Harman International

Modeling of Complex Automotive Infotainment Units

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Modeling is:

- Simplifying the real problem on the basis of physical and/or mathematical arguments, in order to obtain a quantitative, if only approximate, description of the real problem[1)].

Modeling does not mean:

- Solving known basic equations with given boundary conditions
- Inventing (simple) equations to mimic real problems

Reasons for modeling:

- Computational costs
- The real problem too complex
- Time and/or length scales of different orders of magnitude
- Uncertain boundary conditions
- Uncertain or incomplete basic equations

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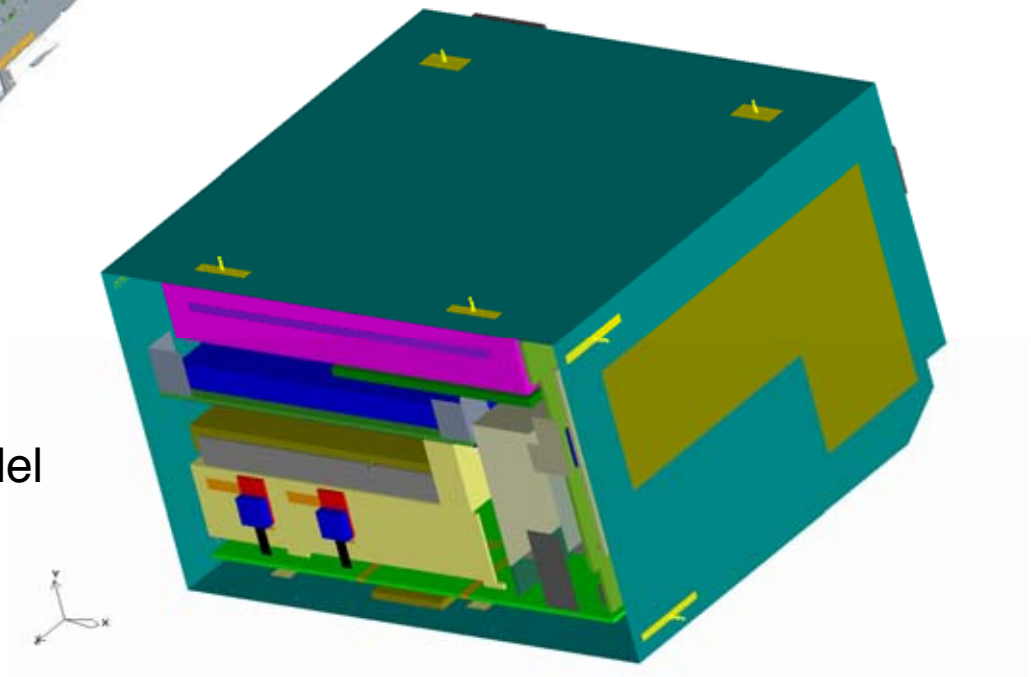
1) Schneider W., 1996 “Introduction to the Modeling of Industrial Fluid Flows”. ZAMM 76 S4, 453-456.



The CAD-model vs. Icepak-model of a typical Infotainment unit.

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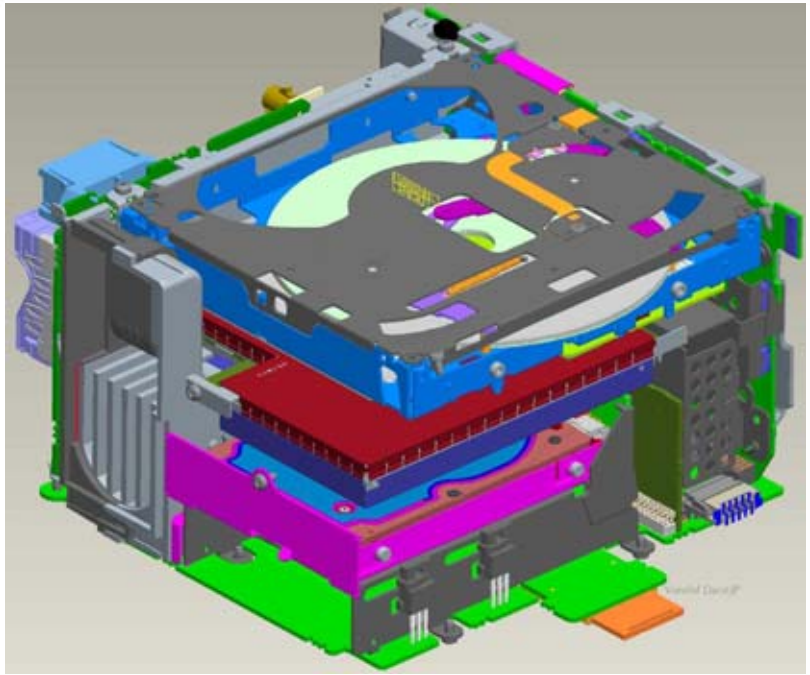

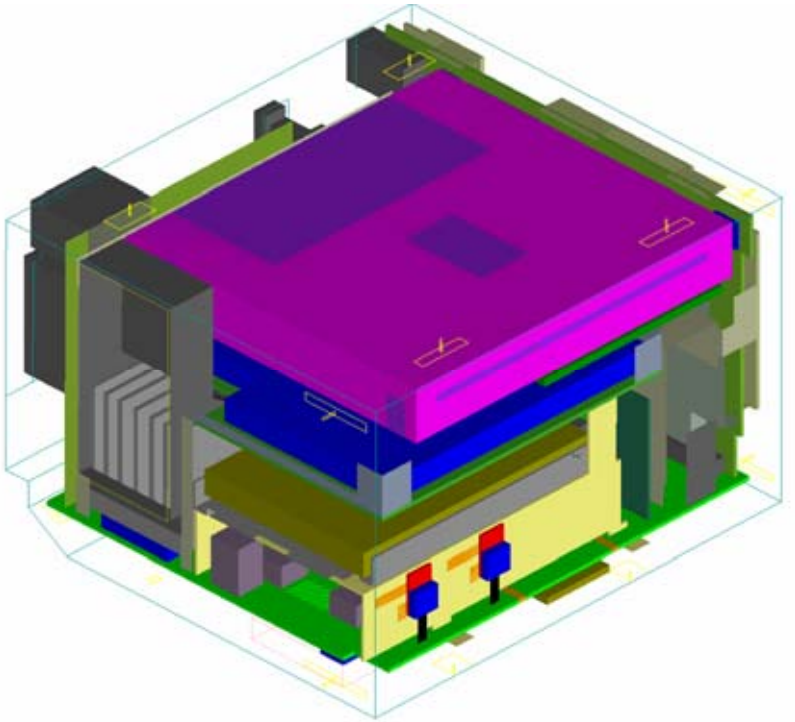

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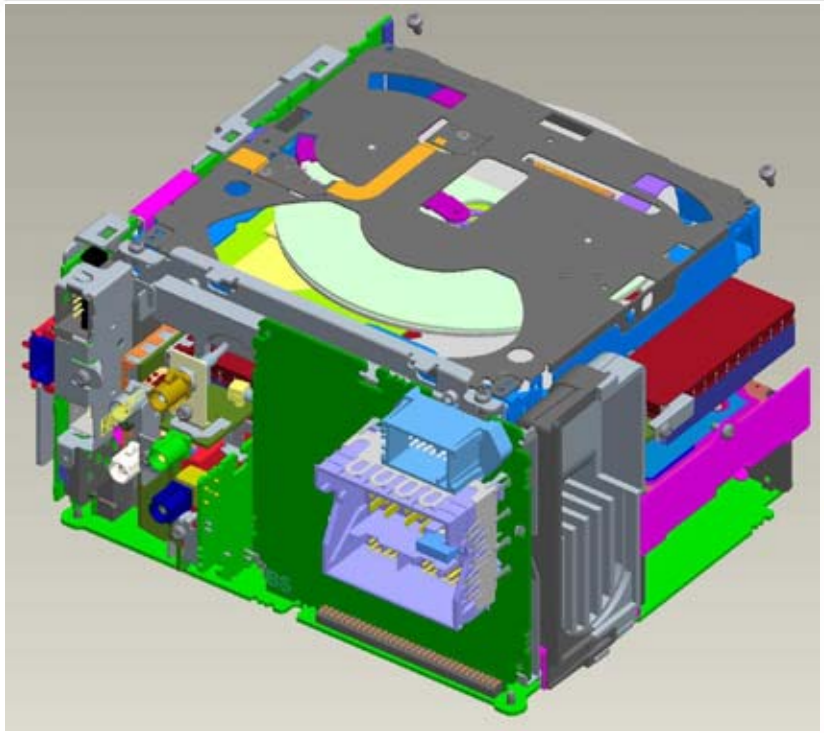

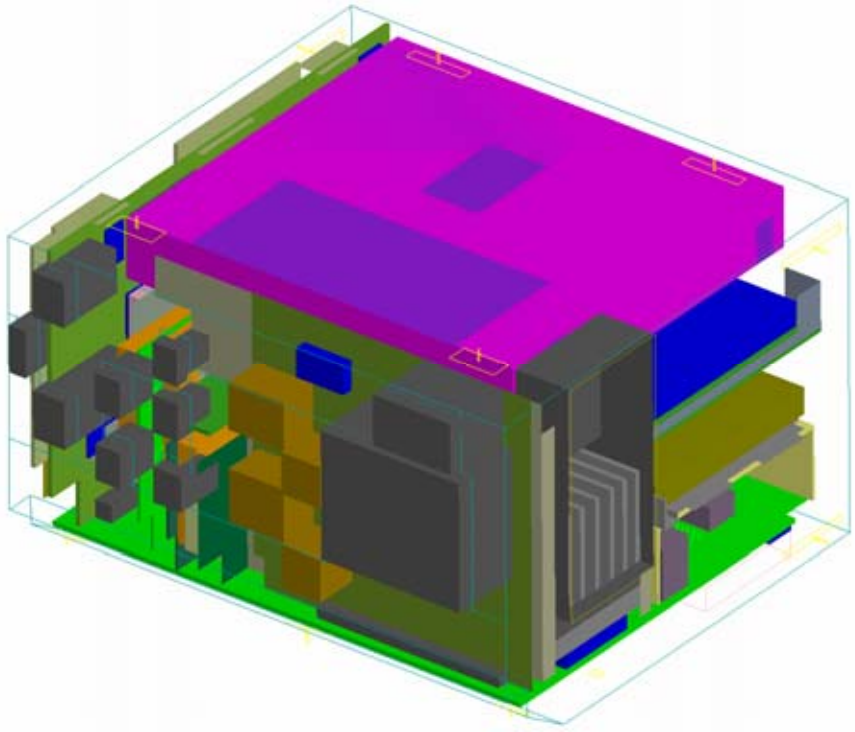

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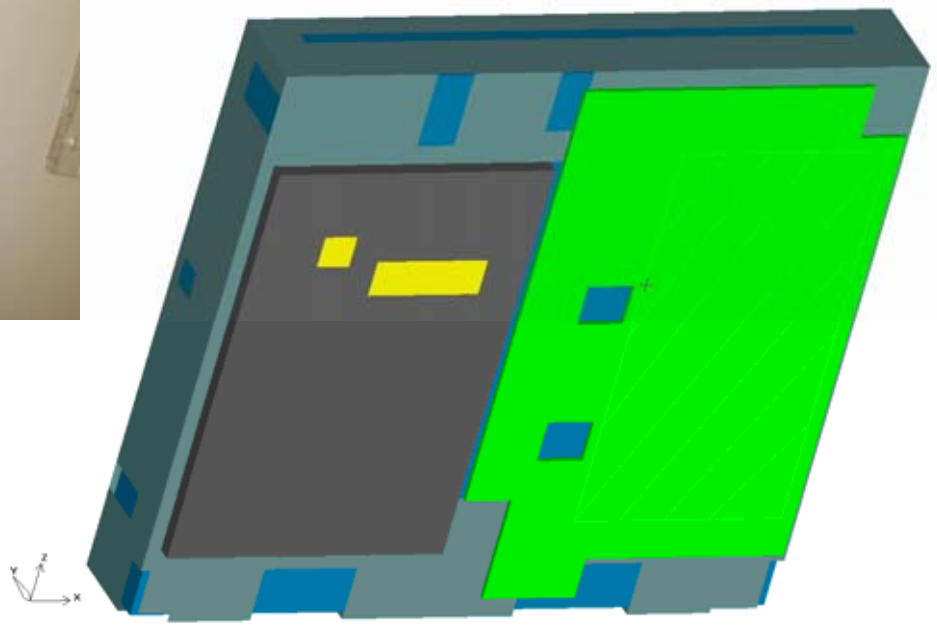

Photo vs. Icepak-model of a DVD-drive. The components over the PCB are replaced with a plane heat source.

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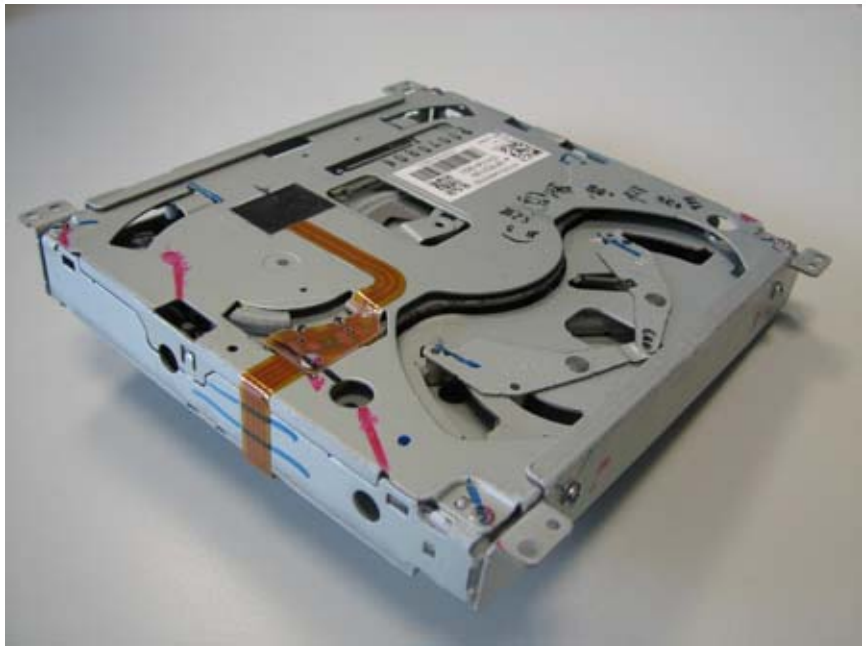
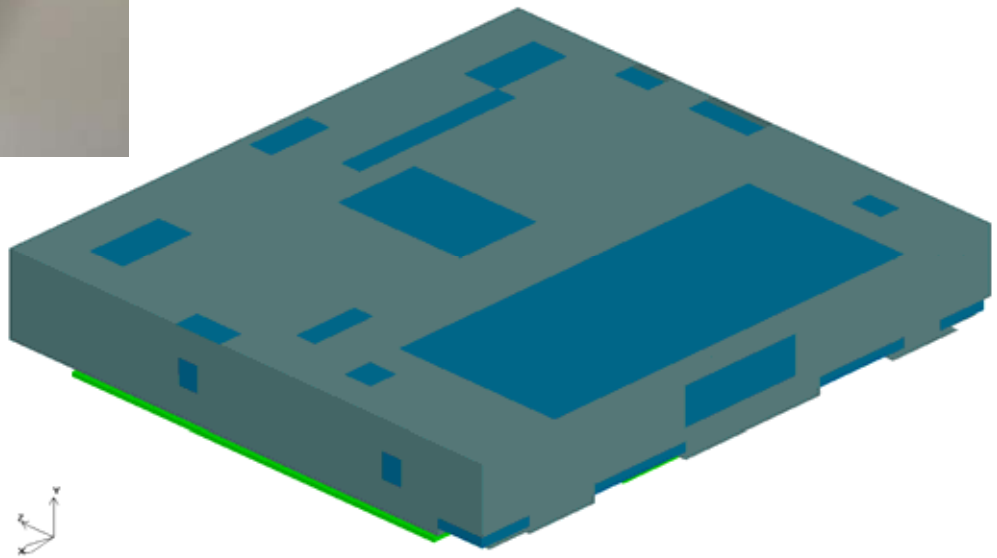


Photo vs. Icepak-model of a DVD-drive. The interior of the drive is replaced with a porous block.



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The hard disk is modeled as a simple solid block with homogeneous heat dissipation

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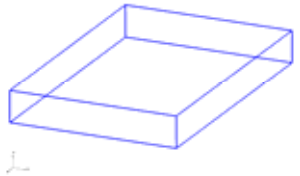
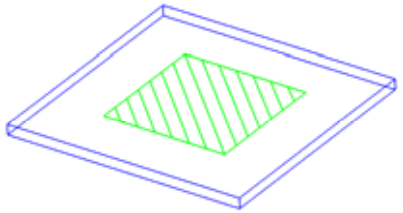
Simplification levels of the chips

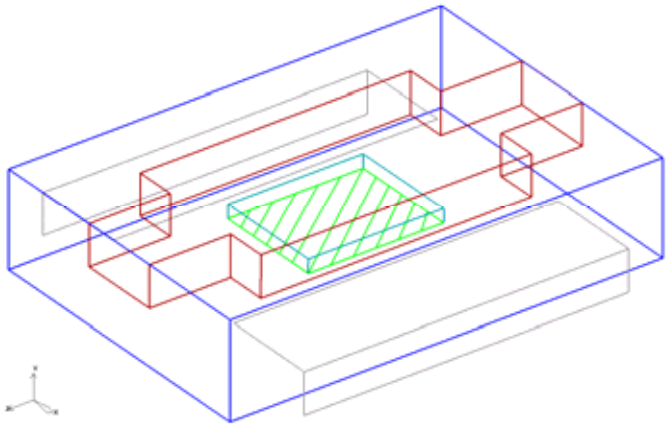
1. Simple solid block with homogeneous heat dissipation

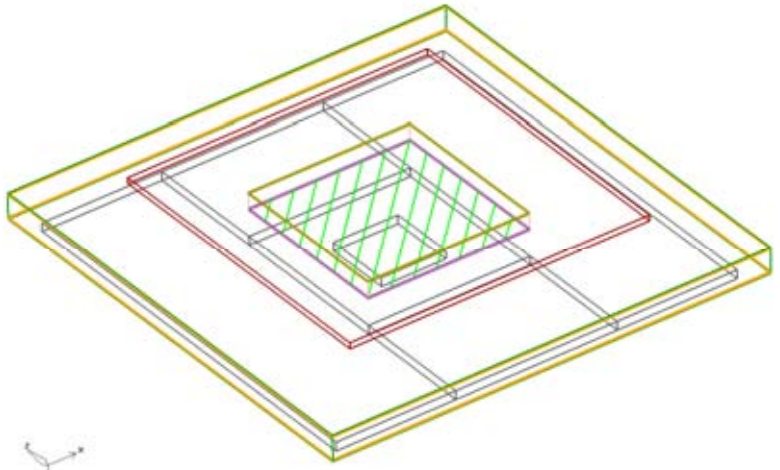


2. Simple solid block with plane heat source



3. Detailed models





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Overview of the applied simplifications

- Using infinitely thin plates
- Replacing connectors with simple solid blocks
- Small holes, apertures, screws, springs as well as parts irrelevant for heat transfer and air flow are neglected
- Perforated plates are replaced with grills
- The PCBS are modeled as homogeneous solids with effective orthotropic thermal conductivities
- Curved geometries are approximated with combinations of rectangular blocks and plates

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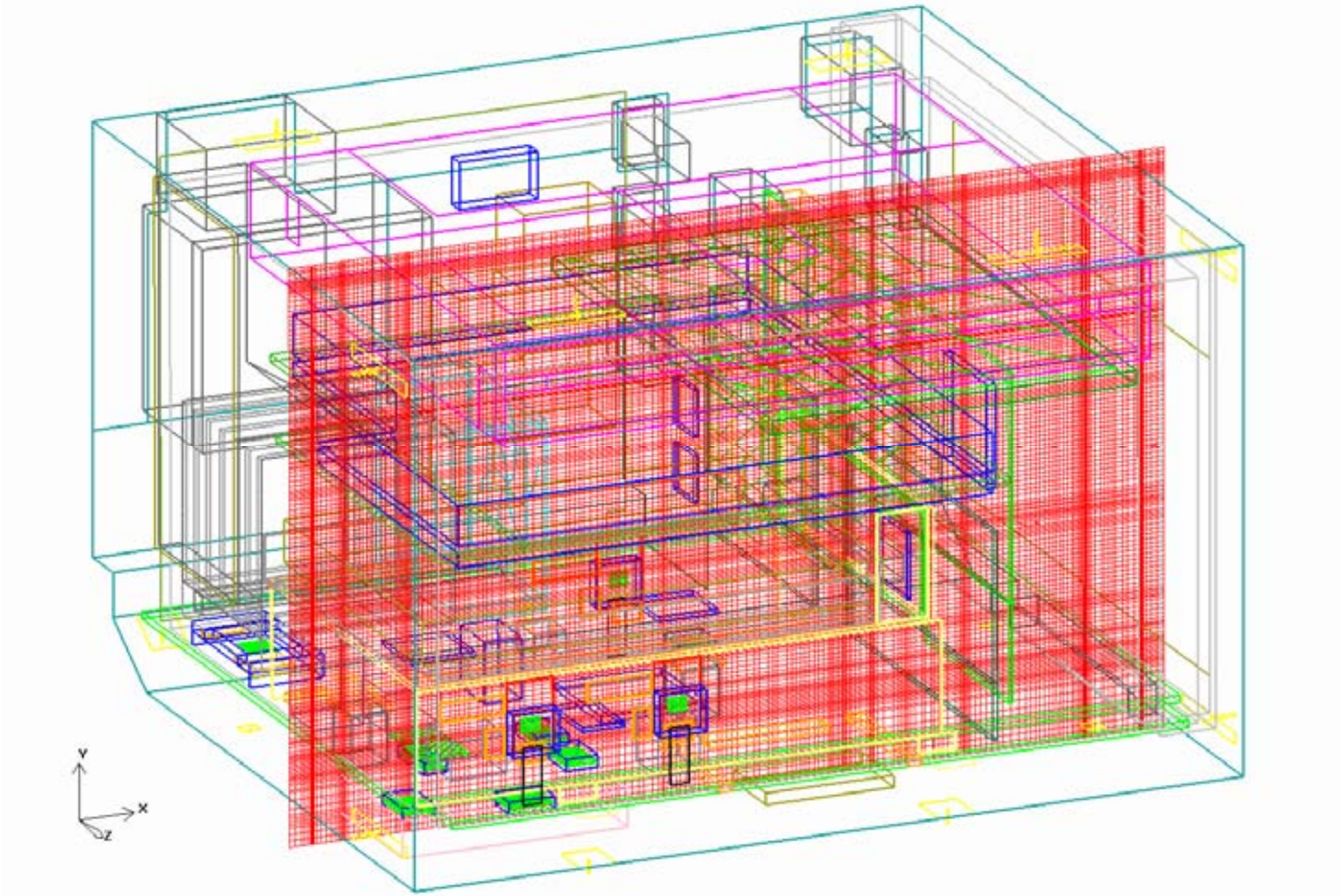

A plane cut through the generated Hexa Unstructured mesh.
Number of elements 6.6 millions.
Necessary memory roughly 7GB.

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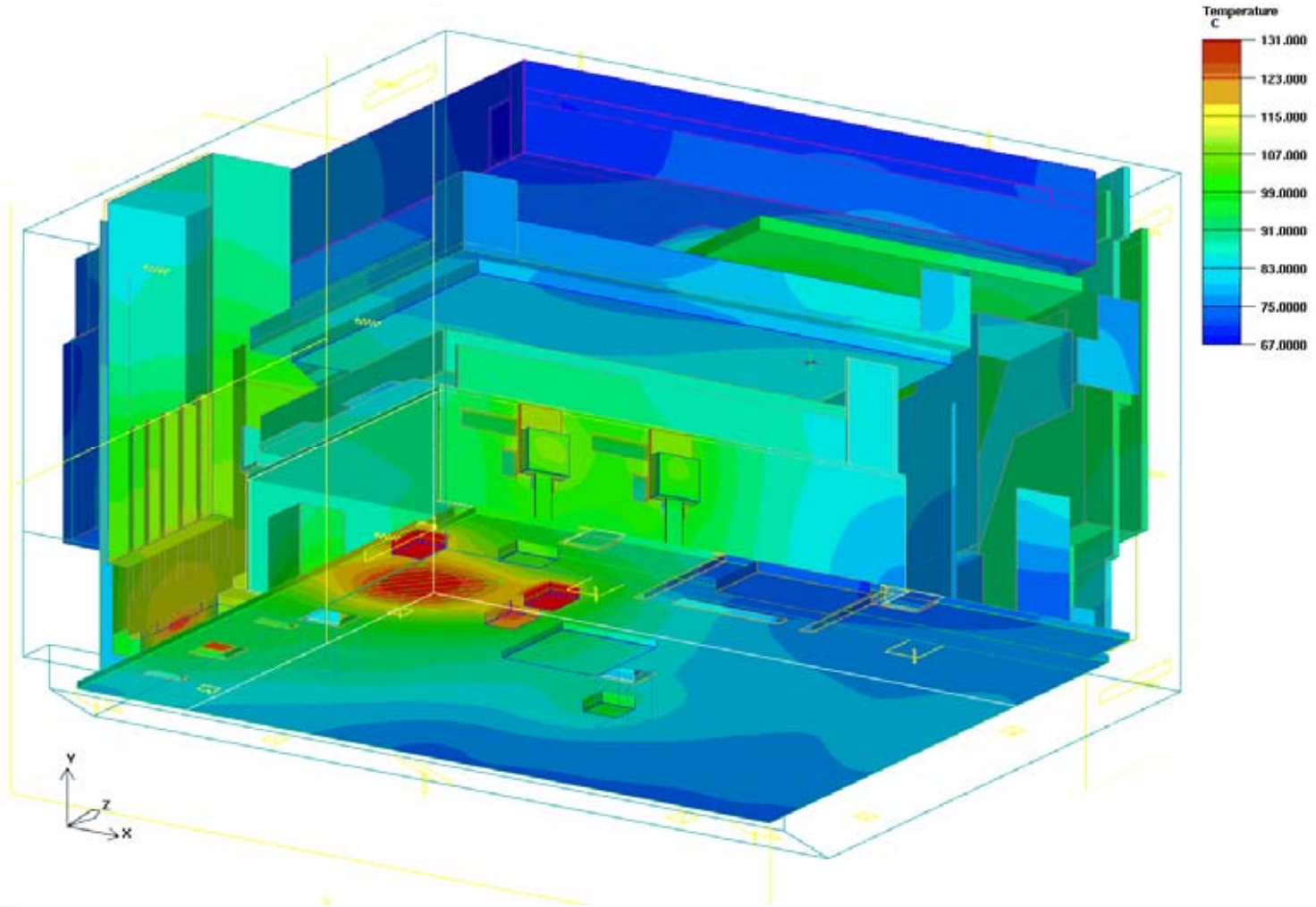

Temperature distribution at the surfaces of the components

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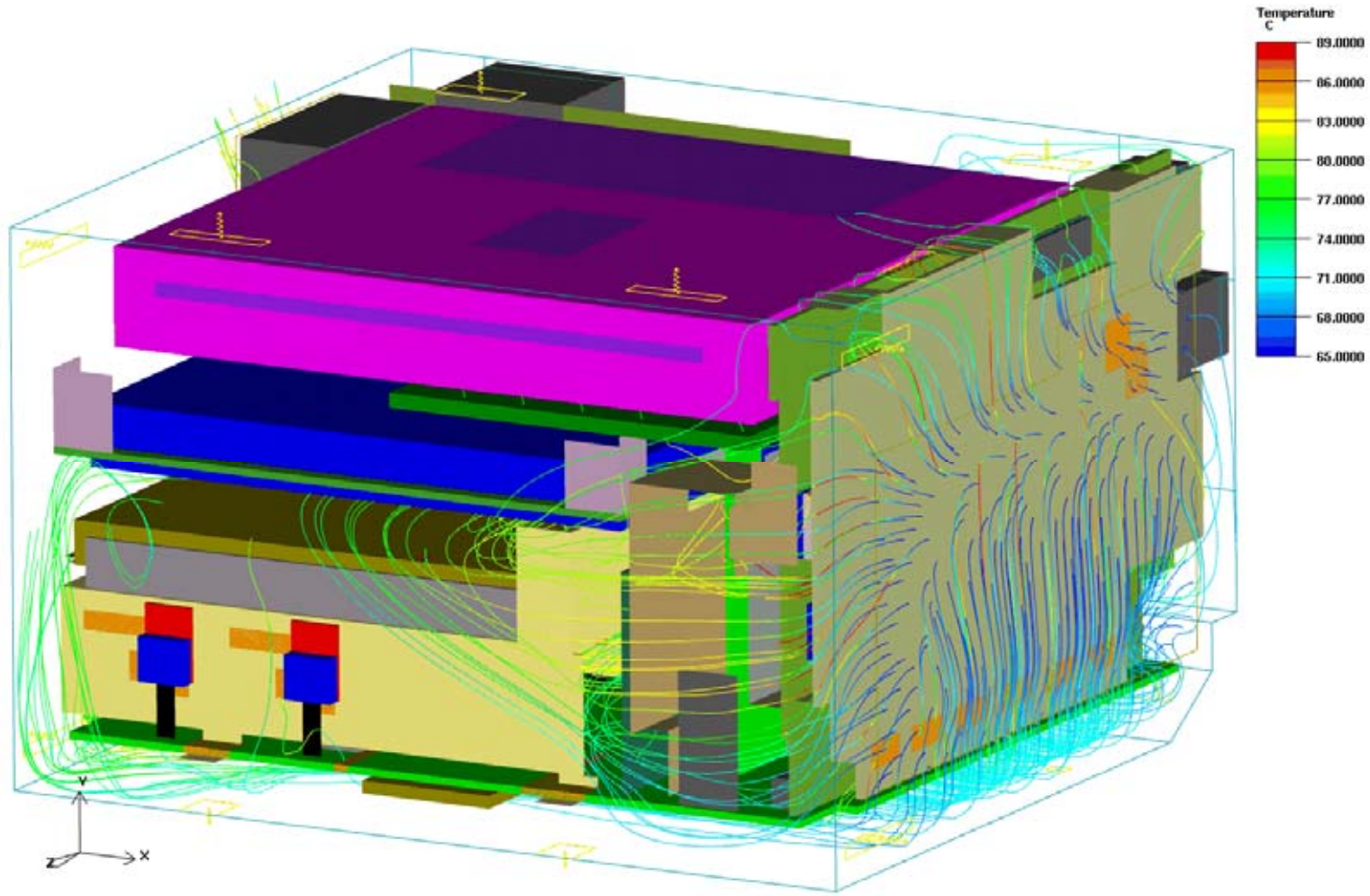

Particle path lines show the air flow through the unit

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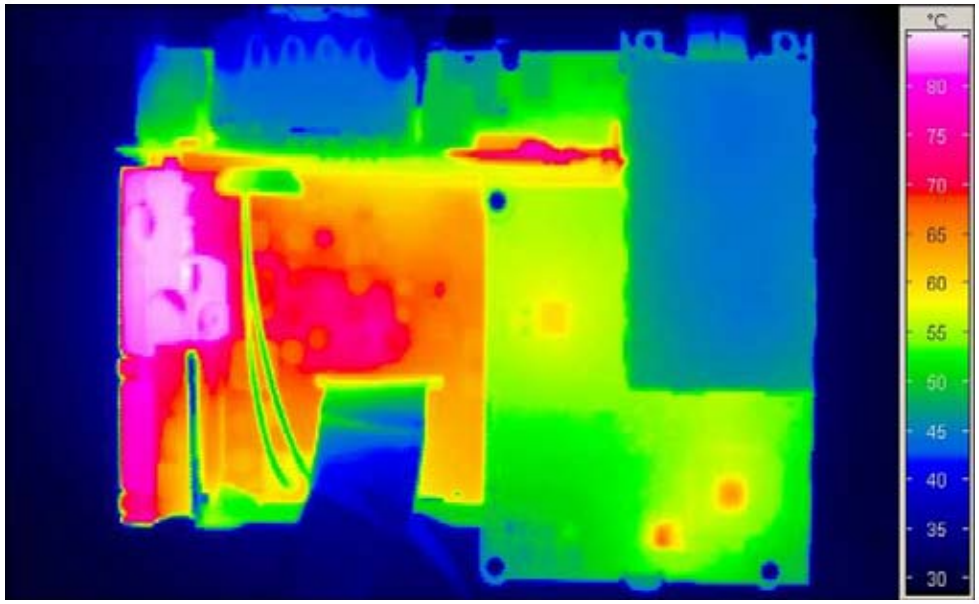
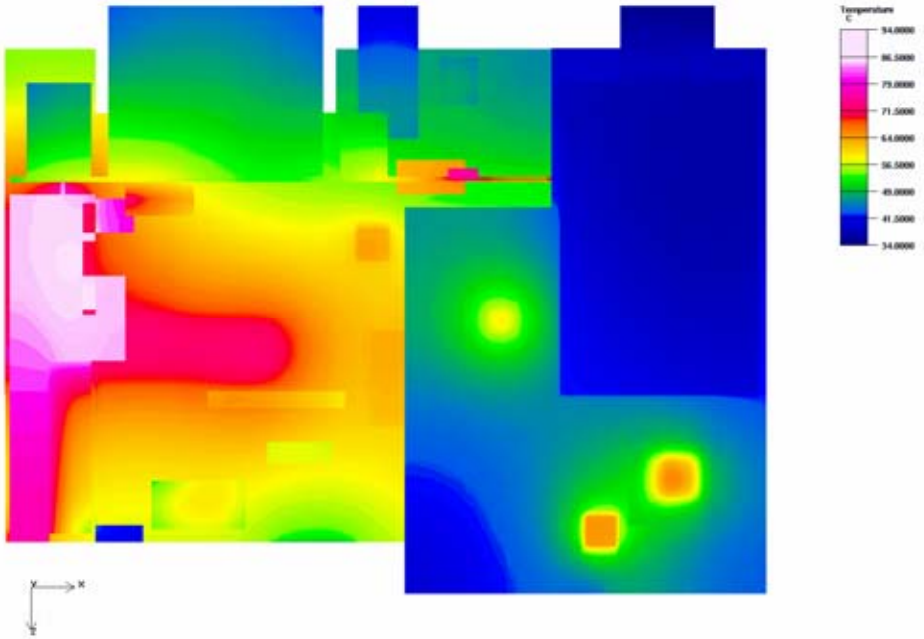


Comparison between the infrared thermography and the result of numerical simulation



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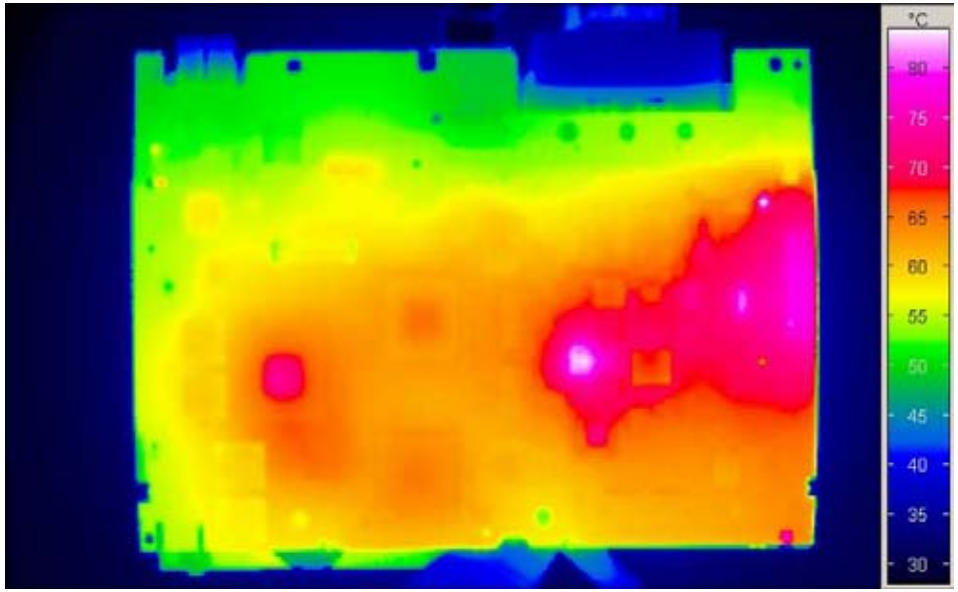

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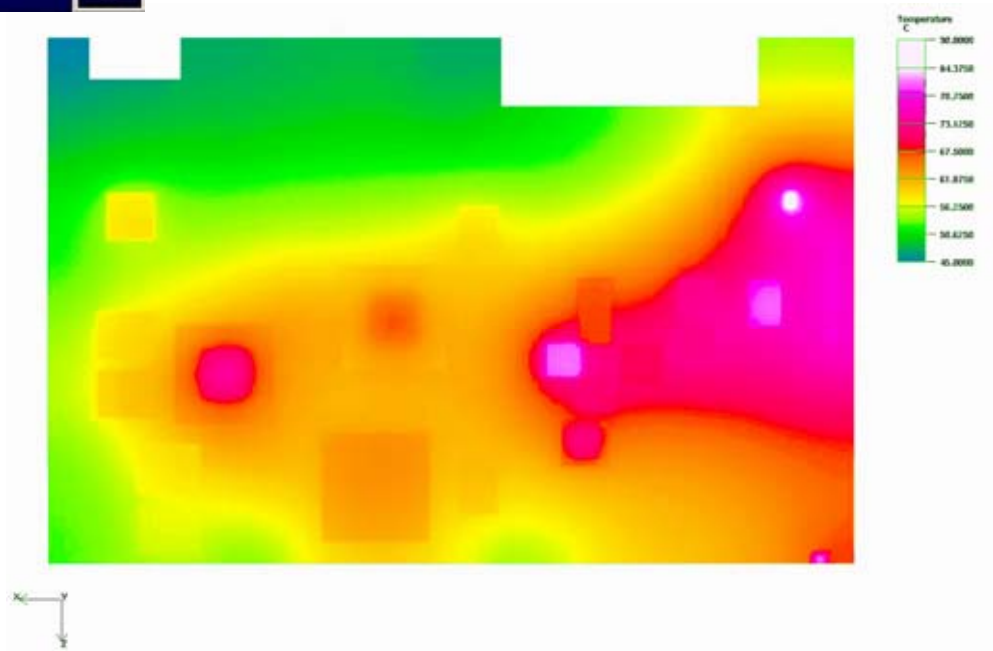

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General sources of uncertainties

- Approximated and/or time averaged heat dissipation rates
- Heat dissipation fluctuations due to differences in the leakage current
- Various operating modes
- Partly undefined, and varying boundary conditions, e.g. cable route

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Sources of uncertainties in CFD

- Simplified geometries, neglected parts
- Homogenous solid blocks, homogeneous heat sources
- Approximated air flow resistance for grills and porous media
- constant material properties
- Approximated thermal contact resistances
- Turbulence and radiation modeling

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Advantages of numerical simulations

- Gain in fundamental understanding
- Identification of important parameters, fast parameter studies
- Access to extreme conditions
- It is possible to evaluate and optimize the cooling concepts in very early development phases, before generating electrical layout and detailed mechanical construction. Changes in the design of the devices are afterwards very difficult, if not impossible.
- Saving time and money by reducing the number of samples and necessary environmental tests.

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