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Generic Motion Control Unit

- Evaluation Results -

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Motion Control & Automation Group

www.europeanspallationsource.se

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Update on MCA Initiatives

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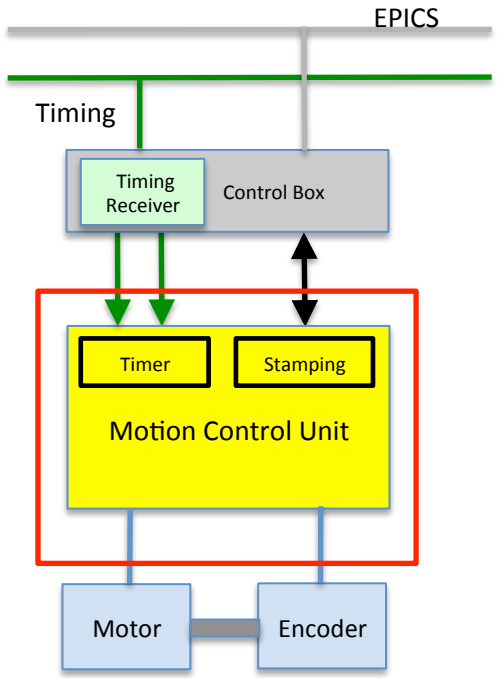
1. Evaluation for Generic Motion Control Unit in final stage
   - Decision process
   - Requirements
   - Market survey
   - Candidates
   - Decision criteria
   - First results
   - Next Steps
2. Start on identifying radiation hard components
3. Motion Control Components Standard issued (ESS-0037290)
4. Guidelines for MCA in Phase 1 issued (ESS-0049514 draft)

MCA Standard: Generic Motion Control Unit

- Standardised Motion Control Unit for most of the ESS applications
- Scope of standardisation:
  - Control Hardware (controller, driver, I/O, power supply, control panel etc.)
  - Control Software (controller firmware, EPICS IOC)
  - Cables, connectors, distribution boxes, field busses
  - Prototypes for different mechanical and electrical format factors (19”box, DIN-rail, 8-axes, 2-axes etc.)
  - Test environments (Control unit + EPICS)
  - Integration workflow
- Workshop April 2016
- Deployment of fully tested system August 2016



Responsibilities

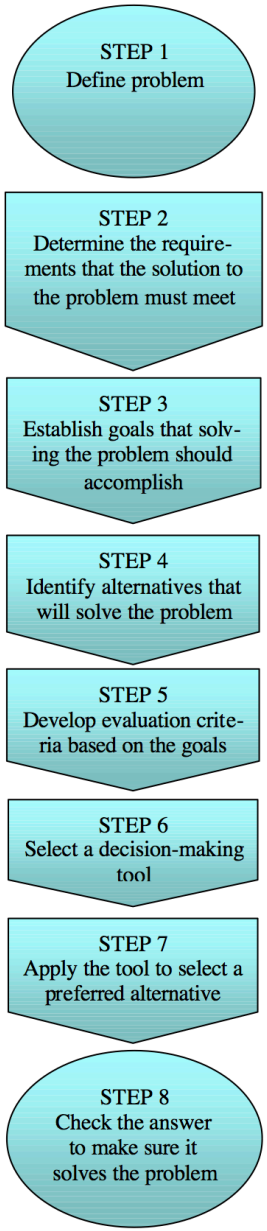
Technology: MCA

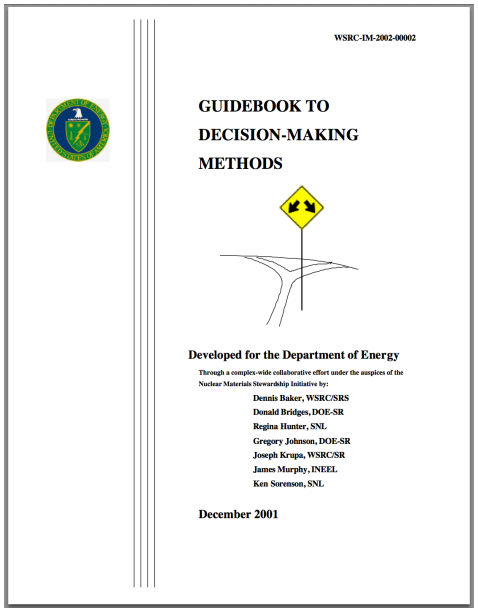
Integration: MCA/ICS

Preliminary Standard: Delta Tau Geo Brick

- 8-Ax 19”crate, Stepper, BLDC motors, INC, SSI, resolver encoder
- Well introduced at Diamond, NSLS-II and Australian Synchrotron
- Covers actual requirements for ESS test stands, prototypes (ACC)
- Will be replaced by final standard 2016 onwards

Decision making process: Basic document




WSRC-IM-2002-00002

GUIDEBOOK TO DECISION-MAKING METHODS

Developed for the Department of Energy

Through a complex-wide collaborative effort under the auspices of the Nuclear Materials Stewardship Initiative by:

Dennis Baker, WSRC/SRS
Donald Bridges, DOE-SR
Regina Hunter, SNL
Gregory Johnson, DOE-SR
Joseph Krupa, WSRC/SR
James Murphy, INEEL
Ken Sorenson, SNL

December 2001

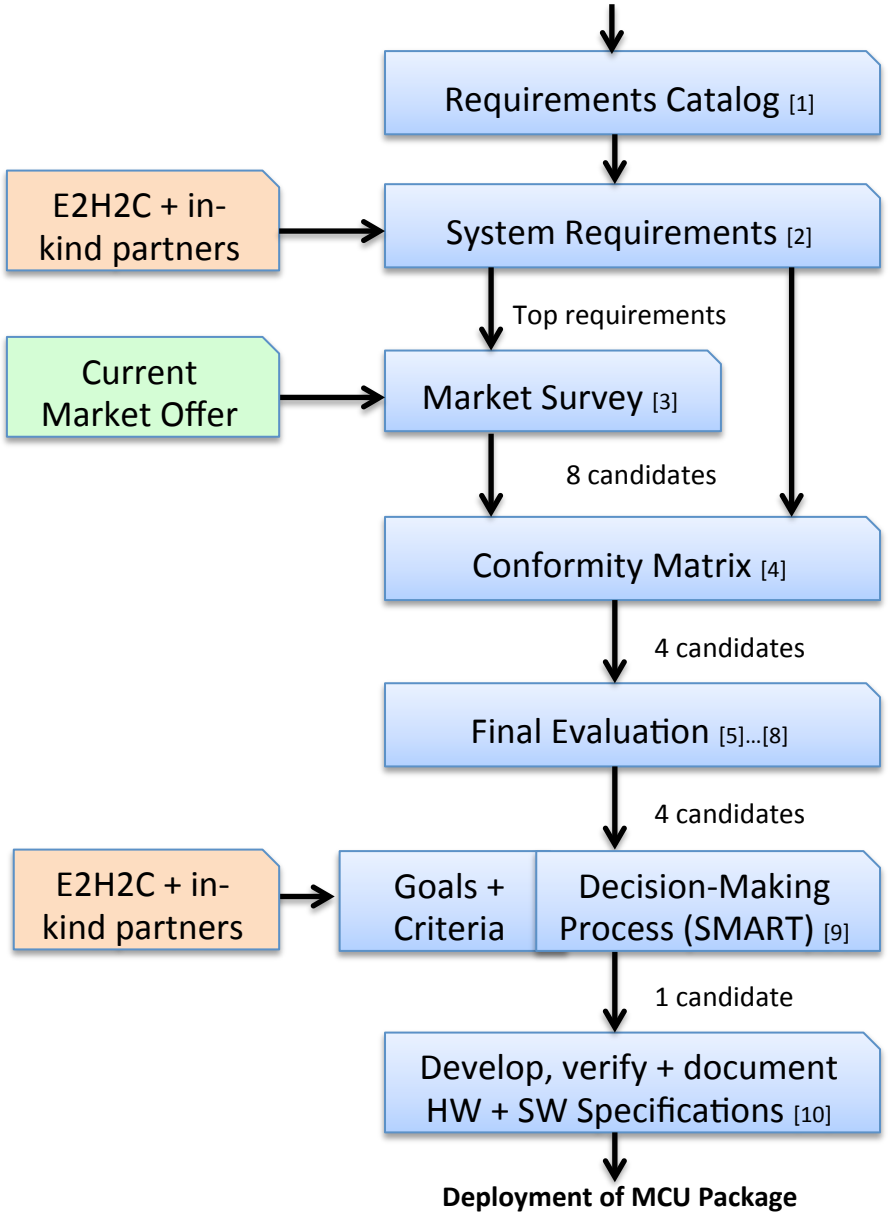
Guidebook to Decision-Making Methods

Developed for the Department of Energy (USA)

WSRC-IM-2002-00002

http://everyspec.com/DOE/DOE-PUBS/WSRC-IM-2002-00002_36284/

Decision making process: Adaptation + documents



Associated Documents

[1] MCU Requirements Catalog

[2] MCU System Requirements List

[3] Market Survey Report

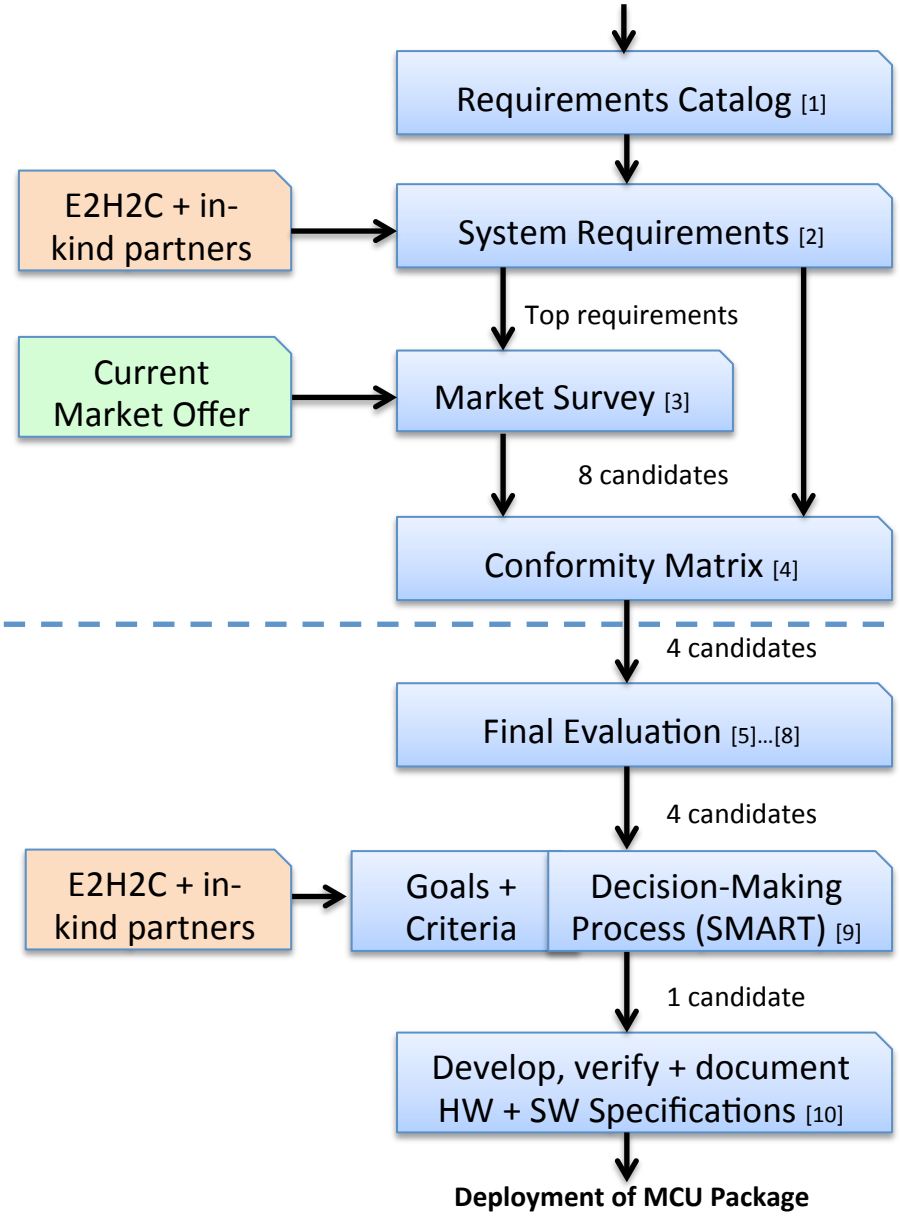
[4] Conformity Matrix of MCU's

[5] .. [8] Evaluation Reports 1 to 4

[9] Decision-Making Report

[10] **MCU Specification Document**

Decision making process: Status last IKON



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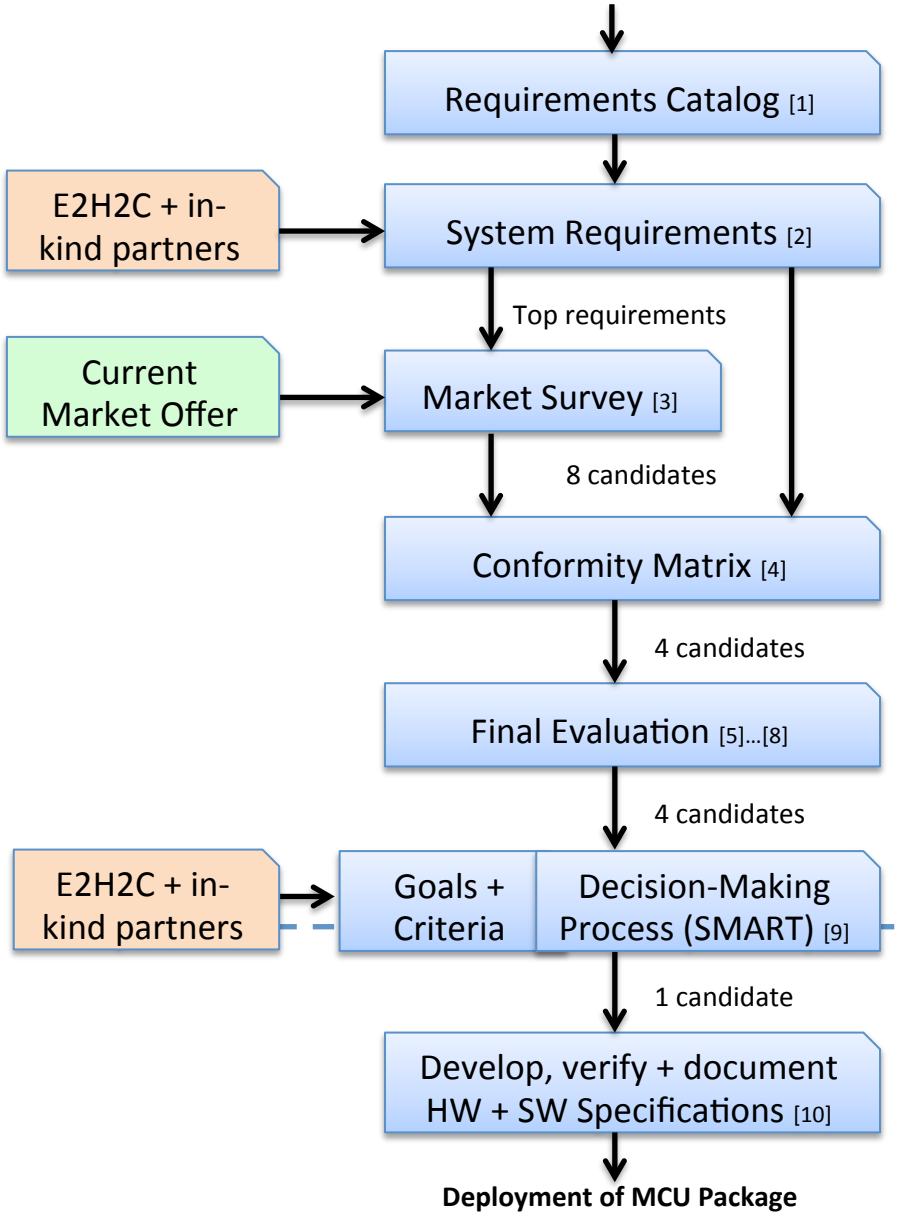
Decision making process: Status now



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[10] **MCU Specification Document**

MCU requirements catalog

- Standard positioning requirements
- Synchronisation of internal clocks with ESS timing system
- Decentralisation through field bus with real-time capabilities and synchronisation
- Multi-axes synchronisation
- Free configurable trajectories
- Modular and scalable (in terms of performance and price)

- Short intervention time (ACC): Diagnostics (preemptive maintenance)
- Short intervention time (ACC): Firmware and parameter management
- Multiple HW platforms (ICS): Open source controller

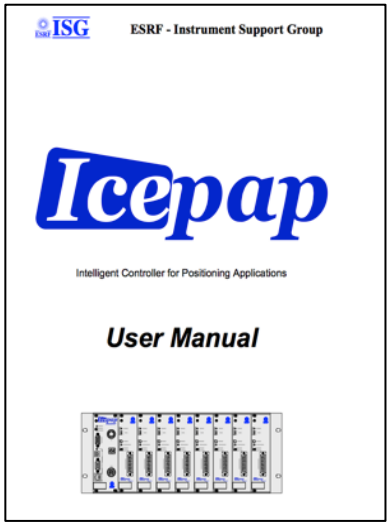
- Stepper motors, DC brushless, frequency converter, piezo
- Encoder inc. quad., abs. SSI, resolver, (analog), (BiSS-C), (EnDat)

Market survey

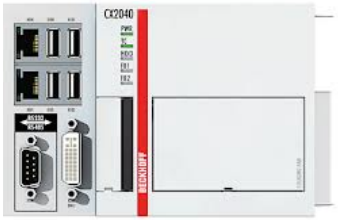
- Selection of candidates on the basis of Top Requirements
- 8 candidates selected
  - Aerotech
  - Beckhoff TwinCAT3
  - Delta Tau Power Brick
  - IcePAP
  - Phytron phyMOTION
  - Siemens SIMOTION C / SIMATIC ET 200S
  - Trio
- Comparison of 8 candidates with the whole list of requirements (conformity matrix) narrowed candidates down to 4

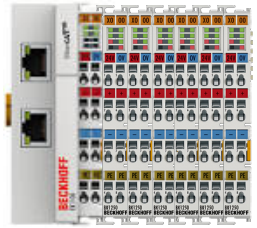
4 Final Candidates

DELTA TAU
EUROPA UK



BECKHOFF





SIEMENS

1STEP

1STEP-Drive
- Phytron

FM357
-4 axes controller

Candidate 1: Delta Tau Power Brick

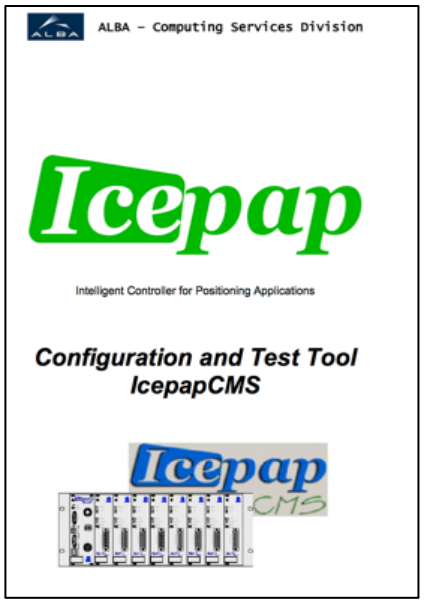
- 8-Ax 19”crate
- Range of encoder types including resolver
- External power supply, Power PC as CPU for calculations (PLC)
- Double H bridge driver for stepper motors, AC and BLDC
- ≈ 1000 EUR / axis (+- 20%)

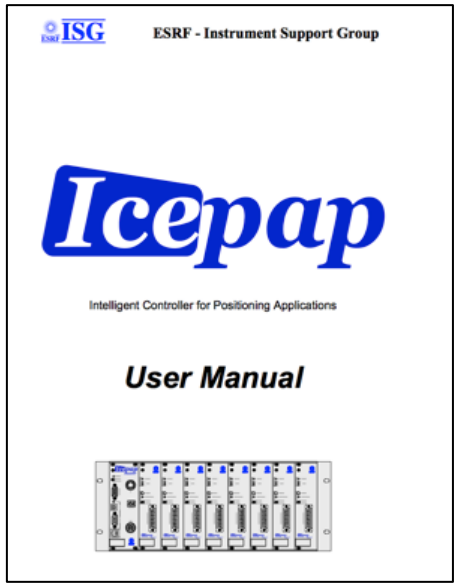
Candidate 1: Delta Tau Power Brick

- Plus: Very good hardware performance (potential)
- Minus: Poor soft-/ firmware and IDE, Support and competence of supplier not convincing, low modularity, low population (new product)
- System is not yet mature!

Candidate 2: IcePAP

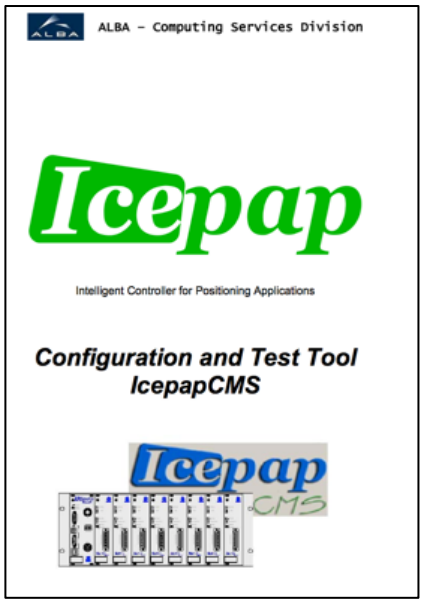
- Custom Motion Control system developed by ESRF
- More than 3000 axes installed at ESRF, ALBA, MaxIV (nearly all steppers)
- 8ax 19”crate, single modules with controller and driver, up to 8 crates synchronized,
- Double H bridge driver for stepper motors, AC and BLDC
- ≈ 600 EUR / axis

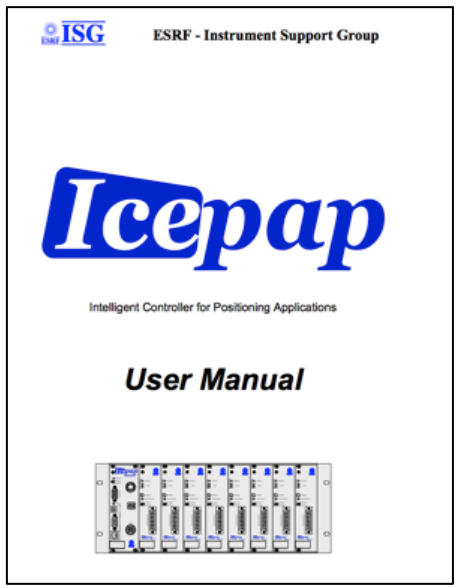




Candidate 2: IcePAP

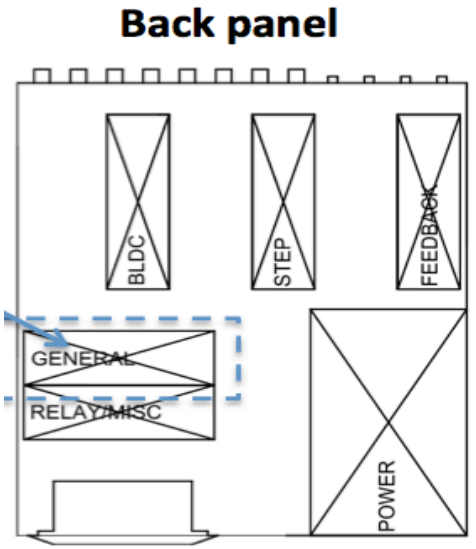
- Plus: Easy to set up, good manuals and support by ESRF, very good parameter management GUI, basic integration into EPICS done, open source (hardware, firmware), good price
- Minus: Currently limited to stepper motors (dc motors possible), no 2nd source (custom product by ESRF), very limited user and developer community, limited obsolescence management, need to rely on limited ESRF ressources

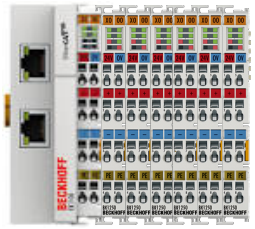


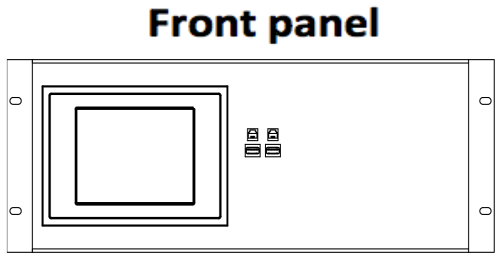


Evaluation 3: Beckhoff

- Industrial modular system based on EtherCAT fieldbus (internal and external) and TwinCAT bus master
- Wide range of modules for motion control (stepper, BLDC, AC, frequency converter = whole power range of applications from one CPU)
- Easy integration of additional modules for IO
- Widely used in industry, standard at European X-FEL
- EtherCAT Technology Group, Open EtherCAT community
- ≈ 550 EUR/ax (Open EtherCAT), ≈ 900 EUR/ax (TwinCAT)

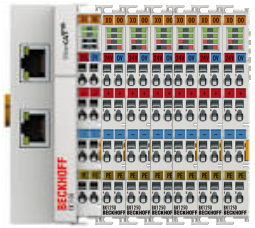


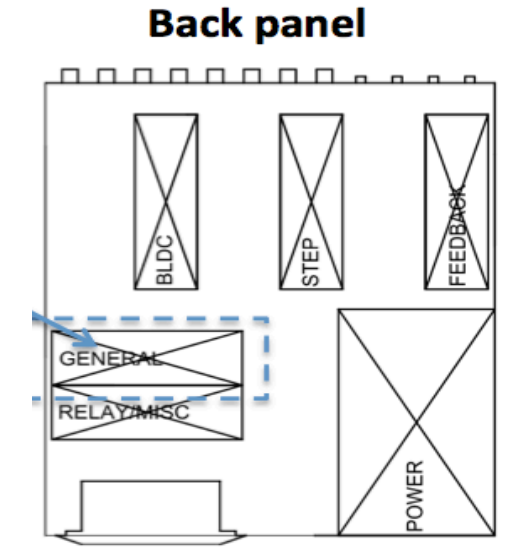


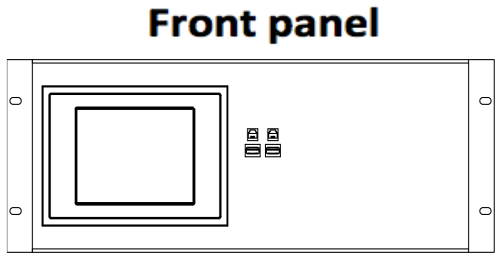


Evaluation 3: Beckhoff

- Plus: Flexible and user friendly system, real-time bus for timing and synchronisation, high modularity, 19”rack assembly is currently prototyped
- Plus: 3rd party EtherCAT modules available, open source Ethercat community as basis for motion master, EPICS and timing system integration ready
- Minus: Costs + Licensing (for TwinCAT solution), constant development necessary (for open EtherCAT solution)







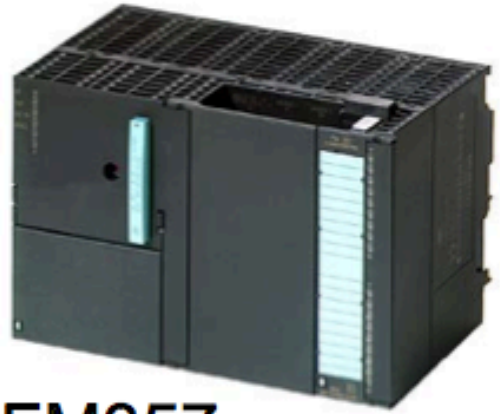
Evaluation 4: Siemens

- Industrial modular system based on proprietary bus (intern) and Profinet (external)
- Two range of controllers: Siemens S7 (PLC) + (external) driver for stepper motors, SIMATIC controller + frequency converter for high power applications
- Well introduced in industry, standard at FRM-II (JCNS)
- ≈ 900 EUR / axis

1STEP

1STEP-Drive

- Phytron



FM357

-4 axes controller

FM353

-DIN 66025

Evaluation 4: Siemens

- Plus: Flexible, reliable and proven system, high modularity, integrated into Siemens PLC system
- Minus: Integration in EPICS and Timing System not yet available, two different line of controller necessary for low and high power applications

1STEP

1STEP-Drive

- Phytron

FM357

-4 axes controller

FM353

-DIN 66025

Decision criteria

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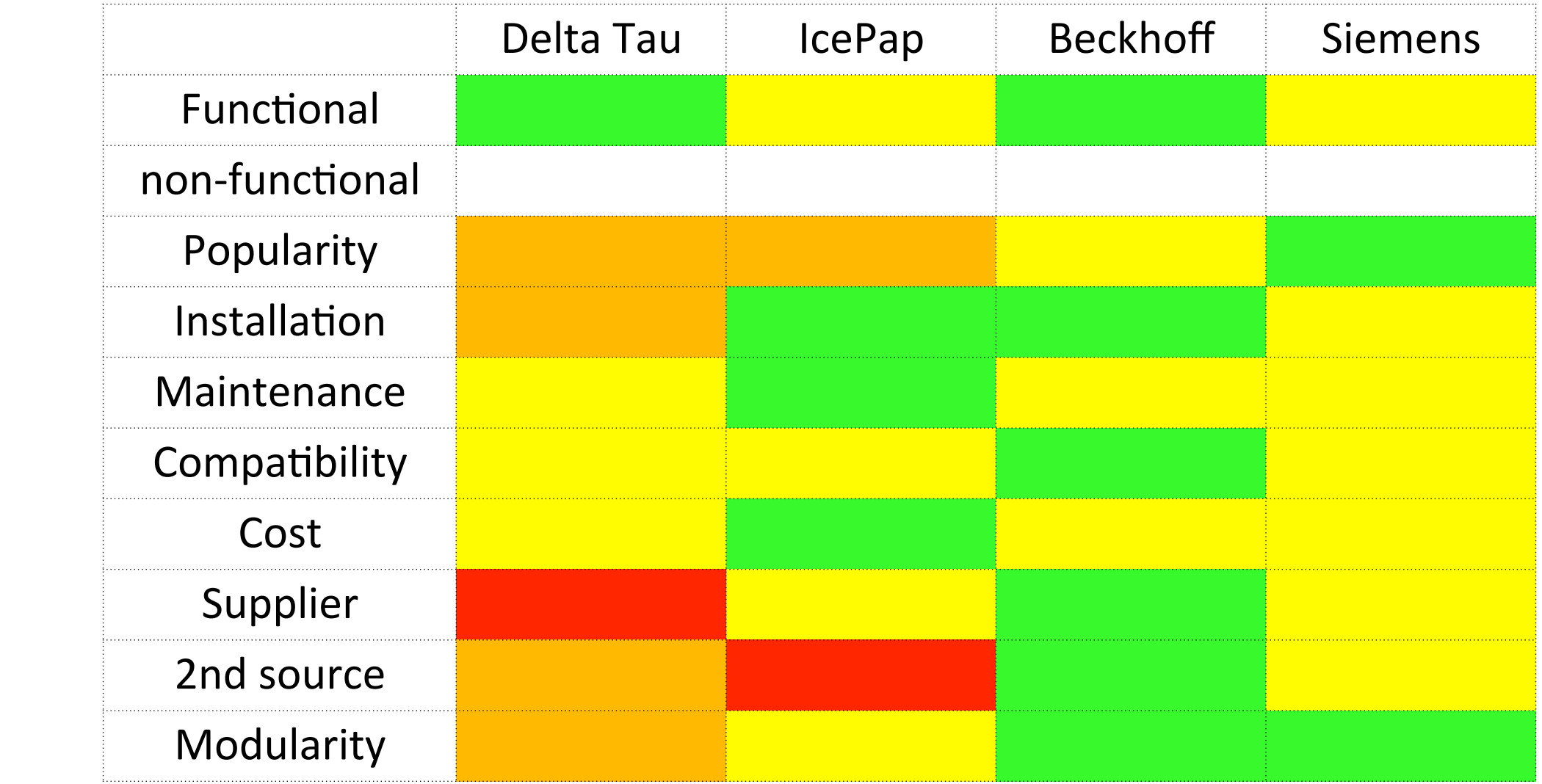
1. Performance against functional requirements
2. Performance against non-functional requirements
3. Wide used and popularity (ESS, in-kind partner, industry)
4. Installation
5. Maintenance
6. Compatibility (to ESS integration)
7. Costs (1ax, 8ax, 32ax)
8. Supplier assessment (competence, support, availability to partner, lifetime/obsolescence management)
9. Second-Source / Open-Source assessment
10. Flexibility / Modularity (design, maintenance, extensions)

First results



	Delta Tau	IcePap	Beckhoff	Siemens
Functional				
non-functional				
Popularity				
Installation				
Maintenance				
Compatibility				
Cost				
Supplier				
2nd source				
Modularity				

Next steps

- Finalise evaluation documents
- Open call-for-tender
- Decision for supplier

- Motion Control Workshop (doodle poll)

- Finalise hardware integration
- Finalise EPICS integration
- Develop deployment package (Hard- and Software)
- Issue Standard Documents, Manuals etc.
- Distribute templates to partners

- Extend Motion Control Components Standard

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Extras

November 2015

Thomas Gahl

E2H2C – MC - Minutes Kick-off Meeting April 2015

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- Meet every month (later bimonthly)
- 1h about standards, development, organisation
- 1h discuss one dedicated use-case per meeting (engineers tech talk)
- Setup of confluence pages (summer worker)
- Upload and maintain application tables for ESS use cases
- Next meeting: present motion control components standard
- Next meetings use case: Target wheel control

E2H2C - MC – Status

- Kick-off in April 2015, start of regular meetings in Nov 2015
- Anders J. Johanson resigned as co-chair, Christine Darve to be proposed at next meeting
- Confluence pages for the Working Group are set up by summer worker https://ess-ics.atlassian.net/wiki/display/EEHHC/MC+-+Standards+Evaluation
- First version of motion control components standard finished, to be reviewed by the Working Group (CHESS Document ESS-0037290)
- Requirements Catalog for Generic MCU finished, to be reviewed by the Working Group and the in-kind partners
- Decision Making Process defined; review and input by the Working Group and the in-kind partners

First application: Chopper Control Demo

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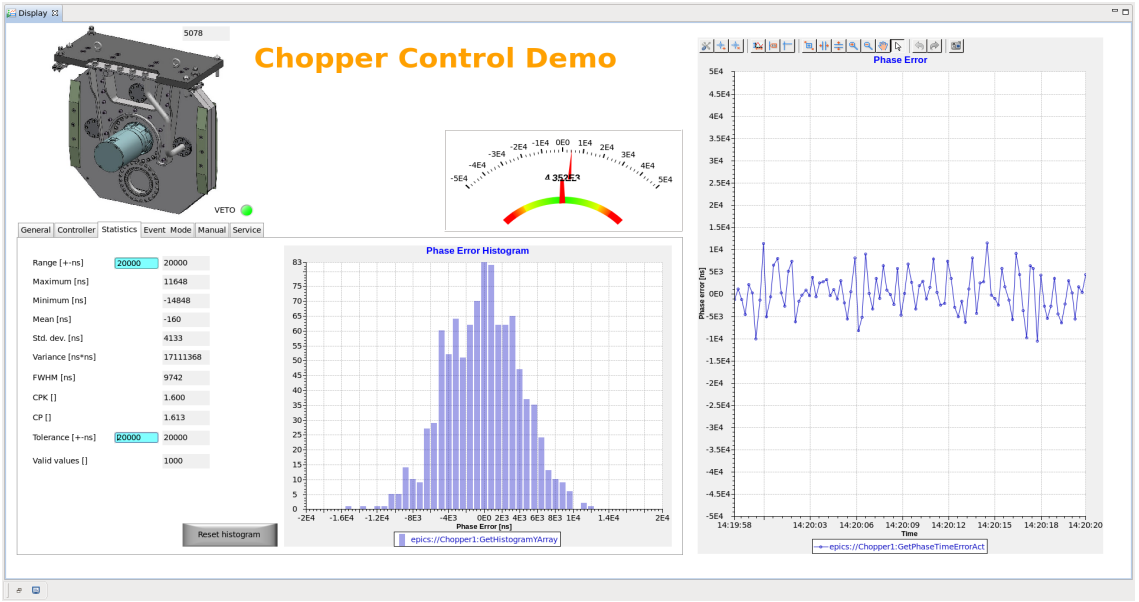
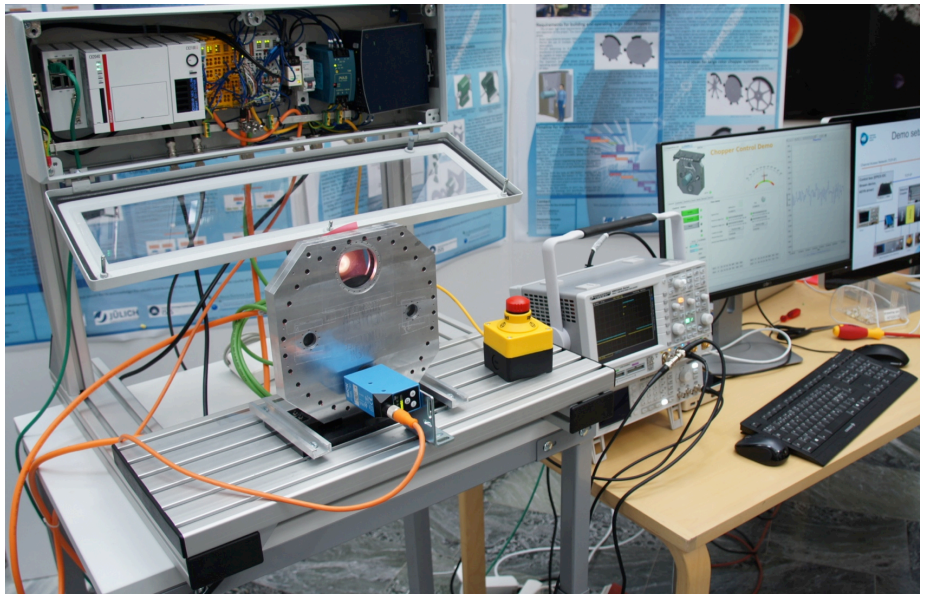
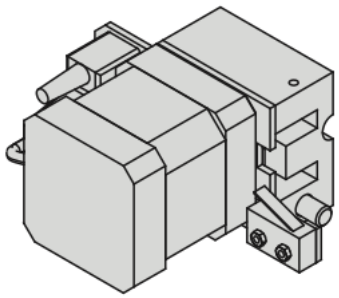
- Development of a motion control for a ¼ scale chopper model and integration in EPICS; interfaces and functionality according to ESS standards
- Demonstration model at IKON8+9 and DENIM 2014 conference in Munich, Germany
- Basis for chopper setup at beam line at IFE Norway (detector tests)



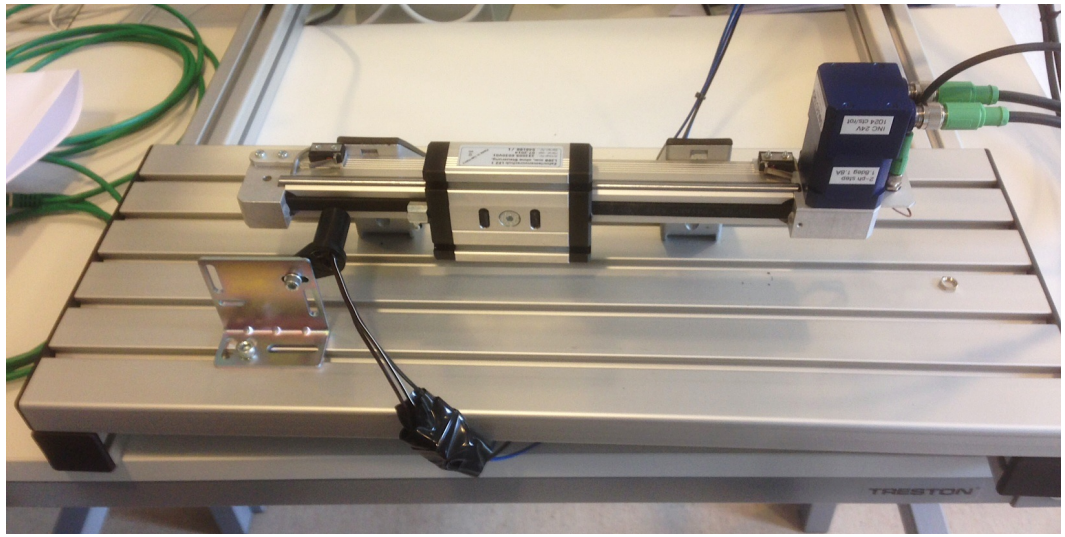


Second application: Linear test bench

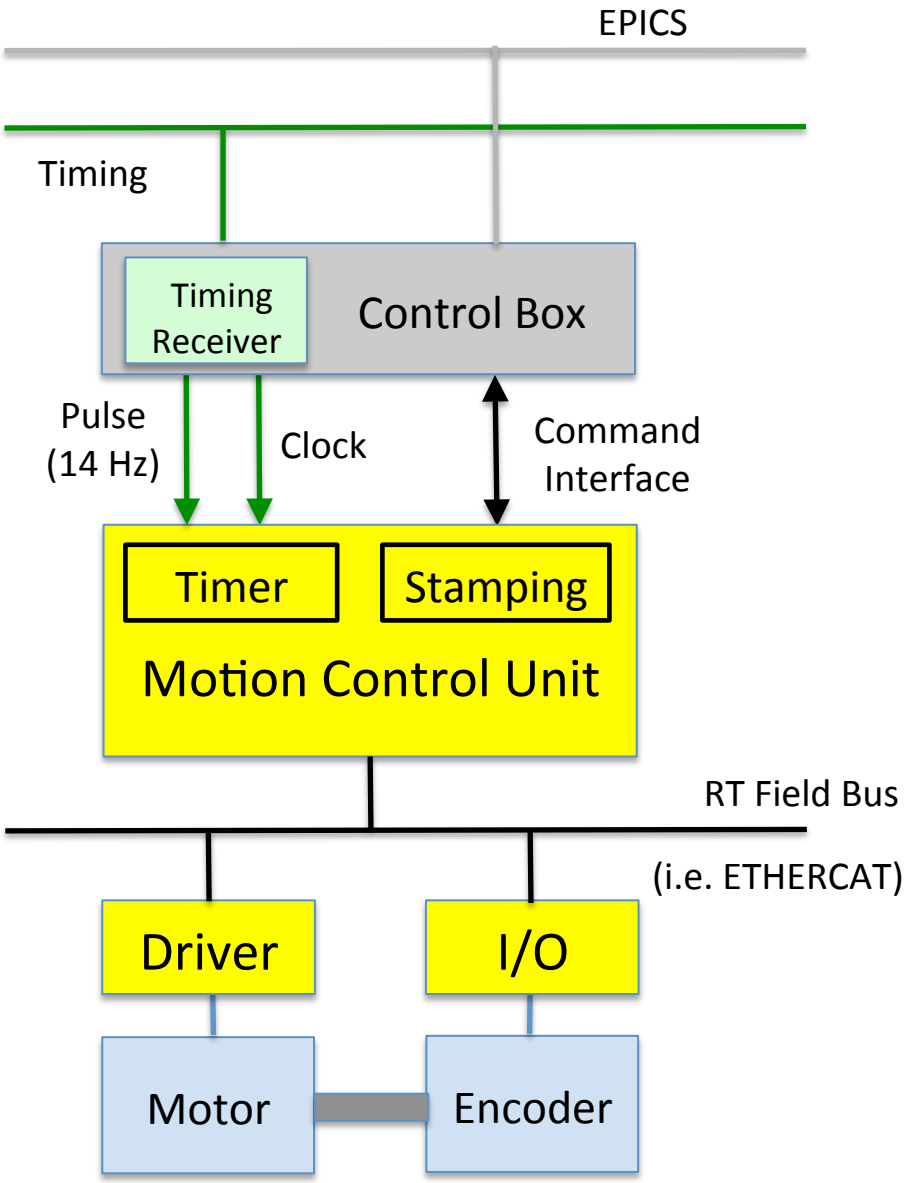
- Linear test bench to control all components of a positioning axis
- Basic mechanical setup for all evaluated motion control units
- Basis for motion control through the motor record of the EPICS IOC
- Further performance tests of single components will follow



- ISEL LEZ 1
- stepper motor Nanotec AS4118L1804
- incremental encoder Nanotec 500 Inc
- end switches (mechanical, n.c.)



Motion Control Concept



- Transfer absolute timing information from Control Box to the local HW control unit:
- Synchronise a timer on the control unit
- Timestamp in the control unit direct readings of the sensor with minimal latencies
- Transfer the sensor readings through the Control Box into EPICS
- Synchronously vs. asynchronously
- Local distribution of control unit functionalities with real time field busses