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Thermal Simulation Report

For

RME21
Rack Mount Enclosure

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Revision History Form

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Introduction

This report was prepared to document the results of the thermal and flow study performed for the Hybricon RME21 Chassis. This simulation effort was undertaken with the primary goal of ensuring adequate airflow through the RME21chassis. Of particular concern is the slot-to-slot variation and meeting providing adequate airflow for highly packaged processor design dissipating 85 Watts. Additional needs to be addressed in a continuation of this work involve detailed board layouts for the final applications and extreme operational altitudes.

Simulation Parameters

1. The ambient temperature was assumed to be 30º C at Mean Sea Level (MSL).
2. Power on each Circuit Card was assumed to be 85-Watts maximum.
3. Furthermore, each board was assumed to have the equivalent pressure drop characteristics of figure 1:

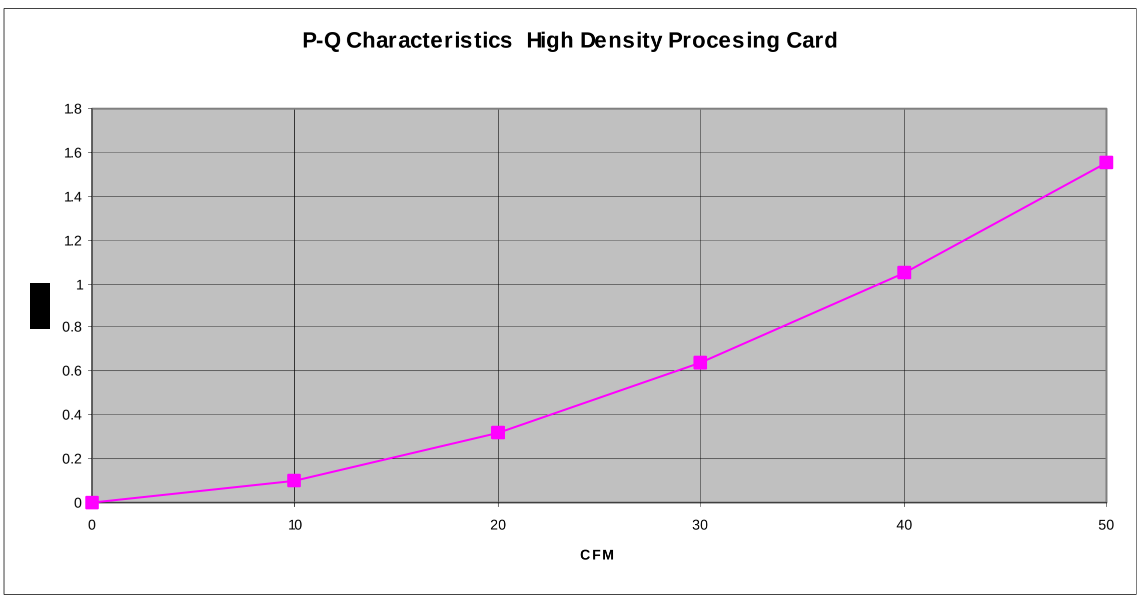

Figure 1: P-Q Card Characteristics

4. The system fans, Four Delta Tubeaxial FFB0912EHE fans were modeled as non-linear devices with flow dependent swirl. Both were modeled according to manufacturer provided P-Q curves. These are the fans recommended for the standard configuration.

Figure 2 shows the relative performance of these two fans.

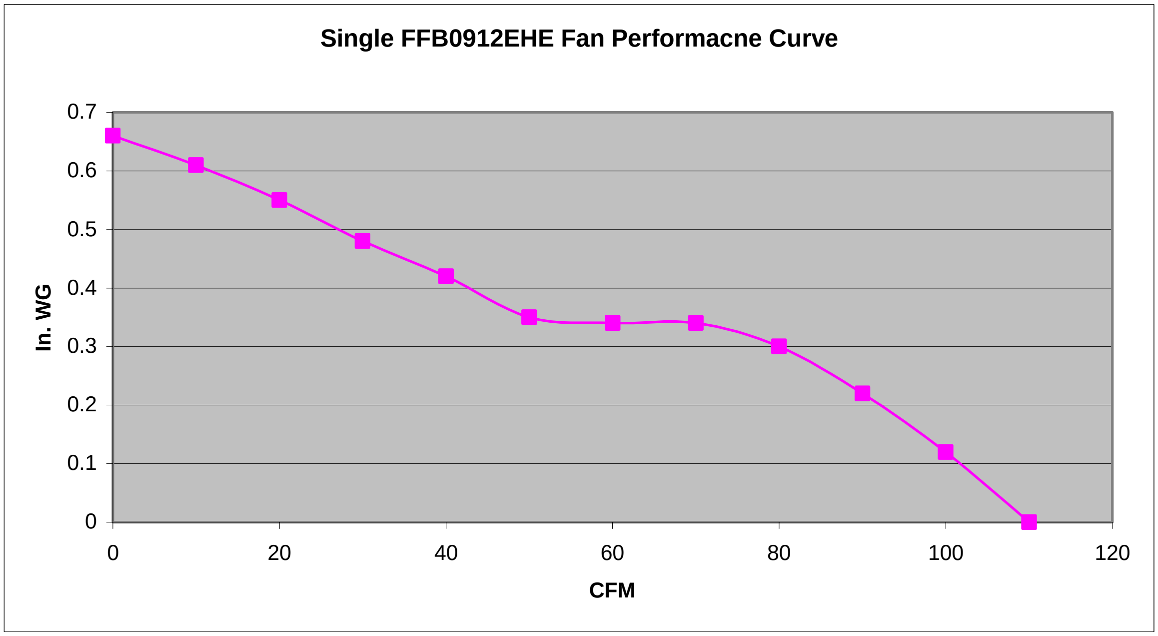

Figure 2: Fan Comparison P-Q Curves

5. An installed air filter was assumed to be a Universal Air Filter 1/4", 45PPI, 80% arrestance foam filter. The resistance characteristics were taken from UAF provided libraries. This air filter design was selected to insure compliance with the Network Building Equipment Specification (NEBS), which is commonly required for telecommunication systems.
6. In total, 1785 W are being dissipated within the card cage. The heat dissipation from the power supply systems is not considered in this report, since the power supplies have a separate thermal flow path, within the chassis.

Preliminary Analysis Setup

For determining the viability of chassis concepts and designs, the following information is required to be collected and understood minimum design goals are to be determined. Table 1shows the minimum required flow to keep the average temperature rise across the card cage to the average temperature rises shown. These temperature rises are determined using the mass flow heat transfer equation of:

$$Q = c_p * dm/dt * (T_{out} - T_{Ambient});$$

Where Q = Total Heat Dissipated in Watts

Cp= The Specific Heat of the Fluid being used.

dm/dt= Mass Flow rate, =ρ* dV/dt,

Where dV/dt = volumetric flow rate and ρ= fluid density

Total power (Watts)	1785	1785	1785	1785	1785	1785	1785	1785
Solved for CFM	358.2	238.8	179.1	143.3	119.4	102.3	89.6	79.6
Temp rise (C°)	10	15	20	25	30	35	40	45

Table 1: Minimum Required Flows for Various System temperature rises

To maintain a maximum surface temperature of 70 º C in accordance with UL 60950, and minimum of 238 CFM is required at the maximum payload of 1785 Watts, to maintain a 15 ºC rise above ambient in a 55º C Ambient temperature.

Modeling Approach

Average per Slot flow resistances were modeled into the chassis, as generic resistance models representing the effects of the P-Q Characteristics of Figure 1. These generic resistances only provide for bulk flow rates and average velocities over the PWA surfaces. The goal at this point is to provide adequate volumetric and mass flow rates to ensure that a high average rise above the card cage is not realized and the maximum surface temperatures of the exhausting air meet know and prescribed equipment safety requirements.

Summarized Results

Note: Bulk rise is generally used as a figure of merit. The bulk rise in this case is the temperature of the air as it leaves the enclosure, thus its heating is due to all heat sources in the enclosure. Local temperatures may be higher (or lower to the limit of the ambient) than this number. This holds true for bulk rises reported by slot. These rises are literally calculated by area averaging the temperatures in each cell along a planar surface.

Mean Flows	Volume Flow Rate (CFM) with FFB0912EHE Fan	Average Temp Rise @ 85 Watts/ Slot

Slot 1	15.5	10.4 º C
Slot 2	10.9	14.9 º C
Slot 3	11.9	13.5 º C
Slot 4	11.9	13.5 º C
Slot 5	11.9	13.6 º C
Slot 6	15.8	10.3 º C
Slot 7	12.7	12.8 º C
Slot 8	12.9	12.5 º C
Slot 9	12.6	12.8 º C
Slot 10	12.4	13.1 º C
Slot 11	16.1	10.0 º C
Slot 12	12.8	12.6 º C
Slot 13	13.0	12.4 º C
Slot 14	12.8	12.7 º C
Slot 15	12.6	12.8 º C
Slot 16	16.6	9.8 º C
Slot 17	13.2	12.2 º C
Slot 18	12.9	12.6 º C
Slot 19	12.2	13.3 º C
Slot 20	11.4	14.2 º C
Slot 21	12.0	13.5 º C

Table 2: Volumetric Flow and Average Temperature Rise Per Slot

Chart 1 shows the above data in a chart format for slot-to-slot flow variations.

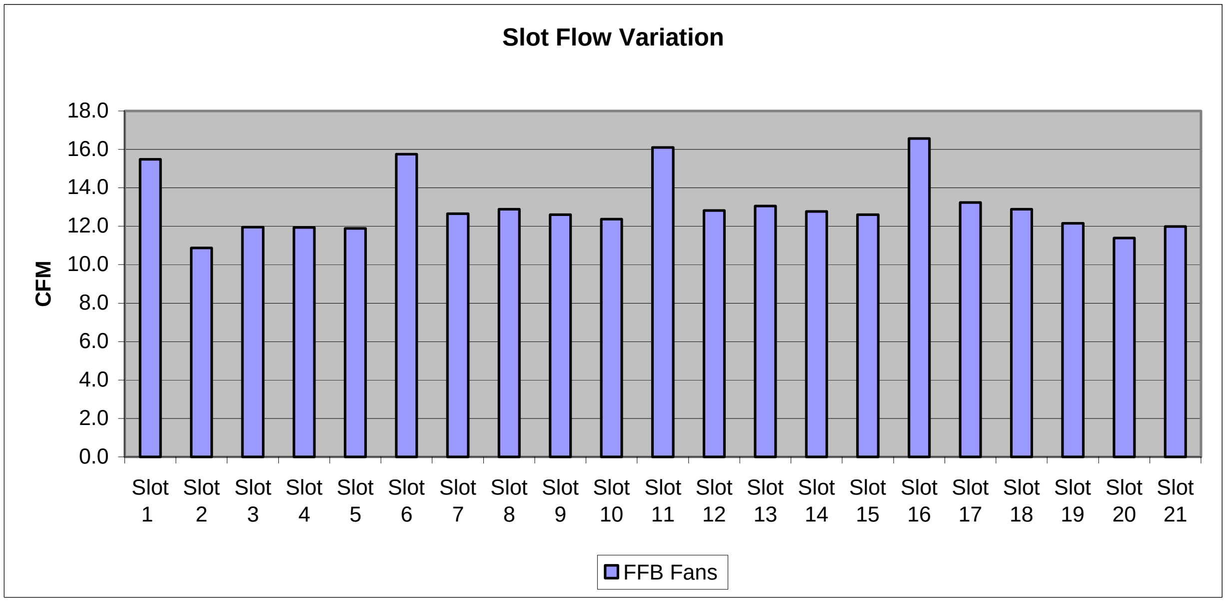

Chart 1: Slot Flow Variations

The results of table one shows that the FFB0914EHE Version fan will provide the minimum system flow to keep the surface temperatures below a 70 º C maximum at the maximum payload of 85 watts per slot or 1785-Watts Total.

Detailed Results

Normal Operation:

Figure 3 below show the general cross section of the RME 21 Chassis to show the major airflow path through the chassis. The air travels through the chassis in the directions indicated by the arrows.

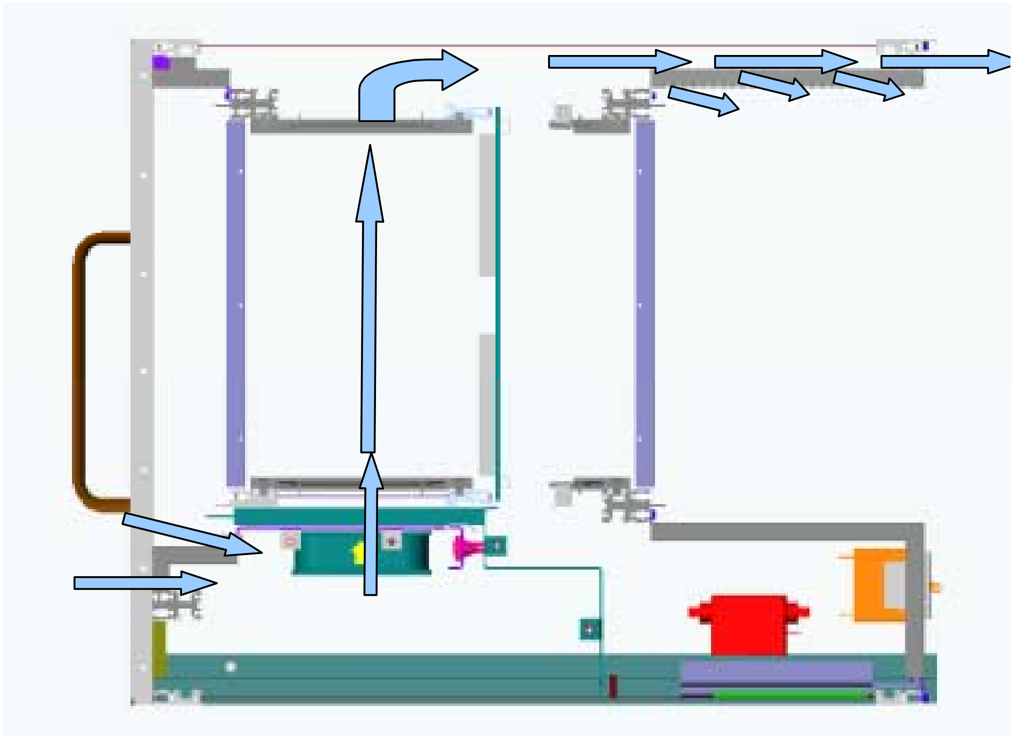

Figure 3: Side view Showing General Air Flow Path

Figure 4 shows the basic geometry used for the airflow models. The chassis side was removed for clarity. It should also be noted that in FLO/THERM iconography, yellow borders indicate flow resistances, the fans are the brown rectangles, Front panels are gray and the metal extrusions and sides are the dark blue rectangles.

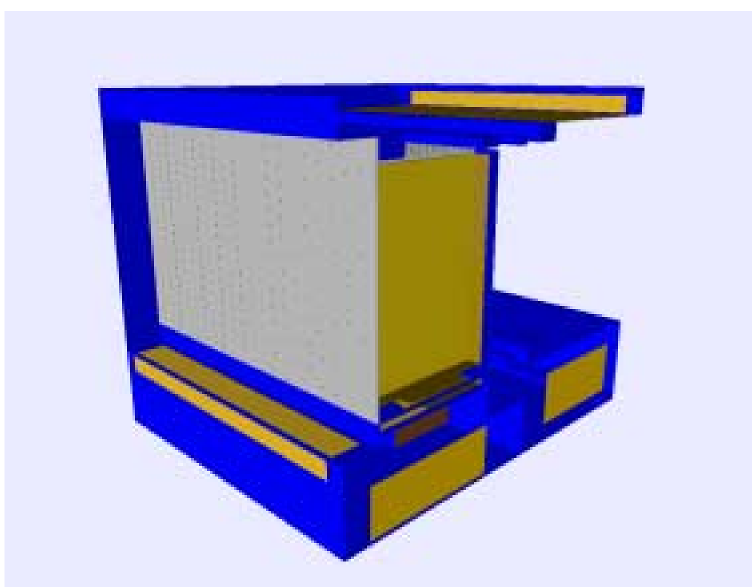

Figure 4: Basic Geometry used For Model

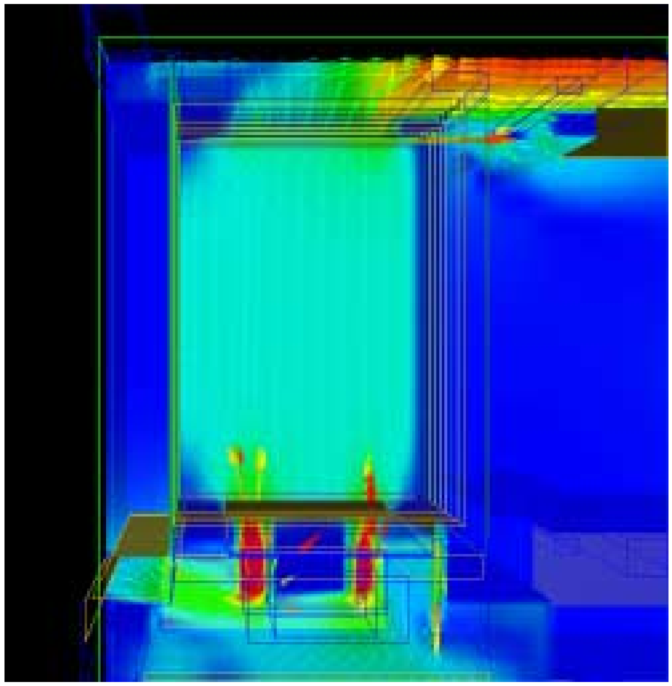

Figure 5: View of The General Slot Airflow.

The average velocity through each slot is approximately 405 lfm using the FFB0912EHE Fan. This result was obtained by averaging the mean slot velocity for each slot. It should also be noted that due to the high face velocities the airflow through the board region is highly directional, since the flow around the card cage extrusions leave some areas of low localized velocities. This is due to the effect of obstructions in the air path combined with the swirl effect from the fans. This is shown in the dark blue area adjacent to the inlet to the boards in figure 5.

Hybricon Corporation's patented CoolSlot™ card-guides (not modeled here) are designed to redirect air flow into these regions, and will improve this distribution problem; nevertheless, hot components still should not be placed in this area.

Combining the effects of the airflow pattern and temperature distribution is shown in Figure 6. This figure shows that the evenly distributed dissipated power has a uniform distribution over the surface of the card in slot 12. This even distribution shows the capacity of the chassis to handle this heat loading.

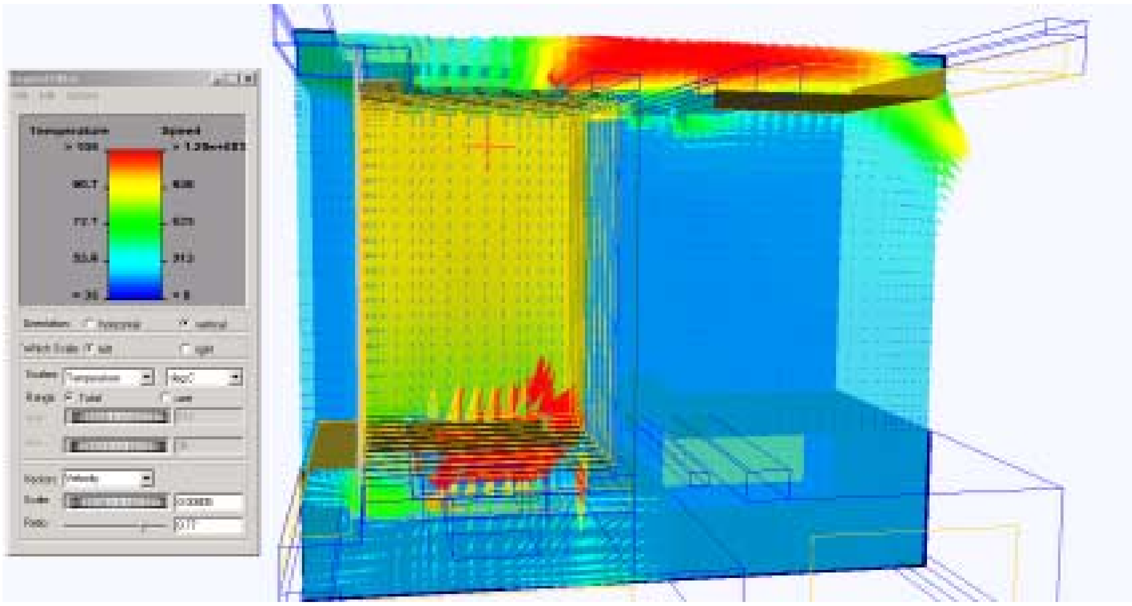

Figure6: Slot 12 Generalized Flow and Temperature Distribution at 85 Watts

From a review of the elements that impact the flow of air through the chassis, improvement in airflow could be realized by the following means:

1. Having card pressure drops below the level of the High Processor card modeled for this evaluation. See Figure 7 for a comparison of the reduction in flow resistance based on card packaging densities.

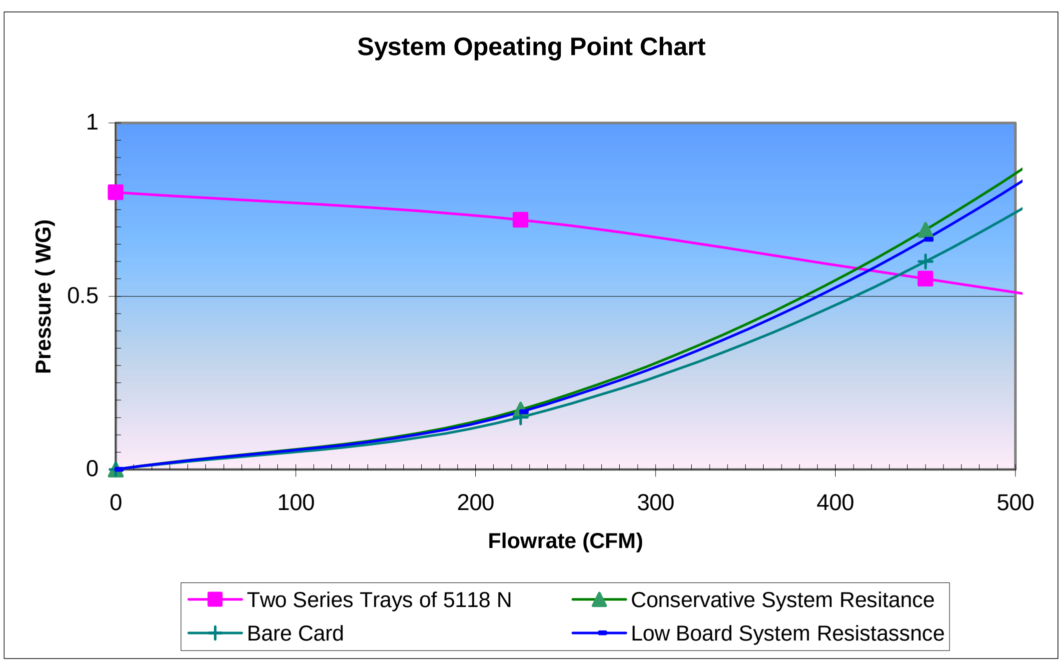

Figure 7: Varying operating point for Card Flow Resistances

For the drop in card flow resistance, the actual flow rate through the overall system improves. This is seen in figure 7 as the system resistance curves show the decreasing resistance as the curves become more horizontal. This improves the total flow and per slot flow through the system and circuit cards. This increase in flow will reduce the overall average temperature seen on devices powered on these cards.

2. Should the option to increase the overall height of the unit become possible, a large area of flow resistance will be greatly reduced. Thus is in the area of the air discharge behind the back plane. The density of the red colored arrows shown in figure 7 sees this. This change in direction and compression of the discharge air restricts the overall flow in the chassis. Increasing the height in this area will reduce the over pressure losses of the system and thus increase flow.

Conclusions:

From the information presented in this report, the RME 21 has the potential of providing cooling air in the range of 10.9 to 16.6 CFM of air per slot using the flow resistance of a highly dense processor card. This is a conservative estimate, since a card pressure drop characteristic of a highly dense processor card was used to model this chassis. The information contained in this report is limited to the assumptions listed in the introduction to this report. The results of this analysis using generic flow resistance will not predict the detailed parameter required for thermal management of critical devices. Detailed models of these card should be performed using the per slot flow to obtain the first order estimate of the detailed performance of critical components.