WHITE PAPER

Next Generation Data Center Infrastructure

ICE Cube™ Modular Data Center Overview and Features

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Introduction to ICE Cube™

SGI® offers a compelling alternative to augment or replace traditional brick-and-mortar data centers, as they relate to deployment of servers, networking and storage. ICE Cube is a self-contained, fully portable data center module featuring extreme server and storage density with highly efficient cooling and easy serviceability. ICE Cube features compute density levels of up to 46,080 cores or storage capacity of 29.8 petabytes in a compact 40' x 8' shipping container. Each container is self-contained as a cohesive system with no additional external structures required.

Designed to reduce data center costs, deployment times and maintenance, ICE Cube is ideal for organizations looking to maximize TCO and easily expand their existing data centers, provide for disaster recovery or completely eliminate the need for expensive raised floor new data center construction. ICE Cube can be deployed in almost any location, and features self-contained cooling and power distribution technologies.

ICE Cube leverages SGI's proven expertise in server, cabinet and power infrastructure to achieve high density in a small form factor. Its unique cooling technology dramatically reduces cooling costs by as much as 80% over a traditional data center. Models leveraging SGI's award-winning, patented managed DC Power technology support in-rack Uninterrupted Power Supply (UPS) functionality. This maximizes efficiency and reliability and even enables the total elimination of system-level fans for further power reductions.

ICE Cube is available in a choice of multiple layouts in order to optimize for different types of equipment. Dual row layouts supporting up to 28 racks of half-depth Rackable™ servers and storage are ideal to maximize power efficiency. This white paper focuses on the many advantages of the dual row designs. Universal layouts are also available that accommodate industry-standard rackmount systems, including not only all products that SGI offers but third-party equipment as well.

ICE Cube Features

Below are features containerized Data Center Modules (DCM) bring forth, as exemplified in ICE Cube.

Rapid Deployment of Systems

The containerized DCM enables delivery of systems pre-cabled and tested at the rack level. Historically, SGI built and delivered a row of racks; this led to DCMs built and delivered on wheels, cabled and tested as a finished unit with no need to unload at the data center; the cost of infrastructure implementation is dramatically reduced with ICE Cube.

Lower Capital Costs

The DCM concept permits customers to "build as you go," as it permits a much simpler facility, which can be acquired much later in the build process. This delays and lowers capital expenditures. An important characteristic of this just-in-time approach to data center facilities is that the container infrastructure scales at the same rate as the IT equipment inside it, dramatically reducing waste. For example, the ICE Cube design allows the UPS to arrive and scale with the rack load; no additional equipment is left idle or over provisioned. Backup power implemented via a simple diesel generator or a second utility feed is supported without requiring a flywheel or elaborate synchronous phase balancing. Air handlers are no longer needed. All of these advantages make the DCM highly attractive relative to traditional brick and mortar data center construction when it comes to lowering capital costs.

Lower Operational Expenses

The techniques employed in the ICE Cube module, including the circulating water loop for operations at much higher temperatures, can effectively remove 80 percent or more of the cooling costs from the data center cost equation.

Dual row ICE Cube models make use of a proven concept in the Telco world of using distributed ELV 48vdc across a distributed single conversion UPS at the rack. This eliminates the sub-optimal and costly inversion stage of the UPS. A second revolutionary step utilized by ICE Cube is the elimination of all server fans—possible with most Rackable server models in the dual row design. When the combined power draw of the system fans that would otherwise be required is subtracted from the power draw of the 48vdc air handler impeller fans, a negative number results. This means that the entire air handling loop effectively operates in the black, giving back power to the energy equation. This is a stark contrast to air handlers taking almost one-half of the chiller power in a large modern data center.

SGI's distributed UPS system utilizes best in class, high rate VRLA cells, with a float life in excess of three years at elevated temperatures. A key component of the UPS system is the fully distributed and automated testing and reporting of the system as a whole. This validation of the UPS system takes place at regular intervals while the container continues to operate at full system load without risk of causing server power outages (even with completely missing cells). When faulty units are identified during normal maintenance windows, the batteries or rectifier modules can be safely and easily replaced without any need for system downtime. The overwhelming simplicity and reliability of this UPS architecture is a substantial advance over the older, painful battery maintenance procedures required in traditional data centers.

Security

The DCM can be far more secure than a typical data center, as it is a locked steel shielded entity, denying physical as well as visual entry to all but authorized personnel. The cube can be placed in remote locations, as well as in bunkers and armored buildings.

Density

The DCM breaks historical density profile records by increasing the compute and heat power footprint by 10 times, allowing power densities beyond 1500W per square foot of complete data center space. If a customer is prepared to consider the stacking capability, the square foot density can be doubled.

Reliability

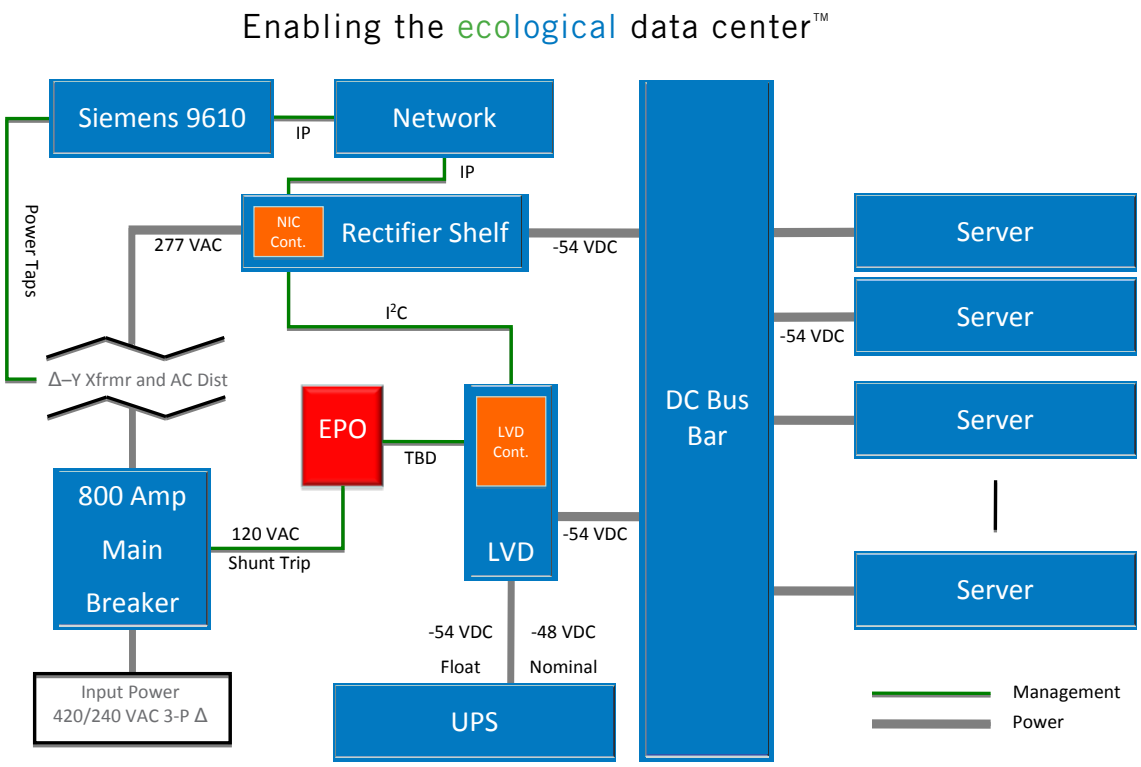
The ICE Cube module should be the most reliable of all data center formats because the two least reliable parts of the server are removed — the AC power supply and the server chassis fans. In addition, through the use of DC power supplies, a pool of redundant power at the rack level is provided to all servers that utilize DC power supplies featuring 2 Million+ hours Mean Time To Failure (MTTF) vs. 100K hours delivered by most AC power supplies. Dual feed DC configurations allow entire incoming circuits to fail by connecting the spare circuits to the "B" feeds on all servers in the container, maintaining availability in the case of circuit failure. The impeller fans included in the ICE Cube cooling infrastructure have much higher MTTF characteristics than the depopulated server fans (not needed in ICE Cube deployments) and there are far fewer of them. This cooling strategy leads to higher rack-level reliability. When the rack level UPS option is installed, the UPS systems can be serviced live without risky and/or complex bypass procedures, further protecting from transients that traditional data center UPS systems often miss.

ICE Cube Power

The ICE Cube system is flexible in terms of power, as it is configured for a number of different power delivery solutions, including but not limited to:

- AC feeds with the power converted from AC to DC at the rack level
- AC feeds with the phase/voltage conversion via internally mounted transformer then converted from AC to DC at the rack level
- Externally rectified DC power direct to the ICE Cube

By far the most energy efficient means of providing power to ICE Cube is via 480/277 VAC 3-phase 5-wire wye (3 phases + neutral + ground). This is the preferred power source since 480 VAC 3-phase splits into three 277 VAC circuits without requiring a supplemental PDU. One or more 277 VAC circuits are then rectified to -48 VAC DC at the rack level and distributed to servers. This can easily be made redundant with the ICE Cube Dual Feed DC power option.



Power Consumption

Within ICE Cube there are three primary sources of power draw beyond that of the servers. The cooling fans for a 40' 24-rack container consume less than 5000 Watts, although this power is more than offset because of the removal of all cooling fans inside the servers. Rectifiers are approximately 93% efficient, which results in additional power draw beyond the connected individual servers and fans. This is mostly offset by the fact that the DC powered servers are approximately 4% more efficient than their AC powered equivalents. There is also a very minor power draw from overhead lighting and alarm panel (~50W).

Power and Mobility

There are multiple power feed and panel options, including 400A, dual 400A, 600A and even dual 600A. This flexibility is combined with an ability to configure the power panels for either a hard-wired stationary installation or a quick-disconnect mobile installation. Both models are equally supported.

DC Bus Bars

Every DC Rack Power Distribution Unit (RPDU) distributes 400 amps of 48 VDC power to 56 individual outlets. Distributed DC power is key to the container's capability to support the in-rack UPS system while avoiding the efficiency loss normally associated with AC UPS systems.

UPS

The ICE Cube solution includes a comprehensive rack level UPS system that can provide sufficient hold-up time for an automatic switch-over from the primary to secondary power source. The UPS system is tightly integrated into the DC power system and provides backup power to servers, network, cooling and other support equipment. It also includes a fully integrated monitoring system and a Low Voltage Disconnect (LVD) to protect the battery packs during discharge. At the rack level, the system consists of a 2U battery tray populated with four VRLA 12v cells with a 3-year service life. This provides for a highly scalable UPS system that can grow or shrink depending upon container/server configuration. The baseline holdup time can be configured for as few as 30 seconds to as many as 10 minutes as required.

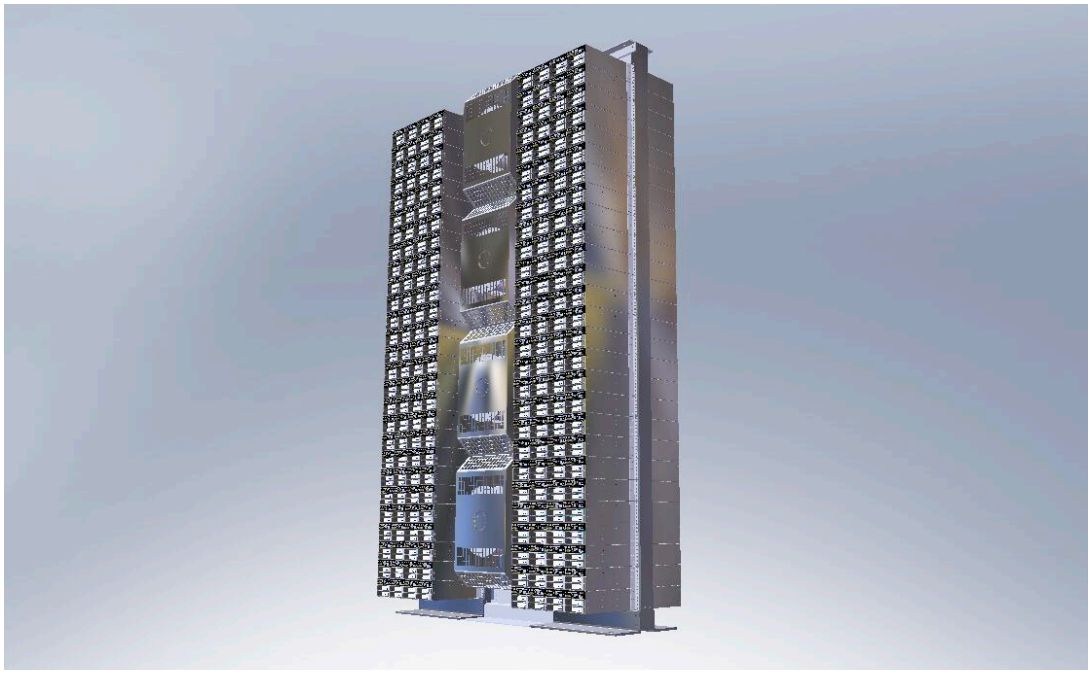
ICE Cube Cooling

ICE Cubes operate as closed-loop systems. The water source is either a chiller loop (including reservoir tank) or any untreated or poorly controlled source, as long as it goes through a heat exchange separation loop. Water should contain a simple organic algaecide and contain as little air as possible (a simple air breather vent should be installed high in the loop or a centrifugal air separator could be added). The cleaner and more air-free it is, the longer the cooling infrastructure will last. The ICE Cube cooling infrastructure has been designed to a 20-year specification to significantly outlive the 3–5 year service lives of most server and storage products.

Cooling load is totally dependent on server power draw. An estimate is approximately 300 tons of cooling on the chiller side per 1 megawatt of power draw. The typical deployment only requires about 900 hours chiller usage in a typical year when water side economizers are used.

Heat Exchangers

SGI has designed a set of water cooled radiators with 10.8 PSI and a flow rate of 244 GPM for water in-let temperatures of 60F – 75F. As well, it can operate at lower temperatures and higher temperatures. Impeller fans are low power and operate at 90 Watts, with 6 fans per impeller unit.



The radiators themselves are highly efficient units constructed similarly to units designed for installation in the harshest external environments. There is a 15-year design point. Each heat exchanger assembly serves a pair of racks, and airflow is drawn through the servers into a common plenum area behind the rack, then drawn through the heat exchanger and expelled, cooled into the center aisle.

The system is optimized to maintain the temperature swing inside the container cold aisle and server environment at about 5F with an inlet temperature of 75–85F. Operating ICE Cube at as high a temperature as possible is recommended to increase the number of free cooling hours per year and reduce condensation issues. The water distribution system is plumbed primarily in copper pipe. This is utilized because of the increased resistance to internal corrosion, greater conductivity, lower initial cost and lower cost of installation.

Environment

SGI has evaluated a wide variety of installation paradigms related to environmental parameters and determined there are no appreciable conflicts with any portion of ICE Cube in relation to functionality when installed indoors or out.

The ICE Cube container features a thermal, sound attenuation coating. The coating will block 95% of heat transfer, 68% of sound transfer and is resistant to moisture, mold and mildew. It has a class “A” fire rating with zero flame spread and smoke production.

Water Connections

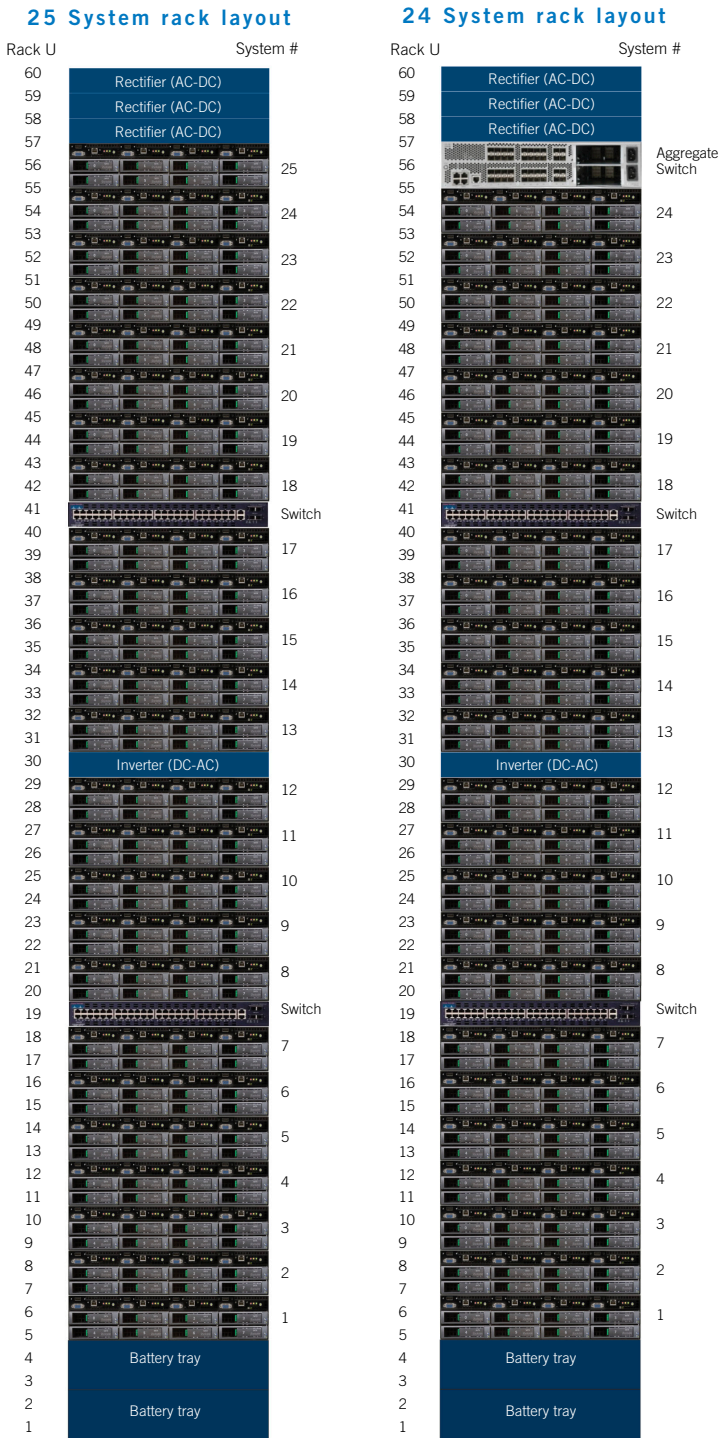
Water is usually supplied to ICE Cube via 2.5" grooved Victaulic connections (http://www.victaulic.com/content/quickvicrigidcoupling.htm), with the stub leaving the container being a male end. A supply and a return line are provided on each side of the container (or end, if so configured). It is recommended that a simple 4" to 2.5" Victaulic “Y” be used about 12' from the container, with the two supply and two return 2.5" hoses going to a 4" feed hose or line. A circuit setter can be placed on the 4" return line to set the flow, if so desired. A 4 or 8 bolt 4" flanged connection is also available as an alternate choice.

The design is simple, elegant, and durable.

ICE Cube Rack Configuration

Sample Rack-level Configuration

Two sample rack layouts follow, illustrating 24 and 25 systems (96 and 100 nodes) per rack:



ICE Cube Monitoring

All ICE Cube containers come standard with a comprehensive environmental monitoring system, monitoring:

- Cold and hot aisle temperatures
- Supply and return water temperatures
- Cooling water inlet flow rate

Very Early Smoke Detection Apparatus (VESDA) fire detection is also included with every container. A power metering package is available to further enhance ICE Cube management for customers interested in monitoring power quality and consumption.

Fire protection

The VESDA system that comes standard with every ICE Cube container uses advanced aspirating smoke detection technology that continuously samples the air in the container to provide the earliest possible warning of an impending fire hazard. By detecting even minute levels of smoke early, facilities personnel gain valuable time to respond before a fire has time to escalate. As an option, SGI can include a fire suppression system that will automatically respond in conjunction with a VESDA alarm.

ICE Cube Technical Specifications

The following table contains the specifications for the dual row models of ICE Cube as discussed in this white paper. Please be sure to also visit the SGI ICE Cube website (www.sgi.com/icecube) for more information, including specifications for the universal class of containers designed to maximize compatibility with standard-depth rackmount systems from SGI and third party manufacturers.

Container Level Specifications

Container Class	Dual Row	Dual Row	Dual Row	Dual Row	Dual Row
Model	IC2012DR	IC4024DR	IC4028DR	IC2010HY	IC4026HY
Max. Half-Depth Racks	12 x 55U	24 x 55U	28 x 55U	8 x 60U	24 x 60U
Max. Standard-Depth Racks	N/A	N/A	N/A	2 x 44U roll-in	2 x 44U roll-in
Max. Rack U	660	1320	1540	480 + 88	1440 + 88
Max. Cores (based on max. 305W per node)	14,832	29,664	34,608	15,072	36,768
Max. Storage (with 2TB drives)	6.2PB	12.5PB	14.5PB	6.6PB	16.0PB
Cooling	In-row chilled water				
Input Power	480/277 VAC				
Max. Power/Container	260 kW	600 kW	600 kW	540 kW	1000 kW
Max. Power/Rack	22 kW	22 kW	22 kW	45 kW	45 kW
Dimensions (Length x Width x Height)	20’ x 8’ x 9.5’	40’ x 8’ x 9.5’	40’ x 8’ x 9.5’	20’ x 8’ x 9.5’	40’ x 8’ x 9.5’

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