ACRP Project 09-22

https://crp.trb.org/acrpwebresource20/

SAFE MAINTENANCE OF AIRFIELD ELECTRICAL SYSTEMS FOR SMALL AIRPORTS

FINAL REPORT

April 1, 2024

Subaward No: ACRP 09-22

Unit Number: 913

Sub-awardee Name: The Aviation Planning Group, LLC

Principal Investigator: Steve Harris

Affective Date: August 12, 2022

Expiration Date: April 15, 2024

NAS Program Manager: Joseph Navarrete

Table of Contents

Figures

Appendices

1. Introduction

1.1 Project Background

Nonqualified or improperly trained airport staff may not be able to recognize hazards or potential dangers in the airfield electrical systems which could lead to serious injury or loss of life. Airport sponsors of many of the country's smallest airports may not have qualified onsite management or staff familiar with the operational needs and risks specific to appropriately managing an airfield electrical system. The maintenance of airfield electrical systems may be left to general airport staff, municipal/county staff, or outside individuals, all of whom may lack proper training. The unintended consequences of improper routine maintenance or catastrophic failure are not only dangerous, but will disrupt safe airfield operations. It appears that there is no cost-effective training on basic airfield electrical system maintenance available for small-hub, non-hub, reliever, and general aviation (GA) airports.

Airport sponsors will benefit from assistance in understanding how to appropriately train, select, and assign individuals and/or resources to safely maintain the airfield electrical systems. They will also benefit by having the understanding to identify qualified local or regional resources.

1.2 Project Objective

The objective of this research is to provide guidance and best practices for safely maintaining airfield electrical systems that are accessible and practical for small-hub, non-hub, reliever, and general aviation (GA) airports. The research team developed a WebResource to provide access to guidance and tools; compile means and methods for recognizing hazards and mitigating risks; and provide curriculum outlines and job aids that airport sponsors can use to ensure that individuals are better equipped to perform assigned tasks.

The WebResource includes and/or addresses the following:

- A summary of industry standards and regulations, electrical safe work conditions, etc.;
- A list of standard practices that should be considered by airport sponsors;
- A list of existing and or recommended airfield electrical training resources;
- An Example Request for Qualifications for cost-effective sourcing of electrical work including how to identify and select qualified contractors.
- A matrix of tasks and the qualifications necessary to complete each task or duty.
- An overview of basic minimum standards that includes understanding electrical hazards, proper personal protective equipment (PPE) recurring skills training, etc.

2. Current State of Practice

The first step in the research was to determine the current state of practice, by outreach, literature/training/regulator review, and performing a GAP analysis. This is the primary topic of discussion of this report per our scope of work requirements.

2.1 Airport Outreach Plan

To comprehensively assess the current state of affairs from an airport perspective, the research team conducted interviews with airport sponsors and manufacturers. The initial step involved formulating a standardized list of 48 questions to gain insights into airport staff capabilities, awareness and utilization of training and literature, contractor accessibility, and prevailing practices.

Each team member employed the questionnaire as a tool to gather pertinent information for understanding the current landscape. Contacts within the team's existing network of airport relationships across various FAA regions were identified, encompassing both National Plan of Integrated Airport System (NPIAS) and Non-NPIAS airports. While the initial research plan included specific airports for interviews, responses from some were unavailable or declined participation. Consequently, the team reached out to alternative airports. The selected small airports for outreach included small-hub, reliever, and general aviation (GA) airports, both within and outside the NPIAS. Additionally, four (4) large-hub airports were contacted to gain insights into their approach to airfield electrical maintenance.

Beyond one-on-one interviews, the research team deployed an ACRP 09-22 Survey on SurveyMonkey.com, utilizing the developed questions. This survey was distributed to specific airports and aviation organizations, such as the Florida Airports Council, Oklahoma Airport Operators Association, Washington Airport Management Association, Wyoming Department of Transportation Division of Aeronautics, American Association of Airport Executives (AAAE) Hub, and Alaska Northern Region Department of Transportation & Public Facilities. The team successfully received responses from 52 airport operators through both interview and SurveyMonkey.com processes.

The results revealed common challenges in safely maintaining airfield electrical systems among the diverse airports that participated. For a condensed version of the survey questions, please refer to Appendix A.

Listed below are commonalities, found while evaluating the 52 survey responses:

- Most airports surveyed had 10 or fewer airfield circuits – small systems.
- Most airports surveyed perform their own electrical system maintenance.
- Most airports surveyed (80%) do not have licensed electricians on staff.
- Most (60+%) have electrical maintenance staff possessing 5 years or more experience.
- About 50% of airports provide electrical training.
- Most training is informal, often on-the-job training with experienced staff.
- The majority of surveyed airports are unaware of available training curriculums.
- 65% thought their training was insufficient.
- Funding, time available, and limited resources are common reasons for lack of training.

2.2 Literature Review

Available literature was reviewed on topics associated with airfield electrical training, safety, and maintenance. A search was conducted utilizing the open web and conducting airport interviews.

- Several documents are maintained by the Federal Aviation Administration (FAA) Advisory Circulars, series 150/5340 and 150/5345 along with Engineering Briefs describing airfield electrical systems, all found at www.faa.gov.

- Though ACRP related research and reports are provided, they are more focused on maintaining LED lighting.

- Industry Associations, such as the AAAE and third-party companies, provide training courses supplemented with training modules. However, these materials are not made available to the public and airport staff unless subscribing to the courses.

- During the interview process, it was discovered that some airports have in-house training and safety programs. But once again, they are not made available to the public and staff at other airports would be unaware they exist unless specifically presented. This may be attributed to each airport possessing distinctive electrical systems (although systems are similar, no two airports are alike) and possible legal liability concerns.

In summary, written materials specifically addressing airfield electrical training and safety are extremely limited and not readily made available for the airport industry.

Existing related literature

FAA AC 150/5340-5D "Segmented Circle Airport Marker System"

FAA AC 150/5340-26C "Maintenance of Airport Visual Aid Facilities"

FAA AC 150/5340-18G "Standards for Airport Sign Systems"

FAA AC 150/5340-30J "Design and Installation Details for Airport Visual Aids"

FAA AC 150/5345 Series (23)

FAA Engineering Briefs

AAAE ACE Airfield Lighting Maintenance Program

ADBsafegate.com. "Airfield Lighting Manual 8" Inset Lights." 2023. https://asset-prod1a-euw.productmarketingcloud.com/api/assetstorage/3813_cd74f072-b40b-4f34-bdd9-0e71e89e8451

ADBsafegate.com. "Airfield Lighting Manual 12" Inset Lights." 2023. https://asset-prod1a-euw.productmarketingcloud.com/api/assetstorage/3813_23e06292-c091-4c3c-9b29-5bbe42434dc2

ADBsafegate.com. "SafeLED IQ Elevated Lights." 2023. https://asset-prod1a-euw.productmarketingcloud.com/api/assetstorage/3813_5d139b1a-7914-4949-bc05-54172e78ec2f

ADBsafegate.com. "Airfield Lighting Bidirectional High-Intensity Elevated Light." 2023. https://asset-prod1a-euw.productmarketingcloud.com/api/assetstorage/3813_068ceddd-2918-41ad-997f-0f3c5b97d903

Burns, J., Dennie, C., Elshetwy, S., Lean, Doron., Vigilante, J. 2015. “ACRP Report 148 - LED Airfield Lighting System Operations and Maintenance.” https://nap.nationalacademies.org/read/22076/chapter/1

Bullough, J.D., “ACRP Synthesis 35 - Issues with Use of Airfield LED Light Fixtures.” 2012 https://nap.nationalacademies.org/read/22746/chapter/1

Civil Aviation Authority of Nepal. “Guidance Material on - CAANEPAL.GOV.NP.” Https://Caanepal.Gov.Np, 2019, https://caanepal.gov.np/storage/app/media/visual-aid-facilities-maintenance-manual-final.pdf.

Eckrose, R.A. & Green, W.H. “How To Assure the Future of Your Airport – Principles of Airport Management and Administration.” 2023 https://www.bonanza.com/listings/How-to-Assure-the-Future-of-Your-Airport-Principles-of-Airport-ppback-revised/738326361

Farmer, Eric. “Airfield Lighting Maintenance - Arkansasairports.Org.” Https://Arkansasairports.Org, 18 Sept. 2018, www.arkansasairports.org/wp-content/uploads/2018/10/EFarmer-2018-Airfield-Lighting-Maintenance.pdf.

Ford, Seward. “Are You Meeting Part 139 Requirements for Airfield Lighting?” Are You Meeting Part 139 Requirements for Airfield Lighting? | Airport Improvement Magazine, Oct. 2022, www.airportimprovement.com/article/are-you-meeting-part-139-requirements-airfield-lighting

Hali-Brite.com. “Maintaining an Efficient Airport Lighting System.” 2023, www.halibrite.com/airport-lighting/maintaining-an-efficient-airport-lighting-system/

Illumination Engineering Society, Center for Excellence for General Aviation, & The Federal Aviation Administration. “Community Service Airports Visual Aids Handbook.” 2010. http://www.iesalc.org/wp-content/uploads/2010/04/CSA_Visual_Aids_Handbook.pdf

Pittman, Steve. “Is Led Airfield Lighting Right for Your Airport?” International Airport Review, 26 Jan. 2017, www.internationalairportreview.com/article/2571/is-led-airfield-lighting-right-for-your-airport/

Scribed.com. “PAPI Precision Approach Path Indicator (PU3L).” 2023. https://www.scribd.com/document/446101154/Airfield-Lighting-Manual-PAPI-Precision-Approach-Path-Indicator-PU3L-1-pdf

TPUB.com. “Airfield Lighting.” 2023, Https://constructionmanuals.tpub.com/14027/css/Airfield-Lighting-158.htm

TPUB.com. “Airfield Lighting Vault.” 2023, Https://constructionmanuals.tpub.com/14027/css/Airfield-Lighitng-Vault-160.htm

U.S. Federal Aviation Administration. “Chapter 2. Aeronautical Lighting and Other Airport Visual Aids.” FAA.gov, 2023, www.faa.gov/air_traffic/flight_info/aeronav/acf/media/Presentations/17-02-RD282_AIM_entry.pdf

U.S. Federal Aviation Administration. “Airport Lighting Aids.” FAA.gov, 2023, https://www.faa.gov/air_traffic/publications/atpubs/aim_html/chap2_section_1.html

U.S. Federal Aviation Administration. “Airport Lighting.” FAA.gov, 2023, https://www.faa.gov/air_traffic/publications/atpubs/atc_html/chap3_section_4.html

VFX Tutorials. “Hands on Testing & Credits Quicktime H 264.” YouTube, YouTube, 31 July 2017, www.youtube.com/watch?v=YVti8bzlkEc

2.3 Training Review

Through research, the team found that most airports are unaware of available training for airfield electrical maintenance. This was particularly true for the small airports without full-time staff. In most instances training was provided in-house by someone with experience with the electrical system.

Various training programs are accessible through resources such as AAAE, manuals, airfield electrical designers, original equipment manufacturer (OEMs), and former airfield/FAA employees, all offering specialized training courses. In an effort to assess the efficacy of available training options for airports, our team acquired a trial subscription to evaluate the AAAE Digicast airfield electrical safety program. Although this program offers a fundamental introduction suitable for untrained personnel, it may fall short of providing the more comprehensive understanding required for airport personnel to operate safely in the airfield electrical environment as "qualified workers." Further analysis and refinement of training programs may be necessary to meet the specific needs and qualifications essential for individuals working in this specialized field.

AAAE does offer the Airport Certified Employee (ACE) program with a concentration in Airfield Lighting and Maintenance. While this program may be cost prohibitive for small airports, it is a week-long course which goes in depth on a multitude of airfield lighting topics. As the course has some detail it does not offer a complete enough training for completely inexperienced and untrained maintenance staff. It is also relatively costly and may not be suitable for small airports with generalist airfield maintenance staff.

Most of the 52 airports responding to the survey had small airfield systems of 10 circuits or fewer, and most of these airport lighting systems are maintained by airport staff that are not licensed electricians. About 50% of surveyed airports offer training to their maintenance workers, and much of the training that is offered is in the form of on-the-job training by coworkers rather than formal training by experts. Reasons for the lack of training were most commonly due to lack of funding, limited resources, and lack of time available for training. Of those surveyed, 65% of respondents said they thought their training was insufficient, and a majority were not aware of available training options.

OEM’s provide training for their equipment and the research team was provided some curriculum from ADB Safegate and Crouse-Hinds Eaton.

ADB Safegate offers a traveling Field Maintenance Seminar. The seminar is typically two days of classroom and hands-on-training. The training covers the following topics:

- L824 Series Circuit theory of operation and components.
- L824 Series circuit maintenance and troubleshooting procedures.
- L828 / L829 Constant Current Regulators (CCR) theory of operation.
- L828 / L829 CCR maintenance and troubleshooting procedures.

- L880 / L881 PAPI systems theory of operation.
- L880 / L881 PAPI systems maintenance and troubleshooting procedures.
- L858 Signage maintenance and troubleshooting procedures.
- L823 / L830 installation methods / cable splicing procedures.
- L854 Radio Controller.
- L862 / L861 Elevated fixture maintenance procedures.
- L850 / L852 Inset fixture maintenance procedures.
- Airfield Lighting System safety procedures. / AC 5340-26 Current Revision

Crouse-Hinds Eaton airport lighting has developed a virtual training series of PowerPoint presentations for airfield lighting maintenance employees. The initial "introduction" presentations are designed for those new to airfield lighting or those without exposure to specific airfield lighting equipment. Available presentations include:

- Airfield Lighting General
  - 101 - Introduction to Airfield Lighting.
  - 102 - FAA L-800 Airfield Lighting Equipment.
  - 102 - Introduction to Airfield Lighting "The 4C's" – Color, Candela Coverage and Configuration.
- Airfield Lighting Safety
  - 101 - Hazards Particular to Airfield Lighting.
- Constant Current Regulators
  - 101 – Introduction to Constant Current Regulators.
  - 102 - Introduction to Constant Current Regulators.
  - 103 - Troubleshooting Specific C-H Eaton Model CCRs.
- PAPI Systems
  - 101 - Introduction to L-880/L-881 PAPI Systems.
  - 102 - L-880/L-881 PAPI Style "A" (Voltage Driven) Systems.
  - 102 - L-880/L-881 PAPI Style "B" (Current Driven) Systems.
- Airfield Series Circuit
  - 101 - Basic Airfield Series Circuit.
  - 102 - The Airfield Series Circuit Troubleshooting.
- Guidance Signs
  - 101 - LED Illuminated Airside Guidance Signs AGSF Model.
  - 101 - LED Illuminated Airside Guidance Signs AGS Model.
- Circuit Selector Switch
  - 101 - L-847 Circuit Selector Switches.
- Elevated RW Fixtures
  - 101 - Elevated RW Fixture Maintenance.
- Inset Fixtures
  - 101 - Inset Fixture Maintenance.
  - 102 - Inset Fixture Maintenance.
  - 102 - L-852G Inset fixture Operation and in Field Programming.
- Isolation Transformers
  - 101 - Isolation Transformer.

    - 101 - L-823 “Super” Connector Kits and Cable Assemblies.
    - 101 - L-823 “Classic” Connector Kits and Cable Assemblies.
- Airport Light Bases
    - 101 - Airport Light Bases.
- Customer Specified Training
    - 101 - Customer Specified C-H Eaton Airfield Lighting Product.
- Airfield Lighting computer Control and Monitoring Systems
    - 101 – Introduction to ALCMS.
    - 102 – Site Specific Advanced ALCMS.
    - 103 – Advanced ALCMS.
- LogicTrac Devices
    - 101 – LogicTrac Device Programming.

Those surveyed were not necessarily aware of training opportunities, and respondents also identified the lack of funds available to send staff for training. These courses can be costly and typically involve the additional expense of travel. For small remote GA airports with budget constraints, it may be even more cost prohibitive to send staff for training. Not only do these airports struggle to budget for offsite training but they may also have limited staff time available to complete day-to-day duties on the airport. Having only one or two employees at an airport creates a challenge when one is absent attending a training seminar for several days.

Many airports interviewed expressed concerns that personnel are operating with little or no electrical field training. A Journeyman Electrician license isn’t required; however, you do need to be qualified to complete tasks such as:

- Change lamps
- Crimp on a connector
- Unplug and re-install a new transformer
- Install a URC board in a regulator

2.4 Regulatory Review

Related to the investigation of current literature that could help provide assistance and training to airfield electrical personnel, the team examined current FAA documents and Advisory Circulars for useful information.

FAA Advisory Circular (AC) 150/5340-26C, Maintenance of “Airport Visual Aid Facilities” provides guidance for the recommended minimum maintenance practices that should be followed for airport visual aid equipment. The AC seeks to provide suggestions about how to establish and maintain an effective preventative maintenance program, but due to the varying complexities of airports and visual aids, it takes a more general approach to these topics. It does in fact provide helpful maintenance suggestions and information for the following topics:

- Airport lighting vault and series lighting circuits
- Constant current regulators
- Runway and taxiway elevated edge lighting systems

- Runway and taxiway in-pavement lighting systems
- Runway guard lights and stop bar lights
- Illuminated runway and taxiway signs
- Rotating beacons
- Lighted wind cone assemblies
- Precision Approach Path Indicator (PAPI) system
- Visual Approach Slope Indicator (VASI)
- Runway End Identifier Lights (REIL) and Omni directional Approach Light System (ODALS)
- Medium Intensity Approach Light System (MALS, MALSF, MALSR)
- Airfield Lighting Control and Monitoring system (ALCMS)
- Runway Status Lights (RWSL)
- Obstruction lights
- Control systems
- Standby power engine generator systems

In addition to this list, AC 150/5340-26C also recommends troubleshooting procedures and safety practices for work related to 5kV airfield lighting circuits. Of particular interest as it relates to project objectives are the sections of the AC dealing with Safety and Preventative Maintenance sections, Chapters 2 and 5 respectively.

The safety section of the AC provides common-sense checklists and basic rules that should be adhered to when working with high voltage (5kV), series circuit airfield lighting equipment. In addition to basic safety knowledge, this chapter attempts to identify the additional knowledge and experience a "Qualified Person" should possess prior to maintaining high voltage systems. Another point made in this chapter, is working in a "hurried manor" as the number one cause of electrical accidents at the airfield. Slowing down the workflow and taking steps to ensure that airfield electrical personnel follow proper safety guidelines is key to a successful maintenance strategy.

The Preventative Maintenance chapter of this AC seeks to provide airports with guidelines on how to set up a preventative maintenance program and establishing routines. This chapter separates preventative monitoring and maintenance practices outlining what equipment should be inspected daily, weekly, monthly, semiannually, and annually. The chapter goes into detail on various different electrical systems and what kind of maintenance or inspections should be conducted and how to perform them safely.

In addition to AC 150/5340-26C, which provides significant information to airports, there are other documents that outline safety practices and procedures that can be very useful resources.

Applicable documents are listed below:

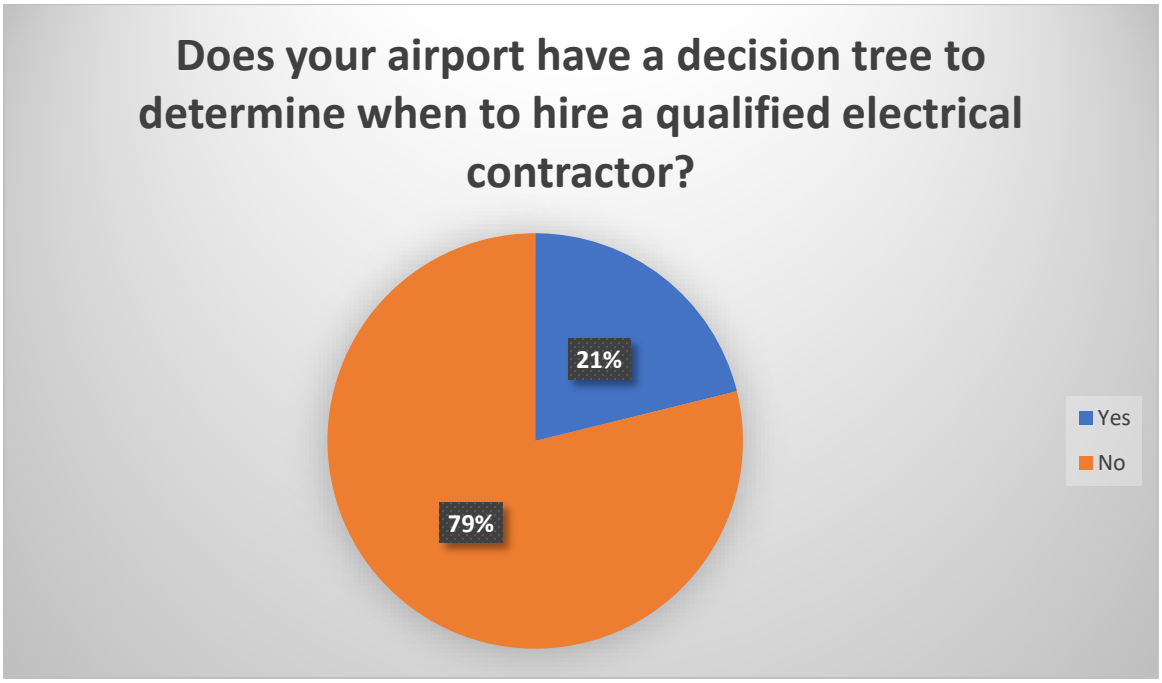
- NFPA 10, Standard for Portable Fire Extinguishers
- NFPA 70E, Standard for Electrical Safety in the Workplace
- OSHA General Industry Safety-Related Work Practices – 29 CFR 1910
- American Society for Testing and Materials (ASTM) D120, Specification for Insulated Rubber Gloves
- FAA AC 150/5210-5, Painting, Marking, and Lighting of Vehicles Used on an Airport
- FAA AC 150/5210-20, Ground Vehicle Operations on Airports

- FAA AC 150/5340-30, Design and Installation Details for Airport Visual Aids
- FAA AC 150/5345-46, Specification for Runway and Taxiway Light Fixtures
- FAA Engineering Brief (EB) 83 - In-pavement Light Fixture Bolts
- FAA JO 7930.2, Notices to Air Missions (NOTAM)

2.5 Lack of Experienced Contractors

A key finding from this project underscores a prevalent challenge: the majority of airports encounter difficulty in discerning the appropriate circumstances to engage external assistance for electrical issues. As depicted in Figure 1 below, 80% of the 52 responding airports revealed the absence of a structured decision tree for gauging when to enlist the services of a qualified electrical contractor. This deficiency in decision-support tools accentuates the need for comprehensive guidelines or frameworks to aid airports in making informed decisions regarding the involvement of external expertise in addressing electrical issues.

Figure 1. Results from Question 38 from Airport Outreach



Almost all airports interviewed stated that they did not, in fact, have a written procedure to make this determination even if they did answer yes to the question above. For airports that answered yes, the research team typically saw that this decision tree was not documented. The decision to seek a qualified electrical contractor was not determined by a formal process but more by the level of comfort the maintenance staff had with the particular issue occurring at the airfield.

Another observation was that when airports do make the decision to obtain outside help by hiring an electrical contractor, it can be quite difficult to find a contractor that is actually qualified to perform the work. See Figures 2, 3, and 4 for details regarding the responses from the 52 participating airports.

Figure 2. Results from Question 42 from Airport Outreach

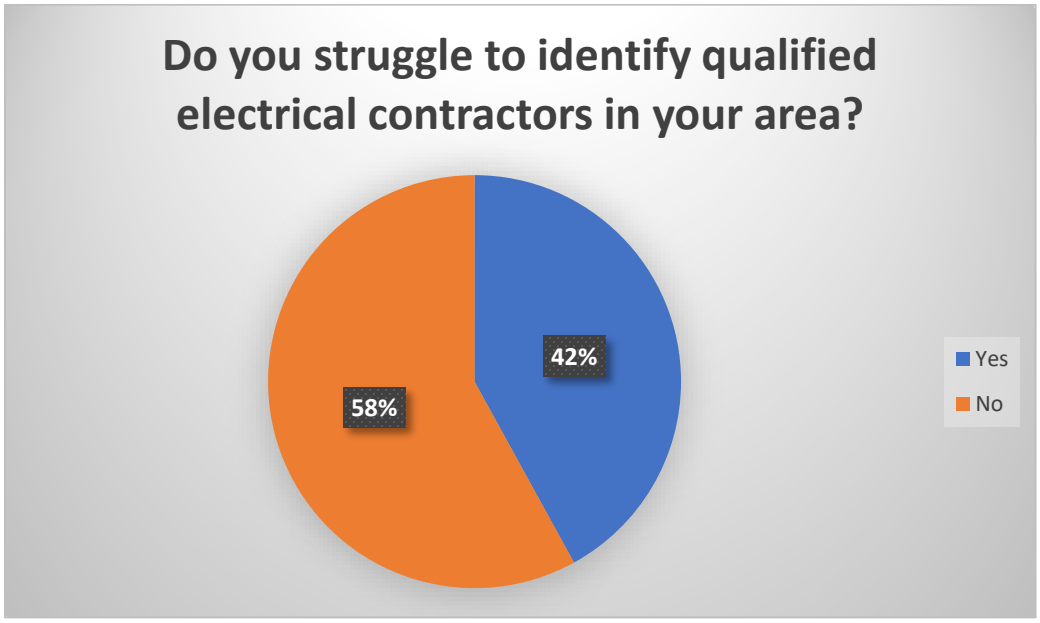


Figure 3. Results from Question 41 from Airport Outreach

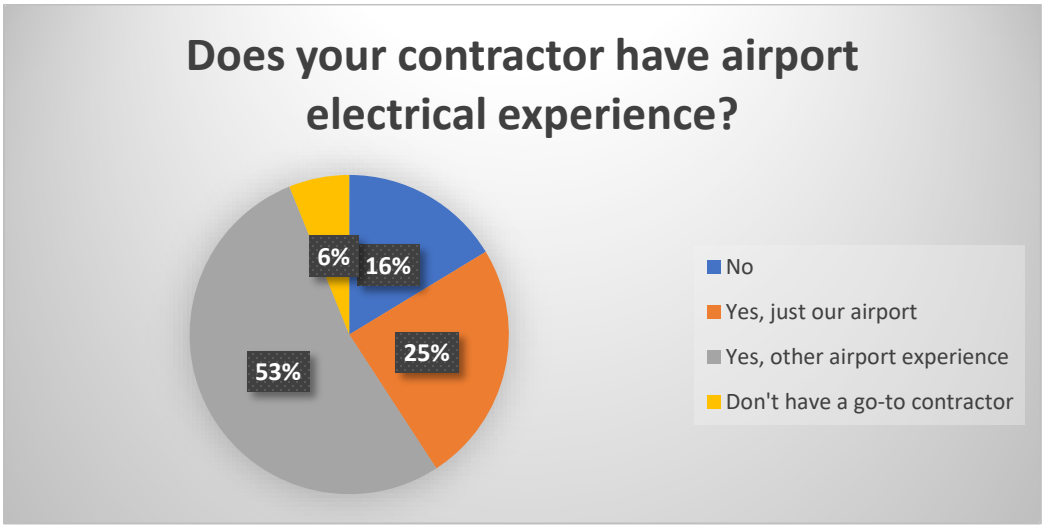
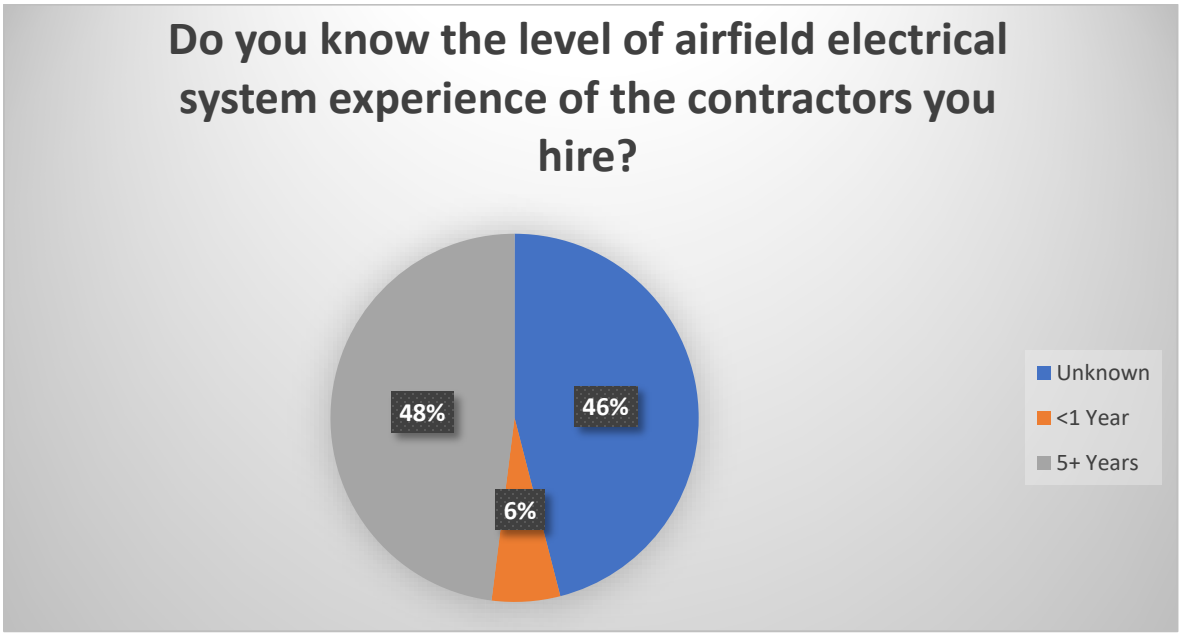


Figure 4. Question 43 from Airport Outreach



Based on the review of the data, finding qualified contractors can be difficult for airports. Exacerbating the problem is the challenge to distinguish what makes a contractor "qualified" to work at their airport.

3. GAP Analysis

As pointed out above, the research indicates that improvements in areas such as awareness of training materials and training programs, resource material, and funding are needed and desired by airport staff. In our gap analysis, the team focused on those areas to compile resources and potential tools that could be used by airports to improve the current state or practice.

Airport managers desire resources that are low cost, easily accessible, and not overly time consuming to provide staff. If provided lengthy or cost prohibitive guidance or tools they will become too cumbersome and most likely overlooked because of the time requirements.

Awareness of available existing resources is a first step to improvement. There is a need to improve awareness and access to available literature, regulatory requirements, and avenues for training personnel. This could be through online, neighboring airports, manufacturers, or assistance with developing a process for internal training. Our intent through our research and final report is to develop tools to assist airport staff to identify viable resources, outline a process to 'qualify' different levels of airport maintenance staff for electrical systems, and outline a process to identify 'qualified' electrical contractors who are knowledgeable of airfield electrical system.

We have identified two areas of maintenance that require different qualification levels. To perform specific duties the levels of supervision, knowledge and training are different for each.

Basic lighting maintenance (re-lamping, and above ground repairs of secondary voltage equipment):

All airport staff that work with airfield lighting must have a basic understanding of how airfield lighting systems work, and the dangers involved with working with them.

Tier 1 – Routine Tasks

Tier 2 – Intermediate Tasks

Advanced lighting maintenance (Troubleshooting, and repairs of primary voltage equipment):

All advanced airport staff must have a firm knowledge of series constant current theory, the dangers involved with working with them, the equipment they maintain, be able to identify all potentially energized parts, and capable of de-energization.

Tier 3 – Complex Tasks

Tier 4 - Complex Troubleshooting

Tier 1 and Tier 2 are those we have identified as the targeted benefactor of this research. These are the jobs that are being done now by airport employees that have minimal or no experience working on airfield electrical systems. We plan to outline the minimum training needed for them to be 'qualified' to do basic level work. With some basic theory, safety, and "how to" training anyone in Tier 2 can safely do a majority of the lighting tasks. The Tier 1 employees just need to know how to shut it down and lock it out with some basic safety and theory. It is also important that staff on all Tiers understand the limits of their qualifications and what work they are not allowed to perform.

4. Decision Matrix

Airport managers need guidance/tools on how to safely maintain their airfield electrical system, assistance identifying the necessary training and capability to properly and safely perform the needed maintenance or repair of an airport electrical system. Airport managers also need to know when it may be appropriate to bring in outside expertise. The developed Decision Matrix incorporates tiers of competency for employees based on the training they have successfully completed (Tier 1, 2, 3 or 4). Each tier identifies task qualification, expected understanding, training, and testing documentation/record keeping. Appendix B illustrates the Decision Matrix developed to assist airport managers in determining the needed training and capabilities of their staff.

5. WebResource

As stated previously, the research revealed that airport managers prioritize resources that are cost-effective, easily accessible, and require minimal time to deliver to their staff. In response to this insight, the Research Team made a strategic shift from a traditional guidebook to a WebResource to better meet the needs of both managers and staff. The Research Team created a dedicated WebResource, offering users a convenient platform to access available comprehensive guidance, best practices, and tools that enhance their understanding of operational needs, processes, and capabilities.

The WebResource is broken down into five main sections: Management, Training and Contracting, Safety, Maintenance, and Resources. This resource is designed to provide airports guidance and best practices for safely maintaining airfield electrical systems that are accessible and practical. The resource compiles guidance and best practices documentation into a single location to assist airport managers and staff incorporate safety processes, training and guidance into their airports standard operating procedures. The intended audience for the resource is small-hub, non-hub, reliever and GA airports with a specific focus on small airports that may not have the resources available of a larger airport.

The guidance provides tools to assist managers to better understand their airfields electrical system, the hazards associated to the system and to develop procedures and guidance to safely maintain the system. It defines levels of skill sets for electrical staff and minimum training associated with each level of skills. This done through a Decision Matrix developed to assist managers in identifying their airfield staff's skills.

For airfield electrical staff, multiple level training options and curriculum are provided along with explanations of basic requirements such as safety procedures, hazards and risk, and safe work conditions. Airfield electrical systems common problems, troubleshooting and preventative maintenance procedures are also included.

You can explore the WebResource page through the following link: https://crp.trb.org/acrpwebresource20/. For a detailed overview of the WebResource content, please refer to Appendix C, which includes a site map.

6. Summary

The research compiled was utilized to complete the final deliverables which includes a WebResource which covers materials such as:

- ✓ List of available resources, downloadable documents, and linked training videos that were discovered through the research (literature, training, regulatory) broken down by subject area.
- ✓ Maintenance checklists based on best practices.
- ✓ A Decision Matrix which recommends training for each tier of employee.
- ✓ An example RFP to assist in identifying qualified electrical contractors.

The research also produced deliverables such as the Summary of Key Findings is provided to give a basic outline and understanding of findings; a Further Recommended Research Memo was developed; and a technical memo titled, “Implementation of Research Findings and Products” will be submitted.

APPENDIX A
Airport Interview Questions

AIRPORT INTERVIEW QUESTIONS

Do you have processes or airfield electrical training documents you are willing to share with the research team? If so please email them.

Name:

Email:

Airport:

GENERAL

1. How many people do you have on staff who perform electrical maintenance at the airport? (Changing lights, troubleshooting, etc.)?
   - 1
   - 2
   - 3
   - 4+ _____
2. How many airfield lighting circuits do you have at the airport? (CCR Series Circuits)?
   - 1-2
   - 3-10
   - 11-30
   - 31+ _____

3. Do you or other airport staff maintain airfield electrical systems at your airport?
   - Yes
   - No

4. Do you have licensed electricians on your staff?
   - Yes
   - No

   If so, how many.

   - 1
   - 2
   - 3
   - 4+

   If not, how are you currently maintaining the lighting?

TRAINING

5. Are you a licensed electrician?
   - Yes
   - No

6. How many years of experience do you have or whoever is most experienced on your staff maintaining airfield electrical systems?
   - N/A
   - <1 years
   - 1-3 years
   - 3-5 years
   - 5+ years

7. How many years of experience do you have or whoever is most experienced in maintaining non airfield electrical systems?
   - N/A
   - <1
   - 1-3 years
   - 3-5 years
   - 5+ years

8. Does your organization provide airfield electrical training?
   - Yes
   - No
   -

9. How do you train new hires on airfield electrical maintenance?
   - Formal airport training program
   - Formal airport training manual
   - Industry training program or classes
     - Off-site training
     - Online training
     - Other

10. What training curriculums are you familiar with? (Not at all, somewhat, very, completed training)
    - AAAE video training through its Digicast program. Example: “Airfield Electrical Safety,”
    - AAAE Airport Certified Employee (ACE) Airfield Lighting Maintenance certification course.

- Training programs through individual companies:
    - Airfield Training Company (ATC)
    - AVCON
    - Airside Solutions
    - Manufacturer Training

11. List any other electrical training you are familiar with.

12. Have you participated in any off-site formal training?

13. How much time [in hours] is dedicated to new hire airfield electrical training? _____

14. How much time annually [in hours] is dedicated to ongoing staff training on airfield electrical? _____

15. Do you feel this training is sufficient?
    - Yes
    - No

16. What are the shortfalls on training and why? Are they due to funding, time or limited resources?

17. How much money annually is spent training staff on airfield electrical? _____
    - $0
    - $1 to $1,000 annually
    - $1,000 to $5,000 annually
    - $5,000 to $10,000 annually
    - $10,000+ annually

AIRFIELD ELECTRICAL SYSTEM MAINTENANCE

18. What are the top three electrical maintenance issues you observe at your airport:
    - #1_____

- #2_____
- #3_____

19. What are the challenges in maintaining your airport's airfield electrical systems?

20. Do you know of any electrical safety incidents that have occurred at your airport while maintaining the electrical system?
    - Yes
    - No

    If yes, what occurred and were policies put in place to avoid similar incidents in the future?

21. Do you have a "Safety Suggestion Form" or some way to document potential safety issues?
    - Yes
    - No

22. Do you have a "Near Miss Form" or some way to document near misses?
    - Yes
    - No

23. Do you have a process for troubleshooting?
    - Yes
    - No

24. How do you maintain safety while maintaining airfield electrical systems?

25. Do you have the proper and necessary tools to perform maintenance on your airport's system?
    - Yes
    - No

    If no, why not?

        - Budget
        - Lack of leadership understanding
        - Other _____

26. Do you have established procedures for replacing your lights, signs, windcones, PAPI's, other?

27. Do you have a preventative maintenance plan?
    - Yes
    - No

28. Is this plan followed?
    - Yes
    - No

    If no, why not?

        - Budget constraints
        - Time constraints
        - Other: _____

29. Do you do any periodic testing of the following electrical systems?
    - Megger readings Yes No
    - Lamp outages Yes No
    - Sign fading or deterioration Yes No

30. How often do you take Megger readings?
    - Never
    - When circuits fail
    - Weekly
    - Monthly
    - Annually

31. Do you have a means to record or chart meggar readings?
    - Yes
    - No

32. Do you ever tighten the terminations at the regulator?
    - Yes
    - No

33. Do you calibrate your regulators on a PM schedule?
    - Yes
    - No
    - Frequency _____

34. Do you use consistent splicing methods?
    - Yes
    - No

    Please describe: _____

35. Do you have a method established for identifying equipment, noting age of equipment?
    - Yes
    - No

    Please describe: _____

36. Do you test the radio system?
    - Yes
    - No

37. Do you feel your airport's leadership understands the hazards and issues associated with maintenance of these systems?
    - Yes
    - No

    If no, where do you think the disconnect is with leadership understanding?

ELECTRICAL CONTRACTORS

38. Do you have a decision tree to determine when to hire qualified electrical contractor?
    - Yes
    - No

    If yes, are you willing to share this document with the research team?

39. Do you have other processes to determine when to hire an electrical contractor?

40. What process do you use to hire an electrician?

41. Does your electrical contractor have airport electrical experience?
    - Yes, just our airport

- Yes, other airport experience
- No

42. Do you struggle to identify qualified electrical contractors in your area?
    - Yes
    - No

43. Do you know the level of airfield electrical system experience of the contractors you hire?
    - <1 year
    - 1-3 years
    - 3-5 years
    - 5+ years
    - Unknown

APPENDIX B
Decision Matrix

ACRP 09-22: Guidance for Small Airports on Safe Maintenance of Airfield Electrical Systems

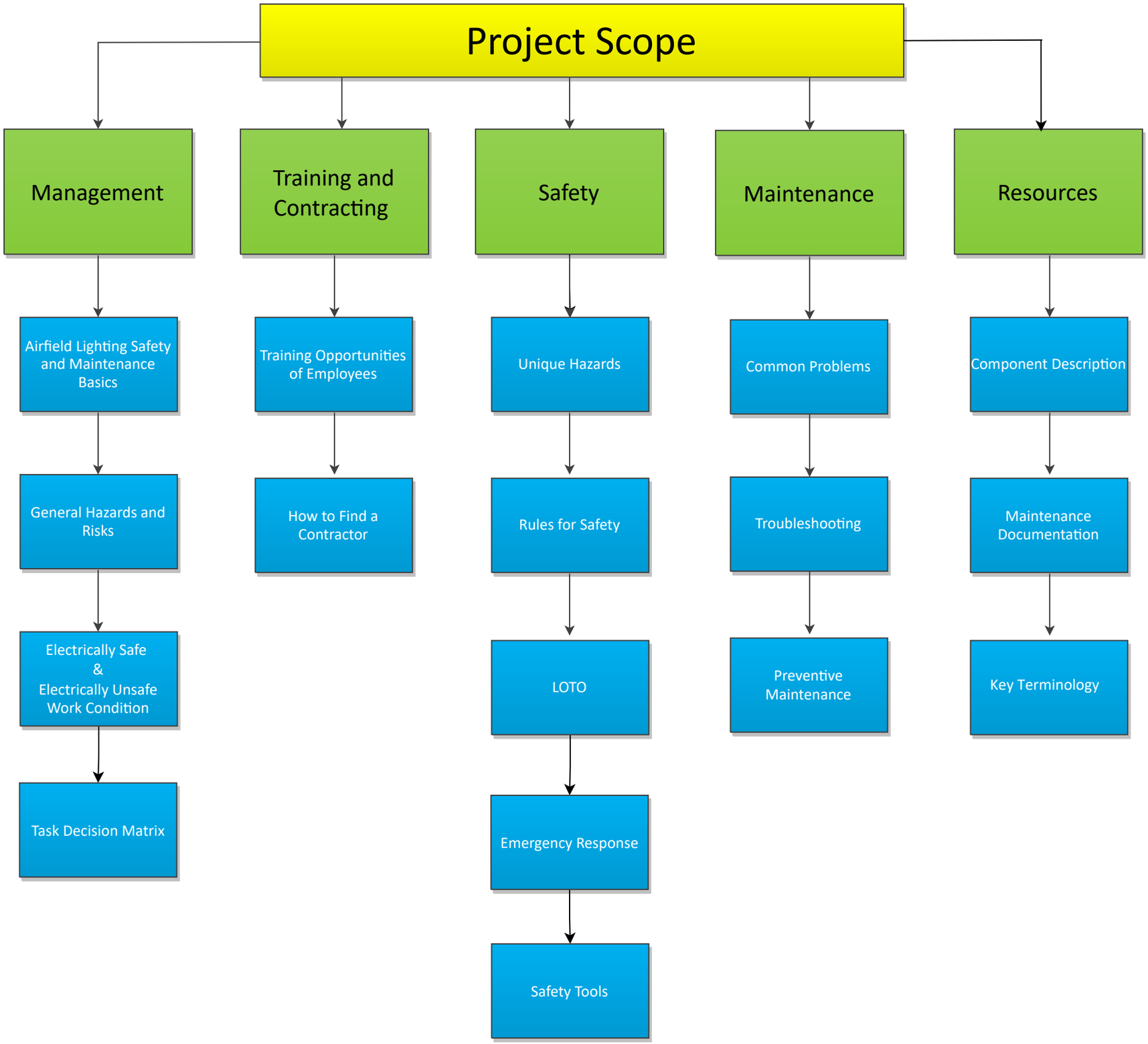
** Requires additional training for qualification (see Tier 2 Training Possibilities)

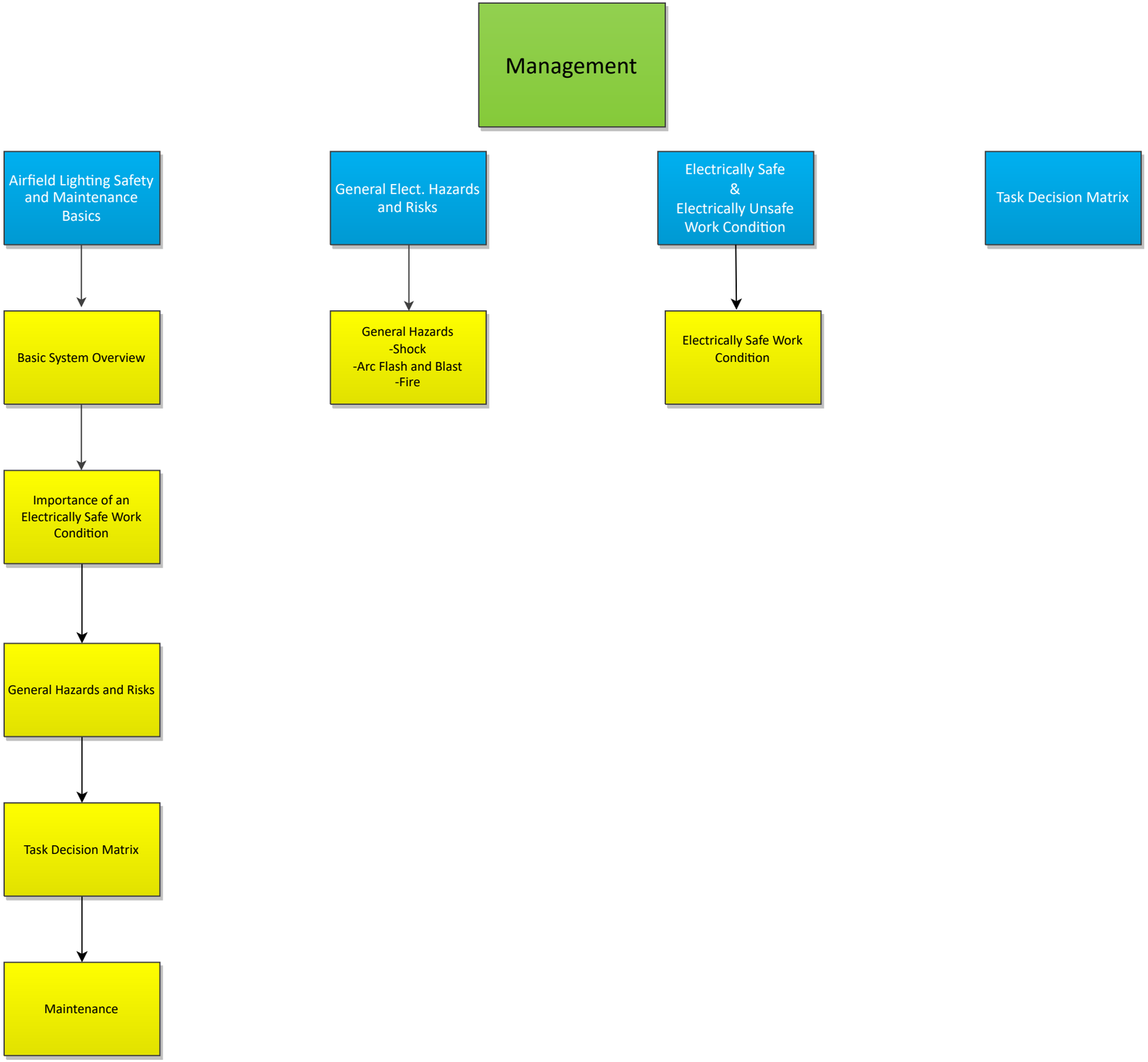
Task Progression

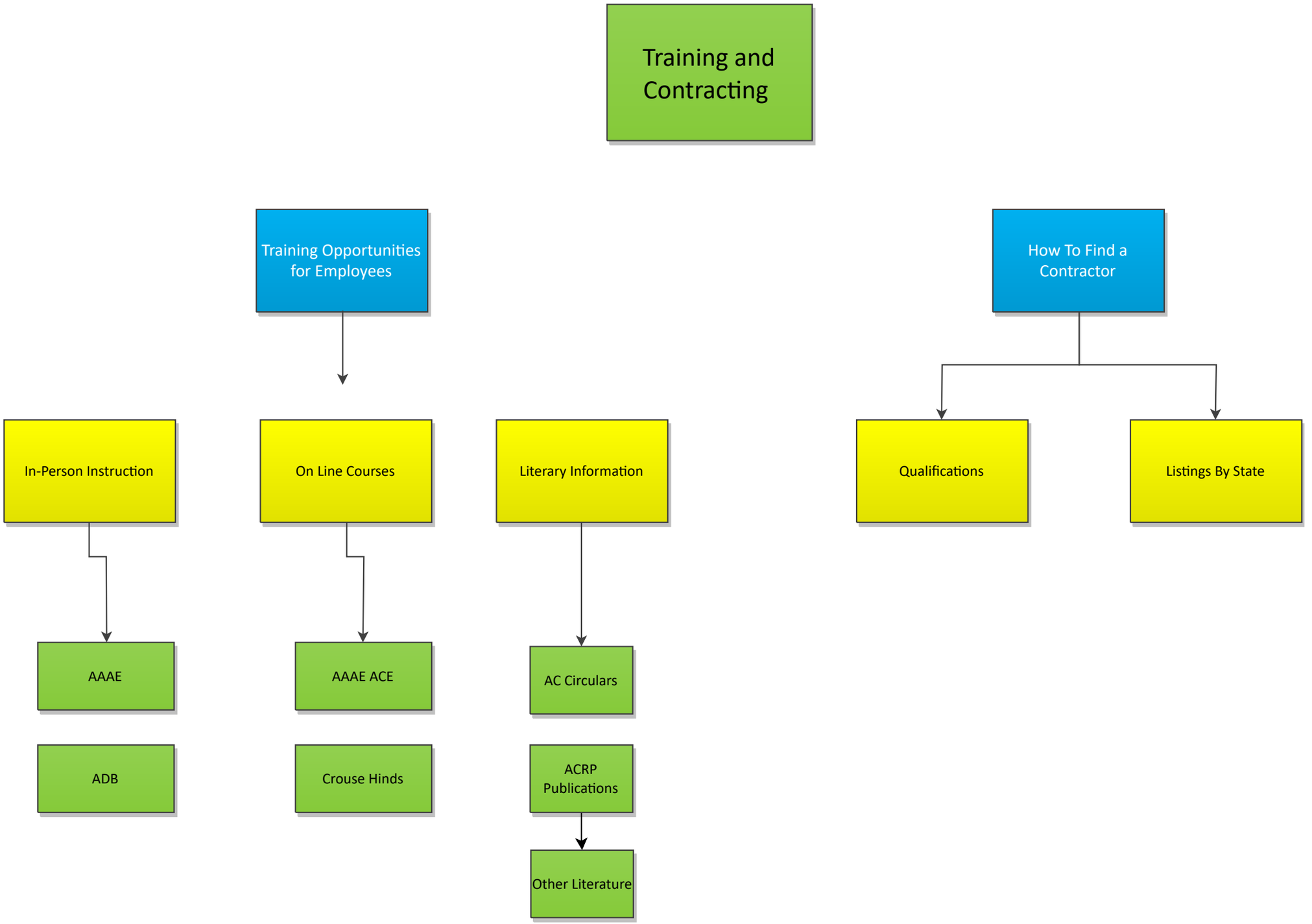
	Tasks	Suggested Training	Training Possibilities	Training Documentation
TIER 4	Complex Regulator Calibration / Troubleshooting** Regulator Major Repairs** New Installation ALCMS computer controls and programming Proprietary equipment installation and repairs	Tier 4 level is someone who is specifically trained to work on lighting equipment and controls by the lighting manufacturer or a contractor under the guidance of the manufacturer. Note: These technicians often are not Journeyman Electricians and may be restricted in their ability to work outside of the manufacturer's equipment such as feed wiring. Example: Installing a new regulator may require a factory technician for control set up and a Journeyman Electrician to make power connections, etc.		
TIER 3	Regulator Calibration / Troubleshooting** Regulator Major Repairs** 120v-600v NEC Regulated Work New Construction and Installation Primary Feed wiring from the Regulator Core to the Power Company Transformer	Journeyman Electrician or Equivalent Note: A licensed Electrician is not necessarily a "Qualified Worker" for airfield lighting** Basic Series Circuit Theory Complete Safety Understanding De-energization/Verification Competency LOTO Distinguish exposed live parts from other parts	All possibilities of Tier 2 (below) AND Federal Journeyman Electrician Apprenticeship Program	Must have a list of airfield lighting tasks which trainee has been verified as "Qualified" by an outside instructor or experienced airport staff member. Must have demonstrated the skills and knowledge of each task and any hazards involved. Journeyman Electrician License
TIER 2	S1 Cut-Out Use Circuit Meggering (Insulation Resistance Testing) Circuit Ohming (Circuit Resistance Testing) Identifying a Fault Identifying a Failed Transformer Identifying an Open Proper Splicing Technique** Regulator Calibration / Troubleshooting** Regulator Minor Repairs**	Basic Series Circuit Theory Complete Safety Understanding Understanding of Tools and Meters De-energization / Verification Competency LOTO Understanding of Component Installation Process Distinguish exposed live parts from other parts	All possibilities of Tier 1 (below) AND Airfield lighting manufacturer training seminars** Accredited airfield lighting course** L-823 Splicing Certification Course**	Must have a list of tasks which trainee has been verified as "Qualified" by an outside instructor or experienced airport staff member. Must have demonstrated the skills and knowledge of each task and any hazards involved.
TIER 1	Regulator Operation Alarm Recognition Re-lamping and Elevated Fixture Replacement Frangible Replacement Bolt Torquing	Basic Safety Understanding Basic Series Circuit Theory De-energization of Circuit Verification of De-energization LOTO	AK DOT Airfield Lighting Safety Video AC Circular AC150-5340-26C Hands-On De-energization / Verification training with experienced staff / instructor LOTO instruction with airport staff	Must have a list of tasks which trainee has been verified as "Qualified" by an outside instructor or experienced airport staff member

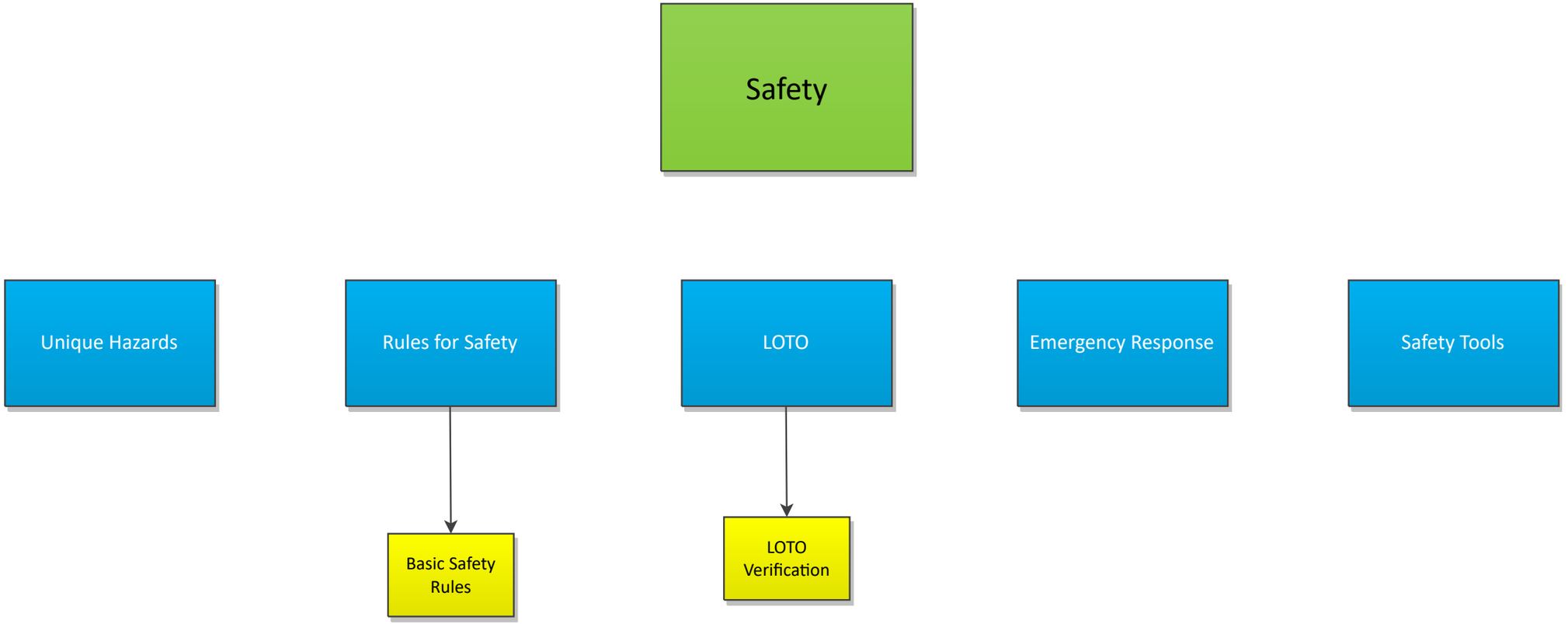
APPENDIX C

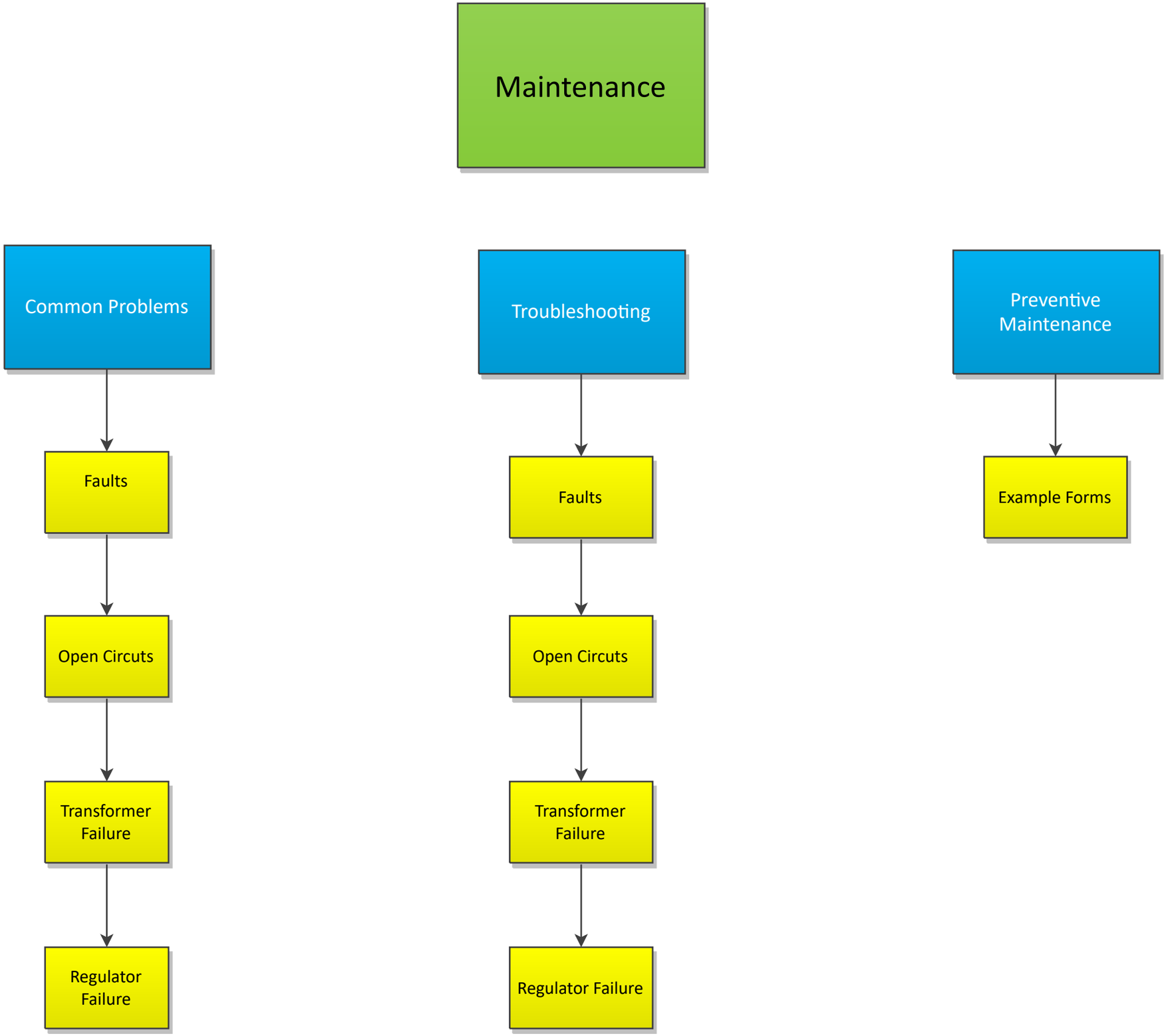
WebResource Site Map

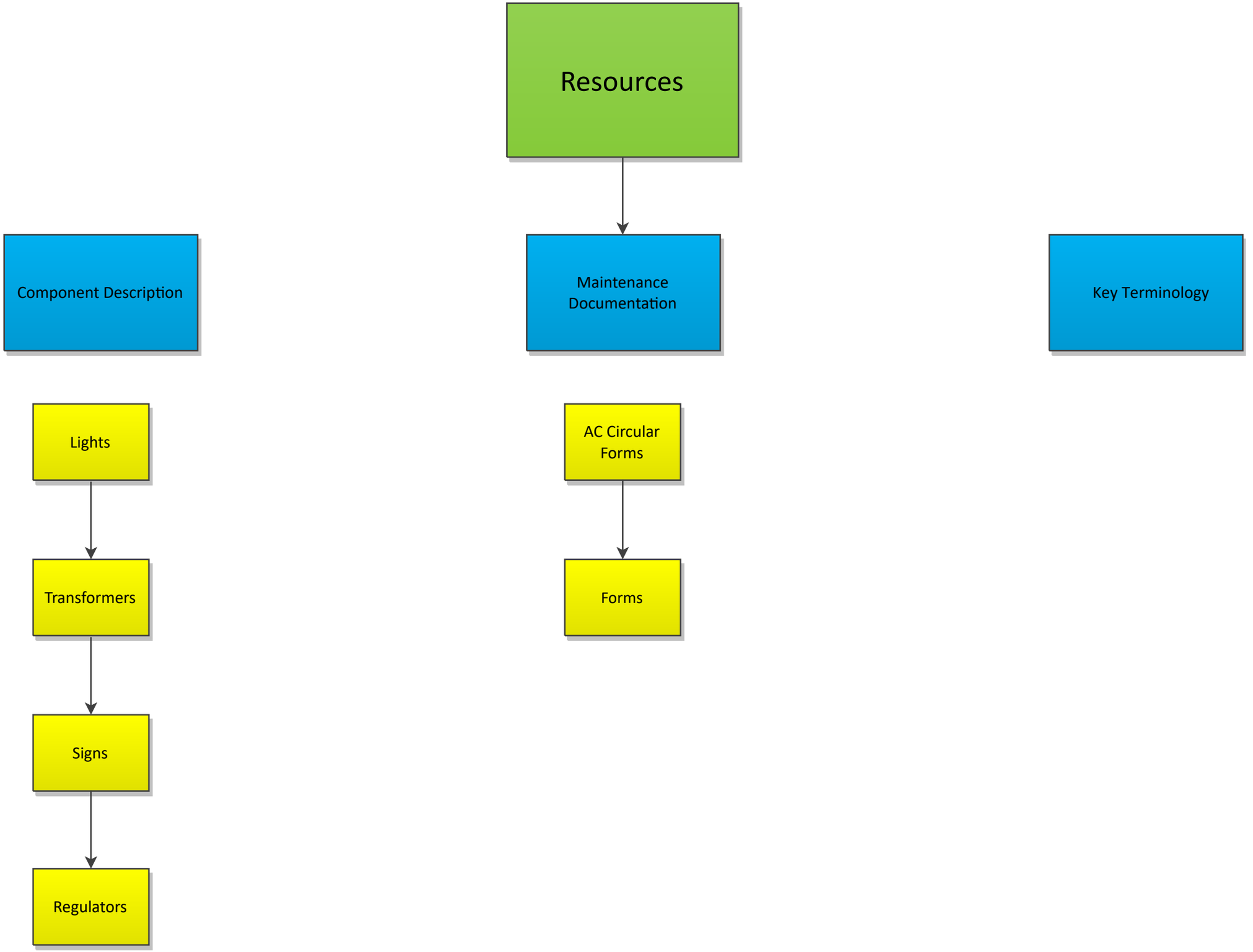

Project Scope
Management
Training and Contracting
Safety
Maintenance
Resources
Airfield Lighting Safety and Maintenance Basics
General Hazards and Risks
Electrically Safe & Electrically Unsafe Work Condition
Task Decision Matrix
Training Opportunities of Employees
How to Find a Contractor
Unique Hazards
Rules for Safety
LOTO
Emergency Response
Safety Tools
Common Problems
Troubleshooting
Preventive Maintenance
Component Description
Maintenance Documentation
Key Terminology


Management
Airfield Lighting Safety and Maintenance Basics
General Elect. Hazards and Risks
Electrically Safe & Electrically Unsafe Work Condition
Task Decision Matrix
Basic System Overview
General Hazards -Shock -Arc Flash and Blast -Fire
Electrically Safe Work Condition
Importance of an Electrically Safe Work Condition
General Hazards and Risks
Task Decision Matrix
Maintenance


Training and Contracting
Training Opportunities for Employees
How To Find a Contractor
In-Person Instruction
On Line Courses
Literary Information
Qualifications
Listings By State
AAAE
AAAE ACE
AC Circulars
ADB
Crouse Hinds
ACRP Publications
Other Literature


Safety
Unique Hazards
Rules for Safety
LOTO
Emergency Response
Safety Tools
Basic Safety Rules
LOTO Verification


Maintenance
Common Problems
Faults
Open Circuts
Transformer Failure
Regulator Failure
Troubleshooting
Faults
Open Circuts
Transformer Failure
Regulator Failure
Preventive Maintenance
Example Forms


Resources
Component Description
Maintenance Documentation
Key Terminology
Lights
Transformers
Signs
Regulators
AC Circular Forms
Forms