



**OPEN**  
Compute Project

Open CloudServer  
chassis specification  
V1.0

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# 1 Revision History

Date	Name	Description
1/28/2014		Version 1.0

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## 2 Scope

This document provides the technical specifications for the design of the Open CloudServer system chassis.

## 3 Contents

1	Revision History .....	2
2	Scope .....	4
3	Contents .....	4
4	Overview.....	5
5	Chassis Specification.....	8
5.1	Chassis Physical Specification.....	8
5.2	Power Delivery .....	15
5.3	Tray Specifications.....	17
5.4	Blade Numbering.....	27
6	Cooling System Specifications .....	27
6.1	Thermal Design Considerations.....	28
6.2	Blade Impedance.....	28
6.3	Fan System Performance .....	32
6.4	Fan Speed Control .....	34
6.5	Fan Failure .....	38
6.6	Thermal Considerations for the Blade .....	39
7	Chassis Power.....	40
8	Operating Environment.....	41
9	Safety and Compliance Documentation.....	41
10	Shock and Vibration Requirements.....	42
11	Appendix: Commonly Used Acronyms .....	46

## 4 Overview

The Open CloudServer system is a fully integrated rack of servers and IT equipment that is highly optimized and streamlined for large, web-scale deployments. The system is intended to support at least two generations of servers to minimize the detailed, time-consuming, and expensive process of setting up networking and infrastructure in a server deployment.

The system utilizes an off-the-shelf (OTS) commodity rack that is loaded with up to four modular chassis, each with trays, power supplies, power distribution, rack management, system fans, and two side-walls, as shown in Figure 1.

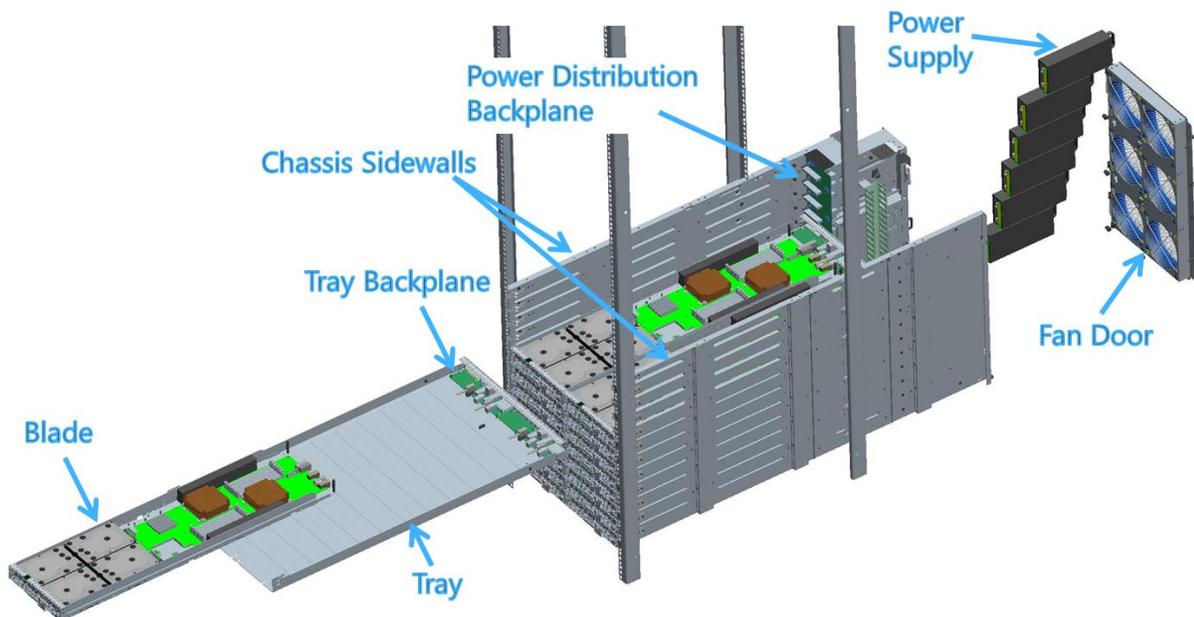
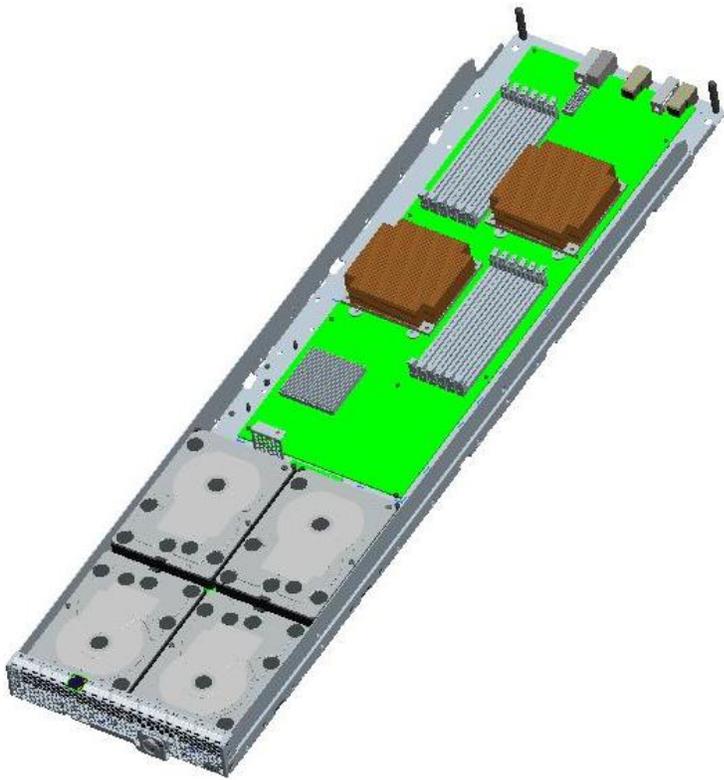


Figure 1. System overview

Blades are highly configurable, and are usually compute blades or storage “just a bunch of disks” (JBOD) blades.

Figure 2 shows an example of a blade.



**Figure 2. Blade assembly**

Each chassis supports 12 rack unit (U or 1U, each 19" wide and 1.75" tall) trays that house up to 24 individual blades (two blades per tray). Blades can be designed to use the full width of the tray. It is also possible to use multiple rack units to house a single tall blade, with certain restrictions.

Power and management are distributed through the chassis power distribution backplane (PDB). The power distribution backplane attaches vertically to the individual trays on one side and to the power supply unit (PSU) on the other side. This arrangement reduces the current carrying requirements of the distribution board, eliminates cabling, and reduces costs.

Figure 3 shows the chassis components.

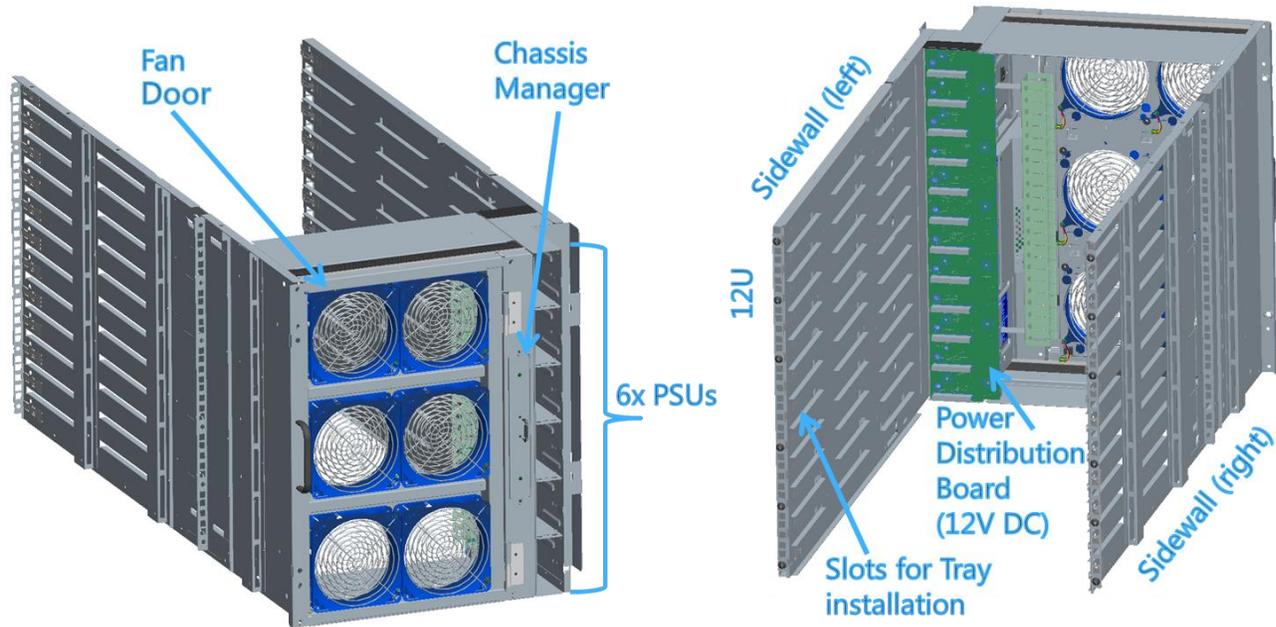


Figure 3. Chassis components

Power is distributed from the power supply units through the PDB to the trays and blades. Management signals are routed between the Chassis Manager and the blades through the PDB and tray via serial communication signals and discrete on/off signals.

The tray backplane carries power, management, and high-speed I/O through a blind-mate connection to the blade as seen in Figure 4. The Ethernet (10 Gigabit) networking and serial-attached small computer system interface (SAS) storage signals pass through the blind-mate connector and are routed to attachments at the rear of the chassis. The cables are routed through the rear of the chassis to networking equipment placed elsewhere. Note that running the cables through the rear of the blade eliminates the need to connect directly to the servers. Once provisioned, the network cabling should only be touched when a cable or switch fails. The type and number of networking switches depends on the specific deployment.

Tray (1U each)  
supports  
2 blades

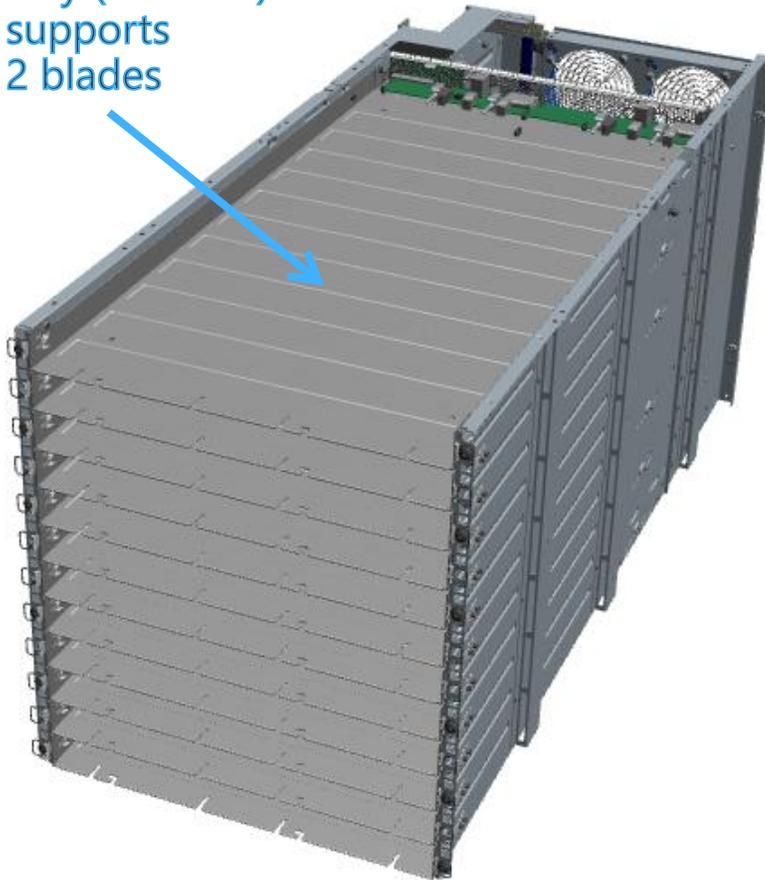


Figure 4. Chassis Trays

## 5 Chassis Specification

The following sections describe the chassis.

The chassis is an assembly of interlocking components designed to be individually mounted to the rack. It provides structure and airflow to the blades and other electrical subsystems.

### 5.1 Chassis Physical Specification

The physical specifications for the chassis include the dimensions and a description of the guiding and latching features.

### 5.1.1 Volumetric Specifications

Figure 5 shows details of the chassis from the rear, and Figure 6 shows details of the chassis from the front.

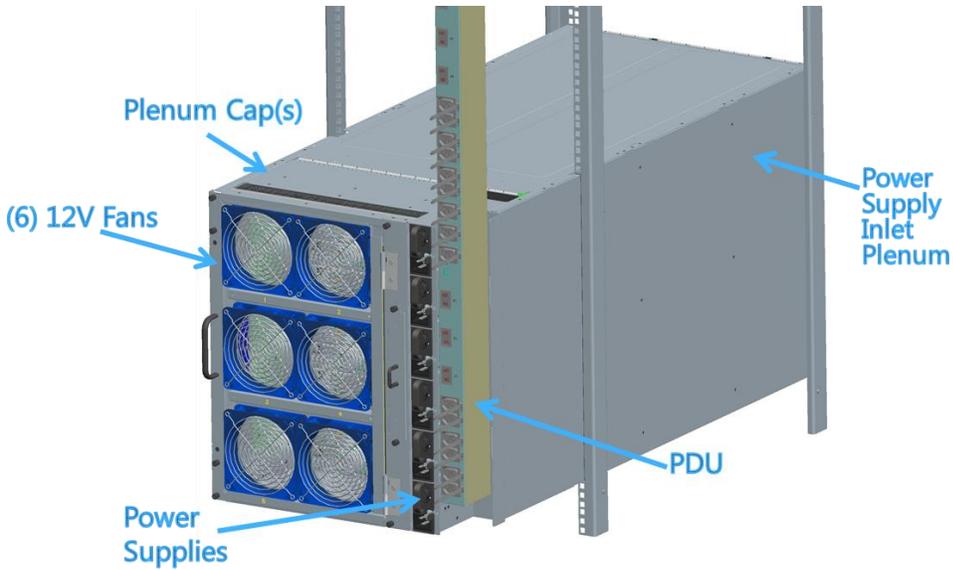


Figure 5. Chassis details, from the rear

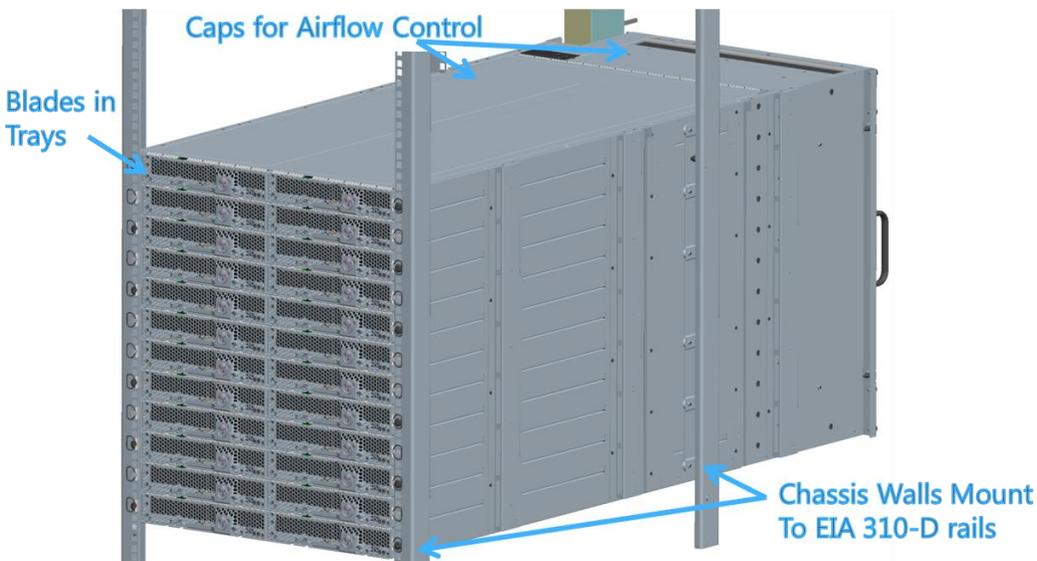


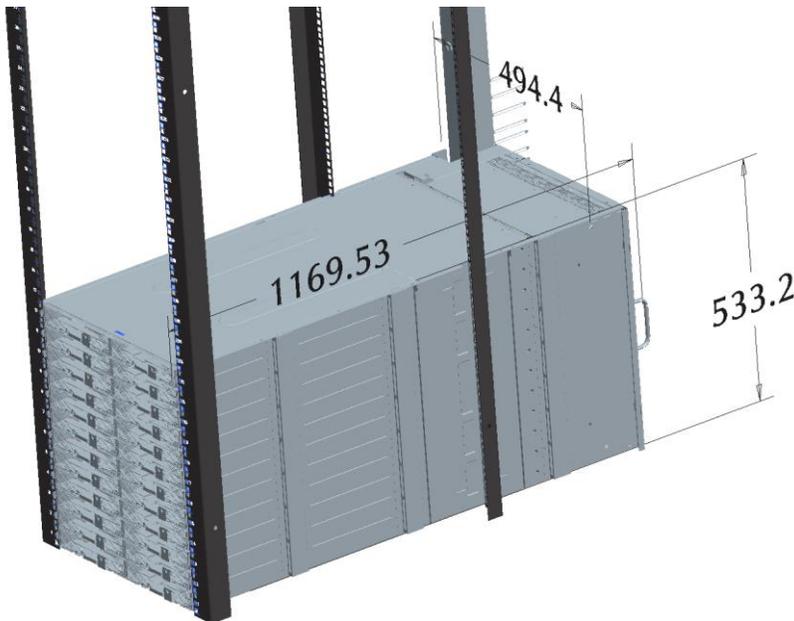
Figure 6. Chassis details, from the front

The chassis is enclosed at the top and bottom of the rear airflow plenum to minimize recirculation and maximize blade cooling. The top of the chassis is also enclosed to

ensure that air passes through the blades. Note that airflow blanks are required for slots that are not occupied by blades. These blanks must be closed to airflow to avoid short-circuiting the adjacent blades.

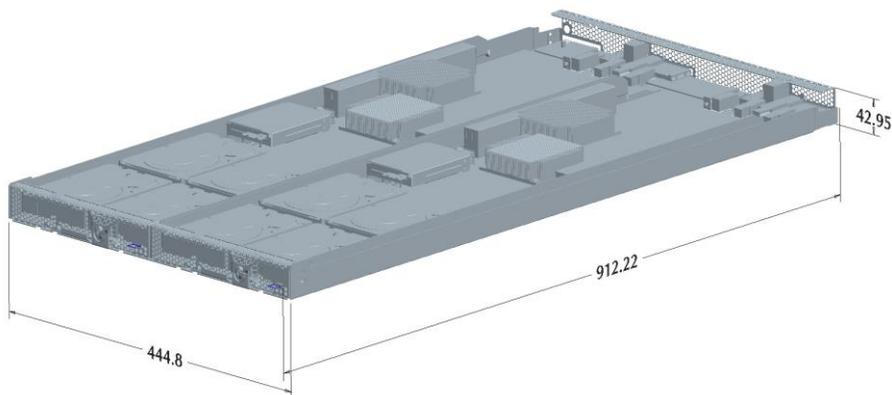
The following figures show the dimensions of the main system components: the chassis, the tray, and the blade.

Figure 7 shows the dimensions of the chassis.



**Figure 7. Overall chassis dimensions (in mm)**

Figure 8 shows the dimensions of the tray.



**Figure 8. Overall tray dimensions (in mm)**

Figure 9 shows the overall dimensions of the blade.

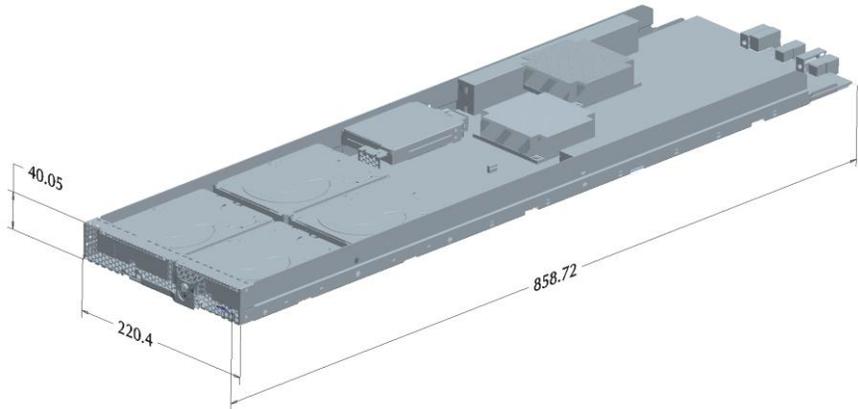


Figure 9. Overall blade dimensions (in mm)

Figure 10 shows the chassis detailed dimensions. This is the volume the fully assembled chassis occupies within the rack.

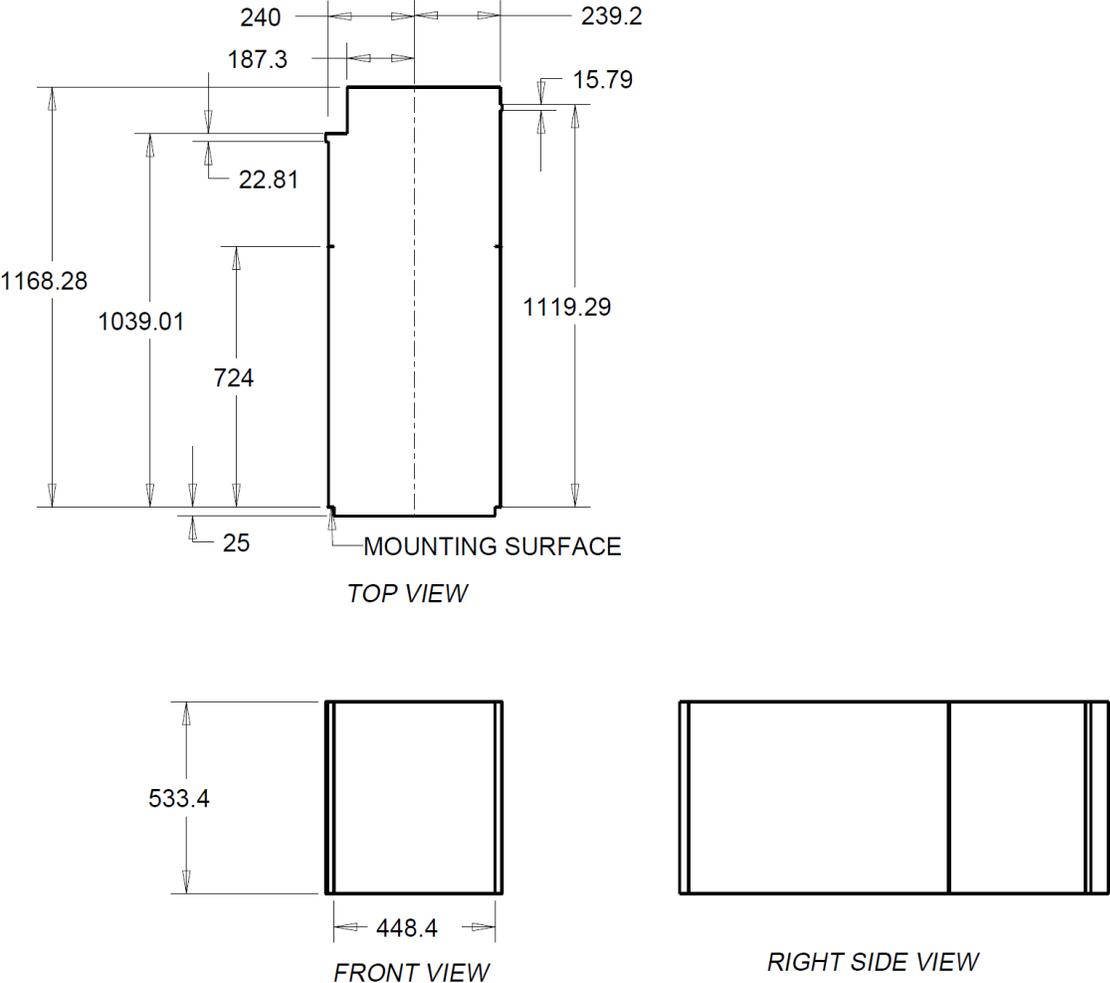


Figure 10. Chassis volumetric requirements (OU plenum removed for clarity)

There is a separate inlet air plenum for the power supplies routed along the “0U” space of the rack. Features in the side plenum help seal this inlet when the chassis is secured in the rack so that the air from the hot aisle cannot enter the power supplies, as shown in Figure 11.

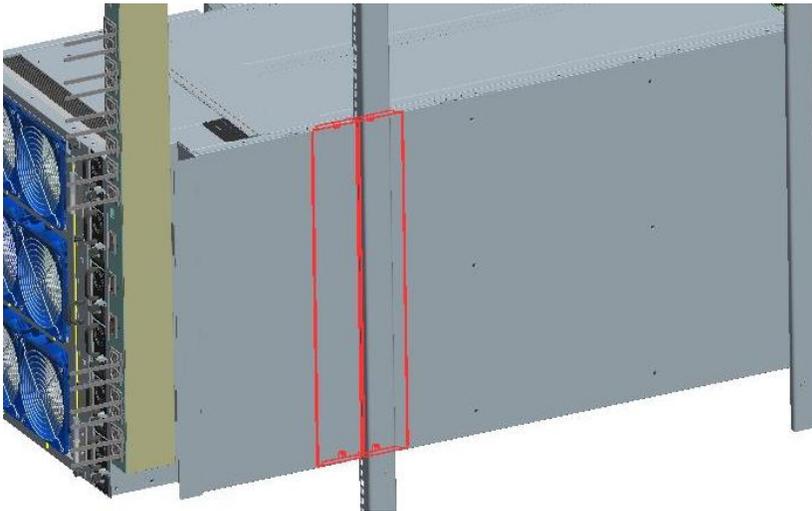
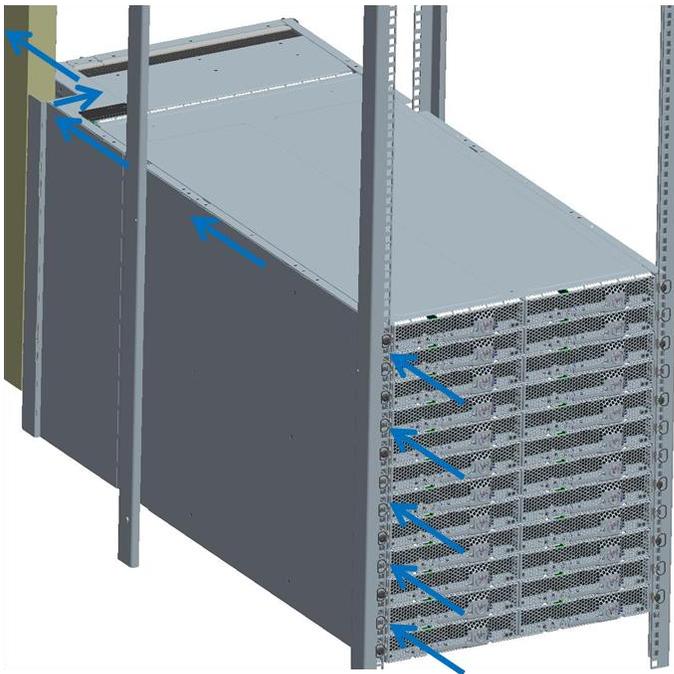


Figure 11. Rear rack column seal

The chassis can accommodate a rack column spacing of 736.6mm. The columns must use 9.5mm square holes. Air for the power supplies is drawn through the columns, as shown in Figure 12.



**Figure 12. Column air flow passage**

Sliding sub-assemblies are keyed to ensure that they are connected correctly, unless incorrect installation causes no damage. For example, the trays and blades are keyed so they will not be installed upside down; power supplies are not keyed because they cause no damage if installed upside down.

Note that if the blades will be shipped within the chassis, additional braces are required for support. The braces transfer forces directly to the rack columns and provide load-bearing support for the front of the blades.

Note also that the chassis is not intended to provide electromagnetic interference (EMI) containment.

### 5.1.2 Latching Features and Fasteners

Latches, as well as thumb screws and other components used to lock, unlock, or remove a subassembly from the chassis, are colored blue (Pantone code 285 C blue) to make them easy to identify. In the chassis, these latching features include:

- Fan door securing features
- Power supply unit latch covers
- Chassis Manager module securing features

To avoid confusion when removing a blade, the tray release wire form loops should not be colored blue.

Fasteners that require Torx drivers can be used to secure the chassis to the rack. Assembling the trays, blades, power supplies, and the fan tray does not require tools.

### 5.1.3 Power Distribution Unit Placement

Figure 13 shows the notch included in the chassis to make the power distribution unit (PDU) in the 1200mm rack replaceable. (Note that other figures in this document do not yet reflect this recent change.)

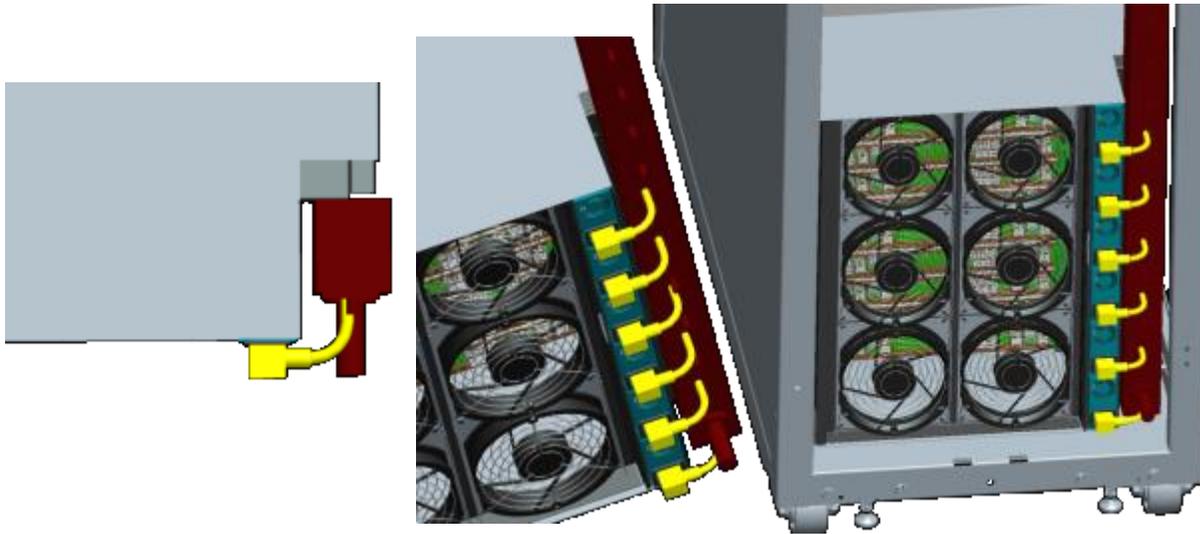


Figure 13. Notched chassis for PDU placement

The chassis includes mounting holes to secure the PDU in the correct position, as shown in Figure 14 (this figure to be used for reference only).

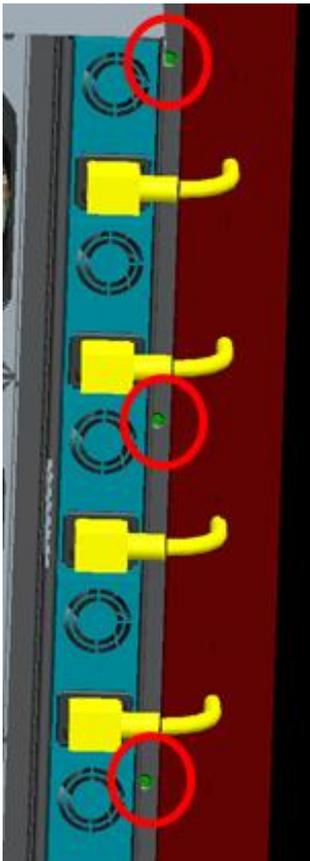


Figure 14. PDU mounting strip

## 5.2 Power Delivery

The chassis delivers power to the trays through the power distribution backplane printed circuit board assembly (PCBA). The PDB accepts six 39.3mm x 86.3mm x 197.6mm commodity off-the-shelf (COTS) power supply units to keep costs low. Six PSUs on a shared power backplane provides nearly ideal phase balancing of three-phase AC inputs, which allows a higher utilization of the incoming power.

Note that most of the weight of the power supplies is supported by the chassis, not by the power connector.

### 5.2.1 Power Distribution Backplane

The power distribution backplane provides power to each tray assembly, to the fan assembly, and to the Chassis Manager card.

The power distribution backplane also acts as the center point for chassis data communications, and includes the following cable connections:

- Local area network (LAN) 1, 2
- Serial COM 1, 2, 5, 6
- Power control switch outputs 1, 2, 3
- Chassis Manager power control input
- Fan door power, control, and monitoring

The power distribution backplane accepts 19 assemblies:

- Chassis Manager
- 12 tray backplane connectors
- Six power supply connectors

Figure 15 shows details of the power distribution backplane.

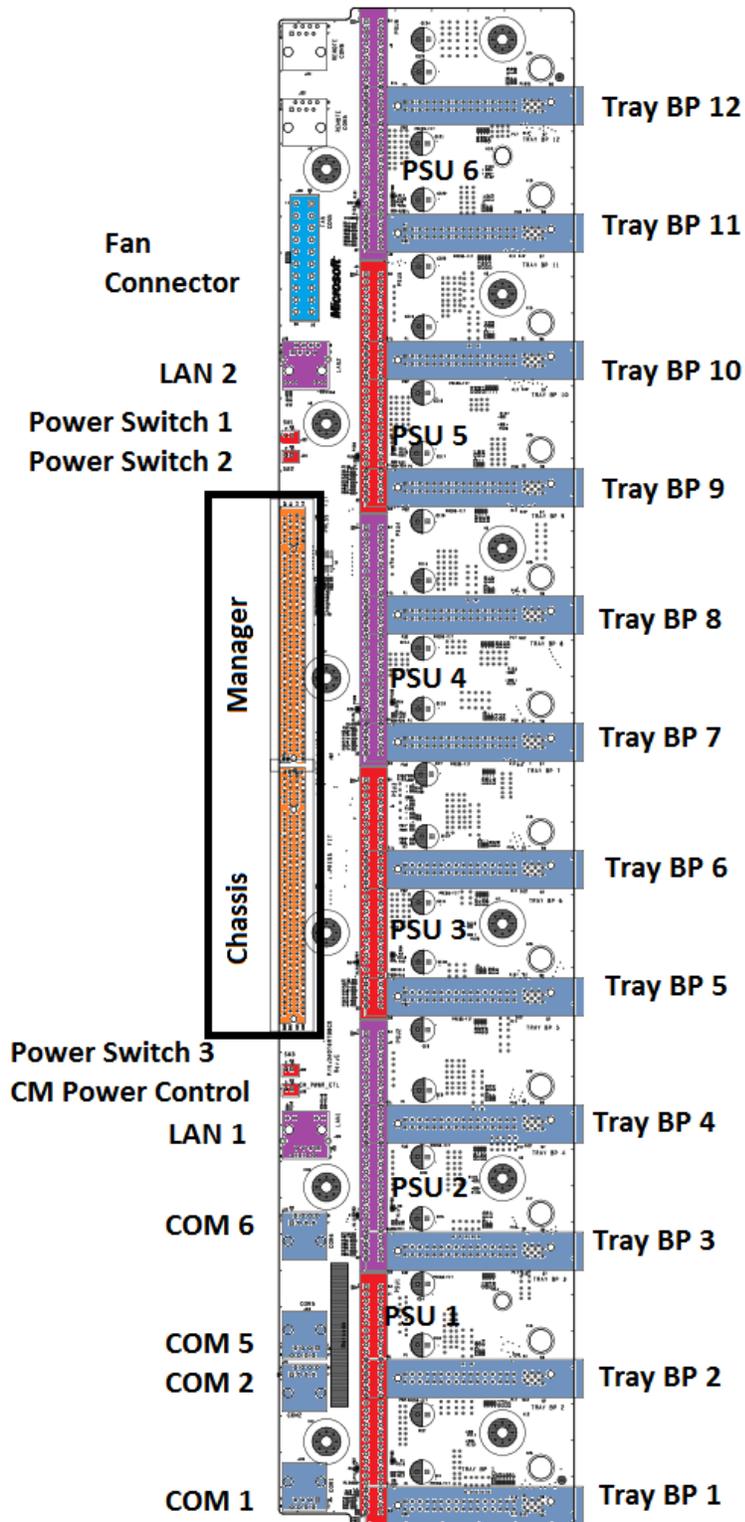


Figure 15. Power distribution board

## 5.2.2 PDB Interconnects

Table 1 lists the power distribution board connections.

**Table 1. Power Distribution Board-to-Tray Backplane Connectors List**

Assembly mounting	Assembly attachment	Connector description	Manufacturing part number
PDB J1-J6	Power supply unit	64 pin receptacle, vertical, two rows, 2.54mm pitch	(FCI) 10046971-001LF
PDB J7-J18	Tray backplane	High-power connector	(FCI) 10117936-003LF
PDB J25, J26	Chassis Manager	Dual, 1.00mm pitch, PCI Express x16 connector, 164 circuits each (328 circuits total)	(Amphenol) G630HAA15012EU
PDB	Fan assembly	20 pin connector, 2 rows, 4.2mm pitch	(Molex) 39-28-1203
PDB	RJ45	RJ45 for serial port	(Tyco) 5569284-1
PDB	RJ45	RJ45 for 1G LAN	(Amphenol) G71B0250100EU
PDB	PDU/Chassis Manager	Power switch control	(Molex) 353030251

## 5.3 Tray Specifications

The following sections describe the trays.

For service and debugging, the tray must be able to function in standalone mode (external to the chassis) for debugging. The tray can attach and receive power, Blade\_EN, and serial signals without impacting cost or operation in production environments. The preferred method to attach to the tray is through headers that are not loaded for operation within the chassis.

The physical specifications for the trays include the dimensions of the tray volume and a description of the guiding and latching features.

### 5.3.1 Volumetric Specifications

Figure 16 shows the tray backplane and Figure 17 shows the tray cabling.

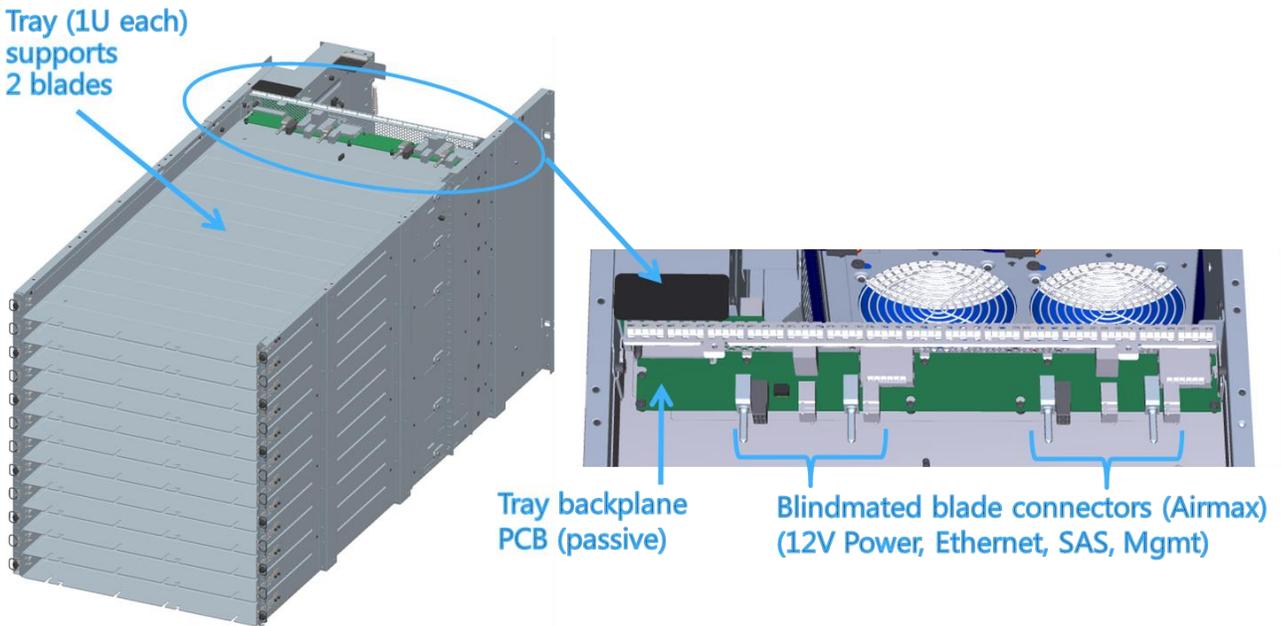


Figure 16. Tray backplane

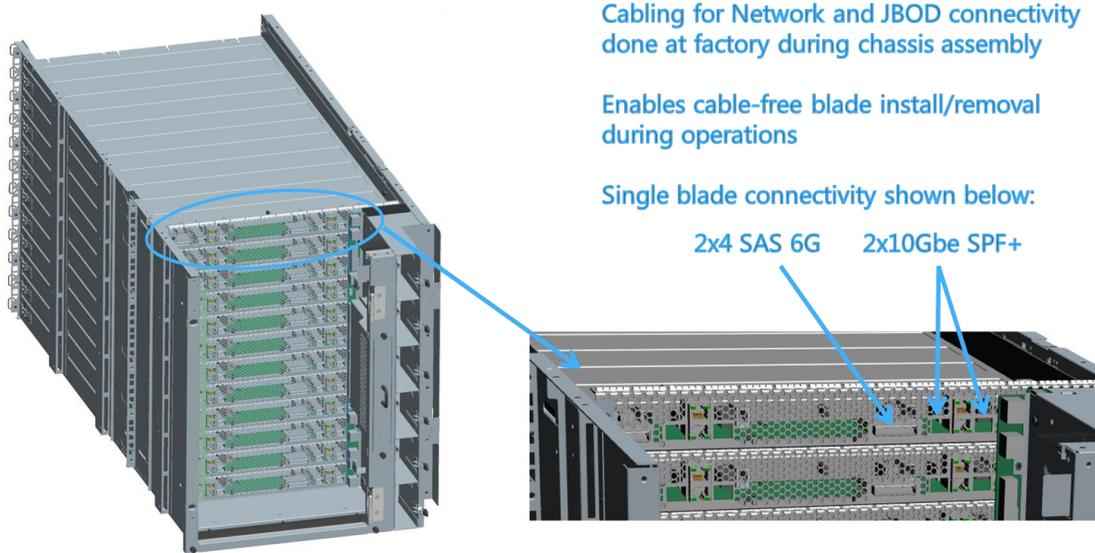


Figure 17. Tray cabling

The tray's outer dimensions must not exceed those described, with all tolerances for different manufacturing methods (such as soft and hard tooling) accounted for; the tray's interior must be able to accept a blade as described in [Section 3.1: Volumetric Specifications](#) of this specification. The tray mechanically interlocks to the power backplane support to minimize the load the connector must support.

The chassis is designed to be installed into a rack that complies with the EIA-310-D standard (the current revision of the Electronic Industries Alliance standard for a 19" rack) without modification.

Figure 18 describes the opening in the chassis that accepts the trays, as viewed from the front of the system.

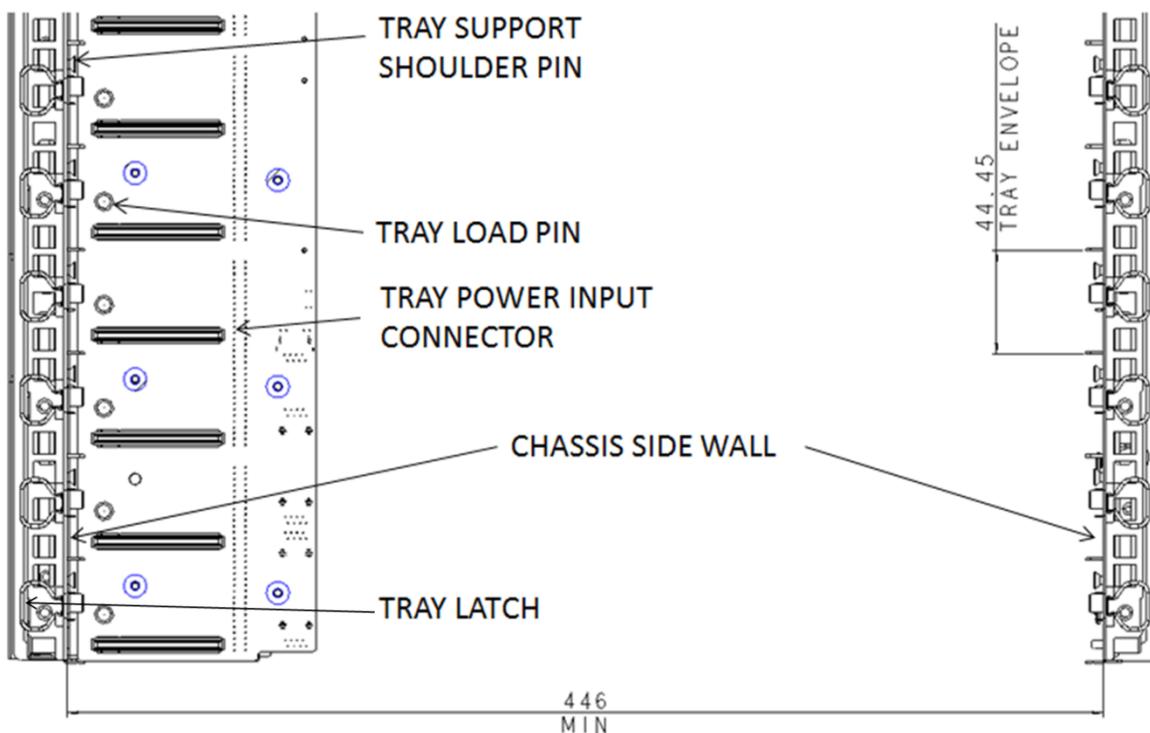
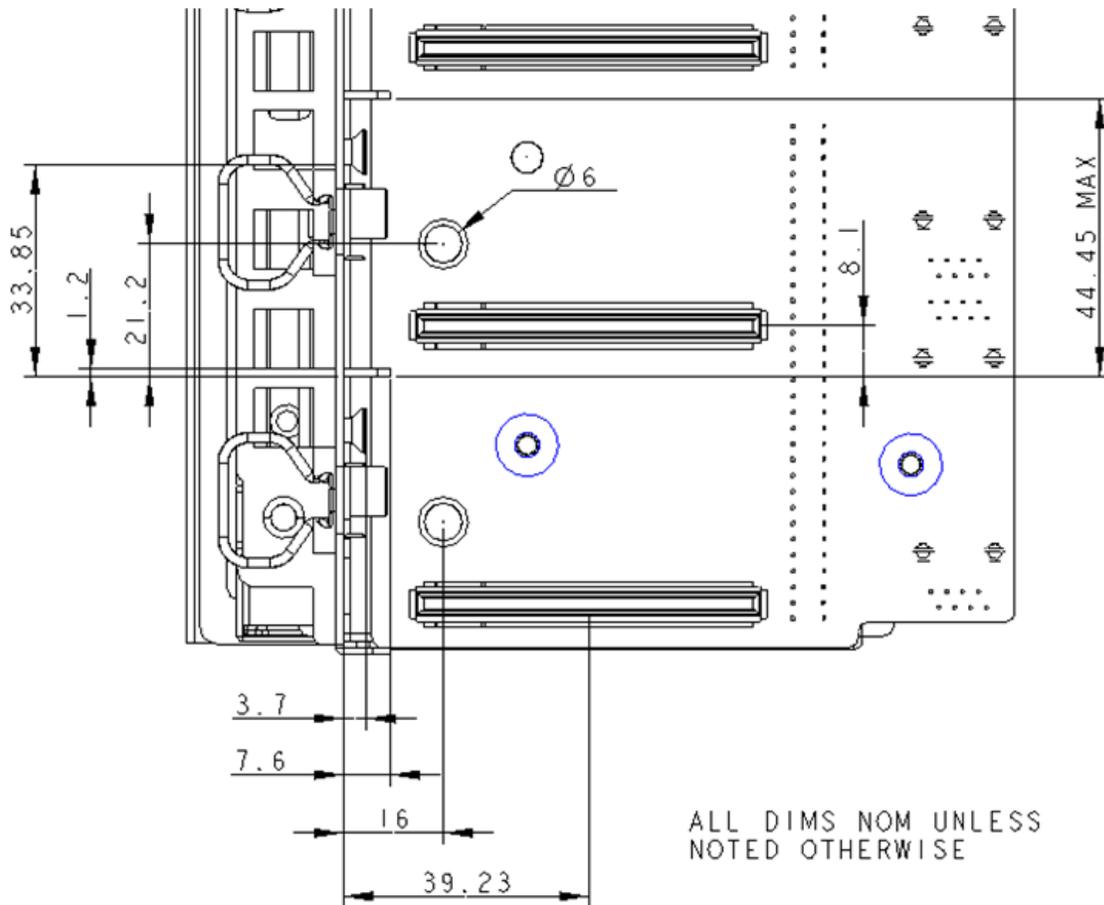


Figure 18. Interior tray opening chassis volumetric

The chassis interior consists of a series of flanges that extend from the side walls to support the trays. A power distribution board is located at the rear of the opening, on the left side as viewed from the front, to transfer power from the bulk power supply units to the trays.

Figure 19 shows the tray volume as seen from the front, and defines the location of the tray supports as related to the power connector.

A tray latch release is integrated into the chassis structure located on the left and right sides of the chassis opening.



**Figure 19. Interior tray opening volumetric detail**

Figure 20 shows a side view of the chassis. These dimensions are critical to the fit and function of the tray.

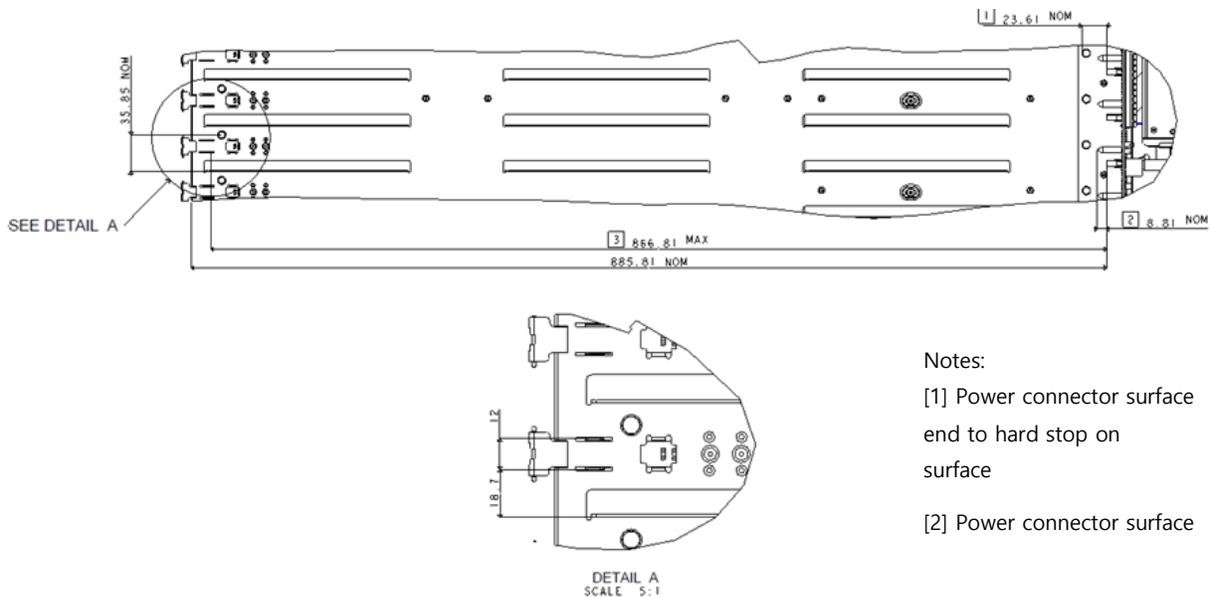


Figure 20. Side view of chassis

### 5.3.2 Guiding and Latching

The chassis supports the tray on a series of ledges located on each side wall. These ledges are designed and manufactured to prevent metallic slivers from forming when the tray is inserted into the chassis. Shoulder pins are included in the chassis side walls to secure the walls of the tray during insertion and prevent the tray from sagging under the load of the blades.

A pull-to-release spring latch is incorporated into the left-side and right-side panels to keep the tray in the chassis. Figure 21 shows a pull-to-release latch. Figure 20 shows the dimensions of the latch.

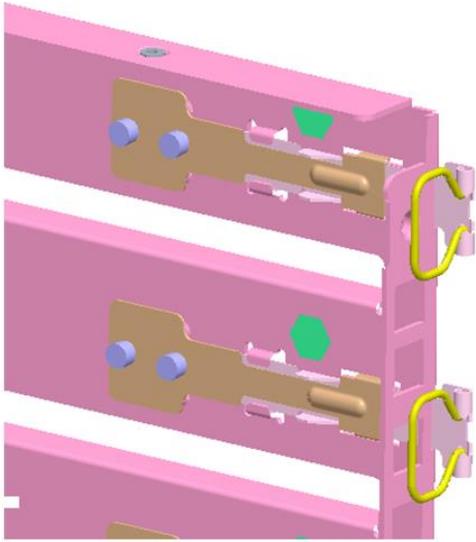


Figure 21. Example view of the push-to-release spring latch

### 5.3.3 Tray Interconnect

The tray provides the electrical interface to the blade, the PDB and external Networking and Storage cables. Figure 22 shows a top view of the tray features.

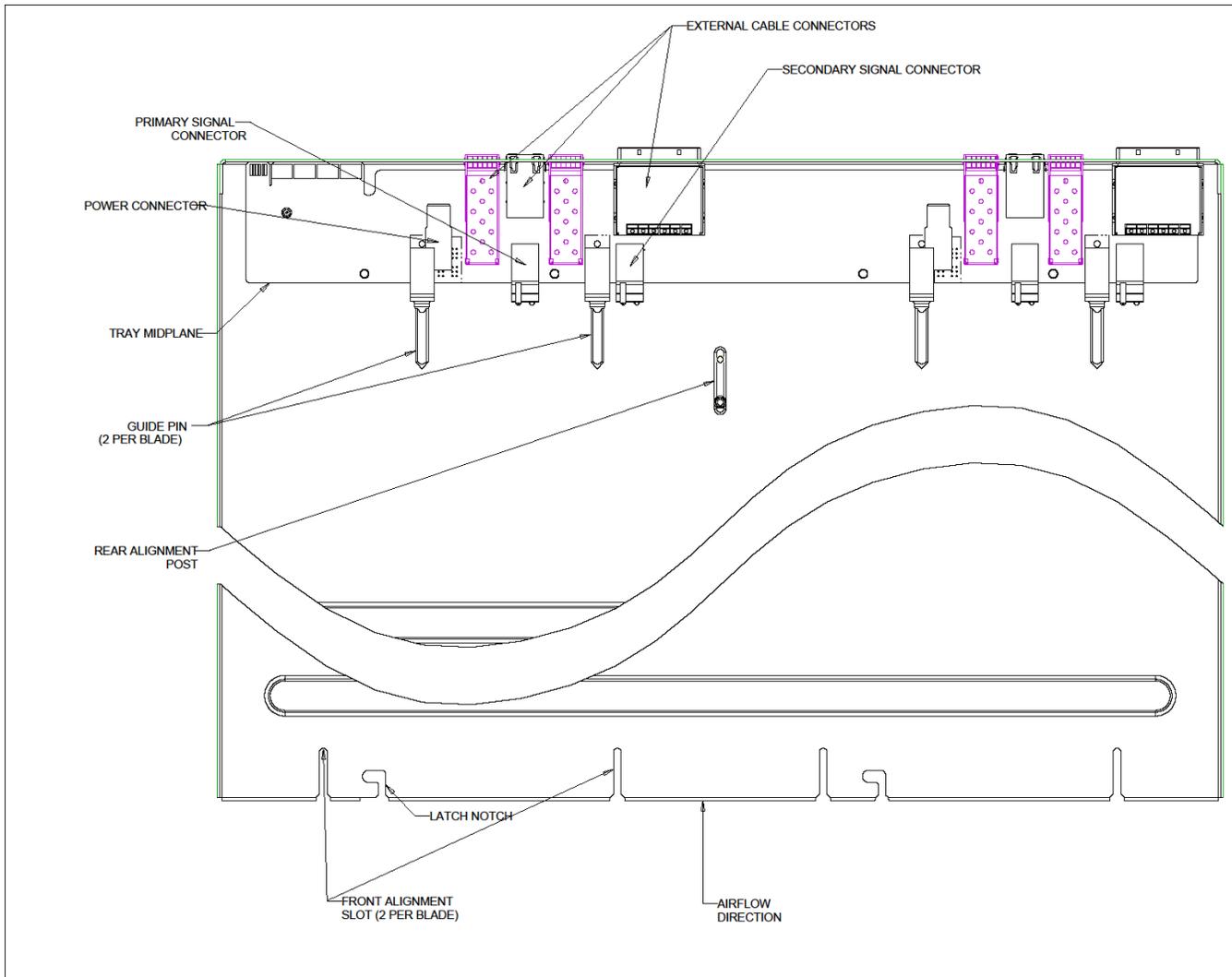


Figure 22. Tray features, top view

### 5.3.3.1 Tray-to-Cable Interconnects

The tray backplane carries high-speed signals from the blade connector to the cable connectors in the rear of the system. All applicable connectors in the backplane are pinned out. Signal delivery is through either one tray SKU with the backplane using all connectors, or through multiple tray SKUs with only specific connectors loaded.

Figure 23 shows the backplane and the connector signals (reference design shown).

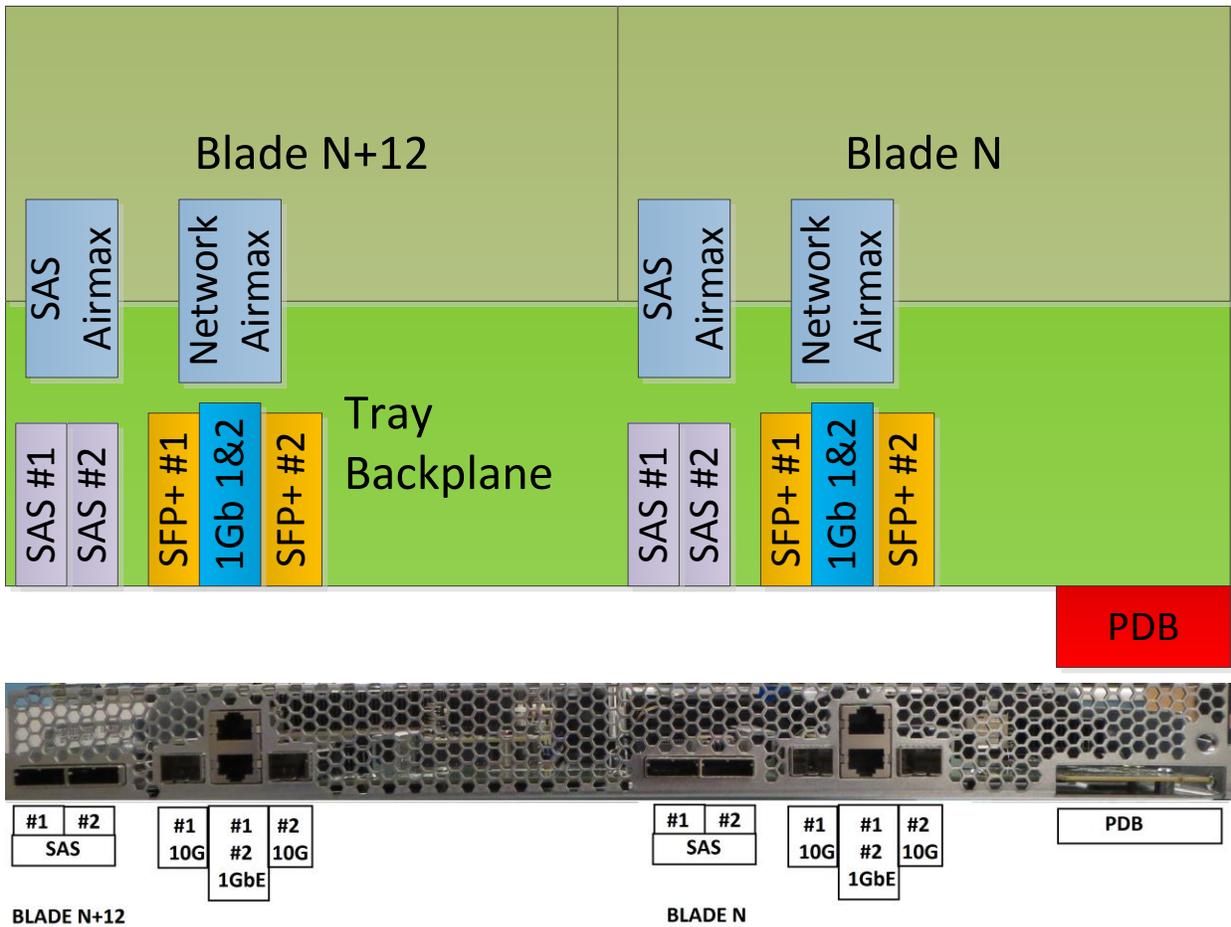


Figure 23. Tray backplane cable interconnects

### 5.3.3.2 Tray Connectors

Table 2 lists the connectors used for the tray-to-blade and tray-to-cable electrical interfaces.

Table 2. Tray-to-Blade and Tray-to-External Cable Electrical Interface Power/Network Distribution PCB Connectors List

Assembly mounting	Assembly attachment	Connector description	Manufacturing part number
Tray backplane	Blade	Power connector—AirMax Power receptacle—coplanar 2x2	(FCI)10052620-4555P00LF
Tray backplane	Blade	Signal connector—three pair, 54 contact, 2mm spacing, 19mm pitch, six-column press fit	(FCI) 10053656-101LF

Assembly mounting	Assembly attachment	Connector description	Manufacturing part number
Tray backplane	Blade	Guide pin— 10.8mm, right angle 0° key	(FCI) 10044366-101LF
Tray backplane	Cable	Mini-serial-attached SCSI (mini-SAS)	Connector— (Molex) 75586-0009 Cage— (Molex) FBRS200101 (or equivalent)
Tray backplane	Cable	Small form-factor pluggable (SFP)+	Connector— (Tyco) 188247-1 Cage —(Tyco) FBS2D00301 (or equivalent)
Tray backplane	Cable	Dual-panel jack RJ45 (Unused in V1 implementation)	(Tyco) 5569381-1 (or equivalent)

Figure 22 and Figure 23 show the placements of the connectors. Note that if a backplane or other design is used, functionally equivalent connectors must be specified and located within the described volume.

Figure 24 shows the PDB connector used to mate with the TB gold fingers.

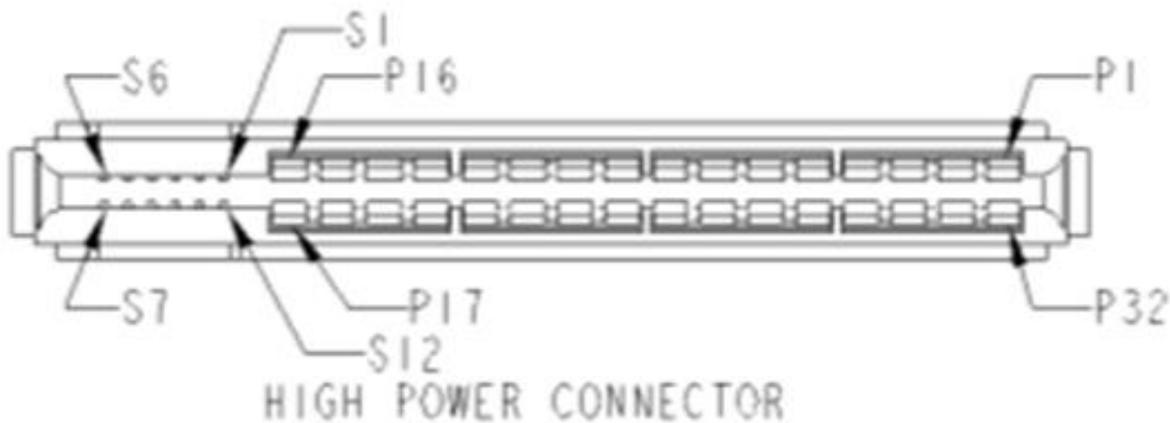


Figure 24. Power connector pin out

The power connector supports a maximum of 1,382W per tray (12V x 16 pins x 9A/pin x 80 percent derating). The power per rack unit is limited to 600W. This connector allows a future 2U server to consume 1200W.

Table 3 shows the pinout for the signal part of the power connector on the tray backplane.

**Table 3. Pinout for Signal Portion of the Power Connector on the Tray Backplane**

Pin	Signal name	Tray input/output	Definition
S1	Node1_TXD	Input	Node 1 serial input
S2	Node1_RXD	Output	Node 1 serial output
S3	Node1_EN	Input	Node 1 power enable
S4	Node2_EN	Input	Node 2 power enable
S5	Node2_TXD	Input	Node 2 serial input
S6	Node2_RXD	Output	Node 2 serial output
S12	Node3_TXD	Input	Node 3 serial input
S11	Node3_RXD	Output	Node 3 serial output
S10	Node3_EN	Input	Node 3 power enable
S9	Node4_EN	Input	Node 4 power enable
S8	Node4_TXD	Input	Node 4 serial input
S7	Node4_RXD	Output	Node 4 serial output

Table 4 shows the power connector pin-out.

**Table 4. Pinout for Power Connector**

Pin	Signal name	Capacity
P1 through P4	12V return	9A per pin
P5 through P8	12V return	9A per pin
P9 through P12	12V supply	9A per pin
P13 through P16	12V supply	9A per pin
P17 through P20	12V supply	9A per pin
P21 through P24	12V supply	9A per pin
P25 through P28	12V return	9A per pin
P29 through P32	12V return	9A per pin

## 5.4 Blade Numbering

Blades are hard wired through the management subsystem to specific positions. This ensures that there is zero ambiguity for service or networking. Table 5 lists the blade numbers, with both front and rear views.

Table 5. Blade Numbers

U number	Blades when viewed from front		Blades when viewed from rear	
12	12	24	24	12
11	11	23	23	11
10	10	22	22	10
9	9	21	21	9
8	8	20	20	8
7	7	19	19	7
6	6	18	18	6
5	5	17	17	5
4	4	16	16	4
3	3	15	15	3
2	2	14	14	2
1	1	13	13	1

## 6 Cooling System Specifications

The following sections describe the cooling system.

Cooling for the blades is provided by six 140mm x 140mm x 38mm shared rear-system fans mounted on the chassis. The fans are configured in an N+1 arrangement; if a fan fails, the system can maintain the required cooling with the remaining fans.

Power supplies are cooled by their internal fans and supplied with fresh air by a channel along the side of the server.

## 6.1 Thermal Design Considerations

The fans provide all of the cooling and airflow required by the blades; it is therefore critical to design the blades so that all of their components are sufficiently cooled by the system fans.

The cooling system was designed so that the fans consume the least amount of power possible while maintaining the necessary cooling. Thermal efficiency is typically reported as temperature rise across the blade ( $\Delta T$ ), which is equal to the difference between the average exhaust temperature and the average inlet temperature. For a given blade power consumption, a higher  $\Delta T$  means that the fans are operating at a lower speed and consuming less power driving up the overall system efficiency; in other words, a slower fan speed means lower power consumption, which means a higher rise in temperature.

The blade server exhaust temperature directly reflects the hot-aisle temperature of a data center. The blade thermal-control system should include an exhaust temperature sensor (or other method to monitor the blade outlet temperature) to ensure that the system meets data center requirements.

## 6.2 Blade Impedance

The system airflow must provide sufficient cooling for an 18°C temperature rise for 600W thermal design power (TDP) per rack unit (equivalent to 300W TDP per blade) at the expected end-of-life of the fan.

Figure 25 shows the airflow impedance the blades must meet to achieve this required performance.

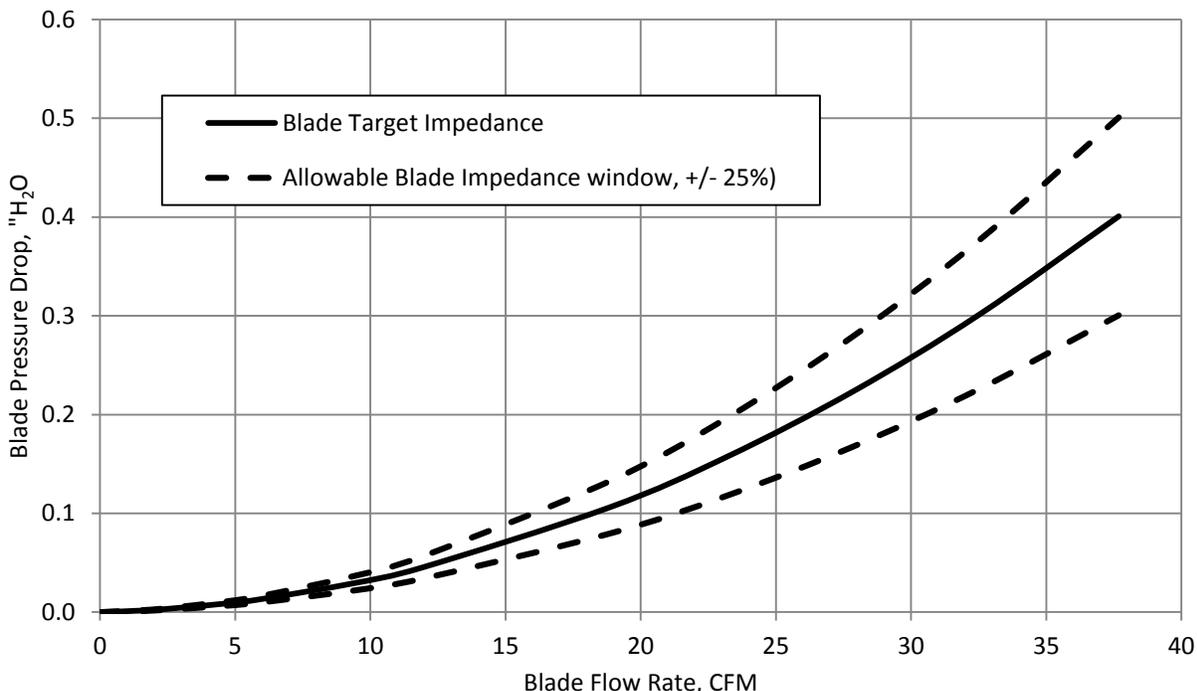


Figure 25. Blade flow specification: allowable blade pressure/flow curve

Blade impedance within 25 percent of the target ensures that all blades within the system receive sufficient airflow. Blade impedance that is too low results in higher airflow through the blade and lower airflow through the other blades in the system. Impedance that is too high results in a lower airflow through the blade.

It is possible to increase the blade impedance if the blade is designed for a TDP less than 300W; however, simulation and testing should be used to verify that there is no negative impact on other blades in the system and that the airflow for the entire system is sufficient. The following example for a blade with a TDP rating of 200W shows the preferred method for modifying the blade impedance curve.

1. Determine the flow rate required to meet the ΔT target by using the following equation.

$$\dot{Q}_2 = TDP_2 * \left[ \frac{\dot{Q}_1}{TDP_1} \right] = 520CFM$$

$TDP_1$  = Thermal design power of the reference system (7200W)

$\dot{Q}_1$  = Flow rate of the nominal target curve of the system (780CFM)

$TDP_2$  = Expected blade thermal design power (4800W)

$\dot{Q}_2$  = Required flow rate of the modified blades in the system

This equation provides the target flow rate for the lower-powered blade at maximum flow rate. The calculations must be based on the entire system flow to resolve the difference between the number of fans and the number of blades.

- Using the end-of-life fan performance curve, find the equivalent pressure required to meet the flow rate ( $\dot{Q}_2$ ). This can be determined graphically or by interpolating the fan curve into an equation.

The following equation is a polynomial interpolation of the fan curve:

$$P_2 = 2.98764 * 10^{-7} \dot{Q}_2^2 - 1.15085 * 10^{-3} \dot{Q}_2 + 9.4015$$

$$P_2 = 0.42 \text{''H}_2\text{O}$$

$$\dot{Q}_2 = 520 \text{CFM}$$

$P_2$  = Required blade pressure at full fan speed for the lower-power blade

- Use the fan law relationships to determine the pressure and flow curves at reduced fan speeds. This involves calculating the fan curve at lower fan speeds and relating the maximum operating point determined in the previous step to the lower fan speed.

$$\dot{Q}_n = \dot{Q}_2 \left[ \frac{\omega_2}{\omega_n} \right]$$

$$P_n = P_2 \left[ \frac{\omega_2}{\omega_n} \right]^2$$

$\omega_2$  = Full fan speed, 6600 RPM

$$\dot{Q}_2 = 520 \text{CFM}$$

$$P_2 = 0.42 \text{''H}_2\text{O}$$

$X_n$  = n represents the fan speed of interest

Table 6 shows the results of the calculations.

**Table 6. Calculation Results**

$\omega_n$ (in RPM)	$\dot{Q}_n$ (in CFM)	$P_n$ (in "H <sub>2</sub> O)
500	39.62	0.00241
935.7	74.14	0.008442
1371	108.7	0.01813
1807	143.2	0.03149
2243	177.7	0.0485
2679	212.2	0.06918
3114	246.8	0.09351
3550	281.3	0.1215
3986	315.8	0.1532
4421	350.3	0.1885
4857	384.9	0.2275
5293	419.4	0.2701
5729	453.9	0.3164
6164	488.4	0.3664
6600	523	0.42

Figure 26 shows the results are shown in graphical form. The curve for the individual blade is the flow result of the analysis divided by 24 blades.

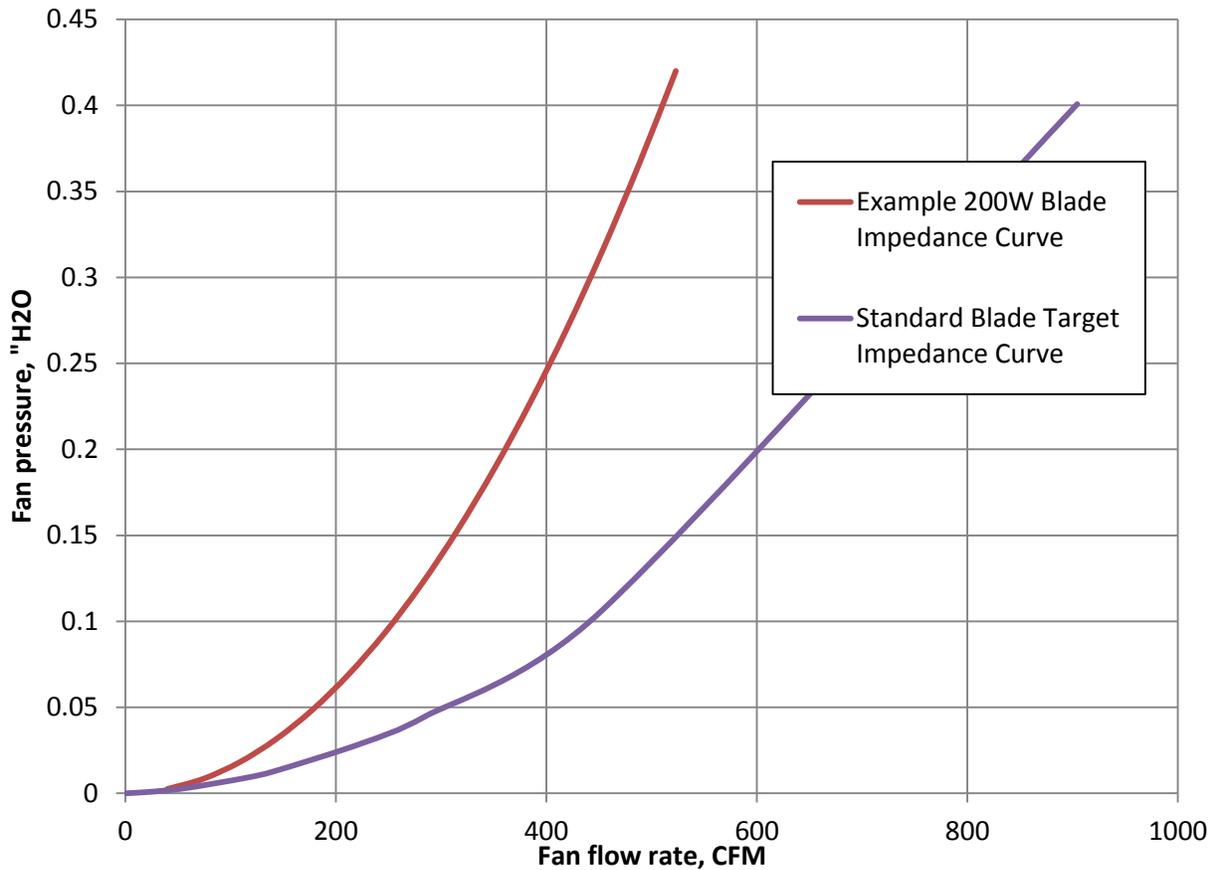


Figure 26. Blade pressure/flow modification example showing expected system performance

### 6.3 Fan System Performance

Figure 27 shows an example of the performance of a fan system that can be used for modeling and prototyping. The example is based on the performance of the 140mm x 140mm x 38mm fan system, with five full speed fans and one inactive fan at end-of-life. The graph gives the flow performance at the system level (for all fans in the plenum).

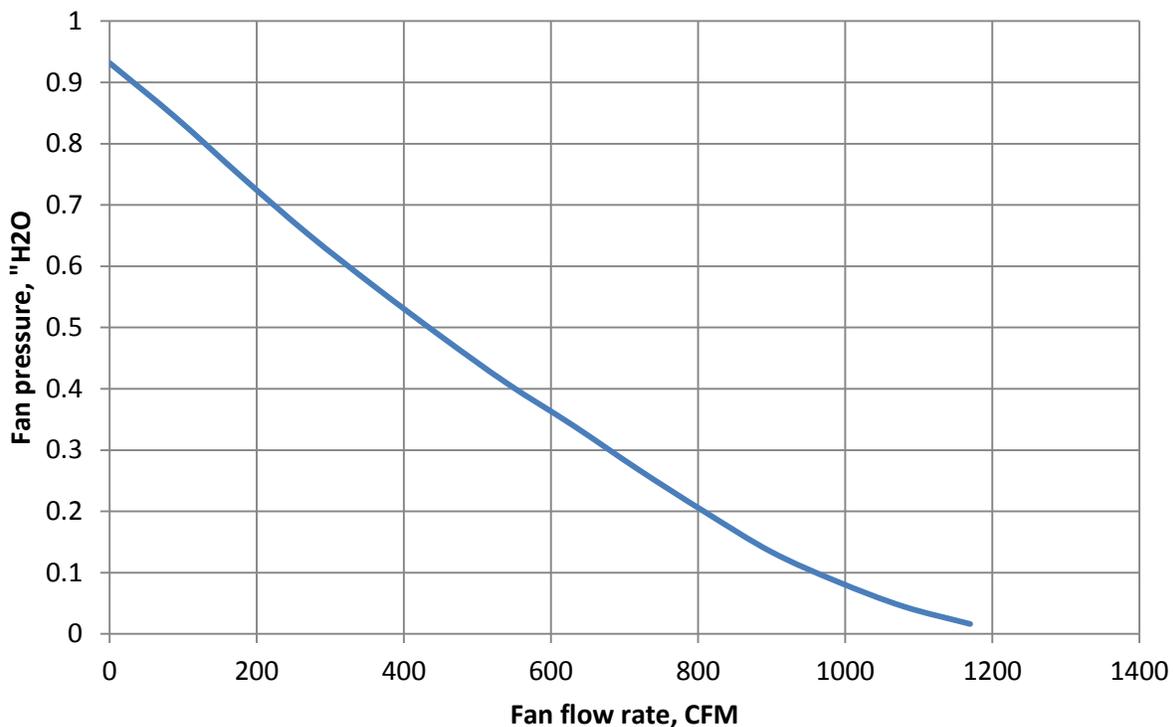


Figure 27. System fan performance curve: expected performance for n fans

To use this data, a designer should build a model or prototype of the chassis, including all pertinent flow restrictions. The designer should then add the appropriate number of blades, and use the N-curve in Figure 27 to evaluate blade thermal performance.

Airflow blanks are required for slots that are not occupied by blades. These blanks should restrict airflow as much as possible to maximize flow performance to the blades within the chassis.

The system is designed to permit a service operation in which the fan tray is rotated away from the chassis for up to five minutes. After five minutes, blade component temperatures might be high enough to cause a thermal shut down. (The precise time that the tray can remain open before shut down will be determined after extensive testing of prototype hardware.)

## 6.4 Fan Speed Control

The fans have variable speed capability; this lets the system drive the fans at speeds only as high as necessary to cool the components, minimizing power consumption, noise, and fan failures.

### 6.4.1 Pulse-Width Modulation Input

The blades exchange thermal information with the Chassis Manager through an intelligent platform management interface (IPMI). The first sensor value in the IPMI table is the pulse-width modulation (PWM) duty cycle fan speed, a value between the non-critical limits of 0 (fan off) and 100 (fan running at full speed). Note that the minimum fan speed is 20 percent of duty cycle to ensure that the fan has enough torque to maintain rotation.

Using PWM signals simplifies the system-level control strategy and allows the system to be blade agnostic. Blades request their own fan speeds. The Chassis Manager polls each blade periodically for its fan flow rate request through a PWM signal, and then drives the fan speeds based on the highest request.

Blades are responsible for monitoring all thermally critical component temperatures and determining an appropriate fan speed. A closed-loop method for monitoring temperature and adjusting speed requests is highly recommended. At minimum, a fan speed table based on measured inlet temperature is required, and the inlet and outlet temperatures of thermally critical components (such as processors, DIMMs, and PCHs) should be available through the IPMI interface. These sensors should have identification values other than 1 and should not have metadata limits.

Table 7 lists important variables in fan control strategy.

**Table 7. Fan Control Variables**

Variable	Value and description
Target temperature band	Used to control limits of processor temperature Upper = target temperature Lower = target temperature – 4°C
Blade poll frequency	Frequency of blade temperature requests 10 seconds

Variable	Value and description
Fan speed decrease hysteresis	The amount of time the fan must wait between speed changes (prevents the fan speed from rising and falling too frequently) 1 minute
Altitude compensation	Increase speed by 3.2 percent for every 1000 ft (304m) above sea level (see Figure 28)
Active fan correction factor	$DC = DC_{base} * (\frac{5}{N_{active}})$ <p><i>DC</i> is the fan speed duty cycle requested by the Chassis Manager  <i>DC<sub>base</sub></i> is the base fan speed duty cycle before fan count and altitude correction  <i>N<sub>active</sub></i> is the number of active system fans (if no fans have failed, this is six)                      (See Figure 29)</p>

#### 6.4.2 Fan Speed Correction for Altitude

Fan speed is increased by 3.2 percent for every 1000 ft (304m) above sea level. The location of the system must therefore be recorded during installation so that the correction can be made.

Figure 28 shows an example of fan speed correction for altitude.

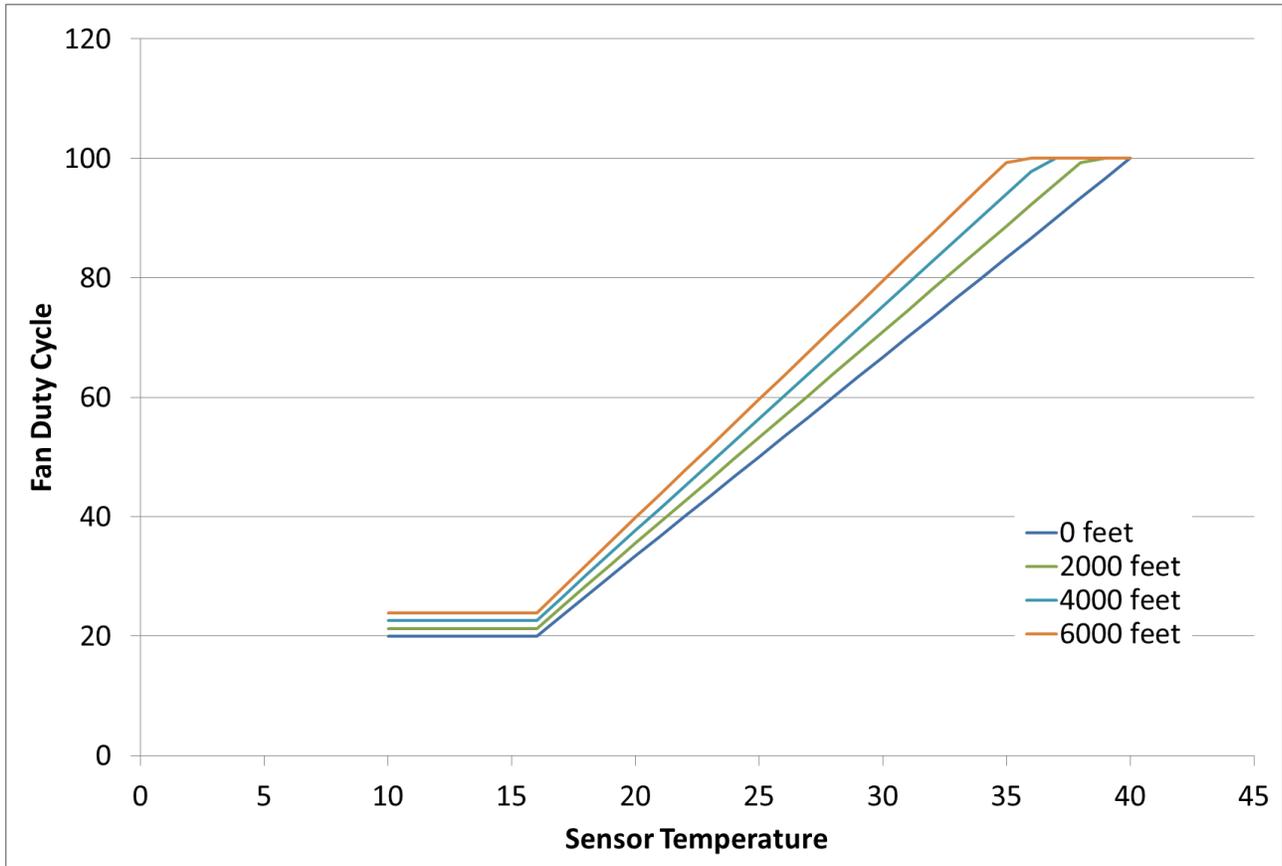


Figure 28. Example of altitude correction factor (non-critical limits: lower=15C ambient, upper=35C ambient)

### 6.4.3 Fan Speed Correction for Fan Failures

The Chassis Manager monitors the number of active fans and makes appropriate adjustments to the fan speed if a fan is detected to have failed ([Section 4.5: Fan Failure](#) provides more information about fan failure). A fan is considered to have failed if the tachometer speed returned to the Chassis Manager is below 20 percent of the requested speed for more than five minutes.

Figure 29 shows an example of the fan failure correction factor.

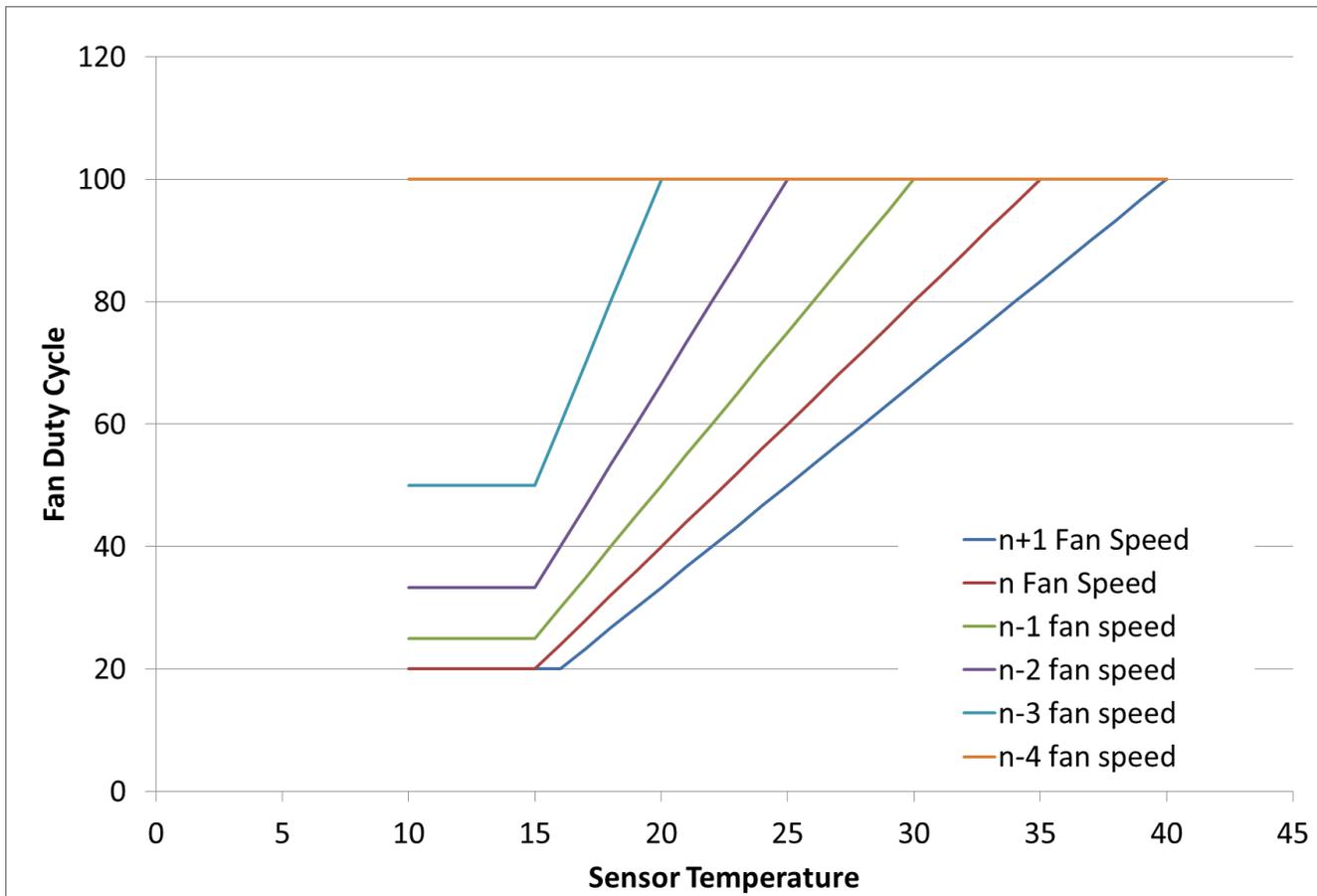


Figure 29. Example of an active fan count correction factor (non-critical limits: lower=15, upper=35)

Note that fan failures trigger an alert so that the fan can be replaced (no action is required on the blade).

#### 6.4.4 Sensor Failure

If a PWM signal from a specific blade is not detected or is determined to be unrealistic (less than 0 or more than 100), the blade is assigned a request of the minimum fan speed, and the speed requests from the other blades in the system will take priority.

If there is only one blade in the system and if the PWM signal is not present, the chassis will operate fans at the minimum speed. If blade activity forces a thermal shut-down under these conditions, the blade must be replaced or repaired.

If the blades in the chassis are plugged in but are in standby mode, the Chassis Manager will drive fan speed at the minimum level.

## 6.5 Fan Failure

Analysis shows that fan failures (tachometer speed below 20 percent of the requested speed for more than five minutes) are rare.

### 6.5.1 Fan Failure Rate

Failure rate for the fans is calculated using the following information:

- Mean time between failures (MTBF) provided by the manufacturer is 50K hours at 60°C
- Failure rate improves two times for every 10°C reduction
- Average outlet operating temperature is approximately 46°C, allowing for a greater than two times reduction
- Annualized failure rate is therefore:
  - $6 \times 10^{-6}$  per chassis
  - $2.4 \times 10^{-5}$  per rack
- Failures per year are therefore:
  - 0.05 for a chassis (one failure every 20 years)
  - 0.20 for a rack (one failure every 5 years)

Data from the server vendor indicates that the most common cause of fan failure is a lubricant leak, which causes a fan to speed up for approximately a week before stopping when the lubricant is gone. Chassis management can monitor the speed of the fans and identify an algorithm to address speeds that are too fast or too slow. When a fan failure is detected, chassis management will speed up the remaining fans to compensate.

### 6.5.2 Fan Repair

Fan repair can generally be deferred because the blades can withstand operation with minimal airflow for a short period of time. (How long fan repair can be deferred will be determined when the repair experience, the airflow data, and the impact on other services are better understood.)

If fan repair does become necessary, two technicians should be assigned to the task to minimize impact on the system. The fan tray assembly is mounted on a pinned

hinge so that the full tray can be easily removed for repair, and both sides of the fans have wire screen guards for safety during service.

The following steps describe how to replace a fan:

1. Prepare all materials and a ladder if the fan is in the upper half of the rack.
2. Open the fan door and disconnect the cable.
3. Lift the fan tray off the hinge.
4. Install the new fan tray onto the hinge.
5. Plug in the cable.
6. Close the fan door.

Note that if chassis management turned the chassis attention LED on because of the fan failure, it will turn the LED off when it detects that the fans are operating correctly.

## 6.6 Thermal Considerations for the Blade

The blade must be able to operate at full-load capacity in all conditions described in this specification, including the upper and lower ambient temperatures, humidity levels, altitude levels, and available fan capability. If conditions are outside the prescribed limits, the blade should continue to operate as long as hardware and data are not at risk; if conditions are likely to cause damage, the blade should be shut down.

For the largest possible operating range, the inlet temperature to the system should not drive blade shut down. The temperature of sensitive components should be individually monitored to prevent an unnecessary system shut down.

Note that blade components frequently have an average operating temperature target that optimizes long-term reliability and an upper temperature limit to prevent hardware damage and maintain data integrity. Components should normally operate at the target, but they can operate at a higher temperature for a short time as long as they remain below the upper limit.

The only thermal response the Chassis Manager gives is control of fan speed. While alerts are logged if a fan or a blade fails, the Chassis Manager does not request

blade shut downs. The blade is responsible for shut downs or throttling caused by high inlet temperature.

## 7 Chassis Power

Within the rack, chassis power limits are determined by the power-supply power limits under worst-case failure conditions. The power supplies cannot be run at more than 95 percent of maximum output capacity for long periods of time. The total blade power of a deployment therefore cannot exceed these values. The specific power cord and redundancy option (N+N or N+1) must also be considered when determining the final sizing.

Table 8 shows the maximum blade power per chassis, the maximum AC cord load, and the AC power per rack for different rack loads. Note that additional power is required for the fans and also contributes to the AC load.

**Table 8. Maximum Blade Power per Chassis**

	Max chassis blade load	Max chassis AC cord load	Rack AC power		
			2 chassis	3 chassis	4 chassis
N+N power	3500 W	4100 W	8.2 kW	12.3 kW	16.4 kW
N+1 power	6000 W	6800 W	13.6 kW	20.4 kW	27.2 kW

Table 9 shows the average power for blades given the chassis limits. Note that the lower the number of blades in the chassis, the higher the amount of power per chassis. Note also that there is a per-blade limit of 300W. For unequal loading (for example, when using storage servers), average power can be estimated by calculating the average power for the compute blades and associated storage blades.

**Table 9. Average Loading for Blades**

Redundancy level	Max chassis blade load	Blades per chassis, average power						
		24	22	20	18	16	14	12
N+N power	3500 W	146 W	159 W	175 W	194 W	219 W	250 W	292 W
N+1 power	6000 W	250 W	273 W	300 W	<i>Above blade power limit</i>			

## 8 Operating Environment

Table 10 describes the environmental requirements in which the blades operate.

**Table 10. Operating Environment**

Specification		Requirement
Inlet temperature	Operating	<ul style="list-style-type: none"> <li>• 50°F to 95°F (10°C to 35°C) at sea level</li> <li>• Maximum rate of change: 18°F (10°C)/hour</li> <li>• Allowable derating guideline of 1.6°F/1000ft (0.9°C/304m) above 3000 ft</li> </ul>
	Non-operating	<ul style="list-style-type: none"> <li>• -40°F to 140°F (-40°C to 60°C)</li> <li>• Rate of change less than 36°F (20°C)/hour</li> </ul>
Humidity	Operating	<ul style="list-style-type: none"> <li>• 10% to 80% non-condensing</li> <li>• Maximum Rate of Change: 20% RH per hour</li> <li>• Maximum dewpoint: 85°F (29.4°C)</li> </ul>
	Non-operating	<ul style="list-style-type: none"> <li>• 5% to 95% non-condensing</li> <li>• 100.4°F (38°C) maximum wet bulb temperature</li> </ul>
Altitude	Operating	<ul style="list-style-type: none"> <li>• 10000ft (3050m) maximum</li> <li>• Rate of change less than 1500 ft/min (457m/min)</li> </ul>
	Non-operating	<ul style="list-style-type: none"> <li>• 30000ft (9144m) maximum</li> <li>• Rate of change less than 1500 ft/min (457m/min)</li> </ul>

## 9 Safety and Compliance Documentation

Table 11 lists the applicable compatibility and safety compliance documentation for the system. The server and/or the server components must comply with regulations and test procedures.

**Table 11. Documents Pertaining to EMC Safety**

Document	Details
CISPR 22/EN 55022 Class A & EN 55024	Immunity requirements
ANSI C63.4 – 2003	"American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz." American National Standards Institute (ANSI), 2003.
UL 60950-1	"Safety of Information Technology Equipment including Electrical Business Equipment, First Edition." Underwriters Laboratories, Inc., 2003.
CSA C22.2 No. 60950-1	Canadian Standards Association, 2003.
EN 55022	"Limits and methods of measurement of radio interference characteristics of information technology equipment." European Committee for Electrotechnical Standardization (CENELEC), Third Edition, 1998.
EN 55024	"Information technology equipment - Immunity characteristics - Limits and methods of measurement." European Committee for Electrotechnical Standardization (CENELEC), 1998.
EN 60320-1	"Appliance Couplers for Household and Similar General Purposes – Part: General Requirements" European Committee for Electrotechnical Standardization (CENELEC), 2001.
IEC 60950-1: 2001	"Safety of Information Technology Equipment - Safety - Part 1: General requirements", First Edition, International Electrotechnical Commission, 2001.
IEC 61000-4 Sections 2 – 6, 11	"Electromagnetic Compatibility (EMC) – Part 4: Testing and measurement techniques." International Electrotechnical Commission (IEC).
C.I.S.P.R. Pub. 22	"Limits and methods of measurement of radio interference characteristics of information technology equipment." International Special Committee on Radio Interference (C.I.S.P.R.), Third Edition, 1997.
CFR 47, Part 15	"Unintentional Radiators." Title 47 of the Code of Federal Regulations, Part 15, FCC Rules, Radio Frequency Devices, Subpart B.

## 10 Shock and Vibration Requirements

Table 12 lists the shock and vibration requirements for the system. These tests simulate normal transportation and handling conditions that the systems might

encounter.

Table 12. Shock and Vibration Requirements

Specification (if applicable)	Packaged/unpackaged	Details	Pass criteria
ASTM D4728	Assembled blades and chassis in rack, packaged	<ul style="list-style-type: none"> <li>Air cushion transportation vibration test</li> <li>Test to the normal rest surface (bottom side) for one hour of vertical direction (Z-axis)</li> <li>Palletized</li> </ul>	<ul style="list-style-type: none"> <li>Normal function after test, no connector or mechanical damage</li> <li>No component unseating</li> </ul>
NEBS GR-63-CORE Issue 3, March 2006	Assembled blades and chassis in rack, packaged	<ul style="list-style-type: none"> <li>100mm (3.9in) drop on the normal rest surface (bottom side)</li> <li>Perform two drops</li> <li>Palletized</li> </ul>	<ul style="list-style-type: none"> <li>Normal function after test, no connector or mechanical damage</li> <li>No component unseating</li> </ul>
Telcordia GR-63-CORE, Section 5.4.2	Rack level, unpackaged in a system	<ul style="list-style-type: none"> <li>Operational</li> <li>Swept sine, 0.1g, 5-100-5Hz, 0.1 octave/min</li> <li>Three axis</li> </ul>	<ul style="list-style-type: none"> <li>No errors in the running of the software</li> </ul>
Not applicable	Rack level, unpackaged in a system	<ul style="list-style-type: none"> <li>Operational</li> <li>System fans at 20, 40, 60, 80, and 100% duty cycle</li> <li>All hard drives running 1K random writes and 64K sequential writes</li> </ul>	<ul style="list-style-type: none"> <li>Hard drive read/write errors within 1K random writes performance <math>\geq 90\%</math></li> <li>64K sequential writes performance <math>\geq 85\%</math> of peak performance</li> </ul>
Not applicable	Blade level, unpackaged	<ul style="list-style-type: none"> <li>Non-operational</li> <li>Random vibration, 10-500Hz, 1.87Grms</li> <li>15min/side, six sides tested</li> </ul>	<ul style="list-style-type: none"> <li>No visible damage</li> <li>Blade operational when tested after vibration</li> </ul>
Not applicable	Blade level, unpackaged, 0=blade $\leq$ 18kg	<ul style="list-style-type: none"> <li>Non-operational</li> <li>Square wave</li> <li>32g peak</li> <li>6.85 m/s velocity change</li> <li>Six sides</li> </ul>	<ul style="list-style-type: none"> <li>No visible damage</li> <li>Blade operational when tested after shock</li> </ul>

Specification (if applicable)	Packaged/unpackaged	Details	Pass criteria
Not applicable	Blade level, unpackaged, 18<blade≤34kg	<ul style="list-style-type: none"> <li>• Non-operational</li> <li>• Square wave</li> <li>• 27g peak</li> <li>• 5.97 m/s velocity change</li> <li>• Six sides</li> </ul>	<ul style="list-style-type: none"> <li>• No visible damage</li> <li>• Blade operational when tested after shock</li> </ul>
Telcordia GR-63-CORE, Section 5.3.1	Blade level, packaged, 0=blade≤15kg	<ul style="list-style-type: none"> <li>• Non-operational</li> <li>• 1000mm drop</li> <li>• 13 drops on sides, edges and corners</li> </ul>	<ul style="list-style-type: none"> <li>• No visible damage</li> <li>• Blade operational when tested after all shocks</li> </ul>
Telcordia GR-63-CORE, Section 5.3.1	Blade level, packaged, 15<blade≤20kg	<ul style="list-style-type: none"> <li>• Non-operational</li> <li>• 800mm drop</li> <li>• 13 drops on sides, edges and corners</li> </ul>	<ul style="list-style-type: none"> <li>• No visible damage</li> <li>• Blade operational when tested after all shock</li> </ul>
Telcordia GR-63-CORE, Section 5.3.1	Blade level, packaged, 20<blade≤30kg	<ul style="list-style-type: none"> <li>• Non-operational</li> <li>• 600mm drop</li> <li>• 13 drops on sides, edges and corners</li> </ul>	<ul style="list-style-type: none"> <li>• No visible damage</li> <li>• Blade operational when tested after all shock</li> </ul>
Not applicable	Blade level, packaged	<ul style="list-style-type: none"> <li>• Non-operational</li> <li>• 1.146 Grams</li> <li>• Single blade package</li> <li>• 15 minutes/side</li> <li>• 6 sides tested</li> <li>• If bulk packaged</li> <li>• One hour on normal rest surface</li> </ul>	<ul style="list-style-type: none"> <li>• No visible damage</li> <li>• Blade operational when tested after vibration</li> </ul>

Figure 30 shows an example of the results of a rack package vibration test.

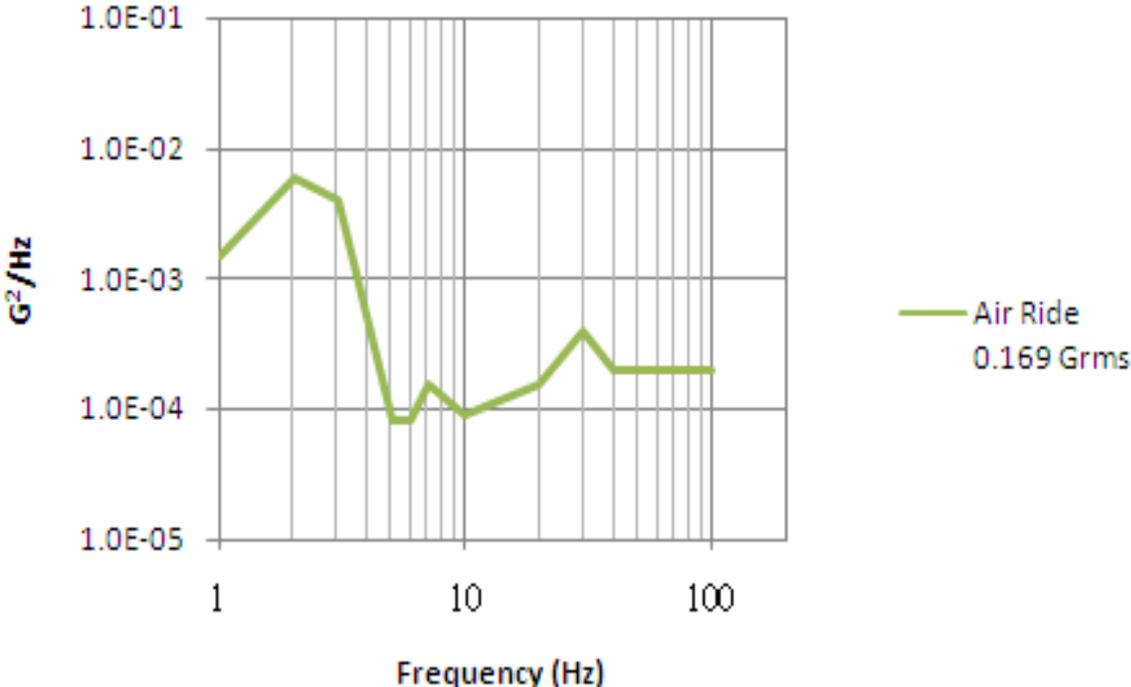


Figure 30. Rack package vibration test, air cushion transportation vibration test levels

## 11 Appendix: Commonly Used Acronyms

This section provides definitions of acronyms used in the system specifications.

**ACPI** – advanced configuration and power interface

**AHCI** – advanced host controller interface

**AHJ** – authority having jurisdiction

**ANSI** – American National Standards Institute

**API** – application programming interface

**ASHRAE** – American Society of Heating, Refrigerating and Air Conditioning Engineers

**ASIC** – application-specific integrated circuit

**BCD** – binary-coded decimal

**BIOS** – basic input/output system

**BMC** – baseboard management controller

**CFM** – cubic feet per minute (measure of volume flow rate)

**CM** – Chassis Manager

**CMOS** – complementary metal-oxide-semiconductor

**COLO** – co-location

**CTS** – clear to send

**DCMI** – Data Center Manageability Interface

**DDR3** – double data rate type 3

**DHCP** – dynamic host configuration protocol

**DIMM** – dual inline memory module

**DPC** – DIMMs per memory channel

**DRAM** – dynamic random access memory

**DSR** – data set ready

**DTR** – data terminal ready

**ECC** – error-correcting code

**EEPROM** – electrically erasable programmable read-only memory

**EIA** – Electronic Industries Alliance

**EMC** – electromagnetic compatibility

**EMI** – electromagnetic interference

**FRU** – field replaceable unit

**FTP** – file transfer protocol

**GPIO** – general purpose input output

**GUID** – globally unique identifier

**HBI** – high business intelligence

**HCK** – Windows Hardware Certification Kit

**HMD** – hardware monitoring device

**HT** – hyperthreading

**I<sup>2</sup>C** – inter-integrated circuit

**IBC** – international building code

**IDE** – integrated development environment

**IEC** – International Electrotechnical Commission

**IOC** – I/O controller

**IPMI** – intelligent platform management interface

**IPsec** – IP security

**ITPAC** – IT pre-assembled components

**JBOD** – “just a bunch of disks”

**KCS** – keyboard controller style

**L2** – layer 2

**LAN** – local area network

**LFF** – large form factor

**LPC** – low pin count

**LS** – least significant

**LUN** – logical unit number

**MAC** – media access control

**MDC** – modular data center containers

**MLC** – multi-level call

**MTBF** – mean time between failures

**MUX** - multiplexer

**NIC** – network interface card

**NUMA** – non-uniform memory access

**OOB** – out of band

**OSHA** – Occupational Safety & Health Administration

**OTS** – off the shelf

**PCB** – printed circuit board

**PCIe** – peripheral component interconnect express

**PCH** – platform control hub

**PDB** – power distribution backplane

**PDU** – power distribution unit

**Ph-ph** – phase to phase

**Ph-N** – phase to neutral

**PNP** – plug and play

**POST** – power-on self-test

**PSU** – power supply unit

**PWM** – pulse-width modulation

**PXE** – preboot execution environment

**QDR** – quad data rate

**QFN** – quad flat package no-lead

**QPI** – Intel QuickPath Interconnect

**QSFP** – Quad small form-factor pluggable

**RAID** – redundant array of independent disks

**REST** – representational state transfer

**RM** – Rack Manager

**RMA** – remote management agent

**ROC** – RAID-on-chip controller

**RSS** – receive-side scaling

**RTS** – request to send

**RU** – rack unit

**RxD** – received data

**SAS** – serial-attached small computer system interface (SCSI)



**SATA** – serial AT attachment

**SCK** – serial clock

**SCSI** – small computer system interface

**SDA** – serial data signal

**SDR** – sensor data record

**SFF** – small form factor

**SFP** - small form-factor pluggable

**SMBUS** – systems management bus

**SMBIOS** – systems management BIOS

**SOL** – serial over LAN

**SPI** – serial peripheral interface

**SSD** – solid-state drive

**TB** – tray backplane

**TDP** – thermal design power

**TB** – tray backplane

**TOR** – top of rack

**TPM** – trusted platform module

**TxD** – transmit data

**U** – rack unit

**UART** – universal asynchronous receiver/transmitter

**UEFI** – unified extensible firmware interface

**UL** – Underwriters Laboratories

**UPS** – uninterruptible power supply

**Vpp** – voltage peak to peak

**WMI** –Windows Management Interface