ROSMOD

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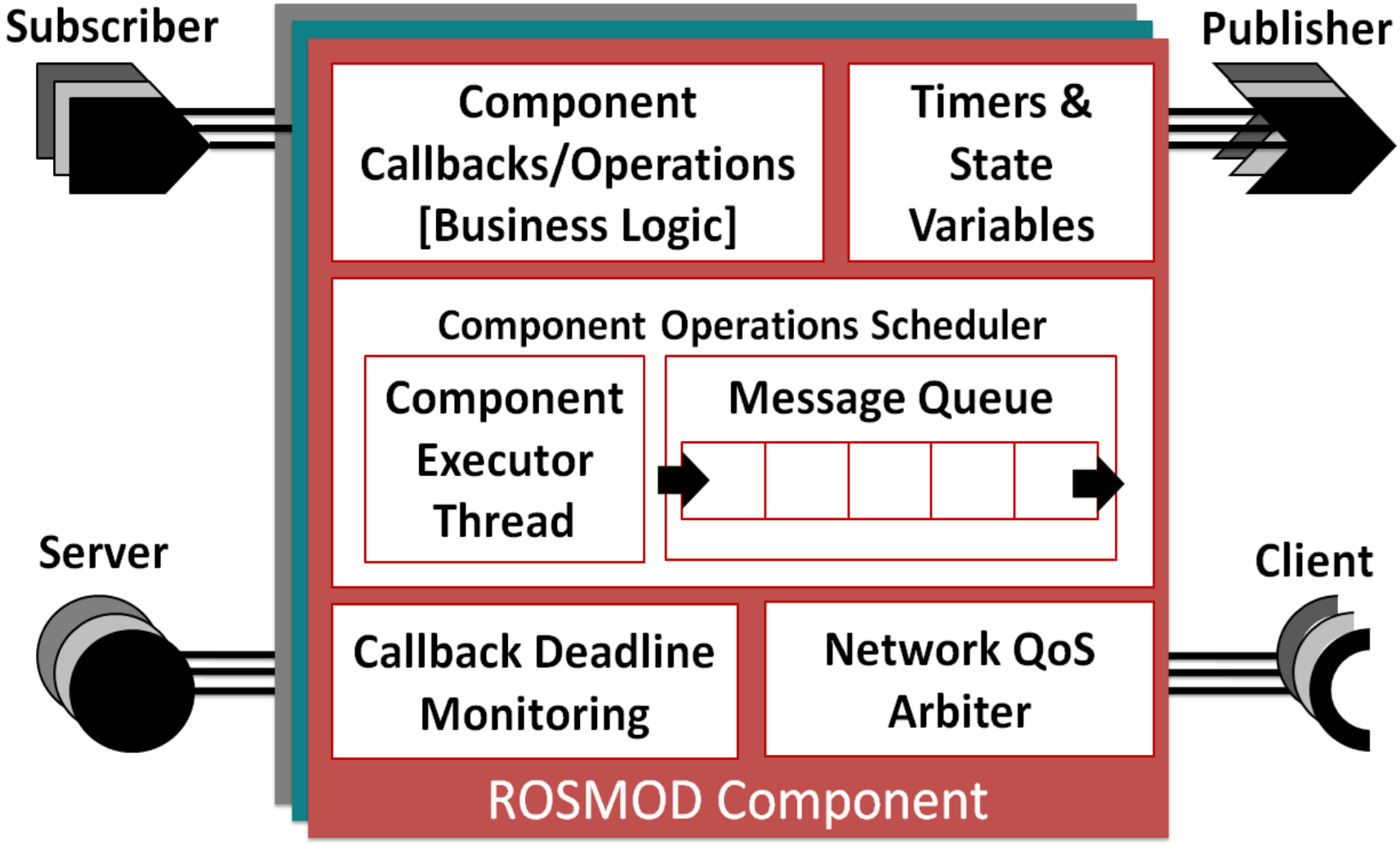
Introduction

- **ROSMOD** is a Model-driven Development (MDD) Toolsuite
- Designed for Rapid Prototyping Component-based Distributed Real-time Embedded (DRE) Applications with the Robot Operating System (ROS)
- Well-suited for large-scale robotic applications on embedded devices
- Provides a Graphical User Interface & Rendering Platform
- Supports ROS Workspace code generation with code preservation
- Supports parallel deployment and monitoring of ROS processes
- Real-World Application: An Autonomous Ground Support Equipment (AGSE) robot for the NASA Student Launch competition, 2014-2015.

Robot Operating System

- Meta-operating system framework for Robotic System Development
- Open-Source Multi-Platform Support
- Industrial Robotics, UAV Swarms, Low-power Image Processing Devices
- Requirement in several DARPA Robotics Projects (DRC)
- Enables Development of Network of Interacting ROS *nodes*
- Various Interaction Patterns: Client-Server, Publish-Subscribe, and Time-triggered Operations
- ROS Applications are packaged set of ROS nodes
- ROS Master: Single Discovery and Communications Broker

ROSMOD Component



Component Model

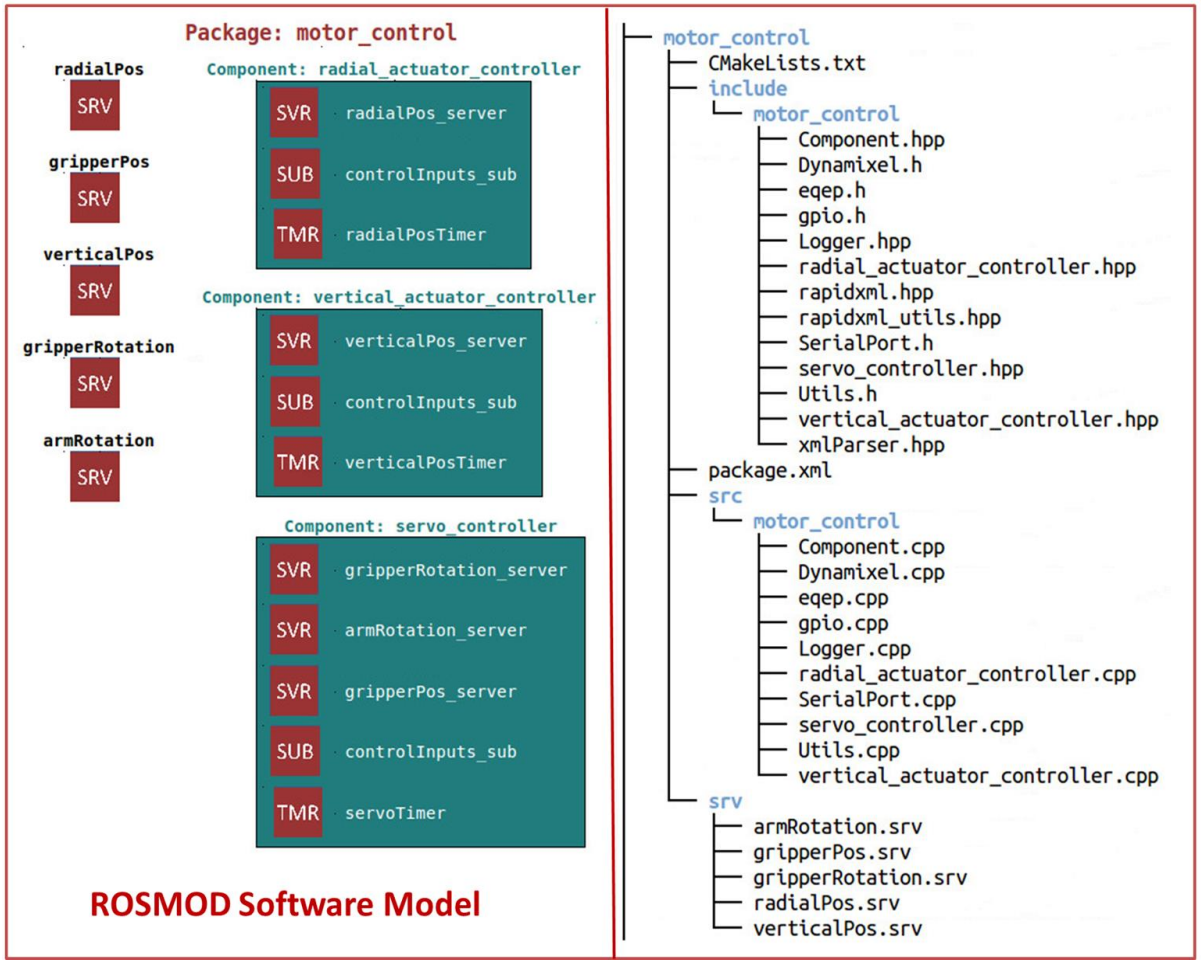
- Each Component has a Message Queue
- Each Component has a *single* executor thread
- Each Component exposes *operations* through port interfaces.
- Message Queue receives operation requests from external entities
- Component Operation Scheduler schedules a request from the queue
- Requests are processed based on a scheduling scheme e.g. FIFO, PFIFO, and EDF scheduling
- Operation Execution is nonpreemptive
- Single threaded operation execution helps avoid synchronization primitives and locking mechanisms

ROSMOD Projects

- Software Model
  - Represents a ROS Workspace
  - Defines Messages, Services and Components
- Hardware Model
  - Defines Hardware Devices - IP Address, SSH Keys, Architecture etc.
- Deployment Model
  - Define ROS Nodes (Processes)
  - Instantiate Components (from Software Model) in ROS Nodes
  - Define a ROS Node to Hardware Mapping

Workspace Generation

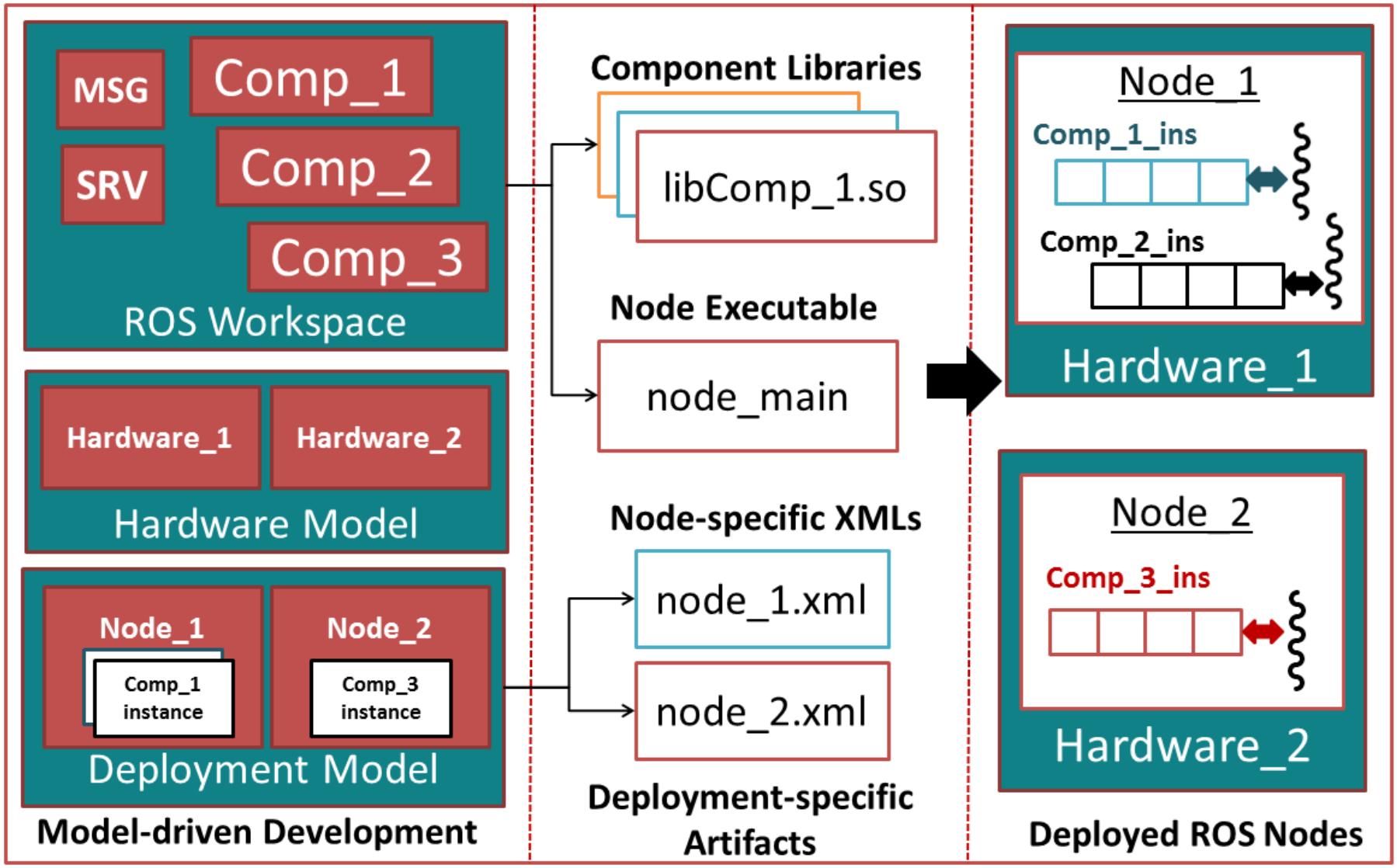
- C++ Classes for each ROSMOD Component
- Package-specific msg and srv files
- Logging and XML parsing framework
- Build system files
- Code preservation markers and Doxygen comments
- Follows ROS Package guidelines



ROSMOD Application Development

- Prepare a ROSMOD Model of the Application
- Generate the ROS Workspace using ROSMOD
  - Generated code includes Code-Preservation Markers
- Add *business logic code* to generated skeleton callbacks/operations
- Add new components, ports, messages etc. to the Model
- Re-generate ROS Workspace
  - Previously added business logic code is preserved
  - Newly added modeling elements manifest as new code segments
- No need to complete the ROSMOD model to begin implementing the Application code
- On-the-fly feature additions and rapid prototyping

Software Deployment Infrastructure



Autonomous **G**round **S**upport **E**quipment (AGSE) Robot

NASA Student Launch Competition, 2014-2015

Vanderbilt Aerospace Club

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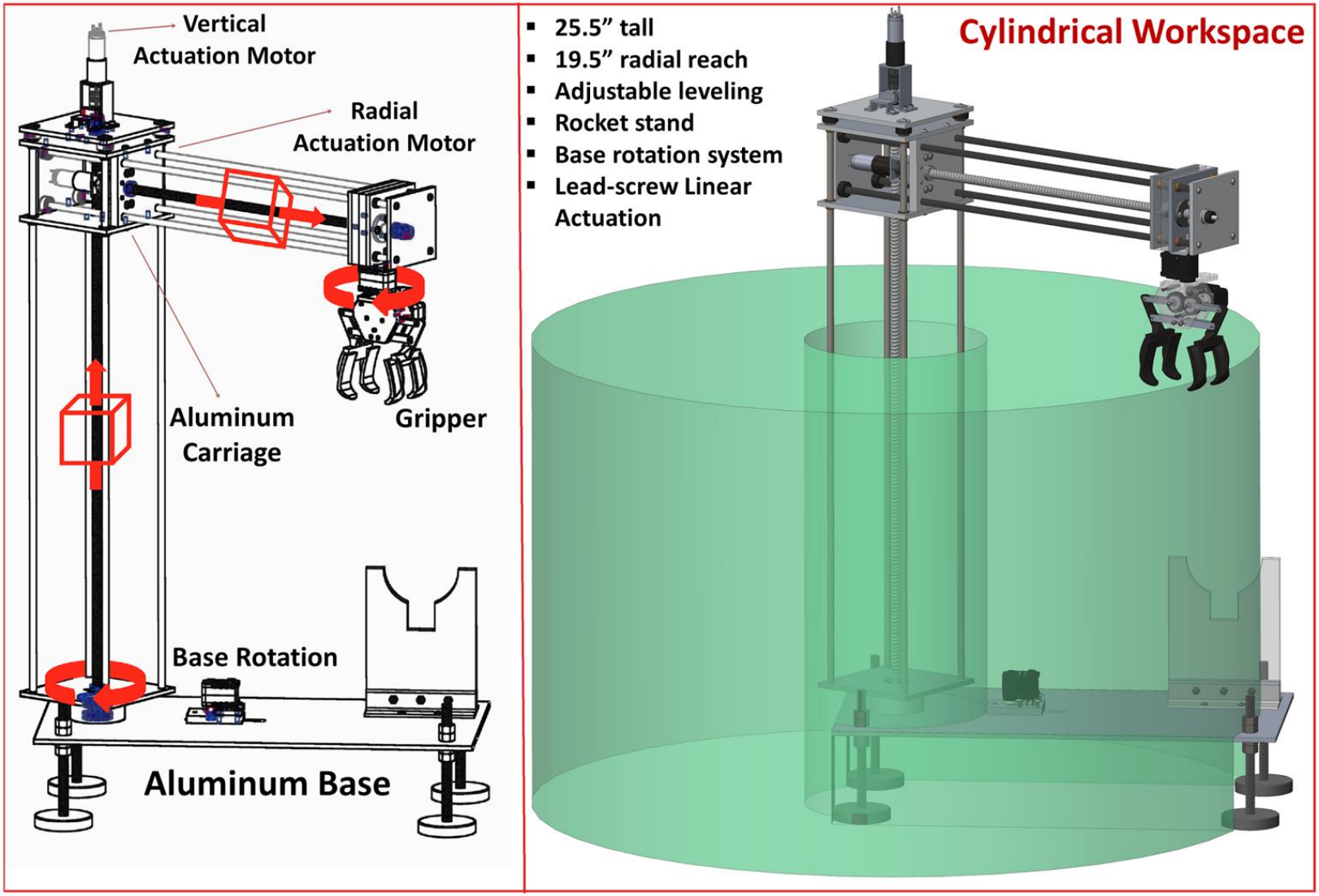
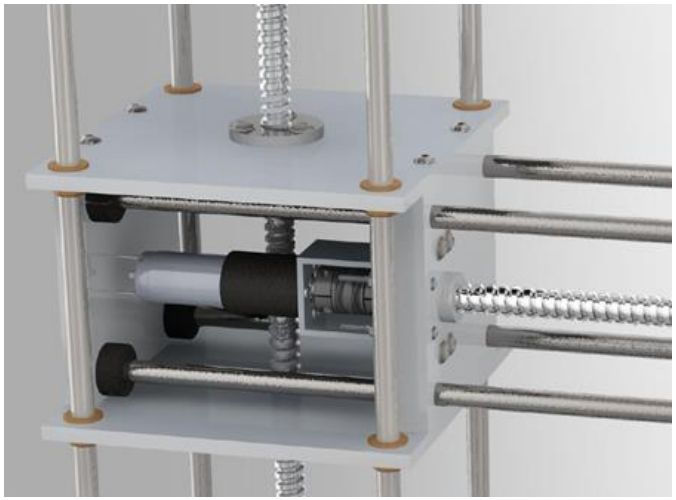
NASA Student Launch Competition

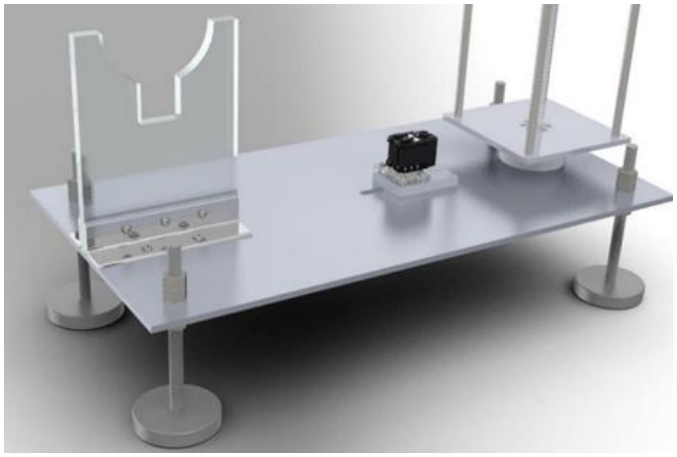
- Research-based Competition: Stimulate Rapid, Low-cost Development of Rocket Propulsion & Space Exploration Systems
- 8 Month Cycle: Design, Fabrication, and Testing of Flight Vehicles, Payloads and Ground Support Equipment
- 2014-2015 Competition: Simulate a **Mars Ascent Vehicle** (MAV)
  - Perform Sample Recovery from the Martian Surface
  - Design & Deploy an AGSE Robot
  - Autonomously retrieve a sample off the ground
  - Store sample in the payload bay of the rocket
  - Launch MAV rocket to an altitude of 3000 ft. and recover sample

AGSE Overview

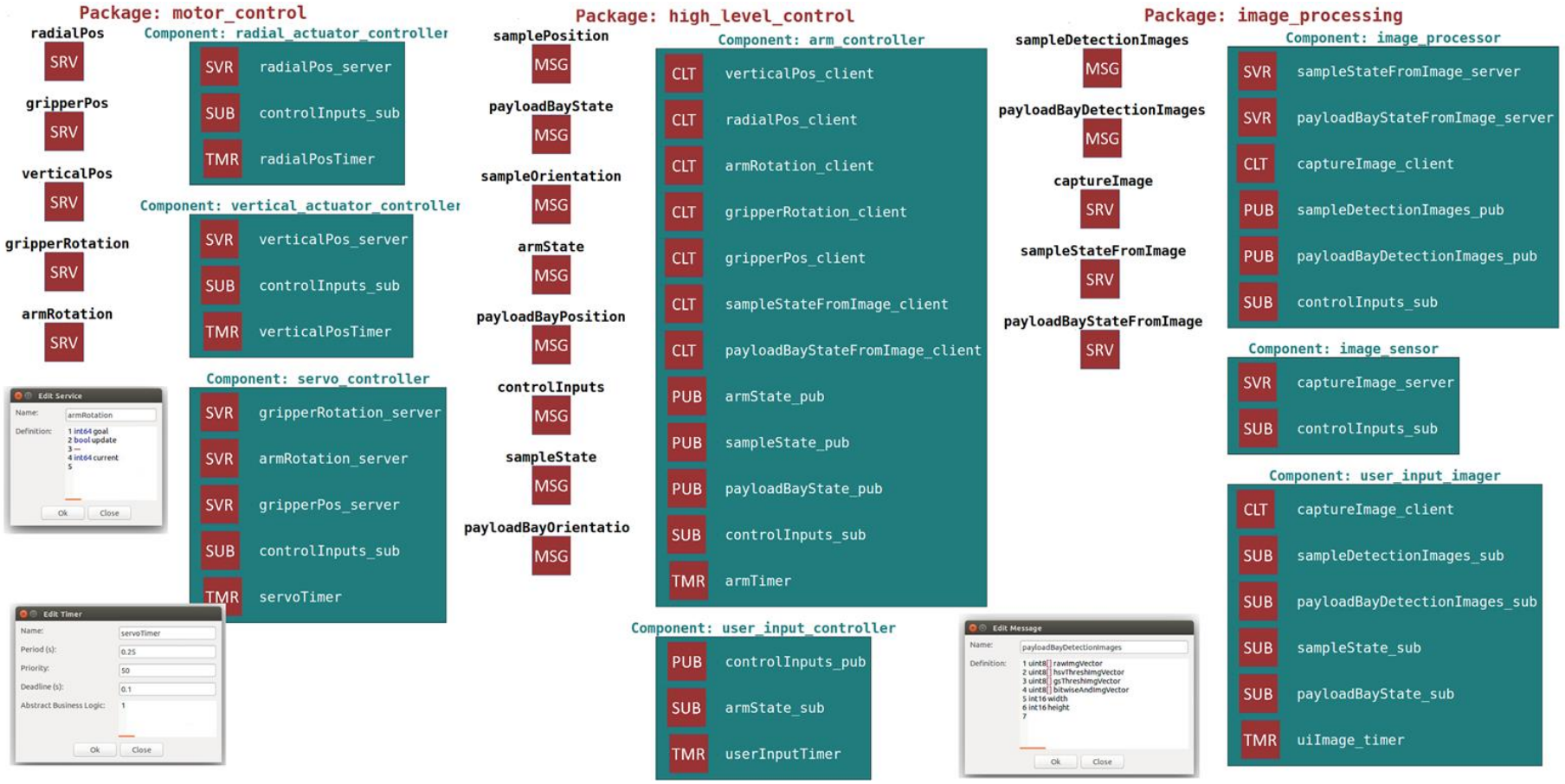


Mechanical Construction





ROSMOD AGSE Software Model

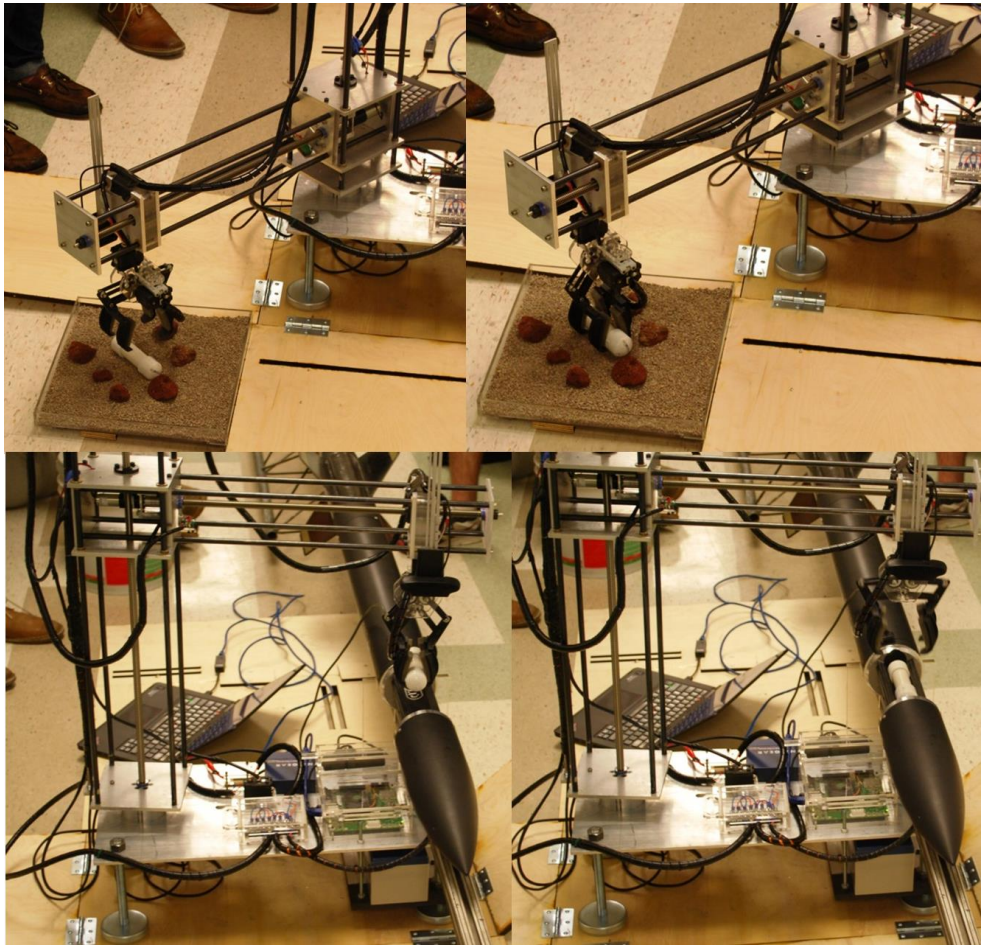


Software Rapid Prototyping

- Iterative Design-Generate-Deploy-Test Cycle
- ROSMOD generated nearly 60% of the AGSE software (6000+ lines)
  - Takes but a few seconds
  - Preserves already written code
  - Developers fill in the missing pieces
  - Quick and easy integration with external libraries e.g. OpenCV
- Overall software frequently redesigned and tweaked
- Large portion of code development in under 3 weeks
  - Difficult without ROSMOD, especially with our small team

Competition Highlights

- Long Night before Competition
  - Dynamixel AX12A Servo Failure
  - Replace with spare MX28T
  - Difficult communication protocol & mounting footprint
  - Mount new servo!
  - Fix servo_controller package!
- Sample Recovery in under 4.5 mins.
- Earned overall *Autonomous Ground Support Equipment Award*
- Won the whole competition!



Links

ROSMOD GitHub Organization
https://github.com/rosmod

AGSE Software GitHub Repository
https://github.com/finger563/agse2015

Vanderbilt Aerospace Club
http://www.vanderbilt.edu/USLI/2015/