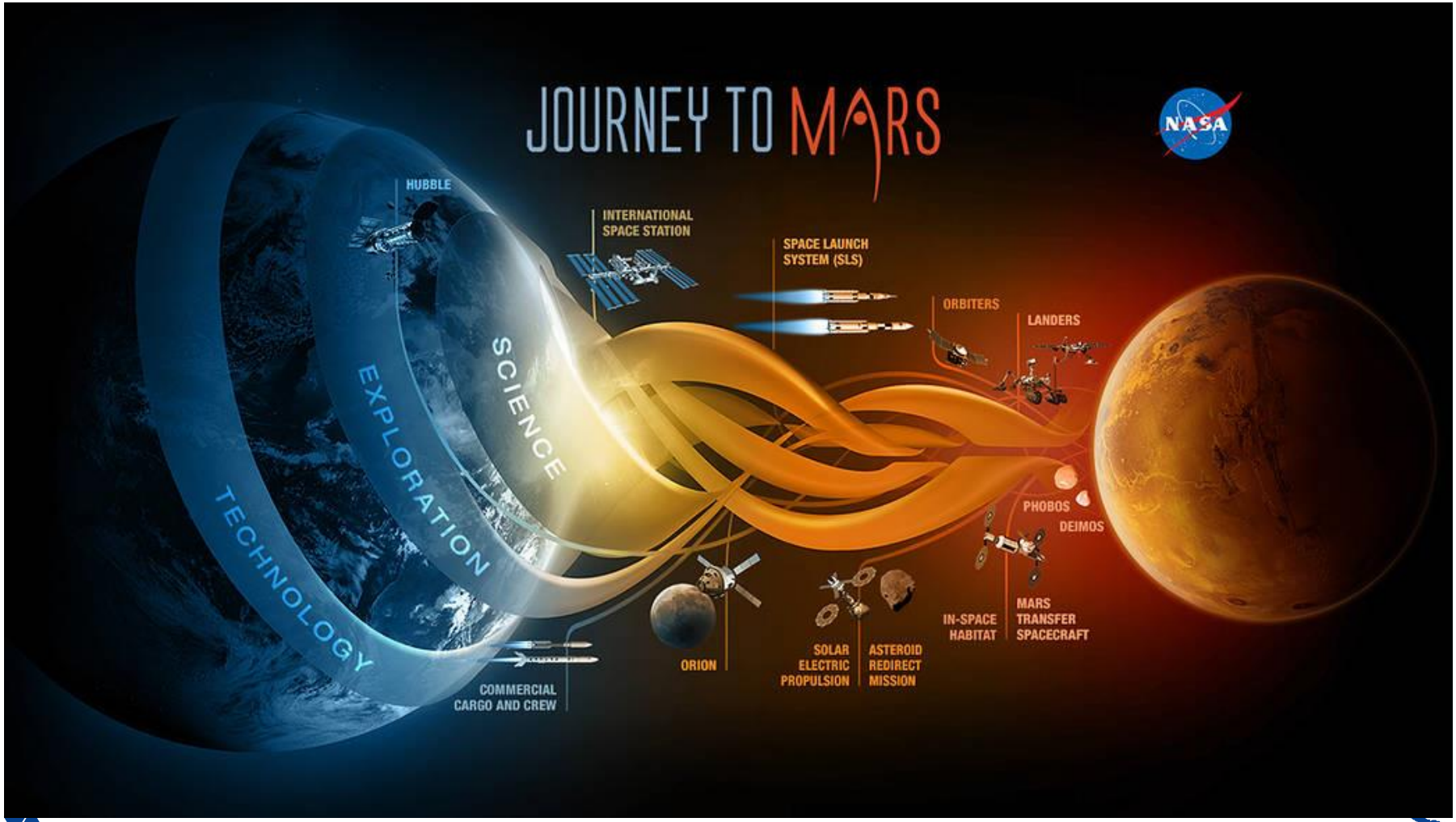
ROS and NASA: Advancing Autonomy for Future Space Robots

Kimberly Hambuchen

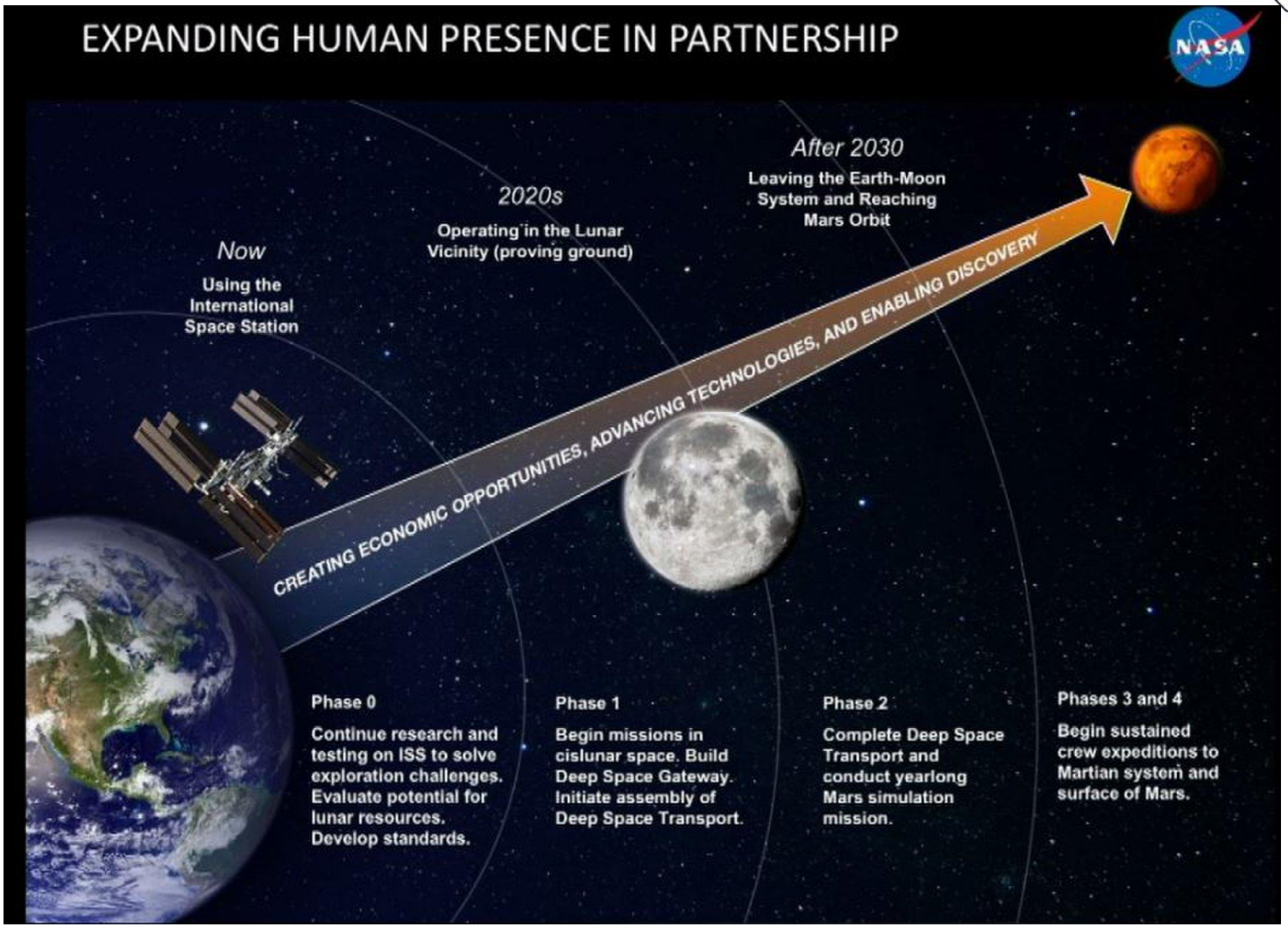
NASA Johnson Space Center

ROS-Industrial Asia Pacific Consortium

NASA's Journey to Mars



NASA Evolving Opportunities



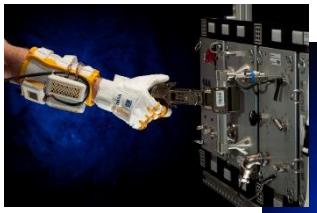
Robotic Involvement in Future NASA Missions

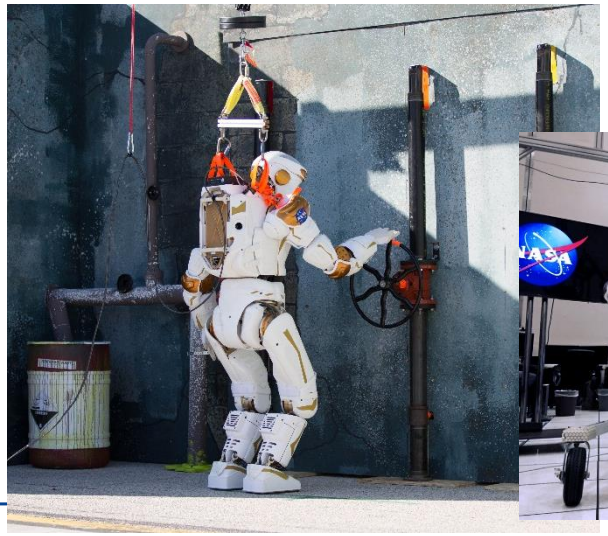
- Caretaker robots
  - Humanoids, manipulators, free-flyers
- Mobility for human crew
  - Rovers, mobile habitats, etc.
- Human augmentation
  - Exoskeletons, augmented spacesuits

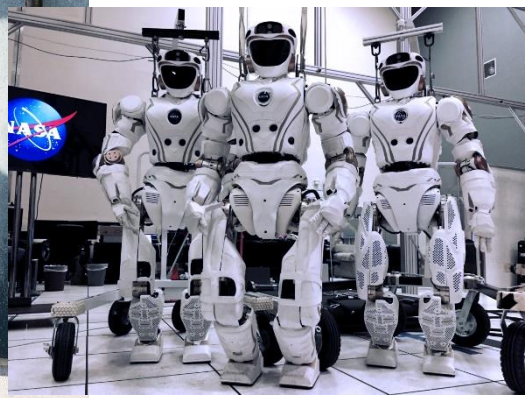
NASA JSC Introduction

- NASA Johnson Space Center
  - Engineering Directorate
  - Software, Robotics and Simulation Division
  - Robotics Technology Systems Branch
- Develop prototype robotic technology for future space exploration missions
  - Human-robotic systems

NASA JSC Robots







ROS use in NASA JSC Robots

- Centaur 2
  - First ROS testbed
- R2
  - Using ROS/Orocos architecture to handle real-time control and “crowd-source” autonomy and human interfaces
- Val
  - Originally designed with ROS-based control architecture, currently ROS API into higher level commanding

Centaur 2

- 2011 – Gazebo simulation with ROS messaging; bridged to RAPID

Robonaut 2

- ROS development began in 2011
  - ROS control was still in its infancy
  - ROS control paradigm was used for R2 control architecture
- ROS is used for:
  - Perception (Image pipeline)
  - Motion planning (MoveIt!)
  - Communication between non-safety critical components
  - Health monitoring of robot
  - User interface (Rviz and Affordance Templates)

Robonaut 2:
Supervisory Control

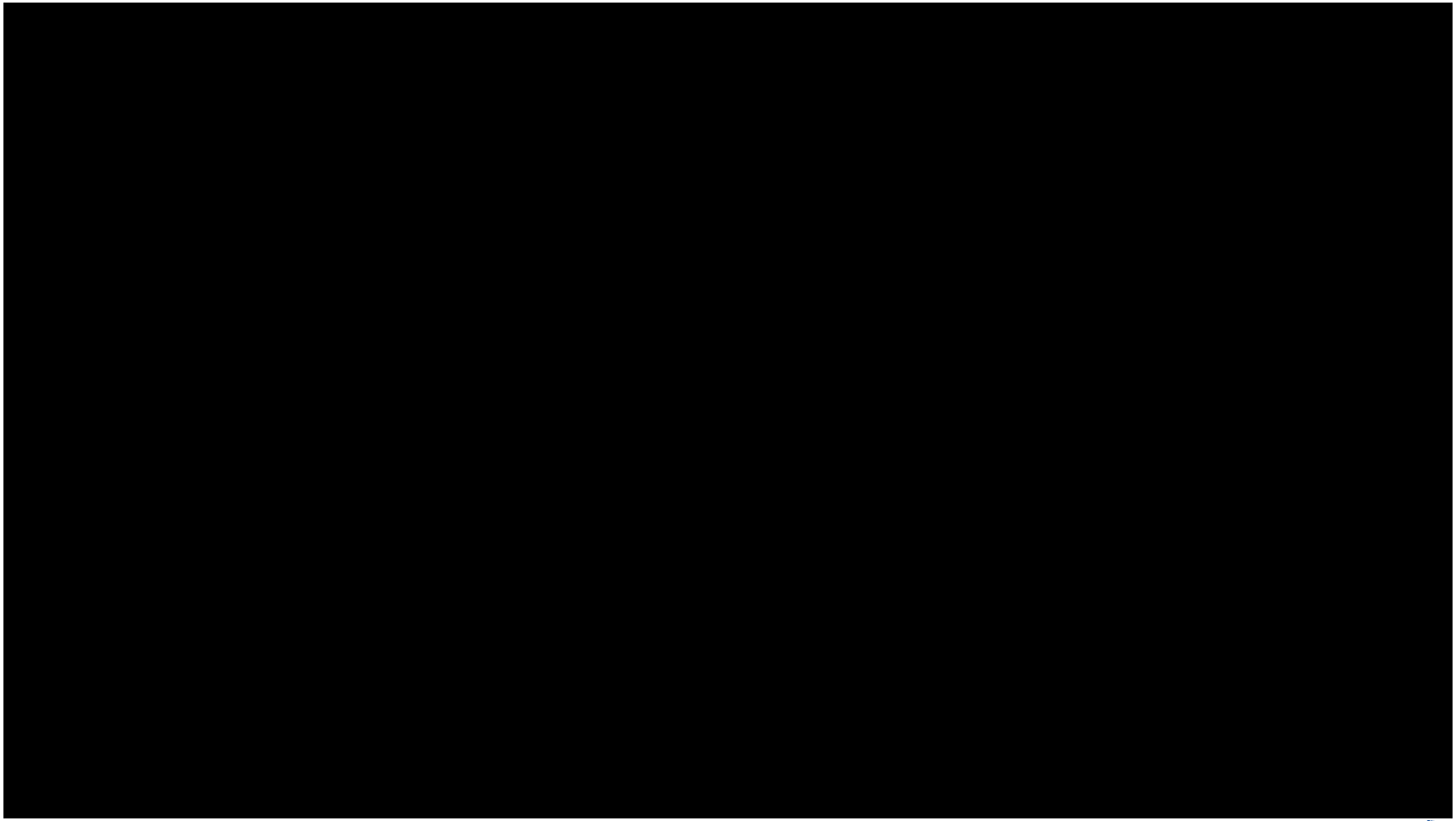
Robonaut 2:
Semi-Autonomous Control

Valkyrie (R5)

- Original software architecture developed using ROS, ros_control and Orocos components
- Development of Affordance Templates human interface software*
  - ROS-based interactive tools using Rviz
- Use of ROS Image Pipeline
- Currently have ROS API “hooks” to the whole-body controller

* Hart, Stephen, Paul Dinh, and Kimberly Hambuchen. "The affordance template ROS package for robot task programming." Robotics and Automation (ICRA), 2015 IEEE International Conference on. IEEE, 2015

Valkyrie



Future Directions

- ROS 2.0
  - Use of DDS and real-time control can eliminate need for specialized communication protocols and dependence on non-ROS based control components
- ROS – CFS integration
  - Core Flight Software (CFS) is a platform and project independent reusable software framework and set of reusable software applications, similar to ROS, for NASA flight missions.

What can you do?

- NASA robotics desires:
  - Advanced autonomy
    - Learning
    - Planning
    - Perception
  - Advanced human interfaces
    - Latent communication methods
    - Better situational awareness
    - Distributed control

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