Block #	Title	Text/Narration
3.3		The control system provides the electrical interface between the on-board TQG or external power and MIRCS electrical and electronic components. The system controls and monitors operation of the ECU, RU, fuel, lighting, and water systems and provides interface points for the operator. The operation of each individual control system component is discussed in the relevant sections of this module.
3.3.1		The MIRCS requires 208 VAC, 3-Phase, 50/60 Hz external electrical power. External power is routed to the ECU control enclosure to a main disconnect switch (SW910). SW910 removes power from the MIRCS when turned off and provides power to the phase monitor (PM920) and main contactor (MC910) when turned on. With MC910 energized, power will be available to feed a bank of circuit breakers. These circuit breakers divide the voltage that will be used by the individual circuit branches.

3.3.2		The output of each circuit breaker is distributed inside the ECU control enclosure, or to the RU control enclosure, RU control box, MA operation enclosure, PA lights enclosure, and water system junction box. Power routed to the RU control box feeds the standby motor through contactor (MC1). All power needed to control RU operation comes from the RU battery and alternator. The RU circuitry is protected by a fusible link and individual fuses in the fuse box. The RU battery also provides 12 VDC power for the fuel level indicator, RSU loading lights, emergency and blackout lights, and equipment fault lights.
3.3.3		AC power used inside the MIRCS is routed through the water system junction box, where additional circuit breakers are located to protect circuit branches for the lighting system, utility receptacles, and water system components. The circuits for the utility receptacles are protected with ground fault circuit interrupter (GFCI) circuit breakers and surge suppressor duplex receptacles.
3.4	Refrigeration Unit	The RU is used to heat or cool the inside of the RSU for remains storage and preservation. The RU is a diesel engine or standby electric motor driven system.

3.4.1	**Refrigeration Unit Belt/Pulley Arrangement**	The engine drives the refrigeration compressor through a centrifugal clutch and pulley system. When the RU is operating from the on-board generator or external electrical power, the clutch is disengaged **[animation shows clutch as disengaged]** from the engine sheave and the compressor is belt-driven by the standby motor. A belt-driven alternator provides the power to operate the electrical evaporator fans, solenoid valves, and RU control circuitry.
3.4.2	**Refrigeration Unit Cooling Process**	When in cooling mode, the compressor raises the temperature and pressure of the refrigerant vapor by compressing it. The vapor flows into the condenser. The condenser fan circulates ambient air over the outside of the condenser tubes, cooling the vapor and causing it to condense into liquid.
3.4.3	**Refrigeration Unit Cooling Process**	The liquid refrigerant flows from the condenser to the receiver, which stores the additional refrigerant charge necessary for low ambient temperature operation and for heating and defrost modes. The refrigerant then leaves the receiver and flows through a sub-cooler that provides additional cooling to the liquid. From the sub-cooler, refrigerant flows to the evaporator.

3.4.4	**Refrigeration Unit Cooling Process**	As the liquid refrigerant passes through the evaporator, heat is removed from the air circulating through the RSU, thereby cooling the air. This cold air is circulated throughout the RSU by fans to maintain the desired temperature. The transfer of heat from the air to the liquid refrigerant causes the liquid to vaporize. This vapor flows into the accumulator where any liquid refrigerant is caught before it can return to the compressor. The compressor draws the vapor out of the accumulator and the cycle starts again.

3.4.5	**Refrigeration Unit Heating Process**	When refrigerant vapor is compressed to a high pressure and temperature in the reciprocating compressor during the RU Heating Process, the mechanical energy necessary to operate the compressor is transferred to the gas as it is being compressed. This energy is referred to as the "heat of compression" and can be used as the source of heat during the heating cycle. In the heating mode, the hot gas valve is energized. This diverts the high temperature, high-pressure refrigerant vapor to the evaporator. The vapor enters the evaporator to give the required heating. When the engine is running and there is a call for additional heat, the controller will also energize a hot water solenoid valve. This valve will allow coolant from the engine to circulate through a coil in the evaporator, supplying additional heat to the interior of the RSU.

3.4.6	**Refrigeration Unit Defrost Process**	The defrost mode is the same as the heat mode, except the evaporator fans are turned off. This keeps the heat at the evaporator coil--where it will melt the frost and ice--instead of circulating it through the RSU. Defrost cycles can be initiated automatically by programming the outside RU control panel or manually at either control panel. The automatic defrost timer can be set for 1.5, 3, 6, or 12-hour intervals. A defrost cycle may also automatically start if the defrost air switch detects frost build-up. Since the RU is set to operate at 34ºF, the RU rarely goes into defrost mode.
3.4.7	**Refrigeration Unit Defrost Process**	The defrost mode is the same as the heat mode, except the evaporator fans are turned off. This keeps the heat at the evaporator coil--where it will melt the frost and ice--instead of circulating it through the RSU. Defrost cycles can be initiated automatically by programming the outside RU control panel or manually at either control panel. The automatic defrost timer can be set for 1.5, 3, 6, or 12-hour intervals. A defrost cycle may also automatically start if the defrost air switch detects frost build-up. Since the RU is set to operate at 34ºF, the RU rarely goes into defrost mode.

3.4.8	**Refrigeration Unit Control Box**	RU operation is controlled by a microprocessor in conjunction with operator input from the control panel located on the RU control enclosure. Once the operator selects the desired operating mode, the microprocessor controls all aspects of unit operation. The RU control system also contains other control circuitry including relays, contactors, and fuses.
3.4.9	**RU Control Enclosure Controls and Indicators**	Most of these components are located on the control relay board. The RU contains several sensors and switches that communicate with the microprocessor to continuously monitor and control the engine, refrigeration and heating components operation.
3.5	**ECU Airflow**	The ECU provides temperature-controlled air at the proper air quality when the MIRCS is operating in the cold and the heat. The ECU is connected to a network of ducting that provides the conditioned air needed to properly ventilate the interior working areas. The outside air blower draws about 200 CFM of fresh air through the inlet filter and sends it to the recirculating air blower. At the same time, the recirculating air blower draws in about 1000 CFM of returning air from the AA and vestibule through the recirculating filter and over the coil of the AA evaporator.

3.5.1	**ECU Airflow**	The recirculating blower mixes the outside air and recirculated air together and sends the air towards the AA ducting and PA ducting. The air moving to the AA ducting passes over heating elements before leaving the ECU. This air then travels through the AA ducting, out into the AA, through the screened panels on the AA soft wall, and back through the vestibule to the recirculating filter. Air moving towards the PA passes over the coils of the PA evaporator then heating elements before moving into the PA ducting. This air then circulates through the PA and is pulled into the exhaust duct by the exhaust blower at a rate slightly higher than the outside (fresh) airflow rate. The exhaust blower sends the air out of the MIRCS through the exhaust screen. Since the exhaust blower is trying to pull slightly more air than is moving out of the PA ducting, a small amount of air will be pulled from around the door separating the vestibule from the supply area. This ensures that air will always flow from the AA towards the PA.

3.5.2	**ECU Heating**	In the heating mode, electric resistance heaters are used to heat the air moving through the ducting to the AA and PA. The AA side of the ducting contains two sets of heating elements **[show inset photo]**. One set, “normal,” generates 3,000 watts of heat and the other set, “auxiliary,” generates 4,500 watts. The PA side of the ducting contains 2,700 watts of heating elements **[show inset photo]**. The AA “normal” heating elements are adequate to provide heated air in most conditions. At extremely cold temperatures, the “auxiliary” heating elements can be turned on for supplemental heating with a switch on the ECU control enclosure.

3.5.2a	**ECU Cooling**	In the cooling mode, the compressor raises the temperature and pressure of the refrigerant vapor by compressing it. The refrigerant then flows into the condenser. The condenser fans circulate ambient air over the outside of the condenser tubes, cooling the refrigerant vapor and causing the refrigerant to condense into liquid. The liquid refrigerant then flows from the condenser to the receiver and from there to the AA and PA evaporators. Refrigerant flow to each evaporator is based on the outside solar conditions. As the liquid refrigerant passes through the evaporators, heat is removed from the air passing around the outside of the evaporators, thereby cooling the air. This cold air is carried throughout the MIRCS by ductwork. The transfer of heat from the air to the liquid refrigerant in the evaporators causes the liquid to vaporize. This vapor passes into the accumulator, where any liquid refrigerant is caught before it can return to the compressor. The compressor draws the vapor out of the accumulator and the cycle starts over.

3.5.3	**ECU Thermostat**	**[Transition from larger view of ECU to close-up of thermostat]** A thermostat with a COOL/OFF/HEAT switch **[callout]** is located on the ECU and is accessible from the vestibule area. The thermostat is used to control ECU operation. **[Pan out to show circulation]** After power is applied to the MIRCS and the ventilation fan switch is turned on, the outside air, recirculating air, and exhaust air blowers turn on and start circulating air through the AA and PA. If cooling or heating is desired, the operator selects COOL or HEAT at the switch then sets the thermostat at the desired temperature level. Once heating or cooling is selected, ECU operation will be controlled through the thermostat in conjunction with control circuitry in the ECU control enclosure.
3.5.4	**ECU Fault Lights**	There are eight fault lights for the ECU. These lights, which are mounted on the ECU enclosure, provide information for specific ECU faults.
3.5.5	**ECU Fault Lights**	An ECU master fault light located on the MA enclosure gives an indication that an ECU fault has occurred. This alerts the operator to go to the ECU enclosure to determine the actual fault condition.

3.6	Fuel System	The MIRCS fuel system provides fuel to the diesel engine on the RU and the fuel tank in the on-board generator**.** A 50-gallon fuel tank **[show photo of fuel tank]** is used to store the fuel. The fuel tank contains six ports or connections points. The fill port **[show photo]** is provided to allow the fuel tank to be gravity refilled. A port **[show photo]** is provided for mounting the fuel vent. The fuel vent contains a ball check that vents fuel vapor to prevent over-pressurizing the tank and also prevents liquid fuel from spilling from the tank when the MIRCS is tilted. A drain port **[show photo]** is provided at the tank bottom to allow draining for maintenance and air transport. A spring-loaded shutoff valve **[show photo]** is connected to the tank drain port. A fuel level sending unit **[show photo]** is provided at the top of the tank. A fuel level sending unit is installed in this port. **A port on the top of the tank is provided for mounting the fuel level sending unit.** **Supply and return ports [show photo] are located on the back wall of the tank.**

3.6.1	Fuel Piping	Fuel flowing out of the tank supply port goes to the fuel/water separator. The fuel/water separator **[callout]** is used to remove water and particulate contamination that may be in the fuel. The fuel/water separator has a drain valve **[callout]** at its base that must be periodically drained to remove any trapped water. Fuel flowing out of the separator flows to the RU and generator supply lines **[callout]**. Each supply line contains a shut-off valve **[callout]** to allow fuel to be shut-off to one branch without interrupting flow to the other branch.

3.6.2	**RU Fuel Supply**	Fuel flowing to the RU engine is drawn from the tank by an electric fuel pump **[callout]**. The pump contains a filter screen **[callout]** to prevent particulates from contaminating the pump. Pressurized fuel then passes through the engine fuel filter, **[callout]** which prevents contaminates from getting to the engine's fuel injection system. The housing of the fuel filter is equipped with a heater **[callout]**. This heater is turned on by the RU's control system at low ambient temperatures to pre-heat the fuel going into the engine. This helps to atomize the fuel during cold engine starts. Fuel flowing out of the engine fuel filter is delivered to the fuel injector pump **[callout]** where it is distributed to the fuel injector of each cylinder. Not all fuel supplied to the fuel injection pump is used by the engine. Unused fuel is returned to the fuel tank for reuse.
3.6.3	**Generator Fuel Supply**	Fuel flowing to the generator is terminated at a quick-connect fitting located in the rear mechanical area. A removable fuel hose **[callout]** is used to connect the fuel supply line to the auxiliary fuel connection located on the generator. An auxiliary fuel pump **[callout]** in the generator draws fuel from the fuel supply as needed to fill the generator's fuel tank **[callout]**. The fuel actually used by the generator's diesel engine is drawn from this internal tank.

3.6.4	**Fuel Monitoring**	The fuel sending unit **[show photo]** located in the fuel tank is a capacitance-type sensor that changes in resistance as the fuel level drops further down the sensing probe. Two output signals are provided by the fuel sending unit. One output is the probe's resistance **[illustrate]**. This resistance changes the voltage output to the fuel level indicator. This provides an analog reading of the tank fuel level in terms from empty to full. The sending unit also provides an output signal that turns on warning lights on the RU and MA control panels if the fuel level in the tank drops below approximately 1/8 full **[illustrate]**.
3.7	Water System	The water system draws water from an external water source and supplies hot or cold water to a personnel sanitation sink and a utility hose connection. The water source can be pressurized or non-pressurized.

3.7.1	Water Pressurizing	Water is drawn from the external water source by an external ¾ HP centrifugal pump **[show photo]**. The water flowing into the external pump passes through a Y-strainer **[show photo]** that will prevent any large particles from contaminating the pump or MIRCS water piping. Pressurized water is then delivered to the water inlet solenoid valve **[show photo]** that controls water flow to the 2-1/2 gallon electric water heater, thermostatic control valve, and the mixing valves of the personnel sink faucet and utility hose faucet. A backflow prevention valve **[show photo]** is installed in the supply piping to prevent the possibility of water backflowing to the water source.

3.7.2	Water Heating	Water coming out of the water heater flows to the thermostatic control valve, where it mixes with cold water to supply water at 100°F-110°F to the hot water connection on the mixing valves of the personnel sink faucet and utility hose faucet. The thermostatic control valve also contains a backflow prevention device to prevent water from backflowing to the water source. The sanitation sink **[show photo]** contains a standard lavatory faucet with independent hot and cold-water levers. The utility hose connection has a shower type-mixing valve with a single volume and temperature control lever. A 25-ft utility hose with spray nozzle **[show photo]** is connected to the utility connection to aid in remains processing and equipment sanitization. The inlet to the spray nozzle contains a backflow prevention device to prevent water from backflowing to the water piping.

3.7.3	Personnel Sink	Water flow to the personnel sink is established by depressing a foot switch under the sink. When the foot switch is depressed, power is applied to a time-delay relay. The time-delay relay energizes and applies power to a control relay and the water inlet solenoid valve. The water inlet solenoid valve opens, and the control relay energizes a motor contactor that starts the external water pump. A pressure switch installed on the water piping provides a signal to the time-delay relay. If there is adequate water pressure coming out of the pump and through the water inlet valve, the time-delay relay will continue to be energized and keep the pump running. If the pressure is not adequate, the time-delay relay will de-energize the motor contactor after 3 seconds--even if the operator continues to press the foot switch. This prevents damaging the pump if the external supply of water runs out or the water system is not primed properly. As long as the foot switch is held down and there is water pressure, the pump and water inlet valve will stay on and water will flow to the sink faucet.

3.7.4	Personnel Sink	**[Photo of personnel sink]** Personnel can then use the hot and cold levers at the sink as necessary to control water volume and temperature. **[flashback to water system diagram]** When the foot switch is released, the motor control relay and the motor contactor will de-energize. Then, the external water pump will turn off and the water inlet valve will close. This prevents unnecessary waste of fresh water and generation of wastewater that may be caused by accidentally leaving the faucet running.
3.7.5	Utility Hose	A push-button switch **[show photo]** located on the water system junction box starts water flow to the utility hose **[show photo]**. Unlike the sink foot switch, the push-button can be depressed and released and water pressure will be available for 15 minutes. **[flashback to water system diagram]** When the push-button switch is depressed, power is applied to two time-delay relays. The first time-delay relay turns on the external water pump through the control relay and motor contactor and energizes the water inlet solenoid valve as described for the sink water flow.

3.7.6		As long as there is adequate water pressure, the pump will stay on and the valve will remain open for 15 minutes. At that time, the second time-delay relay will de-energize, removing power from the control relay and motor contactor. If personnel are not done using the utility hose, the push-button switch can be pushed again and another 15 minutes of water pressure will be available.
3.7.7	**Water Heater**	Anytime power is applied to the MIRCS, the water heater will be on--provided that the water system is primed. When the system is primed, a level switch mounted in piping above the water heater will close, allowing the coil of the water heater relay to energize. The water heater relay will apply power to the heating element in the water heater. This allows water to be heating at all times that the MIRCS has power applied--provided the water level does not drop. If the system is not properly primed or the water supply runs out, the level switch will open and de-energize the water heater relay. This prevents the water heater's heating element from failing due to over-heating. The water heater also contains a relief valve that will open to relieve pressure in the tank if an over-pressure condition exists.

3.7.8	Draining	When the water system is not in use, the water piping and components must be drained to prevent freeze damage. Drain valves are located at the Y-strainer on the external water pump **[show photo]**, exterior water piping **[show photo]**, and interior water piping **[show photo]**. The water heater also contains a drain valve **[show photo]**. **CAUTION** All four drain valves should be left open after the water system has been drained. These valves should not be closed again until the next time the MIRCS is connected to a water source. Valves left closed will prevent residual water from draining and allow it to expand as it freezes. This expansion will damage water system piping or components.

3.8	Waste System	The waste collection system is used to collect all wastewater generated when conducting MA operations. Wastewater generated at the personnel sanitization sink flows through a drain to the main wastewater pipe. Wastewater generated when the RSU is sanitized also flows to this main pipe. The main waste pipe is routed to the front of the MIRCS to a connection port. A drain hose with a shut-off valve is connected between this port and a 10-gallon waste container. An indicator is provided on the drain hose to indicate when the container is full. The shut-off valve is closed so that a full container can be removed and an empty one installed without spilling the wastewater. Wastewater generated when the PA is sanitized flows to the PA platform wastewater pipe. This pipe also contains a connection port where a waste container is connected with a drain hose. Condensation generated by the RU is collected by drain hoses and routed to a 2-1/2-gallon waste container located in the front mechanical area.

3.9	**Hydraulics System**	The hydraulic system is used to lower and raise the AA and PA platforms and to pull the platforms in tight to fit the ISO frame. A manual pump provides the pressure and flow needed to perform these operations. The pump draws fluid out of a 2-gallon reservoir and sends the fluid to control valves that are connected to the raise/lower hydraulic cylinders and extend/retract hydraulic cylinders. The pump has an internal relief valve that prevents over-pressurization due to over-pumping.

3.9.1	Hydraulics System	Each platform is secured in the stowed position by two threaded locks **[show photo]**. These locks are located on the sides of the ISO frame to screw into the platforms using a crank handle. The locks must be disengaged before the platforms are lowered. Each platform has an extend/retract manual valve and a lower/raise manual valve. When the lever of the extend/retract valve is positioned to "EXTEND," hydraulic fluid flows to the piston of the extend/retract cylinder. The piston extends, pushing the catch out about 12 inches so that it is clear of the platform. **[Video of platform lowering appears]** With the catch out of the way, the platform weight is enough for gravity to lower the platform. When the lever of the raise/lower valve is positioned to "LOWER," hydraulic fluid is allowed to flow out of the raise/lower cylinders and the platform lowers to the deployed (horizontal) position.

3.9.2		At anytime during the lowering operation, if the operator chooses, the lever can be returned to the “NULL” position and platform movement will stop. The platforms are raised using the manual pump after the lower/raise valve is positioned to “RAISE.” In the “RAISE” position, hydraulic fluid flows to extend the pistons of the raise/lower cylinders and the platform rises almost to the stowed (vertical) position. To completely close the platform and ensure that the platform will align with the side locks, the extend/retract cylinder must be completely retracted. This is accomplished using the manual pump after the extend/retract valve is positioned to “RETRACT.” In the “RETRACT” position, hydraulic fluid flows to pull in the piston of the extend/retract cylinder. The catch mounted on the end of the piston pulls the platform in tight to the ISO frame. Once in position, the platform side locks are engaged to secure the platform for transport and the valves are returned to the “NULL” position.
3.10	Lights	The MIRCS lighting system consists of both portable and fixed lighting fixtures used to supply lighting when conducting MA operations in normal conditions and in blackout operation. The system also provides emergency lighting to allow personnel to safely exit the MIRCS interior in the event of a power failure.

3.10.1		Seven portable 40-watt fluorescent light fixtures are installed in the ceiling of the AA, PA, and vestibule soft walls when the MIRCS is set up for ground operation.
3.10.2		In the PA, four of these lights are strung to each other and connected to a dedicated electrical duplex receptacle provided at the top of the interior wall. In the AA, two lights are strung together and connected to a dedicated receptacle. One light is set up in the vestibule. This light is connected to the second receptacle on the AA light duplex receptacle. There are two mounted fluorescent light fixtures (rated at 20-watts each) in the ceiling of the supply storage area. These lights are connected to the second receptacle on the PA light duplex receptacle.
3.10.3		There are also four blue LED light fixtures installed above the RSU doors. These lights provide a small amount of light when personnel are performing transfer operations with the MIRCS loaded for transport.
3.10.4		There are ON/OFF switches for the white lights located on the MA operation panel in the vestibule. These switches allow the lights in the AA, PA, supply area, and vestibule to be operated independent of each other.

3.10.5		The lighting above the RSU doors is controlled from a switch located on the RU control enclosure so that the lights can be turned on during rapid remains transfer operations when the MIRCS is loaded for transport.
3.10.6		Three portable blue LED light fixtures are installed in the ceiling of the AA, PA, and vestibule soft walls when the MIRCS is set up for ground operation. In the PA, one light is placed above the emergency/ egress door. This light plugs into a receptacle provided at the PA light enclosure. In the AA, one light is placed next to the partition wall door leading to the vestibule. One light is also set-up in the vestibule leading to the normal entry/egress door. The AA and vestibule lights are connected to receptacles on the MA operation enclosure. There is also one portable blue LED light fixture installed in the ceiling of the supply storage area at the entry/egress point leading from the PA to the vestibule. This light plugs into a receptacle provided at the PA light enclosure. These four lights serve the dual function of emergency lights and blackout lights.

3.10.7		When power is applied to the MIRCS, power is available to turn on the normal (fluorescent) lights in the system. If there is a loss of power due to shutdown or failure of the generator or external power source during MA operations, a control relay will de-energize to allow RU battery power to turn on the emergency lights. The RU battery is connected to the lights through a time-delay relay. After 5 minutes, the relay will de-energize and remove battery power from the lights. This allows personnel to safely exit the MIRCS interior while preventing the excessive draining of RU battery power.
3.10.8		The MA operator enclosure contains a mode switch to allow the MIRCS to be operated in "NORMAL" or "BLACKOUT" mode. In normal mode, the blackout lights are off. In blackout mode, the emergency lights previously described turn on with 12 VDC power from the RU battery. The fluorescent lights in the PA will also remain on, but the fluorescent lights in the AA, vestibule, and storage area will be disabled. With the curtain doors to the AA and supply areas closed, the white lights in the PA will not affect blackout discipline provided the vestibule and PA entry/egress doors are closed.