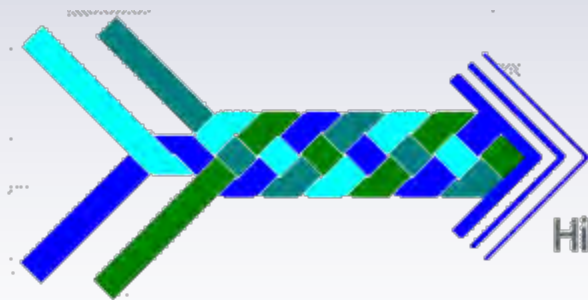


# Cooling 400W boards Challenges and Solutions

***David L Wright***

***President and Systems Infrastructure  
Architect***



**Advanced Platforms**  
High Availability Telecommunications Infrastructure

# Challenges

***Moving heat energy from one area to  
another***

***Quietly  
Efficiently  
Responsibly***

## Does the PICMG section 5 give us what we need?

From the board perspective I think not. (I do not claim to be in the board business)

From the shelf perspective yes, but the spec is too open

From a systems integrators perspective - not yet

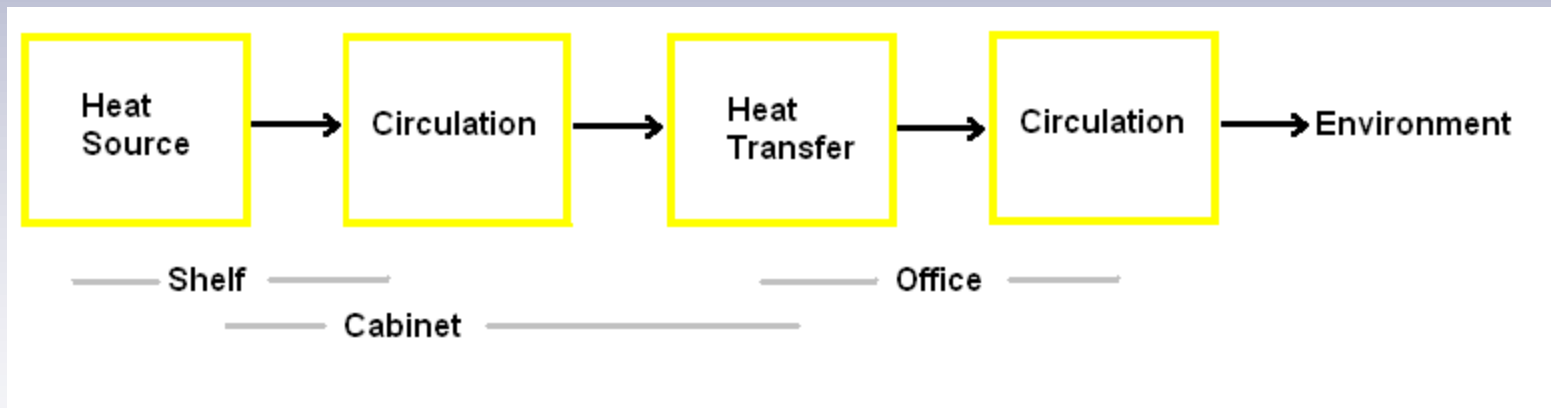
## Specifications Upgrade

***A better specification for board cooling requirements with environmental limits. Use LFM or M/s with a known impedance***

***A better specification for shelf performance with limits. CFM or M<sup>3</sup>s with accurately determined slot airflows***

***An airflow measurement methodology (PICMG or CP-TA)***

# From here to there and back again, a hobbits tale



## Shelf and cabinet circulation

We have these tasks

Get heat out of the components

Get heat energy out of the shelf

Get heat energy out of the cabinet

Consistently (interoperability)

Do we contribute to global warming?

# Board, shelf and cabinet

LFM, CFM, metric and standard air

## The usual formula

$$CFM = (1.830 * W) / dt$$

CFM of what?

Standard air is - -

Why 1.830, what and how?

## Why 1.830, what and how?

1.830 is the simplification of the metric formula for evaluating the volumetric flow needed for cooling a given power (actually energy/sec) which is:

$$Vs^{-1} = \frac{W}{\Delta T * D * J.kg^{-1}}$$

Where

$\Delta T$  is the temperature difference

D is the fluid density

$J.kg^{-1}$  is the specific heat of the cooling fluid

## The air relationships

The ideal gas law can be represented by:

$$P V = n R T$$

where

P = pressure in Pascal (standard air is 101325 Pa)

V = volume (cubic meters)

n = the number of molecules

R = is the gas constant (Standard air is dry 287.05 J(kg T)

T = is the absolute temperature (K)

Cooling is affected by the density . The metric definition is given as kg/m<sup>3</sup>. It is the mass of air that cools components and fans are primarily air mass movers. Nevertheless, the electronics industry is used to volumetric flow definitions and these will be used in the following analysis.

Rearranging gives the volume as:

$$V = (n R T) / P \text{ from which we can derive the flow rate.}$$

## Watt cools

Standard air is a mixture of gases with the key characteristics being the density and the specific heat. Pressure and temperature affect density.

|                   |   |
|-------------------|---|
| Density           | kg/m <sup>3</sup>                                 |
| Pressure          | Pascal  |
| Specific heat     | kJ/kg K (at constant pressure or constant volume) |
| Conductivity      | W/m K   |
| Fluid Temperature | T C or K  |

## Out of the box

This is subject of a patent application

Why use just plain old air? *Apart from that it is free!*

With mixed gases we can change the characteristics of the gas mixture

Increase density

Increase specific heat

Increase thermal conductivity

## Candidate gases

Carbon dioxide      sorry Al

Helium

R-134a Tetrafluoroethane in gaseous form  
and others

The results can be:

Increased cooling for smaller airflow rate

Quieter

Increased reliability

## Mixed gas cooling

It provides better cooling for legacy boards

It allows for better cooling with legacy shelves

It provides for much quieter operation

It uses existing or easily modified rack/cabinet technologies

It uses commonly available gases

Gases are non toxic and non flammable

Control sensors are available

## What about the environment?

20 kW of electricity providing 20W of signalling  
power is 0.1% efficiency

not good

Add 10kW for cooling infrastructure  
even worse!

What can we do with 20kW of low grade heat?

# Low grade heat can generate electricity

It is inefficient

It is still in its early stages

But it uses the heat we want to dispose of so we could save 10kW of heating cost **and the associated infrastructure**

## Heat to electricity using Polymer material

***Low-grade heat has been converted to electricity using a 60%-40% P(VF<sub>2</sub>-TrFE) copolymer film. This uses a pyroelectric conversion cycle conceived and patented by R. B Olsen. An external control voltage cycled between 100 and 1200V and used a heat source temperature between 30°C and 82°C. Experimental data shows that the energy density was between 15-52 J/L of copolymer used.***

## Organic Rankine cycle engine

***Research is being carried out in the UK by DRD Power Ltd. and Star Refrigeration on a Rankine cycle engine using an organic working fluid instead of water.***

***The low grade heat boils the organic fluid and the expanded gas drives a generator to produce electricity. Initial unit is designed to generate 200kW of electricity.***

***There is an Organic Rankine power plant in Germany generating 3.8MW from low grade heat.***

***Organic rankine cycle technology is not new. The first prototype was displayed by Israeli scientists in 1961.***

## Ener-G-Rotors Rankine cycle

Ener-G-Rotors is a US company with a patented Trochoidal Gear Engine™ (TGE™) which is used as an expander in an organic Rankine cycle (ORC). The low friction and simple design of the TGE makes it the most efficient, durable, and cost effective expander for ORC at low temperatures (65°C to 200°C) and small sizes (<200kW).

## Conclusions

Convection cooling is **not** past its 'best by' date

Further work is needed on the specification

It is worth while investigating cooling with mixed gases

It is worth while investigating the use of low grade waste heat

## References

***Open Systems: 'CompactPCI and AdvancedTCA Systems'  
April 2006, Nov 2008 and 2009 David Wright***

***<http://cat.inist.fr/?aModele=afficheN&cpsidt=13754301>***

***[http://www-  
diva.eng.cam.ac.uk/energy/environmental/low\\_grade\\_heat.ht  
ml](http://www-diva.eng.cam.ac.uk/energy/environmental/low_grade_heat.html)***

***DRD Power Ltd. UK contact [info@drdconsultants.co.uk](mailto:info@drdconsultants.co.uk)***

***Ener-G-Rotors 112 Erie Blvd. Schenectady, NY 12305  
[info@energrotors.com](mailto:info@energrotors.com)***

End

David Wright Systems Infrastructure Architect  
Advanced Platforms Ltd.

Ariel 40700 Israel

+1 978 296 4698 Time Zone GMT+2

+972 3 906 8876

+972 547 836 631 mobile

[david@advanced-platforms.com](mailto:david@advanced-platforms.com)

