Mixing Re-Use and Model-Based Development
The CHEOPS Payload SW Experience

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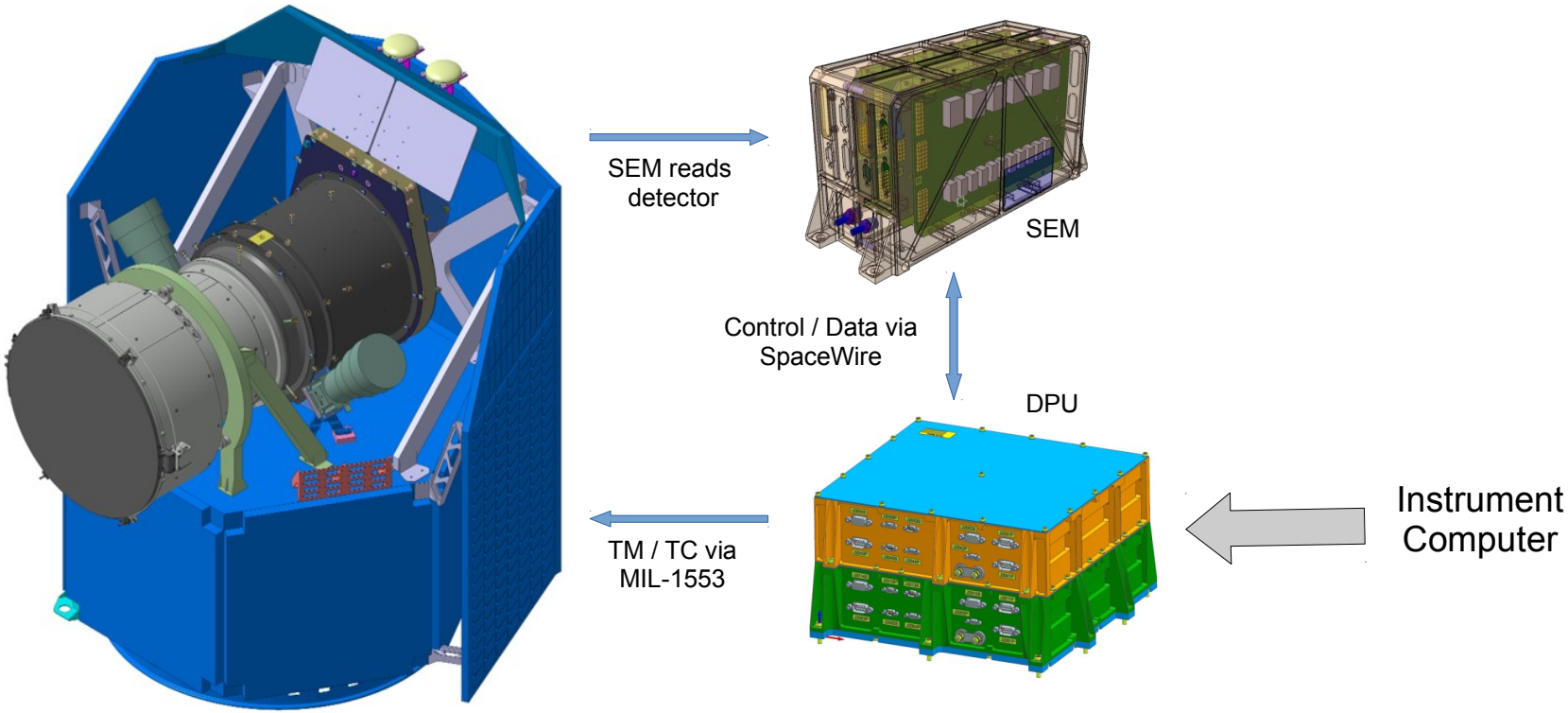
The CHEOPS Instrument

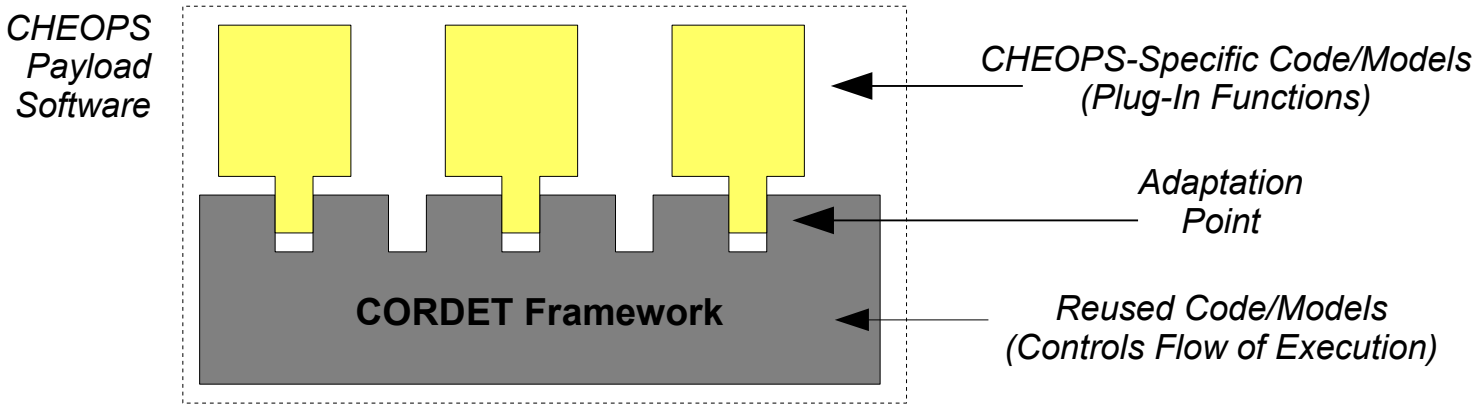
- **CHaracterizing ExOPlanet Satellite (CHEOPS)**: single-instrument spacecraft to be launched in 2018 to study exo-planets



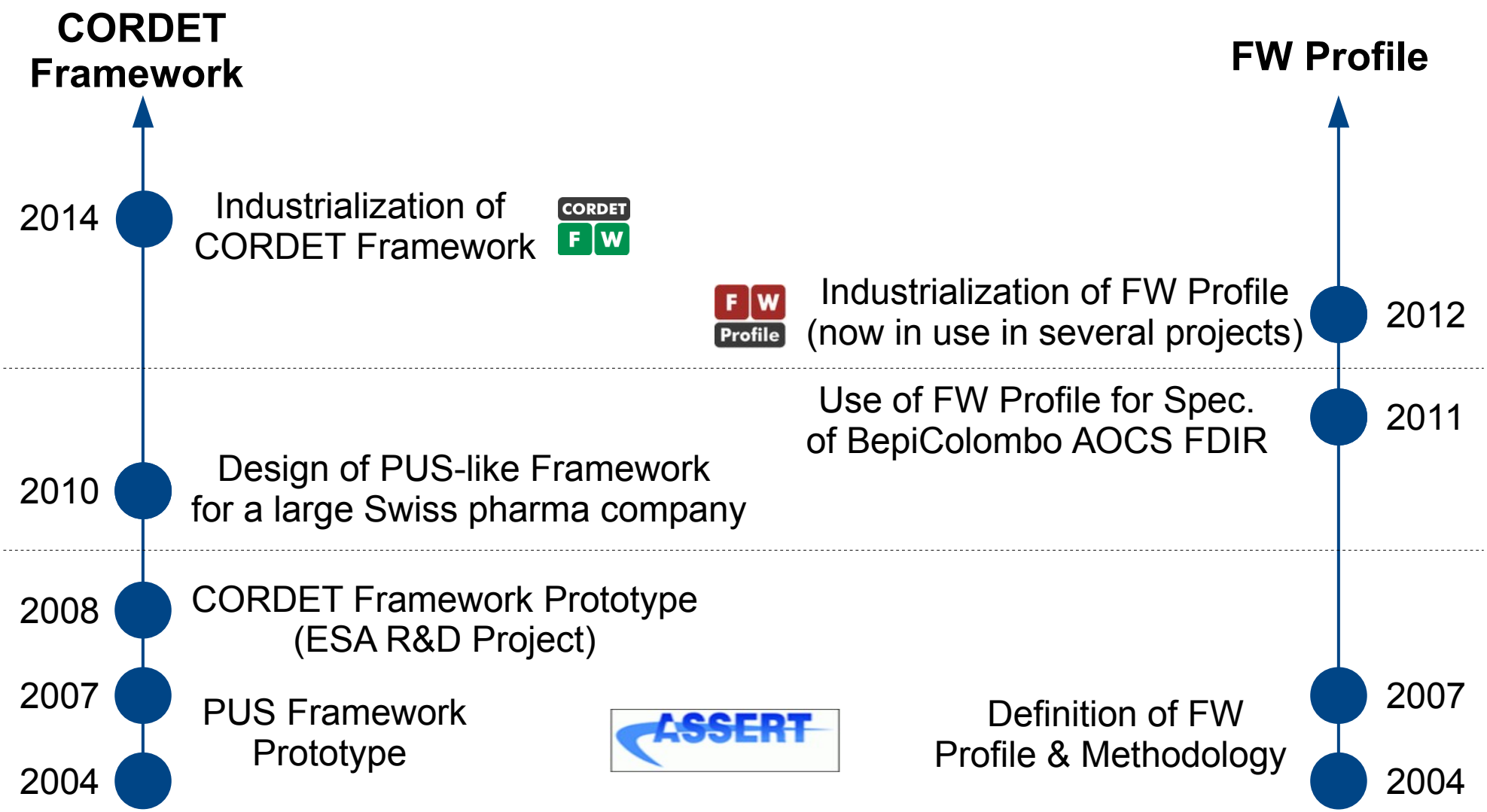
- Instrument Prime Contractor: **University of Bern**
- Instrument Software Development: **University of Vienna**

CHEOPS Payload Software

- Main technical features:
  - **Provider of PUS Services** to Spacecraft Computer (17 Services)
  - **User of PUS Service** from Sensor Electronics Module (7 Services)
  - **Re-routing** of telecommands and telemetry reports
  - Management of **16 Gbytes of Flash** Memory Storage
  - Implementation of **On-Board Science Data Processing**
  - **Dual-Core Architecture** (LEON3FT)
- Development Approach:
  - Development as an instantiation of the **CORDET Framework** -►Reuse + MBSSE
    - CORDET Framework is defined both at model and code level
  - Framework customization developed as **FW Profile** Models -►MBSSE



History & Heritage

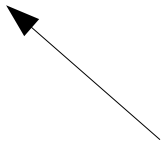


What is the FW Profile?

- The **FW Profile** is a UML profile which consists of:
  - Specification of four **basic concepts** to model application behaviour
    - **State Machines** to model state-dependent functional behaviour
    - **Procedures** (Activity Diagrams) to model sequential functional behaviour
    - **Real-Time Containers** to model timing behaviour
    - **Adaptation Points** to support definition of reusable components
  - **C-language implementation** of these concepts to support translation of specification models into code
  - **Qualification Data Package** for the C implementation to support certification of end-applications
  - **Web-based tool** to build profile-compliant models and generate their code
  - **Free/open licencing** model (LGPL): www.pnp-software.com/fwprofile

What is the CORDET Framework?

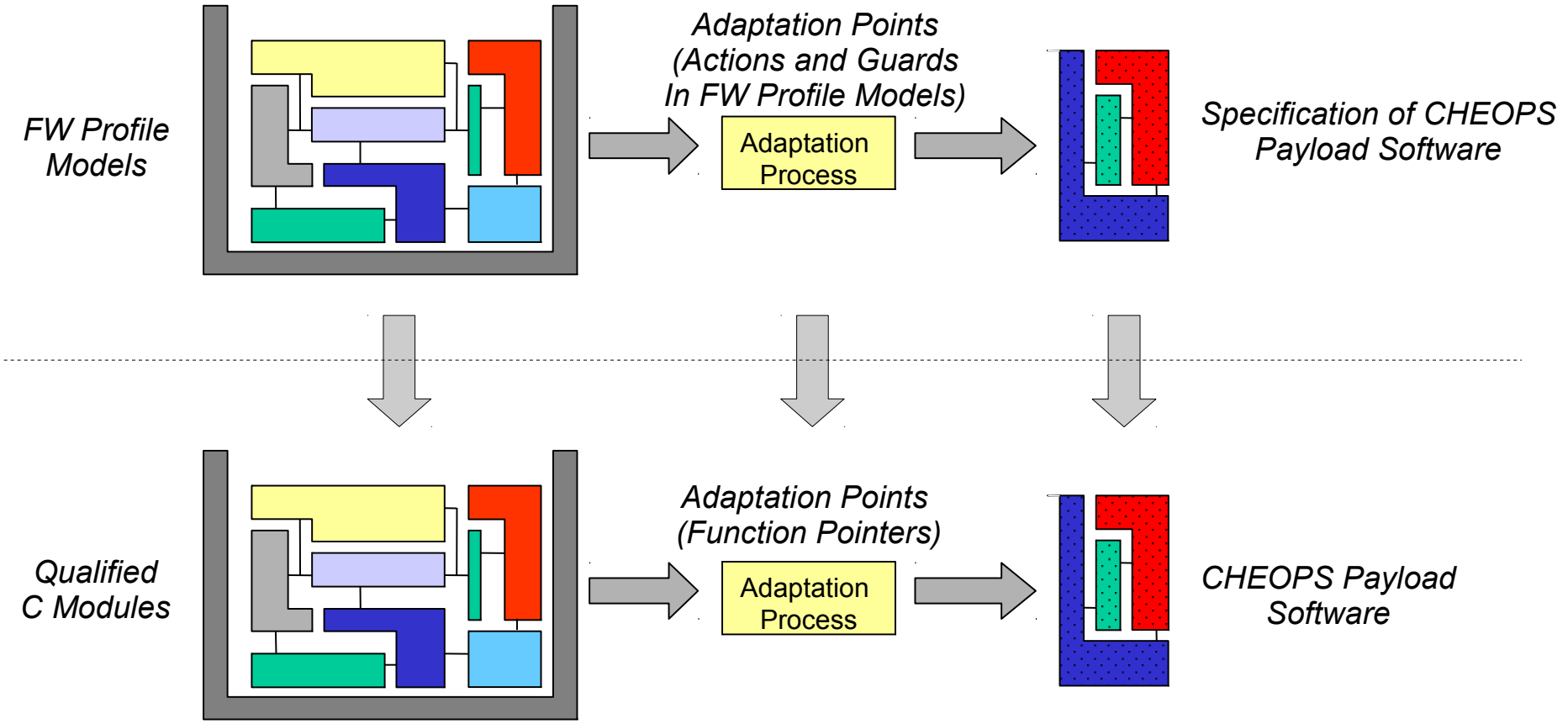
- The **CORDET Framework** consists of:
  - Set of **FW Profile models** which specify:
    - A generic architecture to manage incoming and out-going **commands**
    - A generic architecture to manage incoming and out-going **reports**
    - The **adaptation points** where application specific behaviour can be plugged in
  - **C-language implementation** of these models to support translation of specification models into code
  - **Qualification Data Package** for the C implementation to support certification of end-applications
  - **Free/open licencing** model (LGPL): www.pnp-software.com/cordetfw
  - **Web-Based Tool** to automate the framework-instantiation process



Currently Under Development

A Model-Based Framework

- The CORDET Framework exists both at **model level** and at **code level**
  - The instantiation process is done at both levels
  - The specification is created from the models and the implementation from the code



Impact on Design Process

- Requirements for the CHEOPS Instrument Software have been written using the abstractions provided by the CORDET Framework
  - Requirement definition effectively consisted in defining the close-out for each framework adaptation point
  - **Requirement Baseline serves also as Technical Specification** and is used as input for software design process
- Architectural Design Process effectively disappears
- CHEOPS Instrument Software Development
  - First release of Application SW Technical Specification: 1 month
  - First release of Architectural Design Document: < 1 month

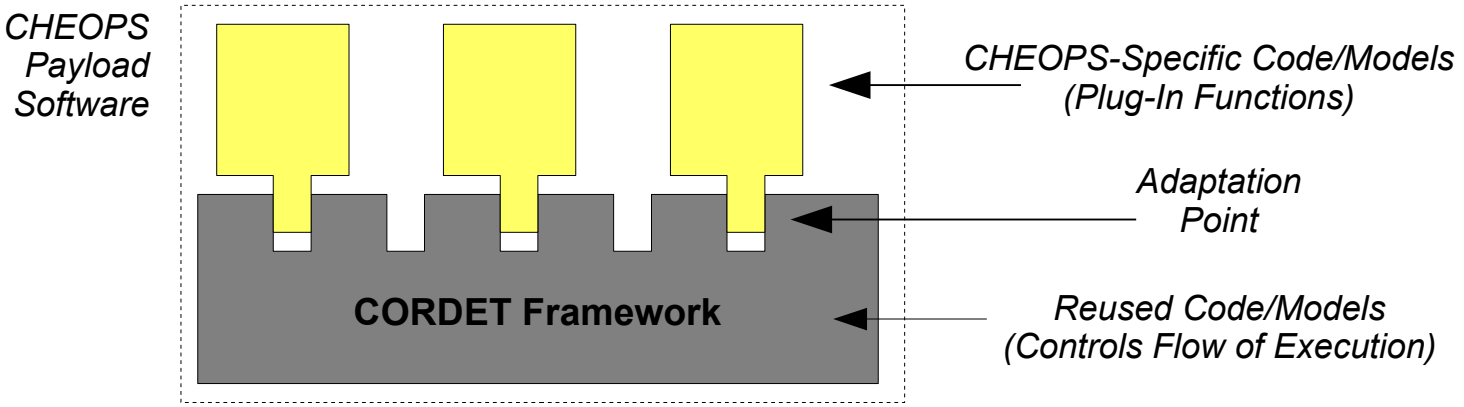
Impact on Qualification Process

- The CORDET FW is provided with a **Qualification Data Package**:
  - Formal specification of framework behaviour through **UML Models** and **Requirements**
    - **Traceability** to code
    - **Traceability** to verification evidence
  - **Test Suite** with 100% code, branch, and condition coverage (excluding system call error branches)
  - **Doxygen Documentation** for the entire code base
  - **User Manual** & **Demo Application**
- The selected adaptation mechanisms require **no change to the source code** of the framework code

- The qualification data package of the framework is **imported** into the qualification data package of the CHEOPS Instrument Software
  - → **No need for re-qualification** of code imported from the framework

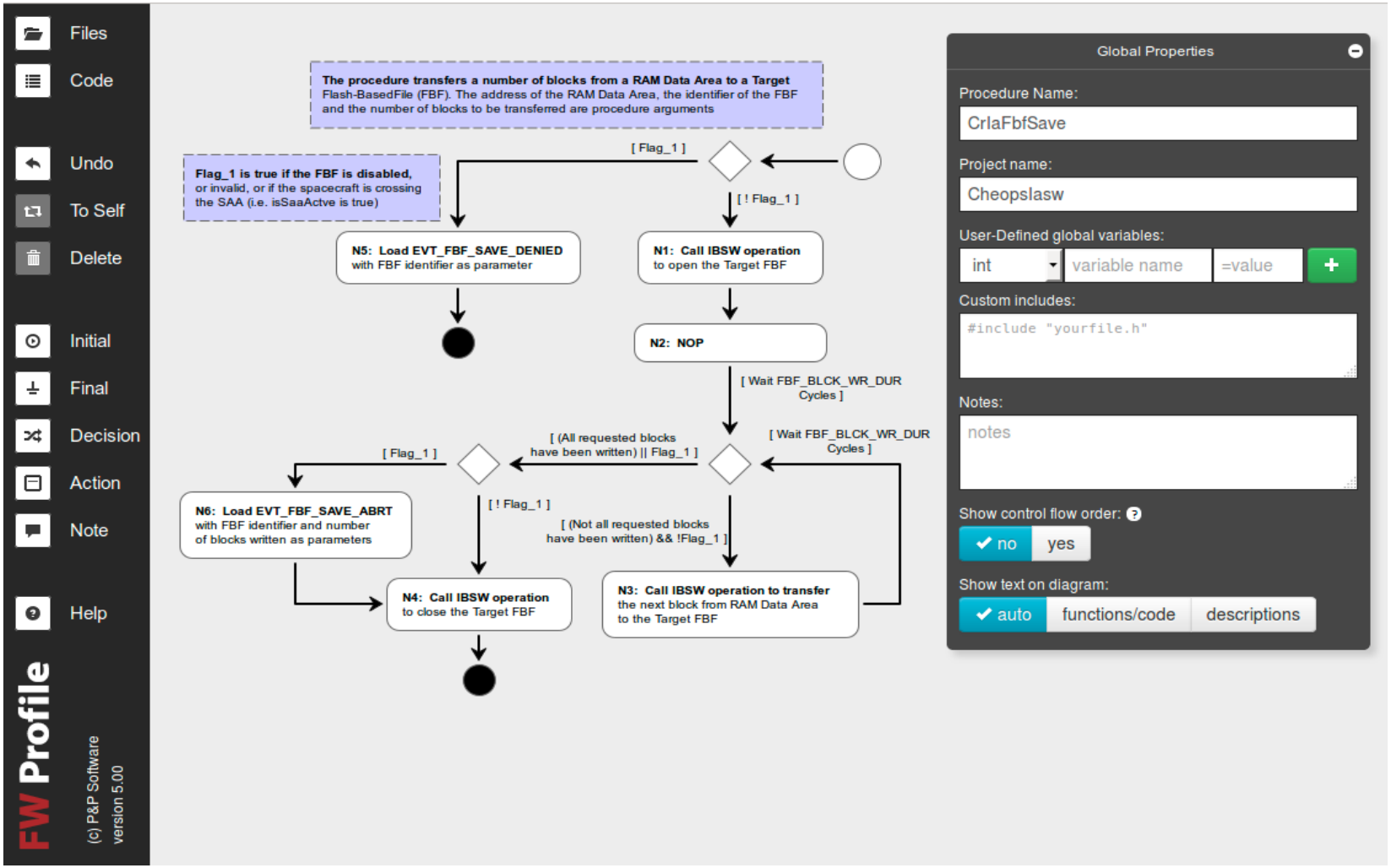
Application Software Structure

- The Framework acts as a **domain-specific operating system**
- Application-specific code consists of **call-back functions** which are registered with the framework and are called by the framework
- A model-based process for application-specific code was used:
  - The specification consisted of FW Profile Models
  - The state machine and activity diagram code was generated automatically
  - Manual development was restricted to code implementing individual actions and guards
  - The manually-developed code was mostly “linear”



Tool Support - FW Profile Editor

www.pnp-software.com/fwprofile/editor-5.00



Contentious Statements

- If we use a model-based approach to software development, then **requirements baseline** and **technical specification** will (tend to) merge
- If we want to design reusable software, then we need to explicitly **model adaptation mechanisms**
- Code generated from models should “look like” manually developed code so that we can **qualify the generated code** rather than the generator