

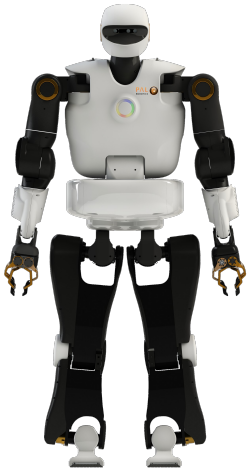
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# HOW to design ROS-powered robots

Luca Marchionni, CTO at PAL Robotics

September 22, Vancouver

ROSCon 2017

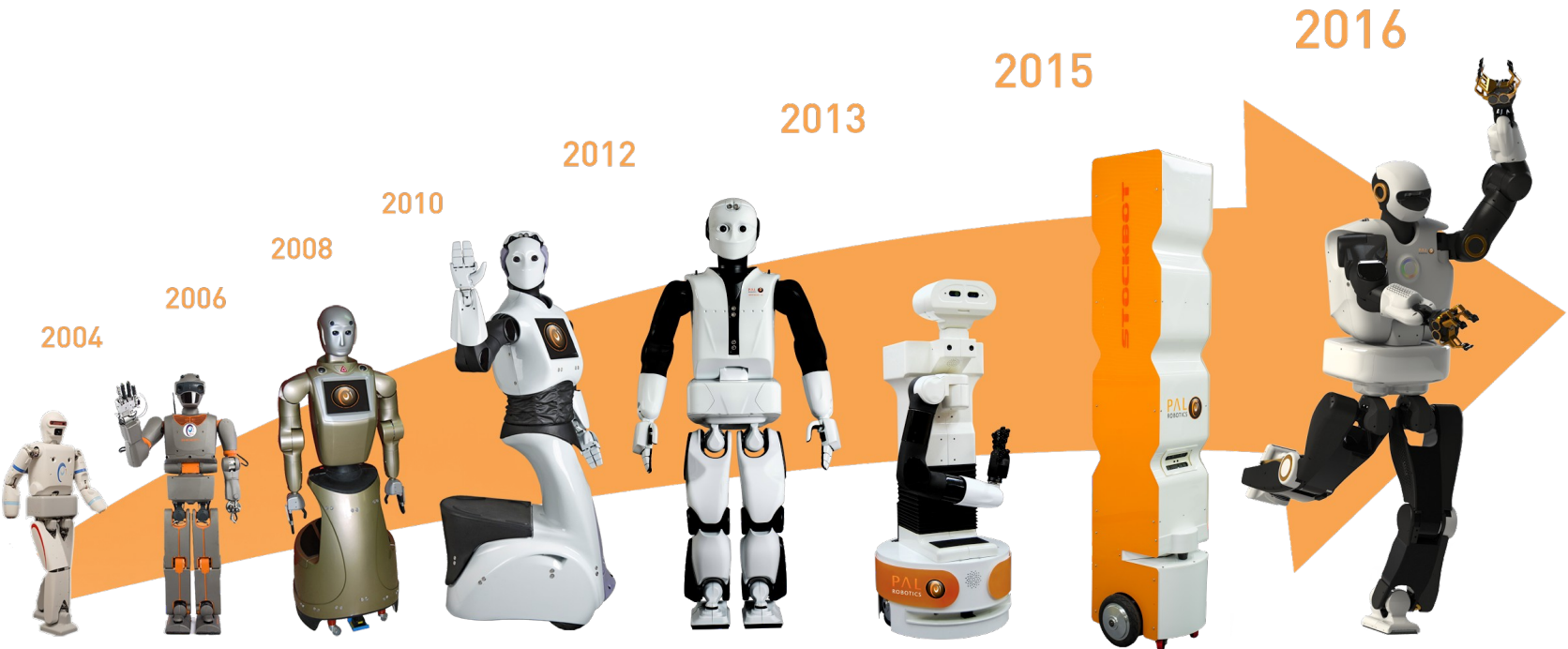


# Outline

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- ✓ PAL Robotics
- ✓ Software overview and deployment
- ✓ Continuous integration
- ✓ Software release system
- ✓ Control architecture
- ✓ Whole Body Control
- ✓ Space Robotics Challenge

# PAL Robotics in a nutshell



# Partners and customers

**SIE**  
**Factory in a Day**  
**growmeup**  
**ENRICH me**  
**RobMoSys**  
**4Robots**  
**EUROPEAN ROBOTICS LEAGUE**  
 Brought to you by SPARC  
**PAL ROBOTICS**

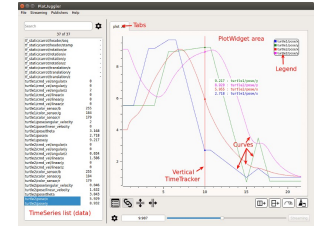
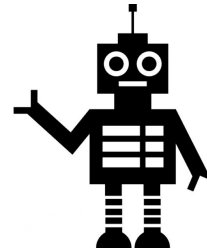
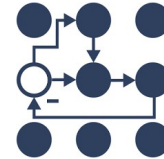


# Why do we use ROS?

- Shorten time to market
- Selling argument
- Leverage powerful development tools
- If you have the code, you can improve it
- Share the effort with community
- Contribute to create “standards”
- Build value, focus on core IP



GAZEBO



# Public repositories

*REEM*



[wiki.ros.org/Robots/REEM](http://wiki.ros.org/Robots/REEM)

[wiki.ros.org/Robots/REEM/Tutorials](http://wiki.ros.org/Robots/REEM/Tutorials)

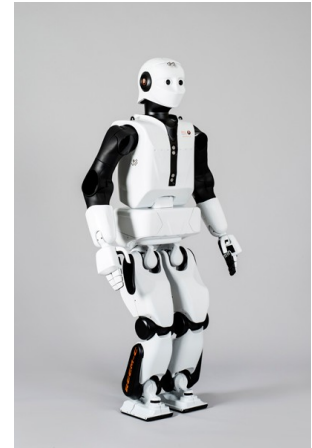
*TIA GO*



[wiki.ros.org/Robots/TIAGo](http://wiki.ros.org/Robots/TIAGo)

[wiki.ros.org/Robots/TIAGo/Tutorials](http://wiki.ros.org/Robots/TIAGo/Tutorials)

*REEM-C*



[wiki.ros.org/Robots/REEM-C](http://wiki.ros.org/Robots/REEM-C)

[wiki.ros.org/Robots/REEM-C/Tutorials](http://wiki.ros.org/Robots/REEM-C/Tutorials)



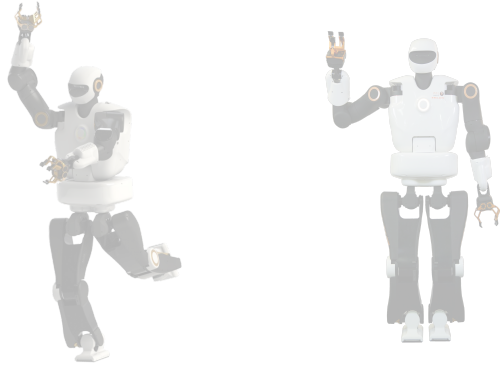
<https://github.com/pal-robotics>

72 repositories

<https://github.com/pal-robotics-forks>

60 repositories

# Public repositories (coming soon)



**TALOS**



- ✓ New generation of biped robot
- ✓ Advanced mobility and manipulation skills for industrial tasks
- ✓ Full torque controllable robot
- ✓ EtherCAT communication bus
- ✓ High power/speed actuators
- ✓ 6 Kg arm payload



# Software overview

	Stable	Work in progress	Future?
Operating System	<ul style="list-style-type: none"><li>● Ubuntu 14.04 LTS 64-bit</li><li>● Xenomai real-time</li><li>● Linux Preemp-rt</li></ul>	<ul style="list-style-type: none"><li>● Ubuntu 16.04 LTS 64-bit</li><li>● Linux Preemp-rt</li></ul>	<ul style="list-style-type: none"><li>● <b>Linux Real Time</b></li></ul>
Robotics middleware	<ul style="list-style-type: none"><li>● Orocos 2.8</li><li>● ROS Indigo</li><li>● PAL Dubnium</li></ul>	<ul style="list-style-type: none"><li>● Orocos 2.8</li><li>● ROS Kinetic</li><li>● PAL Erbium</li></ul>	<ul style="list-style-type: none"><li>● <b>ROS 2.0</b></li><li>● <b>PAL Fermium</b></li></ul>



# Software deployment

---



- Add/Overlay packages to a robot
- Validate package installation rules
- Discourage file editing on robot
- Multiple workspaces
- Test before release
- Restore original package version

# Software deployment

---



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# Software deployment

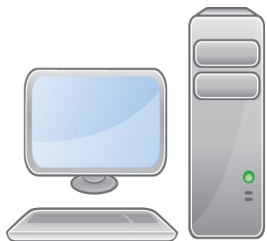


- Add/Overlay packages to a robot
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`/opt/ros/indigo`

# Software deployment

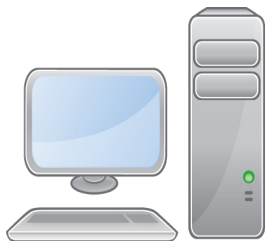


- Add/Overlay packages to a robot
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**/opt/pal/dubnium**

**/opt/ros/indigo**

# Software deployment



- Add/Overlay packages to a robot
- Validate package installation rules
- Discourage file editing on robot
- Multiple workspaces
- Test before release
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**/home/pal/deployed\_ws**

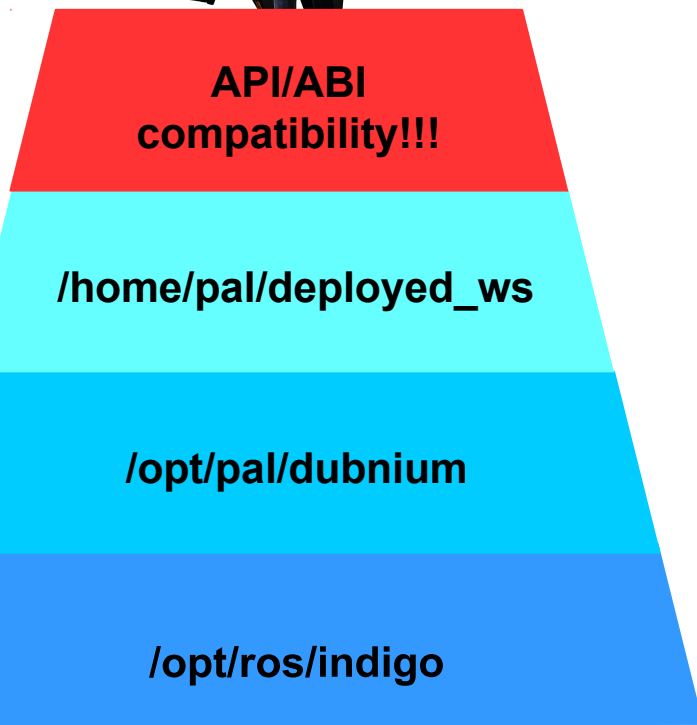
**/opt/pal/dubnium**

**/opt/ros/indigo**

# Software deployment



- Add/Overlay packages to a robot
- Validate package installation rules
- Discourage file editing on robot
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# Continuous integration



# Jenkins

Name	Last Success	Last Failure	Last Duration
ISO-pat_deploy_rtd_www-dubium-devel_dubium	2 hr 17 min - #2	N/A	1 min 5 sec
ISO-Test-Merge-Request	3 hr 4 min - #820	8 days 8 hr - #812	5 min 25 sec
CS20-dubium_stage_pat-inventory-andrer-browseby_trusty_arm64	4 hr 51 min - #8	N/A	1 min 58 sec
CS20-dubium_stage_pat-inventory-andrer-browseby_trusty_arm64	4 hr 53 min - #2	N/A	1 min 51 sec
ISO-pat_inventory_andrer-master_dubium	4 hr 55 min - #30	15 days - #23	2 min 28 sec
R502-Trigger-stable-build	4 hr 56 min - #523	N/A	2 min 46 sec
R501-release-stable	4 hr 57 min - #1209	15 days - #1205	43 sec
R500-Release	8 hr 20 min - #2133	5 days 21 hr - #2131	3 min 2 sec
ISO-pat_collect-dubium-devel_dubium	8 hr 23 min - #21	1 mo 20 days - #20	3 min 5 sec
ISO-lake_robot-dubium-devel_dubium	2 days 0 hr - #15	N/A	1 min 19 sec
ISO-lake_simulation-dubium-devel_dubium	2 days 0 hr - #13	20 days - #7	1 min 39 sec
D20-dubium_staging_halo-moment-core-browseby_trusty_arm64	2 days 6 hr - #1	N/A	1 min 6 sec
R501-Trigger-build	2 days 6 hr - #2712	N/A	1 min 33 sec
R501-release	2 days 6 hr - #3186	5 days 21 hr - #3179	39 sec
D20-dubium_staging_halo-simulation-browseby_trusty_arm64	2 days 9 hr - #5	20 days - #4	1 min 45 sec
D20-dubium_staging_halo-inbox-browseby_trusty_arm64	2 days 9 hr - #3	N/A	1 min 22 sec
D20-dubium_staging_pat-core-browseby_trusty_arm64	5 days 5 hr - #11	1 yr 0 mo - #1	3 min 16 sec
D20-dubium_staging_halo-1-specific-browseby_trusty_arm64	5 days 6 hr - #5	N/A	2 min 47 sec
ISO-tag_1_specific-master_dubium	5 days 9 hr - #11	6 days 4 hr - #2	3 min 10 sec
D20-dubium_staging_ghon-response-core-browseby_trusty_arm64	5 days 13 hr - #16	21 days - #12	1 min 23 sec
D20-dubium_staging_pat-led-manager-browseby_trusty_arm64	5 days 13 hr - #5	22 days - #3	1 min 59 sec

- Builds in clean environment
- Unit testing
- Coverage
- API/ABI check
- Functional testing

# Continuous integration



# Jenkins



Notify developers and maintainers if:

- Compilation error
- Test failure
- Coverage below 70%
- API/ABI breaking

Name	Last Success	Last Failure	Last Duration
90-pal_deploy_rob_tasks_dubium-devel_dubium	2 hr 17 min - #2	N/A	1 min 6 sec
90-Test-Merge-Request	3 hr 4 min - #820	8 days 9 hr - #812	5 min 25 sec
CS20-dubium_stable_pal_inventory_andres_bonayeb_trusty_arm64	4 hr 51 min - #8	N/A	1 min 58 sec
CS20-dubium_stable_pal_inventory_andres_bonayeb_trusty_arm64	4 hr 53 min - #2	N/A	1 min 51 sec
90-pal_inventory_andres_bonayeb_dubium	4 hr 55 min - #30	15 days - #23	2 min 28 sec
RS02-Trigger-stable-build	4 hr 56 min - #523	N/A	2 min 46 sec
RS01-release-stable	4 hr 57 min - #1209	15 days - #1205	43 sec
ROS-PreRelease	8 hr 20 min - #2133	5 days 21 hr - #2131	3 min 2 sec
90-pal_collect_dubium-devel_dubium	8 hr 23 min - #21	1 mo 20 days - #20	3 min 5 sec
90-lake_robot_dubium-devel_dubium	2 days 0 hr - #15	N/A	1 min 19 sec
90-lake_simulation_dubium-devel_dubium	2 days 0 hr - #13	20 days - #7	1 min 39 sec
D20-dubium_staging_halo-event-config_bonayeb_trusty_arm64	2 days 6 hr - #1	N/A	1 min 6 sec
ROS-Trigger-build	2 days 6 hr - #2712	N/A	1 min 33 sec
ROS-release	2 days 6 hr - #3186	5 days 21 hr - #3179	39 sec
D20-dubium_staging_halo-simulation_bonayeb_trusty_arm64	2 days 9 hr - #5	20 days - #4	1 min 45 sec
D20-dubium_staging_halo-robot_bonayeb_trusty_arm64	2 days 9 hr - #3	N/A	1 min 22 sec
D20-dubium_staging_pal-con_bonayeb_trusty_arm64	5 days 5 hr - #14	1 yr 0 mo - #4	3 min 16 sec
D20-dubium_staging_halo-1-specific_bonayeb_trusty_arm64	5 days 9 hr - #5	N/A	2 min 47 sec
90-8-pal_1_specific_pal_dubium	5 days 9 hr - #11	6 days 4 hr - #2	3 min 10 sec
D20-dubium_staging_photon-robotic-con_bonayeb_trusty_arm64	5 days 13 hr - #16	21 days - #12	1 min 23 sec
D20-dubium_staging_pal-led-manager_bonayeb_trusty_arm64	5 days 13 hr - #5	22 days - #3	1 min 59 sec

Run it on master/develop branch  
(GitFlow branching model)



# Continuous integration

Jeremie Deray @jeremiederay added 1 commit 2 weeks ago

- fe56d1f3 - moar tests

[Compare with previous version](#)



PAL Bot @anonymous commented 2 weeks ago

Reporter



<b>extend-tests</b>	build <b>stable</b>	tests <b>34/34</b>	C++ coverage <b>99%</b>	Py coverage --	API <b>compatible</b>	ABI <b>compatible</b>
<b>master</b>	build <b>success</b>	tests <b>22/22</b>	C++ coverage <b>88%</b>	Py coverage --	API No Info	ABI No Info

Build details in: <http://venus:8080/job/I50-Test-Merge-Request/1840/>

Edited less than a minute ago by Victor Lopez



Jeremie Deray @jeremiederay commented 2 weeks ago

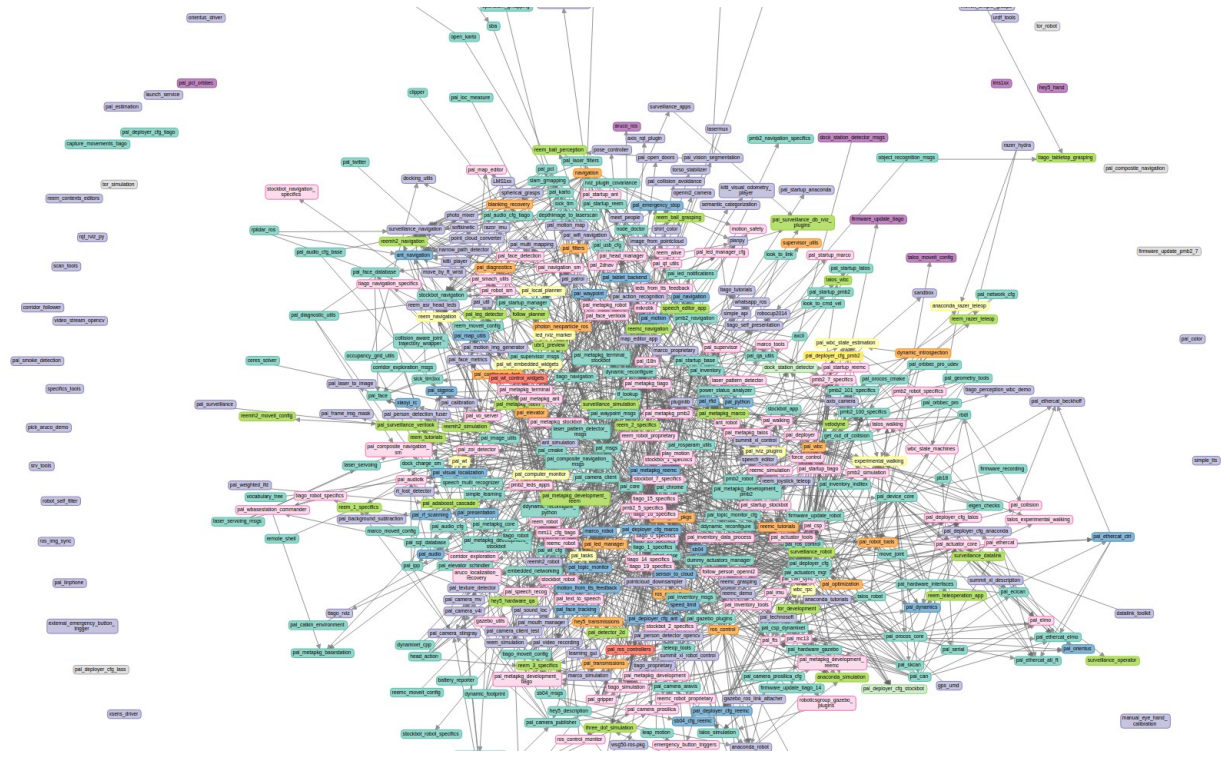
Master



As pointed by @victor giving the `PropertyBag` a name may not be of any use... @victor @hilariotome let me know your opinion before I remove it from this PR.

# Software release system

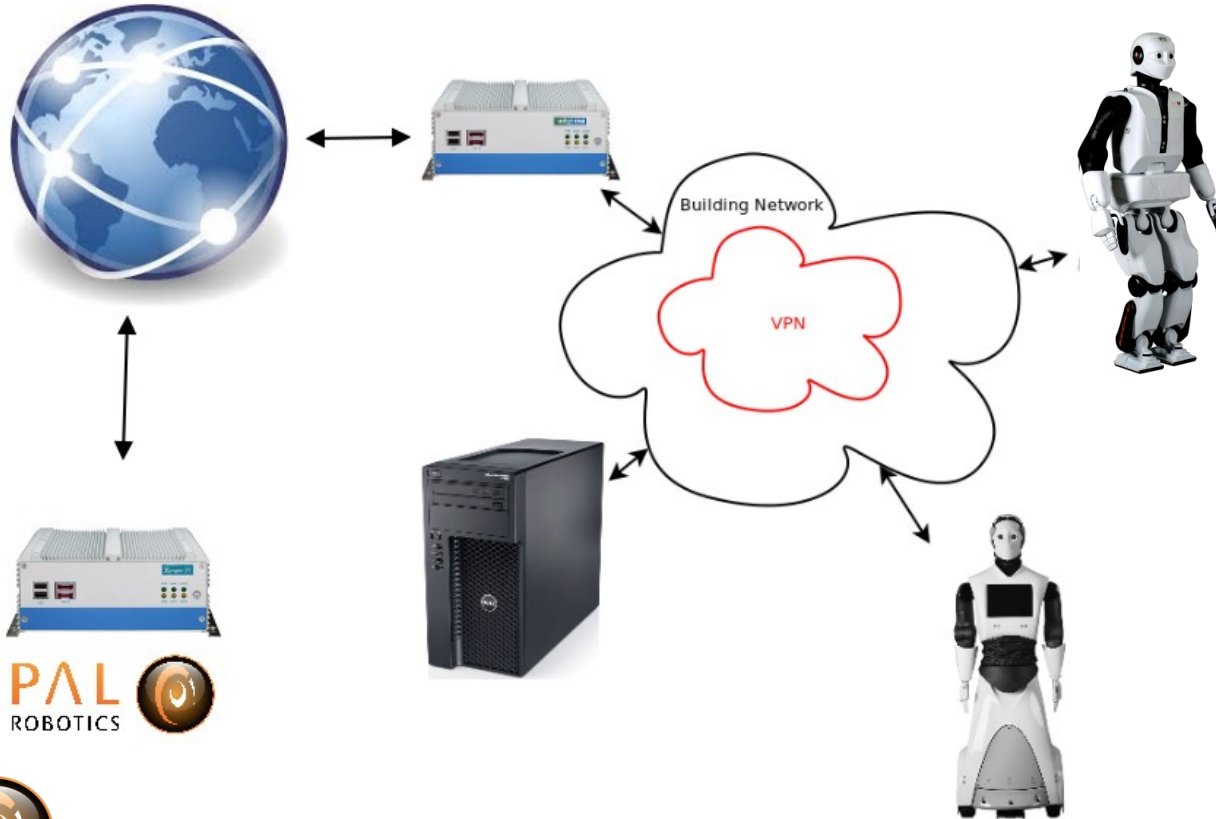
- unreleased-releasable
- upgradable-unreleasable
- updated-releasable
- broken-releasable
- broken-unreleasable
- updated-unreleasable
- unreleased-unreleasable
- upgradable-releasable
- unreleased
- updated
- upgradable
- broken







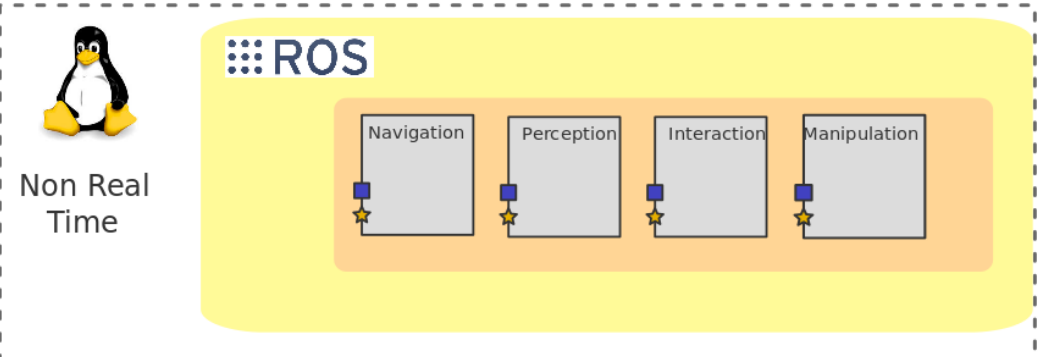
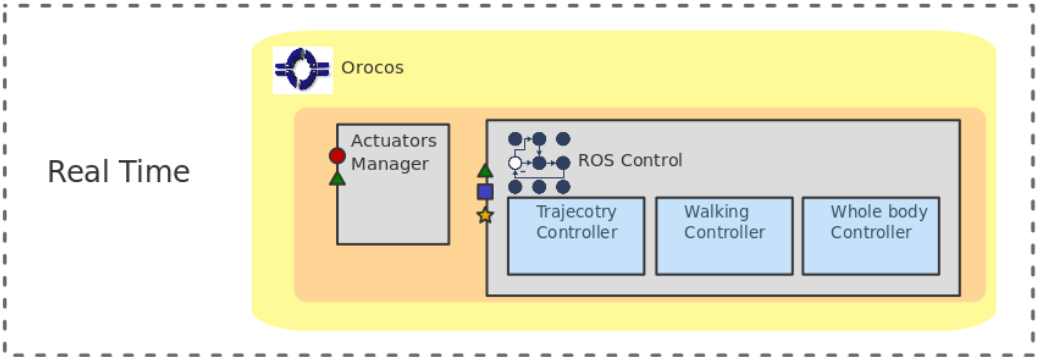
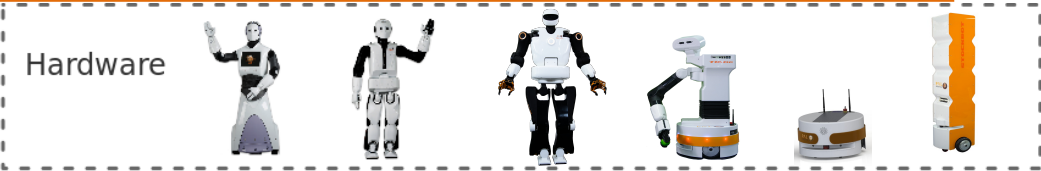
# Software release system



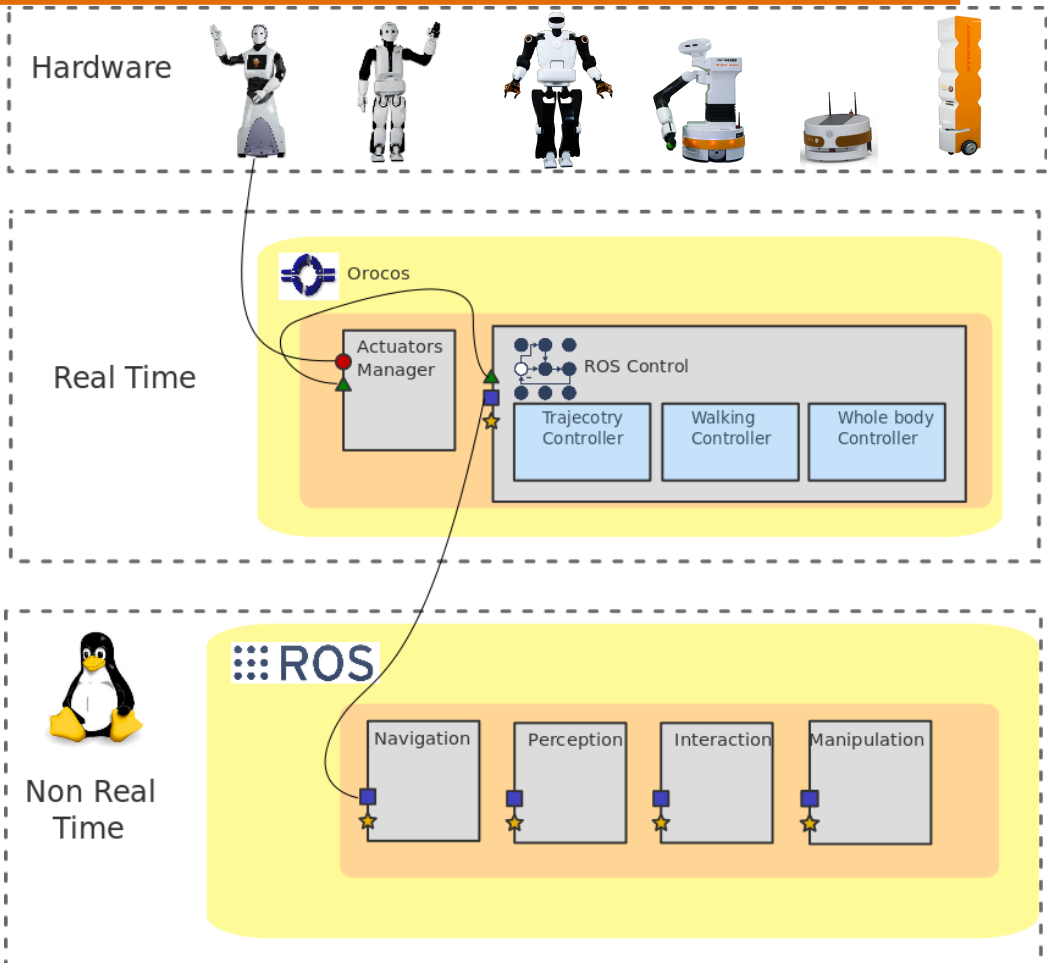
PAL  
ROBOTICS

PAL  
ROBOTICS

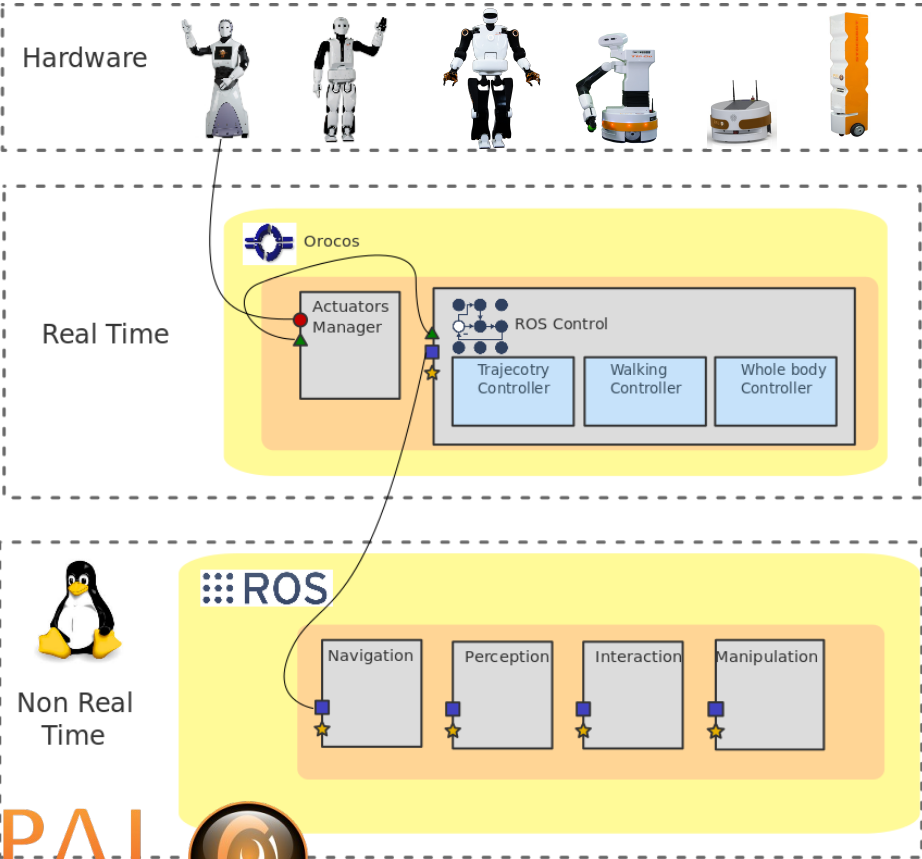
# Control architecture



# Control architecture



# Control architecture



## Why?

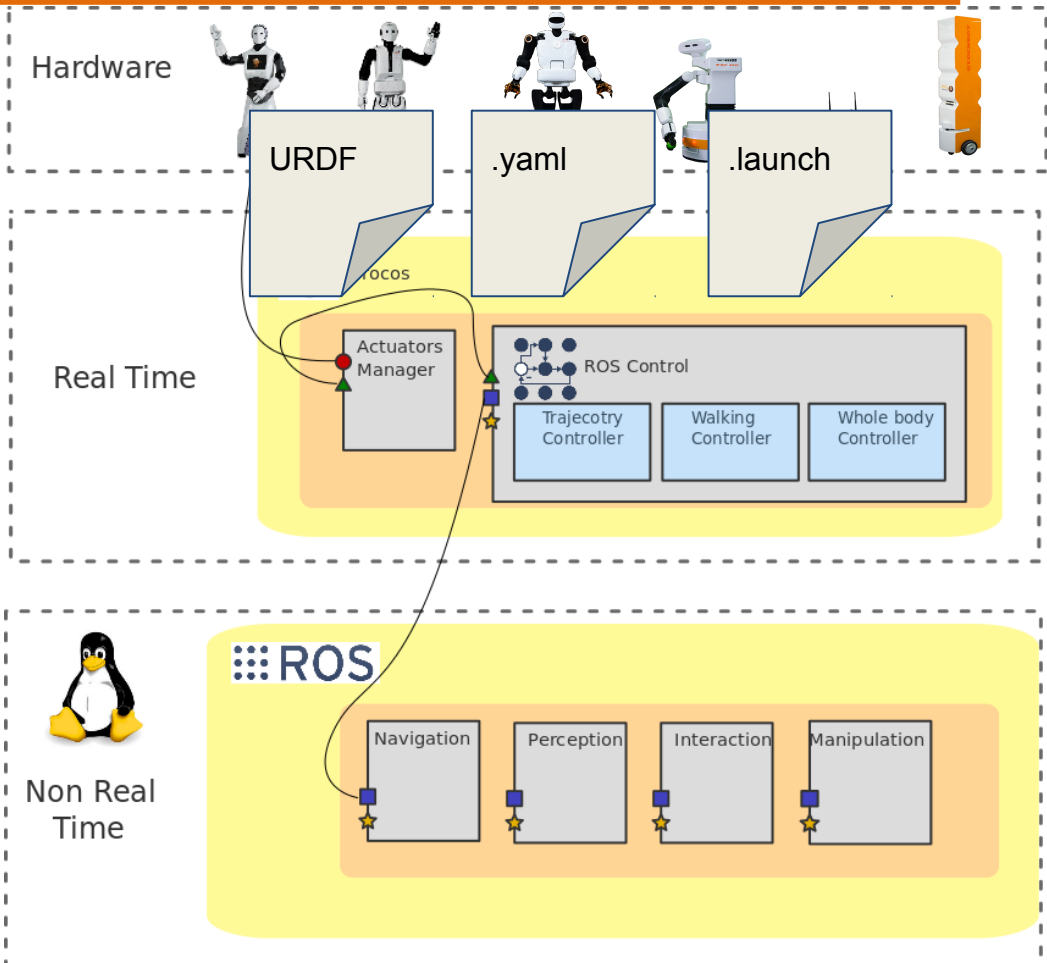
- Hardware needs real time communication
- Controllers need determinism regardless of system load

## How?

- Xenomai co-kernel or Preempt-RT patch
- Never block the real time thread!



# Control architecture



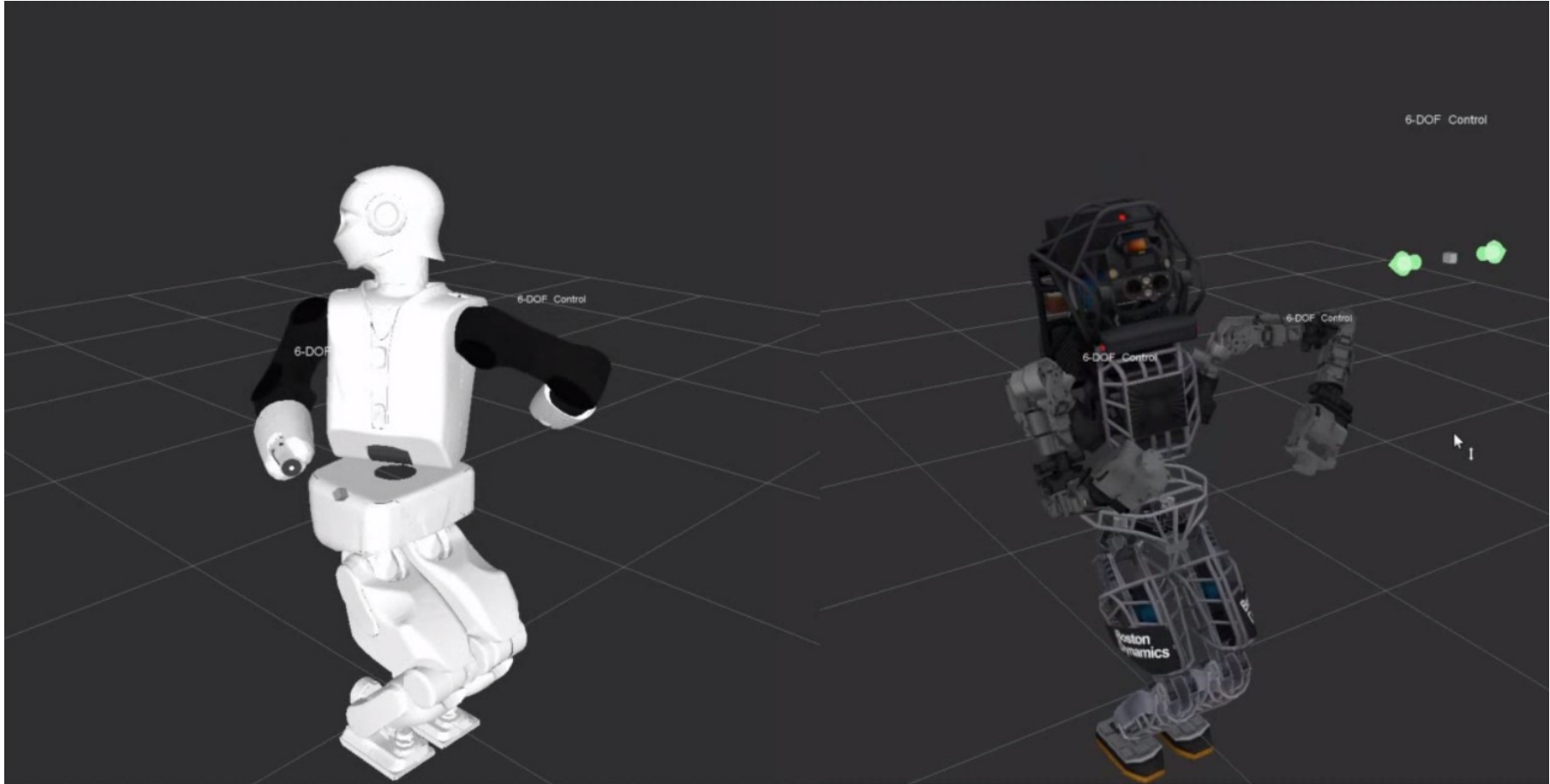
# Whole body control

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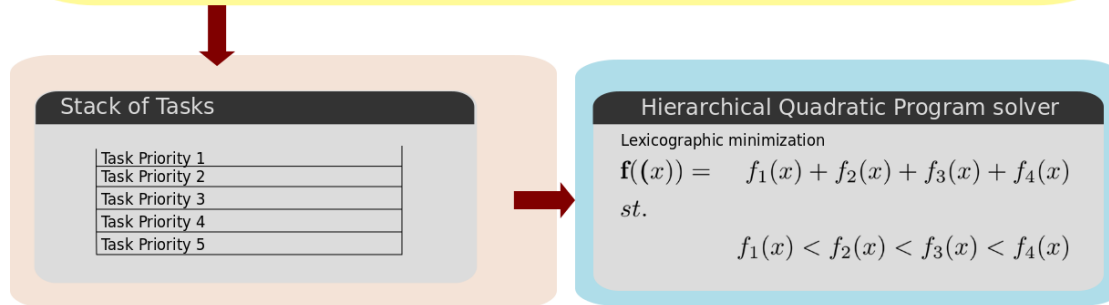
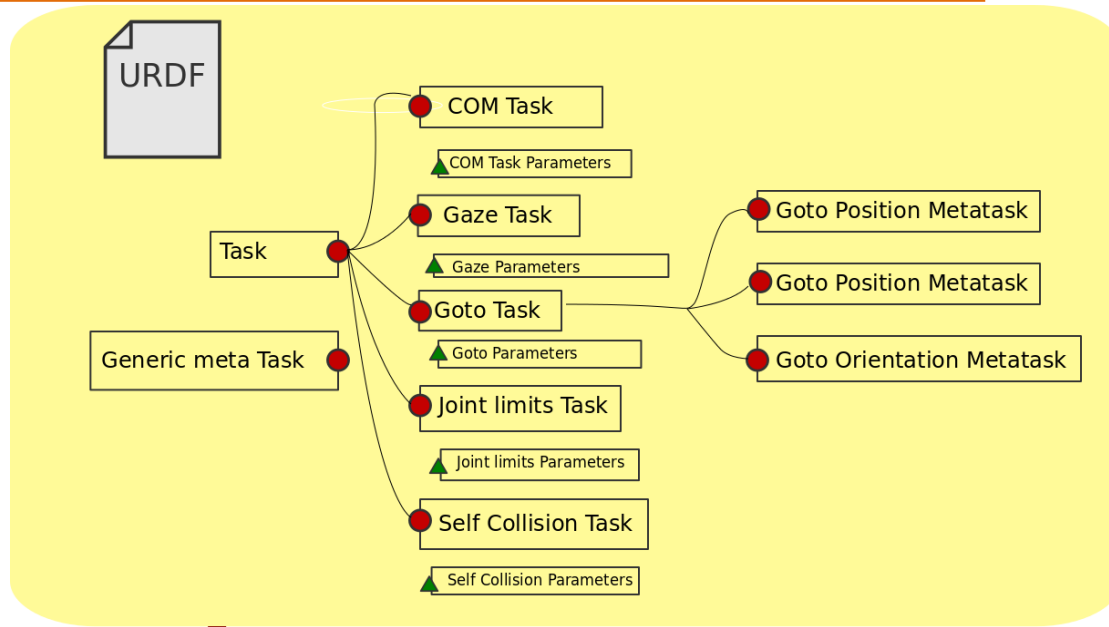
- 1) set of simple, low-dimensional rules
- 2) the rules are sufficient to guarantee the correct execution of any single task or of simultaneous multiple tasks
- 3) exploiting the full capabilities of the entire body of redundant, floating-based robots in compliant multi-contact interaction with the environment

source: <http://www.ieee-ras.org/whole-body-control>

# Whole body control




# Whole body control



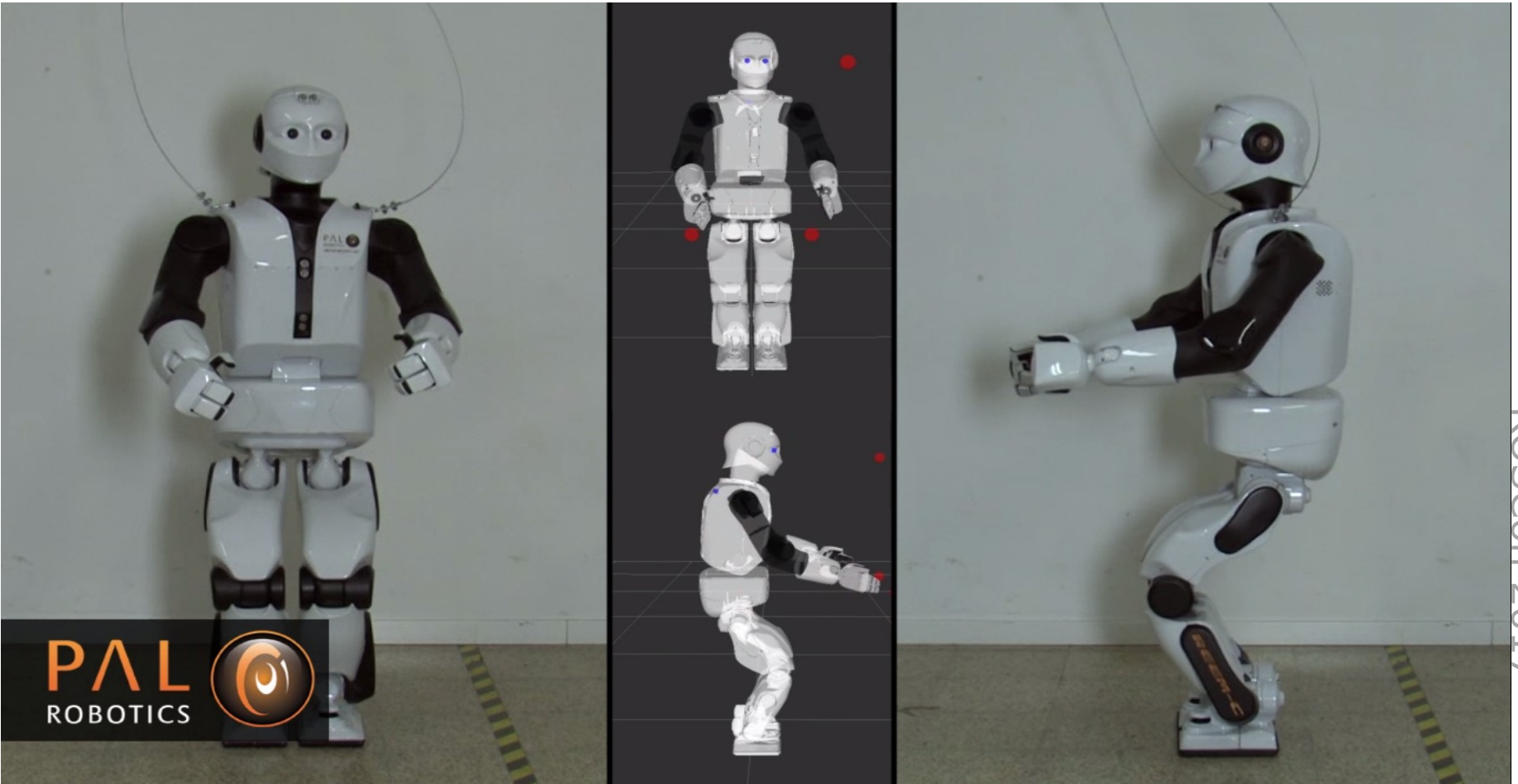
# Whole body control

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Stack of Tasks	
High priority	Joint limits
	Self collision avoidance
	Fixed feet + CoM centered
	Gaze
	Hands position
	Torso orientation upright
Low priority	Joint reference posture



# Whole body control



**PAL**  
ROBOTICS



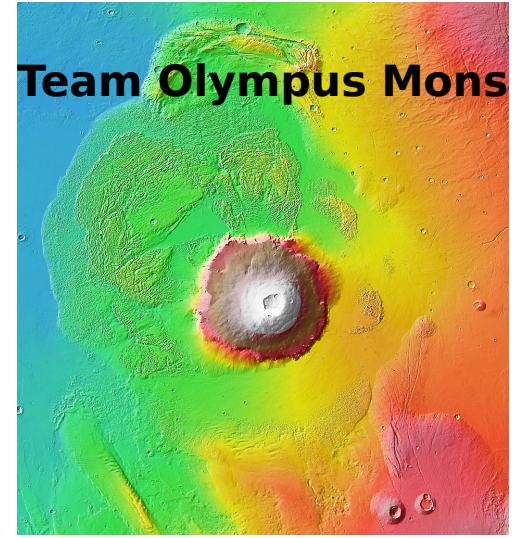
# Whole body control



**PAL**  
ROBOTICS



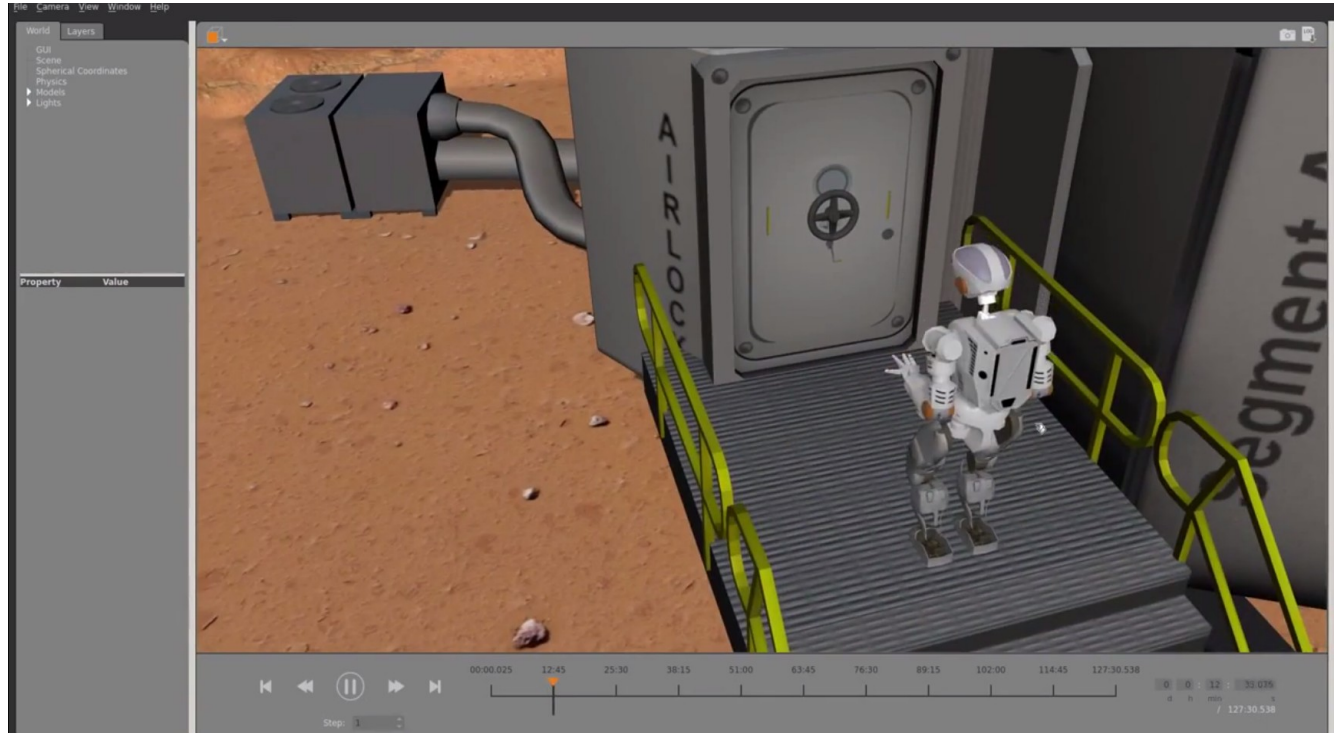
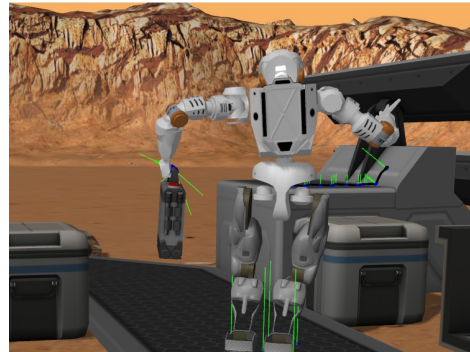
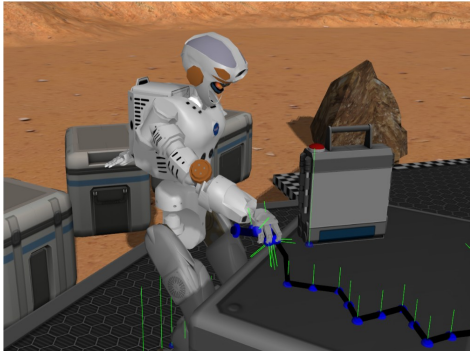
# Space Robotics Challenge



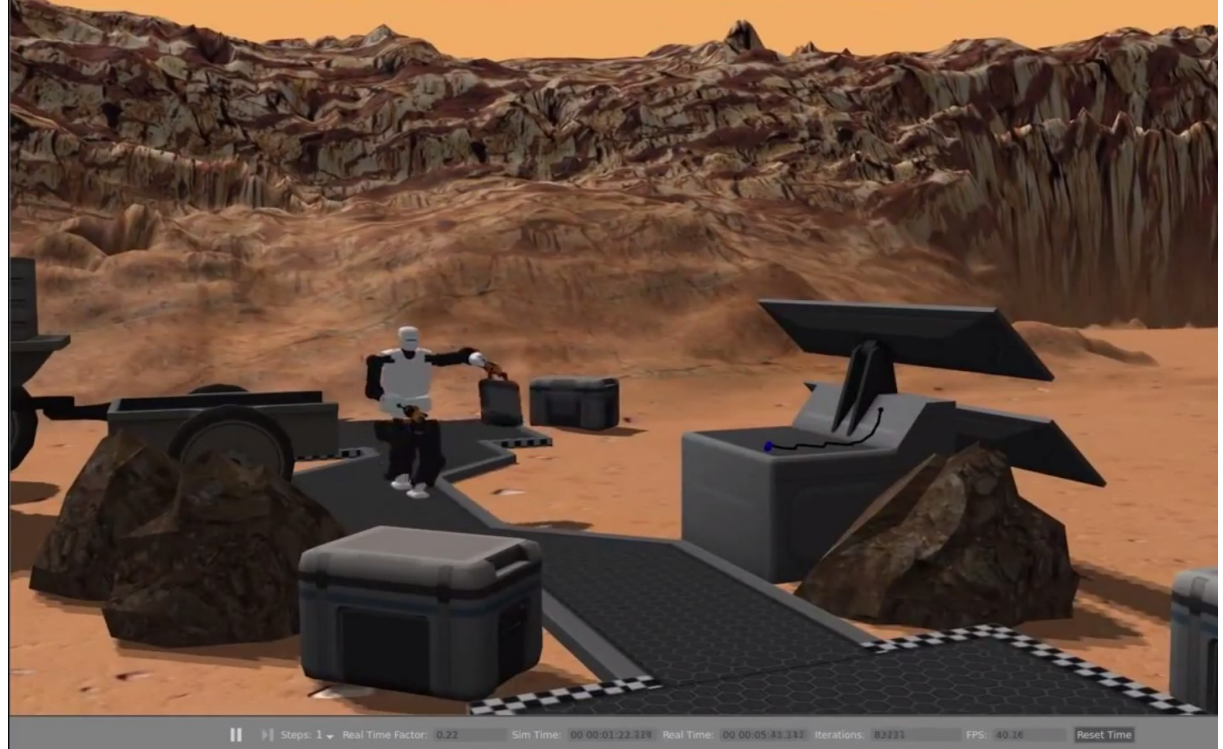
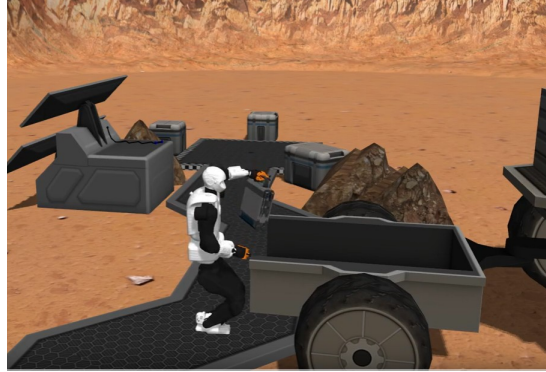
- 440 inscribed teams, 20 finalists
- Control Valkyrie robot in simulated Mars mission
- Team composed by current and former PAL employees
- Ineligible for prize, motivated by passion for robotics



# Space Robotics Challenge



# TALOS Robotics Challenge (work in progress)



# Thank you ROS community!!!



[www.pal-robotics.com](http://www.pal-robotics.com)

