ESRDC Notional Ship Data

For further information, please contact
Julie Chalfant, chalfant@mit.edu

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Revision History

Date	Version	Description	Author
May 5, 2017	0.1	DRAFT Initial Notional Ship Data	J. Chalfant

Document Use and Modification

This document will be updated as additional information becomes available, and the revision history will be tabulated above. Please make changes in the Word version of this document using track changes. When sufficient recommendations for change are made, they will be incorporated and a new revision will be released.

This document will be stored on the ESRDC website in .pdf format, along with a Word format and an Excel spreadsheet containing the data.

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Introduction

The Electric Ship Research and Development Consortium (ESRDC) has created a notional ship for use as a test case in developing research to advance the state of the art in electric ship concepts. The notional ship is a nominal 100MW, 10,000 ton displacement surface combatant, using data compiled from open source documentation. This document provides data relative to the ship, for use by ESRDC researchers.

A model of the ship was created in the Smart Ship Systems Design (S3D) design environment, to include electrical, piping and mechanical schematics along with three-dimensional placement of equipment on a ship hull in a naval architecture view.

Please note that this ship was designed by ESRDC researchers and is not intended to meet or represent any current or future Navy designed vessel. It is merely a somewhat realistic representative example for testing electrical and thermal system concepts.

The systems delineated in this document are a single, baseline reference ship. It is intended that alternative designs can be tested against this design; these alternatives may make adjustments such as replacing single pieces or classes of equipment, rearranging equipment using different topology and connectivity, or replacing entire support systems with systems using a different paradigm entirely.

Notes

Nomenclature

Decks are numbered sequentially downwards with the main deck numbered 1 and the next deck numbered 2, etc. Decks above main deck are referred to as levels, with the deck above main deck called the "01 level", increasing upwards.

Bulkheads are numbered from the bow of the ship, increasing aft.

Zones are numbered beginning at the bow of the ship, increasing aft. In this notional ship, zones are divided by watertight bulkheads and extend from baseline to the top of the ship. While this is an accepted practice, it is not the only method for dividing ships into zones; in some cases, zonal divisions may not be vertical planes, and there may be horizontal divisions as well. For example, the superstructure could be a separate zone.

The Ships Work Breakdown Structure (SWBS) is a Navy categorization system for organizing equipment. SWBS numbers are included for reference.

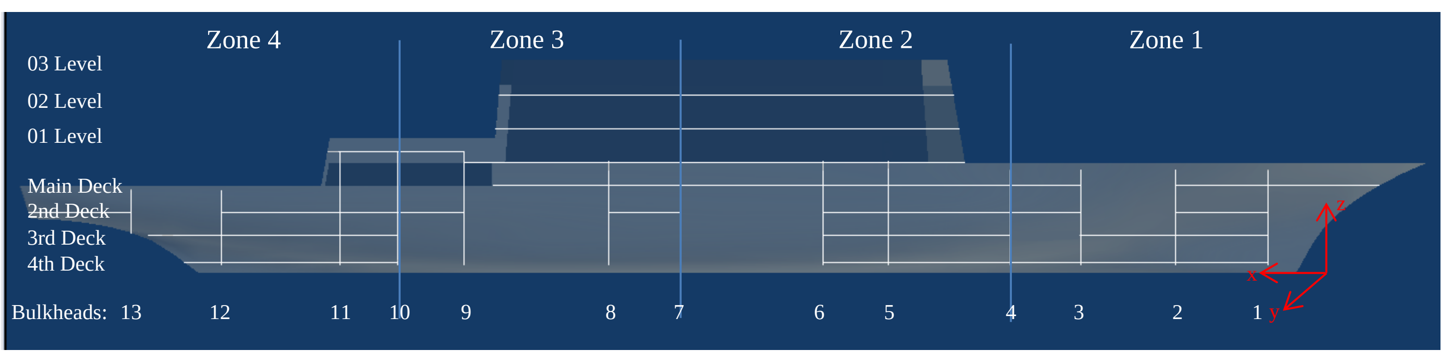

Figure 1. Nomenclature (old hullform – need to update; decks and bhds are in the proper (new) locations

Origin

The origin is located at the intersection of the forward perpendicular, the baseline, and the centerline. The forward perpendicular is located where the design waterline crosses the bow. The x-axis is positive pointing aft in the longitudinal direction; the y-axis is positive pointing to the starboard side of the ship, and the z-axis is positive pointing up.

Margining

Mission systems, aggregated loads and propulsion loads do not include a margin as modeled in this ship design in S3D. Service system items such as cables, switchboards, disconnects, and converters are sized to carry 20% greater load than is connected. Generators and chillers were selected for 20% greater capacity than the connected load demands.

Energy Storage

The only energy storage explicitly modeled in this baseline ship design is the energy storage modules (ESMs) associated with the railgun. In this instantiation, the railgun ESMs are available only to the railgun and not for any other purpose. Although the Integrated Power Node Centers (IPNCs) and Power Conversion Module 1As (PCM1As) are designed to contain energy storage, the current model does not include energy storage in these locations.

Hullform Data

The notional ship is a destroyer-sized monohull with a 10,000 ton displacement.

Hullform View

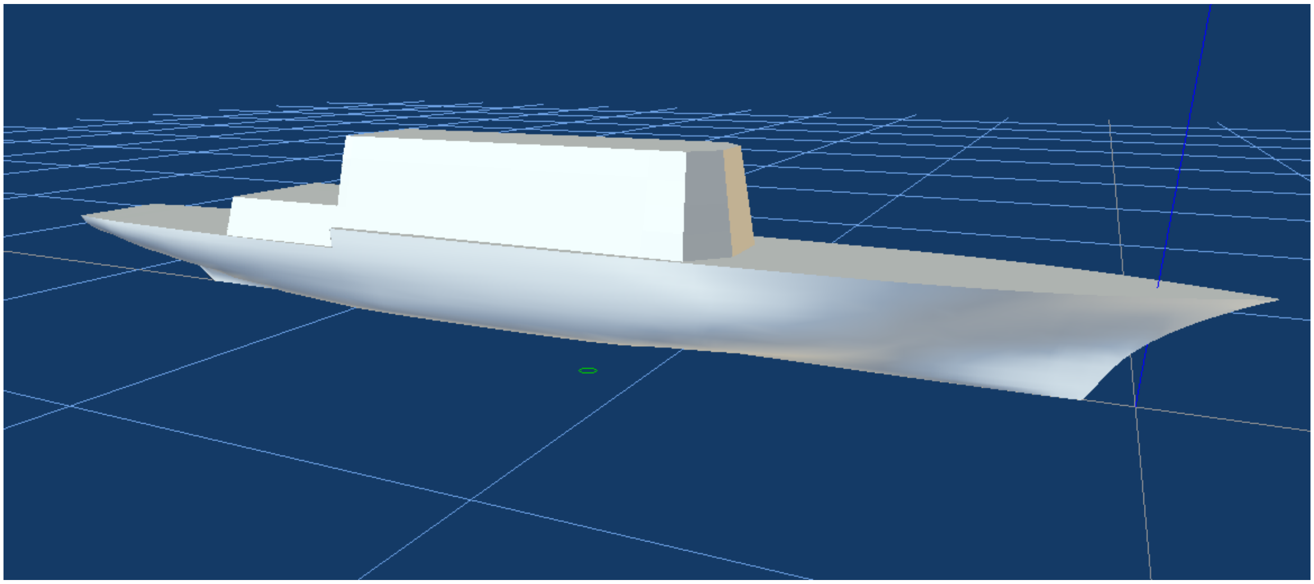

Figure 2. S3D view of hull. This is the old 10kt ship; need image of new hull (similar, but not exactly the same).

Hullform Dimensions

Length Overall	163 m
Beam Overall	20.9 m
Depth Overall (baseline to top of superstructure)	23.6 m
Length Between Perpendiculars	152.3 m
Beam at Waterline	18.9 m
Draft	6.6 m
Depth at Midship	12.8 m

Bulkhead Locations and Deck Heights

Transverse watertight bulkheads in the hull are located at the indicated distance in meters measured aft of the forward perpendicular. Deck heights are given in meters above baseline

Bulkhead Number	Location (m)
1	8
2	19
3	30
4	38
5	52
6	60
7	76
8	85
9	101
10	109
11	116
12	129
13	140

Deck Number	Height (m)
03 Level	23.6
02 Level	20.6
01 Level	16.7
Main Deck	12.7
Second Deck	10.1
Third Deck	7
Fourth Deck	4.3
Inner Bottom	1.2
Top of Hangar	*14.0*

Propulsion Data

Speed Data

The maximum speed is the highest speed attainable by the ship in calm water. The sustained speed is the maximum speed the ship can sustain for long periods of time in calm water. Battle speed is the maximum speed the ship can attain with all shipboard electrical systems operating at maximum power. Endurance speed is the design speed for long transits. The range is the distance a ship can travel, without refueling, at the endurance speed with a given nominal electrical load.

Max Speed	32.0 kt
Sustained Speed	30.5 kt
Battle Speed	27.3 kt
Endurance Speed	18.0 kt
Range	2478 nm

Speed-Power Curve

The tables below display power in kW required to drive the ship at the given speed in knots. The power is the shaft power required at the output of the propulsion motor; thus, it already accounts for any changes in efficiency due to the propeller design and location and any losses in the transmission through the shaft and bearings.

Speed (knots)	Power (kW)
5	138
6	241
7	372
8	534
9	794
10	1,121
11	1,502
12	1,918
13	2,359
14	2,851
15	3,432
16	4,434
17	5,543
18	6,760

Speed (knots)	Power (kW)
19	8,157
20	9,698
21	11,359
22	12,894
23	14,151
24	15,482
25	17,004
26	20,755
27	24,780
28	29,074
29	35,362
30	42,840
31	50,811

Propulsion Equipment

The two propulsion motors are Converteam 15-phase Advanced Induction Motors. For information on the motor drives, see the section on Power Generation and Distribution.

Propulsion Equipment Data (Dimensions, Location)

Identification		Dimensions				Location			
Name	SWBS	Length (m)	Width (m)	Height (m)	Weight (kg)	Zone	X (m)	Y (m)	Z (m)
Propulsion Motor	235	5.1	5.4	5.3	127,000	2	80.29	3.75	3.49
Propulsion Motor	235	5.1	5.4	5.3	127,000	3	104.8	-3.75	3.52
Motor Drive	235	4.8	3.5	2.36	9,210	2	79.9	-1.06	2.74
Motor Drive	235	4.8	3.5	2.36	9,210	3	105.02	0.58	2.11

Propulsion Equipment Data (Power, Efficiency)

Name	Rated Mechanical Power (kW)	Rated Electrical Power (MW)	Efficiency (%)	Primary Rated Voltage (kV)	Primary Current Type	Secondary Rated Voltage (kV)	Secondary Current Type
Propulsion Motor	36.5	37.5	var	6.9	AC		
Propulsion Motor	36.5	37.5	var	6.9	AC		
Motor Drive		37.5	98	12	DC	6.9	AC
Motor Drive		37.5	98	12	DC	6.9	AC

Propulsion Motor Efficiency Curve

Percent Full Load	Efficiency (%)
0	10
20	80
35	92
60	96
100	95

Mission Equipment Data

To place the design in the realm of future capabilities, we performed a survey of new weapon and sensor technologies in the world's navies and selected several leading-edge technologies that would tax the power and cooling systems onboard the ship. Using publicly available information, a list of sensors, communications and weapons equipment along with the associated power and cooling system loads, efficiencies, weights and dimensions was compiled. Information on the sources of data and decisions made in sizing the equipment can be found in Appendix B of [Smart et al., 2017].

Some mission packages include the weapon or sensor and "support equipment." Although the support equipment is represented as a single component, this component may in actuality be realized as several cabinets and functions. For the purposes of this notional vessel, we assume the mission packages to be "black boxes" that require power and cooling. Note that the weapon and support equipment may have separate efficiencies in order for the cooling system to remove heat produced in different locations.

The railgun system is comprised of the railgun, four energy storage components, four charging power supplies, and an electrical storage mechanism (ESM). The ESM stores incoming power from the bus during the railgun discharge cycle to maintain a constant load on the ship's electrical distribution system of approximately 17 MW instead of inducing a reverse pulse during the discharge. There is also a relatively small ammunition handling equipment load. The S3D model of the rail gun mount is assigned an efficiency of 100% because this model does not address the cooling system for the railgun mount itself.

Weapons Data (Dimensions, Location)

Identification		Dimensions				Location			
Name	SWBS	Length (m)	Width (m)	Height (m)	Weight (kg)	Zone	X (m)	Y (m)	Z (m)
Active Denial System	711	0.6	2	2	1,000	2	80.5	-5.6	19.83
Active Denial System	711	0.6	2	2	1,000	2	80.5	5.6	19.83
Laser	711	4	4	3	4,000	4	113.37	0	15.47
Laser Support Equipment	711	6	4	3	4,000	3	112.64	0	11.69
Vertical Launch System	721	6.8	5.08	7.7	56,000	1	24.84	0	8.85
Vertical Launch System	721	6.8	5.08	7.7	56,000	3	105.03	0	10.97
Railgun	711	3	10	3	78,000	2	44.03	0	14.32
Railgun Capacitor Bank	711	4	2	1	15,369	2	41.05	1.5	9.08
Railgun Capacitor Bank	711	4	2	1	15,369	2	41.05	-1.5	7.62
Railgun Capacitor Bank	711	4	2	1	15,369	2	46.6	1.5	9.18
Railgun Capacitor Bank	711	4	2	1	15,369	2	46.6	-1.5	7.62
Railgun dc Charging Power Supply	711	7	1.6	2.36	5,000	2	42.4	3.8	8.3
Railgun dc Charging Power Supply	711	7	1.6	2.36	5,000	2	42.4	-3.8	8.3
Railgun dc Charging Power Supply	711	7	1.6	2.36	5,000	2	48.2	6	8.3
Railgun dc Charging Power Supply	711	7	1.6	2.36	5,000	2	48.2	-6	8.3
Railgun Energy Storage Module	711	2.17	1.9	1.51	15,000	2	50.5	-3.26	7.88
Railgun Switchboard	324	3.07	0.75	1.47	840	2	49.58	0	8.16
Railgun Ammunition Handling	711	6	2	2.36	13,560	2	44.85	0	11.37

Weapons Data (Electrical Power, Efficiency)

Name	Rated Electrical Power (MW)	Efficiency (%)	Primary Rated Voltage (kV)	Primary Current Type	Secondary Rated Voltage (kV)	Secondary Current Type
Active Denial System	0.3	35	1	DC		
Active Denial System	0.3	35	1	DC		
Laser	0.3	100	1	DC		
Laser Support Equipment	0.31	25	1	DC		
Vertical Launch System	0.48	75	0.45	AC		
Vertical Launch System	0.48	75	0.45	AC		
Railgun	10	100	1	DC		
Railgun Capacitor Bank	3.58	98	1	DC	1	DC
Railgun Capacitor Bank	3.58	98	1	DC	1	DC
Railgun Capacitor Bank	3.58	98	1	DC	1	DC
Railgun Capacitor Bank	3.58	98	1	DC	1	DC
Railgun dc Charging Power Supply	4.16	98	12	DC	1	DC
Railgun dc Charging Power Supply	4.16	98	12	DC	1	DC
Railgun dc Charging Power Supply	4.16	98	12	DC	1	DC
Railgun dc Charging Power Supply	4.16	98	12	DC	1	DC
Railgun Energy Storage Module	17	98	12	DC	12	DC
Railgun Switchboard		100	12	DC		
Railgun Ammunition Handling	0.4	100	1	DC		

Sensor Data (Dimensions, Location)

Identification		Dimensions				Location			
Name	SWBS	Length (m)	Width (m)	Height (m)	Weight (kg)	Zone	X (m)	Y (m)	Z (m)
Integrated Topside Array	410	2	1	1	2,000	2	72	-7.6	24.23
Integrated Topside Array	410	2	1	1	2,000	2	72	7.6	24.23
Integrated Topside Support Equipment	410	2.5	2.5	2.5	2,000	2	72	-5.82	22
Integrated Topside Support Equipment	410	2.5	2.5	2.5	2,000	2	72	5.82	22
Hull-mounted Sonar	461	5	5	1.5	30,000	1	4	0	0
Sonar Support Equipment	461	10	2	5.3	15,000	1	14.19	0	3.85
Towed-Array Sonar	461	3	6	2	14,000	4	148.61	3.5	8.12
S-band Radar Array	456	4	1	4	10,000	2	55	-5	18.75
S-band Radar Array	456	4	1	4	10,000	2	55	5	18.75
S-band Radar Array	456	4	1	4	10,000	3	100	0	18.75
X-band Radar Array	456	2.5	1	2.5	2,500	2	55.5	-3.85	23
X-band Radar Array	456	2.5	1	2.5	2,500	2	55.5	3.85	23
X-band Radar Array	456	2.5	1	2.5	2,500	3	99.5	0	23
Radar Support Equipment	456	5	10	4	32,000	2	57.55	0	14.85
Radar Support Equipment	456	5	5	4	16,000	3	95.33	0	14.85

Sensor Data (Electrical Power, Efficiency)

Name	Rated Electrical Power (MW)	High Energy Power (MW)	Medium Energy Power (MW)	Low Energy Power (MW)	Efficiency (%)	Primary Rated Voltage (kV)	Primary Current Type
Integrated Topside Array	1.5	1.5	0.38	0	33.33	1	DC
Integrated Topside Array	1.5	1.5	0.38	0	33.33	1	DC
Integrated Topside Support Equipment	1.5				75	1	DC
Integrated Topside Support Equipment	1.5				75	1	DC
Hull-mounted Sonar	0.3				100	1	DC
Hull-mounted Sonar Support Equipment	0.3				75	1	DC
Towed-Array Sonar	0.15				75	1	DC
S-band Radar Array	0.75	0.75	0.38	0.02	50	1	DC
S-band Radar Array	0.75	0.75	0.38	0.02	50	1	DC
S-band Radar Array	0.75	0.75	0.38	0.02	50	1	DC
X-band Radar Array	0.24	0.24	0.12	0.01	50	1	DC
X-band Radar Array	0.24	0.24	0.12	0.01	50	1	DC
X-band Radar Array	0.24	0.24	0.12	0.01	50	1	DC
Radar Support Equipment	2				60	1	DC
Radar Support Equipment	1				60	1	DC

Aggregated Vital and Non-Vital Loads

Some electrical loads are individually modeled, such as the Railgun and the Radar; these loads are described in “mission loads” above. The remainder of all electrical loads were estimated and aggregated into a single dc vital load and a single ac non-vital load for each zone. Since these are representative aggregated loads and not actual loads with specific locations and sizes, they are not assigned a weight or dimensions and no cable or cooling piping is routed to them. They are assigned an electrical power and an efficiency to provide both and electrical and a heat load to the ship’s systems.

Aggregated Vital and Non-Vital Load Data

Name	SWBS	Zone	Rated Electrical Power (MW)	High Energy Power (MW)	Medium Energy Power (MW)	Low Energy Power (MW)	Efficiency (%)	Primary Rated Voltage (kV)	Primary Current Type
Aggregated AC Non-vital Loads	600	1	0.03	0.03	0.01	0	80	0.45	AC
Aggregated AC Non-vital Loads	600	2	0.04	0.04	0.02	0	80	0.45	AC
Aggregated AC Non-vital Loads	600	3	0.04	0.04	0.02	0	80	0.45	AC
Aggregated AC Non-vital Loads	600	4	0.03	0.03	0.01	0	80	0.45	AC
Aggregated DC Vital Loads	600	1	1.43	1.43	0.65	0.09	80	1	DC
Aggregated DC Vital Loads	600	2	1.61	1.61	0.96	0.27	80	1	DC
Aggregated DC Vital Loads	600	3	1.61	1.61	0.96	0.26	80	1	DC
Aggregated DC Vital Loads	600	4	1.51	1.51	0.77	0.18	80	1	DC

Power Generation Module (PGM)

A power generation module (PGM) in this design is composed of an engine, a generator, a breaker and a rectifier.

The engines and generators were selected in order to meet the power requirements of the ship and to have generation capability in each zone. Thus, there is a Caterpillar C18 emergency diesel generator in zone 1, two LM2500+G4 gas turbine generators in zone 2, one LM2500+G4 and one LM500 gas turbine generator in zone 3, and one LM500 gas turbine generator in zone 4, for a total of 95MW of installed power.

The generators are dual-wound generators with a separate rectifier for each set of windings and thus can provide power to each bus separately.

The generation power of the generators is rated for 100^{o}F; it is expected that the generator may produce significantly greater than 100% power for short periods of time, especially if the ambient temperature is low. Therefore, the rectifiers are rated for higher power than the generators with which they are associated.

An ac breaker is placed between the generator and rectifier.

Power Generation Module Data (Dimensions, Location)

Name	SWBS	Height (m)	Width (m)	Length (m)	Weight (kg)	Zone	X (m)	Y (m)	Z (m)
Emergency Diesel Generator (EDG)	311	1.57	1.1	3.21	6,600	1	34.93	2.75	3.8
LM2500+G4 Gas Turbine Generator	311	4	3.81	14.3	97,045	2	67.7	-2.5	3.19
LM2500+G4 Gas Turbine Generator	311	4	3.81	14.3	97,045	2	67.7	2.5	3.19
LM2500+G4 Gas Turbine Generator	311	4	3.81	14.3	97,045	3	93.13	-3	3.19
LM500 Gas Turbine Generator	311	2.39	2.36	7.14	27,273	3	89.02	3	3.19
LM500 Gas Turbine Generator	311	2.39	2.36	7.14	27,273	4	133.8	6.51	8.15
EDG Breaker	311	0.4	0.4	0.4	25	1	31.99	2.63	5.16
LM2500 Breaker	311	0.8	0.8	0.8	250	2	75.4	-4.5	5.02
LM2500 Breaker	311	0.8	0.8	0.8	250	3	75.4	-4.5	3.8
LM2500 Breaker	311	0.8	0.8	0.8	250	2	75.4	4.5	5.02
LM2500 Breaker	311	0.8	0.8	0.8	250	3	75.4	4.5	3.8
LM2500 Breaker	311	0.8	0.8	0.8	250	2	100.8	-4.5	5.02
LM2500 Breaker	311	0.8	0.8	0.8	250	2	100.8	-4.5	3.8
LM500 Breaker	311	0.6	0.6	0.6	50	3	93	3.55	5.02
LM500 Breaker	311	0.6	0.6	0.6	50	4	93	3.55	3.8
LM500 Breaker	311	0.6	0.6	0.6	50	3	138	8	10.02
LM500 Breaker	311	0.6	0.6	0.6	50	4	138	8	8.8
EDG Rectifier	311	2.36	3.4	1.6	2,550	1	31.9	2.59	2.88
LM2500 Rectifier	311	2.36	1.6	5.5	5,730	2	64	-6	2.85
LM2500 Rectifier	311	2.36	1.6	5.5	5,730	2	70.9	-6	2.85
LM2500 Rectifier	311	2.36	1.6	5.5	5,730	2	64	6	2.85
LM2500 Rectifier	311	2.36	1.6	5.5	5,730	2	70.9	6	2.85

LM2500 Rectifier	311	2.36	1.6	5.5	5,730	3	96.31	-6.5	2.85
LM2500 Rectifier	311	2.36	1.6	5.5	5,730	3	89.88	-6.5	2.85
LM500 Rectifier	311	2.36	1.6	3.4	2,910	3	91.7	5.38	2.85
LM500 Rectifier	311	2.36	1.6	3.4	2,910	3	87.3	5.38	2.85
LM500 Rectifier	311	2.36	1.6	3.4	2,910	4	132	3.54	8.5
LM500 Rectifier	311	2.36	1.6	3.4	2,910	4	136.3	3.54	8.5

Power Generation Module Data (Electrical Power, Efficiency)

Name	Rated Electrical Power (MW)	Rated Continuous Current (kA)	Efficiency (%)	Primary Rated Voltage (kV)	Primary Current Type	Secondary Rated Voltage (kV)	Secondary Current Type
Emergency Diesel Generator (EDG)	0.55		var	6.9	AC		
LM2500+G4 Gas Turbine Generator	29		var	6.9	AC		
LM2500+G4 Gas Turbine Generator	29		var	6.9	AC		
LM2500+G4 Gas Turbine Generator	29		var	6.9	AC		
LM500 Gas Turbine Generator	3.7		var	6.9	AC		
LM500 Gas Turbine Generator	3.7		var	6.9	AC		
EDG Breaker		0.1		6.9	AC		
LM2500 Breaker		2.5		6.9	AC		
LM2500 Breaker		2.5		6.9	AC		
LM2500 Breaker		2.5		6.9	AC		
LM2500 Breaker		2.5		6.9	AC		
LM2500 Breaker		2.5		6.9	AC		
LM2500 Breaker		2.5		6.9	AC		
LM500 Breaker		0.5		6.9	AC		
LM500 Breaker		0.5		6.9	AC		
LM500 Breaker		0.5		6.9	AC		
LM500 Breaker		0.5		6.9	AC		
EDG Rectifier	0.66		98	6.9	AC	12	DC
LM2500 Rectifier	17.4		98	6.9	AC	12	DC
LM2500 Rectifier	17.4		98	6.9	AC	12	DC
LM2500 Rectifier	17.4		98	6.9	AC	12	DC
LM2500 Rectifier	17.4		98	6.9	AC	12	DC
LM2500 Rectifier	17.4		98	6.9	AC	12	DC
LM2500 Rectifier	17.4		98	6.9	AC	12	DC
LM500 Rectifier	2.24		98	6.9	AC	12	DC
LM500 Rectifier	2.24		98	6.9	AC	12	DC
LM500 Rectifier	2.24		98	6.9	AC	12	DC
LM500 Rectifier	2.24		98	6.9	AC	12	DC

Specific Fuel Consumption

LM2500+G4 Specific Fuel Consumption		LM500 Specific Fuel Consumption		Diesel Specific Fuel Consumption	
Power (MW)	**SFC (kg/Mj)**	**Power (MW)**	**SFC (kg/Mj)**	**Power (MW)**	**SFC (kg/Mj)**
2	0.268	0.3	0.186	0.159	0.066
8	0.155	0.9	0.124	0.184	0.064
20	0.072	1.5	0.093	0.272	0.063
29	0.062	2.25	0.082	0.31	0.061
		3.7	0.077	0.55	0.061

Power Distribution Data

The electrical distribution system is modeled after the proposed MVDC architecture circulated by the U.S. Navy [Doerry 2016] as depicted in Figure 3. Main bus distribution voltage is 12 kV (+-6kV). The notional ship described herein uses four electrical zones instead of six and is modified to accommodate the equipment selected for this ship design, but uses the same paradigm for distribution, e.g. cross-zone connections between ac load centers in adjacent zones, dedicated converters for electrical loads greater than 1 MW, and a combination of bus nodes, power conversion modules (PCM 1As), integrated power node centers (IPNCs) and ac Load Centers (ACLCs) to provide the required power supply. The resultant power distribution system is depicted in Figure 4. Note that all loads are individually switched; although some ports on the Bus Nodes, ACLCs and IPNCs appear to have multiple loads connected to a single port, this is a rendering problem and does not indicate that the loads are switched as a group. Similarly, cables that appear coincident are actually separate.

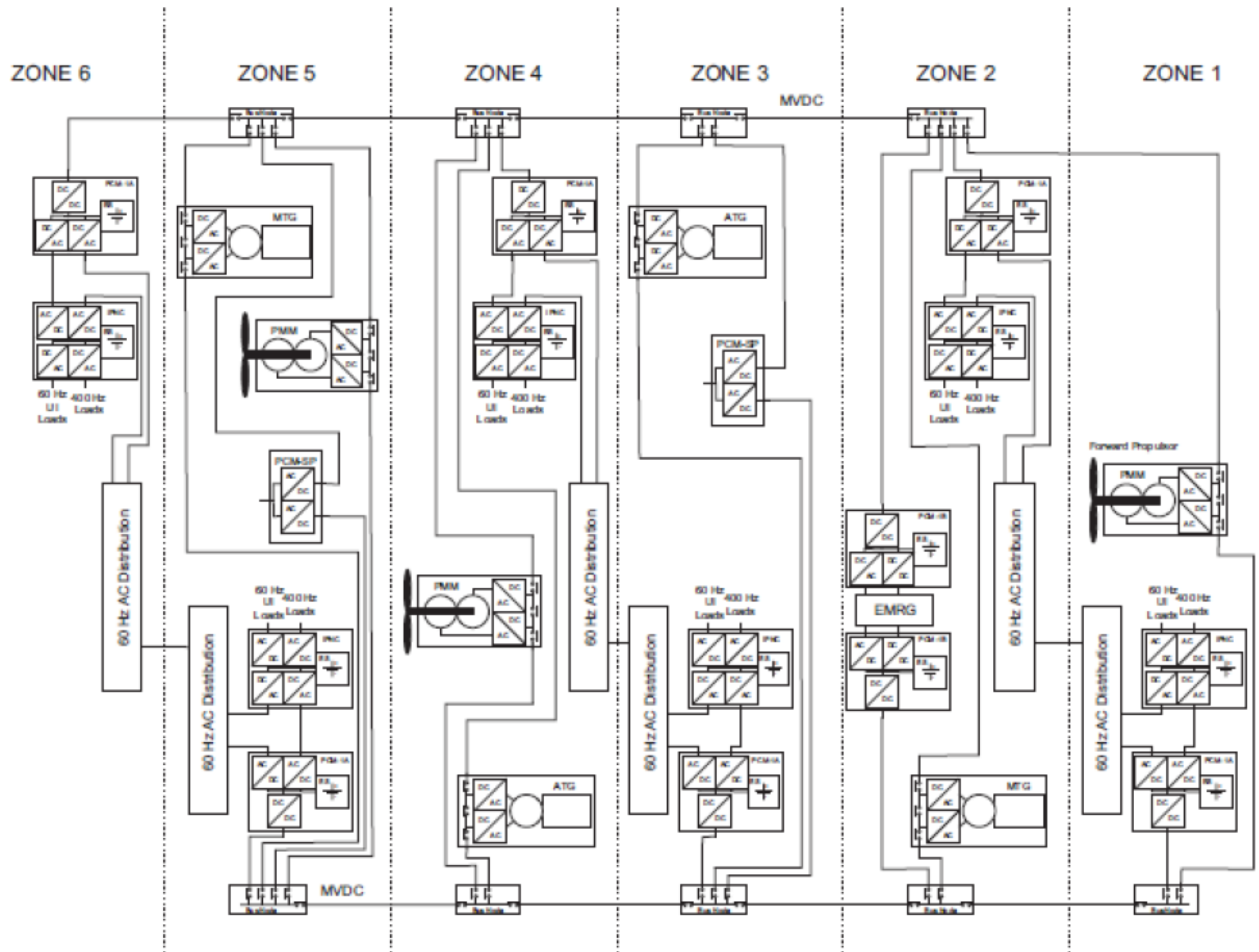

Figure 3. Proposed Navy distribution system [Doerry 2016]

Electrical View

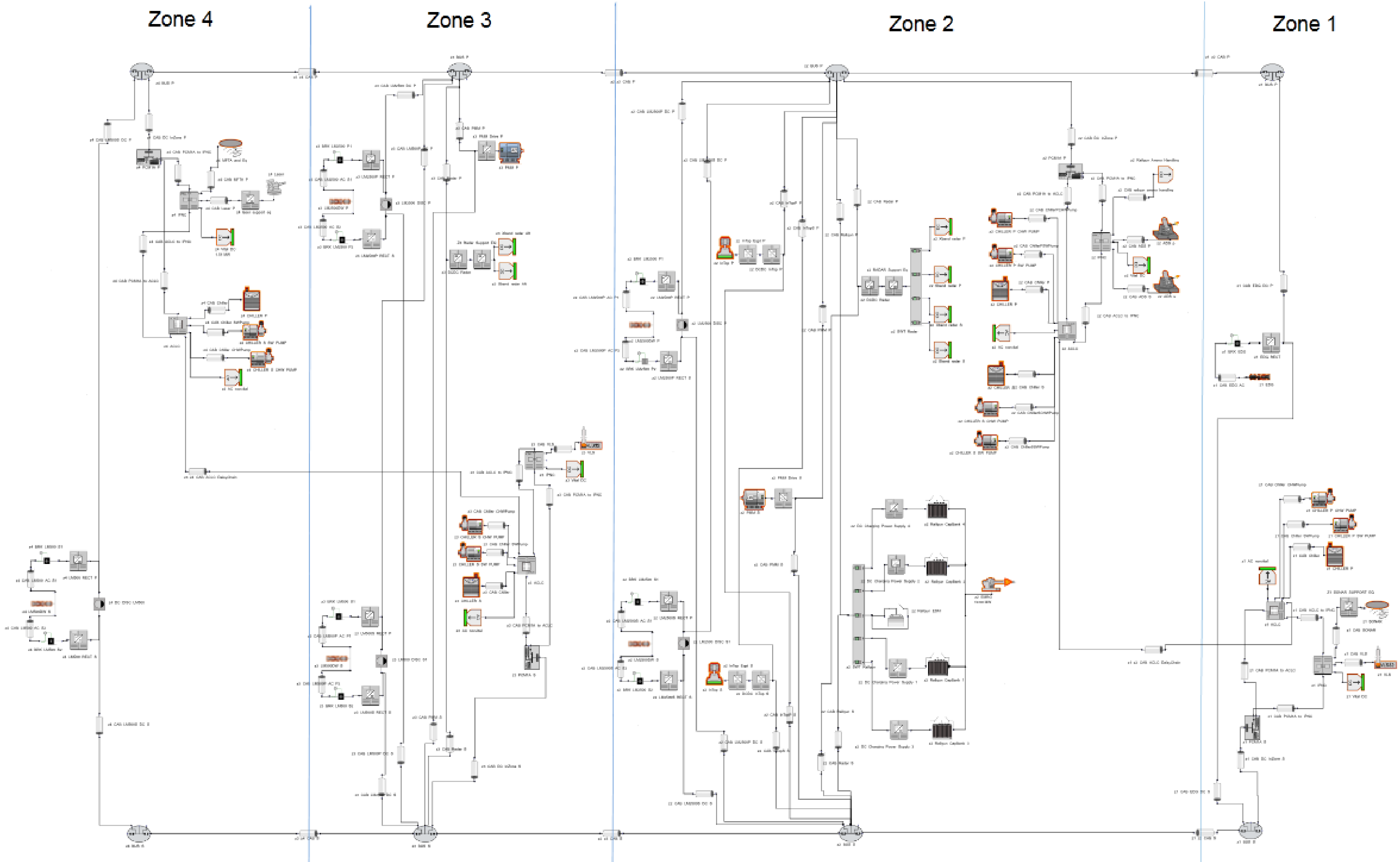

Figure 4. Notional Ship Electrical Distribution System, from S3D Model (model simplified to make connections more clear).

Power Conversion and Distribution Equipment

Bus nodes provide dc disconnect capability for each line. They are sized for the number of connections that are made.

The PCM1A (power conversion module 1A) converts power from bus voltage to an internal 1kVdc bus, then provides power at1kVdc to the IPNC via a disconnect, and power at 450Vac to the ACLC via a circuit breaker.

The ACLC (ac Load Center) is a traditional 450 Vac switchboard, with a connection to the next zone load center for casualty power operations.

The IPNC (integrated power node center) supplies power to loads with special power needs, such as dc, 400Hz ac, or variable speed motors, and supplies power to un-interruptible loads; thus, it contains energy storage for about one second.

In normal operations, the ACLC and IPNC are fed from the PCM1A in the same zone. If a casualty exists that prevents this, power is provided from the ACLC in the adjacent zone to the in-zone ACLC and then to the IPNC.

We assume that the flow of power throughout the distribution system is controlled by the power electronics. No-load dc disconnects are included to provide galvanic isolation where needed.

Sizing of all power conversion equipment in this model is adapted from [Soltau et al., 2014]. A summary table for sizing is shown below.

Nominal Power Converter Sizing Chart

	dc/ac or ac/dc			
Power Rating (MW)	Weight (kg)	Length (m)	Depth (m)	Height (m)
1	2550	3.4	1.6	2.36
2	2730	3.4	1.6	2.36
3	2910	3.4	1.6	2.36
4	3090	3.4	1.6	2.36
6	3720	4	1.6	2.36
8	3780	4	1.6	2.36
10	3900	4	1.6	2.36
12	3960	4	1.6	2.36
14	5610	5.5	1.6	2.36
18	5730	5.5	1.6	2.36
22	6438	6.4	1.6	2.36
24	6618	6.4	1.6	2.36

Power Conversion and Distribution Equipment Data (Dimensions, Location)

Identification		Dimensions				Location			
Name	SWBS	Height (m)	Width (m)	Length (m)	Weight (kg)	Zone	X (m)	Y (m)	Z (m)
Bus Node	324	0.8	0.8	1.2	100	1	17.47	-1.7	4.99
Bus Node	324	1.6	0.8	2.36	800	2	67.31	-8.68	5.87
Bus Node	324	1.6	0.8	2.36	800	3	104.09	-7	3.8
Bus Node	324	0.8	0.8	1.8	300	4	133.62	-3.5	6.28
Bus Node	324	0.8	0.8	1.8	300	1	32.8	7.05	8.11
Bus Node	324	1.6	0.8	2.36	800	2	46.37	8.5	9.25
Bus Node	324	1.6	0.8	2.36	800	3	89.55	8.65	9.25
Bus Node	324	0.8	0.8	1.2	200	4	131.57	0.12	8.51
Power Conversion Module 1A	314	4	1.6	2.36	3,960	1	33.85	4.44	8.22
Power Conversion Module 1A	314	4	1.6	2.36	3,960	2	64.8	-6.75	5.24
Power Conversion Module 1A	314	4	1.6	2.36	3,960	3	89.53	7.13	8.22
Power Conversion Module 1A	314	4	1.6	2.36	3,960	4	134.46	3.41	6.02
ac Load Center	324	2	1.6	2.36	1,500	1	35.77	2.31	8.22
ac Load Center	324	2	1.6	2.36	1,500	2	71.02	-6.43	5.17
ac Load Center	324	2	1.6	2.36	1,500	3	91.41	4.97	8.22
ac Load Center	324	2	1.6	2.36	1,500	4	136.55	1.18	6.14
Integrated Power Node Center (IPNC)	314	4	1.6	2.36	5,000	1	31.94	2.2	8.22
Integrated Power Node Center (IPNC)	314	4	1.6	2.36	5,000	2	62.88	-5.25	1.9
Integrated Power Node Center (IPNC)	314	4	1.6	2.36	5,000	3	87.57	4.92	8.22
Integrated Power Node Center (IPNC)	314	4	1.6	2.36	5,000	4	132.42	1.13	6.01
Radar dc/dc Converter	314	4	1.6	2.36	5,000	3	95.33	0	11.52
Radar dc/dc Converter	314	1.6	7	2.36	5,000	2	61.53	0	14
Integrated Topside dc/dc Converter	314	4	1.6	2.36	5,000	2	72	-5.82	18.5
Integrated Topside dc/dc Converter	314	4	1.6	2.36	5,000	2	72	5.82	18.5

Although the S3D models for converters allow efficiency to vary with load, the notional baseline converters were modeled with a constant 98% efficiency. Switches and switchboards are ideal (no losses).

Power Conversion and Distribution Equipment Data (Electrical Power)

Name	Rated Electrical Power (MW)	Rated Continuous Current (kA)	Efficiency (%)	Primary Rated Voltage (kV)	Primary Current Type	Secondary Rated Voltage (kV)	Secondary Current Type
Bus Node		0.1	100	12	DC		
Bus Node		5	100	12	DC		
Bus Node		5	100	12	DC		
Bus Node		1	100	12	DC		
Bus Node		1	100	12	DC		
Bus Node		5	100	12	DC		
Bus Node		5	100	12	DC		
Bus Node		0.5	100	12	DC		
Power Conversion Module 1A	10.64		98	12	DC	var	var
Power Conversion Module 1A	10.64		98	12	DC	var	var
Power Conversion Module 1A	9.17		98	12	DC	var	var
Power Conversion Module 1A	9.17		98	12	DC	var	var
ac Load Center	7.82		100	0.45	AC	0.45	AC
ac Load Center	7.45		100	0.45	AC	0.45	AC
ac Load Center	5.14		100	0.45	AC	0.45	AC
ac Load Center	7.14		100	0.45	AC	0.45	AC
Integrated Power Node Center (IPNC)	2.77		98	var	var	var	var
Integrated Power Node Center (IPNC)	3.13		98	var	var	var	var
Integrated Power Node Center (IPNC)	3.95		98	var	var	var	var
Integrated Power Node Center (IPNC)	1.99		98	var	var	var	var
Radar dc/dc Converter	1.65		98	12	DC	1	DC
Radar dc/dc Converter	3.3		98	12	DC	1	DC
Integrated Topside dc/dc Converter	2		98	12	DC	1	DC
Integrated Topside dc/dc Converter	2		98	12	DC	1	DC

Cable Data

The cables in this model are based on Caledonian Medium Voltage Cables for Marine Applications [Caledonian 2016].

Cable Data (Location, Dimensions)

Name	SWBS	Zone	Length (m)	Connecting Equipment	
z1_CAB_ACLC_to_IPNC	321	1	3.94	z1_ACLC	z1_IPNC
z1_CAB_Chiller	321	1	9.14	z1_ACLC	z1_CHILLER
z1_CAB_Chiller_CHWPump	321	1	12.4	z1_ACLC	z1_CHILLER_P_CHW_PUMP
z1_CAB_Chiller_SWPump	321	1	9.39	z1_ACLC	z1_CHILLER_P_SW_PUMP
z1_CAB_DC_InZone_S	321	1	3.77	z1_BUS_S	z1_PCM1A_S
z1_CAB_EDG_AC	321	1	4.42	z1_EDG	z1_BRK_EDG
z1_CAB_EDG_DC_P	321	1	19.72	z1_EDG_RECT	z1_BUS_P
z1_CAB_EDG_DC_S	321	1	9.46	z1_EDG_RECT	z1_BUS_S
z1_CAB_PCM1A_to_ACLC	321	1	2.6	z1_PCM1A_S	z1_ACLC
z1_CAB_PCM1A_to_IPNC	321	1	3.1	z1_PCM1A_S	z1_IPNC
z1_CAB_SONAR	321	1	22.97	z1_IPNC	z1_SONAR_SUPPORT_EQ
z1_CAB_VLS	321	1	9.19	z1_IPNC	z1_VLS
z1_z2_CAB_ACLC_DaisyChain	321	1 / 2	44.15	z1_ACLC	z2_ACLC
z1_z2_CAB_P	321	1 / 2	57.13	z1_BUS_P	z2_BUS_P
z1_z2_CAB_S	321	1 / 2	15.11	z1_BUS_S	z2_BUS_S
z2_CAB_ACLC_to_IPNC	321	2	12.6	z2_ACLC	z2_IPNC
z2_CAB_ADS_P	321	2	35.89	z2_IPNC	z2_ADS_P
z2_CAB_ADS_S	321	2	45.12	z2_ACLC	z2_ADS_S
z2_CAB_Chiller_P	321	2	17.93	z2_ACLC	z2_CHILLER_P
z2_CAB_Chiller_S	321	2	26.08	z2_ACLC	z2_CHILLER_S
z2_CAB_ChillerPCHWPump	321	2	22.96	z2_ACLC	z2_CHILLER_P_CHW_PUMP
z2_CAB_ChillerPSWPump	321	2	20.08	z2_ACLC	z2_CHILLER_P_SW_PUMP
z2_CAB_ChillerSCHWPump	321	2	24.79	z2_ACLC	z2_CHILLER_S_CHW_PUMP
z2_CAB_ChillerSSWPump	321	2	22.01	z2_ACLC	z2_CHILLER_S_SW_PUMP
z2_CAB_DC_InZone_P	321	2	4.02	z2_BUS_P	z2_PCM1A_P
z2_CAB_InTopP_P	321	2	19.43	z2_BUS_P	z2_InTop_Eqpt_P
z2_CAB_InTopP_S	321	2	36.37	z2_BUS_S	z2_InTop_Eqpt_P
z2_CAB_InTopS_P	321	2	31.07	z2_BUS_P	z2_InTop_Eqpt_S
z2_CAB_InTopS_S	321	2	48.01	z2_BUS_S	z2_InTop_Eqpt_S
z2_CAB_LM2500P_AC_P1	321	2	9.44	z2_LM2500_P	z2_BRK_LM2500_P1
z2_CAB_LM2500P_AC_P2	321		9.26	z2_LM2500_P	z2_BRK_LM2500_P2
z2_CAB_LM2500P_DC_P	321	2	3.72	z2_LM2500_RECT_P	z2_BUS_P
z2_CAB_LM2500P_DC_S	321	2	42.68	z2_LM2500_RECT_P	z2_BUS_S
z2_CAB_LM2500S_AC_S1	321	2	9.44	z2_LM2500_S	z2_BRK_LM2500_S1
z2_CAB_LM2500S_AC_S2	321		9.26	z2_LM2500_S	z2_BRK_LM2500_S2
z2_CAB_LM2500S_DC_P	321	2	17.65	z2_LM2500_RECT_S	z2_BUS_P
z2_CAB_LM2500S_DC_S	321	2	27.21	z2_LM2500_RECT_S	z2_BUS_S

z2_CAB_PCM1A_to_ACLC	321	2	6.6	z2_PCM1A_P	z2_ACLC
z2_CAB_PCM1A_to_IPNC	321	2	4.66	z2_PCM1A_P	z2_ACLC
z2_CAB_PMM_P	321	2	20.38	z2_BUS_P	z2_PMM_Drive_S
z2_CAB_PMM_S	321	2	47.08	z2_BUS_S	z2_PMM_Drive_S
z2_CAB_Radar_P	321	2	21.75	z2_BUS_P	z2_DCDC_Radar
z2_CAB_Radar_S	321	2	27.14	z2_BUS_S	z2_DCDC_Radar
z2_CAB_railgun_ammo_handling	321	2	31.4	z2_IPNC	z2_Railgun_Ammo_Handling
z2_CAB_Railgun_P	321	2	27.04	z2_BUS_P	z2_SWT_Railgun
z2_CAB_Railgun_S	321	2	11.75	z2_BUS_S	z2_SWT_Railgun
z2_z3_CAB_P	321	2 / 3	38	z2_BUS_P	z3_BUS_P
z2_z3_CAB_S	321	2 / 3	43.33	z2_BUS_S	z3_BUS_S
z3_CAB_ACLC_to_IPNC	321	3	3.89	z3_ACLC	z3_IPNC
z3_CAB_Chiller	321	3	17.82	z3_ACLC	z3_CHILLER_S
z3_CAB_Chiller_CHWPump	321	3	20.2	z3_ACLC	z3_CHILLER_S_CHW_PUMP
z3_CAB_Chiller_SWPump	321	3	17.46	z3_ACLC	z3_CHILLER_S_SW_PUMP
z3_CAB_DC_InZone_S	321	3	2.57	z3_BUS_S	z3_PCM1A_S
z3_CAB_LM2500_AC_S1	321	3	8.91	z3_LM2500_P	z3_BRK_LM2500_P1
z3_CAB_LM2500_AC_S2	321		8.73	z3_LM2500_P	z3_BRK_LM2500_P2
z3_CAB_LM2500_DC_P	321	3	13.3	z3_LM2500_RECT_P	z3_BUS_P
z3_CAB_LM2500_DC_S	321	3	24.95	z3_LM2500_RECT_P	z3_BUS_S
z3_CAB_LM500P_AC_P1	321	3	5.78	z3_LM500_S	z3_BRK_LM500_S1
z3_CAB_LM500P_AC_P2	321		5.32	z3_LM500_S	z3_BRK_LM500_S2
z3_CAB_LM500P_DC_P	321	3	29.63	z3_LM500_RECT_S	z3_BUS_P
z3_CAB_LM500P_DC_S	321	3	7.54	z3_LM500_RECT_S	z3_BUS_S
z3_CAB_PCM1A_to_ACLC	321	3	2.78	z3_PCM1A_S	z3_ACLC
z3_CAB_PCM1A_to_IPNC	321	3	2.91	z3_PCM1A_S	z3_IPNC
z3_CAB_PMM_P	321	3	9.28	z3_PMM_Drive_P	z3_BUS_P
z3_CAB_PMM_S	321	3	28.86	z3_PMM_Drive_P	z3_BUS_S
z3_CAB_Radar_P	321	3	22.32	z3_RADAR_Support_Eq	z3_BUS_P
z3_CAB_Radar_S	321	3	15.54	z3_RADAR_Support_Eq	z3_BUS_S
z3_CAB_VLS	321	3	23.65	z3_IPNC	z3_VLS
z3_z4_CAB_ACLC_DaisyChain	321	3 / 4	48.48	z3_ACLC	z4_ACLC
z3_z4_CAB_P	321	3 / 4	34.16	z3_BUS_P	z4_BUS_P
z3_z4_CAB_S	321	3 / 4	50.65	z3_BUS_S	z4_BUS_S
z4_CAB_ACLC_to_IPNC	321	4	4.31	z4_ACLC	z4_IPNC
z4_CAB_Chiller	321	4	7.06	z4_ACLC	z4_CHILLER_P
z4_CAB_Chiller_CHWPump	321	4	3.93	z4_ACLC	z4_CHILLER_S_CHW_PUMP
z4_CAB_Chiller_SWPump	321	4	3.03	z4_ACLC	z4_CHILLER_S_SW_PUMP
z4_CAB_DC_InZone_P	321	4	8.01	z4_BUS_P	z4_PCM1A_P
z4_CAB_Laser_P	321	3	26.59	z3_IPNC	z3_laser_support_eq
z4_CAB_LM500_AC_S1	321	4	6.03	z4_LM500_S	z4_BRK_LM500_S1
z4_CAB_LM500_AC_S2	321		5.58	z4_LM500_S	z4_BRK_LM500_S2
z4_CAB_LM500S_DC_P	321	4	4.89	z4_LM500_RECT_S	z4_BUS_P
z4_CAB_LM500S_DC_S	321	4	2.38	z4_LM500_RECT_S	z4_BUS_S

z4_CAB_MFTA_P	321	4	19.5	z4_MFTA_and_Eq	z4_IPNC
z4_CAB_PCM1A_to_ACLC	321	4	3.01	z4_PCM1A_P	z4_ACLC
z4_CAB_PCM1A_to_IPNC	321	4	3.27	z4_PCM1A_P	z4_IPNC

Cable Data (Electrical Power, Weight)

Name	Rated Voltage (kV)	Current Type	Number of Cables in Bundle	Rated Continuous Current per Cable (A)	Total Rated Continuous Current (A)	Weight Per Unit Length (kg/m)	Weight (kg)
z1_CAB_ACLC_to_IPNC	0.45	AC	5	780	3900	33.05	390.45
z1_CAB_Chiller	0.45	AC	2	890	1780	16.34	448.21
z1_CAB_Chiller_CHWPump	0.45	AC	1	127	127	1.02	37.94
z1_CAB_Chiller_SWPump	0.45	AC	1	127	127	1.02	28.74
z1_CAB_DC_InZone_S	12	DC	2	522	1044	7.45	56.11
z1_CAB_EDG_AC	6.9	AC	1	127	127	1.02	13.53
z1_CAB_EDG_DC_P	12	DC	1	127	127	1.02	40.22
z1_CAB_EDG_DC_S	12	DC	1	127	127	1.02	19.29
z1_CAB_PCM1A_to_ACLC	0.45	AC	12	890	10680	98.04	766.03
z1_CAB_PCM1A_to_IPNC	1	DC	4	780	3120	26.44	164.04
z1_CAB_SONAR	1	DC	1	522	522	3.72	171.14
z1_CAB_VLS	0.45	AC	1	780	780	6.61	182.25
z1_z2_CAB_ACLC_DaisyChain	0.45	AC	10	890	8900	81.7	10822
z1_z2_CAB_P	12	DC	1	127	127	1.02	116.55
z1_z2_CAB_S	12	DC	2	522	1044	7.45	225.16
z2_CAB_ACLC_to_IPNC	0.45	AC	5	890	4450	40.85	1544.58
z2_CAB_ADS_P	1	DC	1	389	389	2.55	183.04
z2_CAB_ADS_S	1	DC	1	389	389	2.55	230.13
z2_CAB_Chiller_P	0.45	AC	2	890	1780	16.34	879.09
z2_CAB_Chiller_S	0.45	AC	2	890	1780	16.34	1278.6
z2_CAB_ChillerPCHWPump	0.45	AC	1	127	127	1.02	70.26
z2_CAB_ChillerPSWPump	0.45	AC	1	127	127	1.02	61.44
z2_CAB_ChillerSCHWPump	0.45	AC	1	127	127	1.02	75.86
z2_CAB_ChillerSSWPump	0.45	AC	1	127	127	1.02	67.35
z2_CAB_DC_InZone_P	12	DC	2	522	1044	7.45	59.93
z2_CAB_InTopP_P	12	DC	1	242	242	1.6	61.98
z2_CAB_InTopP_S	12	DC	1	242	242	1.6	116.02
z2_CAB_InTopS_P	12	DC	1	242	242	1.6	99.11
z2_CAB_InTopS_S	12	DC	1	242	242	1.6	153.15
z2_CAB_LM2500P_AC_P1	6.9	AC	2	780	1560	13.22	374.21
z2_CAB_LM2500P_AC_P2	6.9	AC	2	780	1560	13.22	367.32
z2_CAB_LM2500P_DC_P	12	DC	4	780	3120	26.44	196.75
z2_CAB_LM2500P_DC_S	12	DC	4	780	3120	26.44	2257.05
z2_CAB_LM2500S_AC_S1	6.9	AC	2	780	1560	13.22	374.21

z2_CAB_LM2500S_AC_S2	6.9	AC	2	780	1560	13.22	367.37
z2_CAB_LM2500S_DC_P	12	DC	4	780	3120	26.44	933.34
z2_CAB_LM2500S_DC_S	12	DC	4	780	3120	26.44	1438.68
z2_CAB_PCM1A_to_ACLC	0.45	AC	11	890	9790	89.87	1780.72
z2_CAB_PCM1A_to_IPNC	1	DC	4	890	3560	32.68	304.76
z2_CAB_PMM_P	12	DC	5	780	3900	33.05	1346.83
z2_CAB_PMM_S	12	DC	5	780	3900	33.05	3111.7
z2_CAB_Radar_P	12	DC	1	339	339	2.24	97.23
z2_CAB_Radar_S	12	DC	1	339	339	2.24	121.3
z2_CAB_railgun_ammo_handling	1	DC	1	522	522	3.72	233.93
z2_CAB_Railgun_P	12	DC	2	890	1780	16.34	883.78
z2_CAB_Railgun_S	12	DC	2	890	1780	16.34	384.04
z2_z3_CAB_P	12	DC	6	890	5340	49.02	3725.49
z2_z3_CAB_S	12	DC	6	890	5340	49.02	4248.27
z3_CAB_ACLC_to_IPNC	0.45	AC	6	890	5340	49.02	572.06
z3_CAB_Chiller	0.45	AC	2	890	1780	16.34	873.43
z3_CAB_Chiller_CHWPump	0.45	AC	1	127	127	1.02	61.81
z3_CAB_Chiller_SWPump	0.45	AC	1	127	127	1.02	53.43
z3_CAB_DC_InZone_S	12	DC	1	780	780	6.61	33.98
z3_CAB_LM2500_AC_S1	6.9	AC	2	780	1560	13.22	353.19
z3_CAB_LM2500_AC_S2	6.9	AC	2	780	1560	13.22	346.3
z3_CAB_LM2500_DC_P	12	DC	4	780	3120	26.44	703.34
z3_CAB_LM2500_DC_S	12	DC	4	780	3120	26.44	1319.27
z3_CAB_LM500P_AC_P1	6.9	AC	1	196	196	1.32	22.89
z3_CAB_LM500P_AC_P2	6.9	AC	1	196	196	1.32	21.08
z3_CAB_LM500P_DC_P	12	DC	1	389	389	2.55	151.13
z3_CAB_LM500P_DC_S	12	DC	1	389	389	2.55	38.45
z3_CAB_PCM1A_to_ACLC	0.45	AC	8	890	7120	65.36	544.19
z3_CAB_PCM1A_to_IPNC	1	DC	5	890	4450	40.85	237.37
z3_CAB_PMM_P	12	DC	5	780	3900	33.05	613.68
z3_CAB_PMM_S	12	DC	5	780	3900	33.05	1907.51
z3_CAB_Radar_P	12	DC	1	196	196	1.32	58.92
z3_CAB_Radar_S	12	DC	1	196	196	1.32	41.02
z3_CAB_VLS	0.45	AC	1	780	780	6.61	469.04
z3_z4_CAB_ACLC_DaisyChain	0.45	AC	7	890	6230	57.19	8317.82
z3_z4_CAB_P	12	DC	1	780	780	6.61	451.55
z3_z4_CAB_S	12	DC	1	389	389	2.55	258.31
z4_CAB_ACLC_to_IPNC	0.45	AC	3	890	2670	24.51	316.77
z4_CAB_Chiller	0.45	AC	2	890	1780	16.34	346.03
z4_CAB_Chiller_CHWPump	0.45	AC	1	127	127	1.02	12.04
z4_CAB_Chiller_SWPump	0.45	AC	1	127	127	1.02	9.27
z4_CAB_DC_InZone_P	12	DC	1	780	780	6.61	105.94
z4_CAB_Laser_P	1	DC	2	780	1560	13.22	703.11
z4_CAB_LM500_AC_S1	6.9	AC	1	196	196	1.32	23.88

z4_CAB_LM500_AC_S2	6.9	AC	1	196	196	1.32	22.08
z4_CAB_LM500S_DC_P	12	DC	1	389	389	2.55	24.93
z4_CAB_LM500S_DC_S	12	DC	1	389	389	2.55	12.13
z4_CAB_MFTA_P	1	DC	1	196	196	1.32	51.47
z4_CAB_PCM1A_to_ACLC	0.45	AC	11	890	9790	89.87	811.07
z4_CAB_PCM1A_to_IPNC	1	DC	3	690	2070	16.26	106.38

Thermal System Data

Thermal view

Diagram to be added

Cooling Equipment Data (Dimensions, Location)

Identification		Dimensions				Location			
Name	SWBS	Length (m)	Width (m)	Height (m)	Weight (kg)	Zone	X (m)	Y (m)	Z (m)
Chiller	514	2.9	2.3	5.7	38500	1	34.18	-2.78	3.66
Chiller	514	2.9	2.3	5.7	38500	2	56.16	-3.97	2.46
Chiller	514	2.9	2.3	5.7	38500	2	133.81	-4.11	6.22
Chiller	514	2.9	2.3	5.7	38500	3	56.17	4.19	2.46
Chiller	514	2.9	2.3	5.7	38500	4	105.19	3.73	5.42
Seawater Pump	514	1	1	2	1000	1	36.91	-0.68	1.81
Seawater Pump	514	1	1	2	1000	2	58.37	-1.22	1.81
Seawater Pump	514	1	1	2	1000	2	58.49	0.83	1.81
Seawater Pump	514	1	1	2	1000	3	104.16	6	3.4
Seawater Pump	514	1	1	2	1000	4	136.5	-1.13	4.9
Chilled Water Pump	514	1	1	2	1000	1	31.61	-0.66	1.81
Chilled Water Pump	514	1	1	2	1000	2	55.76	-0.95	1.81
Chilled Water Pump	514	1	1	2	1000	2	55.85	0.97	1.81
Chilled Water Pump	514	1	1	2	1000	3	106.9	6	3.4
Chilled Water Pump	514	1	1	2	1000	4	134.99	-1.09	4.9

Cooling Equipment Data (Electrical Power, Efficiency)

Name	Rated Electrical Power (MW)	Efficiency (%)	Rated Voltage (kV)	Current Type	Coefficient of Performance
Chiller	3.87	1.1		0.45	AC
Chiller	3.87	1.1		0.45	AC
Chiller	3.87	1.1		0.45	AC
Chiller	3.87	1.1		0.45	AC
Chiller	3.87	1.1		0.45	AC
Seawater Pump		0.08	80	0.45	AC
Seawater Pump		0.08	80	0.45	AC
Seawater Pump		0.08	80	0.45	AC
Seawater Pump		0.08	80	0.45	AC
Seawater Pump		0.08	80	0.45	AC
Chilled Water Pump		0.08	80	0.45	AC
Chilled Water Pump		0.08	80	0.45	AC
Chilled Water Pump		0.08	80	0.45	AC
Chilled Water Pump		0.08	80	0.45	AC
Chilled Water Pump		0.08	80	0.45	AC

Mission Definition

Static Mission Conditions

Four static mission conditions are defined as follows. These missions are intended for quasi-static system analysis for such evaluations as annual fuel usage.

Equipment	Peacetime Cruise	Sprint to Station	Battle	Anchor
Active Denial System	off	off	high	low
Laser	off	medium	high	off
Railgun	off	off	high	off
Vertical Launch System	off	off	high	off
Integrated Topside	medium	medium	high	medium
Radar	medium	high	high	low
Sonar	off	off	on	off
Towed-Array Sonar	off	off	off	off
Aggregated AC Non-vital Loads	high	medium	medium	high
Aggregated DC Vital Loads	medium	high	high	medium
Ship Speed	15 kts	31 kts	8 kts	0 kts

Dynamic Mission Scenario

An example dynamic mission scenario. This scenario is intended for dynamic system evaluations.

Equipment	Initial state
Active Denial System	standby
Laser	standby
Railgun	standby
Vertical Launch System	standby
Integrated Topside	high
Radar	high
Sonar	on
Towed-Array Sonar	off
Aggregated AC Non-vital Loads	medium
Aggregated DC Vital Loads	high
Ship Speed	8 kts

Beginning in the initial state indicated above, flow through the following sequence:

- Charge railgun (5 seconds)
- Fire railgun (1 second)
- Charge railgun (5 seconds)
- Fire railgun (1 second)
- Increase speed to 25 kts
- Fire laser (15 seconds)

Fault Scenarios

(expand description)

These fault scenarios are intended for dynamic system testing. Since S3D is currently a quasi-static analysis tool, fault testing is not applicable in that environment beyond manually opening the appropriate breakers or disconnects and determining whether power is available from a different source.

Example fault scenario 1: Beginning in the Sprint to Station condition described above, a fault develops in the cable leading from the zone 2 port bus node to the zone 2 dc/dc converter for the radar. This fault requires isolation of the cable from the bus node and the converter, and requires re-alignment of power to the radar from the starboard bus.

Example fault scenario 2: Beginning in the Sprint to Station condition described above, a fault develops in the zone 3 starboard bus node, requiring isolation of all connections to the bus node. This will require re-routing of power into zone three from the port bus; since the PCM1A in Zone 3 is connected to the starboard bus, power must be fed to in-zone loads via the ACLC in Zone 4. Additionally, the generators must deliver power to the starboard bus only and the radars and propulsion motor in zone 3 must receive power from the starboard bus.

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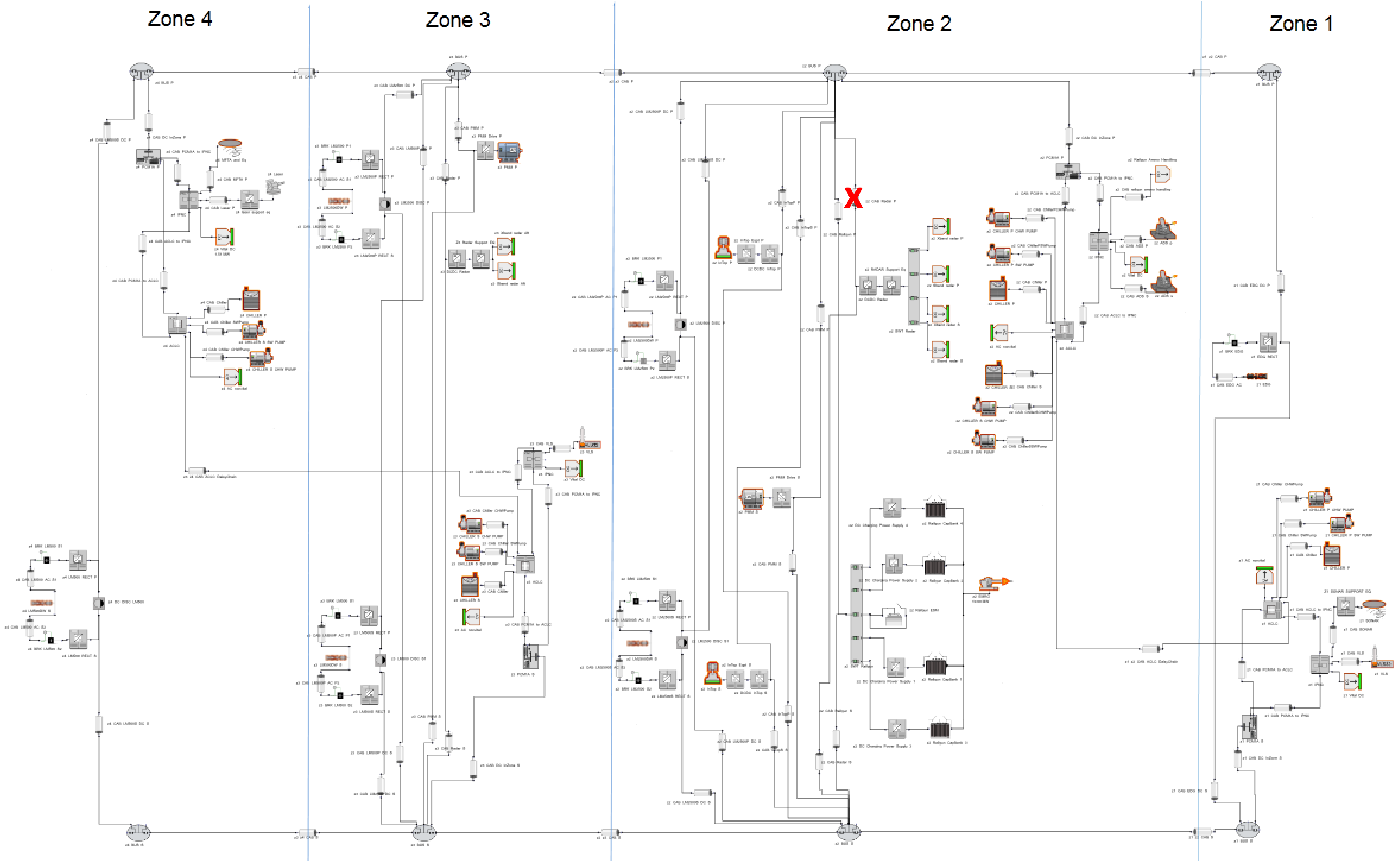

Figure 5. Example Fault Scenario 1

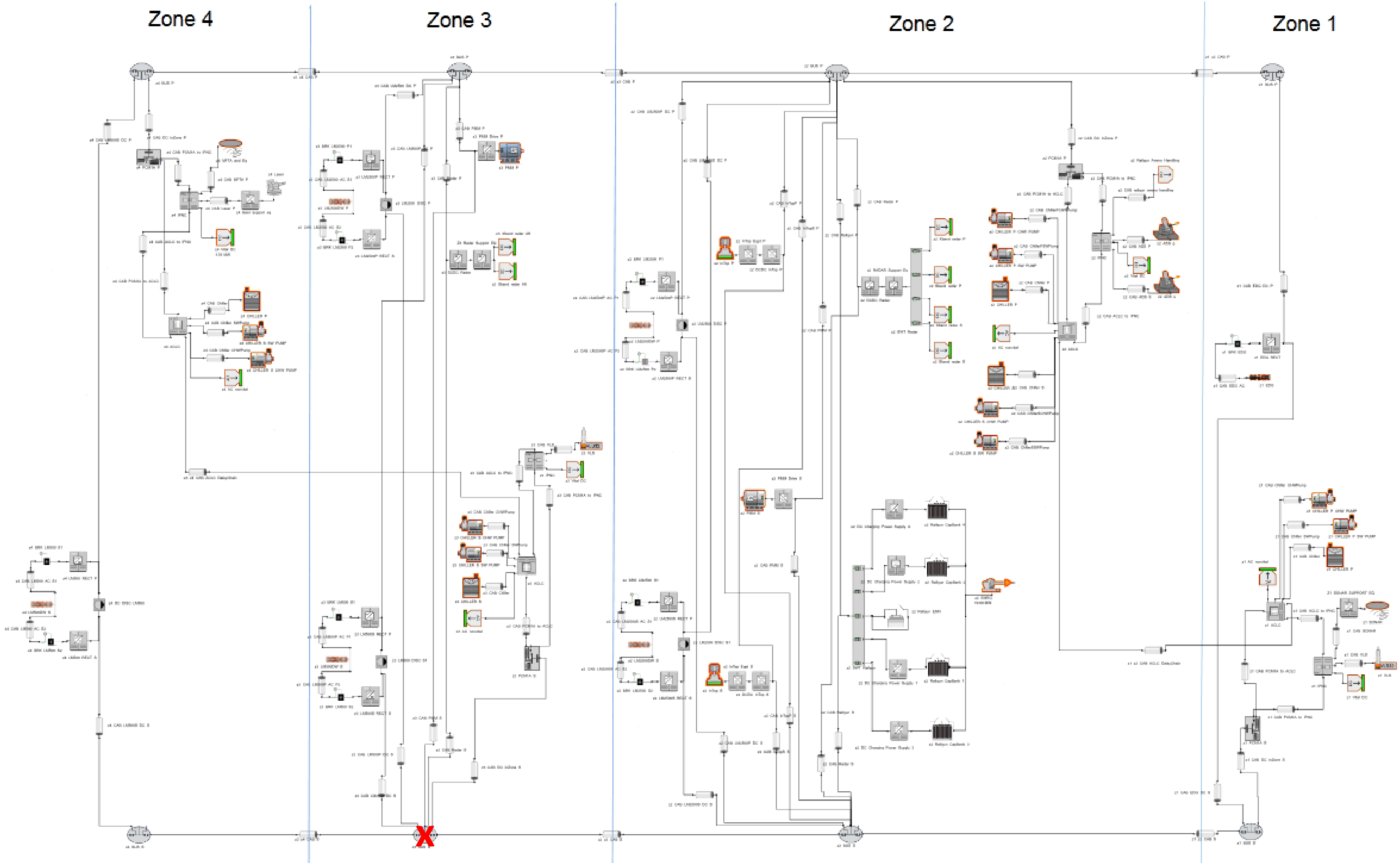

Figure 6. Example Fault Scenario 2