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sense and simplicity

Philips Innovation Services

Code Generation at Mechatronics

Oct, 2011

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Contents

- **Introduction Mechatronics**
- Mechatronic design challenge
- Control-design ‘old-style’
- Control-design with code generation
- Code details
- Questions

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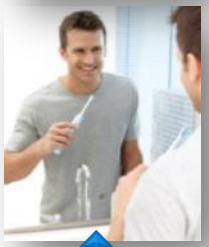
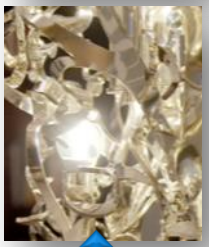
Position in Philips

Royal Philips Electronics

Consumer Lifestyle



Lighting

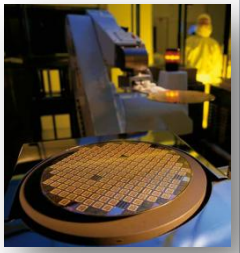


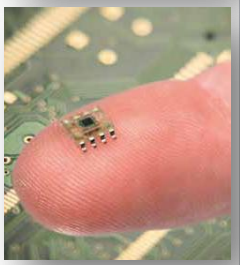
Healthcare

Corporate Technologies

- Incubators
- Research
- IP&S
- **Philips Innovation Services**

Non-Philips Customers





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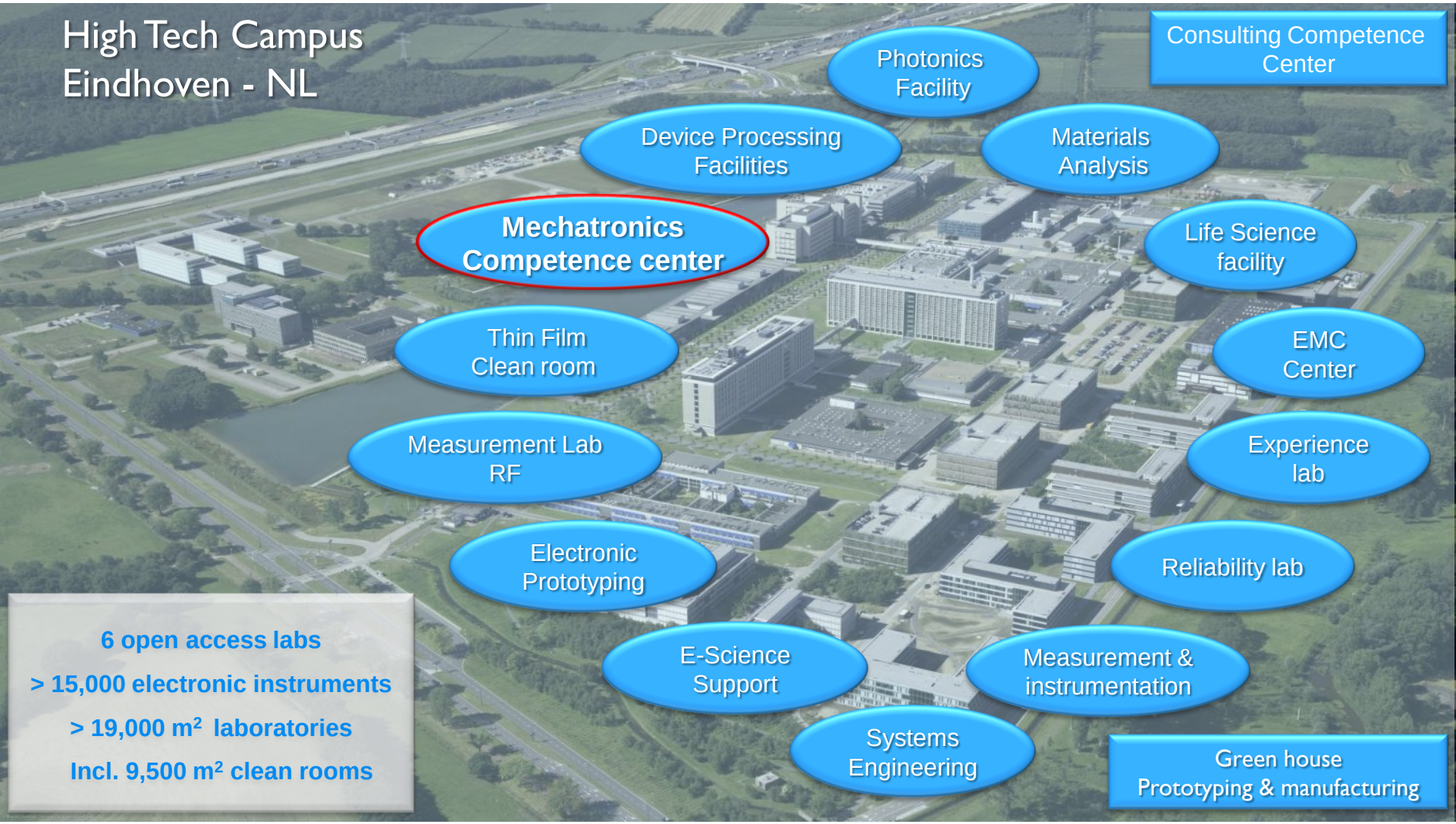
650 technical specialists / 50 consultants



Mechatronics

- Provides its customers with drives, control and mechanical construction for smooth motion and high accuracy positioning

- Is both active in equipment and subsystem design, as well as in supporting the development of consumer and healthcare products.

- Staff: 150 Technical specialists,40 % University degree / Ph.D.s, 50 % Bachelors & Engineers, 10 % other education

- Customers:

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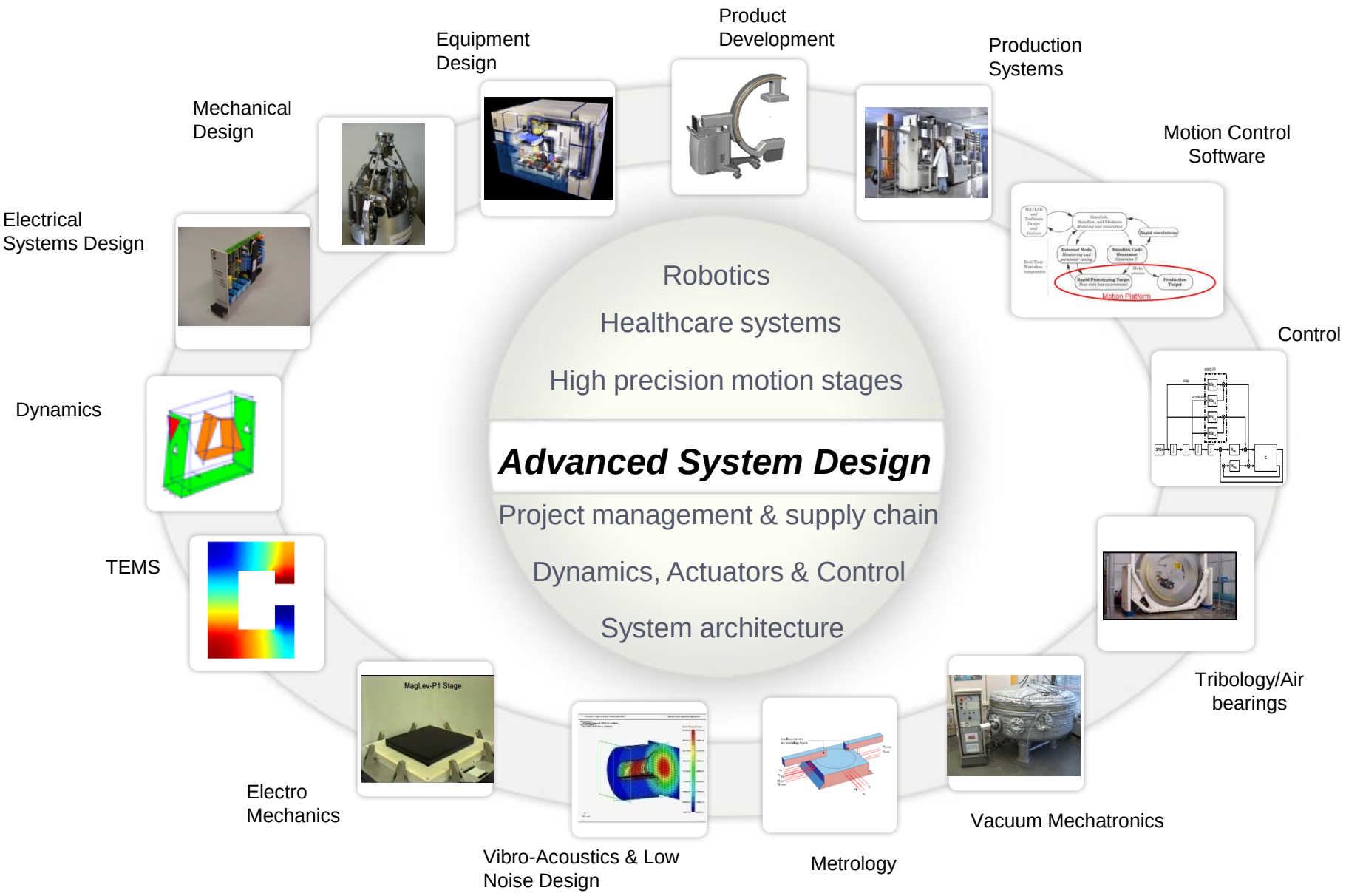
PHILIPS Mechatronics Competences



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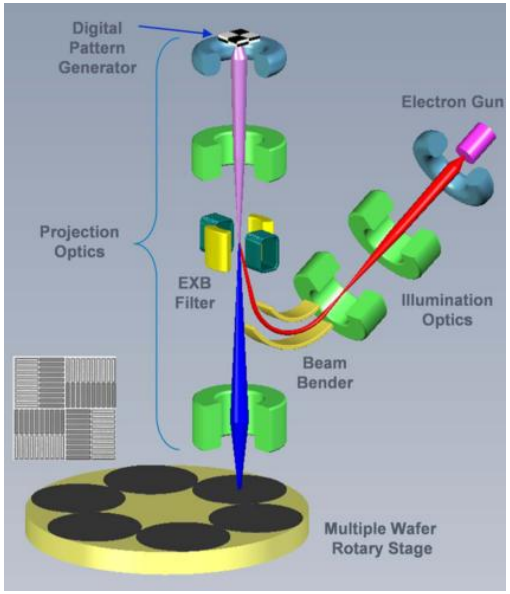
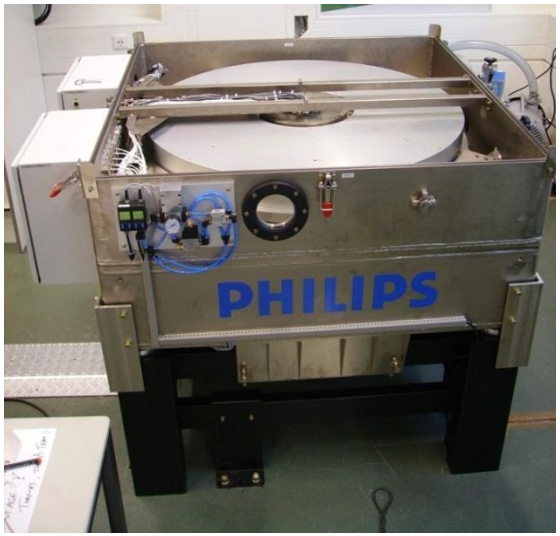
Reflective electron beam lithography



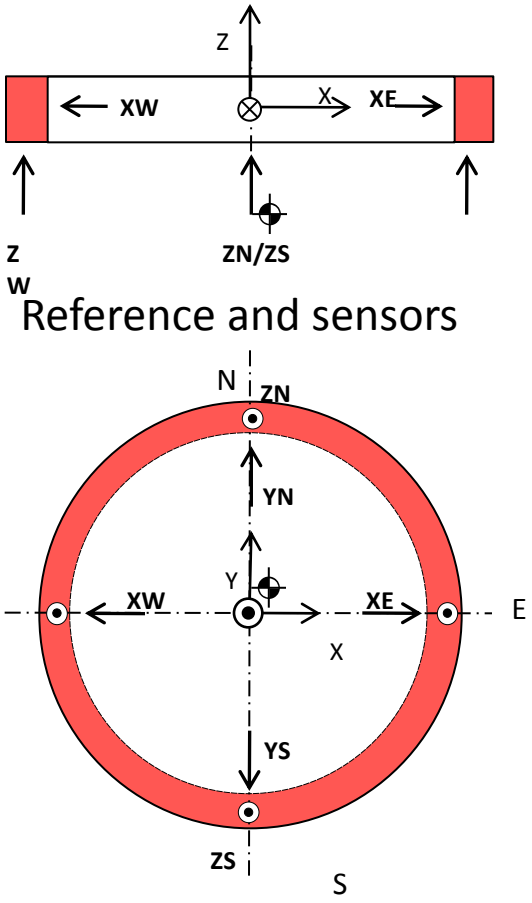
Challenge
- Rotary stage 1.2 m diameter
- High Accuracy positioning

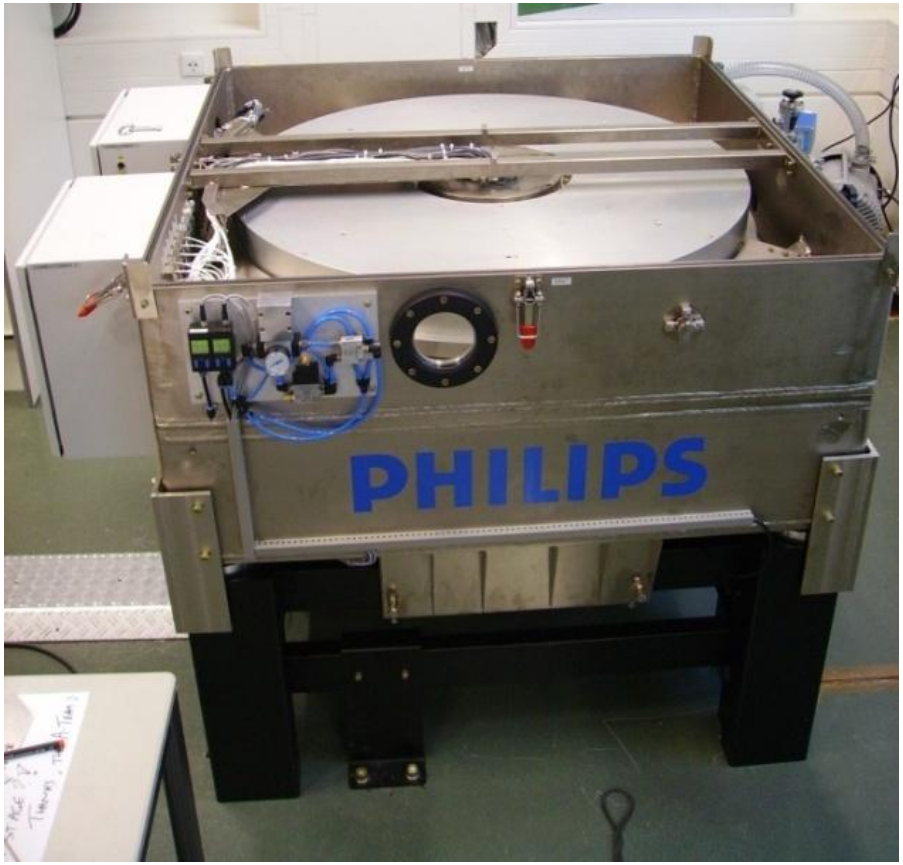
Results
- MagLev rotary stage
- Performance well within specification
- Prototypes installed at customer

Customer Benefits
- Competitive platform for introduction direct write technology
- Throughput wph/footprint
- Low energy dissipation (low forces)

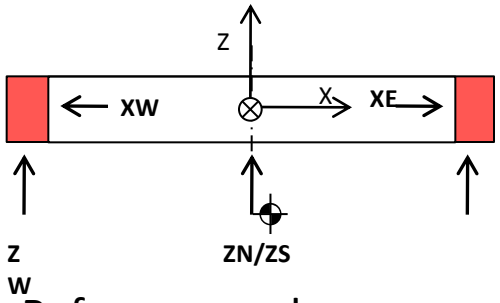


Design Challenge: measure disc position

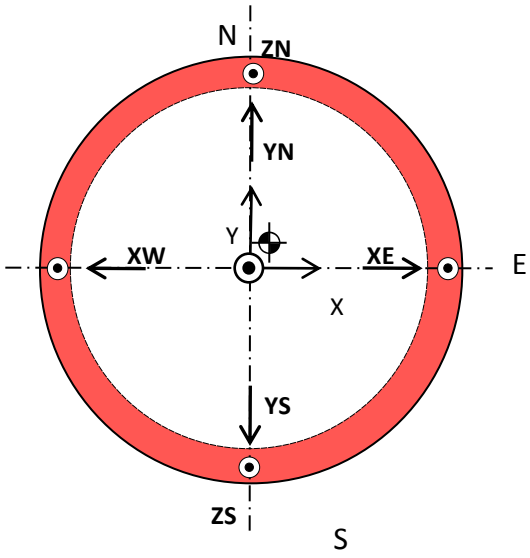




Design Challenge: Sensor transformations



Reference and sensors



4 x sensor Axial

4 x sensor Radial

Transformation

8 ➔ 5

5DOF

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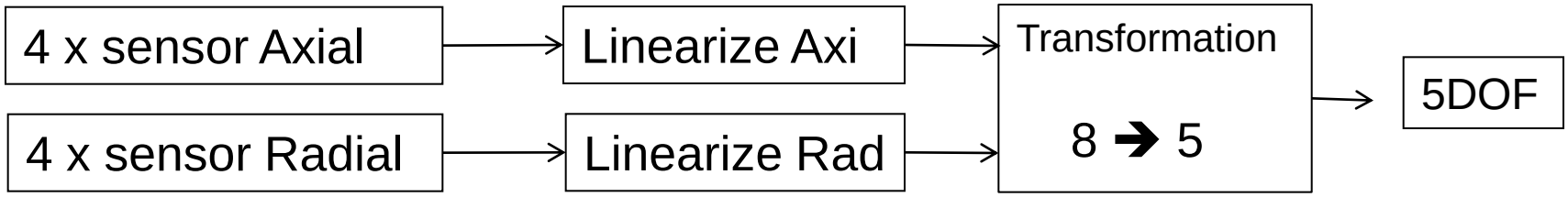
Design Challenge: Sensor linearization required



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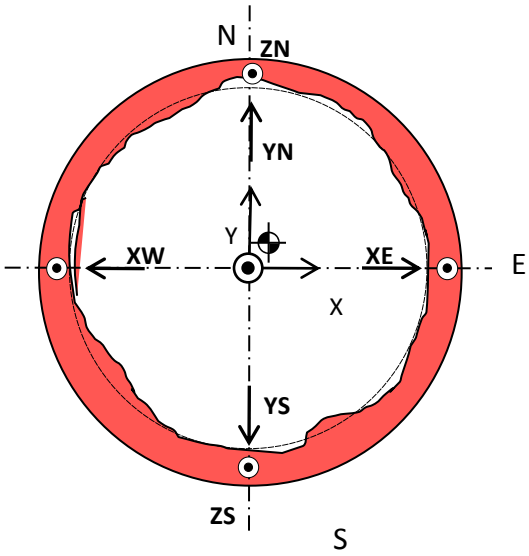
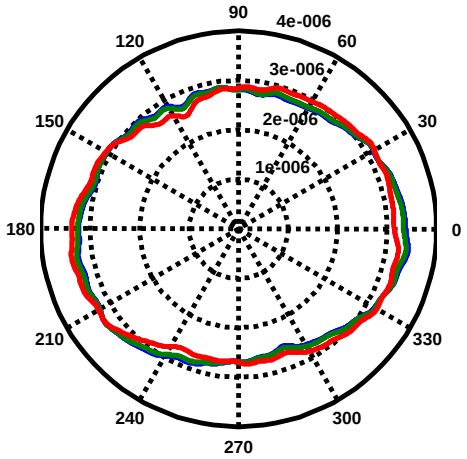
Design Challenge: Ref surface is not flat





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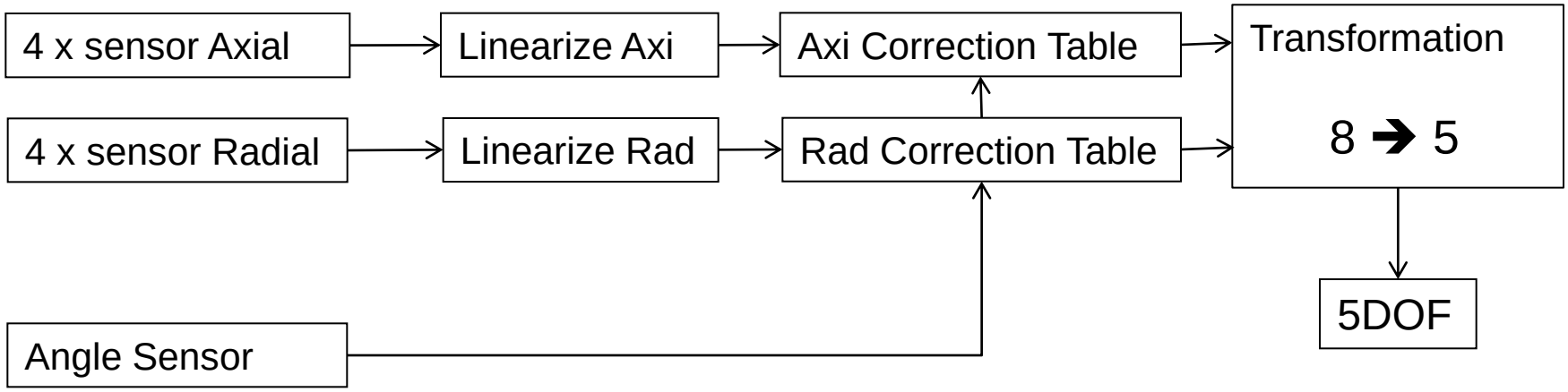
Design Challenge: Add calibration table



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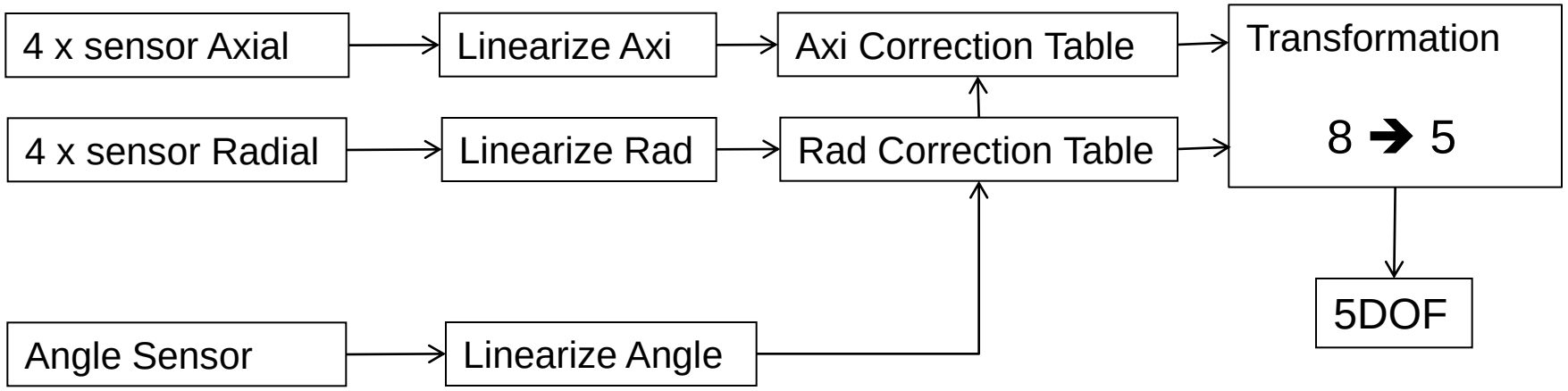
Design Challenge: Angle linearization required



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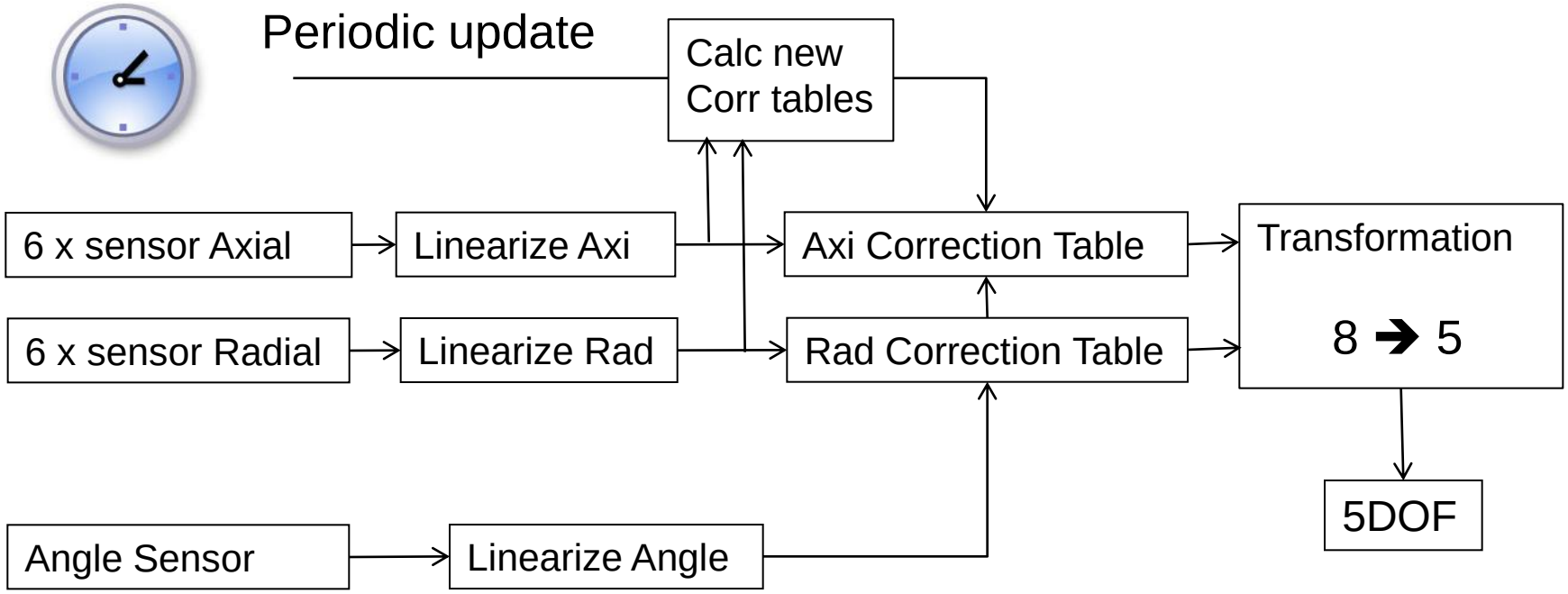
Design Challenge: Surfaces change with speed



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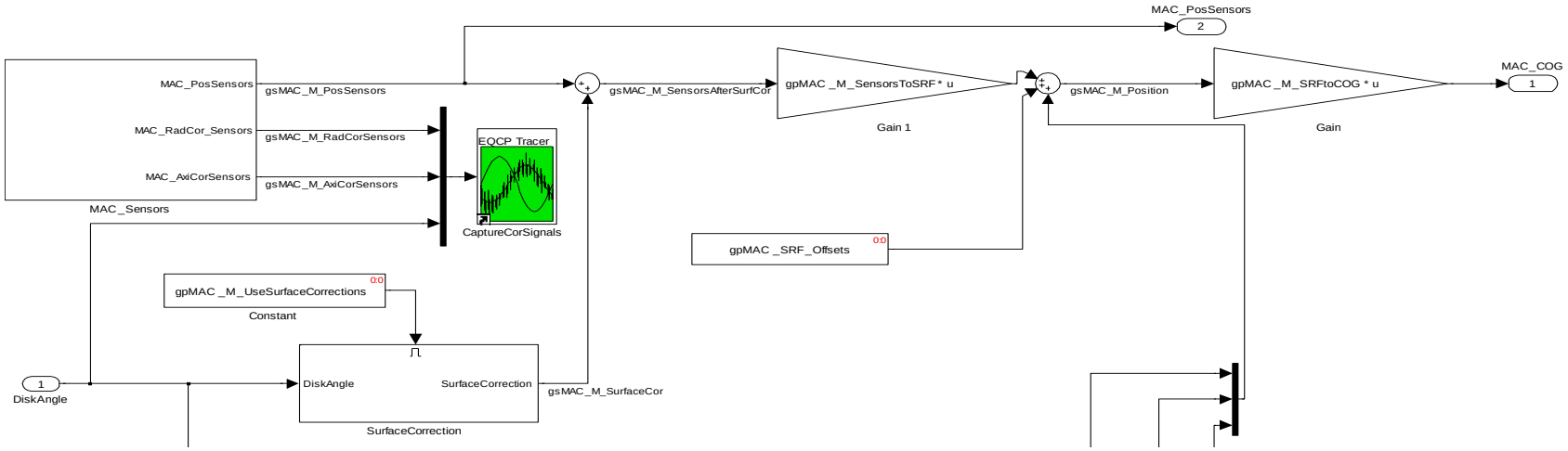
Implementation: measurement system



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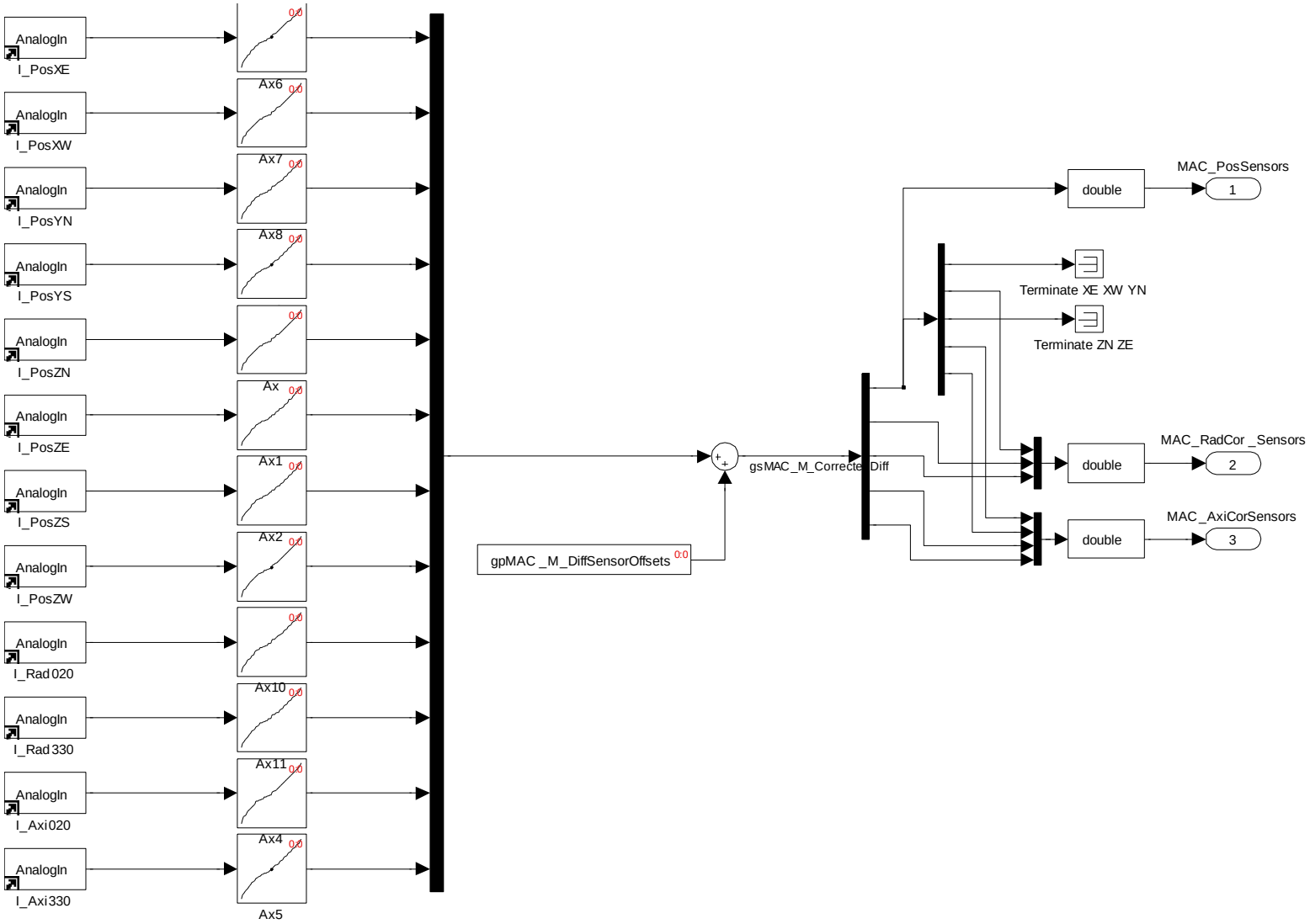
Implementation: sensor linearization



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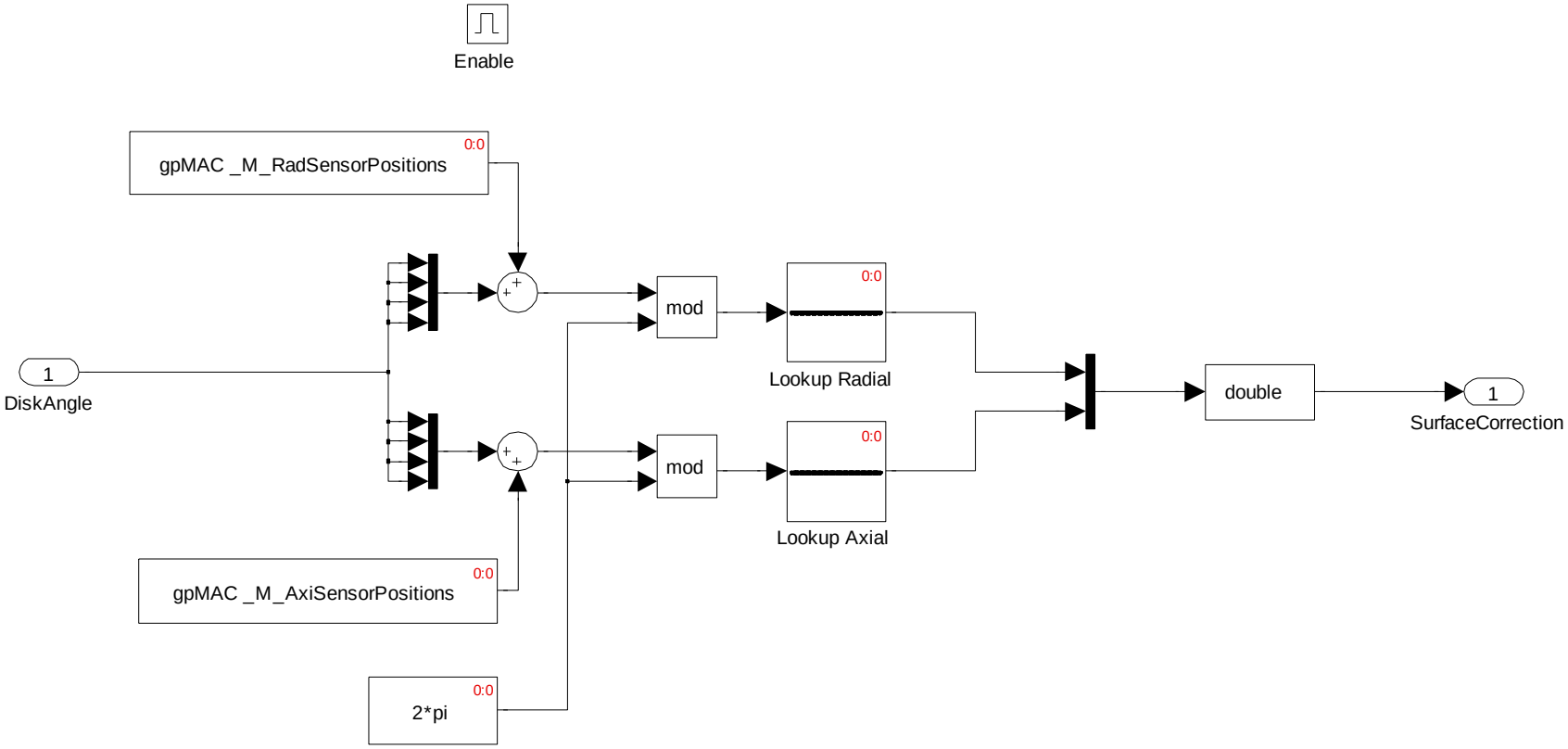
Implementation: Ref correction



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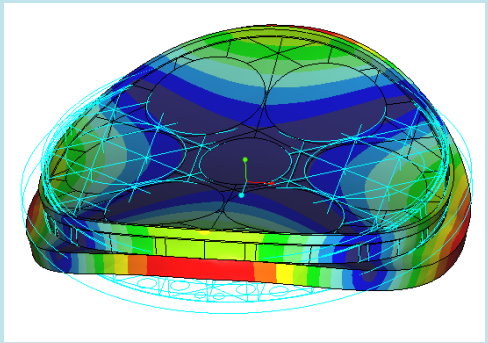
Motion Control Design flow ‘old-style’

User Spec

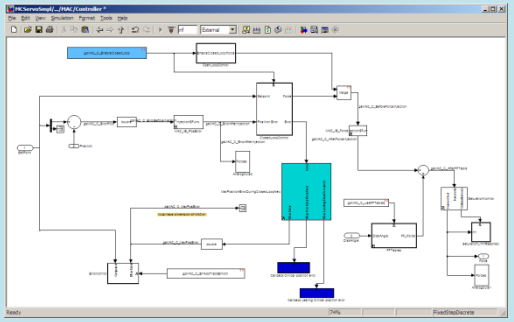
Mech Designer

Control Designer

Concept design and analysis

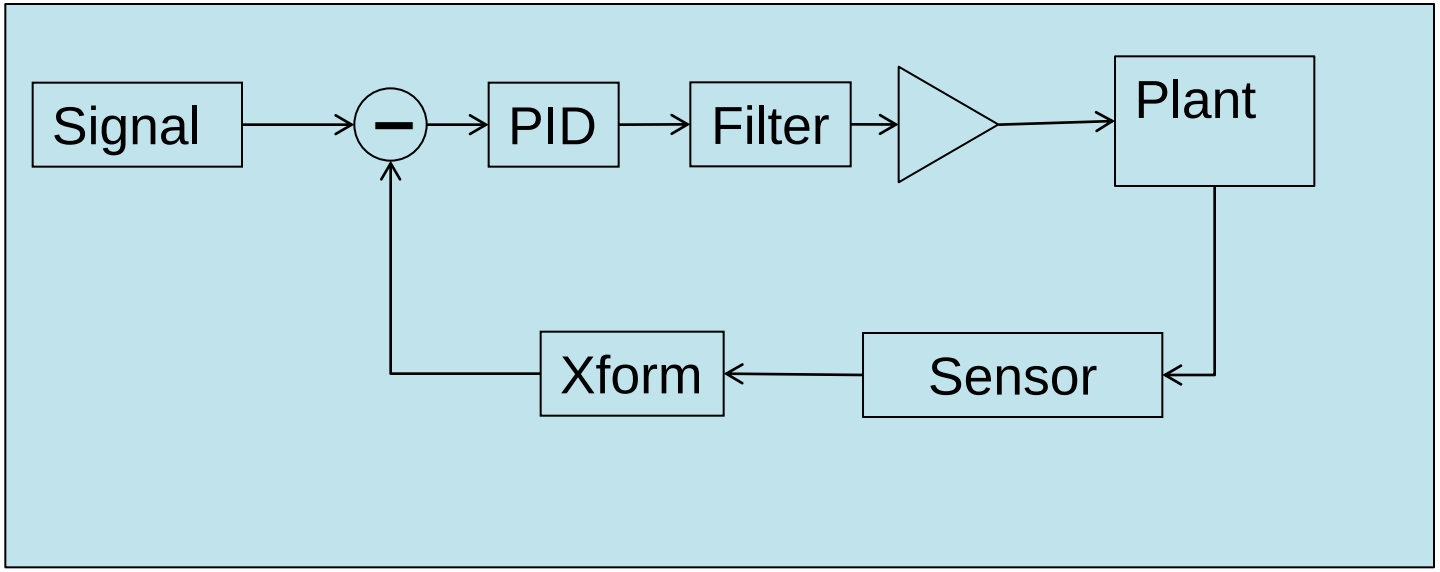


Control design

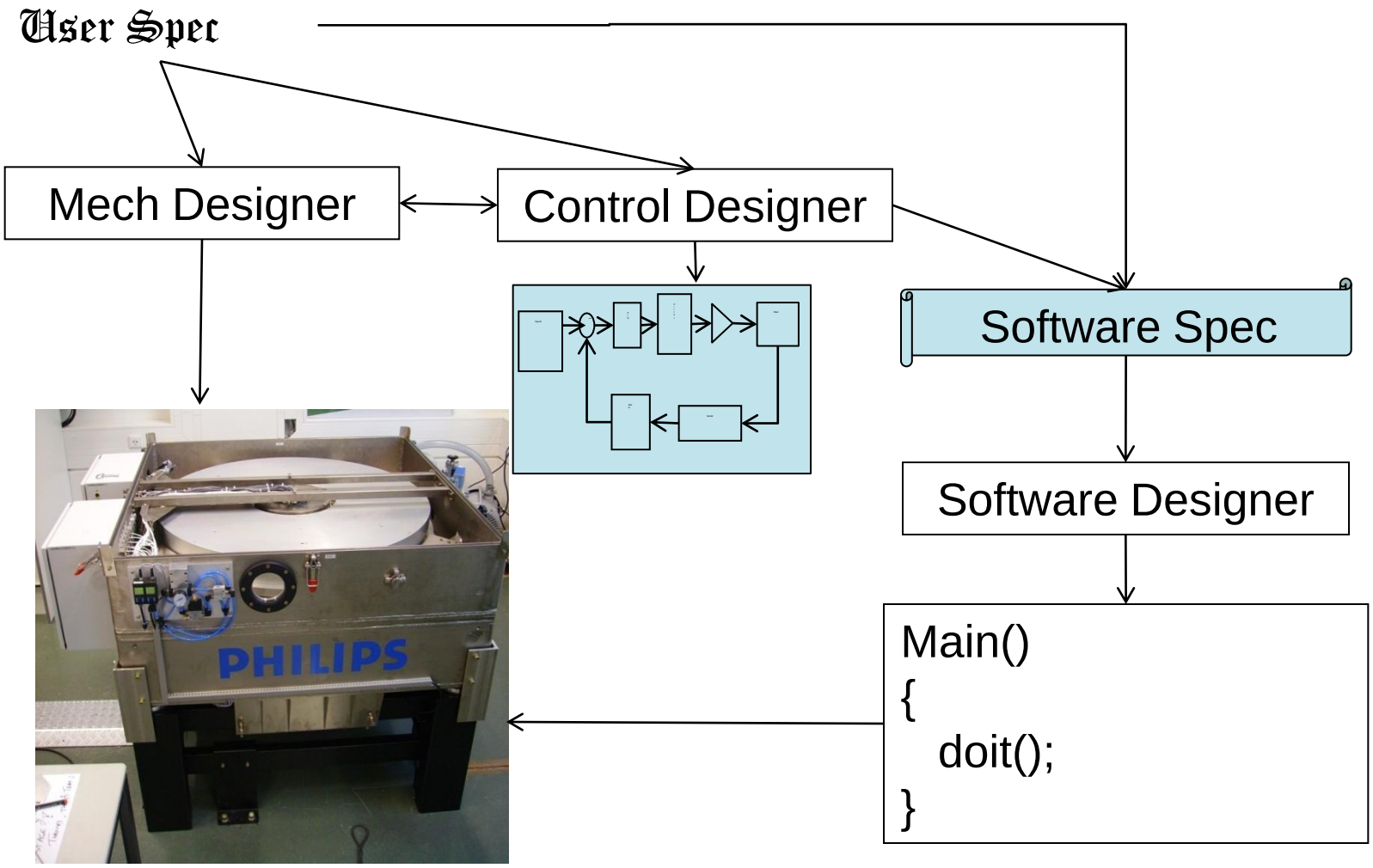


Motion Control Design flow ‘old-style’

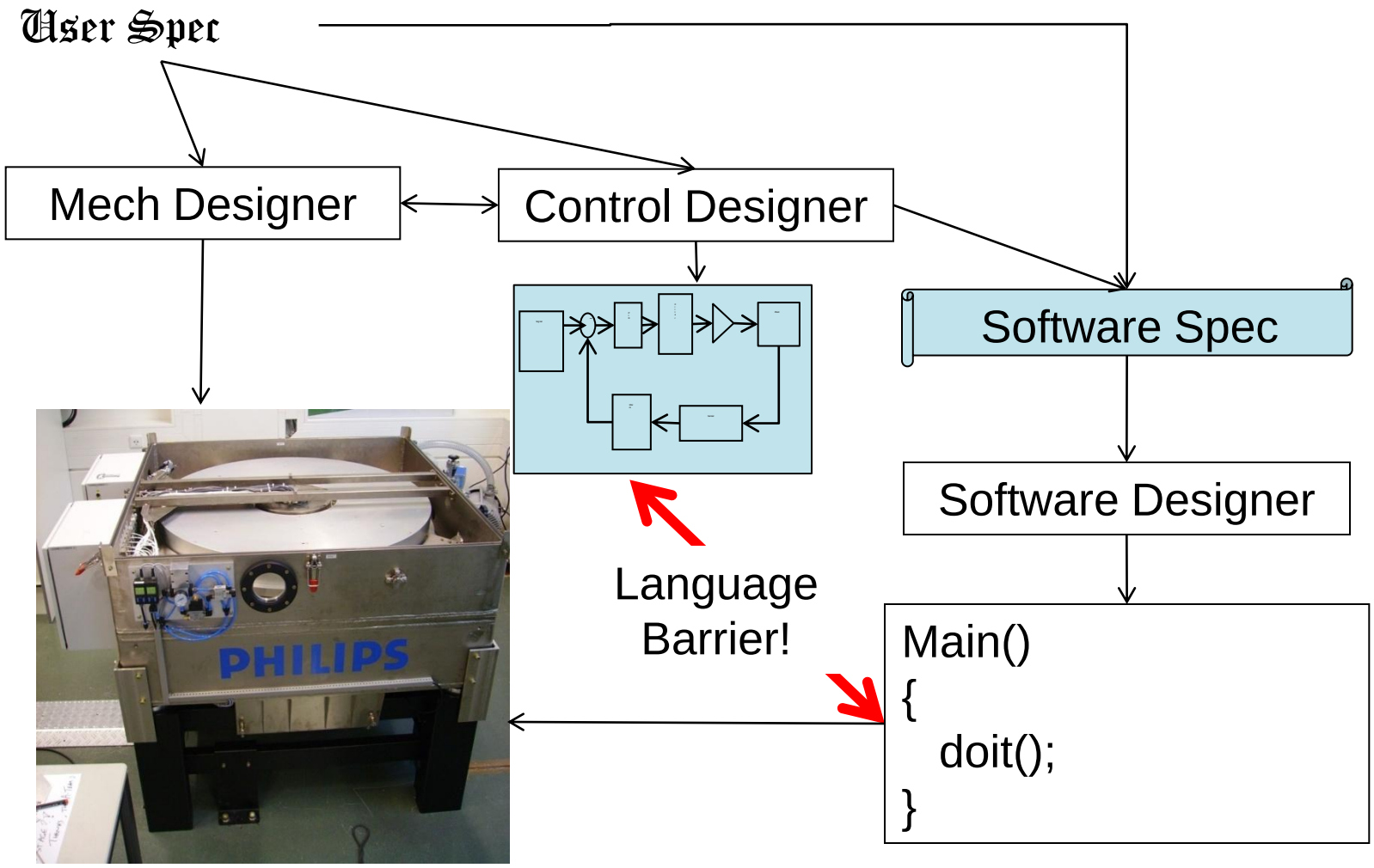
Control model



Motion Control Design flow ‘old-style’



Motion Control Design flow ‘old-style’



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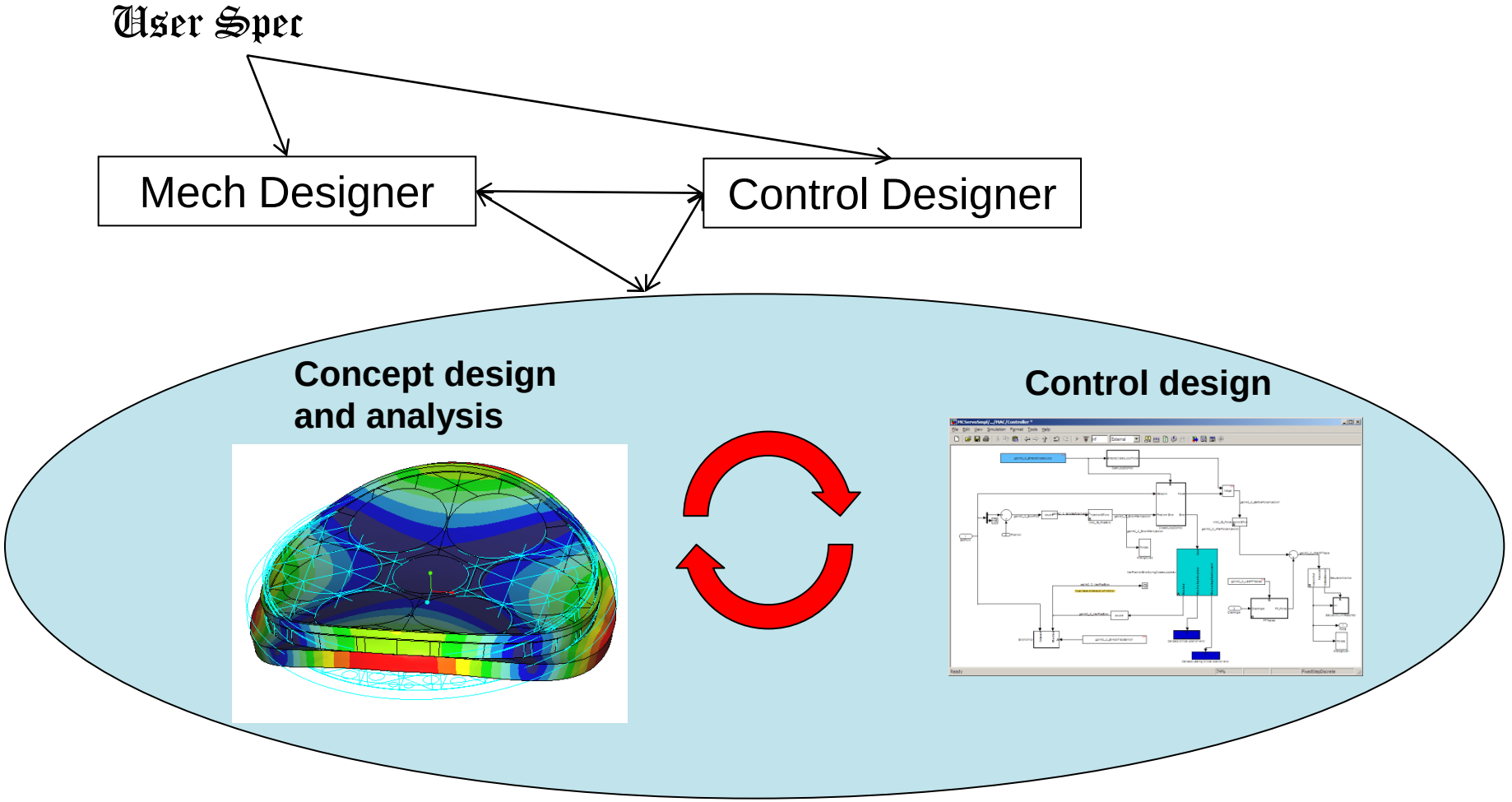
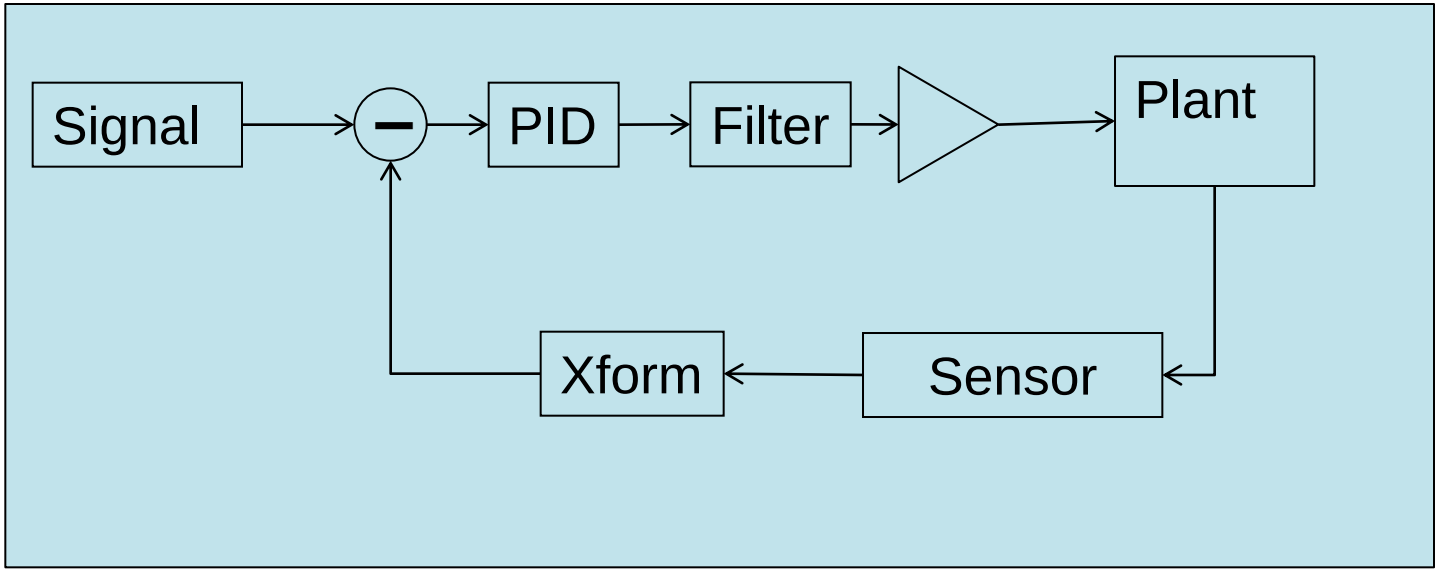
Motion Control Design flow using code generation



Motion Control Design flow using code generation

Control model



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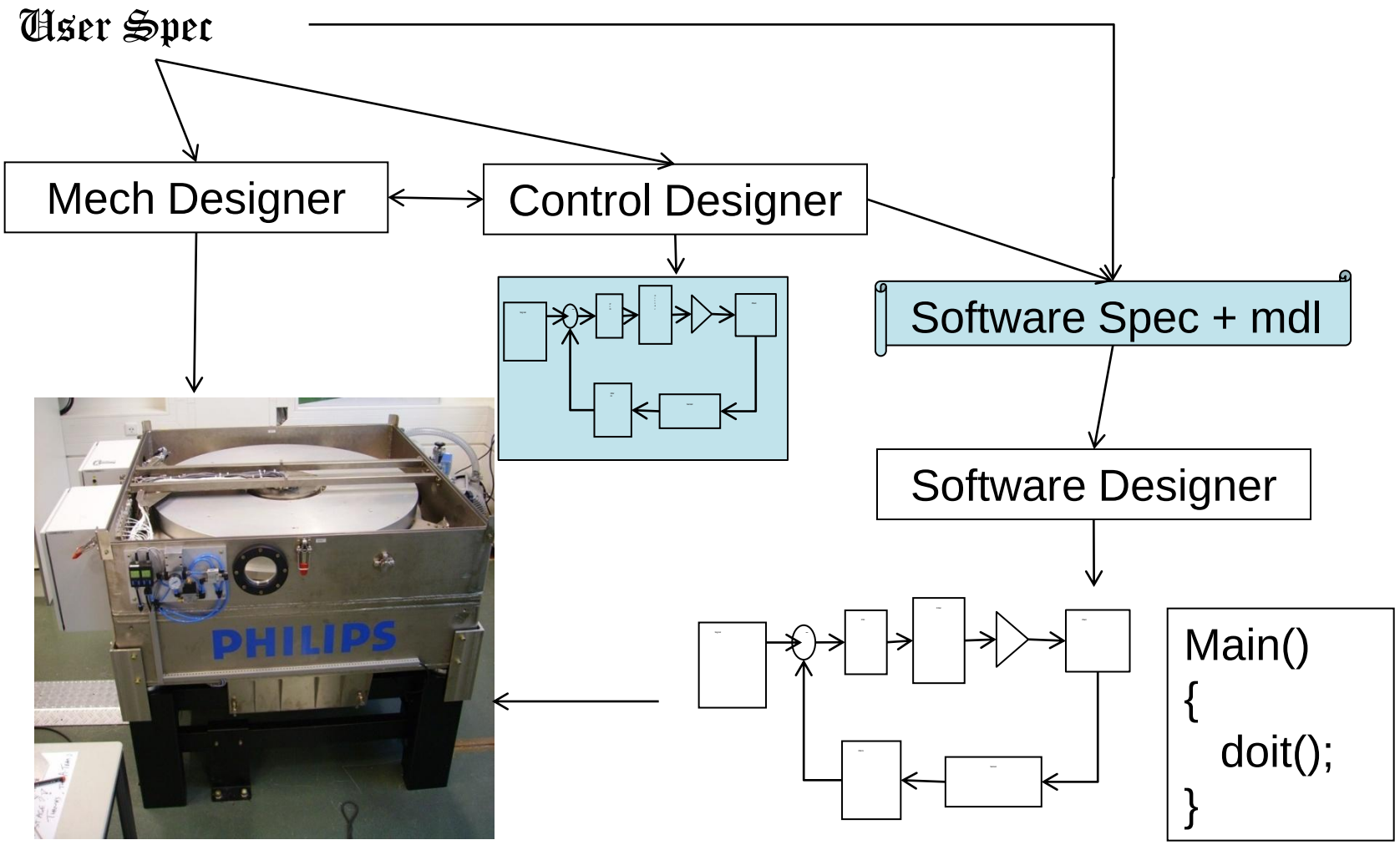
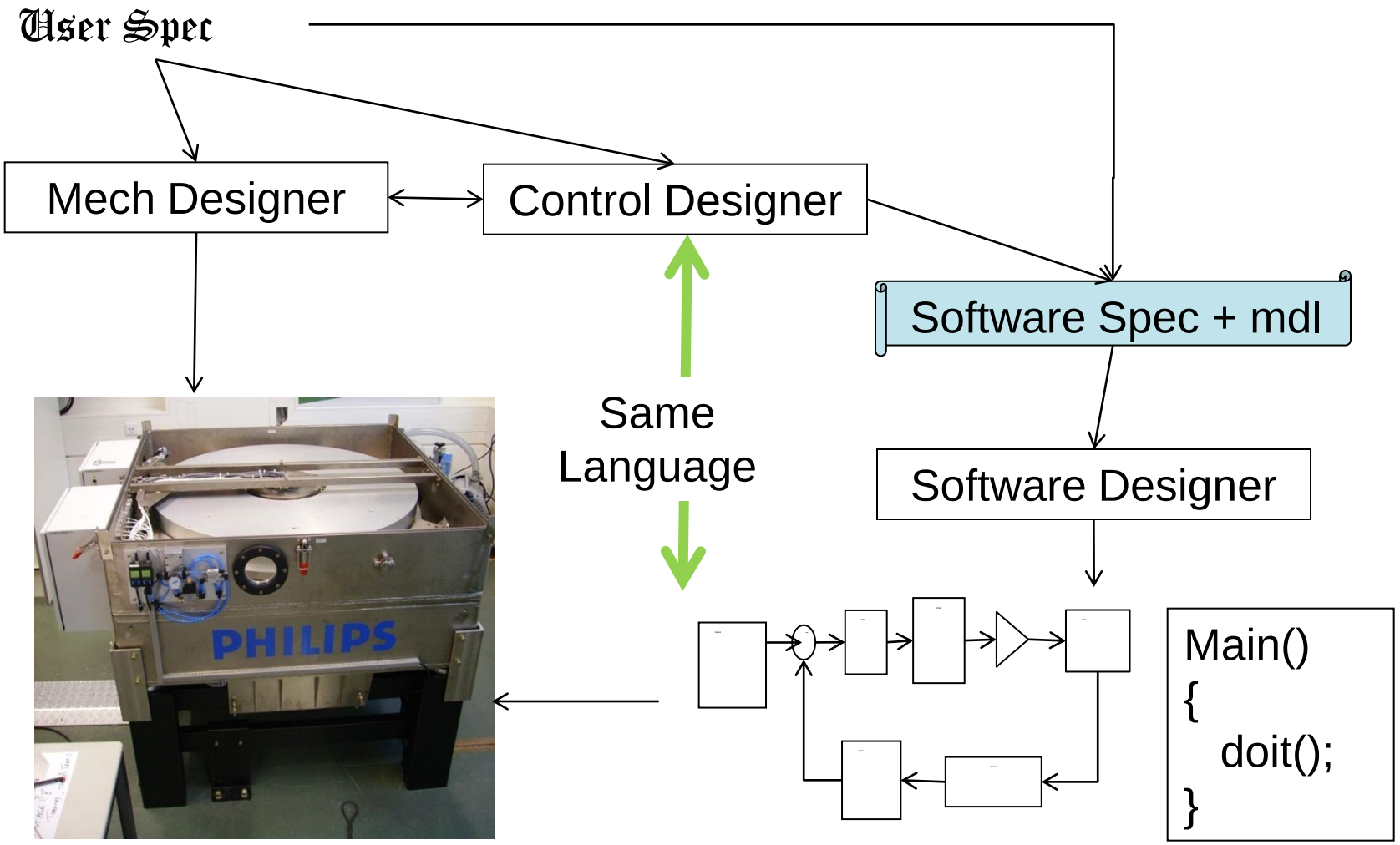
Motion Control Design flow using code generation



Motion Control Design flow using code generation



Motion Control Design flow using code generation

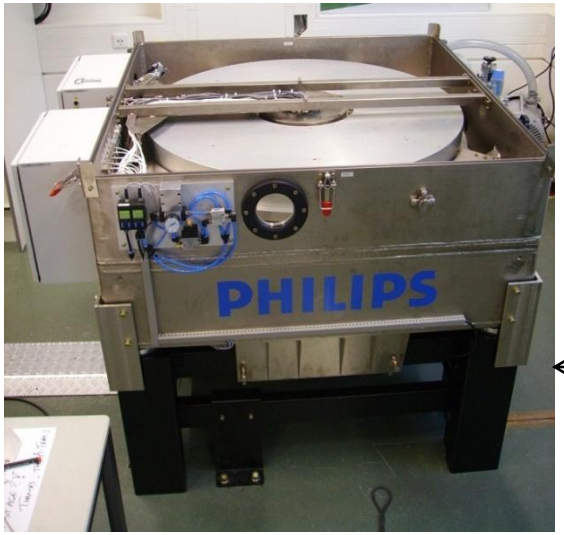
User Spec

Mech Designer

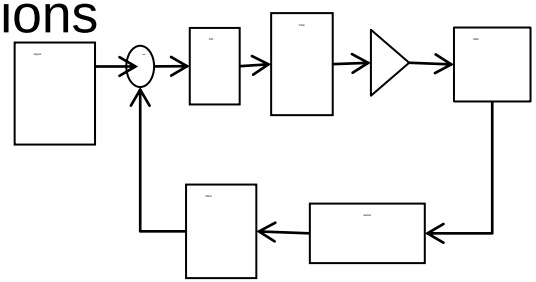
Control Designer

Software Spec + mdl

Software Designer



Same model
Allows fast
iterations



```
Main()
{
   doit();
}
```

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Code details

- Used in 10+ projects, various applications (RobotArm … REBL)
  - Sample rates 500Hz … 20kHz
  - # controlled axes 1 – 15
  - No defects found yet!

- Control models only, no state diagrams
  - General Matlab/Simulink blocks from library
  - Hardware inputs and output blocks are custom designed
  - Some custom blocks to interface with C++ code

Code details

- Efficiency of the generated code:
  - Double precision math by default
  - Simulink blocks that are not enabled are not evaluated
  - 30k lines at 4kHz on 2.8GHz P4.

- RTW-generated code is not nice to read
  - Each block in the model becomes a little code-block
  - The program is an ‘endless’ list of code-blocks
  - A signal with a name becomes a variable with same name

Code details: conclusion

- Pros
  - No language barrier with other mechatronic disciplines
  - Fast iterations in integration phase
  - No bugs

- Cons
  - Toolchain licensing
  - Testing
  - In Simulink variable scope is flat: use naming convention

- Note
  - Some effort required for creating custom IO blocks

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Questions

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