infrastructure has a strong impact on the performance of the transmission grid. Until significant investment in restoration or reconstruction of these facilities can be made,~~ maintenance planners are under ~~growing~~ pressure to squeeze more life out of ~~the~~ existing facilities and asset managers are under pressure to optimize the cost-effectiveness of cradle-to-grave facility management decisions. Informed maintenance and asset management decision-making requires robust information on the conditions, configurations, and risks of facilities' components and equipment. Such information is generally gathered through transmission line inspections ~~system~~. There are a variety of industry-recognized inspection programs, and all have been developed to satisfy specific requirements. Data collection tools should reflect these requirements ~~this~~, and complement ~~need to build on~~ the ultimate purpose of the inspections.

The migration from paper-based to computer-based means for collecting and managing transmission line inspection and maintenance data has been underway for more than ~~three~~ two decades. While this is the case, the migration has been slow, and some ~~proceeded very slowly until recently, hence a large percentage of~~ utilities have yet to ~~initiate a transition or~~ make a complete and effective transition to using electronic media to collect and manage the large volume of ~~available~~ inspection and maintenance data. Additionally, many utilities that have made the transition recognize opportunities to enhance their approaches, tools, and systems. For these reasons ~~Today, the migration is progressing at a higher rate than ever before due to a variety of factors and pressures (see Clause 2) and~~ utilities are seeking resources to guide the design, ~~and~~ development, and refinement of systems appropriate for their work practices and reporting requirements. This guide was developed in response to this need in the area of transmission line inspection and maintenance.

1.5 Application

The guide is applicable to the requirements for computer-based data collection and management needs specifically related to the inspection and maintenance of transmission lines. It is intended to be useful for operations and engineering personnel and managers responsible for transmission line maintenance as well as software developers and information technology (IT) personnel supporting the maintenance function and/or other relevant corporate functions.

1.6 Contents and organization

The contents of this guide are organized to provide a logical flow of relevant information. Table 1 provides a summary of the content of the clauses of the guide beginning with Clause 2.

Table 1 — Summary of the contents of individual clauses of the guide

Topics and description	Clause
Drivers for developing a system for collecting and managing inspection and maintenance data: Reasons/rationale supporting the need to collect and manage inspection and maintenance information using efficiently designed computer-based systems are provided.	2
Starting to design a data management system: A variety of key considerations ranging from determining stakeholders and development drivers to establishing requirements and resources necessary to design, develop, implement, and support a system are provided.	3
Data requirements: The types of data that need to be collected to meet various goals for system use are outlined.	4
Data management systems and management tools for data collection: Issues that may be encountered and should be addressed when using multiple data collection and management tools within a data management system are discussed.	5
Role of GIS: Capabilities offered by and advantages of integrating GIS functionality with data collection and management systems are discussed.	6
Data collection methods: Brief explanations of the various methods for data collection are provided, including general considerations for each.	7
Matching data collection capabilities with various types of inspections: The capabilities of various types of inspections and the data collection features needed to support them are reviewed.	8
Sample data models: Graphical depictions of data models representative of those required to support systems with varying degrees of sophistication and functionality are provided.	9
Optimizing data quality and usability: Data collection system design features that help ensure data quality and usability are reviewed.	10
Applying advances in data science: Scientific and statistical data science methods for the collection, cleaning, analyzing, and presentation of data are discussed.	11
Data collection and communication hardware: Various hardware options for field data collection and data communication are discussed and the features and advantages of each are reviewed.	12
Reporting functionality: A variety of types of reports, and report generation and presentation options designed to meet different asset management needs are discussed.	13

[\(New\)](#)

Topics and description	Clause
Drivers for collecting and managing inspection and maintenance information: Reasons/rationale supporting the need to collect and manage inspection and maintenance information using efficiently designed computer-based systems are provided.	2
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Data requirements: The types of data that need to be collected to meet various goals for system use are outlined.	4
Data collection and management tools versus data management systems: Issues that will be encountered and must be addressed when using multiple data collection and management tools within a data management system are discussed.	5
Role of GIS: Capabilities offered by and advantages of integrating GIS functionality with data collection and management systems are discussed.	6
Data collection methods: Brief explanations of the various methods for data collection are provided, including general considerations for each.	7
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Reporting functionality: A variety of types of reports, and report generation and presentation options designed to meet different asset management needs are discussed.	12

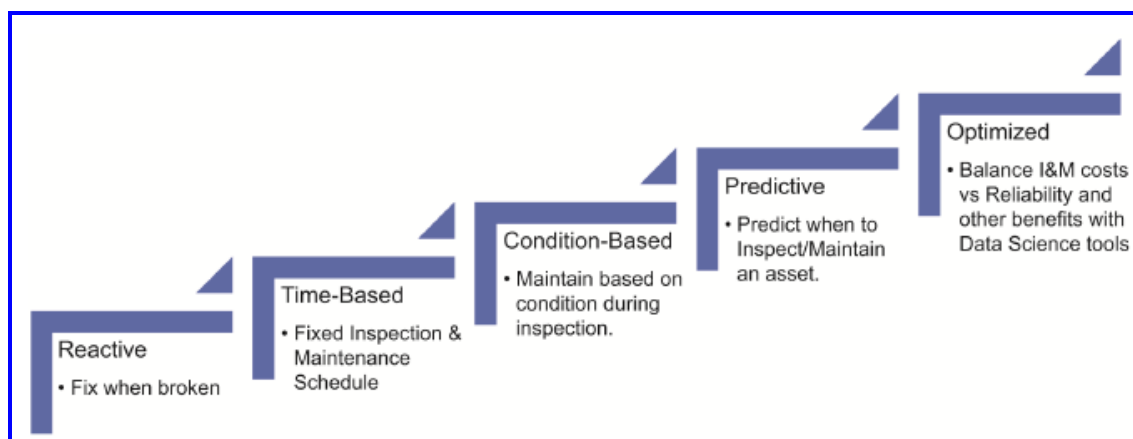
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1.7 Data management to support risk-based inspection and maintenance decision making

Risk is increasingly becoming a cornerstone of decision making around all assets, including transmission assets. There is the possibility or uncertainty of not achieving desired outcomes due to risks. For transmission assets the main risk is failure before their next maintenance or replacement cycle. The probability and consequence of asset failure drives the type and frequency of both collecting inspection data and performing maintenance.

High risk levels in a utility's transmission line physical assets and in the management system of these assets could lead to serious consequences, such as the impact of power outages on customers and potential revenue losses for the utility. Utilities are getting increasingly sophisticated in their risk-based decision making in identifying the likelihood of serious risk events and in assessing and mitigating such serious risk events.

The emergence of new inspection, data analysis, and maintenance techniques is allowing an evolution in inspection and maintenance strategy, as the stages in Figure 1 depict. Today many maintenance strategies are "reactive" – fix the asset when it breaks. Many transmission overhead line inspections are time-based – inspect the lines every X years. Utilities are beginning to adjust inspection frequencies based on the condition of the assets in the previous inspection. Over time advanced analytics applied to large conditioned-based data sets should allow utilities to predict when an asset inspection should be made. Other industries have found that applying data science tools to optimize the type and timing of inspection data collection along with the type and timing of maintenance can both reduce maintenance costs and reduce asset downtime by 20% to 30% along with other benefits. This is a variation of preventive, condition-based, and reliability-centered maintenance that optimizes costs and reliability. Utilities are beginning to see similar risk-based optimization opportunities using data science for the electric grid.



(New)

Figure 1 – Levels of sophistication in risk-based inspection and maintenance (I&M)

Throughout this guide various risks are mentioned.

Summarized in Annex A are examples only of key management system controls and their associated elements related to each clause. These elements should be identified in a utility's management system and assessed for risks and opportunities for improvement to optimize the collecting and use of inspection data.

As an example, consider Clause 8 that covers "Data collection capabilities with various types of inspections". In this case "inspection data management" as one of the subsystems in a utility's overall data management system could have risks that if not identified and assessed could lead to serious consequences. Below is an example from Table A.1, subclause 8.2.1, which is one of the controls (subclauses) with its associated elements that support the inspection data management. Risk assessments of these elements in the utility's management system should be performed.

CLAUSE	CONTROLS	ELEMENTS
8.2.1	Matching data collection capabilities with various types of inspections – Types of inspection methods – Aerial patrol manned	Aerial patrol Manned aircraft – Routine
		Aerial patrol Manned aircraft – Comprehensive detail
		Aerial patrol Manned aircraft – Emergency

(New)

The above table shows that there are three elements associated with this control. If any of these elements do not function as expected due to deficiencies, the control performance is at risk. This could lead to inspection data management issues that could have a negative impact on the overall data management system and subsequent maintenance practices.

Risk assessment of these elements using resources with the right skillset and effective methodology would highlight the risk levels (consequences, probability) in these three elements.

The same process can be repeated in performing risk assessment on other elements of controls listed in Annex A, wherever applicable to the utility's data management system.

2. Drivers for developing a system for collecting and managing inspection and maintenance data

2.1 Introduction

Common drivers are described as follows for the purpose of catalyzing thought and discussion among those setting out to develop [or refine](#) a data collection and management system and to assist with prioritizing development activities. When undertaking the development of a system for collecting and managing transmission line inspection and maintenance data, it is important to consider all needs, pressures, and opportunities that are driving a specific development, not just the highest profile items, as the secondary drivers ~~will~~ often impact the design and become more important with time.

- *Regulations* regarding transmission line inspection and maintenance are on the rise and often include requirements for recordkeeping/reporting and audits. Proactive response is needed to establish tractable approaches to meeting [such](#) ~~the~~ requirements [and, by being proactive, potentially avert efforts to establish and promulgate what may end up being intractable and overly](#) ~~before~~ prescriptive standards ~~are established~~.
- *Timely access to information* is required to facilitate the restoration of safety and availability following transmission line degradation or failure.
- Implementation of *condition-based*, [or risk-based](#), or *reliability-centered* [or](#) *preventative maintenance programs* is only practical and cost-effective if information on physical system conditions can be accessed in a timely manner using automated processes.
- Ready access to relevant information is needed to help utilities develop *cost-effective responses* to pressures to optimize the life, availability, reliability, value, and throughput of existing infrastructure as well as optimizing the use of available resources including personnel, equipment, and maintenance budgets.

- Asset management business models are becoming increasingly prevalent within electric utilities. With these models *fewer personnel are responsible for more infrastructure than ever before*. As a result, ready access to meaningful information has become a prominent prerequisite for successful decision-making in this business environment.
- *Asset management is a data-intensive process requiring the use of IT to enable the productivity gains necessitated by the shrinking workforce. IT is required to facilitate the collection, storage, and analysis of data as well as the presentation and communication of analytical results to decision makers.*
- Services, outside of those identified as core competencies, are being increasingly outsourced and *utilities need to set the standard for data/information requirements to [help](#) ensure the integrity and usability of information in the future.*
- Executive level managers are increasingly requiring *demonstrable evidence of maintenance effectiveness* as a basis for justifying budgets.
- The power and durability of mobile computing tools has progressed to the point that many field *data collection/recording and information access functions can be performed [far](#) more efficiently with electronic media* than paper-based processes.
- *Historical performance and condition data represent powerful resources [to support training of AI and ML algorithms](#), for forecasting and optimizing facility maintenance and replacement decisions, and [for](#) enhancing the designs of new facilities if they are available in a format that can be efficiently analyzed.*
- An unprecedented number of experienced personnel are [retiring](#) ~~positioned to retire~~ from electric utilities [without adequate backfilling](#) ~~in the next decade~~. Their *knowledge needs to be captured and retained* before it is lost so that it ~~is~~ [will be](#) available to the next generation of utility operations personnel.

- Electronic access to information *facilitates improvements in management of maintenance programs* by enabling key questions to be more thoroughly investigated. For example: What problems are being found? Are existing programs effectively addressing the root causes of the problems so that the severity and number of problems can be mitigated? Are program changes having the desired impact? Are known problems being addressed in a timely manner? Are critical problems being addressed before minor problems?
- Detailed information collected over multiple years can be used to support analytics and queried for *trending and profiling problems* and their locations. This information can be used to *better allocate limited resources* where they are needed most.
- Information that is in a database can be better used by multiple groups and people throughout the organization. *Productivity improves and duplication of effort is reduced or eliminated* when information is readily available by many and usable with a variety of software tools.
- Optimized tools increase process efficiency as the attention of subject matter experts (SMEs) can be redirected from repetitive automatable tasks towards activities requiring their highly specialized knowledge.
- Responsive and user-friendly tools reduce the probability for human mistakes by reducing the time to drill up and down to the expected level of information, the time to switch tasks, boredom and frustration, therefore reducing the probability of errors for humans in the loop.

3. Starting to design a data management system

3.1 General

~~There is~~ A wide variety of information is required by any asset management organization. Unfortunately, ~~and~~ it is not uncommon in a historically siloed industry for a subset of the organization ~~people~~ to develop information systems in isolation from the rest of the organization, and end up with a suboptimal solutions ~~solution~~. A recurring ~~common~~ cause for this is the tendency to look from within only one group of the organization out to the assets and develop systems to assist only this organizational group. In contrast, a focus that looks from the asset into all ~~of~~ the needs of the organization provides the basis for ~~will provide~~ a more holistic approach to management and help ensure ~~provides~~ flexibility to adapt quickly to future change.

There are a variety of key considerations that should ~~need to~~ be accounted for when establishing a data collection and management system. This clause provides some general steps that can be followed when starting to develop or seeking to refine such a system. The process of developing the system is ~~will~~ likely to be iterative as the importance of drivers may have to be reevaluated depending on the ability to meet the established requirements due to lack of resources or other reasons.

3.2 Assemble a team

It is important to assemble ~~put together~~ a team of individuals that together represent ~~all of~~ the various business sectors of the company that would have a stake in the management of assets. Diversifying the fields of expertise of such a team increases the probability that the most relevant scenarios are addressed, and the value of the collected data is maximized. The positions of the team members could vary significantly and might include the following:

- Senior ~~Upper~~ management
- Accountants
- Real-estate tax specialists

- Engineers
- [Siting and land rights analysts](#)
- Environmentalists
- Asset management analysts
- Planners/schedulers
- GIS [specialists](#) ~~technicians~~
- IT personnel
- Linemen/patrolmen
- Operations personnel

[Asset managers and/or](#) maintenance planners may need to know when an asset went into service, identify triggers for maintenance, forecast expenditures to maintain the asset, and develop cradle-to-grave models to determine when upgrades or replacements are required. [Stakeholders](#) ~~People~~ involved in finance and taxation need to access information about where assets are located, generate detailed financial reports, and determine tax implications associated with the assets. Assets may be subject to regulatory review, and accurate accounting of when infrastructure is added or retired is ~~very~~ important. Shareholders require accurate information about the value and performance of assets for a variety of reasons. Engineering, procurement, and construction departments require access to asset information to assist in making decisions about design, location, stakeholder impact, environmental impacts, budget projections, and public response to new facilities and upgrades to existing infrastructure.

A system's success depends on buy-in from end users and therefore ~~it is imperative to seek~~ their input [should be sought](#) throughout the design, development, and implementation stages of the process, [and when seeking to refine existing systems](#). ~~The~~ Input from people who are performing the actual data collection in the field(, i.e., [line](#) ~~linemen~~ and [patrol workers](#)) ~~patrolmen~~, is vital to the success of any data collection program.

3.3 Determine the drivers

It is important to identify all ~~of~~ the drivers ~~that are~~ influencing the decision to establish or refine the ~~data collection management~~ system. The drivers are likely ~~will be~~ different for different utilities and may ~~they will likely~~ change over time within a utility as philosophies change due to personnel changes or other internal or external influences. Nonetheless, ~~but~~ it is these drivers that provide the building blocks for system development. The broader the spectrum of potential drivers identified early ~~on~~ in the development process, the more likely a system can be developed to meet current needs while having the flexibility to accommodate future needs without significant additional development ~~constraints to meeting all needs whether included in the initial design or addressed at some point in the future.~~

These drivers should include estimated cost-benefit information when possible and be prioritized if resources are limited to help ensure the higher priority drivers are addressed early ~~on~~ in the development of the data management system.

3.4 Determine the system requirements

Once the drivers are determined and prioritized, ~~specific~~ requirements should ~~can~~ be developed to help ensure that the drivers are adequately addressed. There can be general requirements and specific requirements. ~~There may be~~ Several specific requirements may ~~that~~ need to be met to fulfill ~~before~~ a general requirement and ~~can be met~~. many of the requirements may serve to help achieve more goals than one. For example, if one of the goals is to prove to a regulator that a transmission pole is being intrusively inspected at the ground line every 10 years and another goal is to establish an inspection scheduling program because the person who has been responsible for that task is retiring after 30 years, a specific data requirement necessary to meet both goals would be the ground line inspection date.

Requirements are not limited to data requirements. There are also process requirements, hardware requirements, etc., that should ~~must~~ be addressed. For example, if a goal is to achieve rapid storm restoration through enhanced automation of field data collection and transfer, then ~~perhaps~~ a process may need ~~needs~~ to be in place to enable uploading of information from first responders to material/warehouse personnel as close to real time as possible. This ~~not only~~ requires the process of the first responder capturing ~~to capture~~ the information and sending ~~send~~ it on in a specified manner as well as ~~, but~~ the field computer and communication hardware necessary to enable that process ~~to happen~~.

Just as effective maintenance of assets is intrinsically dependent on ~~connected to~~ the effectiveness of the overall organization, so too is ~~should~~ the effectiveness of the data management system dependent on the effectiveness of ~~be to~~ other information systems. ~~All systems need to be ultimately connected back to the asset to improve the quality of maintenance decisions.~~

3.5 Assess existing systems and information

Existing systems and data should be evaluated to determine if they help meet any of the requirements set forth in the previous steps even if they are suboptimal. It often requires ~~is critical~~ ~~for people to understand that many systems that exist within an organization were developed to meet specific needs and may not be optimal. It is~~ a major ~~paradigm~~ shift in perspective for stakeholders ~~people~~ to step back and take a high-level look at how and what information is required for the whole organization and ~~. It will be necessary for people~~ to understand that changes are needed ~~there will likely be change~~ to move to a fully integrated data management system. For systems and information that appear to be useful, it should ~~must~~ be decided how those systems and/or data ~~will~~ fit into an overall data management system that addresses all ~~of~~ the requirements and drivers. It may be that existing systems are adequate to satisfy all ~~of~~ the requirements with minor modification, or it could be that some of the existing systems meet some of the requirements ~~very~~ well but do not meet other requirements at all. If that is the case, it should ~~must~~ be decided whether to integrate the existing system with a new system, redevelop the functionality in a new system and possibly use the data from the existing system, or ~~to~~ modify the existing system to meet the additional identified requirements.

There are many possible scenarios; ~~but~~ the important thing is to recognize and document how existing systems may or may not help meet the requirements and use that information to determine the necessary plan and resources to develop a system that meets ~~will meet~~ all ~~of~~ the requirements.

3.6 Identify necessary resources

Every effort should be made to identify the hardware, software, personnel, and other resources ~~that will be~~ required to not only develop the initial system, but to utilize and support it. ~~An the system.~~ The underlying key to obtaining the necessary resources is funding; ~~and~~ therefore, it is important to have strong initial drivers, set realistic goals, and develop a solid plan for achieving those goals, to help justify the appropriate funding for the system.

Unfortunately, the desired amount of funding is sometimes not ~~always~~ available no matter how strong the argument; ~~and~~ therefore, it will likely be necessary to review the drivers and requirements in an effort to postpone less critical elements until funding is available. When doing this, it is important to keep the initial plan in mind to help ensure that the system is flexible enough to allow for future enhancements without significant investigation and redevelopment to accommodate those elements that have ~~already~~ been identified as important but cannot ~~that will not~~ be implemented initially due to budgetary constraints ~~inadequate funding~~.

4. Data requirements

4.1 General

The principal ~~main~~ drivers for collecting and managing transmission line inspection and maintenance data were identified in Clause 2 of this guide. Understanding the ~~These~~ drivers is helpful for identifying ~~also help to identify~~ the types of data that need to be collected and what existing databases may need to be utilized to meet the various goals for system use. ~~Having an~~ Understanding ~~of~~ the required output of any data storage and management system is fundamental in its development and to verifying the proper data is collected and stored in a consistent manner. It is also critical to understand who in the organization may be accessing the information, and what their needs are. ~~Any asset management system requires input from all potential stakeholders to ensure the proper data is collected and stored in a consistent manner.~~

~~Generally,~~ Data requirements for system development and use typically ~~will~~ fall into four ~~broad~~ categories: (1) *control center data*, (2) *transmission network data*, (3) *maintenance/process data*, and (4) *land-related data*, each of which is more fully described in the following subclauses. The categories, across which ~~These categorizations are only for convenience, since~~ there are many areas of overlap among ~~between the four in terms of~~ the data elements to be collected , are ~~. Also, we expect that the data elements identified in this clause is~~ sufficiently broad ~~enough to encompass~~ capture the general inspection information, condition information, and inventory information needed to operate and manage the assets of most electric transmission utilities. ~~These are further expanded on in the following subclauses.~~

4.2 Control center data

A control center continuously monitors the transmission system, collects, and stores important data on its state, and ~~also~~ allows for manual and automatic control of field equipment. Data requirements for control center operations are fairly standardized within the electric transmission sector, and fall within the realm of instrumentation engineering.

Data collection and maintenance in a control center is usually handled by a Supervisory Control and Data Acquisition (SCADA) system. The data collection component of ~~a~~ SCADA gathers and transmits important data on the state of the system using *remote terminal units* (RTU) and *programmable logic controllers* (PLC) attached to specific components of the transmission network. The ~~data so~~ collected data is analyzed in real time and ~~graphical representation~~ displayed graphically to control center operators who can use it to make decisions to adjust the state of the system when required. Typical data collected by RTUs and/or PLCs may include measurements such as pressure, current or voltage flow along a circuit, and equipment status data such as open and close status of a switch. Outage data, insulator burnouts, and other alarm triggering conditions are also collected by the SCADA system and form a major part of the database.

While SCADA systems can save time and money by reducing the need for personnel to visit sites for equipment inspection and data collection/logging, they can also be used to:

- Provide information to help determine possible causes of conditions, ~~i.e.g.~~, lightning strikes versus high operating temperatures, annealing of conductor, etc., by time tagging the events.
- Assess inspection and maintenance program effectiveness using outage and alarm statistics.
- Focus inspection and maintenance program activities on problem areas/lines.

4.3 Transmission network data

A transmission system comprises ~~forms~~ a distinct network feature on the landscape, and ~~it also~~ represents the physical assets of a transmission utility. It is important that the major components of the transmission network ~~should~~ form the basic data of any system developed for transmission line ~~data~~ inspection, management, and maintenance purposes. At a disaggregated level, the main components of a typical transmission network ~~will~~ include substations, transmission circuits, structures, and associated equipment.

Each of these components has specific attributes that should ~~have to~~ be collected and managed within the system. There are also many other items that could be supported by or included in the transmission network such as the following:

- Communication ~~facilities~~ ~~facilities~~ (e.g., structures, antenna, fiber-optic cable)
- Distribution underbuild
- Streetlights

The need to collect and/or the amount of information necessary to collect on these items should be addressed when developing a system.

4.3.1 Substations

~~Collectively, substations comprise a key component of~~ ~~Substations are central to~~ a transmission network, and data pertaining to this component is essential to successful ~~system~~ operation and maintenance. ~~of the network. However,~~ An entire document could be written on substation inspection and maintenance; ~~however,~~ ~~and~~ the discussion of substations in this document ~~is~~ ~~will be~~ limited to ~~them~~ ~~the fact that substations are~~ typically ~~being~~ the terminal points of transmission lines. One thing to consider when developing a data management system is ~~the need to identify~~ who ~~is~~ ~~will be~~ responsible for inspecting and maintaining data on the line components inside of the substation fences.

4.3.2 Circuits

Data is also required on key attributes of ~~the~~ transmission circuits for inspection, maintenance, and in some cases, reporting purposes. Unique circuit designation code, circuit owner, from substation, to substation, in-service date, ~~the~~ design voltage, ~~the~~ nominal voltage, thermal segments and their ratings (summer and winter MVA rating, etc.), whether the circuit is ~~part of a multi-~~ ~~double~~ ~~circuit~~ ~~line segment~~ [(e.g., two circuits running on the same set of towers or poles (~~also known as a double-circuit segment~~))], or single circuit are all important data components that need to be tracked and maintained. Additional attributes of a circuit that should be collected include the following:

- Circuit type (ac/dc, overhead, underground cable)
- Conductor type, size, and number in bundle (if bundled)

- Overhead shield wire size and type
- Limiting conductor size
- Load limiting condition/component

Changes pertaining to any [of](#) these attributes [need](#) ~~have~~ to be tracked and updated in the database accordingly.

Additionally, circuits support other equipment that needs to be considered such as the following:

- Splices
- Aerial marker balls
- Spacers
- Dampers

4.3.3 Transmission line support structures (towers/poles)

Transmission towers and poles provide the physical support for circuits. Critical attributes of these components that should form part of the database for data maintenance and management purposes include unique tower/pole identification, when the tower/pole was installed and/or replaced, tower/pole type, structure material, structure function (suspension, dead-end, angle, etc.), span distances between structures, type of insulator used on each structure, install dates of insulators and conductors, tower/pole height, arm type, phasing data, data on anchors, guying and grounding, and the presence or absence of flight warning markers.

4.3.4 Structure mounted equipment

Information about structure mounted equipment, i.e., switches, arresters, etc., can be collected separately, or as part of the attributes of structures. Typical attributes [of](#) ~~on~~ equipment that should form part of data collection efforts include the following:

- Equipment number
- Voltage
- Operating amps
- Normal status (i.e., open or closed)
- Current rating
- BIL rating
- Manufacturer
- Usage type
- Mounting type
- Install date
- Owner

4.4 Maintenance/process data

Although the network data types identified previously are also a key part of the overall data collected for system maintenance, for the purpose of this guide, ~~we will define~~ maintenance data is defined in a narrow context as being ~~those~~ directly related to the day-to-day maintenance and operation of the transmission network. In some cases, the collection and maintenance of these types of data were initiated in response to ~~are due to existing~~ regulations governing the operations of transmission lines. However, in most cases ~~however,~~ collecting and maintaining these types of data are ~~is~~ proactively recognized by most utilities as critical to verifying ~~ensuring~~ the reliability and safe operation of the transmission system.

Data in this category may also be process-related. In this sense, their collection and maintenance are ~~is~~ governed by established transmission line inspection and maintenance processes, which have evolved over time, and have been integrated tightly with ~~all~~-other corporate data collection standards ~~standard~~ and strategies ~~strategy~~.

Data that needs to be collected under this category include vegetation management, brushing and right-of-way maintenance data, line patrol and inspection data (i.e., data for ground, ~~and~~ aerial ~~patrol schedules~~, climbing, wood pole test and treat, and special inspections/patrols, etc.), land ownership data, compensation data, pole fire occurrence and distribution, insulator burnouts, and outage and fault data.

It is also important to know, track, validate, and justify the costs associated with maintaining transmission line assets. For that reason, applications have been developed that can identify ~~are capable of identifying~~ installation costs, depreciation, and estimated maintenance expenditures and provide ~~providing~~ a real-time picture of the value of assets, and the costs to maintain them. Data collected from inspections and patrols needs ~~need~~ to support and accurately reflect the health of the system.

In addition, data in this category may be collected as part of special studies aimed at determining bottlenecks within the transmission system. For instance, corrosion studies, insulator contamination, bird hazards ~~hazard~~, environmental impacts of transmission network, etc., are all useful data that should be collected and tracked within the system.

4.5 Land-base data

Land-base data ~~This~~ refers to topographic, landownership, and easement data, as well as data on human activities within which the electric transmission network is located. Data in this category is needed to show the characteristics of the landscape through which the transmission network passes. Examples include the following:

- Hydrology (rivers, streams, and lakes)
- Contour and digital elevation data

- Access data—roads
- Utility crossings (e.g., third-party OH and UG power and telecommunication facilities)
- Railway
- Cutlines
- Pipelines
- **Areas of cultural significance**
- Parcel data
- **Rights-of-way and easements**
- Habitat
- **Endangered species distribution**
- **Potential chemical-free areas** (schools, wildlife management areas, domestic water supplies, etc.)
- Settlement distribution
- Political boundaries
- Soil properties
- **Land ownership and contact information**
- **Special procedures before entering the easement** (e.g., contact owner, gate lock combination)

The bolded examples are some of the most critical items for inspection and maintenance related purposes.