U.S. Department of
Homeland Security

United States
Coast Guard

Lighthouse Modernization Manual

COMDTINST M16500.8B

OCTOBER 2011

U.S. Department of
Homeland Security

United States
Coast Guard

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COMMANDANT INSTRUCTION M16500.8B

Subj: LIGHTHOUSE MODERNIZATION MANUAL

1. PURPOSE. The purpose of this Manual is to promulgate the updated information and provide users with a new manual title.

2. ACTION. All Coast Guard unit commanders, commanding officers, officers-in-charge, deputy/assistant commandants, and chiefs of headquarters staff elements shall comply with the provisions of this Manual. Internet release is authorized.

3. DIRECTIVES AFFECTED. The Automation Technical Guidelines, COMDTINST M16500.8A, is cancelled.

4. DISCUSSION. The Lighthouse Modernization Manual presents technical philosophies and guidelines which are used in the selection of modern aids to navigation signal and power equipment along with the system design during modernization of an existing lighthouse. The U.S. Coast Guard's Aids to Navigation Program has routinely exploited the continual advancements in lighting, acoustics, power, and electronics technology; this Manual utilizes these advancements and applies them to modern lighthouse design.

5. POLLUTION PREVENTION (P2) CONSIDERATIONS. Pollution Prevention considerations were examined in the development of this directive and have been fully addressed.

6. PROCEDURES. No paper distribution will be made of this Manual. Official distribution will be via the Coast Guard Directive (CGDS) DVD. An electronic version will be located on the following Commandant (CG-612) websites. Intranet: http://cgweb.comdt.uscg.mil/CGDirectives/Welcome.htm, Internet: http://www.uscg.mil/directives/, and CGPortal: https://cgportal.uscg.mil/delivery/Satellite/CG612.

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NON-STANDARD DISTRIBUTION:

7. CICA Disclaimer. Although equipment references within this Manual employ make and model nomenclature, all acquisitions of ATON equipment comply with the requirements of the Competition in Contracting Act, 10 U.S.C. § 2304.

8. RECORDS MANAGEMENT CONSIDERATIONS. This Manual has been thoroughly reviewed by the USCG, and the undersigned have determined this action requires further scheduling requirements, in accordance with Federal Records Act, 44 U.S.C. 3101 et seq., NARA requirements, and Information and Life Cycle Management Manual, COMDTINST M5212.12 (series). This policy has significant or substantial change to existing records management requirements, or inconsistencies with existing determinations relating to documentation requirements.

9. ENVIRONMENTAL ASPECT AND IMPACT CONSIDERATIONS.

    a. The development of this directive and the general policies contained within it have been thoroughly reviewed by the originating office and are categorically excluded under current USCG Categorical Exclusion (CE) 33 from further environmental analysis, in accordance with Section 2.B.2. and Figure 2-1 of the National Environmental Policy Act Implementing Procedures and Policy for Considering Environmental Impacts, COMDTINST M16475.1 (series).

    b. This directive will not have any of the following: significant cumulative impacts on the human environment; substantial controversy or substantial change to existing environmental conditions; or inconsistencies with any Federal, State, or local laws or administrative determinations relating to the environment. All future specific actions resulting from the general policies in this Manual must be individually evaluated for compliance with the National Environmental Policy Act (NEPA), Council on Environmental Policy NEPA regulations at 40 CFR Parts 1500-1508, DHS and Coast Guard NEPA policy, and compliance with all other environmental mandates.

10. FORMS/REPORTS. The forms referenced in this Manual are available in USCG Electronic Forms on the Standard Workstation or on the Internet: http://www.uscg.mil/forms/; CGPortal at https://cgportal.uscg.mil/delivery/Satellite/uscg/References; and Intranet at http://cgweb.comdt.uscg.mil/CGForms.

R. J. RÁBAGO /s/
Assistant Commandant for Engineering and Logistics

RECORD OF CHANGES			
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CHAPTER 1. GENERAL OVERVIEW

A. Introduction. The Aids to Navigation (ATON) Design Tool Flowchart, Figure 1-1, is provided to assist aids to navigation designers in selecting the proper publications and spreadsheet-tools (programs) to use when establishing a new aid or upgrading an existing one. This Manual provides technical guidance to be used in selecting all the necessary ATON equipment for the modernization of an existing lighthouse. The Coast Guard's ATON Program has routinely exploited the continual advancements in lighting, acoustics, power, and electronics technology to achieve the two primary goals of lighthouse automation and modernization: (1) to reduce Operations & Maintenance (O&M) costs; and (2) to greatly reduce servicing visits by Coast Guard personnel to remote lighthouses while still providing the mariner with reliable aids to navigation. These goals are being achieved through a consistent, long-term commitment to standardization of equipment and system design configurations.

B. Background. With the development of reliable electro-mechanical switching devices and high-endurance diesel engine generator sets, automated lighthouse operation became feasible in the early 1960's. Thus began an era of about 25 years during which automation replaced personnel at lighthouses with resultant savings in operating costs. Over time, as technology advanced and improved, the reliability of major aid hardware also improved. As lighthouse automation took hold and became the new standard, the structural condition of the lighthouses began to decline because there were no light keepers left behind to perform the year-round structural maintenance and repair tasks. As such, a bulk of the O&M costs are now spent on emergency maintenance and repair of the structures themselves. One solution has been the Coast Guard's adopt-a-lighthouse program, officially known as the "National Historic Lighthouse Preservation Act (NHLPA)." Under this program, federal agencies, state and local governments, nonprofit corporations, educational agencies, community development organizations, and even qualifying private citizens may adopt historic lighthouses listed in the National Register of Historic Places on a no-cost basis. In return, these organizations or persons must agree to comply with conditions set forth in NHLPA, and be financially able to maintain the historic lighthouse. Ultimately, the Coast Guard's goal is to transfer ownership of most lighthouse structures either through the NHLPA, decommissioning, or other divestiture programs. In addition to structural maintenance, a large portion of the lighthouse O&M expenditure is taken up by transportation costs required for the service visits. Having achieved a relatively high level of reliability for major aids to navigation, our new challenge is to reduce O&M costs by extending the periods between routine service visits from months to years. This goal is achievable as the reliability of hardware, system design, and installations improve.

C. Scope. This Manual provides technical guidance or it references the related publications and/or documents to successfully execute a new solar-powered Major Aids to Navigation lighthouse modernization project of an existing lighthouse, and achieve, with a little effort on the user's part, a quality, reliable, and low-maintenance lighthouse signal system. When guidance pertaining to lighthouse solarization in referenced manuals and/or supporting documents conflict, direction in this Manual applies.

ATON Design Tool Flowchart

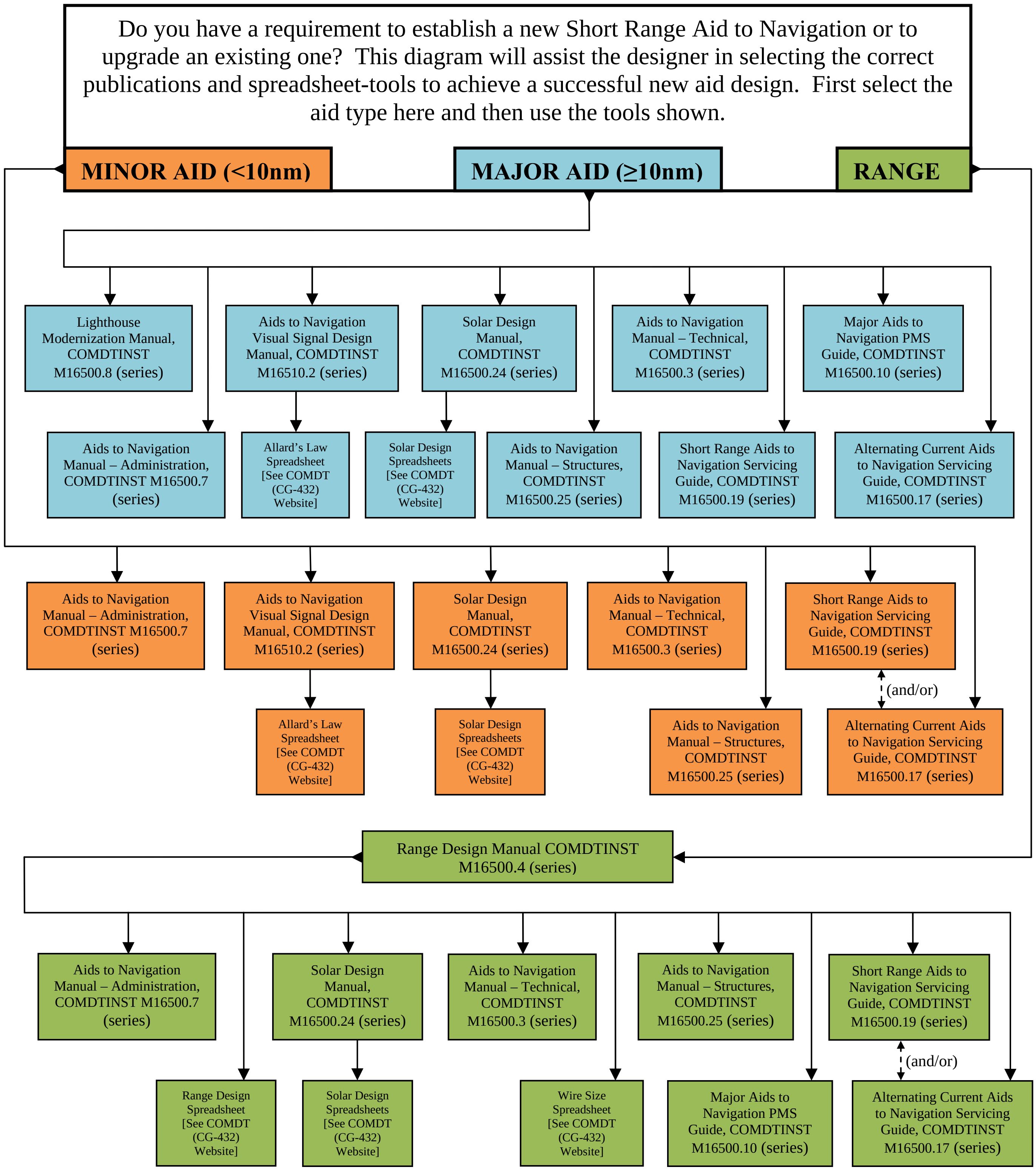


Figure 1-1

D. Lighthouse Equipment Configuration Categories.

1. Purpose. Categories help the engineering support manager and the district program manager to discern which equipment configuration will meet the operational needs of the aid to navigation site. The various categories are designed to meet various and distinct levels of operational need. Figure 1-2 merges the operational requirement and engineering support issues into one decision flow diagram. Generally speaking, higher levels of operational need require more signal range (power), better signal availability (equipment redundancy), and shorter time to restore the signal after an outage or advise the mariner of an outage.

2. Rationale. Standard equipment configurations encourage better engineering design and operational need decision-making by district program managers. Standardization also allows for economies in personnel training and equipment procurement, and it promotes the effectiveness of maintenance personnel.

3. Configurations. Installation, interconnection, and troubleshooting drawings for these equipment configuration categories are available from the Commandant (CG-432) website (http://www.uscg.mil/hq/cg4/cg432/). All standard equipment is described in the Aids to Navigation Manual – Technical, COMDTINST M16500.3 (series). Detailed information for a few of our more-specialized electronic hardware, such as the VM100 Fog Detector and the Aid Control and Monitor System (ACMS), can be found at C3CEN's Short Range Aids to Navigation (SRAN) webpage, http://cgweb.lant.uscg.mil/c2cen/SRAN.htm, at Manuals/Operating Manuals weblink.

   a. Solar Category I Equipment Configuration. Often, lights in this category were once manned and were a critically important aid to navigation but may now have a diminished signal range requirement. This equipment suite can provide a seacoast light with a nominal range of up to 22 nautical miles, a 2-mile sound signal, and a Radar Beacon (RACON). Variables of latitude, cloudiness, visibility, solar panel array mounting area, and battery capacity all constrain these system capabilities for some sites. Emergency signals and remote electronic monitoring make this the most complex solar-powered equipment suite. (Figure 1-3).

   b. Solar Category II Equipment Configuration. This equipment suite resembles the Category I solar-powered aid to navigation except that it does not have remote electronic monitoring capability. (Figure 1-4).

   c. Solar Category III Equipment Configuration. This simple solar-powered equipment suite consists of a rechargeable battery, a light signal, and a sound signal, but no emergency signals nor electronic control/monitoring. (Figure 1-5).

   d. Simplified Commercial Category I and II Equipment Configurations. These systems are identical to Solar Category I and II discussed above except for its power source. These systems should be considered for installation if reliable commercial power is available at the lighthouse site. Variables of latitude and cloudiness do not constrain the system capabilities, as it does for many solar-powered sites. However, sufficient sunlight is required by the emergency solar panel, if not using a battery charger, to keep the emergency NiCad battery fully charged during standby. Emergency signals and remote electronic monitoring make the Simplified Commercial Category I the most complex commercially-powered equipment suite. (Figure 1-6). Simplified Commercial Category II is the less complex system without remote monitoring and control capability. (Figure 1-7).

e. Category V Equipment Configuration. Use this equipment configuration where commercial electrical power is reliable and emergency signals are not required. The 12VDC light and sound signals are powered by a commercially-powered 12VDC power supply, usually the standard ATON High-Watt Power Supply (HWPS). The 12VDC power is distributed to the signals via the Cat V Load Center. (Figure 1-8).

E. Program Planning.

1. Waterways Analysis Management System (WAMS) Studies. Output from WAMS evaluations may be the most significant tool for specifically identifying which lighthouse category adequately meets the operational need. WAMS evaluations identify waterway criticality and requirements for ATON systems.

2. Backlog Development. Accurate forecasts of program and standard equipment needs are maintained through Civil Engineering Unit (CEU) and District (dpw) project lists or backlogs. These forecasted needs are normally communicated upward by a Federal Aid to Navigation Operation Request form (CG-3213) as a result of a WAMS evaluation or a Shore Station Maintenance Request (SSMR) submission resulting from a biennial civil engineering inspection.

3. Project Execution. Engineering support for lighthouse systems should be incorporated into the entire engineering support function. If available, we recommend use of experienced Coast Guard in-house engineering talent and capacity when possible. Each new lighthouse modernization will likely differ to some extent from previous projects.

F. Project Submission.

1. Required Documentation. Lighthouse modernization projects require submission of a CG-3213 / 3213A Federal Aid to Navigation Operation Request project package for headquarters review. See Figure 1-9 for the project documentation approval process.

a. Federal Aid to Navigation Operation Request (Standard Forms CG-3213 and CG-3213A). The completed standard forms CG-3213 and CG-3213A shall present a clear indication of existing ATON equipment to remain and new equipment to be installed. The environmental impact of sound signals must be addressed in the CG-3213. Also, any historic property and classical lens disposition issues must be addressed here.

2. Approval Process. District (dpw) launches a new project by developing and submitting the CG-3213 / 3213A project documentation to the Visual Navigation Division, Commandant (CG-5531), and taking account of environmental and historic preservation requirements. See Figure 1-9. Commandant (CG-5531) will then review the project requirements and either approve, disapprove, or submit to Commandant (CG-432) for technical review, verification of funding source, and prioritization of project (e.g., AFC-30, AFC-43, or AC&I Waterways). Final approval of the project requirements will be indicated by a Commandant (CG-5531) endorsement of the standard form CG-3213. This endorsement will address equipment availability. Headquarters-furnished equipment will be shipped upon request (submit request to Commandant (CG-432) via e-mail) for specific projects after those projects are submitted, approved, and ready for execution. Any significant project change should be resubmitted for approval prior to Architectural Engineering (A/E) contract award, or as soon as the need for change is revealed thereafter. Also, CG-3213 / 3213A documentation is required for any project that requires an ATON signal or category change or one that requests HQ-furnished equipment for a Category I or II solar or simplified commercial lighthouse.

3. Radio Frequency Allocation for Electronic Monitor and Control Equipment. If a new radio link is required for aid monitoring purposes, frequency authorization shall be requested in accordance with Telecommunication Manual, COMDTINST M2000.3 (series).

G. Program Guidance. Commandant (CG-432) prepares and maintains a wide variety of directives to guide the execution of lighthouse modernization projects. Commandant (CG-432) also maintains several spreadsheet-tools (programs) to support in-house and field design efforts. Much of this information is available to the district designers, operators, and support personnel via the Commandant (CG-432) Internet page (http://www.uscg.mil/hq/cg4/cg432/). This website also provides easy access to other valuable resources including a directory of personnel with contact information and areas of responsibility, and many frequently used references such as directives, specifications, technical data sheets, and standard engineering drawings (most of which are in the easy-to-download and print pdf-file format). This information will be maintained in accordance with Information and Life Cycle Management Manual, COMDTINST M5212.12 (series).

1. Directives Maintained by Commandant (CG-432). These highly-specialized directives provide guidance to operating units and support partners for the effective deployment and management of lighthouses and other related Ocean Engineering systems and equipment.

    a. Aids to Navigation Manual – Structures, COMDTINST M16500.25 (series). This manual establishes policies, procedures, and criteria for the design and inspection of short range aids to navigation structures.

    b. Aids to Navigation Manual – Technical, COMDTINST M16500.3 (series). This manual is a general hardware selection guide with installation and maintenance requirements and General Description Data Sheets.

c. Major Aids to Navigation Preventive Maintenance System Guide, COMDTINST M16500.10 (series). This field guide promulgates equipment-specific Preventive Maintenance System (PMS) procedures for preventive maintenance of standard lighthouse equipment.

d. Short Range Aids to Navigation Servicing Guide, COMDTINST M16500.19 (series). This is a field guide for Coast Guard personnel who service aids to navigation hardware powered by 12 volt direct-current systems.

e. Solar Design Manual, COMDTINST M16500.24 (series). This is a guide for Coast Guard personnel who design solar powered aids to navigation power systems.

f. Aids to Navigation Visual Signal Design Manual, COMDTINST M16510.2 (series). This discusses the theory of visual signaling as it pertains to lighted aids to navigation, establishes step-by-step procedures for the selection and evaluation of signaling hardware, forwards the Allard's Law Computer Program for evaluation of signaling hardware, and provides tabulated photometric data on Coast Guard optical systems used for lighted aids to navigation.

g. Classical Lens Maintenance, COMDTINST 16500.9 (series). This instruction manual documents the procedures for inspecting the condition of classical lenses, its cleaning and focusing, and provides guidance on stabilization of loose prisms.

2. Directives Maintained by Other Program Offices. Other relevant documents include the following:

a. Aids to Navigation Manual – Administration, COMDTINST M16500.7 (series). Maintained by Commandant (CG-5531), this promulgates policy and guidance for the administration of the Short Range Aids to Navigation Program.

b. Coatings and Color Manual, COMDTINST M10360.3 (series). Maintained by Commandant (CG-45), this provides guidance on coatings for vessels, buildings, structures, fixed equipment, and aids to navigation.

c. Light List, COMDTPUB P16502.1 thru P16502.7 (seven volumes). Contains a list of lights, sound signals, buoys, daybeacons, and other aids to navigation.

3. Design Aids Maintained by Commandant (CG-432). Commandant (CG-432) directs the development, maintenance, and support of lighthouse-related engineering and design aids.

a. Solar Design Spreadsheets. The Commandant (CG-432) website contains solar sizing programs for designing and evaluating solar power systems for ATON.

b. Allard's Law Spreadsheet. Allard's Law can be used to calculate a light's required effective intensity as a function of operational range and meteorological visibility.

The value for meteorological visibility used in the calculations is based on historical visibility data. Further information can be found in the Aids to Navigation Visual Signal Design Manual, COMDTINST M16510.2 (series). The Allard's Law Spreadsheet Program, available on the Commandant (CG-432) website, performs the required calculations.

LIGHTHOUSE MODERNIZATION CATEGORY SELECTION AID

CATEGORY DEFINITIONS

SOLAR CAT I -	REMOTELY MONITORED AND CONTROLLED, 12VDC SOLAR POWERED SYSTEM WITH EMERGENCY SIGNALS.	SIMPLIFIED COMMERCIAL CAT I -	NOMINAL 12VDC SYSTEM, REMOTELY MONITORED AND CONTROLLED, AC-RECTIFIED AND STEPPED DOWN TO 14VDC, WITH EMERGENCY SIGNALS.
SOLAR CAT II -	UNMONITORED, 12VDC SOLAR POWERED SYSTEM WITH EMERGENCY SIGNALS OPTIONAL.	SIMPLIFIED COMMERCIAL CAT II -	NOMINAL 12VDC SYSTEM, UNMONITORED, AC-RECTIFIED AND STEPPED DOWN TO 14VDC, WITH EMERGENCY SIGNALS OPTIONAL.
SOLAR CAT III -	UNMONITORED, 12VDC SOLAR POWERED SYSTEM WITHOUT EMERGENCY SIGNALS.	CATEGORY V -	A/C RECTIFIED AND STEPPED DOWN TO 12VDC SYSTEM WITHOUT EMERGENCY SIGNALS.

Increasing Ops Capability & Complexity

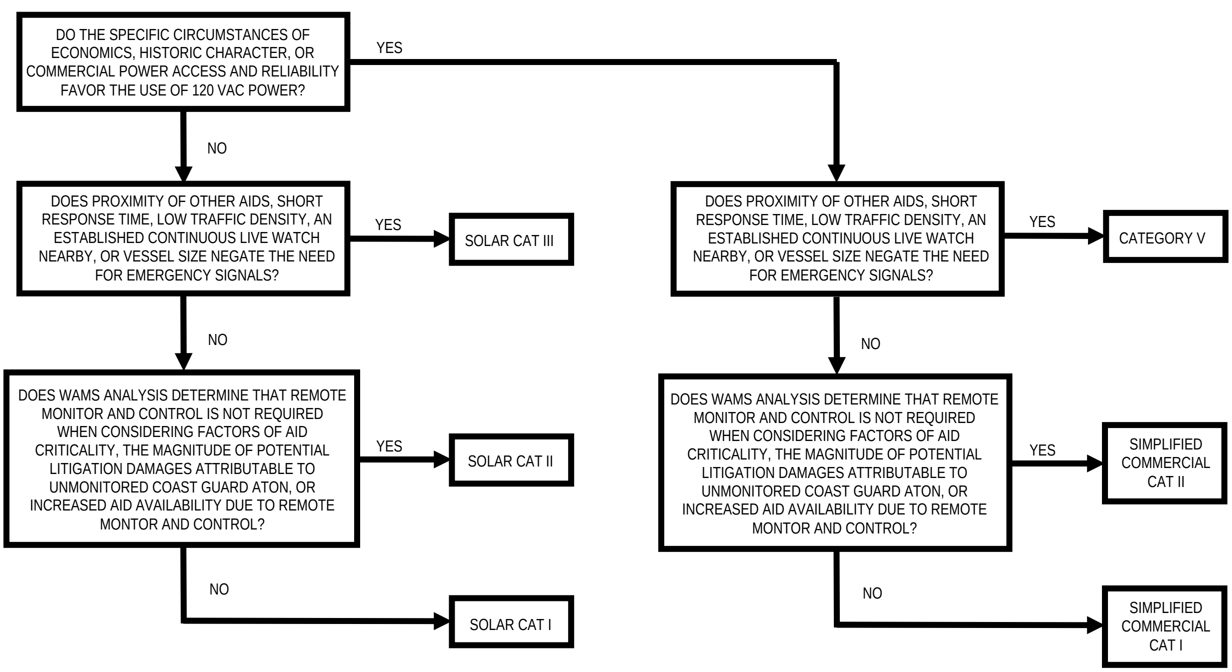
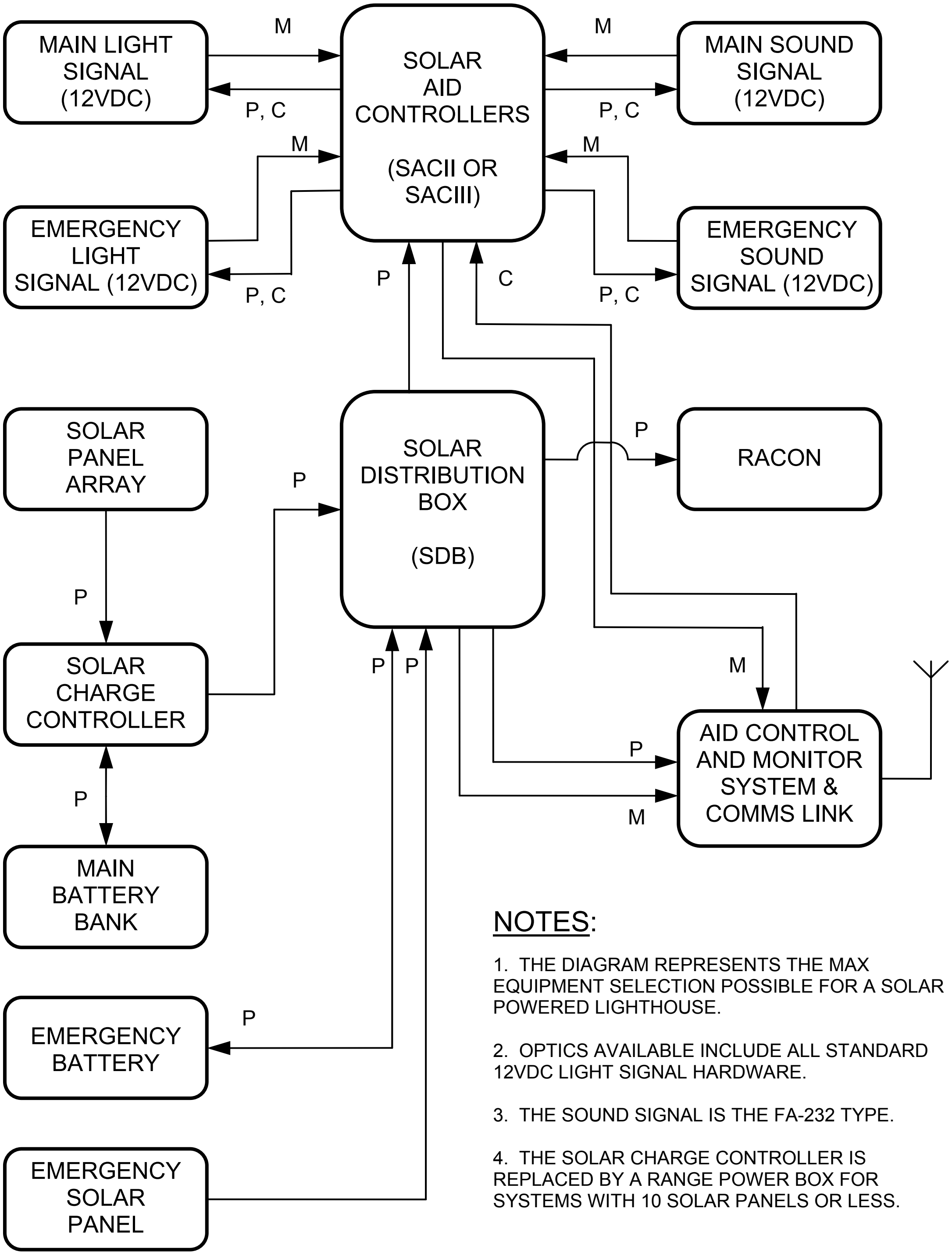


Figure 1-2

SOLAR CATEGORY I

SOLAR POWERED, MONITORED, AND CONTROLLED, WITH RACON,
EMERGENCY SIGNALS, AND SOLAR DISTRIBUTION BOX (SDB)

SYMBOLS: **M** = MONITOR, **P** = POWER, **C** = CONTROL



NOTES:

1. THE DIAGRAM REPRESENTS THE MAX EQUIPMENT SELECTION POSSIBLE FOR A SOLAR POWERED LIGHTHOUSE.

2. OPTICS AVAILABLE INCLUDE ALL STANDARD 12VDC LIGHT SIGNAL HARDWARE.

3. THE SOUND SIGNAL IS THE FA-232 TYPE.

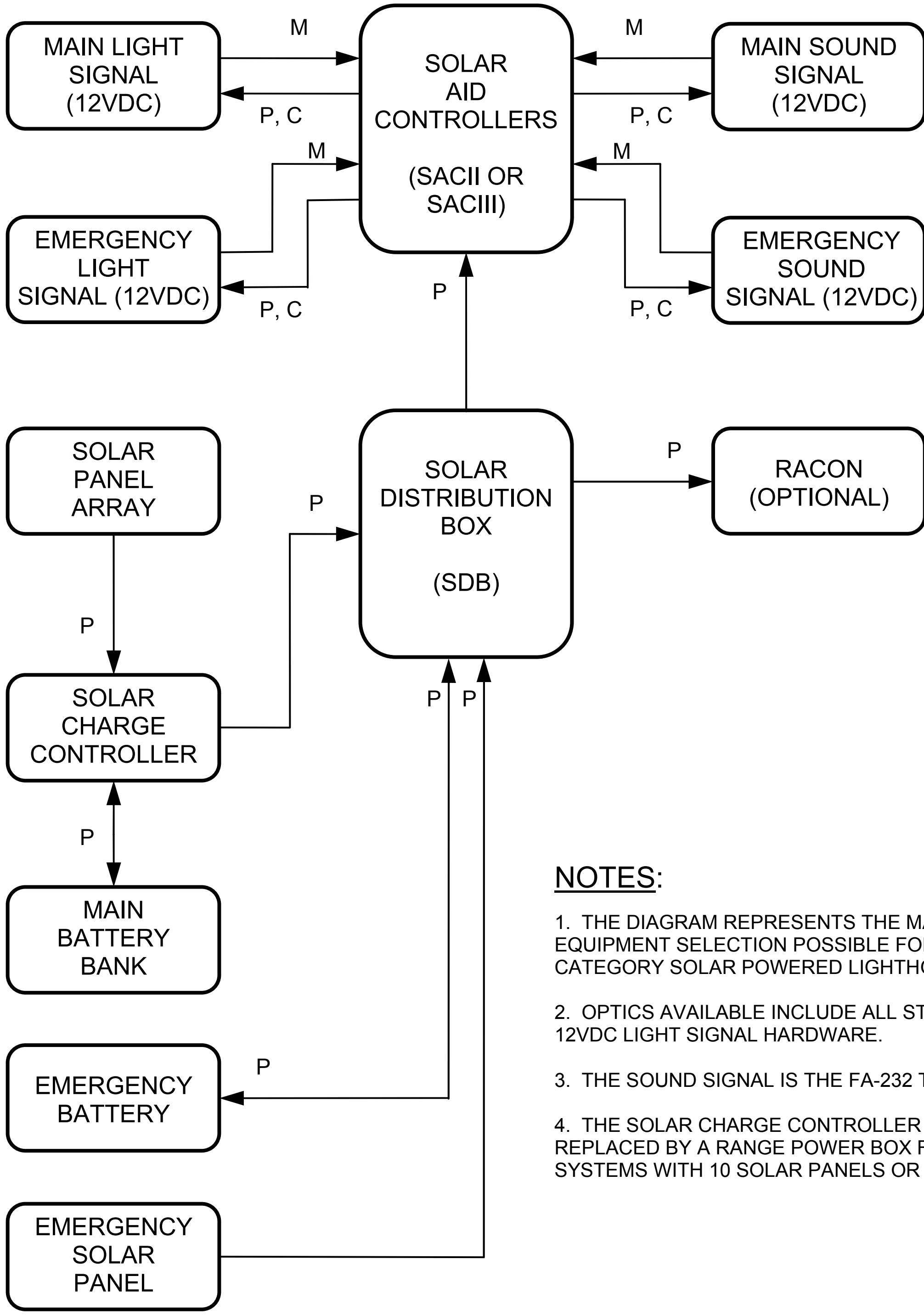
4. THE SOLAR CHARGE CONTROLLER IS REPLACED BY A RANGE POWER BOX FOR SYSTEMS WITH 10 SOLAR PANELS OR LESS.

Figure 1-3

SOLAR CATEGORY II

SOLAR POWERED, WITH EMERGENCY SIGNALS, OPTIONAL RACON,
AND SOLAR DISTRIBUTION BOX (SDB)

SYMBOLS: **M** = MONITOR, **P** = POWER, **C** = CONTROL



NOTES:

1. THE DIAGRAM REPRESENTS THE MAX EQUIPMENT SELECTION POSSIBLE FOR THIS CATEGORY SOLAR POWERED LIGHTHOUSE.

2. OPTICS AVAILABLE INCLUDE ALL STANDARD 12VDC LIGHT SIGNAL HARDWARE.

3. THE SOUND SIGNAL IS THE FA-232 TYPE.

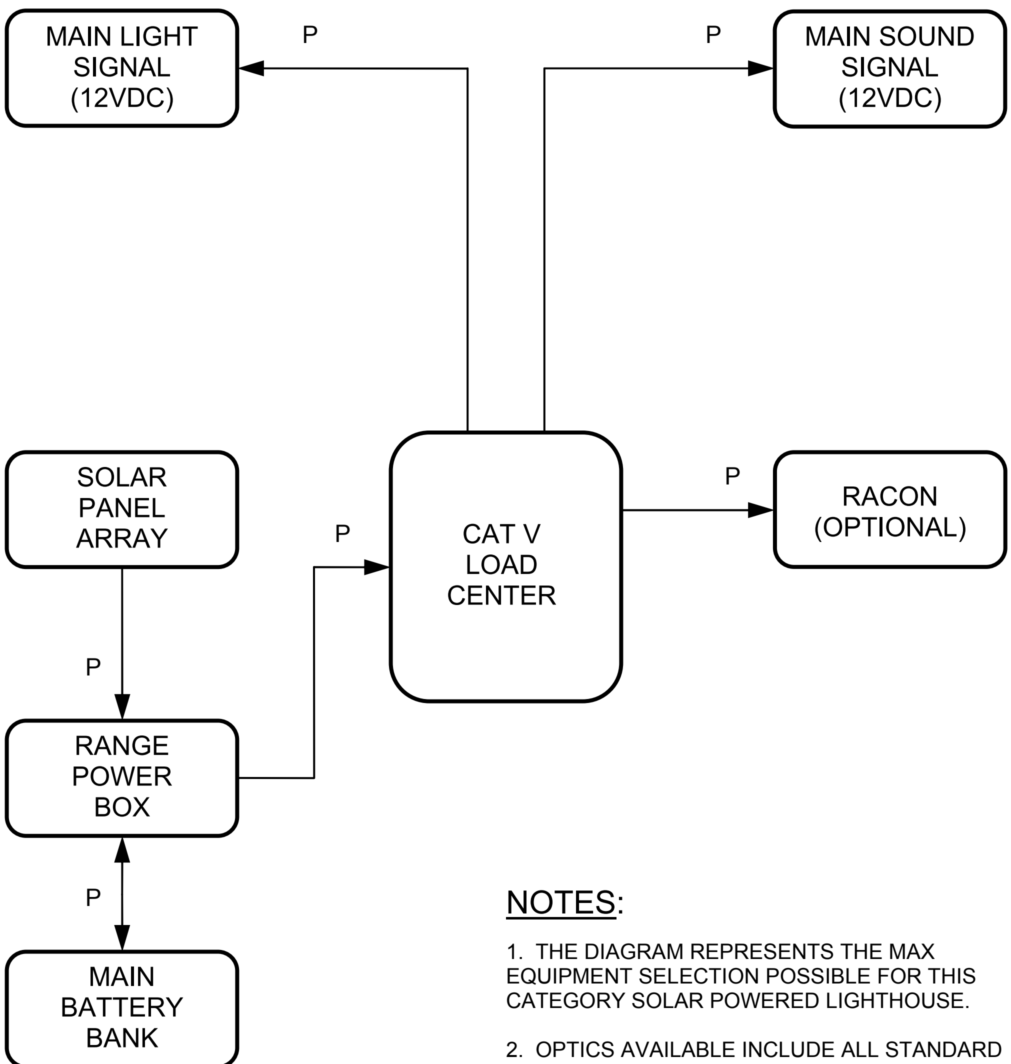
4. THE SOLAR CHARGE CONTROLLER IS REPLACED BY A RANGE POWER BOX FOR SYSTEMS WITH 10 SOLAR PANELS OR LESS.

Figure 1-4

SOLAR CATEGORY III

SOLAR POWERED, WITH OPTIONAL RACON

SYMBOLS: **P** = POWER



NOTES:

1. THE DIAGRAM REPRESENTS THE MAX EQUIPMENT SELECTION POSSIBLE FOR THIS CATEGORY SOLAR POWERED LIGHTHOUSE.

2. OPTICS AVAILABLE INCLUDE ALL STANDARD 12VDC LIGHT SIGNAL HARDWARE.

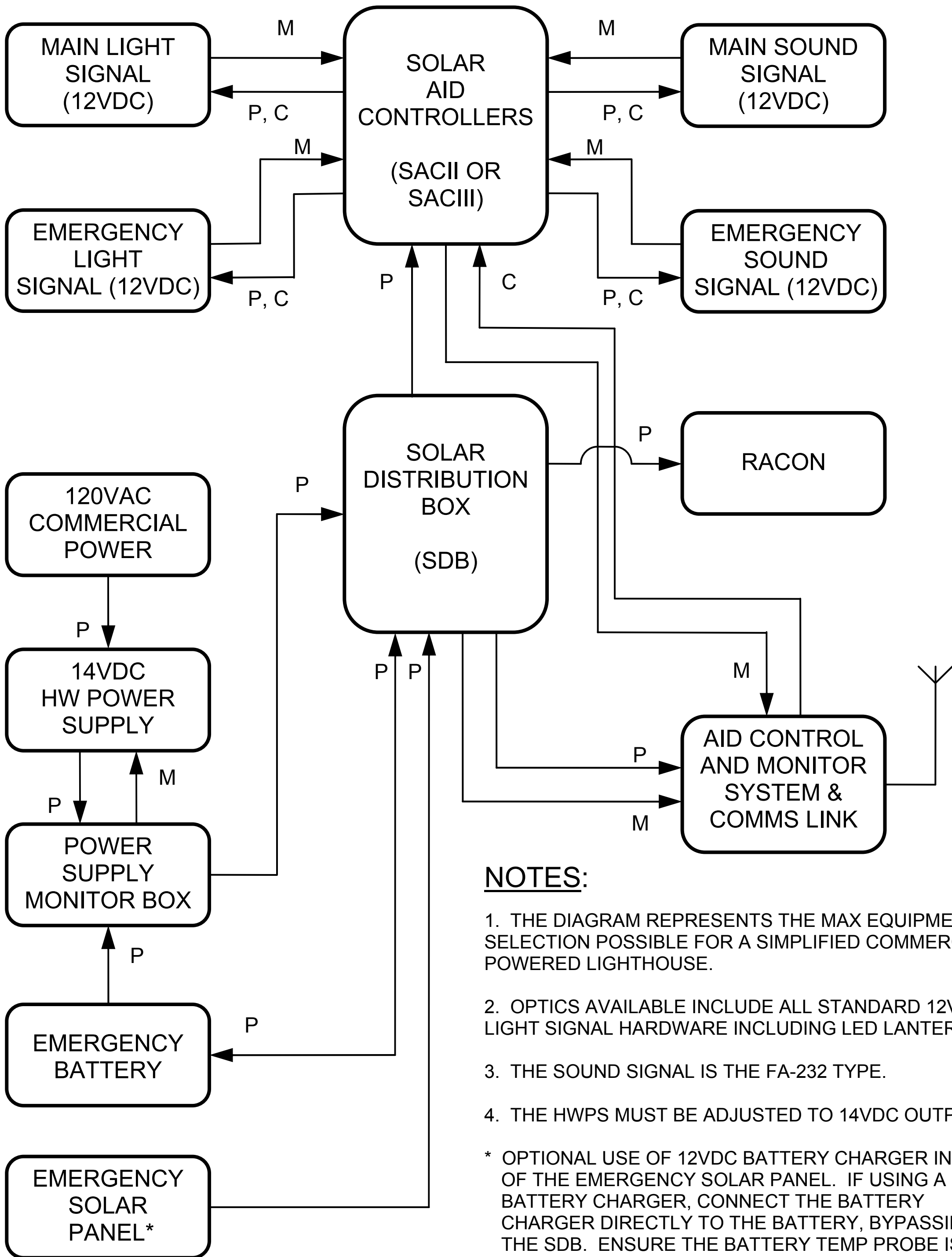
3. THE SOUND SIGNAL IS THE FA-232 TYPE.

Figure 1-5

COMMERCIAL (SIMPLIFIED) CATEGORY I

COMMERCIAL POWERED, MONITORED, AND CONTROLLED, WITH RACON, EMERGENCY SIGNALS, AND SOLAR DISTRIBUTION BOX (SDB)

SYMBOLS: **M** = MONITOR, **P** = POWER, **C** = CONTROL



NOTES:

1. THE DIAGRAM REPRESENTS THE MAX EQUIPMENT SELECTION POSSIBLE FOR A SIMPLIFIED COMMERCIAL POWERED LIGHTHOUSE.

2. OPTICS AVAILABLE INCLUDE ALL STANDARD 12VDC LIGHT SIGNAL HARDWARE INCLUDING LED LANTERNS.

3. THE SOUND SIGNAL IS THE FA-232 TYPE.

4. THE HWPS MUST BE ADJUSTED TO 14VDC OUTPUT.

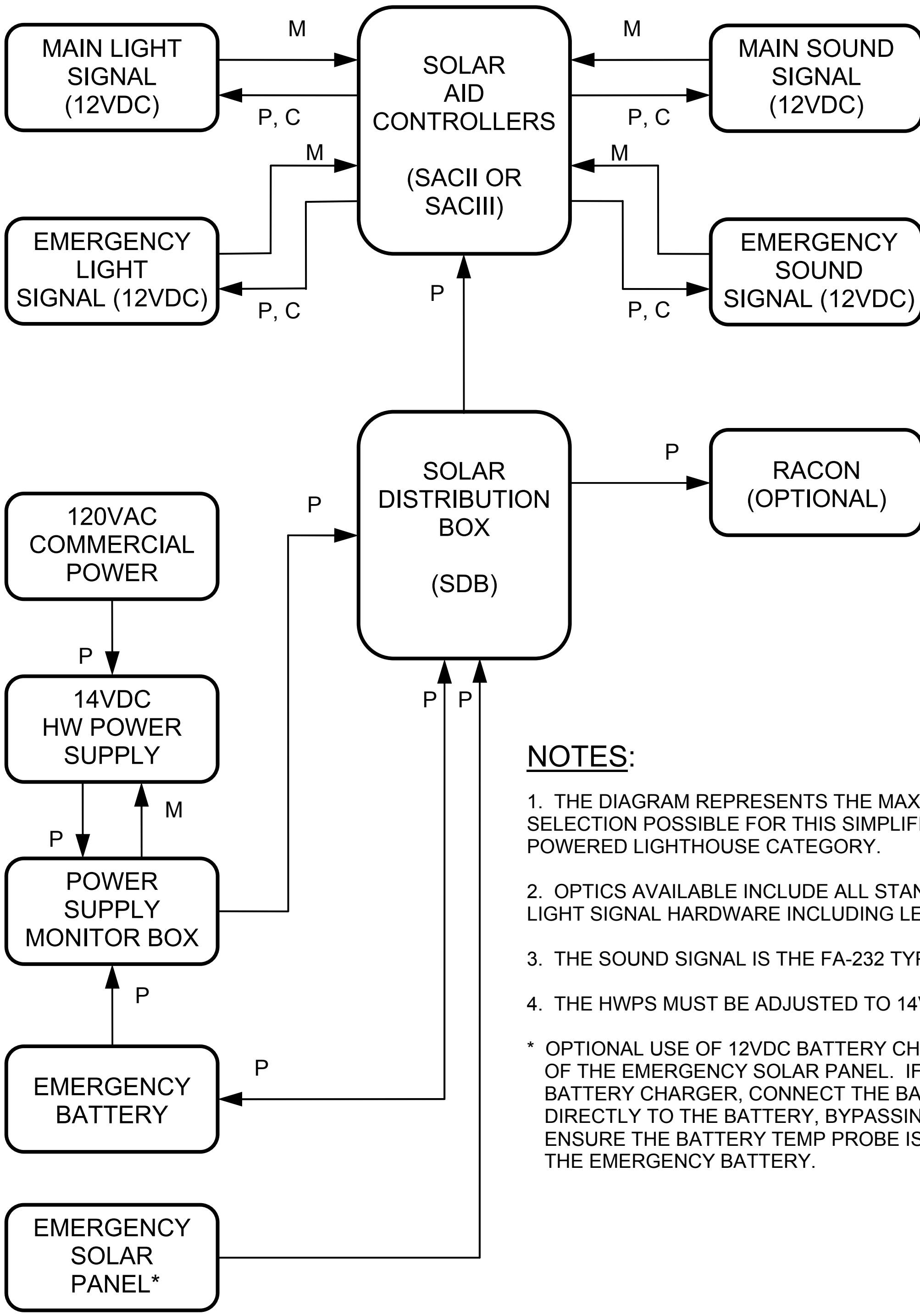
* OPTIONAL USE OF 12VDC BATTERY CHARGER IN LIEU OF THE EMERGENCY SOLAR PANEL. IF USING A BATTERY CHARGER, CONNECT THE BATTERY CHARGER DIRECTLY TO THE BATTERY, BYPASSING THE SDB. ENSURE THE BATTERY TEMP PROBE IS INSTALLED ON THE EMERGENCY BATTERY.

Figure 1-6

COMMERCIAL (SIMPLIFIED) CATEGORY II

COMMERCIAL POWERED, WITH EMERGENCY SIGNALS,
OPTIONAL RACON, AND SOLAR DISTRIBUTION BOX (SDB)

SYMBOLS: **M** = MONITOR, **P** = POWER, **C** = CONTROL



NOTES:

1. THE DIAGRAM REPRESENTS THE MAX EQUIPMENT SELECTION POSSIBLE FOR THIS SIMPLIFIED COMMERCIAL POWERED LIGHTHOUSE CATEGORY.

2. OPTICS AVAILABLE INCLUDE ALL STANDARD 12VDC LIGHT SIGNAL HARDWARE INCLUDING LED LANTERNS.

3. THE SOUND SIGNAL IS THE FA-232 TYPE.

4. THE HWPS MUST BE ADJUSTED TO 14VDC OUTPUT.

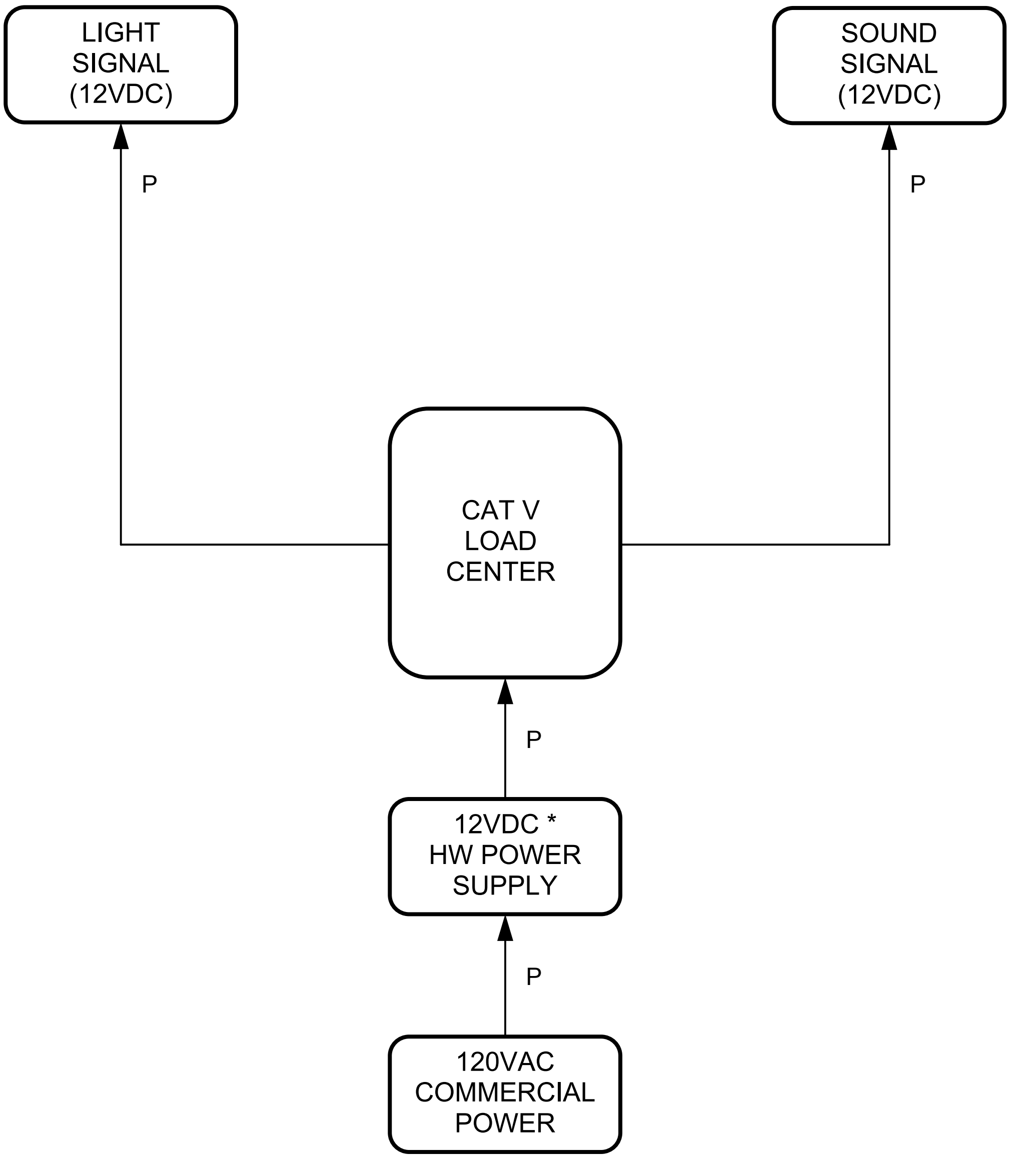
* OPTIONAL USE OF 12VDC BATTERY CHARGER IN LIEU OF THE EMERGENCY SOLAR PANEL. IF USING A BATTERY CHARGER, CONNECT THE BATTERY CHARGER DIRECTLY TO THE BATTERY, BYPASSING THE SDB. ENSURE THE BATTERY TEMP PROBE IS INSTALLED ON THE EMERGENCY BATTERY.

Figure 1-7

CATEGORY V

120VAC-RECTIFIED AND STEPPED-DOWN TO 12VDC OR
OPTIONAL BATTERY CHARGER AND RECHARGEABLE BATTERY

SYMBOLS: **P** = POWER



* NOTE:

OPTIONAL USE OF 12VDC RECHARGEABLE BATTERY AND BATTERY CHARGER IN LIEU OF THE HWPS (HW POWER SUPPLY).

Figure 1-8

Project Documentation Approval Process

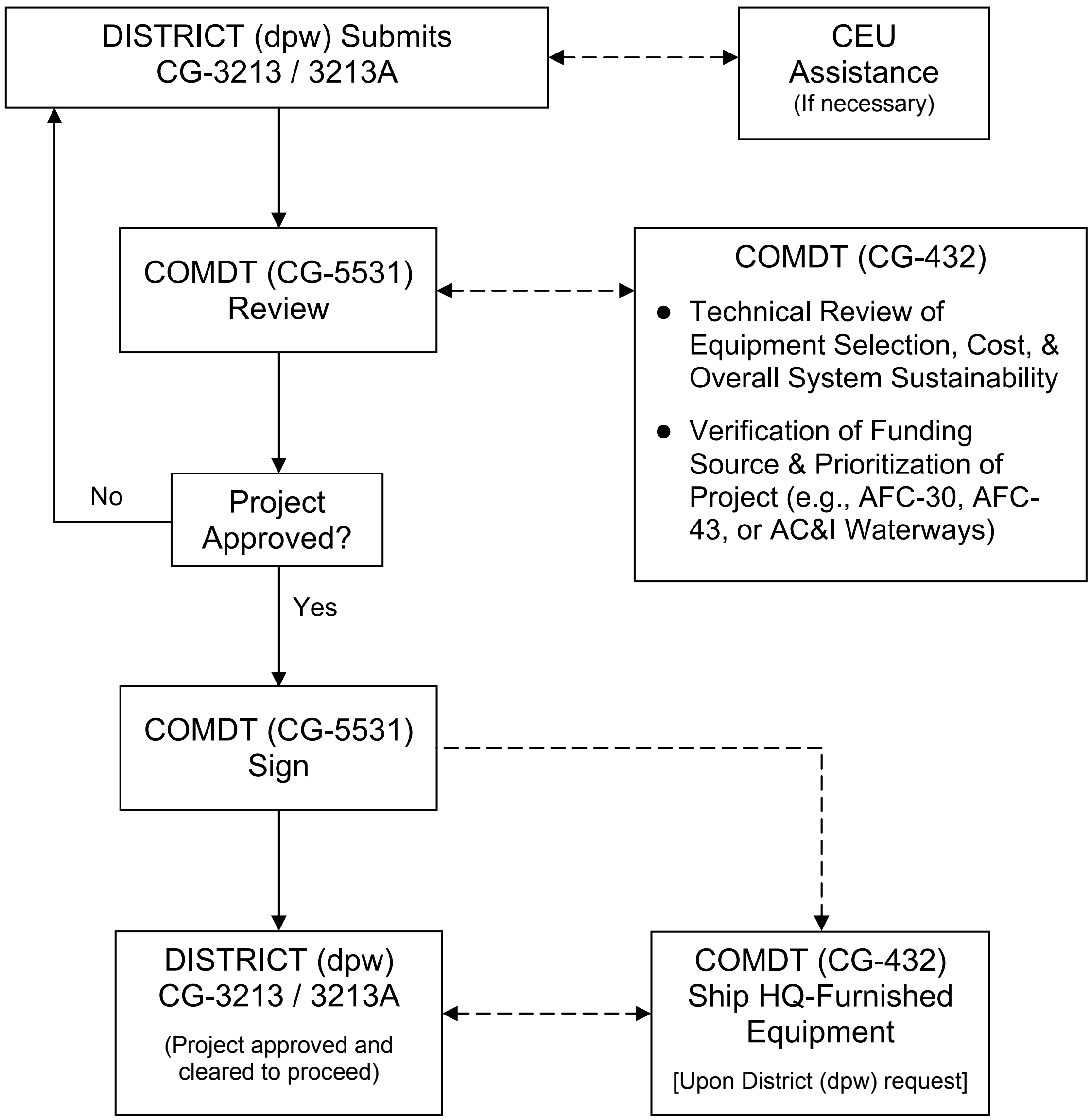


Figure 1-9

CHAPTER 2. AID EQUIPMENT

A. General. The standard light signals and sound signals for solarizing major aid lighthouses are described in this chapter. Also discussed are standard equipment to monitor and control the operation of light and sound signals, and fog detectors. Outlined are the optics, sound signals, control and monitor equipment, and ancillary equipment which may be used at a lighthouse site. Power systems for these various aid types are discussed in Chapter 3. Effective intensities for standard beacons, which shall be used to select the correct beacon to meet the operational requirements of the light, are published in the Aids to Navigation Visual Signal Design Manual, COMDTINST M16510.2 (series); the Aids to Navigation Manual – Technical, COMDTINST M16500.3 (series); in Technical Data Sheets that are posted on the Commandant (CG-432) website; and/or are shown on many of the Solar Sizing spreadsheets available on the Commandant (CG-432) website.

1. Sites with reliable commercial power. In some cases, the use of 12VDC signals may be more desirable at a site where reliable 120VAC commercial power is available. This may be due to the limited size of the lantern house on the structure, or for uniformity of systems within a district. Guidance on integration of 12VDC optics and sound signals at previously commercial-powered aids is discussed in greater detail in paragraph 2.C. System configurations for these aids are depicted in Figures 1-6, 1-7, and 1-8, which are Commercial (Simplified) Category I, Commercial (Simplified) Category II, and Category V lighthouses, respectively.

2. 120VAC Lighthouses. Guidance on the use and maintenance of 120VAC signals and control equipment, such as DCB-24/224 rotating beacons, CG-1000 sound signals, and Audio Visual Controllers are beyond the scope of this manual. This information, however, will be available in a Technical Data Sheet posted on the Commandant (CG-432) website. Also, refer to the Aids to Navigation Manual – Technical, COMDTINST M16500.3 (series) for more detailed information on 120VAC signal and control equipment. Refer to the Major Aids to Navigation Preventive Maintenance System Guide, COMDTINST M16500.10 (series) and the Alternating Current Aids to Navigation Servicing Guide, COMDTINST M16500.17 (series) for maintenance and servicing information on 120VAC signal and control equipment.

3. Classical (Fresnel) Lenses. The Coast Guard continues to operate lighthouses with Classical Lenses at some locations. All CG-owned Classical Lenses are Heritage Assets and need to be preserved. Almost all of them have high historic and monetary value and therefore they are historic artifacts. Classical Lenses shall always be treated with the utmost care. If the Classical Lens is no longer required to achieve the desired operational range, it should be replaced by a more modern optic if it is more economically beneficial. A flow diagram charting the continued operation or disposition of Classical Lenses is presented in Figure 2-1. If the chart decision leads to removing the Classical Lens, then follow policy in the U.S. Coast Guard Personal Property Management Manual, COMDTINST M4500.5 (series) and the Aids to Navigation Manual – Administration, COMDTINST M16500.7 (series) for official guidance on the proper disposition of the lens; for example, the lens may be transferred to the USCG Historian's Office,

Commandant (CG-0922), for subsequent loan to a maritime museum or it may be transferred to a qualified preservation group under rules of the NHLPA (along with the lighthouse structure). If the chart decision leads to retaining the Classical Lens as a viable and operational visual aid to navigation, then refer to Classical Lens Maintenance, COMDTINST 16500.9 (series), for guidance on properly maintaining the lens. In either case, the State Historic Preservation Officer (SHPO) is usually involved as well.

Classical (Fresnel) Lens Disposition Flowchart

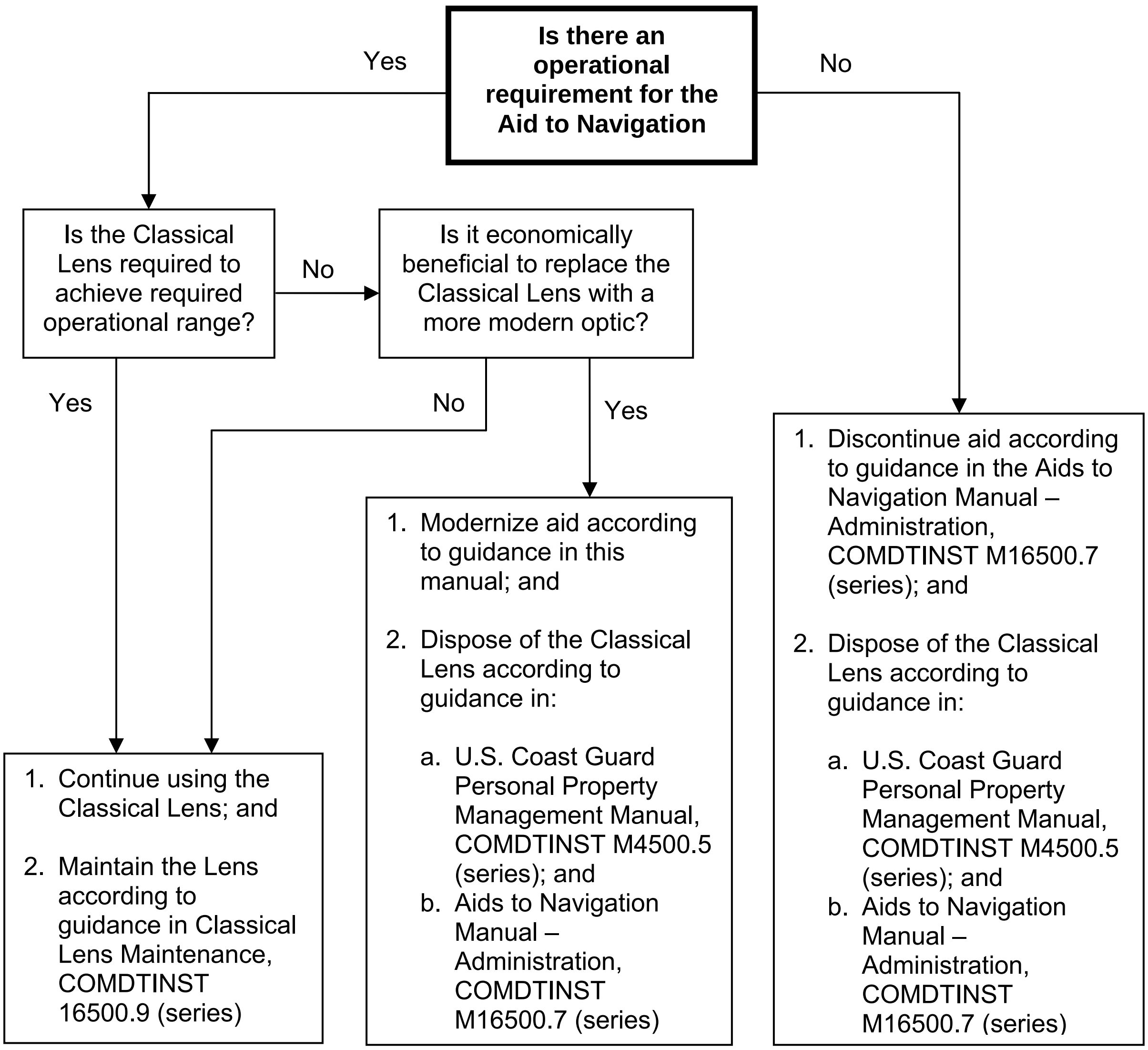


Figure 2-1

B. Standard 12VDC Solar Lighthouses.

1. Standard 12VDC Rotating Beacons. The standard 12VDC rotating beacon is the VRB-25. The VRB-25 is based on six bulls-eye lenses which rotate about a common focal point, producing up to six pencil beams. The lenses have a 180mm focal-length, making the dimension across the lens cage 360mm (14.2 inches). Lenses for the VRB-25 may be of any approved signal color, with blanking panels available to produce group flash characteristics.

   a. Rotation. The rotation speed is field selectable, ranging from 0.5 to 16 rpm, with a factory-setting of one rpm. Rotation detection is sensed for each half revolution to insure an appropriately timed signal is sent to monitoring equipment even for speeds as low as 0.5 rpm.

   b. Control. The VRB-25 may be ***externally-controlled***, using the standard 12VDC control hardware described later in this chapter, or it can also be ***internally-controlled*** using a standard CG-504 universal programmable flasher installed inside the beacon and with all standard 12VDC marine signal lamps, including the 110W lamp. Alternatively, when outfitted with lamps rated at 50 watts or greater, a CG-481 high-watt flasher may be used if one is available; and the old standard CG-493 programmable flasher may be used with lamps smaller than 50 watts.

2. Non-rotating Optics.

   a. LED Lanterns. New omnidirectional Light Emitting Diode (LED)-based optics can provide light outputs equal to (or greater than) the legacy 300mm & 250mm-based systems but use only a fraction of the power. In addition to requiring a smaller power system, a big advantage of using LED lanterns is the elimination of individual lamps, lampchangers, wiring kits, and flashers. LED lanterns are not programmed to a specific flash characteristic at the factory. The desired flash rhythm is usually programmed by the Coast Guard ATON unit before installation using the supplied programmer. For a new solar-powered installation, the Vega VLB-44 LED lantern is likely the best choice due to higher energy-efficiency and greater vertical divergence than a 300mm or 250mm legacy lantern. The VLB-44 lantern provides up to 15nm nominal range at 14,000 candela (color white, 8-tier, 2.5 degree lantern @0.74T). VLB-44 LED lanterns are available commercially directly from the manufacturer or may be available from Commandant (CG-432) (contact CG-432 by phone or email for more information).

      (1) Sector Lights. One shortcoming of omnidirectional LED lanterns is they cannot be easily configured for use as color sector lights. For sector lights, use legacy 300mm or 250mm lanterns or the new VSL-73 dedicated LED sector light manufactured by Vega. The primary reason standard omnidirectional LED lanterns cannot be configured for use as sector lights is because the light source in these lanterns are not point-source emitters: The light source in an LED lantern is usually made up of multiple individual LEDs configured concentrically

in a ring. Useful color sectors within this ring cannot be achieved without large vanes or shields due to excessive light "spillage" between adjacent and nearby LEDs. Even if an ultra-bright white LED can be configured to operate as a single point source emitter centered inside a legacy-type lantern, color sectoring will still not be possible due to the lack of a red or green light component emitted by a white LED to be useful. Unlike an incandescent lamp, a white LED does not emit the full color spectrum of light.

b. Legacy Lanterns. The primary non-LED omnidirectional legacy lantern is the 300mm marine signal lantern. The 250mm marine signal lantern may be used at sites requiring low-intensity light signals. These lanterns can be sectored and should be used if a low-cost color sector light is desired. However, if a single-color omnidirectional light is desired, the LED lantern described in the previous subparagraph should generally be chosen over these legacy lanterns due to the advantages that LED-based lanterns provide, which are lower power consumption and greater vertical divergence. The 300mm and 250mm lanterns are available commercially. Both of these lanterns use a molded acrylic Fresnel lens. Selection of a lantern for installation must include an evaluation of power dissipation (heat). The unvented version of the 250mm can safely dissipate only 75 watts continuous, while a vented version can dissipate up to 200 watts. The 300mm can safely dissipate 250 watts continuously.

3. Emergency Lights. In Cat I and II lighthouses, emergency lights serve as backup signals for the main lights and operate during main light failure. The flash characteristics of emergency lights are the same as that of the main lights but their intensities are usually reduced. When required, emergency lights shall be provided by standard 12VDC omnidirectional LED or legacy lanterns. For legacy lanterns, non-standard special-rhythm flashers may be special ordered from approved flasher manufacturers [contact Commandant (CG-432) for a list of approved flasher vendors].

4. Sound Signals. The standard sound signal for a solar lighthouse is the 12VDC-powered, 390Hz, omnidirectional, twin-emitter FA-232/02. The FA-232/02 generates an SPL (Sound Pressure Level, a measure of loudness) of 128.7 dBC, which corresponds to a usual audible range of one (1) nautical mile. A section of the horn may be plugged to convert it to a directional emitter. Aids to Navigation Manual – Technical, COMDTINST M16500.3 (series) provides information on this procedure. The FA-232, with an SPL of 122.7 dBC (½ nautical mile) may be used as the primary sound signal in areas where a reduced range is sufficient. If a greater audible range is desired, a four (4) emitter version of this sound signal, the FA-232/04, is available for aids which have an operational requirement for a two (2) nautical mile sound signal. All the FA-232's electronic subassemblies, including the oscillator, timer, and driver circuit cards, are mandatory turn-in 0C (zero cost) designated items, previously XB, (returnable to the Item Manager at SFLC under the ATON Product Line) for subsequent repair by C3CEN's ERF (Electronics Repair Facility) Branch at SFLC Baltimore. In the logistics world, the "0C" label (previously "XB") is a standard designation that tags the item as being repairable, replaceable, or recyclable for "zero cost" to the operational unit.

5. Emergency Sound Signals. In Cat I and II lighthouses, emergency sound signals serve as backup signals for the main sound signals and operate during main sound signal failure. The standard emergency sound signal is the 390Hz, omnidirectional FA-232, with an SPL of 122.7 dBC (usual audible range of one-half (½) nautical mile). Like the FA-232/02 signal, this horn may be converted to a directional emitter as well by plugging a section of the horn.

6. 12VDC Light Control Systems. DC-powered beacons may be externally or internally controlled. In a Solar Category I and II Lighthouse, external control is recommended when the main light has a 50W lamp or larger. External control of the main light is provided by the Solar Aid Controller II or III (SACII or SACIII) which performs both the lampchanging function upon lamp fail sense and also the daylight control operation via a standard Type L photoresistor. This includes both legacy lights, such as the VRB-25 rotating lantern, and all LED-based main lights; however, the exception is that with LED lanterns, the lampchanging function is obviously not required. For legacy rotating lanterns with lamps smaller than 50W in all lighthouse categories, internal control is preferred and performed by a flasher mounted inside the beacon. The flasher provides voltage regulation for the lamp and the lampchanging drive signal (or the F-pulse) to the lampchanger upon lamp fail sense; a standard Type L photoresistor connected to the flasher but mounted outside the beacon provides the daylight control operation. For LED lanterns, complete internal control is provided by its own on-board control electronics; however, when using an LED lantern in a Solar Category I or II Lighthouse, its internal daylight sensor must be disabled to allow the SACII (or SACIII) to provide the daylight control operation (external control). Solar Category III Lighthouses are always internally controlled. The equipment discussed here is for control of the light signal itself, and is not part of the Aid Control and Monitor System (ACMS). It does, however, provide the inputs to the ACMS for remote monitoring of the signal status, if one is present.

   a. Solar Distribution Box (SDB). In a Category I and II lighthouse, an SDB is needed not only to distribute 12VDC power to multiple aid loads, but also to manage the power system to ensure that the emergency battery connects during main battery failure. As such, the SDB selects between main and emergency batteries. There are two voltage monitoring circuits in the SDB: the first monitor circuit posts a low voltage alarm when the main battery State of Charge (SOC) drops to approximately 40% (11.5 volts), and the second circuit activates a load transfer relay in the event main battery voltage continues to drop and falls below 20% SOC (11.0 volts), which is considered main battery failure. If the main battery fails, or reaches a 20% SOC, the loads, with the exception of the main light and sound signals, are switched to the emergency battery. The main light and sound signals are taken off line to reduce the burden on, and therefore to extend the operating life of, the emergency battery. If and when the main battery is able to recharge to 12.75 volts, the SDB will switch all loads back to the main battery, including the main light and main sound signals. The SDB also provides a mounting location for up to two Solar Aid Controllers (SACs II or III); one for the light signals and one for the sound signals.

b. Solar Aid Controller II or III (SACII or SACIII). A SACII or SACIII is used to control and monitor the operation of DC powered aids to navigation signals, including LED-based lanterns, in Category I and II Solar Lighthouses. However, as discussed earlier, when using an LED lantern in a Solar Category I or II Lighthouse, its internal daylight sensor must be disabled to allow the SACII (or SACIII) to provide the daylight control operation. The SACIII has a few improvements and some new features over the older SACII. However, the SACII is still a perfectly valid controller and should not be replaced as a matter of routine action. If the primary aid malfunctions, the SACII (or SACIII) provides a signal to indirectly control the secondary aid. In addition, if the SDB switches the loads to the emergency battery, the SACII (or SACIII) will note a "failure" of the main light and main sound signals, and, after a brief delay, will activate the emergency signals. The SACII (or SACIII) also accepts the output from a Type L photoresistor to provide daylight switching for both main and emergency lights, and transmits signal status to the ACMS, when installed. Similarly, the SACII (or SACIII) accepts the output from a fog detector, if installed, to control the operation of the sound signals.

c. Equipment Interconnections. Standard drawings and diagrams for lighthouse systems consisting of an SDB, SACII (or SACIII), VRB-25, and an emergency light are available on Commandant (CG-432) website (http://www.uscg.mil/hq/cg4/cg432/) in the Drawings listing under Products & Services for the Signal & Power Team, Commandant (CG-432A).

d. Flashers, CG-493 / CG-481 / CG-504. The CG-493 & CG-504 programmable and CG-481 high-watt flashers are used for internal control of 12VDC signals in legacy VRB-25, 300mm, and 250mm lanterns. The CG-504 or CG-481 is used with lamps rated for 50 watts or more. A CG-504 or CG-493 flasher programmed for fixed-characteristic may be used for internal control of rotating 12VDC beacons.

e. Daylight Control. All solar powered aids should be daylight controlled with a Type-L, C, or R photoresistor so as to conserve battery power. A Type L photoresistor is used with rotating beacons and with LED beacons that are externally controlled. Internally-controlled rotating beacons should also use a Type L photoresistor, but the photoresistor must be mounted in a suitable location outside the beacon. For the non-LED omnidirectional legacy beacons (300mm & 250mm), a Type C photoresistor is used with clear or yellow lenses, while a Type R is used with red or green lenses in a Solar Cat III or Cat V lighthouse.

7. Sound Signal Control Systems. FA-232 sound signals have integrated timer cards and can be connected directly to power without auxiliary control equipment. However, if the sound signal must be remotely monitored or is backed up by an emergency sound signal, an SDB and SACII (or SACIII) are required. The same SDB as that controlling the main and emergency lights should be used, as it provides mounting and connections for both a SACII (or SACIII) to control the light and a SACII (or SACIII) to control the sound signals.

a. Fog Detectors. Although not encouraged for installation at solar powered lighthouses due to their large power demands, fog detectors, which are used primarily to reduce noise complaints from fog horns, can be used to control sound signals but their use will increase the size of the solar array by several panels and the size of the battery by several hundred amp-hours. For fog detector load profile data, refer to the Solar Design Manual, COMDTINST M16500.24 (series) or contact Commandant (CG-432) or the SRAN Product Line manager at C3CEN.

(1) VM100 Fog Detector. The standard VM100 fog detector uses the principle of atmospheric backscatter of light to measure the visibility for a given optical path. It consists of a light projector, a receiver, amplifiers, and support circuitry to interpret the measured backscattered light. The VM100's projector and receiver tubes are aligned horizontally. VM100 Electronic Assemblies are available from Commandant (CG-432) for new installations; the assemblies are designated as 0C (XB) items which indicate that when failures occur the discrepant hardware can be sent to C3CEN's Electronics Repair Facility (ERF) Branch at SFLC Baltimore for cost-free repairs. Units may obtain VM100 installation kits for new installations from Commandant (CG-432) as well. Ensure that all the latest Field Changes have been implemented in each VM100 fog detector in your AOR by checking the SRAN field change listing for the VM100 at the following C3CEN Webpage: http://cgweb.lant.uscg.mil/c2cen/fc.htm#sran. The VM100 should be installed on a concrete pad such that its projector and receiver tubes point between North Northwest (NNW) and North Northeast (NNE) (equivalent to 22.5º of True North). In general, fog detectors should be used only when local or remote control of the sound signal is not possible. Before installing a fog detector as a response to noise complaints, attempts should be made to reduce the sound signal's audible intensity (loudness) in sensitive areas by plugging the emitter or placing the emitter in a baffle. These procedures are described in Aids to Navigation Manual – Technical, COMDTINST M16500.3 (series). The VM100 is delivered with the sounding point set for four (4) nautical miles of visibility; however, the sounding point is adjustable. The VM100 Technical Manual can be found listed under Manuals/Operating Manuals for SRAN at the following C3CEN Webpage: http://cgweb.lant.uscg.mil/c2cen/manuals.htm#sran.

b. Emergency Sound Signals. For configuration drawings of an FA-232/02 with an emergency sound signal, SDB, and SACII (or SACIII), refer to the Drawings listing under Products & Services for the Signal & Power Team, Commandant (CG-432A) on the Commandant (CG-432) website (http://www.uscg.mil/hq/cg4/cg432/). If the aid is already equipped with a fog detector, it will control the operation of the emergency sound signal as well during main sound failure.

c. User-Activated Sound Signals. The Coast Guard standard user-activated sound signal controller system developed by C3CEN is the Mariner Radio Activated Sound Signal (MRASS). Additionally, a similar but commercially available user-activated remote control system has been successfully used in D1, D9, D11, and D13 (this commercial system has been adapted for maritime use from a controller originally designed for airport runway lighting). A sound signal operated by either of these controllers can be commanded on remotely by anyone with a standard marine-band VHF communications transceiver. These systems are comprised of a controller/receiver box installed near and connected to the sound signal to provide a dry contact closure to turn on/off the sound signal. The user activates the sound signal remotely by selecting a predetermined channel published in the Light List on their VHF marine band radio transceiver radio and then keying the microphone five times in quick succession. If the sound signal is within radio range of the transmitter, it will turn on within ten seconds and remain on for forty-five (45) minutes. However, the on-time of the sound signal can be custom selected on MRASS. On-times of 15, 30, 45, and 60 minutes are available. After this pre-selected on-time period has elapsed the sound signal turns off and assumes standby mode awaiting the next sound signal activation command. The power consumption of the MRASS is 190mA at 12VDC.

d. Remote Radio Activated Sound Signal (RRASS) Control. The RRASS, a new remote controlled sound signal system, is available for locations where a single controller (that is, either a fog detector or a manually-operated on/off switch) is desired to control the on/off operation of one or two remote sound signal(s) in a local region. It can also be used to remotely control light signals (such as bar lights). The RRASS system consists of at least two RRASS controller boxes, one at the master controller (e.g., fog detector, or manual switch) called the Control Unit (CU) and one at each remote sound signal called the Receiver Unit (RU). Up to two RUs can be controlled by one CU. Each RRASS unit consists of a Single Board Computer (SBC) housed in an environment-proof container along with a VHF transceiver/modem. This remote control system can also be installed in any lighthouse category to operate remote sound or light signals. The RRASS CU and RU systems will periodically communicate as part of a "handshake" function. If the RU fails to receive the "handshake" communications from the CU, the RU will energize the interconnected sound or light signal as part of its failsafe capability. The interval between handshake communications is programmable to 15, 30, 45, or 60 minutes. Up to 8 RRASS CU and RU pairs can be co-located in the same geographic area and configured to operate independently of each other. The power consumption of the RRASS RU is 235mA nominal at rest and 1174mA (for about 10 seconds) during the transmit cycle (happens once an hour). The RRASS CU consumes 355mA nominal. For more detailed information on the RRASS system, visit the C3CEN SRAN webpage: http://cgweb.lant.uscg.mil/c2cen/SRAN.htm and link over to the RRASS' tech manual which is listed under the Manuals/Operating Manuals weblink (http://cgweb.lant.uscg.mil/c2cen/Files/1SG38RRASStech_man.pdf). Both RRASS and MRASS hardware is designated 0C (XB) which indicates that when failures occur the discrepant hardware can be sent to C3CEN's Electronics Repair Facility (ERF) Branch at SFLC Baltimore for cost-free repairs or replacement.

8. RACON. Radar Beacons, or RACONs, provide an all-weather radio navigation signal at any 12VDC lighthouse, including solar. RACON system description, performance standards, and maintenance requirements are covered in detail in the Electronics Manual, COMDTINST M10550.25 (series). The current Coast Guard standard RACON is The

SeaBeacon® 2 System 6 RACON manufactured by Tideland Signal Corp. which provides the mariner information in the form of a coded trace on the radar screen that can readily be identified as specific to a particular RACON. The coded trace identifies and fixes the position of the RACON with respect to other targets. The RACON installation manual can be obtained by following the link on C3CEN's webpage: http://cgweb.lant.uscg.mil/c2cen/manuals.htm#sran. For 95% of all RACON locations, the average input power is 90mA at 12VDC (based upon a typical heavy vessel traffic area).

a. General Operation. The SeaBeacon® 2 System 6 RACON is an all-weather aid to navigation that operates in response to radar pulses, both X-band and S-band. The RACON is a form of transponder in that it receives a radar pulse from interrogating radar and replies to that pulse with a coded response. The presence of that response on the radar display provides the mariner precise information regarding the identity and location of the RACON. The RACON can be used to provide range and bearing information to nearby vessels and to vessels that are up to fifteen (15) nautical miles away. The S-band has a longer useful range due to its smaller weather return component compared to the X-band. The X-band, on the other hand, provides a greater weather return signature on the radar display which may be more desirable for some users. The SeaBeacon® 2 System 6 RACON is frequency agile, which means that it can respond at the same frequency as the pulse from the interrogating radar. Moreover, the length of the coded RACON response on the radar display is scaled to be proportional to the radar pulsewidth. Digital signal processing techniques employed in the SeaBeacon® 2 System 6 RACON design enable the RACON to reply to several hundred vessels simultaneously.

9. Remote Control and Monitor Systems. The standard remote control and monitoring system for use with Coast Guard aids to navigation is the Aid Control and Monitor System (ACMS) made by Tideland Signal Corporation. The ACMS is designed to provide 24-hour monitoring and control to remote unmanned navigational lights, sound signals, intrusion alarms, fire alarm and protection systems, flood detection systems, etc. The centralized ACMS Master Unit (MU) is usually located at a Coast Guard Sector office and/or an Aids to Navigation Team shop. Some MU's are shared between units such as an ANT during the day and the Sector office at night to assure 24-hour personnel coverage. MU's can monitor several remote locations at a time. The Remote Monitor and Control Unit (RMCU), comprised of the MC-1 single board computer, is installed at the lighthouse and serves as the interface between the ACMS system and all the signal and control hardware at the lighthouse. For details on design, installation, and maintenance, contact C3CEN's SRAN Product Line via the SMEF Desk at 757-686-2156 and/or refer to the 1SG38-ACMS User's Guide, published by C3CEN and available online at http://cgweb.lant.uscg.mil/c2cen/manuals.htm#sran. The ACMS remote MC-1 unit's average power consumption is 90mA at 12VDC. Other useful ACMS-related manuals and documents are listed immediately after the 1SG38-ACMS User's Guide as well.

C. Simplified Commercial-Powered 12VDC-Signal Lighthouses. The entire discussion in paragraph B above applies to this paragraph except that electrical power is supplied to the Solar Distribution Box by the standard ATON High-Watt Power Supply (HWPS) instead of solar power. Although these simplified commercial-powered lighthouse configurations are considered to be nominally a 12VDC system, the output of the HWPS must be adjusted to 14VDC in order for the power monitoring circuits of the Power Supply Monitor Box (PSMB) to operate properly – the HWPS is shipped from the factory with output voltage set to 12.5VDC. To ensure proper SDB operation during power outages, the HWPS's power feeder must first run through the PSMB before supplying the SDB. The PSMB continuously monitors the HWPS's output voltage and when commercial power failure is detected, it immediately provides 10.5VDC to the SDB's voltage-monitoring circuits to enable the system to operate under emergency conditions (same as when the main battery fails in a large solar-powered system). The circuits of the PSMB are continuously powered by the auxiliary battery; therefore, the health and state of charge of the auxiliary battery is critical for proper system operation during a commercial power outage. A diagram of this system is available as standard drawing 130426, Commercial Powered Category I-III 12VDC Lighthouse System with Emergency Signals, and can be viewed and downloaded from the Commandant (CG-432) website (http://www.uscg.mil/hq/cg4/cg432/) in the Drawings listing under Products & Services for the Signal & Power Team (CG-432A). A detailed theory of system operation and notes contained in the first page of this drawing fully explain the need for and the operation of the PSMB.

CHAPTER 3. POWER SYSTEMS

A. General. Electrical power systems on lighthouses have a primary influence on signal reliability. Therefore, power system selection and design (for solar-powered systems) is important.

B. Power System Choice. The decision on which power source to use for lighthouses, solar or commercial, is quite simple:

1. Shore Aids – Commercial Power. The preferred power source for a shore lighthouse is commercial power. Generally, the reliability and economy of this power source cannot be matched by any alternative system, even solar.

a. Availability. The availability of commercial power must be measured in order to determine if a backup power source is required. A power utility that experiences many failures, but corrects them in seconds is more desirable than a utility that experiences few failures, but takes days to repair. In general, if a utility has power availability of greater than or equal to 99.9 percent, no backup power is required unless the aid is determined by the program manager to be highly sensitive. Power availability is calculated by:

$$\text{Availability (\%)} = \frac{100\ \text{MTBF}}{(\text{MTBF} + \text{MTTR})}$$

Where: MTBF is the mean time between failures;
MTTR is the mean time to repair (units same as MTBF).

To determine MTBF and MTTR, District Offices and Civil Engineering Units (CEUs) should study utility company records. The time and duration of outages should be tabulated for at least three years, if possible. Where such historical data cannot be obtained, a data recorder, available through most electronic equipment rental centers, should be installed at the intended point of service for six to twelve months to obtain meaningful data.

b. Accessibility. If the aid is commercially powered, but significant lengths of feeders are buried or where overhead wires are not readily accessible, ensure that backup battery power is provided. In simplified Cat I and Cat II commercial-powered lighthouses, the emergency NiCad backup battery may be charge-maintained by either an emergency solar panel, if feasible, or by a 12VDC battery charger. In extremely unreliable commercial power service locations, the use of an external Uninterruptible Power Supply (UPS) may be required. But locations with extremely unreliable commercial power service are prime candidates for conversion to solar power (see Figure 3-1).

2. Shore Aids - Solar Power. An aid with reduced signal capacity, e.g., 10-mile (nominal) light, ½- mile sound signal, and 15-mile RACON, may be powered with a solar power

system. As discussed above, this should not preclude the use of commercial power, if available and reliable. Pre-existing commercial powered aids considered for conversion to solar power must satisfy the criteria set forth in Figure 3-1.

a. Sizing Programs. Solar sizing computer programs, readily available from Commandant (CG-432)'s website under Pubs/Software, should be used to determine array and battery size in order to determine if currently available hardware exists to power the aid. A copy of the printout should be provided in the project documents.

b. Site Survey. A site survey is required to determine whether the array can be installed in the desired orientation to facilitate servicing, protection from vandalism, and protection against shading. Transportation of the batteries to the lighthouse and an adequate shelter, with emphasis on floor loading capabilities, are required as the cells (battery) used in these systems are extremely heavy and fragile. Consult manufacturers' literature for physical characteristics of battery systems.

c. State Historic Preservation Office. The State Historic Preservation Officer (SHPO) should be notified of the intent to install a solar array and conversion or removal of the current optic at a lighthouse to solar power. Solar arrays generally take up a lot of space and will change the visage of a lighthouse site; however, new LED-based lanterns which require considerably less energy to operate use smaller and less obtrusive, and in many cases much smaller and obtrusive, solar arrays.

3. Offshore Aids - Solar Power. An aid with reduced signal capacity, e.g., 10-mile (nominal) light, ½-mile sound signal, and 15-mile RACON, may be powered with a solar power system. This should not preclude the continual use of commercial power via submarine cable, if one is present, has proven to be reliable, and solarization is not possible; however, resources to service sub-cable have become almost non-existent and current policy is to discontinue sub-cable use if and when an acceptable solar power system is achievable.

CRITERIA FOR CONVERTING A 120VAC LIGHTHOUSE TO SOLAR POWER

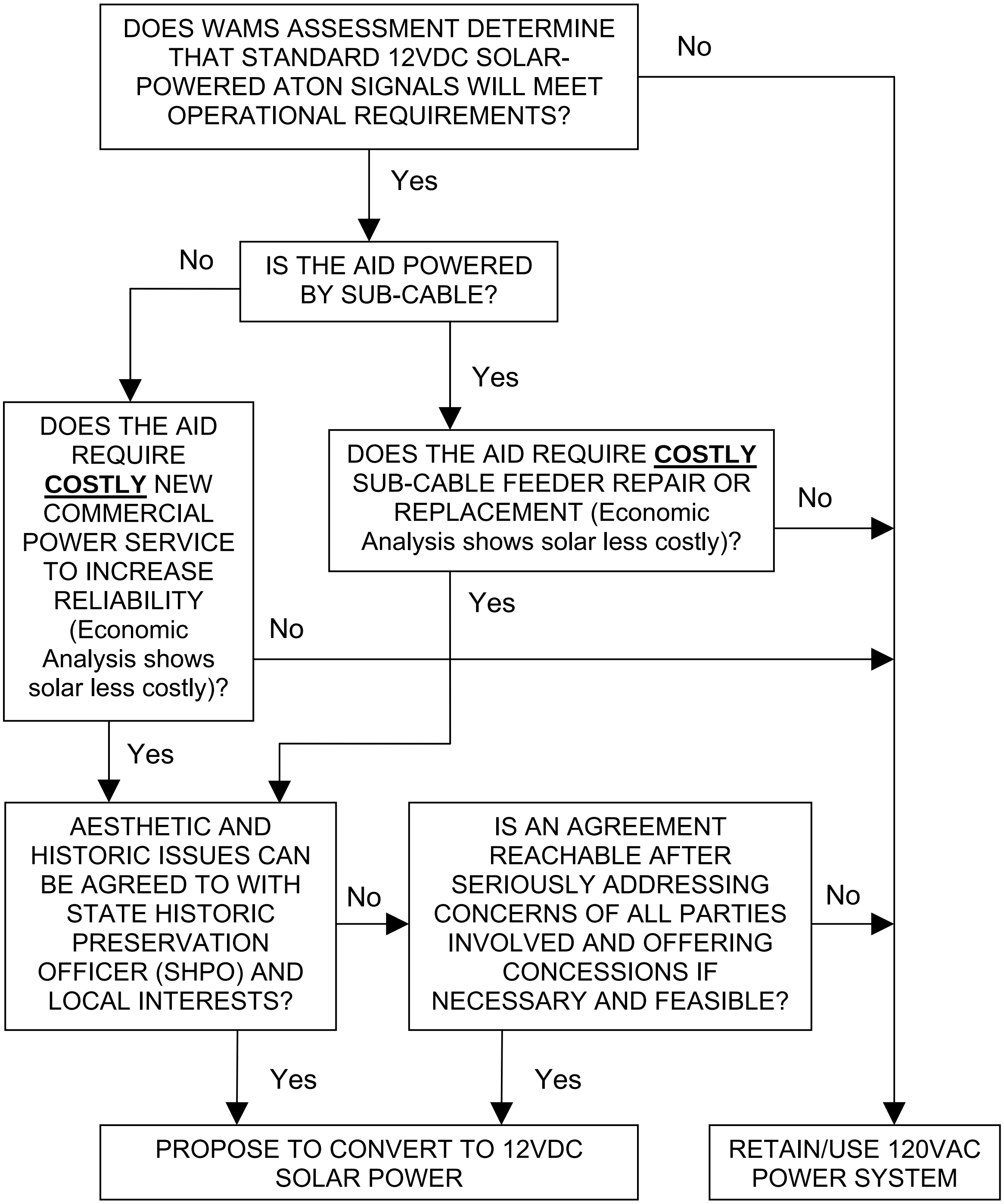


Figure 3-1

C. Economic Analysis of Power Source.

1. Determination of Service Life of Solar Power Systems. The estimated service life of large photovoltaic systems, based on manufacturers' predictions and experience to date, is 20 years for solar panels and 10 years for batteries.

2. Determination of Average Annual Maintenance Cost and Net Present Value. The cost estimating form for solar power system average annual maintenance (Figure 3-2) is provided to assist in identifying and evaluating annual maintenance costs. Input to this form must be based on the District's operating experience in the area under consideration. The present value analysis for a solar power system (Figure 3-3) assists in developing the Net Present Value (NPV) and equivalent Uniform Annual Cost (UAC) for solar power systems.

D. Solar Power Systems. When the requirements of Figure 3-1 are met, a solar power system may be installed at an aid. The components used in large solar power systems are in many cases the same or similar to minor aid hardware. The array usually consists of standard 40 watt or 35 watt (old) solar modules, or high-density 54 watt or 43 watt (old) modules, a large lead-acid battery and a solar charge controller. Standard drawing 140410, available under the Drawings listing under Products & Services for the Signal & Power Team on the Commandant (CG-432) website (http://www.uscg.mil/hq/cg4/cg432/), depicts a typical large solar powered lighthouse. Commandant (CG-432) can provide assistance in designing large solar power systems using the Solar Design Spreadsheet computer program. Additional information on hardware used at solar powered lighthouses is detailed in the Aids to Navigation Manual – Technical, COMDTINST M16500.3 (series). With the exception of solar panels and batteries, all of the following equipment is available from Commandant (CG-432) as free issue:

1. Main Solar Array. The solar array is sized to maintain a minimum of 80% state of charge on the battery during winter months and fully charged at all other times. The array is sized based on the actual output of solar panels. However, since the charging system is regulated by a charge controller, we can safely design for an 80% minimum state of charge based on autonomy of 10 to 14 days. Solar panels used for installations are standard 40 watt units available from the SFLC Baltimore using standard MILSTRIP procedures. A limited number of higher-density 43 and 54 watt units are available free-issue from CG-432A for use on small platforms or where State Historic Preservation Offices (SHPO) object to large array structures; however, these modules do not fit the standard bolt pattern nor do they have the robustness of the standard marine module. For these reasons these panels are not recommended for offshore use. The array support structure should be designed by the CEU. The structure should be large enough to accommodate a few additional solar panels for system flexibility. The structure should be designed to survive a 100-year storm. The structure must be designed so that servicing personnel can easily and safely access all of the solar panels from the front and back of the array at all times.

2. Standby Solar Panel. The standby solar panel charges the standby battery and keeps it fully charged until it is needed to power the emergency signals. The solar panel can be mounted on the support structure of the main solar array or on a separate mounting stand. The standby solar panel is different from the main solar panels in that it produces a higher output voltage to effectively charge the NiCad battery. The solar panel approved for use with emergency batteries is the SW50A made by SunWize. Previously-approved solar panels were Siemens Solar's SM50-H and M75. A blocking diode is not installed in these panels as this function is available in and performed by the Solar Distribution Box (SDB); however, bypass diodes may already be installed in some of these solar panels. These bypass diodes have no effect on our solar systems and so they may be left alone (preferred) or removed. In higher-voltage more-complex solar arrays, a bypass diode is necessary to pass electrical current unimpeded through a shaded solar panel(s). For our nominal 12VDC solar arrays, bypass diodes are neither beneficial nor detrimental.

3. Local Terminal Boxes. Local Terminal Boxes (LTB's) are enclosures containing terminal strips used to combine the inputs of up to ten solar panels if wire runs are very short. The LTB should be installed close to the group of panels feeding it, thereby keeping the wire run from each solar panel as short as possible. A limited number of LTB-d's (that is, with blocking diodes) are available from Commandant (CG-432) for use with the HD (high-density) 43 and 54 watt solar panels that contain no blocking diodes.

4. PV Combiner Box. The PV Combiner Box (PVCB) combines the inputs from all of the LTB's, and provides fuse and lightning protection. The output is divided up (usually evenly) into three strings to feed the solar charge controller. The PVCB is typically located on or near the array to keep wire runs from the LTB's as short as possible.

5. Solar Charge Controller. The Solar Charge Controller (SCC) prevents the battery from overcharging. The SCC has a 180-amp continuous charge current and a 60-amp continuous load current capability. The three outputs from the PV Combiner Box feed the solar charge controller's three array inputs; all three are controlled by mercury contact relays that open when predetermined battery voltages are reached. A battery temperature probe is included with each solar charge controller to ensure that proper battery charging is carried out in all seasons and under all ambient temperatures.

6. Range Power Box. The Range Power Box (RPB) is a small charge controller typically used for solar powered ranges; however, it can be used at any smaller 12VDC solar powered aid system, including lighthouses, that has an array with up to ten solar panels. The RPB has a 30-amp continuous charge current and a 30-amp continuous load current capability. A battery temperature probe is installed in each RPB to ensure that proper battery charging is carried out in all seasons. The RPB is depicted in Commandant (CG-432) standard drawing no. 140414.

7. Cat V Load Center. The Cat V Load Center is a simplified power distribution box. It has one 12VDC power input and four output distribution branches each protected by circuit breakers. The Cat V Load Center is used in conjunction with the RPB at Category III solar powered lighthouses with no emergency signals or an emergency backup power

system (see standard drawing 140414). It's also used exclusively at all Cat V lighthouses for power distribution to the light signal and sound signal.

8. Main Battery. Rechargeable batteries for solar applications are generally procured on the open market from vendors providing products that meet specific salient features. Occasionally, a General Services Administration schedule will be available for certain battery types. Battery ordering information and guidance is provided in Aids to Navigation Manual – Technical, COMDTINST M16500.3 (series).

    a. Discharge Rate. Most batteries for commercial use are rated at the 8 or 20 hour discharge rate. Capacities of batteries used in photovoltaic systems are generally specified at the 100-hour discharge rate. As an example, a 12VDC, 100 amp-hour battery must be able to power a 1 ampere load for 100 hours.

    b. Battery Type. Batteries for major (greater than 400-ah) solar powered applications (main battery) are generally purchased as 2-volt cells. Six cells are needed for a 12-volt system. The minimum battery size (capacity) is calculated by the Solar Design computer program and is based on the maximum daily load and the desired autonomy (10-14 days typical). Batteries for these applications will typically last 10 years. The choice between liquid, gelled, or absorbed electrolyte depends on personal preference, the ability to transport cells, installation area, cost, and whether visual status of the internal condition of the battery is desired. For optimal charging and maintenance, both the Range Power Box's and the Solar Charge Controller's charge algorhythms are user-selectable to best match the battery type selected.

        (1) Wet Batteries. Wet batteries are the most forgiving and reliable; however, they must be installed on very stable platforms (monopoles are unacceptable). They require semiannual watering and the cases are quite fragile so the logistics of transporting the cells to their final location at the lighthouse is a consideration. The wet battery approved for use at a solar lighthouse is the Classic OPzS Solar from Exide; they are identical in construction to the discontinued Yuasa EI/EJ/FHGS cells and Fulman Solar.

        (2) Gelled and Absorbed Electrolyte Batteries. Alternatives to Classic OPzS wet batteries are gelled electrolyte imported from Germany (Sonnenschein Dryfit A600) and absorbed electrolyte (GNB Absolyte II). These types are spill-proof and can be stacked vertically if floor loading will allow. These batteries are limited to voltage checks as the electrolyte is immobile and cases are opaque.

    c. Electrolyte. Batteries undergoing a charge cycle will break down water in the electrolyte by electrolysis into hydrogen and oxygen. The degree of charging and overcharging will determine the amount of water lost. In wet type batteries, the water level can be monitored and a schedule established to re-water. In absorbed and gelled batteries, the same gassing process occurs, but cells usually have recombination caps which convert the gases generated back into water. However, these batteries have a safety valve that will vent when gassing is severe. Prolonged gassing of these cells will dry out the battery, which is undetectable and will lead to premature failure. This is why the charge set-points in solar charge controllers for absorbed and gelled batteries are more conservative (lower).

9. Standby Battery. When used with the SDB, the 12VDC standby battery drives the emergency signals when the main battery is disconnected temporarily due to low voltage.

   a. Battery Type. Nickel-cadmium (NiCad) storage batteries of the vented pocket plate construction should be used for the 12VDC emergency battery system. The battery system is comprised of 10 cells wired in series. Each cell is rated for approximately 90, 275, or 415 ampere-hours and has a nominal voltage of 1.2 volts. A list of vendors and salient features are available from Commandant (CG-432).

   b. System Autonomy. The emergency battery system must be capable of providing a source of 12VDC to operate the emergency signals for approximately 12 days; therefore, the size (capacity) of the standby battery should be chosen accordingly. Base the autonomy directly on the emergency signal load profile. Unique flash rhythms will require calculation of the average daily power consumption, as described in Aids to Navigation Manual – Technical, COMDTINST M16500.3 (series).

10. Battery Charging. A portable 12VDC engine-generator has been staged at selected support facilities to provide the initial freshening charge on the main battery and to recharge it if a failure occurs. The generator is diesel powered, weighs 120 pounds, is capable of providing 70 amperes continuous, 100 amperes maximum, with adjustable output voltage, and carries enough fuel for 24 hours of operation. Contact Commandant (CG-432) for the location of a portable e/g set nearest to your unit.

11. Wire Sizing. Properly-sized wires at any lighthouse are important, especially solar. Refer to the Solar Design Manual, COMDTINST M16500.24 (series), for detailed guidance. Additionally, a wire sizing program for lighthouses is under development. Like the wire sizing program for ranges, this program will determine correct wire sizes for given lengths in a lighthouse to keep voltage drops below maximum allowable values. The maximum allowable voltage drop values for solar lighthouses are 0.35 volts on the load side and 0.75 volts on the charging side.

E. Commercial Power Systems. When requirements of Figure 3-1 cannot be met and reliable commercial power is available, one of the following commercial power systems may be installed.

1. Category V. This is the simplest commercial power system available consisting of nothing more than the standard 12VDC ATON High-Watt Power Supply (HWPS), fed by a 120VAC commercial power feeder, operating a single standard 12VDC ATON light signal and a single standard 12VDC ATON sound signal via the Cat V Load Center power distribution box. There are no backup emergency signals or power sources.

2. Simplified Category I and Category II. Except for the solar power equipment, simplified Cat I and Cat II commercial-powered lighthouse systems use the same 12VDC power distribution, control, monitor, and signal hardware as that used in standard solar-powered lighthouses (see Commandant (CG-432) standard drawing 130426).

   a. Main Power Source. For these commercially-powered 12VDC nominal installations, the standard 12VDC ATON High-Watt Power Supply (HWPS) is the primary power source but with its output voltage adjusted to 14.0 volts dc.

   b. Main Power Monitoring. A Power Supply Monitor Box (PSMB) is required to continuously monitor the HWPS's output voltage (14VDC) and ensure proper system operation during inevitable commercial power outages.

   c. System Description. All the paragraph D discussions above on topics unrelated to the primary solar-power equipment, such as wire, terminations, the standby solar panel, and the standby battery, apply here as well. However, regarding wire sizing and maximum allowable voltage drops, only the 0.35 volts maximum voltage drop for loads apply here; the 0.75 volts maximum allowable voltage drop requirement for the charging side is eliminated since there is no primary charging system in these commercial-powered configurations.

   d. Standby Battery Charging. An alternative to the standby solar panel for charging the standby battery is the 12VDC battery charger. If a battery charger is required, usually due to insufficient charging capability of a standby solar panel in certain northern geographical regions, one will be provided by Commandant (CG-432). The charger is designed to float charge NiCad or lead-acid batteries and is rated at a current of 25 amps. The charger has three sets of connections: AC input, DC output, and temperature sensing of the standby battery. It also has adjustments for "float" and "equalize" voltage levels and an equalizing timer. If using the battery charger in lieu of the emergency solar panel, connect the battery charger's plus (+) and minus (-) leads directly to the battery thereby completely bypassing the SDB.

Average Annual Maintenance Costs for Power Systems (Prepared:)		Aid Name & LLNR:
	Solar Power System	
	Trips	Cost
1. Regular Service		
2. Discrepancy Visits		
3. Solar Battery Change-Out		
4. Crew Preparation Shoreside		
5. Utility Costs		
6. Cable Failure Repair		
7. Other Miscellaneous Costs		
TOTAL SYSTEM COST		

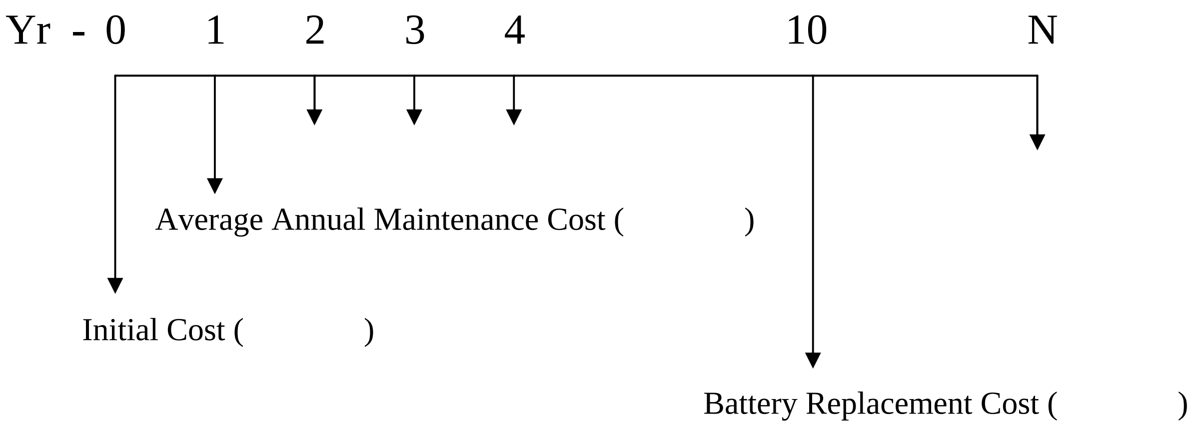
ASSUMPTIONS:

Figure 3-2

Cost Estimating Form for Power System Annual Maintenance

Aid Name: ____________________
Economic Life (N): ____________
NPV: _________________________
UAC: _________________________

Cost Flow Diagram:



Net Present Value (NPV) = **Initial Cost** + **Present Value** (PV) **of Average Annual Maintenance Cost** (AMC) + **Present Value** (PV) **of Battery Replacement Cost** (BRC)

OR

NPV = Initial Cost + PV(AMC) + PV(BRC)

Equivalent Uniform Annual Cost (UAC) = NPV / **Cumulative Sum Factor** (CSF) for Year N

Notes:

1. The initial cost is based on the materials labor costs to procure and install the solar power system. Actual costs will vary based on: size of the power system, availability of in-house industrial facilities, personnel and transportation costs, and how much site preparation is required.
2. Average annual maintenance costs (AMC) from figure 3-2.
3. Cumulative Sum Factor (CSF); pick factor for nth year.
4. Present Value (PV) of AMC = (AMC) x (CSF).

Figure 3-3

Solar Power System Cost Estimate

CHAPTER 4. PROCUREMENT AND MAINTENANCE OVERVIEW

A. General. This chapter provides a listing (including cost) of components needed to modernize and solarize lighthouses, suggests a maintenance organization, and outlines support details for certain equipment.

B. Procurement. Commandant (CG-432) centrally procures and stocks much of the standard components required to modernize and solarize lighthouses. Recurring procurements of this equipment are scheduled after review of the annual district and Civil Engineering Unit (CEU) modernization and solarization planning updates. No further action other than periodic update submission is needed to insure procurement. For a complete aids to navigation equipment listing, visit http://www.uscg.mil/hq/cg4/cg432/2a_equipment.asp.

1. Equipment Source. Centrally procured equipment for approved lighthouse projects can be obtained by email request to Commandant (CG-432). The remaining equipment and materials required are obtained by local purchase.

2. Equipment Listing. Tables 4-1, 4-2, and 4-3 are a comprehensive listing of equipment and material needed to assemble standard modern lighthouse systems. Approximate costs are included for use in computing total project cost estimates.

C. Maintenance. Maintenance of lighthouse aids consists of periodic on-site checks to insure that they are operating correctly; scheduled maintenance trips to perform preventive maintenance of the equipment, structures, and grounds; and response to monitored or reported discrepancies and outages. Major Aids to Navigation Preventive Maintenance System Guide, COMDTINST M16500.10 (series), spells out specific PMS procedures for all standard lighthouse equipment and hardware, which, when followed, will provide best system performance.

D. Support. The standard systems and equipment referred to in this manual are described in Aids to Navigation Manual – Technical, COMDTINST M16500.3 (series), and in standard Commandant (CG-432) drawings listed in the Ocean Engineering webpage under Products & Services (http://www.uscg.mil/hq/cg4/cg432/products.asp). Each component usually has a technical manual or data sheet shipped with it for use by installers and maintenance units. Table 4-4 lists parts and repair information for the lighthouse hardware that has proven to require the most maintenance and support.

1. Personnel Training. A lighthouse maintenance training course (ANC LT), course number 230470, is available from the NATON School at TRACEN Yorktown to train military and civilian personnel to assume responsibility for the maintenance and repair of lighthouse aids to navigation equipment. Additionally, technicians will learn about fog detector systems, ACMS systems, and administrative procedures. Companion NATON courses include Tower Climber Certification and Minor and Advanced Minor aids to navigation equipment maintenance.

Table 4-1

Power System Equipment Listing

Equipment	Source	Approximate Cost ($)
Wiring and Ducting	Local	Cost is site-specific
12VDC ATON HW Power Supply (HWPS)	CG-432	1,000
10 Watt Solar Panel	SFLC	200
20 Watt Solar Panel	SFLC	300
40 Watt Solar Panel	SFLC	400
Solar Distribution Box (SDB)	CG-432	1,500
Cat V Load center	CG-432	300
Solar Charge Controller (SCC)	CG-432	2,000
Range Power Box (RPB)	CG-432	500
PV Combiner Box (PVCB)	CG-432	500
Local Terminal Box (LTB)	CG-432	200
Power Supply Monitor Box (PSMB)	CG-432	500
54 Watt High Density Solar Panel	CG-432	500
43 Watt High Density Solar Panel	CG-432	300
SW50A Solar Panel (for NiCads)	Local	400
Classic OPzS Solar main battery	Local / GSA Contract	3,000 to 6,000
Sonnenschein and GNB Absolyte II main battery	Local / GSA Contract	4,000 to 7,000
Saft America Sunica-Plus series NiCAD battery	Local	4,000
Battery Charger, for NiCads	CG-432	500

Table 4-2

Signal Control System Equipment Listing

Equipment	Source	Approximate Cost ($)
Wiring and Ducting	Local	5,000
VM100 Fog Detector	C3CEN	5,000
RRASS	C3CEN/SFLC	1,900
MRASS	C3CEN/SFLC	1,200
Solar Aid Controller II or III (SACII or SACIII)	CG-432	100
Sound Signal Current Detector (SSCD)	CG-432	100
ACMS System Hardware and Spare Parts	C3CEN	Cost dependent on number of monitored sites

Table 4-3

Signal System Equipment Listing

Equipment	Source	Approximate Cost ($)
VRB-25 Rotating Beacon	CG-432	6,000
300mm Lantern	Local	1,000
250mm Lantern	Local	1,000
VLB-44 LED Lantern (single tier)	Vega/CG-432	1,500
CG-504 Universal Flasher	SFLC	150
CG-493 Programmable Flasher	SFLC	100
CG-481 HW Flasher	SFLC	100
CG-6P Lampchanger	SFLC	100
HW CG-6P Lampchanger	SFLC	200
FA-232 Sound Signal (single)	C3CEN	5,000
FA-232/02 Sound Signal (dual)	C3CEN	10,000
RACON, System 6	SFLC	22,000

Table 4-4

Lighthouse Equipment Support Overview

Equipment	Parts Support
Battery Chargers	Local purchase of parts and repair from manufacturer
VM100 Fog Detector	Spare parts provided, entire unit 0C (XB) repairable by C3CEN’s Electronics Repair Facility (ERF) Branch at SFLC Baltimore
VRB-25 Rotating Beacon	Stator and Calc-20 are 0C (XB) repairable by C3CEN’s ERF Branch at SFLC Baltimore
FA-232 Sound Signals	Constituent electronic circuit card assemblies 0C (XB) repairable by C3CEN’s ERF Branch at SFLC Baltimore
ACMS Equipment, including Modem and Radio Link Hardware	Spare parts provided, C3CEN depot level support
RACON, System 6	Unit replacements, mandatory return to C3CEN’s ERF Branch at SFLC Baltimore
HW ATON Power Supply	0C (XB) repairable by C3CEN’s ERF Branch at SFLC Baltimore
MRASS	0C (XB) repairable by C3CEN’s ERF Branch at SFLC Baltimore
RRASS	0C (XB) repairable by C3CEN’s ERF Branch at SFLC Baltimore