Naval Post Graduate School

Cohort 311-0912

Capstone Project

“A Systems Engineering Analysis of Energy Economy Options for the DDG 51 Class of U.S. Naval Ships"

DDG 51 Class Ship Survey

NAVFAC San Diego, CA

**Purpose**

To conduct an unclassified survey of specified shipboard technology within the Heating, Ventilation and Air Conditioning (HVAC) System, Auxiliary Systems, Lighting System and Outfitting and Furnishing, as well as, relating standard operational practices for energy efficiency opportunities in support of the data gathering process step of the capstone project on energy economy options for the DDG 51 Class.

**Objective**

To collect and assess existing and measured energy consumption data of specified shipboard technology on the DDG 51 Class Ship while in a pier-side loading condition and in cruise condition. The information gathered on the technologies (existing and future) and standard operating practices will be used to develop alternative energy economy options with improved efficiencies and war-fighting capabilities.

**Visit Duration**

5 days, May 24-28, 2010

**Survey Team & Responsibility**

1. Student A – Technical (Procedural)
2. Student B – Technical (Technology)
3. Student C – Risk
4. Student D – Human Systems Integration (HSI) & Photography
5. Student E – Technical (Technology)
6. Student F – Technical (Procedural)

**Information Gathering Sources**

1. Available Information – Logs, manuals
2. Interviews with Key DDG 51 Crew Members & NAVSEA
   1. Ship Chief Engineer
   2. Ship Electrical Plant Manager and/or Energy Officer
   3. Ship Engineers knowledgeable about operating and maintaining equipment
   4. Ship Environmental Engineers
3. Existing Ship Instrumentation
   1. Meters
   2. Gauges
   3. Other
4. Previous Research

**Survey Checklists to Complete**

1. Energy Survey Checklist – Appendix A
2. HSI Survey – Appendix B
3. Risk Survey – Appendix C

**Survey Questions**

1. What is the current mission / operational profiles of the ship while at sea in cruise winter condition? Shore winter condition?
   1. What would be considered the biggest energy savings under these conditions?
   2. Geographical operating locations?
   3. Transit Time, speed and distance?
      1. Does the CO have authorization to transit at less than top speed and if so, is that done in practice or typically always run at top speed when in transit?
   4. Cruise condition electric load?
   5. Shore condition electric load?
   6. How do you account for activity aboard ship? (i.e., Duty assignments within 8, 12 or 24 hour shift….etc.)
   7. Based on SPAWAR System Center, San Diego DDG 51 manning study, there are 8 ship operational areas; is the current manning profile consistent with that study to date?
      1. If not, what is the current manning profile and how is that number dispersed throughout the ship operational areas?
      2. What is the component breakdown of each operational area?
      3. How many personnel are assigned to each component?
      4. What are their duties/tasks to be performed?
      5. When are they performing their tasks / duties?
      6. What are the procedural aspects of their duties?
      7. How long are they performing their tasks/duties?
      8. What energy sources are necessary / required?
      9. How much or how long use is required?
   8. What is the workload overlap?
2. What is the total fuel usage and cost?
   1. Are fuel consumption curves available?
3. What is the average cost of shipboard delivered fuel?
4. How is fuel usage measured? (methods / instrumentation)
5. Are efficiencies measured, rated or estimated?
6. During what time of the day is energy loading the highest? Why?
7. During what time of the day is energy loading the lowest? Why?
8. What equipment on ship currently draws the largest electrical load?
9. What energy efficiency retrofits has the ship already completed?
   1. Do any include COTS replacements?
   2. Do any include energy star options?
10. What energy efficiency changes/improvements does the ship plan to complete; operational and procedural?
    1. What alternatives are being considered & schedule opportunities?
    2. What are the TRLs for such alternatives?
11. What energy efficiency strategies are currently being practiced aboard ship (ECON, engineering operations sequencing system manual EOSS?
12. Types of questions to ask on the GTGs – typical practices
    1. How many generators are usually running at any given time?
    2. At what capacity are the generators usually running?
    3. At what efficiency are the generators usually running?
    4. Are there safety/survivability issues you're aware of for running fewer generators (but at least one)?
    5. Under what conditions would you consider it safe to run with one generator?
    6. How many hours of maintenance do you spend on a generator besides what is required by the MRCs?
13. For Anchored ships and fuel consumption, what are the minimum loads for stand by only?
14. What is the energy usage while the ship is on shore-based power?
15. What is the granularity of your ability to measure energy usage?
16. How much power is fed to the ship from shore-base generation plants vs. How much power is coming from the ship's own GTGs when in pier-side
    1. Are ship services fully connected to the shore?
    2. What % of power fed to a ship from shore-based plants is petroleum based?
    3. What is the cost of power when connected to shore?
17. How long is a ship typically dock-side vs. at sea? (Scenario)
18. Are there records of emissions measurements?
    1. Types of emissions?
    2. Under what circumstances?
19. What are the "SHED" impacts...or issues...vulnerabilities...costs?
20. When less critical equipment is off what are the estimated savings?
21. From your experience aboard ship, while underway and / or in port what are some energy saving opportunities you think might be beneficial to consider?
22. How do you measure effectiveness?
23. Are there records of the volume or weight of waste generated by the ship and crew?
    1. How do these measurements change over the operating cycle

**DDG 51 System Focus**

Energy efficiency focus is on the following systems and associated equipment.

SWBS 514 HVAC Systems: SWBS 514

1. Pre-heaters
2. AC Compressor
3. AC Chill Water Pumps

SWBS 500 Auxiliary Systems: Sub-SWBS 521, 533, 541, 593

* 1. Fireman and Flushing Sea water Systems (Sea Water Services)
     1. Fire Pumps
  2. Potable Water
     1. Hot Water Heaters
  3. Ship Fuel and Fuel Compensating System
     1. Fuel Transfer Heaters
  4. Environmental Pollution Control Systems

SWBS 300 Electric Plant: Sub- SWBS 332

1. Illumination Systems

SWBS 600 Outfitting & Furnishing: Sub-SWBS 651, 655

* 1. Commissary Spaces (Food Service Spaces)
     + 1. Ovens
       2. Dishwasher Heaters
  2. Laundry
     1. Dryers

**General System Questions**

* 1. What is the purpose of the equipment listed?
  2. Which would be considered the biggest energy consumer per existing/measured data?
  3. Are there any other areas that are not considered that contribute to a large percentage of energy consumption aboard ship?

**System Specific Questions**

**SWBS 514 HVAC**

* + - 1. General HVAC system questions
    1. Where is the HVAC plant located on the ship?
    2. What is the HVAC plant configuration?
    3. What codes does HVAC plant follow for plumbing, electric, mechanical, fuel gas– international, Navy?
    4. What are the (fuel) inputs for HVAC plant operations?
    5. What is the plants full capacity Vs actual energy loading?
    6. Does the HVAC system have Variable Volume Variable Temperature Boxes? Are they manual or automatic?
    7. What are the maintenance requirements for the overall plant?
    8. What are the parts inventory requirements for the HVAC plant?
    9. What is the HVAC plant contingency back-up plan in case of battle damage?
    10. What is the stress level of the HVAC operators – are they overworked, underpaid?
    11. How many shutdowns in a year does the HVAC plant go through? When and how long do the shutdowns last?
    12. What type of cooling liquid is used to cool the plant motors?
    13. How much is the vibration and acoustics?
    14. How is the indoor air quality of the current system?
    15. How is the ship compartments insulated? Type of material?
    16. Does the ship apply principles of zoned heating such as thermostats in various compartments; dampers inside the vents?
    17. Does ship have heat pump devices?
    18. Is the ship’s exhaust air used to reheat the utility water?
    19. Does ships use mix flow impeller fan (25% more efficient) or the traditional centrifugal exhaust fan?
    20. How is heat loss prevented?
        1. Pre-Heaters

1. What types of pre-heaters are installed aboard ship? Where located?
2. What is the rated efficiency?
3. What is the operating efficiency?
4. What type of energy is used to operate units?
5. What is the measured energy consumption?
6. Are heaters baseline technology or new energy efficiency upgrade?
7. What are the governing standard operating procedures for the equipment?
   1. Are there any deviations from the standards currently being practiced?
   2. What are the manning requirements for standard operation?
   3. Has anyone modified the equipment in any way?
      1. If so, how?
8. How is maintenance addressed?
   1. What energy related resources are required for task performance?
   2. What are the manning requirements for maintenance?
   3. How much energy is consumed?
   4. What additional maintenance is done on equipment besides what is required by MRC’s?
   5. What is the reliability and availability of the equipment?
   6. What equipment do you consider redundant?
9. Is accessibility to equipment easy or difficult for repair or replacement?
   1. If so, how often does that equipment need to be accessed for repair or replacement?
10. What units are measurements expressed?
    * + 1. AC Compressor
11. What types of compressors are installed aboard ship? Where located?
12. What are the condensing and evaporative temperatures?
13. What type of refrigerant?
14. What is the motor RPM setting? Rated output?
15. Are all settings for the above consistent across the ship or vary?
16. What is the efficiency of the compressors? Partial and Full Load?
17. Can standard set of conditions above be adjusted for optimum efficiency, less use of energy?
18. Are compressors baseline technology or new energy efficiency upgrade?
19. What are the governing standard operating procedures for the equipment?
    1. Are there any deviations from the standards currently being practiced?
    2. What are the manning requirements for standard operation?
    3. Has anyone modified the equipment in any way?
       1. If so, how?
20. How is maintenance addressed?
    1. What energy related resources are required for task performance?
    2. What are the manning requirements for maintenance?
    3. How much energy is consumed?
    4. What additional maintenance is done on equipment besides what is required by MRC’s?
    5. What is the reliability and availability of the equipment?
    6. What equipment do you consider redundant?
21. Is accessibility to equipment easy or difficult for repair or replacement?
    1. If so, how often does that equipment need to be accessed for repair or replacement?
22. What units are measurements expressed?
    * + 1. AC Chill Water Pumps
23. What types of chill water pumps are installed aboard ship? Where located?
24. What is the rated efficiency?
25. What is the operating efficiency?
26. What type of energy used to operate units?
27. What is the measured energy consumption?
28. Are pumps baseline technology or new energy efficiency upgrade?
29. What are the governing standard operating procedures for the equipment?
    1. Are there any deviations from the standards currently being practiced?
    2. What are the manning requirements for standard operation?
    3. Has anyone modified the equipment in any way?
       1. If so, how?
30. How is maintenance addressed?
    1. What energy related resources are required for task performance?
    2. What are the manning requirements for maintenance?
    3. How much energy is consumed?
    4. What additional maintenance is done on equipment besides what is required by MRC’s?
    5. What is the reliability and availability of the equipment?
    6. What equipment do you consider redundant?
31. Is accessibility to equipment easy or difficult for repair or replacement?
    1. If so, how often does that equipment need to be accessed for repair or replacement?
32. What units are measurements expressed?

**SWBS 500 AUXILIARY**

**SWBS: 521 - Fireman and Flushing Sea water Systems (Sea Water Services)**

* 1. Fire Pumps

1. What type of fire pumps are installed aboard ship? Where located?
2. How many? Location?
3. How often used?
4. What is the rated efficiency?
5. What is the operating efficiency?
6. What type of energy is used to operate units?
7. What is the measured energy consumption?
8. Are pumps baseline technology or new energy efficiency upgrade?
9. Do you know of any special certifications (e.g., safety?) required for modification or replacement of the fire pumps?
   1. Special training?
10. What are the governing standard operating procedures for the equipment?
    1. Are there any deviations from the standards currently being practiced?
    2. What are the manning requirements for standard operation?
    3. Has anyone modified the equipment in any way?
       1. If so, how?
11. How is maintenance addressed?
    1. What energy related resources are required for task performance?
    2. What are the manning requirements for maintenance?
    3. How much energy is consumed?
    4. What additional maintenance is done on equipment besides what is required by MRC’s?
    5. What is the reliability and availability of the equipment?
    6. What equipment do you consider redundant?
12. Is accessibility to equipment easy or difficult for repair or replacement?
    1. If so, how often does that equipment need to be accessed for repair or replacement?
13. What units are measurements expressed?

**SWBS: 533 - Potable Water**

* 1. Hot Water Heaters

1. What types of water heaters are install aboard ship? Where located?
2. What is the current operating temperature and is it adjustable?
   1. How is hot water usage by crew governed?
3. Do any conform to the energy star?
4. Are there any retrofit/replacement opportunities underway? If so, what are the alternatives being pursued?
5. What percentage of energy is expected to be reduced by such changes?
6. What percent efficiency is expected to be gained?
7. What type of energy is used to operate units?
8. What is the measured energy consumption?
9. Are heaters baseline technology or new energy efficiency upgrade?
10. What are the governing standard operating procedures for the equipment?
    1. Are there any deviations from the standards currently being practiced?
    2. What are the manning requirements for standard operation?
    3. Has anyone modified the equipment in any way?
       1. If so, how?
11. How is maintenance addressed?
    1. What energy related resources are required for task performance?
    2. What are the manning requirements for maintenance?
    3. How much energy is consumed?
    4. What additional maintenance is done on equipment besides what is required by MRC’s?
    5. What is the reliability and availability of the equipment?
    6. What equipment do you consider redundant?
12. Is accessibility to equipment easy or difficult for repair or replacement?
    1. If so, how often does that equipment need to be accessed for repair or replacement?
13. What units are measurements expressed?

**SWBS: 541 - Ship Fuel and Fuel Compensating System**

* 1. Fuel Transfer Heaters

1. What types of heaters are installed aboard ship? Where located?
2. What is the rated efficiency?
3. What is the operating efficiency?
4. What type of energy is used to operate units?
5. What is the measured energy consumption?
6. Are heaters baseline technology or new energy efficiency upgrade?
7. What are the governing standard operating procedures for the equipment?
   1. Are there any deviations from the standards currently being practiced?
   2. What are the manning requirements for standard operation?
   3. Has anyone modified the equipment in any way?
      1. If so, how?
8. How is maintenance addressed?
   1. What energy related resources are required for task performance?
   2. What are the manning requirements for maintenance?
   3. How much energy is consumed?
   4. What additional maintenance is done on equipment besides what is required by MRC’s?
   5. What is the reliability and availability of the equipment?
   6. What equipment do you consider redundant?
9. Is accessibility to equipment easy or difficult for repair or replacement?
   1. If so, how often does that equipment need to be accessed for repair or replacement?
10. What units are measurements expressed?

**SWBS: 593 - Environmental Pollution Control Systems**

1. Is gray water measured? If so, how?
2. Is (weight or volume) of waste material measured? (Paint cans, cardboard, light bulbs, scrap metal...)
3. Under what conditions is material disposed of overboard?
4. Is soot or other pollutants measured? If so, what are they, how measured and under what conditions?
5. Is there a recycling program? What gets recycled? Is there compensation for recycling?
6. Are any of the recycled products used as alternative energy aboard ship? If so, for what applications and under what conditions?
7. For all of the above what are the results?
8. What is the ship hazardous waste process or what are the governing standard operating procedures for the equipment?
   1. Are there any deviations from the standards currently being practiced?
   2. What are the manning requirements for standard operation?
   3. Has anyone modified the equipment in any way?
      1. If so, how?
9. How is maintenance addressed?
   1. What energy related resources are required for task performance?
   2. What are the manning requirements for maintenance?
   3. How much energy is consumed?
   4. What additional maintenance is done on equipment besides what is required by MRC’s?
   5. What is the reliability and availability of the equipment?
   6. What equipment do you consider redundant?
10. Is accessibility to equipment easy or difficult for repair or replacement?
    1. If so, how often does that equipment need to be accessed for repair or replacement?
11. What units are measurements expressed?

**SWBS 300 Electric Plant**

**SWBS 332 – Illumination Systems**

1. What type of lighting is currently used aboard ship? Any special types?
2. Which types require frequent maintenance activity? (e.g., frequent failures)
3. Are there any retrofit/replacement opportunities underway for replacing lighting types and/or complete fixtures? If so, what are the alternatives being pursued? (e.g., LED, etc.)
4. What percentage of energy is expected to be reduced by such changes?
5. What percent efficiency is expected to be gained?
6. What are the governing standard operating procedures for the equipment?
   1. Are there any deviations from the standards currently being practiced?
   2. What are the manning requirements for standard operation?
   3. Has anyone modified the equipment in any way?
      1. If so, how?
7. How is maintenance addressed?
   1. What energy related resources are required for task performance?
   2. What are the manning requirements for maintenance?
   3. How much energy is consumed?
   4. What additional maintenance is done on equipment besides what is required by MRC’s?
   5. What is the reliability and availability of the equipment?
   6. What equipment do you consider redundant?
8. Is accessibility to equipment easy or difficult for repair or replacement?
   1. If so, how often does that equipment need to be accessed for repair or replacement?
9. What units are measurements expressed?

**SWBS 600 OUTFITTING & FURNISHING**

**SWBS: 651 - Commissary Spaces (Food Service Spaces)**

* 1. Ovens

1. What types of ovens are installed aboard ship?
2. What are the operational duty cycles? (e.g., 3 days a week or in use several times a day)?
3. Are there any restrictions on when ovens can be in use or must be secured?
4. Is there any guidance on minimum temperature set-points?
5. Are ovens baseline technology or new energy efficiency upgrade?
6. What are the governing standard operating procedures for the equipment?
   1. Are there any deviations from the standards currently being practiced?
   2. What are the manning requirements for standard operation?
   3. Has anyone modified the equipment in any way?
      1. If so, how?
7. How is maintenance addressed?
   1. What energy related resources are required for task performance?
   2. What are the manning requirements for maintenance?
   3. How much energy is consumed?
   4. What additional maintenance is done on equipment besides what is required by MRC’s?
   5. What is the reliability and availability of the equipment?
   6. What equipment do you consider redundant?
8. Is accessibility to equipment easy or difficult for repair or replacement?
   1. If so, how often does that equipment need to be accessed for repair or replacement?
9. What units are measurements expressed?
10. Dishwasher Heaters
11. What types of heaters are installed?
12. What are the operational duty cycle (e.g., 3 days a week or in use several times a day)?
13. Is temperature set-point fixed or controllable by an operator?
14. Are heaters baseline technology or new energy efficiency upgrade?
15. What are the governing standard operating procedures for the equipment?
    1. Are there any deviations from the standards currently being practiced?
    2. What are the manning requirements for standard operation?
    3. Has anyone modified the equipment in any way?
       1. If so, how?
16. How is maintenance addressed?
    1. What energy related resources are required for task performance?
    2. What are the manning requirements for maintenance?
    3. How much energy is consumed?
    4. What additional maintenance is done on equipment besides what is required by MRC’s?
    5. What is the reliability and availability of the equipment?
    6. What equipment do you consider redundant?
17. Is accessibility to equipment easy or difficult for repair or replacement?
    1. If so, how often does that equipment need to be accessed for repair or replacement?
18. What units are measurements expressed?

**SWBS: 655 – Laundry**

* 1. Dryers

1. What types of dryers are installed aboard ship?
2. Quantity?
3. What is the Capacity/Loading?
4. How often operated? Peak usage?
5. What are the maintenance schedules for the dryers?
6. What amount of energy is required for operation?
7. Are dryer’s baseline technology or new energy efficiency upgrade?
8. What are the governing standard operating procedures for the equipment?
   1. Are there any deviations from the standards currently being practiced?
   2. What are the manning requirements for standard operation?
   3. Has anyone modified the equipment in any way?
      1. If so, how?
9. How is maintenance addressed?
   1. What energy related resources are required for task performance?
   2. What are the manning requirements for maintenance?
   3. How much energy is consumed?
   4. What additional maintenance is done on equipment besides what is required by MRC’s?
   5. What is the reliability and availability of the equipment?
   6. What equipment do you consider redundant?
10. Is accessibility to equipment easy or difficult for repair or replacement?
    1. If so, how often does that equipment need to be accessed for repair or replacement?
11. What units are measurements expressed?

**APPENDIX A**

**NAVSEA ENCON ENERGY SURVEY CHECKLIST**

http://www.navsea.navy.mil/encon/checklist.htm.

**ENERGY SURVEY CHECKLIST FOR IMPROVED FUEL ECONOMY**

The purpose of this checklist is to assess whether the ship is following good energy conserving practices.

The energy survey check list below is generally applicable to all types of nonnuclear ships. It can be utilized by ship's command to identify the areas where a ship needs better energy conservation practices which will result in improved fuel economy.

1. Is energy conservation considered?
   1. When planning ship operations?
   2. When reviewing fuel and water consumption?
2. Is an energy efficient plant alignment consciously selected for each day's operations in accordance with the POG?
3. Are fuel consumption and economical speed curves maintained to reflect current performance?
4. Are reasonably current fuel consumption and economical speed curves posted on the bridge, engine room and fire room?
5. Are machinery alignment tables and fuel consumption tables available for development of fuel curve data?
6. Are fuel consumption and economical speed curves used for planning ship's daily operations?
7. Are a minimum number of evaporators operated when water supplies are adequate for mission to meet anticipated periods of peak demand?
8. Is the minimum number of ship service generators operated when the total electrical load is below 90 percent rated capacity of the generators in operation?
9. Is the minimum number of fire pumps used whenever possible? Are MD vice TD fire pumps operated when needed?
10. Is a machinery alignment status board conscientiously maintained?
11. Is permission obtained from EOOW for all equipment status changes?
12. Is EOSS validated, properly maintained, and routinely used?
13. Does ship attempt to operate at or near economical speed as much as possible during independent operations or long transits?
14. Does ship attempt to minimize speed change: whenever possible while maintaining station frequency and magnitude)?
15. Does ship use acceleration/deceleration tables?
16. Are all gauges critical to plant performance properly calibrated?
17. Does ship have personnel trained and certified in gauge calibration?
18. Does ship have an on-condition hull and propeller maintenance program (*e.g.*, when inspection determines need based on significant fouling)?
19. Does engineering department have a valve maintenance program?
20. Is there a program to minimize fresh water usage such as daily announcements for water conservation?
21. Are low flow shower heads installed and in good operating condition?
22. Are faucets in heads spring loaded or metering and in good operating condition?
23. Does ship minimize fresh water leaks throughout ship (e.g., laundry, showers, galley, etc.)?
24. Is there a program to promote electric load reduction?
25. Does ship secure electrical/electronic equipment when not required to meet ship operational requirements?
26. Is minimum number of A/C units operated when conditions permit?
27. Are A/C boundary doors in good condition and identified with posted signs?
28. Are light fixtures clean and well maintained?
29. Are lights turned off in unmanned spaces?
30. Is the insulation of piping in machinery spaces and throughout ship maintained in good condition?
31. Is crew responsive to maintenance requirements and the need to promptly correct deficiencies?
32. Are interdepartmental zone inspections conducted to uncover deficiencies such as leaks, missing insulation, etc., for tagging and corrective action?
33. Does ship adjust liquid load for slight trim by bow prior to getting underway and does engineering department assure maintenance of trim by the bow?
34. Does ship keep speed at a minimum while independent steaming overnight (6 knots or less)?
35. Is fuel and water usage: a. Documented for trend analysis? b. Published in Plan of the Day?
36. Does ship utilize shore services to: a. Minimize in port steaming? b. Minimize use of its distilling plant?
37. Are ship's personnel aware of the importance of energy conservation?
38. Does ship have an Energy Officer recognized as such with his responsibilities designated in writing?

**APPENDIX B**

**HSI SURVEY**

1. How often [HVAC] ship crew is trained and where?

2.    How many operators required for HVAC operations? Of these how many are standbys?

1. What are the warning systems for oil leak, duct leaks, fire, flooding in main space, unusual vibration and acoustics and loss of chilled water system?
2. Does the crew have signs posted to shut-off lights, heat, A/C for compartments not in use?

 4.   How many technicians are required to deal with HVAC related emergencies in worst case scenario?

5.    Do you cross train the [non-HVAC] crew for HVAC duties?

6.    How many [training] drills it require to gain proficiency to meet minimum standards of effectiveness?

7.    How close the simulator training is to real environment? Does it provide 3-D graphics, actual noise and vibration encountered in underway operations, series of commands from senior officers for regular operations and emergencies, panic mode scenarios etc?

8.    How many yearly injuries or incapacitation occur to HVAC technicians during regular operations? What are their causes?

9.    HVAC displays – are they colored touch screen or conventional type?

10. Regular maintenance alerts – automated or chart-paper?

11. Does the chilling plant uses Variable frequency drive (VFD) for chiller or [less reliable] electro-mechanical motor starters?

12. Vibration and acoustics level at HVAC, Chilling plant?

**APPENDIX C**

**RISK SURVEY**

The following survey addresses HVAC, Auxiliary, and Lighting Systems, and Outfitting & Furnishing.

1. Which of the below systems presents the most risk to implement new components into in terms of Man Hours needed to replace:

|  |  |  |  |
| --- | --- | --- | --- |
| HVAC | Auxiliary | Lighting | Outfitting &Furnishings |
|  |  |  |  |

Rate the amount of Risk for the selected system above, 5 is for High, 3 is Medium and 1 is Low

|  |  |  |
| --- | --- | --- |
| **5** | **3** | **1** |
|  |  |  |

1. Which of the above systems presents the most risk to implement new components into in terms of Design Complexity:

|  |  |  |  |
| --- | --- | --- | --- |
| HVAC | Auxiliary | Lighting | Outfitting &Furnishings |
|  |  |  |  |

Rate the amount of Risk for the selected system above, 5 is for High, 3 is Medium and 1 is Low

|  |  |  |
| --- | --- | --- |
| **5** | **3** | **1** |
|  |  |  |

1. Which of the above systems presents the most risk to implement new components into in terms of Availability of Replacements:

|  |  |  |  |
| --- | --- | --- | --- |
| HVAC | Auxiliary | Lighting | Outfitting &Furnishings |
|  |  |  |  |

Rate the amount of Risk for the selected system above, 5 is for High, 3 is Medium and 1 is Low

|  |  |  |
| --- | --- | --- |
| **5** | **3** | **1** |
|  |  |  |

1. Which of the above systems presents the most risk to implement new components into in terms of Interoperability with other subsystems/components:

|  |  |  |  |
| --- | --- | --- | --- |
| HVAC | Auxiliary | Lighting | Outfitting &Furnishings |
|  |  |  |  |

Rate the amount of Risk for the selected system above, 5 is for High, 3 is Medium and 1 is Low

|  |  |  |
| --- | --- | --- |
| **5** | **3** | **1** |
|  |  |  |

1. Which of the above systems presents the most risk to implement new components into in terms of Enablers:

|  |  |  |  |
| --- | --- | --- | --- |
| HVAC | Auxiliary | Lighting | Outfitting &Furnishings |
|  |  |  |  |

Rate the amount of Risk for the selected system above, 5 is for High, 3 is Medium and 1 is Low

|  |  |  |
| --- | --- | --- |
| **5** | **3** | **1** |
|  |  |  |

1. Which of the above systems presents the most risk to implement new components into in terms of down time:

|  |  |  |  |
| --- | --- | --- | --- |
| HVAC | Auxiliary | Lighting | Outfitting &Furnishings |
|  |  |  |  |

Rate the amount of Risk for the selected system above, 5 is for High, 3 is Medium and 1 is Low

|  |  |  |
| --- | --- | --- |
| **5** | **3** | **1** |
|  |  |  |