CHAM Limited
Pioneering CFD Software for Education & Industry

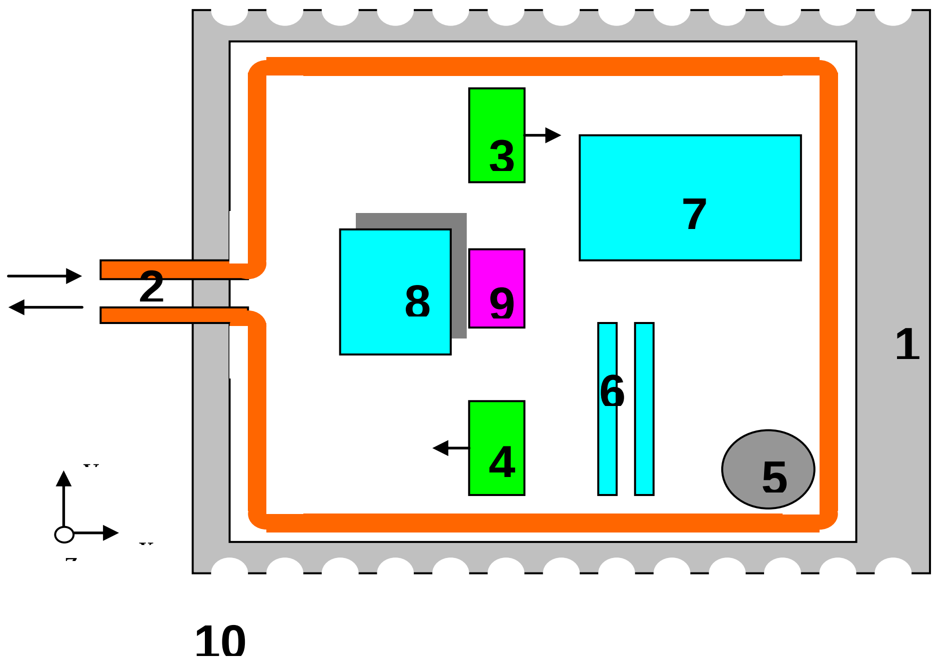
CHAM Case Study – Flow in a Water-cooled Electronics Box

PHOENICS/HOTBOX Demonstration Case using PHOENICS-3.6.2 (2007)

Introduction
CHAM was approached by Norwegian technology development giant, Kongsberg Devotek AS, and requested to model its prototype design for a water-cooled electronics system housed in a finned aluminium box filled with air at 1 bar.

The problem considered
The pump supplying the water to the cooling system can sometimes break down so that the water remains within the pipes but no longer circulates – or cools. The system fails when one of the boards within the section labeled '8' reaches 75°C. The primary concerns for the customer being "Will the system fail and when? For how long can the system safely be operated after the breakdown? "

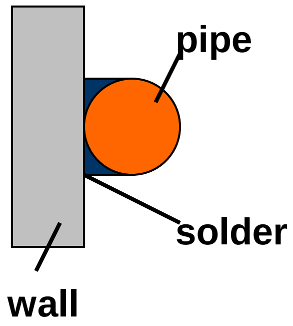
Geometry and boundary conditions
The basic geometry of the system is simplified and shown in the following figure (viewed from the top):



Coordinate system
The zero position is set at the outer lower left corner of the casing as shown in the figure. Zero z-position is at the bottom of the box. Gravity is pointing in negative z-direction.

Component 1 – Housing
Material: aluminium

Component 2 – Water Cooling System



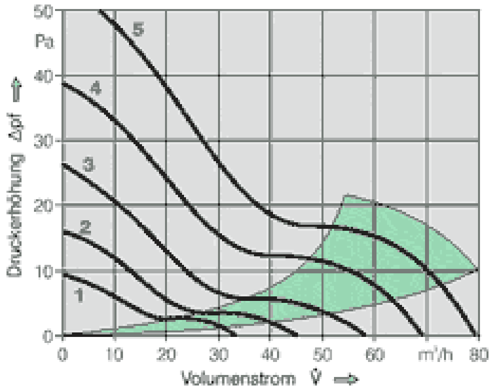
Pipes:
Material: copper
The pipes are soldered to the walls inside the box as shown in the following figure (z-x-plane):

Cooling fluid:
Material: water at 1 bar
Flow rate: 1 l/min
Fluid inlet temperature: 35 °C

Component 3 – Ventilation Fan
Dimensions:
- diameter : 80 mm
- mounted on the bottom plate

Operation conditions:
- fan speed: 2050 rpm
- direction of flow: positive x-direction

Pressure raise ("Druckerhöhung") as function of the volume flow rate ("Volumenstrom") as depicted for line 2.



Component 4 – Ventilation Fan
The same as Component 3 except that the direction of flow is negative x-direction.

Component 5 - Electrolytic capacitor
Material: Aluminium / Heat release: 0.5 W

Component 6 – two identical boards
Material: FR4 / Heat release: 5 W each

Component 7 – board
Material: FR4 / Heat release: 7.5 W

Component 8 – two identical stacked boards, with connector board
Material: FR4 / Heat release: 8 W each

Component 9 – power supply unit with voltage convertor
Material: Copper / Heat release: 22 W

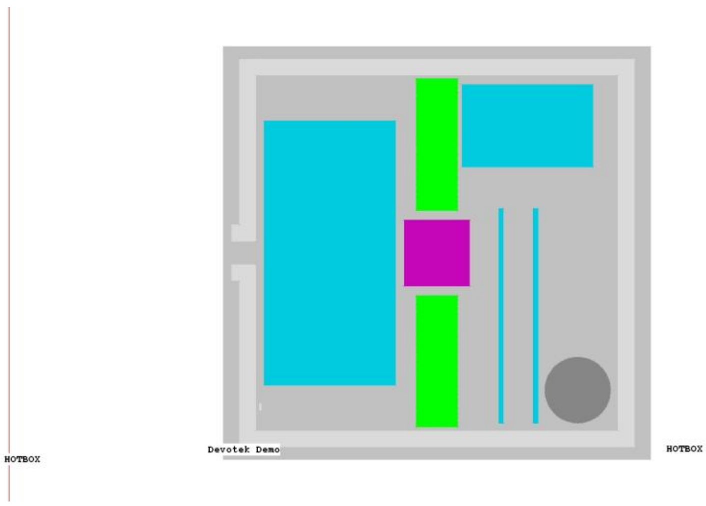
Component 10 – ambiance
Air at 1 bar with a constant temperature of 33 °C is surrounding the box.
The ambiance is enclosed by walls at 33 °C with emissivity of ε = 1.

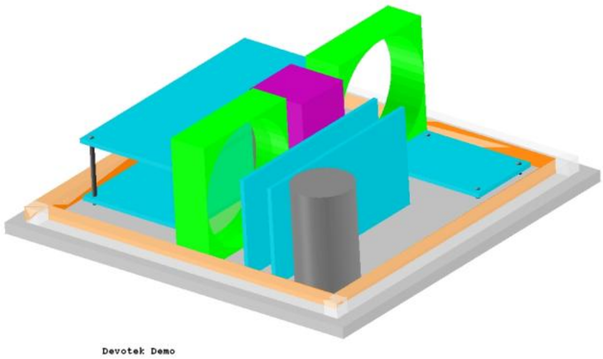
Material properties

Name	density [kg/m3]	heat capacity [J/kgK]	thermal conductivity [W/mK]	emissivity [-]
Copper and Solder	8930	382	399	0.76
Steel	7800	500	15	0.24
FR4	1938	878	17	0.9
Aluminium	2700	888	237	0.2
filling of the capacitor	1300	1250	0.2	-
water	992	4177	0.631	-

The CFD model

A CFD model was created using objects from the built-in HOTBOX library within PHOENICS using the dimensional and operational data supplied by the client, as above.

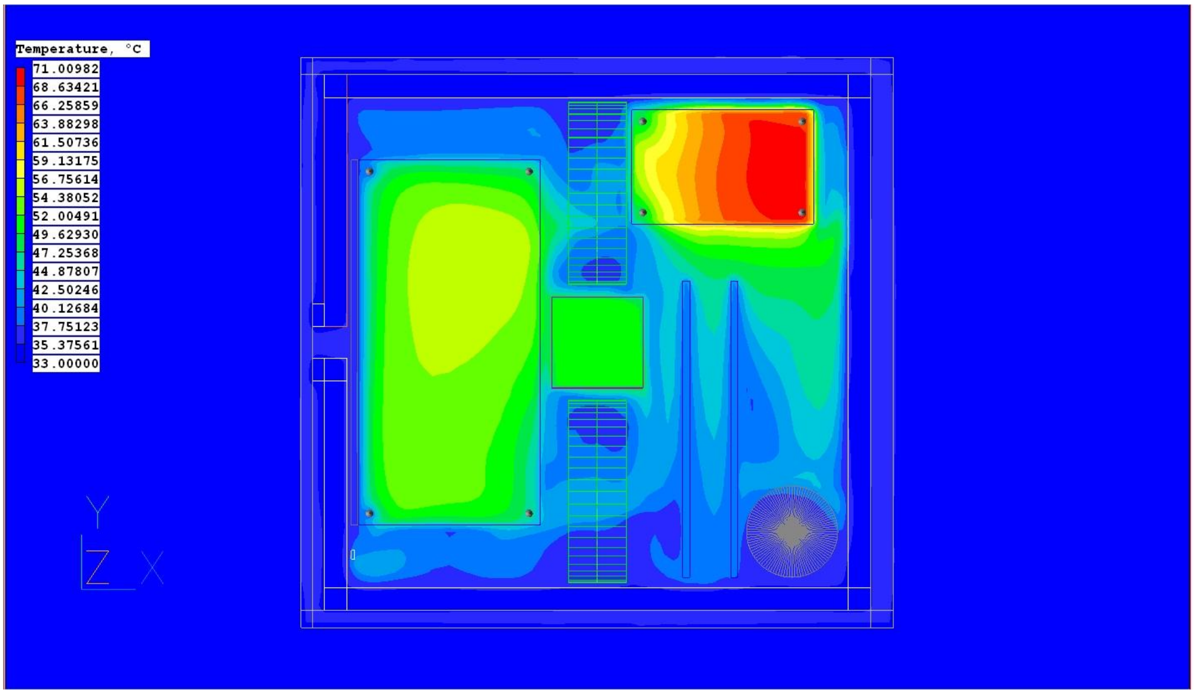




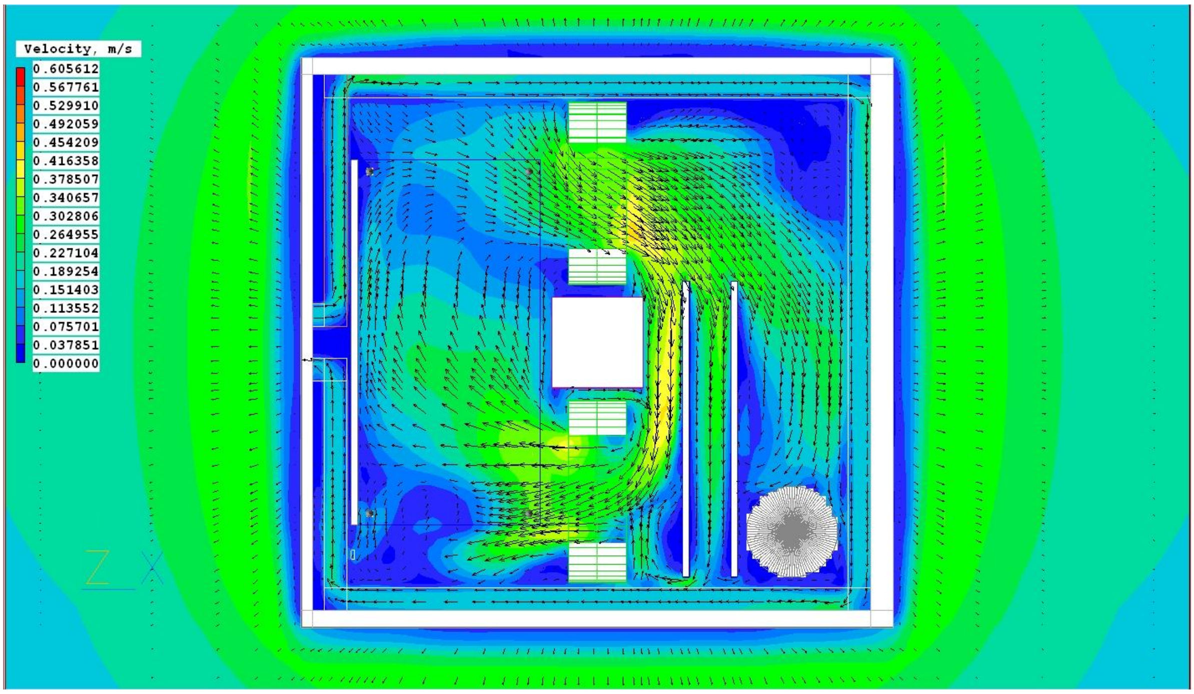
A relatively coarse mesh of 119 x 141 x 76 was applied. Given the nature of the geometric features, PARSOL, was not required. The IMMERSOL radiation model was activated, with the LVEL turbulence model selected, and a transient (time-dependent) operation of 10 time steps covering a 5-minute period. The run time, on a 3GHz PC was 12.7 hours.

The following images show velocity and temperature results after 300 seconds, in plan and cross-sectional views through the domain. The geometry is shown in wire-frame.

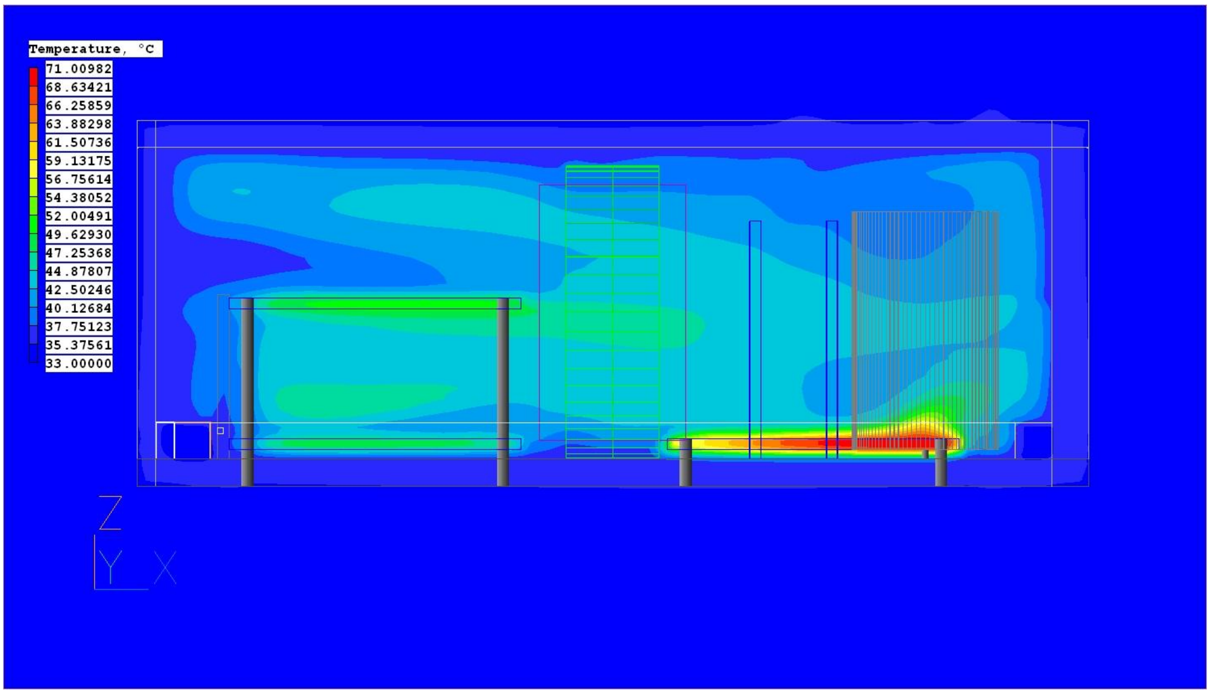
An animation of velocity can be found by clicking here.
An animation of temperature can be found by clicking here.



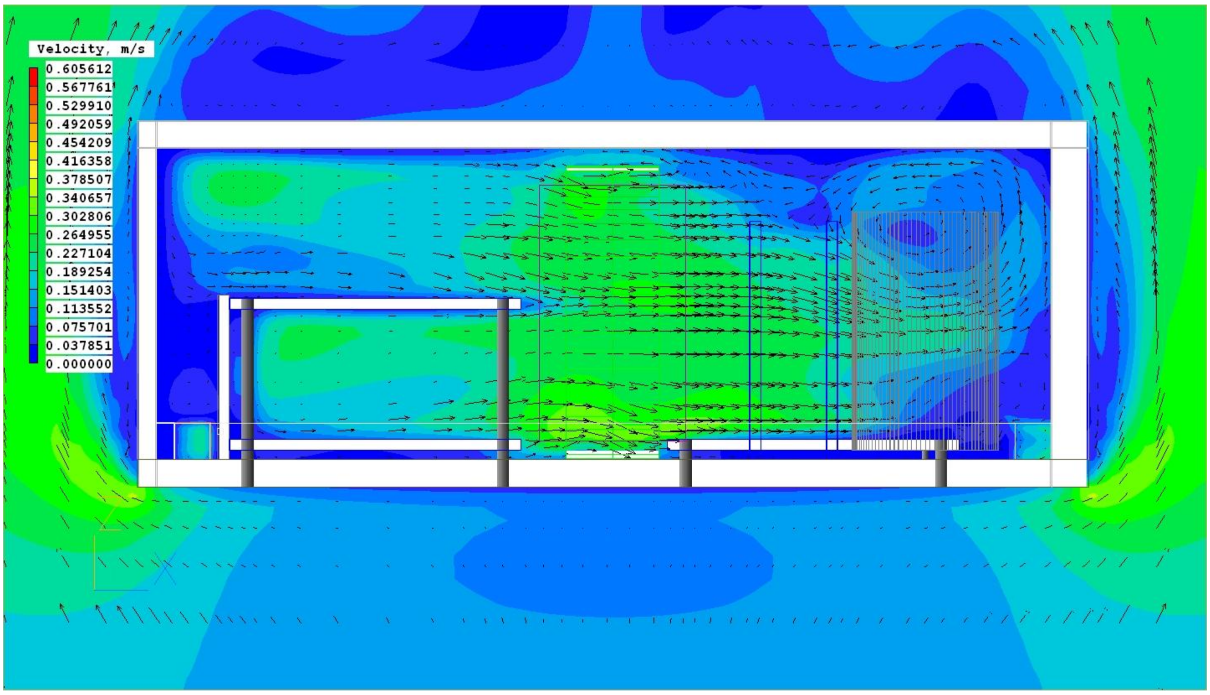
Temperature High Spot XY



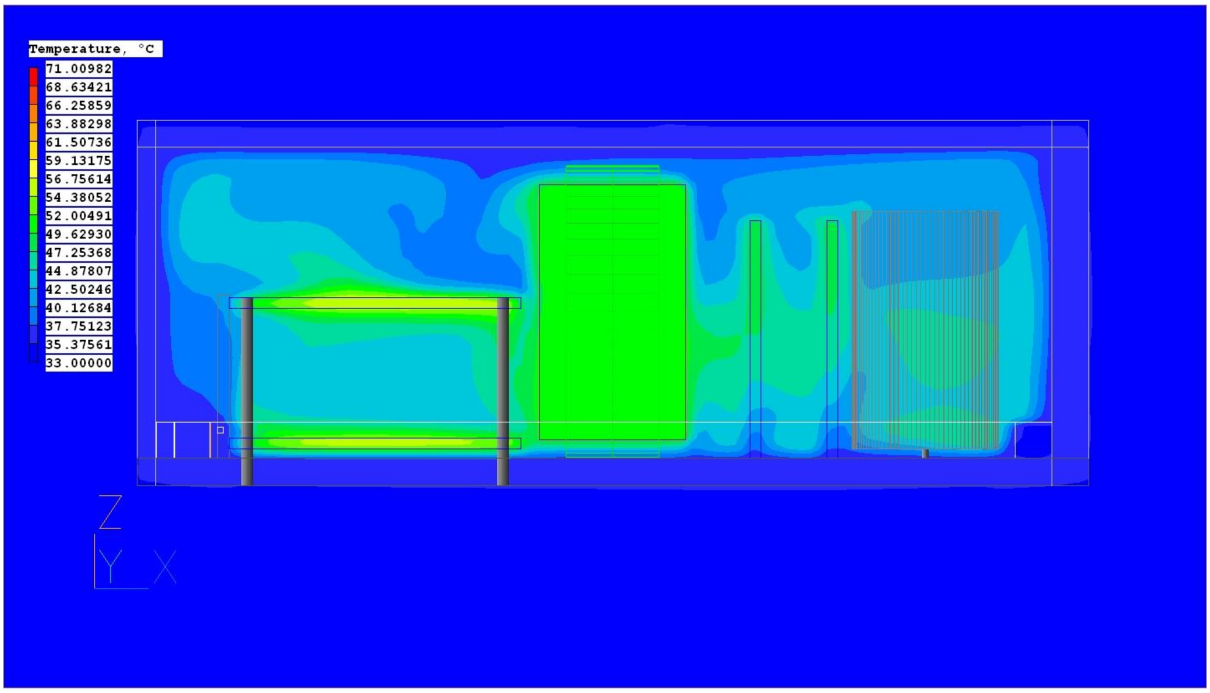
Velocity High Spot XY



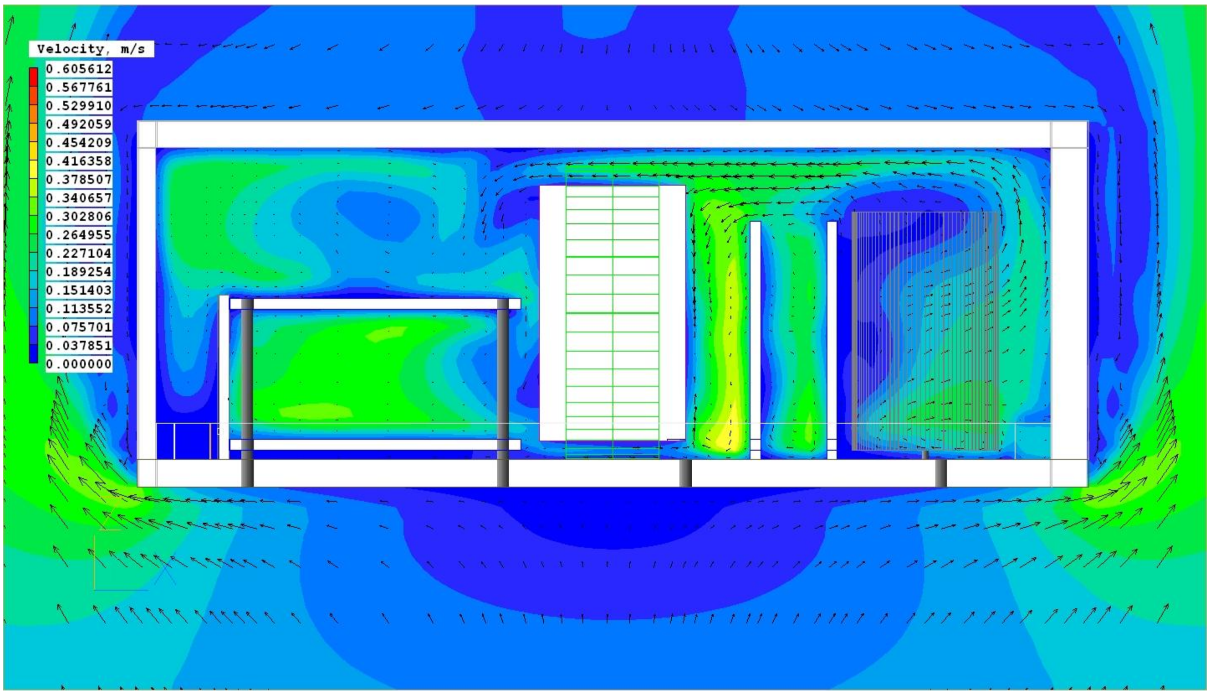
Temperature High Spot XZ



Velocity High Spot XZ



Temperature Centreline XZ



Temperature Centreline XZ

CHAM Ltd, Bakery House, 40 High Street, Wimbledon Village, London SW19 5AU, UK
Tel: +44 (0)20 8947 7651 Fax: +44 (0)20 8879 3497 Email: phoenics@cham.co.uk
Web: http://www.cham.co.uk