Headquarters
## Group figures

- Danfoss is a family-owned, global company (no public shares, but approx. 3% employee shares)
- Net sales 2007: EUR 2,900 mill
- Employees: 22,323 worldwide (January 2008)
- Production of 250,000 items per day

### Group figures table

<table>
<thead>
<tr>
<th></th>
<th>Europe</th>
<th>North America</th>
<th>Latin America</th>
<th>Africa</th>
<th>Asia</th>
<th>Pacific</th>
<th>Total</th>
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<tbody>
<tr>
<td>Manufacturing sites</td>
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<td>12</td>
<td>2</td>
<td>1</td>
<td>5</td>
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<tr>
<td>Sales companies</td>
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<td>10</td>
<td>5</td>
<td>1</td>
<td>13</td>
<td>2</td>
<td>114</td>
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<tr>
<td>Agents and distributors</td>
<td>~115</td>
<td></td>
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Advanced Engineering
RA-D

2008 RA-D Priorities
RA-D activities

- Technology development
- Consulting
- Exploit internal and external synergies
RA-D focus areas, related projects & stake holders

<table>
<thead>
<tr>
<th>Focus areas</th>
<th>Stake holders</th>
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</thead>
<tbody>
<tr>
<td>Compression technologies</td>
<td>AC, DE</td>
</tr>
<tr>
<td>Intelligent components / controls</td>
<td>RA, JV</td>
</tr>
<tr>
<td>Heat exchangers</td>
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</table>
RA-D’s structured process for transforming pre-competitive knowledge into profit

RA gets out of the process…

• the relevant technologies at the right time
• to know what is the cutting edge in the industry
• the opportunity to recruit the best candidates
Market challenges

We are mainly a component manufacturer, but we also make subsystems:

- Our controllers are application specific, but general purpose within the application. Hence we know the generic type, but not the specific type of components.
- The installer is typically an independent refrigeration installer that employs all brands of controllers.
- The installation costs is likely to exceed the cost of the controller.
- We are mass producing the components in a competitive market.
Market challenges

To gain market advantages we need to focus on the lifetime cost of the components

• Commissioning costs are in the same order as the control system

• Faulty configurations are very expensive (food quality as well as energy consumption) and questions the quality of our refrigeration control systems

Hence,

• We need to reduce the configuration/installation time and reduce the number of faulty installations to gain competitiveness.
Failure rate

Commissioning Phase

De-commissioning Phase

Normal operation

Time

Failure rate
A simple example
– a supermarket display case
A simple example
– a supermarket display case

The controller
A simple example
- wiring of the controller
- a controller handles 1-4 evaporators.
A simple example
– a supermarket display case

A simple application example – a supermarket display case

Problems
- A sensor is not connected -solved
- A temperature and pressure sensor are switched -solved
- Two temperature sensors are switched
  - on the same evaporator -unsolved
  - on different evaporators -unsolved
- A wrongly placed temperature sensor -unsolved
Theoretical challenges

• Generic (and robust) solution is desired → Depends highly on the type of model abstraction

• Applications exhibit nonlinear behaviour

• Hybrid dynamics (different actuators, when active, change the dynamic behaviour of the system - ).

----------------------------- Additional challenges -----------------------------

• Software complexity (have not looked at yet):
  – Different modes of Operation ↔ faults’ diagnosability (and vice versa)

  – New code representing new functionality is added (how does it affect the existing functionality and vice versa).

• Plug & play requirements:
  – Software/Hardware architecture that can deal with it.
  – Controller design and analysis
Conclusions

Objectives
To develop concepts for automatic configuration validation of systems during commissioning and service.

Vision
To enable a dramatic reduction in commissioning cost related to configuration validation of sensors and actuators in refrigeration systems.

Added value:
- Increased installer confidence in controller ability to achieve first time setup success
- Increased supermarket management confidence in the ability of Danfoss controllers to reduce extended commissioning time
- Decreased life-time cost due to more efficient service and commissioning process
Summary

• Components for control (mass production) in large networks are different than dedicated control applications.

• Efficient use is of paramount importance. Automated configuration validation is one approach that addresses this issue.

• Sensors are getting cheaper, but we need to address the commissioning efficiency to gain competitiveness.