INTEGRATING ROS INTO NASA SPACE EXPLORATION MISSIONS

**Now**
Using the International Space Station

**2020s**
Operating in the Lunar Vicinity (proving ground)

**Phase 0**
Continue research and testing on ISS to solve exploration challenges. Evaluate potential for lunar resources. Develop standards.

**Phase 1**

**Phase 2**
Complete Deep Space Transport and conduct yearlong Mars simulation mission.

**After 2030**
Leaving the Earth-Moon System and Reaching Mars Orbit

**Phases 3 and 4**
Begin sustained crew expeditions to Martian system and surface of Mars.

HTTPS://WWW.NASA.GOV/JOHNSON/EXPLORATION/DEEP-SPACE
FUTURE EXPLORATION MISSIONS

- Lunar Proving Grounds
- Deep Space Gateway
- Surface Operations
- Mars and Other Worlds
- In-Orbit Habitats
- On-Surface Habitats
- Science Scouting
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ROBOTICS AND AUTONOMOUS SYSTEMS

- As precursors to crewed missions
- As crew helpers in space
- As caretakers of assets sent ahead or left behind
- Capabilities will be extended in:
  - Sensing and Perception
  - Mobility
  - Manipulation
  - Human-System Interaction
  - System-Level Autonomy

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CURRENT ROBOTICS AND AUTONOMOUS SYSTEMS USING ROS

Astrobee
Dragonfly
ARC

AutoNav
μAVs
Rovers
JPL

Robonaut2
Valkyrie
JSC

RP
LaRC
GSFC

ADP
TALISMAN
HIGHLIGHT: AFFORDANCE TEMPLATES

Originally developed to support *Valkyrie* during the DARPA Robotics Challenge.

Improved in recent *Robonaut2* autonomous resupply demonstration.

HTTP://IEEEXPLORE.IEEE.ORG/DOCUMENT/7140073 — HTTP://IEEEXPLORE.IEEE.ORG/DOCUMENT/8206229
HIGHLIGHT: RESOURCE PROSPECTOR

- Joint project between ARC and JSC, developing future science rover technologies.
- Mobility and sensor development based on advanced Gazebo simulations.
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ROS INTEGRATION: ADVANTAGES

- Enables external organizations to collaborate more easily with NASA labs
- ROS is easy to get, use, and it's free!
- Students and researchers are already familiar with ROS
- Plenty of functionality right out of the box
  - "Core ROS" packages provide solutions to common problems
  - Large, active community of developers and researchers provide solutions for many areas of research
- Adding functionality is natural
  - ROS is designed to support adding functionality in a modular way
  - Projects can easily mix community and custom solutions, enabling rapid prototyping and development

HTTPS://WWW.YOUTUBE.COM/CHANNEL/UC0PRF6EBGFCFHC GG MUCG3RG
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ROS INTEGRATION: DISADVANTAGES

- NASA software development requirements can make using ROS on safety-critical systems a challenge.
- NPR 7150.2B and NASA-GB-8719.13
- Some products in “Core ROS” simply don’t meet the needs of the flight community.
- No reliable communication over degraded networks.
- Real-time determinism is questionable.
- Limited or no support for embedded hardware and operating systems.
- Some existing domain solutions aren’t easily portable to ROS’ way of doing business.

NPR 7150.2B, Section 3.9, regarding the use of COTS/GOTS/MOTS software.

- The requirements to be met by the software component are identified.
- The software component includes documentation to fulfill its intended purpose (e.g., usage instructions).
- Proprietary rights, usage rights, ownership, warranty, licensing rights, and transfer rights have been addressed.
- Future support for the software product is planned and adequate for project needs.
- The software component is verified and validated to the same level required to accept a similar developed software component for its intended use.
- The project has a plan to perform periodic assessments of vendor reported defects to ensure the defects do not impact the selected software components.
The “up and coming” flight software system at NASA is the in-house and open-source Core Flight Software.

Provides an environment for real-time execution of C and C++ code, plus some common utilities.

Prototypes in work to get CFS and ROS to share data.

Initial success with the “bridge” approach. Next up is native support for ROS comm within CFS.
THANK YOU