

# Ontology-Driven Robot Design for Future Orbital and Planetary Robotics with korcut

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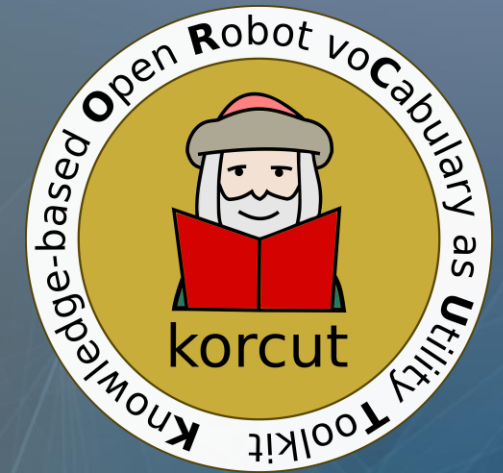
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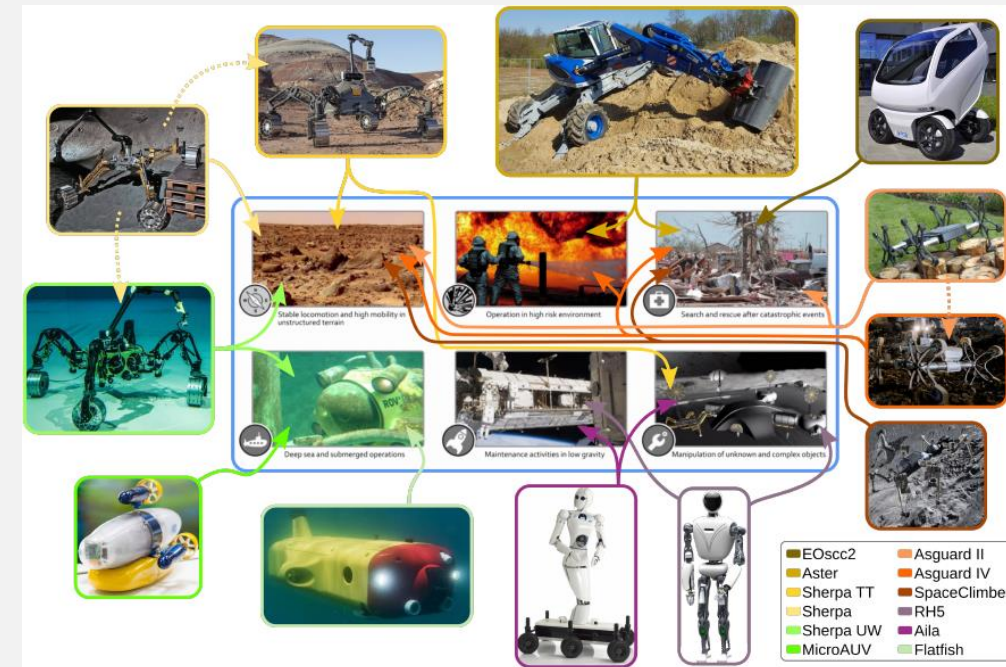
- Introduction
  - Related projects in space domain (motivation)
    - Q-Rock Project
    - KiMMI-SF Project
    - PERIOD Project
  - Information paradox
- Solution approach: Knowledge-based Open Robot voCabulary as Utility Toolkit (korcut)
- Test: Using of korcut ontologies in test applications
  - PERIOD ontology → PERIOD Project
  - System modeling ontology → Q-Rock Project
  - Kastro ontology → KiMMI-SF Project
- Conclusion and Outlook

# Introduction - Q-Rock

{Planetary Robotics}

AI-based Qualification of Deliberative Behaviour for a Robotic Construction Kit

- Assembly of robots in the future:
  - Large robotic structures on planets.
    - Re-configurable, reassemble
  - Who will do it? How will it be done?
    - Redesign, rescale and maintenance of robot later
- Autonomous assembly and manufacturing for deliberative capability and behavior
  - Development is supported by prior knowledge and user (requirements)
  - Robots directly **learn** their skills from their **hardware** in **simulation**
- Q-Rock aids **bidirectional mapping** between **hardware** and **robot behavior**



# Introduction - PERIOD (OG12)

{Orbital Robotics}

PERASPERA In-Orbit Demonstration (Operational Grant 12)

- Increase the maturity of space technologies and prepare them for an in-orbit demonstration
- Raise the technology readiness level (TRL) of core technologies
- Define an orbital demonstration concept for on-orbit servicing and assembly
  - **self-deployed objects** single piece (**in orbit factory**)
  - Standard interconnect (SI) to connect (sub)systems in a (re)configurable way
- Robotics: Interface is necessary for modularity
  - a mechatronic device
  - covers **electric, mechanics** and **software** domains
- PERIOD: Develop a benchmark method to understand and distinguish the generic properties of an interface based on experience gained from real test experiments.



*Mission demonstration scenario  
(credit: Space Applications Services NV/SA)*



*Tested SIs mounted on adapters from left to right:  
iSSI® active & passive with optional formfits,  
HOTDOCK active & passive and  
SIROM active & passive.*

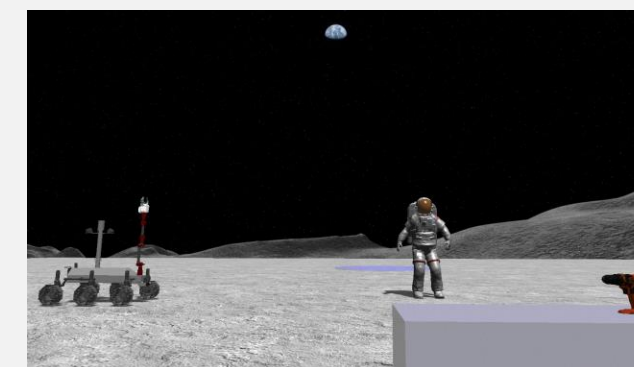
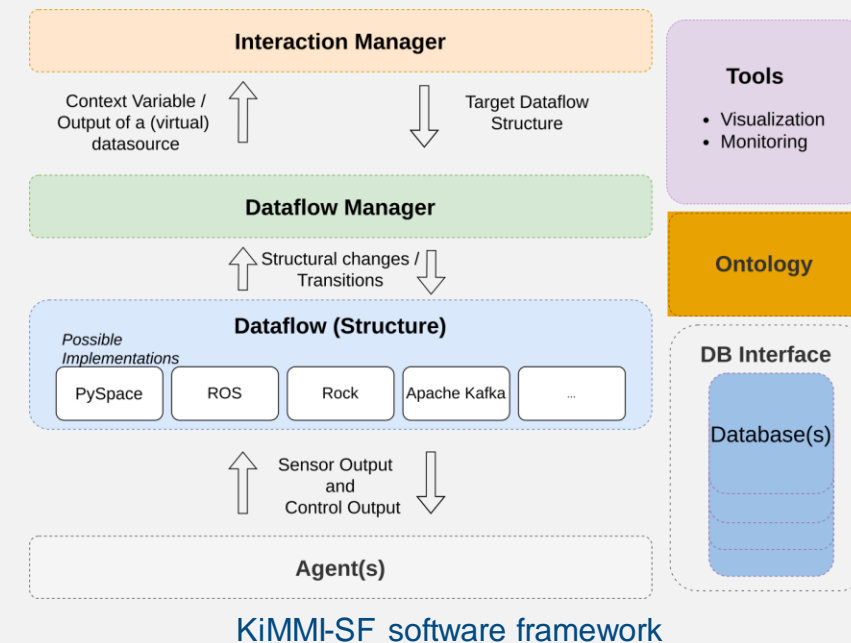


# Introduction - KiMMI-SF project

{Planetary Robotics}

The adaptive software framework for context-sensitive, intuitive man-machine-interaction

- Future tasks of the planetary missions need human-robot collaboration.
- Most modern Man-Machine-Interface(MMI) approaches work very robustly...  
... as long as they are limited to a specific context.
- The framework:
  - a **multi-modal** assessment of the **human, agent** and **environmental** situation
  - online **reconfigurable data processing** based on **different data types** from various data sources
- Application Scenario:
  - prediction of human intention in a simulated space environment
- KiMMI-SF aims to provide the necessary knowledge for the relationship between an assistance robot and an astronaut for the exemplary daily task on an exemplary future lunar terrain

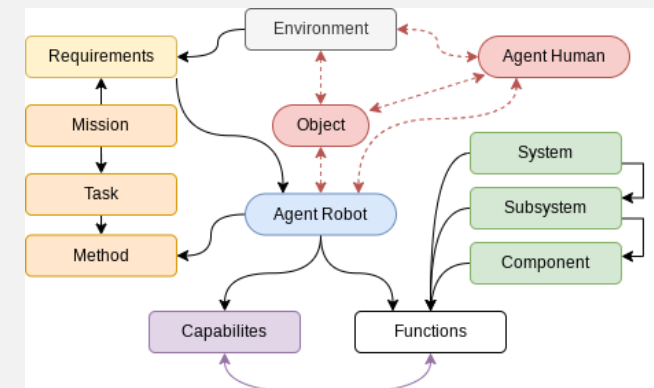
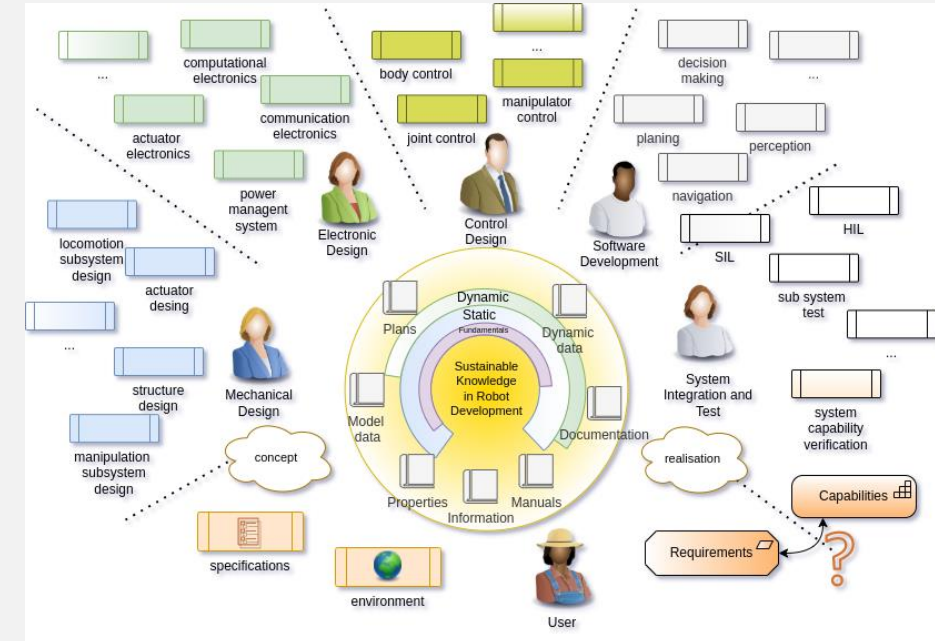


KiMMI-SF application scenario

# Introduction - Information paradox

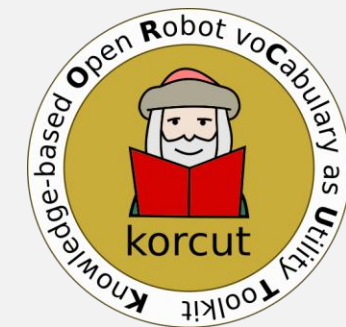
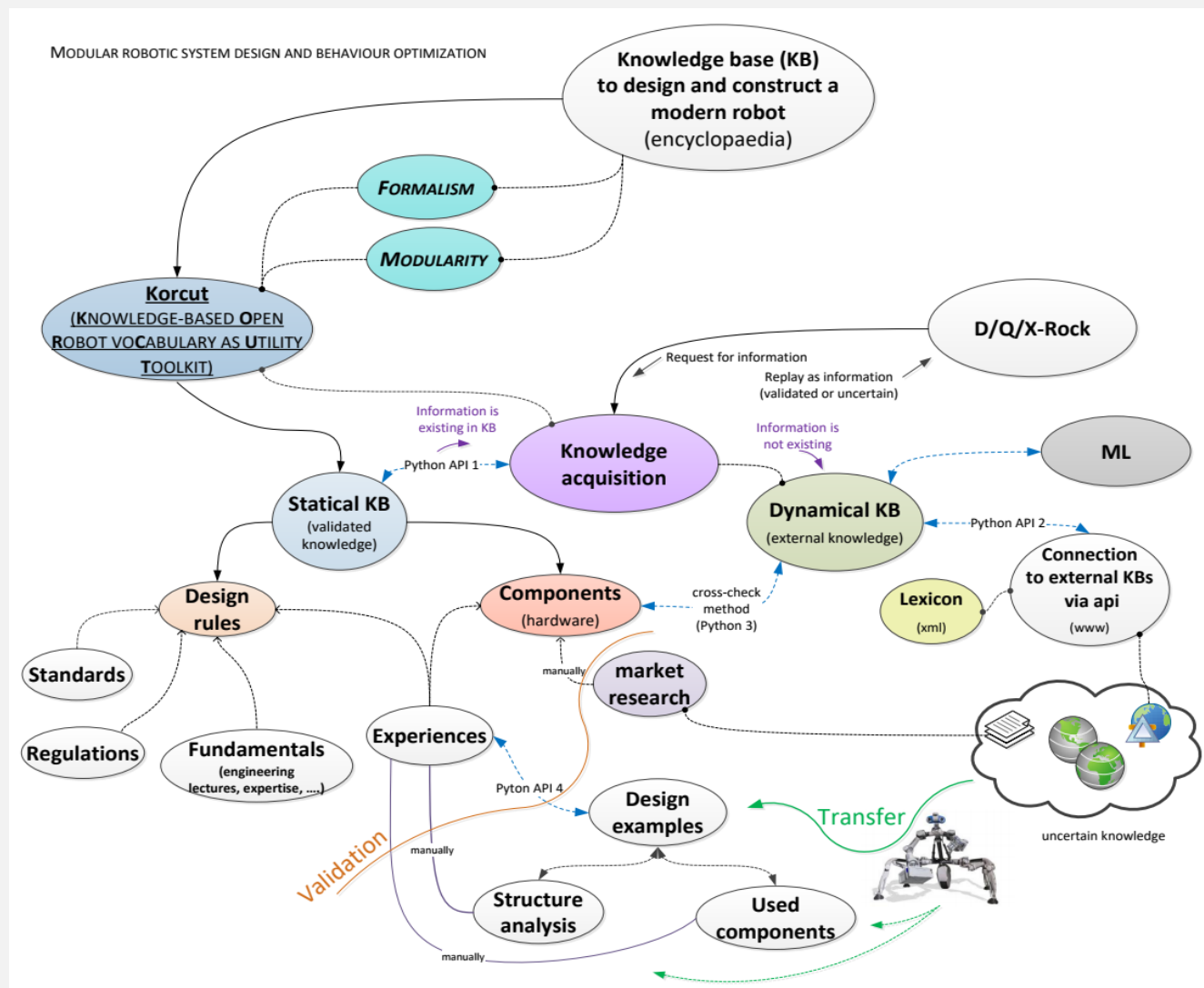
{Robotics} *in field of experimental-agile robot development and execution*

- The **lack of coherence** of the available **interdisciplinary information**
- Difficulties in **creating, transferring, and sharing** specialized or interdisciplinary knowledge in a **standardized way**.
  - The **missing** linking of **concepts** between disciplines, or the facts
- Using particular development tools or hardware capability needs some limitations
  - Filtering out unnecessary data (!!?)
  - Some information is not suitable for common use
- Defined, stored and used internally by several threads several times in different ways
  - Domain dependent in different formats (\*.urdf, \*.smurf, \*.json, ...)
  - In code
- A by human and machine-readable solution



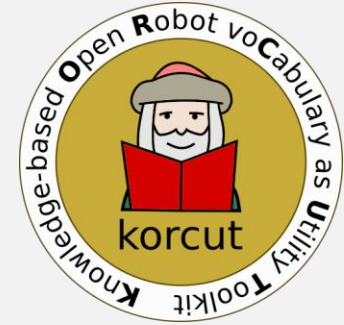
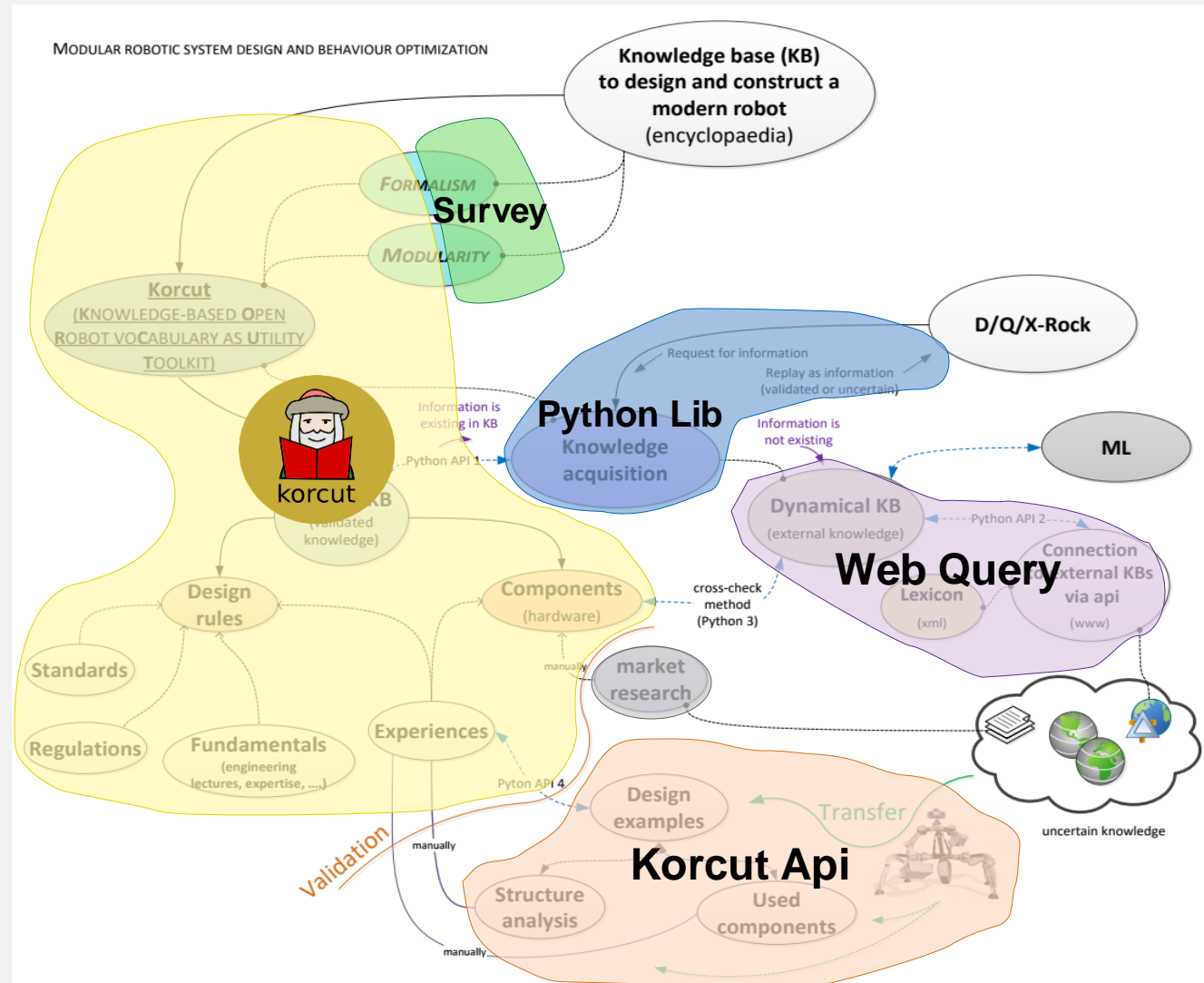
# Korcut – Idea : to support robot design task

(Knowledge-based Open Robot Vocabulary as Utility Toolkit)



# Korcut – Idea : to support robot design task

(Knowledge-based Open Robot Vocabulary as Utility Toolkit)





# Korcut in application - PERIOD ontology

*(Benchmark test results management and evolution)*

## The PERIOD Benchmark for mechanical and electrical domains

- Multi step process
- Practical and repeatable test in the laboratory environment.

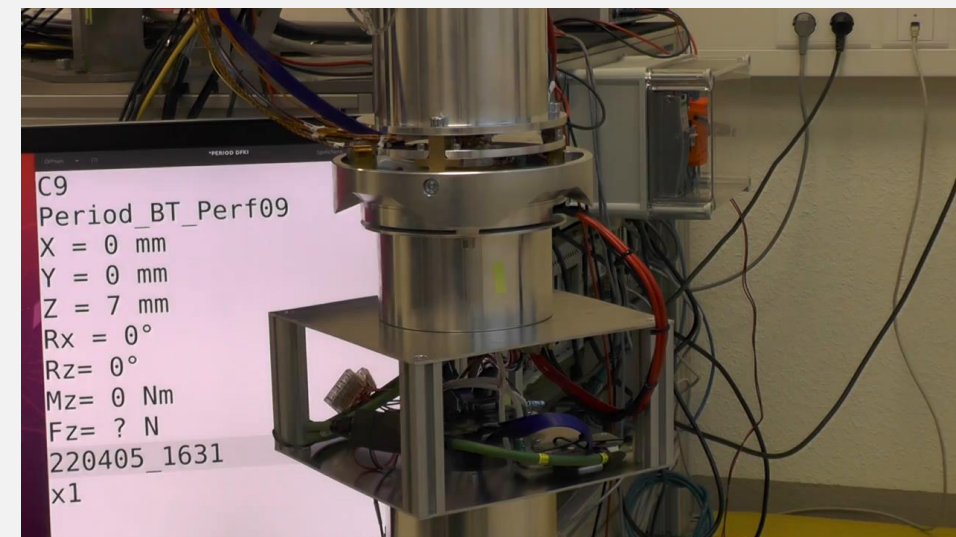
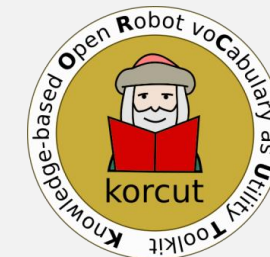
## To compare SI we rank them using the benchmark test metric

- From a mechanical point of view [3],

- **Characterization** of SIs
- **Functional tests** of SIs
- **Performance tests** of SIs:
  - *Capture range*
  - *Misalignment*
  - *Contact retention*
  - *Additional cases (release under load)*

- From an electrical point of view [4],

- **Specification** of SIs
- **Operational tests** of SIs
- **Interference tests** of SIs
- **Recovery tests** of SIs

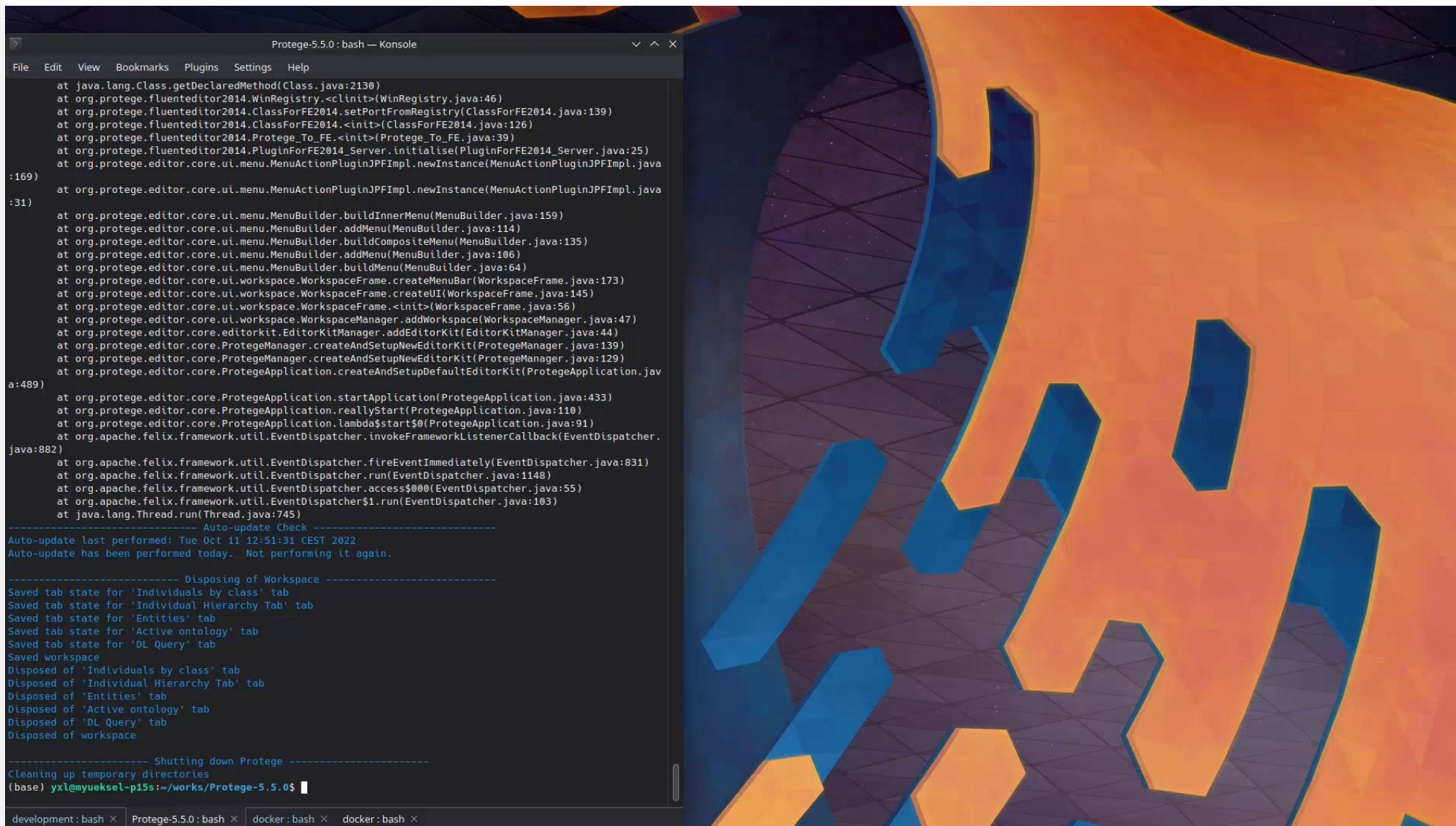


*Release under load test with iSSI®, HOTDOCK and SIROM*

[3] Brinkmann et al., A Standard Interconnect Benchmark for a European In-orbit Services, Manufacturing and Assembly (ISMA) Demonstrator, IAC 2022  
DOI: [10.5281/zenodo.7064066](https://doi.org/10.5281/zenodo.7064066)

[4] Yüksel et al, A methodology for electromechanical evaluation of multifunctional interconnects for on-orbit servicing demonstration, Astra 2022  
DOI: 10.13140/RG.2.2.27983.56484

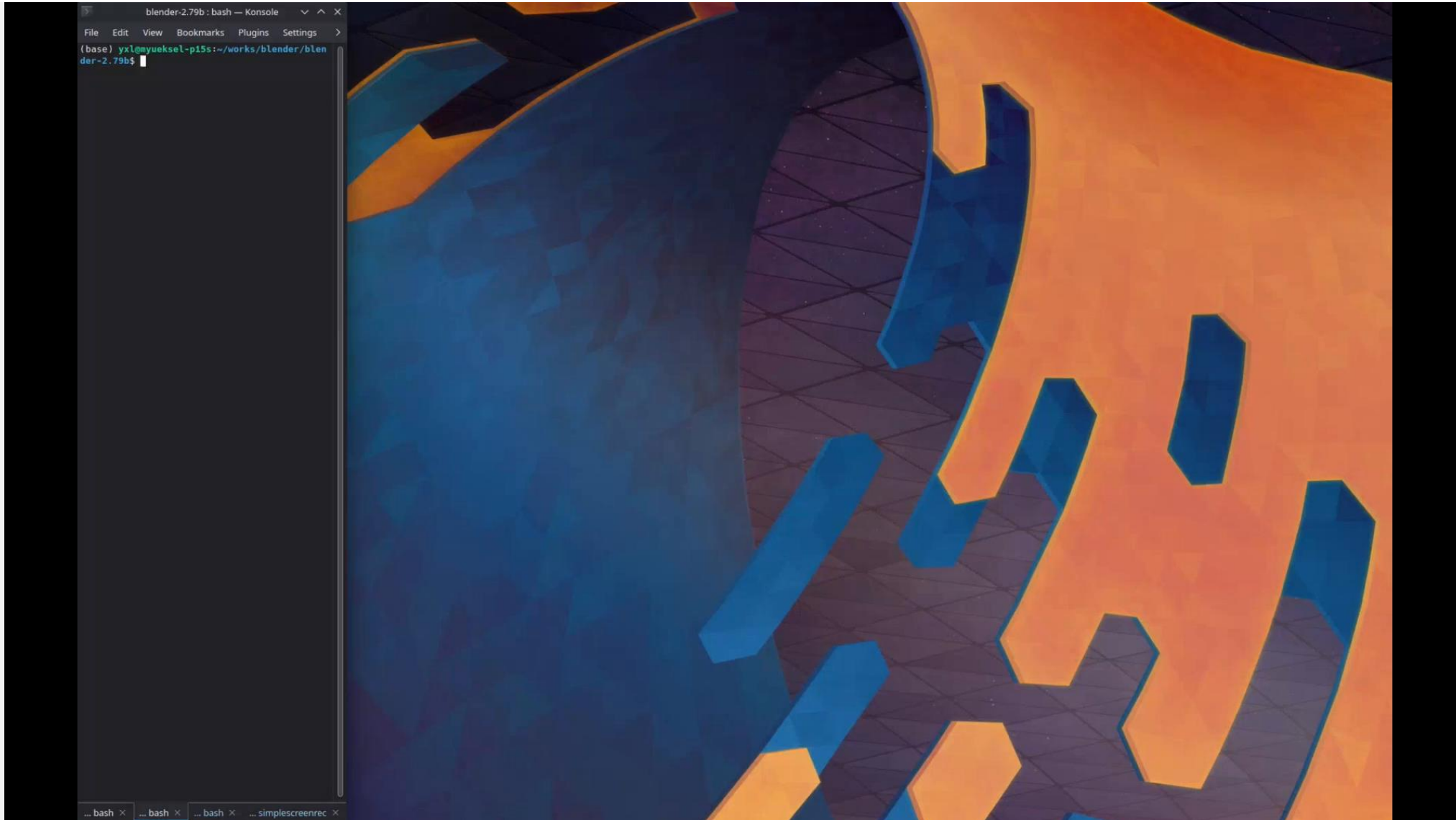
# Korcut in application – Representation of PERIOD Benchmark



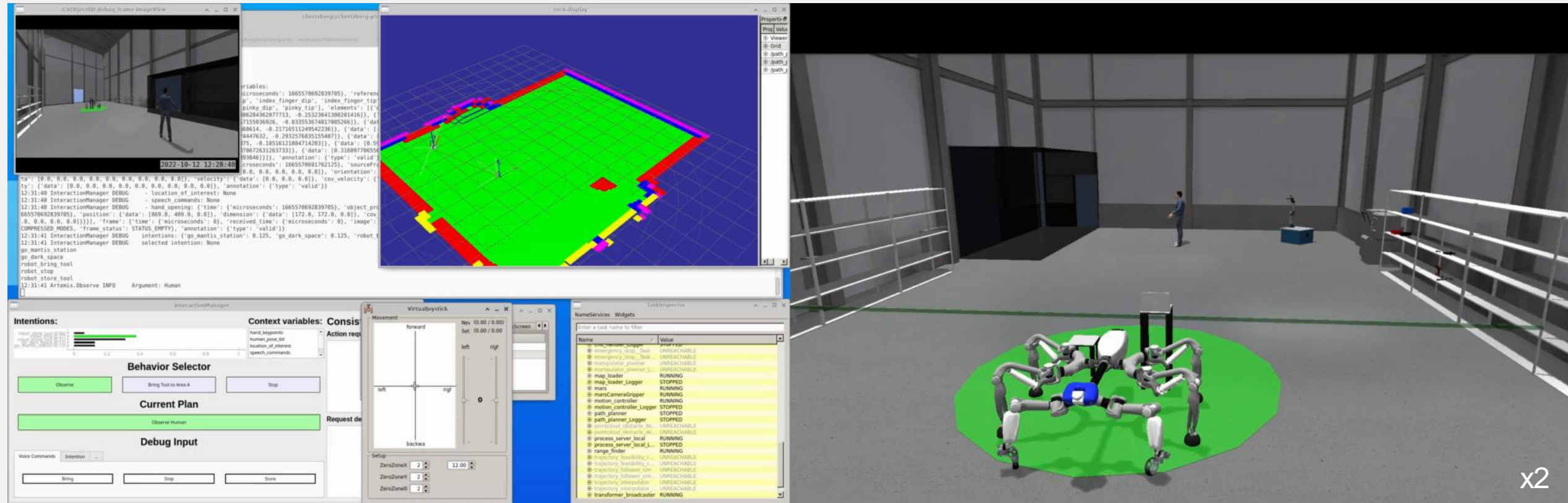
```

Protege-5.5.0: bash — Konsole
File Edit View Bookmarks Plugins Settings Help
at java.lang.Class.getDeclaredMethod(Class.java:2130)
at org.protege.fluenteditor2014.WinRegistry.<clinit>(WinRegistry.java:46)
at org.protege.fluenteditor2014.ClassForFE2014.setPortFromRegistry(ClassForFE2014.java:139)
at org.protege.fluenteditor2014.ClassForFE2014.<init>(ClassForFE2014.java:126)
at org.protege.fluenteditor2014.Protege_To_FE.<init>(Protege_To_FE.java:39)
at org.protege.fluenteditor2014.PluginForFE2014_Server.initialise(PluginForFE2014_Server.java:25)
at org.protege.editor.core.ui.menu.MenuActionPluginJPFImpl.newInstance(MenuActionPluginJPFImpl.java
:169)
at org.protege.editor.core.ui.menu.MenuActionPluginJPFImpl.newInstance(MenuActionPluginJPFImpl.java
:31)
at org.protege.editor.core.ui.menu.MenuBuilder.buildInnerMenu(MenuBuilder.java:159)
at org.protege.editor.core.ui.menu.MenuBuilder.addMenu(MenuBuilder.java:114)
at org.protege.editor.core.ui.menu.MenuBuilder.buildCompositeMenu(MenuBuilder.java:135)
at org.protege.editor.core.ui.menu.MenuBuilder.addMenu(MenuBuilder.java:106)
at org.protege.editor.core.ui.menu.MenuBuilder.buildMenu(MenuBuilder.java:64)
at org.protege.editor.core.ui.workspace.WorkspaceFrame.createMenuBar(WorkspaceFrame.java:173)
at org.protege.editor.core.ui.workspace.WorkspaceFrame.createUI(WorkspaceFrame.java:145)
at org.protege.editor.core.ui.workspace.WorkspaceFrame.<init>(WorkspaceFrame.java:56)
at org.protege.editor.core.ui.workspace.WorkspaceManager.addWorkspace(WorkspaceManager.java:47)
at org.protege.editor.core.editorkit.EditorKitManager.addEditorKit(EditorKitManager.java:44)
at org.protege.editor.core.ProtegeManager.createAndSetupNewEditorKit(ProtegeManager.java:139)
at org.protege.editor.core.ProtegeManager.createAndSetupNewEditorKit(ProtegeManager.java:129)
at org.protege.editor.core.ProtegeApplication.createAndSetupDefaultEditorKit(ProtegeApplication.jav
a:489)
at org.protege.editor.core.ProtegeApplication.startApplication(ProtegeApplication.java:433)
at org.protege.editor.core.ProtegeApplication.reallyStart(ProtegeApplication.java:110)
at org.protege.editor.core.ProtegeApplication.lambda$start$0(ProtegeApplication.java:91)
at org.apache.felix.framework.util.EventDispatcher.invokeFrameworkListenerCallback(EventDispatcher.
java:882)
at org.apache.felix.framework.util.EventDispatcher.fireEventImmediately(EventDispatcher.java:831)
at org.apache.felix.framework.util.EventDispatcher.run(EventDispatcher.java:1148)
at org.apache.felix.framework.util.EventDispatcher.access$000(EventDispatcher.java:55)
at org.apache.felix.framework.util.EventDispatcher$1.run(EventDispatcher.java:103)
at java.lang.Thread.run(Thread.java:745)
----- Auto-update Check -----
Auto-update last performed: Tue Oct 11 12:51:31 CEST 2022
Auto-update has been performed today. Not performing it again.
----- Disposing of Workspace -----
Saved tab state for 'Individuals by class' tab
Saved tab state for 'Individual Hierarchy Tab' tab
Saved tab state for 'Entities' tab
Saved tab state for 'Active ontology' tab
Saved tab state for 'DL Query' tab
Saved workspace
Disposed of 'Individuals by class' tab
Disposed of 'Individual Hierarchy Tab' tab
Disposed of 'Entities' tab
Disposed of 'Active ontology' tab
Disposed of 'DL Query' tab
Disposed of workspace
----- Shutting down Protege -----
Cleaning up temporary directories
(base) yxl@myueksel-p15s:~/works/Protege-5.5.0$
development: bash x Protege-5.5.0: bash x docker: bash x docker: bash x
  
```

# Korcut in application - Ontology driven robotic system design and configuration



# Ontology in application - Ontology supported



x2

# Conclusion

- **korcut** family has been presented in three different perspectives

- Hardware domain
  - Modeling of system and system components
    - **Generic model** for the **mechatronical level** of components
    - **Representing hardware specific data in a uniform and rich way**
  - Design rules of robotic systems
  - Inherit information about system structures
- Software domain
  - **Semantic representation** of necessary prior knowledge
  - Task / mission modeling **dynamic** and **reasonable knowledge**
    - Representation of requirement / capabilities
    - Dynamic querying or traceability for variable use case requirements

- **korcut ontologies provide domain-specific knowledge**

- external experts
- domain internal
- non-experts

- *Outlook:*

- korcut ontologies will be further developed and used for **terrestrial and extraterrestrial robotic domain**.
  - PERIOD ontology can be used for the development of standards within the European Operation Framework.

# Thank you for your attention!

## Questions?

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