Proposal of a specification for ATCA shelves for experiments at CERN (for phase 1)

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TWEPP-16, 11th meeting of the xTCA interest group
Outline

• Context (reminder)
  o MTCA procurement framework in place
  o ATCA shelf and rack cooling evaluation

• ATCA shelf specification proposal
  o Technical specification key points
  o Status and next steps
Outline

• Context (reminder)
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Power module specification
- Output power: 800W
- Input voltage range: -40V to -60V
- Payload power:
  - 12V ± 10%
  - 80W per channel
  - Output voltage stability: ±200 mV
  - Maximum output noise and ripple: 100 mV (pk-pk)
- Management power
  - 3.3V ± 5%

Selection of the NAT DC840 power module
- Output power: 840W
- Compliant (CERN Specs): Yes
- Pros: Efficiency and IPMI compliance

Shelf specification
- Slots:
  - Up to 12 double width/full-size AMCs
  - 2 MCHs
  - 2 PMs (front) and 4 PMs (rear)
  - 6 RTMs
  - 1 JSM
- 2 interchangeable backplanes
  - Custom backplane connections
  - MTCA.4 compliant
- Max. output air temperature 55°C (ambient: 25°C and 80W per slots)
- Vertically cooled (bottom – top airflow)

Selection of the Schroff crate
- Compliant (CERN spec): Yes
- Pros: cooling homogeneity, mechanical robustness and remote support
MTCA procurement framework in place

Outcome (power module)

- Most of the results are within the specification
- Qualification process finished successfully
- Qualification report available on request
- Few issues addressed by NAT:
  - Detection of critical temperature (thresholds)
  - Detection of input voltage failure
  - Heat sink

- Purchase framework is established
  - [https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/Procurement/_layouts/15/start.aspx#/SitePages/Home.aspx](https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/Procurement/_layouts/15/start.aspx#/SitePages/Home.aspx)
MTCA procurement framework in place

Outcome (shelf)

- All of the results are within the specification
- Qualification process finished successfully
- Few issues addressed by Schroff:
  - Separated management of front and rear cooling
  - Slot identification
- Recommendations to user:
  - Power module redundancy to be used with care
  - Limitation of the power module to 600W

- Purchase framework is established in 2016
  - https://espace.cern.ch/ph-dep-ESE-BE-uTCAEvaluationProject/Procurement/_layouts/15/start.aspx#/SitePages/Home.aspx
MTCA procurement framework in place

MTCA infrastructure base kit soon available at the electronics pool:

A few sets of MTCA infrastructure equipment will become available for rental in a few weeks:

- Schroff 12 slots Schroff MTCA shelf (custom bkpl topology)
- NAT MCH (base interface, XAUI fat pipe, SFP+ uplink and clk module)
- NAT AC input power module PM-AC600
ATCA shelves evaluated

- Standard commercial shelves (front-to-back airflow)
  - Schroff 14-slot 13U ATCA
  - ASIS 14-slot 13U ATCA
  - Comtel 14 slot
  - ELMA 14 slot

- ASIS custom shelf (vertical airflow for standard LHC rack)
  - Schroff 2-slot ATCA 11990-705
  - ASIS custom shelf

- Evaluation reports available: https://espace.cern.ch/ph-dep-ESE-BE-ATCAEvaluationProject
ATCA shelf and rack cooling evaluation and tests

• Goals:
  – Common specifications for shelves
  – Asses the possibility to re-use existing racks system or specify rack infrastructure for horizontally cooled crates

• AdvancedTCA shelves cooling simulation (CERN rack)
  – Simulations performed (vertical airflow)
  – Some rack improvement has been proposed
  – Simulation report available on request

• AdvancedTCA shelves cooling measurements (CERN rack)
  – ATLAS ATCA cooling evaluation project (C. Bortolin)
  – Measurements performed using vertical and horizontal configurations (using ASIS shelves)
ATCA shelf and rack cooling evaluation and tests

Vertical vs horizontal rack cooling configuration

Vertical rack layout, front view

Horizontal rack layout, side view
ATCA shelf and rack cooling evaluation and tests
Test results (vertical rack layout, high power test)

Test conditions:
• Bottom (ASIS vert. shelf): 14x400[W] - Asis Load Boards (air temp.)
• Top (ASIS vert. shelf): 14x350 [W] - Comtel Load Boards (blade temp.)
• 4th heat exchanger between both shelves

<table>
<thead>
<tr>
<th>Temperature °C</th>
<th>Top shelf</th>
<th>Bottom shelf</th>
</tr>
</thead>
<tbody>
<tr>
<td>34°C</td>
<td>49.4</td>
<td>49.4</td>
</tr>
<tr>
<td>36°C</td>
<td></td>
<td></td>
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<tr>
<td>38°C</td>
<td></td>
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<tr>
<td>40°C</td>
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<tr>
<td>42°C</td>
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<tr>
<td>44°C</td>
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<tr>
<td>46°C</td>
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<tr>
<td>48°C</td>
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<tr>
<td>50°C</td>
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<tr>
<td>52°C</td>
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<td></td>
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<tr>
<td>54°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average air temperature delta between shelf inlet and outlet [°C]

<table>
<thead>
<tr>
<th>Top shelf</th>
<th>Bottom shelf</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.5</td>
<td>9.4</td>
</tr>
</tbody>
</table>

Average of maximal temp. on load blades [°C]

<table>
<thead>
<tr>
<th>Top shelf</th>
<th>Bottom shelf</th>
</tr>
</thead>
<tbody>
<tr>
<td>49.4</td>
<td>49.4</td>
</tr>
</tbody>
</table>
ATCA shelf and rack cooling evaluation and tests

Test results (horizontal rack layout)

Test conditions:
- Bottom (ASIS hori. shelf): 14x350 [W] - Asis Load Boards (air temp.)
- Top (ASIS hori. shelf): 14x350 [W] - Comtel Load Boards (blade temp.)

Average air temperature delta between shelf inlet and outlet [°C]

<table>
<thead>
<tr>
<th></th>
<th>Top shelf</th>
<th>Bottom shelf</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.4</td>
<td>9.6</td>
<td></td>
</tr>
</tbody>
</table>

Average of maximal temp. on load blades [°C]

<table>
<thead>
<tr>
<th></th>
<th>Top shelf</th>
<th>Bottom shelf</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>37.5</td>
<td></td>
</tr>
</tbody>
</table>

![Graph showing temperature distribution across blade positions](#)
Vertical vs horizontal rack cooling airflow

- Simulations and measurements show that both rack layouts can be adopted and are viable for ATCA shelves.
- Vertical rack layout requires some adaptations (adding an heat exchanger, adapting the deflector position).
- With horizontal racks, environmental temperature could become an issue once a room is equipped with many shelves.
- Shelves are noisy (safety measures must be taken: possible sounds barriers, etc.).
- Specific to the used shelves (ASIS): Removing the shelves bottom fans a more homogeneous air flow distribution was observed and the average temperature in the load boards decreases.

This leads to the decision of specifying two variants of ATCA shelves, vertical and horizontal. Final decision on rack layout must be taken by the experiment (possible important infrastructure implications).
Outline

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• ATCA shelf specification proposal
  o Technical specification key points
  o Status and next steps
ATCA shelf specification proposal

Technical specification key points (1/2)

Physical shelf baseline:

- 19” rack system compatible card cage
- 14 ATCA blade slots with RTM
- 2 shelf manager slots
- 2 redundant power entry module (PEM) slots (-48Vdc input)
- Removable cable management trays (front and rear)
- Hot-swappable cooling units
- Cooling variants:
  - Variant 1: Shelf compatible with in-rack vertical air flow
  - Variant 2: Shelf compatible with PICMG standard front to back air flow
- Shelf maximum height: 14U with variant 1; 16U with variant 2

Backplane requirements:

- Topology 1: Dual star
- Topology 2: Full mesh
- Fabric lane bit rate: 40Gbase-KR4
- Option: 100Gbase-KR4 (for phase 2)

Module location and accessibility:

- Front access:
  - 14 ATCA blades
  - 2 shelf managers
  - Air filter
- Rear access:
  - 14 RTM
  - 2 PEM

Full technical specification available here
ATCA shelf specification proposal

Technical specification key points (2/2)

Other requirements:

Electrical

- Shelf power distribution for minimum: 400W (front blade) + 50W (RTM) to each slot

Shelf manager

- Based on Pigeon Point Systems ShMM700 or newer
- Support the following protocols and interfaces: RMCP, SNMP, SSH
- Support for HPM.1 and HPM.3

Standards, Rules and Regulations:

- PICMG standard:
  - AdvancedTCA base specification PICMG-3.0 Revision-3.0
  - AdvancedTCA base extensions specification PICMG-3.7 Revision-1.0 section 5 for cooling aspects
- Intel specification: IPMI v2.0
- EMC compliance: CISPR22 and CISPR24 Class A and IEC/EN 61000-6-3
- Safety standard: IEC/EN 60950-1 and CERN IS-23 and IS-41
- Ethernet standard: IEEE standard 802.3
- ROHS compliance: WEEE Directive 2012/19/EU
- CE compliance and related regulations

Full technical specification available here
ATCA shelf specification proposal
Status and next steps (1/2)

Status:

• Specification draft submitted to the experiments electronics coordinators.
• Feedback received from the experiments.
  o Specification adapted where appropriate and of common interest.
• Informal market survey carried out with selected manufacturers
  o MS Outcome:
    o All contacted suppliers propose compliant COTS equipment for horizontal airflow.
    o Most of them require development (NRE) for vertical airflow and/or backplane bandwidth (100G) and/or topology (full-mesh).
• Specification for a modular -48Vdc rectifier system drafted.

Missing: Quantities and procurement schedule figures from the experiments for phase 1!
Next steps:

- Finalize the technical specification with the latest feedback received from the experiments • Q4 2016
- Perform technical evaluation of proposed COTS ATCA chassis from the suppliers • Q1 2017
- Launch an official CERN price enquiry • Q1 2017
- Final qualification of 3 pre-series units • Q2 2017
- Once approved, setup procurement contract • Q3 2017
- Follow the same path for the -48Vdc rectifier system • Q3-Q4 2017

Missing: Quantities and procurement schedule figures from the experiments for phase 1!
Questions
Backup slides
### ATCA shelf and rack cooling evaluation and tests

**Load blades**

- **ASIS load blades**: maximum power 600W
- **Comtel load blades**: maximum power 350W

14 x Comtel blades: 6 Embedded Temperature sensors (green) + 6 air T sensors (blue)

14 x ASIS blades: 6 air Temperature sensors (inlet and outlet)
ATCA shelf and rack cooling evaluation and tests

Test results (vertical layout, mixed blade test)

**Test conditions:**
- **Bottom shelf:** 7x400[W] - Asis Load Boards + 7x350 [W] - Comtel Load Boards
- **Top shelf:** 7x400[W] - Asis Load Boards + 7x350 [W] - Comtel Load Boards
- 4th heat exchanger between both shelves

![Graph showing temperature distribution for Top and Bottom shelf](image)
# ATCA shelf and rack cooling evaluation and tests

## Horizontal or vertical cooling?

<table>
<thead>
<tr>
<th>Horizontal</th>
<th>Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of <strong>COTS</strong> xTCA shelves</td>
<td>Custom xTCA shelves mandatory (related NRE costs and potential higher lead-time)</td>
</tr>
<tr>
<td>Sufficient cooling capacity available per rack (up to 15kW per cooling door with water inlet at 13°C, now we have 16°C!)</td>
<td><strong>Limited heat-exchanger efficiency</strong> (2/3 of surface capacity resulting in 2kW cooling power)</td>
</tr>
<tr>
<td>Heat of 48V AC-DC removed by the rack rear cooling door</td>
<td>48V AC-DC converter (horizontally cooled) must be placed outside of vertical airflow (below the deflector and its cooling must rely on the CR AC)</td>
</tr>
<tr>
<td>Less damage risk in case of water leak from the heat exchanger</td>
<td>Risk of water dripping on the ATCA electronics</td>
</tr>
<tr>
<td><strong>Independent shelf airflow</strong> (one shelf could be turned OFF while the other is loaded)</td>
<td>Cross shelf airflow dependency (in case one shelf is stopped the other sees a high airflow resistance). Can lead to potential electronics overheating</td>
</tr>
<tr>
<td>Racks to be modified and equipped with rear cooling doors</td>
<td>Reuse of the rack (horizontal heat exchangers and deflectors may have to be repositioned)</td>
</tr>
<tr>
<td>In-rack smoke detection must be adapted for rear-cooling doors</td>
<td>Reuse of the existing rack infrastructure (smoke detection, monitoring and control)</td>
</tr>
<tr>
<td>Front and back <strong>cabling must be managed appropriately</strong> in order not to obstruct the air inlet and outlet</td>
<td>Free access to both sides of the shelf</td>
</tr>
<tr>
<td>Some racks are currently equipped with a full height glass front door. It is not know yet if such doors can be used with horizontal airflow</td>
<td>Racks can be closed with doors</td>
</tr>
<tr>
<td>Higher level of noise (~85 dB @1 m and 75 % fan speed)</td>
<td>Also noisy.... Easier to install sound absorbing material</td>
</tr>
</tbody>
</table>
ATCA shelf specification proposal
Feedback received from the experiments

ATLAS:

- Higher power rating per slot would be useful
- Maximum depth and use of ETMs / EBs (PICMG 3.7)
- Shelf manager HPM.3 support
- Slot labelling: physical or logical numbering?
- Cable trays shall be removable with the shelf is installed in rack
- Is shelf height restriction required? Where does the requirement for pull-only fans come from?

CMS:

- 100Gbps is likely to be required
- Selection process shall include some signal integrity verification
- Power figures are minimum sufficient
- Both backplane topologies (FM and DS) shall be available
- Suggestion: steer suppliers towards the use of latest generation of ADF connector for zone 2.

ALICE

- Suggestion: get the specs reviewed by BE-ICS for control aspects

- Preferences:
  - Dual star
  - Vertical airflow
  - Total height: the lower the better
Simulation and rack layout baseline

Goal of the simulation study:

- Airflow simulation of an ATCA shelf in a standard LHC rack
- Thermal and airflow simulation results of a std LHC rack with 2 shelves and 1U heat exchangers
  - Simulation of different in-rack layout
  - With turbine in the rack
  - Without turbine blowers/chassis

- Simulation performed by ASIS (shelf manufacturer)
- Layout of rack, turbine, heat exchanger and deflector given by CERN
ATCA shelf and rack cooling evaluation and tests

Vertical cooling configuration

30 x Temperature sensors (accuracy 0.1C)
8 x Velocity sensors (accuracy 0.05 m/s)

- Air/water heat exchangers (1U), providing up to 3.8 kW of thermal capacity each
- Exchanged surface reduced (approx. 2/3)
- Plexiglas panel installed to improve the leak tightness

Back view of the heat exchanger

Plexiglas panel
Heat exchange area

Heat exchangers T sensors
Flow stopper

Rack 52U
Spare space 15 U
Power supply 1 – 3U
Air Deflector – 2U
ATCA 1 – 14U
Heat exchanger – 1U
ATCA 2 – 14U
Heat exchanger -1U
Turbines – 4U

Vertical cooling configuration:
- 30 x Temperature sensors (accuracy 0.1C)
- 8 x Velocity sensors (accuracy 0.05 m/s)

- Air/water heat exchangers (1U), providing up to 3.8 kW of thermal capacity each
- Exchanged surface reduced (approx. 2/3)
- Plexiglas panel installed to improve the leak tightness
Scenarios, first results and recommendations

1. First simulation run

- 2 x 13U Asis Chassis.
- Chassis air flow bottom up.
- Up to 400W per blade, and 50W RTM
- Heat Exchange 1U, water cooling 16 C
Scenarios, first results and recommendations

1. First simulation run

- MAX TEMP at Hot spots (FAN outlets of to chassis) is 37°C.
- Delta T inside the chassis is ~12°C.

- Air flow circulates via the gap of ~75mm on the RACK sides.
- Air speed on the side walls is 15m/s. It is driven by the top chassis FAN drawer.
- Air flow bottleneck at the top turbine level. Suspected to induce important noise level. Air speed in excess of 35 m/s in this location.
Scenarios, first results and recommendations

2. No turbine rotor simulation run

- Other conditions as in run 1
Scenarios, first results and recommendations

2. No turbine rotor simulation run

- MAX TEMP at Hot spots (FAN outlets of to chassis) is 36°C.
- Delta T inside the chassis is ~12°C.

- Air flow circulates more easily in/via the turbine chassis.
- Still a bottleneck at the top turbine. Suspected to induce important noise level. Air speed reduced to 25-26 m/s.
3. No turbine chassis simulation run

- Other conditions as in run 1

Turbine is removed entirely
Scenarios, first results and recommendations

3. No turbine chassis simulation run

- MAX TEMP at Hot spots (FAN outlets of to chassis) is 33.5C.
- Delta T inside the chassis is ~10C.

- Turbine bottleneck is removed.
- Maximum air speed is now reduced to 16 m/s
- Next bottleneck at the bottom deflector where some air turbulences provoke less efficient airflow on the bottom shelf side slots

Air Flow Speed results
Scenarios, first results and recommendations

Recommendations

- The turbine blowers deliver less air flow than certain ATCA fan trays.
- In racks where important ATCA blade dissipation is foreseen, the turbine chassis shall be removed.
  - If turbine chassis is removed, maximum in-rack air speed is reduced to 16 m/s (reduced noise level)
  - Turbine chassis could be replaced by a standard empty 4U chassis with front and back panels. This empty chassis could then also be made to still house the rack monitoring module.

Next steps

- Get a new run (as run 3) but with a higher deflector (3 or 4U)
  - Goal: minimize the air turbulences at the rack bottom.
- More accurate simulations at ATCA blade level once rack layout is known
- Final simulation report from ASIS
Failure mode: full power only in one crate

Mixed water data taken while ATCA 1 was fully powered

- Flow: 0.8 m³/h
- T inlet 15.5°C, T outlet 20.9°C

\[
Q = \dot{m}C_p (T_{\text{out}} - T_{\text{in}}) = 0.22 \times 4.18 \times (20.9 - 15.5) = 5.01 \text{ kW}
\]
Air Temperatures

The plot shows the average temperatures measured on the air deflector, before and after HX1 with only ATCA 1 full power.

Air temperatures comparison shows that the simulation reproduced lower T, the difference was about 5°C.

Simulations carried out by ASIS with the same configuration.

ASIS run new simulations using our measurements as input data. It was identified a general lack of performance of the 25% (i.e.: leaks). Further simulations identify another issue.
Flow distribution issue

ASIS comments:
1) In order to improve the flow instability on the RTM side try to remove the bottom fan tray and rely only on the pull flow.
2) Introducing gaps between heat exchangers and try to improve the whole heat exchangers surface.
New layout (October 2015)

In the RTM volume the flow circulation was not effective and the suggestions of ASIS were:

1) To remove the chassis bottom fans
2) To introduce some gaps before and after each heat exchanger
Removing bottom fans improved significantly the performance: flow distribution more homogeneous.
ATCA2 14x343[W] – Comtel Load Boards (Top)
ATCA1 14x322[W] – Asis Load Boards (Bottom)

Measurements of the maximum temperatures on Comtel LB

Max power limited by the a smaller power supply of the top shelf
ATCA2 14x343[W] – Comtel Load Boards (Top)
ATCA1 14x322[W] – Asis Load Boards (Bottom)

4th heat exchangers added between ATCA 1 and 2

Measurements of the maximum temperatures on Comtel LB

The average T decreased of 3-4 degrees
Air T increased without bottom fans: more effective heating removal
High power test
ATCA2 13x350 [W] slot 9 at 336[W] – Comtel Load Boards (Top)
ATCA1 14x400[W] – Asis Load Boards (Bottom)

4th heat exchanger between ATCA 1 and 2

Top shelf temperature on board, bottom shelf air temperature

Average maximal temperature on load blades [°C]

<table>
<thead>
<tr>
<th>Top shelf</th>
<th>Bottom shelf</th>
</tr>
</thead>
<tbody>
<tr>
<td>49.4</td>
<td>49.4</td>
</tr>
</tbody>
</table>

Lower power due to an hardware issue
ATCA2 14x350[W] – Comtel Load Boards (Top)
ATCA1 14x350[W] – Asis Load Boards (Bottom)

Measurements of the maximum AIR temperatures

With Bottom Fans
Without Bottom Fans

Temperature [°C]

<table>
<thead>
<tr>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
<th>Zone 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>35 33 34 29 32</td>
<td>37 41 39 35 36</td>
<td>34 39 38 37 35</td>
<td>36 38 37 35 34</td>
</tr>
<tr>
<td>35 33 31 33 31</td>
<td>31 31 33 35 38</td>
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<tr>
<td>34 31 35 31 34</td>
<td>35 38 36 37 36</td>
<td>37 36 36 36 36</td>
<td>35 37 36 36 36</td>
</tr>
</tbody>
</table>

With Bottom Fans
Without Bottom Fans

<table>
<thead>
<tr>
<th>Inlet 1</th>
<th>Inlet WOUTBF</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 21 21 20 21</td>
<td>21 21 21 22 23</td>
</tr>
<tr>
<td>21 21 21 21 22</td>
<td>23 23 23 22 23</td>
</tr>
<tr>
<td>20 20 20 20 20</td>
<td>20 20 20 20 20</td>
</tr>
<tr>
<td>19 19 19 19 19</td>
<td>21 21 22 23 23</td>
</tr>
<tr>
<td>15°C 20°C 25°C 30°C 35°C 40°C 45°C 50°C 55°C 60°C</td>
<td></td>
</tr>
</tbody>
</table>
ATCA2 14x350[W] – Comtel Load Boards (Top)
ATCA1 14x350[W] – Asis Load Boards (Bottom)

Measurements of the maximum temperatures on Comtel LB

<table>
<thead>
<tr>
<th>Temperature [°C]</th>
<th>Zone 4</th>
<th>Zone 4 WOUTBF</th>
</tr>
</thead>
<tbody>
<tr>
<td>15°C</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td>20°C</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>25°C</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>30°C</td>
<td>46</td>
<td>44</td>
</tr>
<tr>
<td>35°C</td>
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<tr>
<td>40°C</td>
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<td>45°C</td>
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<td>50°C</td>
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<tr>
<td>55°C</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>60°C</td>
<td>52</td>
<td>54</td>
</tr>
</tbody>
</table>
Air velocity measurements

Measurements of the maximum velocity

<table>
<thead>
<tr>
<th></th>
<th>Velocity [m/s]</th>
</tr>
</thead>
<tbody>
<tr>
<td>V4 - Rear in the center - ATCA Comtel</td>
<td>15.2</td>
</tr>
<tr>
<td>V5 - Rear in the center - ATCA ASIS</td>
<td>13.9</td>
</tr>
<tr>
<td>V7 - Front in the center - ATCA Comtel</td>
<td>12.5</td>
</tr>
<tr>
<td>V6 - Front in the center - ATCA - ASIS</td>
<td>12.4</td>
</tr>
<tr>
<td>2xHC 16U With BF</td>
<td>13.9</td>
</tr>
<tr>
<td>2xHC 16U Without BF</td>
<td>12.1</td>
</tr>
</tbody>
</table>
Shelves Air Temperature inlet - Outlet

Measurements of the maximum temperature

Temperature [°C]

<table>
<thead>
<tr>
<th>Temperature</th>
<th>V4 - Rear in the center - ATCA Comtel</th>
<th>V5 - Rear in the center - ATCA ASIS</th>
<th>V7 - Front in the center - ATCA Comtel</th>
<th>V6 - Front in the center - ATCA - ASIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>15°C</td>
<td>30.6</td>
<td>28.8</td>
<td>19.2</td>
<td>18.5</td>
</tr>
<tr>
<td>17°C</td>
<td>28.7</td>
<td>29.4</td>
<td>20.3</td>
<td>19.8</td>
</tr>
<tr>
<td>19°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21°C</td>
<td></td>
<td></td>
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<tr>
<td>23°C</td>
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<tr>
<td>25°C</td>
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<tr>
<td>27°C</td>
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<td>29°C</td>
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<td>31°C</td>
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<td>33°C</td>
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<tr>
<td>35°C</td>
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</table>
Mixed water data taken while the shelves were fully powered

- Flow: 1.8 m$^3$/h
- $T_{\text{inlet}}$ 16°C, $T_{\text{outlet}}$ 18.6°C

$Q = mC_p (T_{\text{out}} - T_{\text{in}}) = 0.5 \times 4.18 \times (18.6-16) = 5.43$ kW (50% of the total power)
The air T outlet is about 2.5 degrees higher of the environmental temperature.
**ATCA shelf and rack cooling evaluation and tests**

**Measurement summary**

**Vertical Cooling**

- Removing the shelves bottom fans we observed a more homogeneous flow distribution and the average temperature in the load boards decreased significantly.
- The 4th Heat exchanger is required to keep the temperature below 50C, the best average boards T achieved was about 46C.
- Shelves are noisy (safety measures must be taken: sounds barriers etc.)

**Horizontal cooling:**

- Removing the shelves bottom fans we observed a more homogeneous flow distribution and the average temperature in the load boards decreased significantly.
- The best average boards T achieved was about 45C
- The environmental temperature could become an issue once equipping the room with many shelves.
- Shelves are very noisy (safety measures must be taken: sounds barriers etc.)

*Full rack cooling test report available upon request*
Noisy measurements (HSE group): Horizontal shelves

- The level of noise increased by 3 dB every time the number of equipment is doubled.
- For future installations in the room it will be required to take actions in order to reduce the level of noise (acoustic isolation panels, etc.)

HSE expert report:
- >85 db for 8 hours a day required safety personal protection and a yearly medical check for the operators
- The level of noise increased by 3 dB every time the number of equipment is doubled.
- For future installations in the room it will be required to take actions in order to reduce the level of noise (acoustic isolation panels, etc.)

<table>
<thead>
<tr>
<th>Lieu de mesure</th>
<th>$L_{Aeq}$ (dB(A))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesure 1</td>
<td>Dist. 80 cm</td>
</tr>
<tr>
<td>Mesure 2</td>
<td>Dist. 140 cm</td>
</tr>
<tr>
<td>Mesure 3</td>
<td>cm</td>
</tr>
<tr>
<td>Mesure 4</td>
<td></td>
</tr>
</tbody>
</table>

For safety reasons the access to the counting room once equipped with many racks will be allowed only to people that followed the required safety training, wearing the ears protection equipment, and the daily exposition to the noisy must be limited.
Evaluated MicroTCA commercial equipment

### MicroTCA Crates

- Vadatech MTCA.0 VT892
- Schroff MTCA.4 11890
- Schroff MTCA.4 + AC/DC CM100
- ELMA MTCA.4 043-012
- ELMA MTCA.4 045-821
- ELMA Blu!Eco

### Power Modules (PM)

- NAT DC840 840W
- Vadatech UTC010 792W
- Vadatech UTC020 936W
- Wiener AC/DC 1000W
- Telkoor AC/DC 600W
- NAT AC/DC AC600 600W

### AMCs

- ELMA Load Board
- Processor Kontron AM5030
- ESD ADIO24
- Processor CCT AM310

### MicroTCA Carrier Hubs (MCH)

- Vadatech UTC001
- NAT
- Kontron AM4904
## ATCA shelf specification proposal

### Informal MS outcome

<table>
<thead>
<tr>
<th></th>
<th>ASIS</th>
<th>Pentair Schroff</th>
<th>ELMA</th>
<th>Comtel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Which standard catalogue shelf type(s) fulfils all or part of the requirements given in the tech. spec?</strong></td>
<td>For the F2B chassis it's our MaXum550. For the B2T chassis it's the MaXum450.</td>
<td>The platform which fits best in our 450/40 crate 14 slots p/n 1199010x.</td>
<td>Please find attached our compliance matrix for one of the latest ELMA ATCA model CAP004406 vs. your technical specification.</td>
<td>No precise reference given but a compliant horizontal version is available.</td>
</tr>
<tr>
<td><strong>Which options and/or requirements from the spec. can currently not be provided?</strong></td>
<td></td>
<td>The non-compliant key points are listed below. In most cases these can be addressed by a redesign at fixed NRE costs and depending on total shelf quantities.</td>
<td></td>
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</tr>
<tr>
<td><strong>Could these requirements be developed and/or adapted at defined NRE costs?</strong></td>
<td>YES – any changes that you would like to implement according to the standard or customizing the standard we can develop for you.</td>
<td>The technical requirements can be met by a custom design. NRE costs will occur but the volume of these costs depends on the quantities and the grade of customization.</td>
<td>There are some points where we are partial or even not compliant. Most of them can be solved with a modification or redesign.</td>
<td>Yes, for all, see the details.</td>
</tr>
<tr>
<td><strong>Non-compliant key points</strong></td>
<td>None</td>
<td>No 100 G yet No full-mesh topology (not on their roadmap) No vertical cooling (custom dev. possible depending on volume)</td>
<td>100 G not on roadmap No vertical cooling (could be done at defined NRE) Fan trays without IPMC and not hot swappable</td>
<td>No vertical cooling (could be done at defined NRE)</td>
</tr>
</tbody>
</table>

*Detailed answers available upon request.*