ROSMOD

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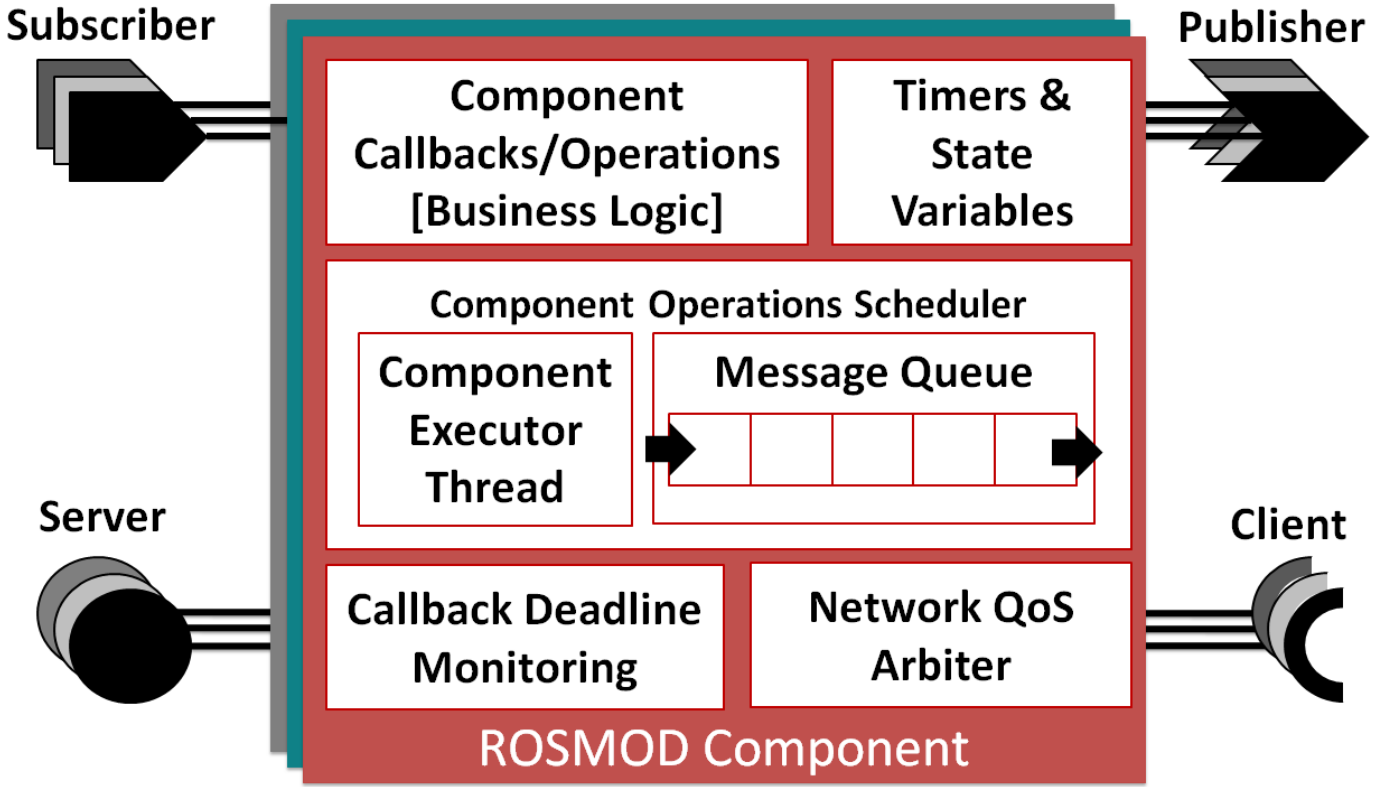
Introduction

- **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
- ROS Applications are packaged sets of ROS nodes
- ROS Master: Single Discovery and Communications Broker

ROSMOD Component



Component Model

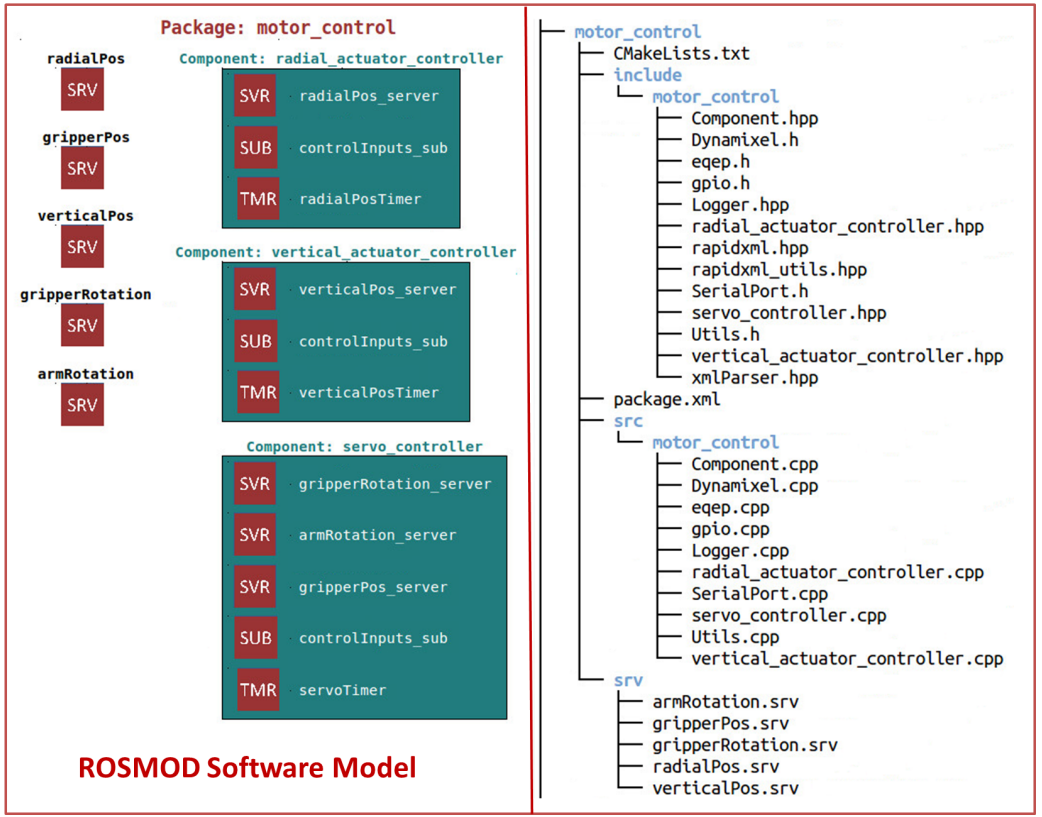
- Each Component has a Message Queue
- Each Component has a *single* executor thread
- Each Component exposes *operations* through port interfaces.
- Message Queue receives operation requests from external entities
- Component Operation Scheduler schedules a request from the queue
- Requests are processed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

ROSMOD Projects

- Software Model
  - Represents a ROS Workspace
  - Define Messages, Services and Components
- Hardware Model
  - Define Hardware devices, IP addresses, architecture, SSH keys etc.
- Deployment Model
  - Define ROS Nodes (Processes)
  - Instantiate Components (from Software Model) in ROS Nodes
    - Each node spawns an executor thread per component instance
  - Define a ROS Node to Hardware mapping

Workspace Generation

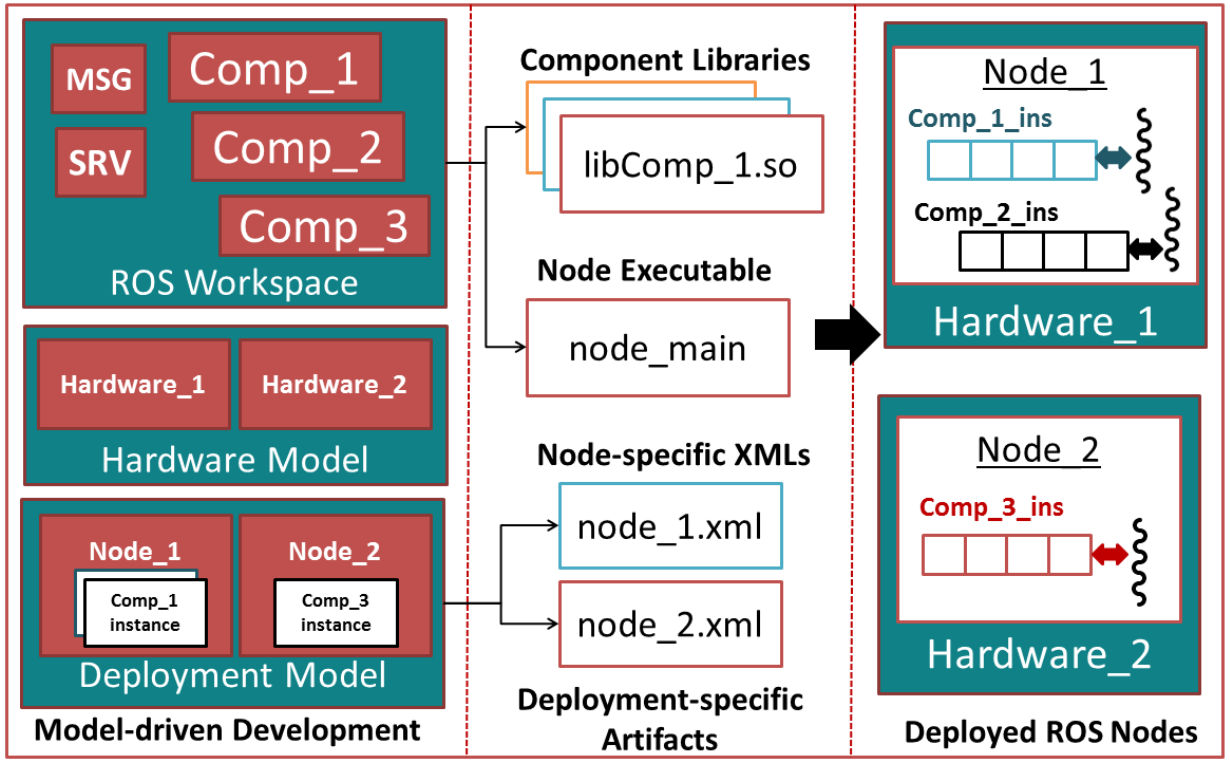
- C++ Classes for each ROSMOD component
- Package-specific Message and Service files
- Logging and XML parsing framework
- Build system files
- Code preservation markers & Doxygen comments
- Following ROS Package guidelines



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
  - Server operations, Timer callback operations etc.
- Add new components, ports, messages etc. to the Model using the GUI
- 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 App!
- On-the-fly feature additions and rapid prototyping

Software Deployment Infrastructure



- Dynamically Loadable Libraries, one for each Component Definition
- Generic ROS node executable
- Configuration XML for each ROS Node
- Parallel Deployment in each Hardware
- Runtime Monitoring with PID and Logs

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

NASA Student Launch Competition, 2014-2015

Vanderbilt Aerospace Club

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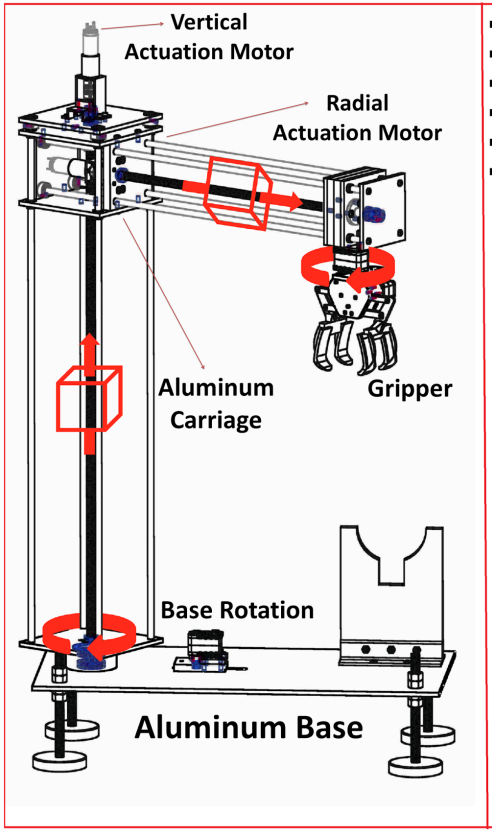
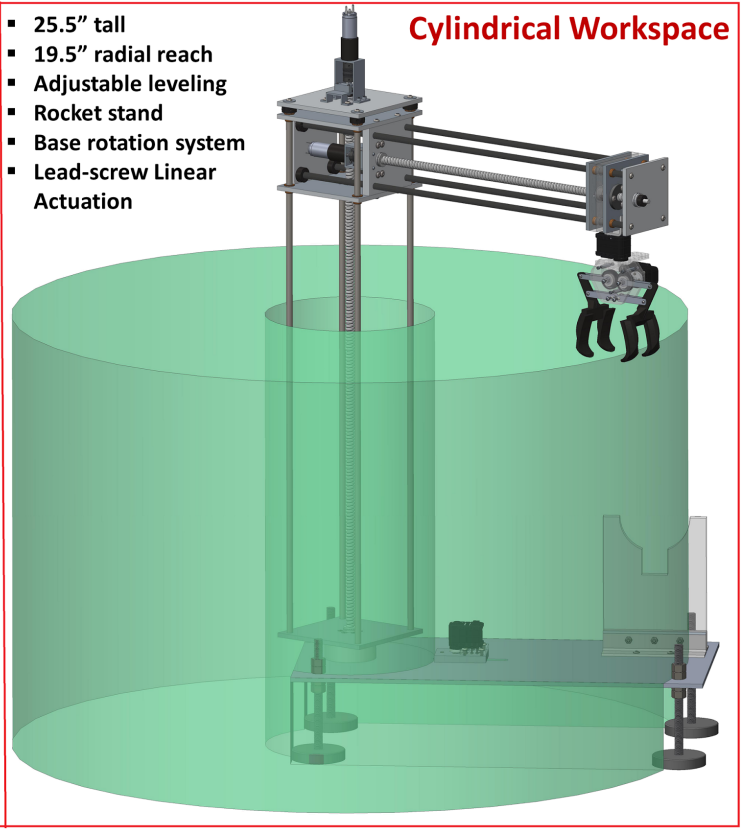
NASA Student Launch Competition

- Research-based Competition: Stimulate Rapid, Low-cost Development of Rocket Propulsion & Space Exploration Systems
- 8 Months 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 rocket to an altitude of 3000 ft. and recover sample

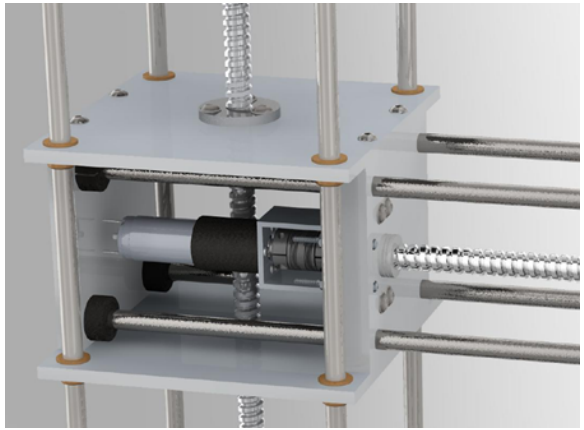
AGSE Overview

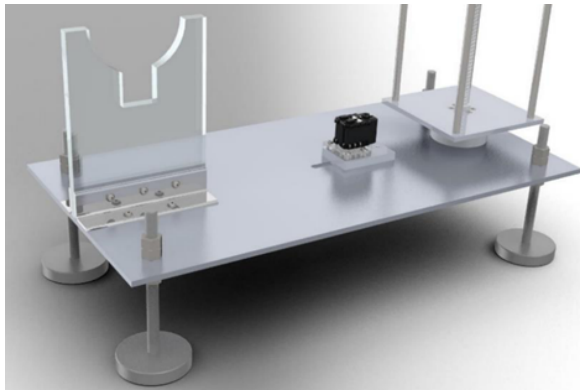
- Sample Retrieval
- Design Goals
  - Reliability
  - Simplicity
  - Robustness
- Design Considerations
  - Minimum degrees of freedom
  - Image Processing
  - DRE system
  - MDD workflow



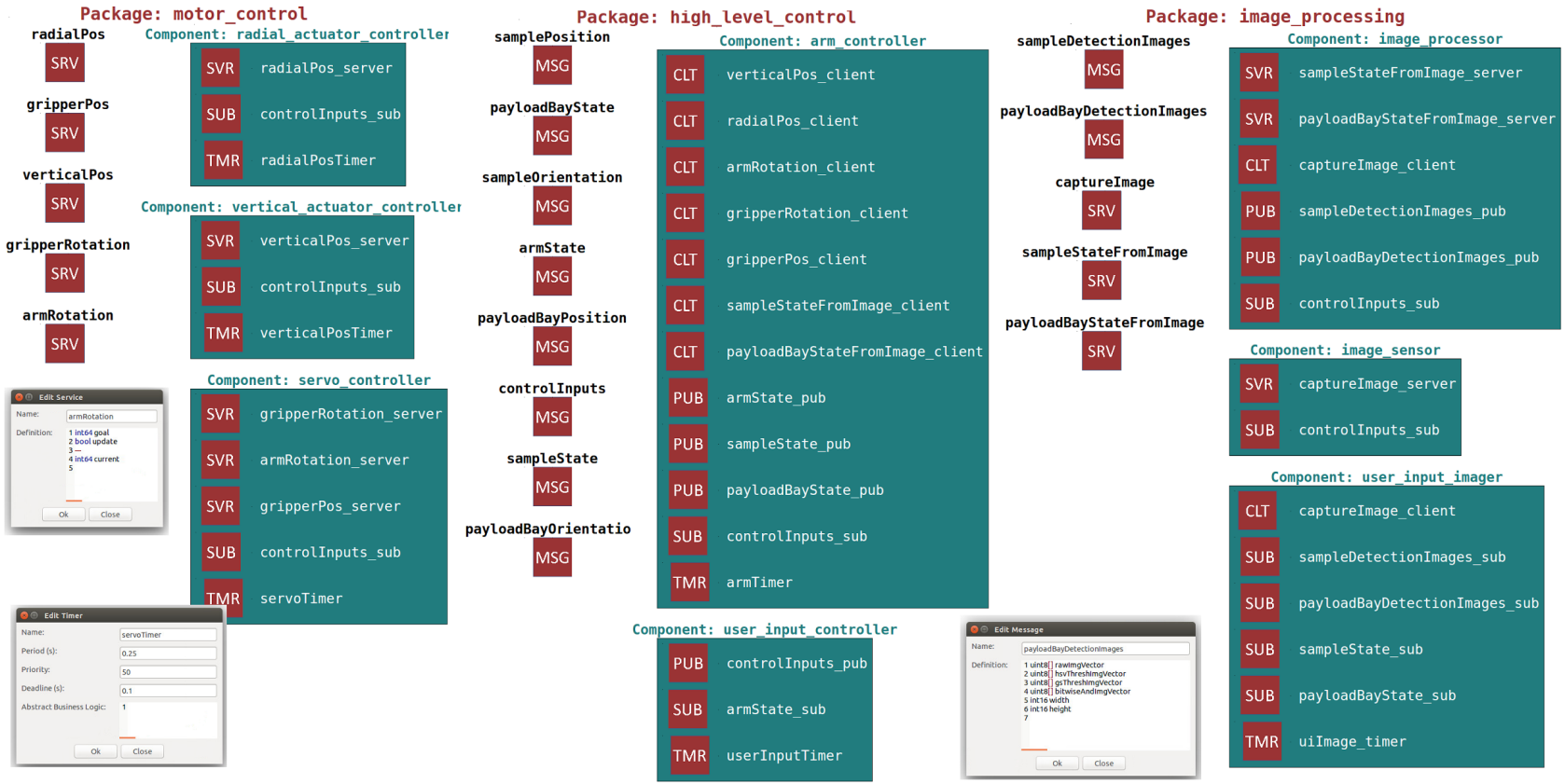


Mechanical Construction





ROSMOD AGSE Software Model

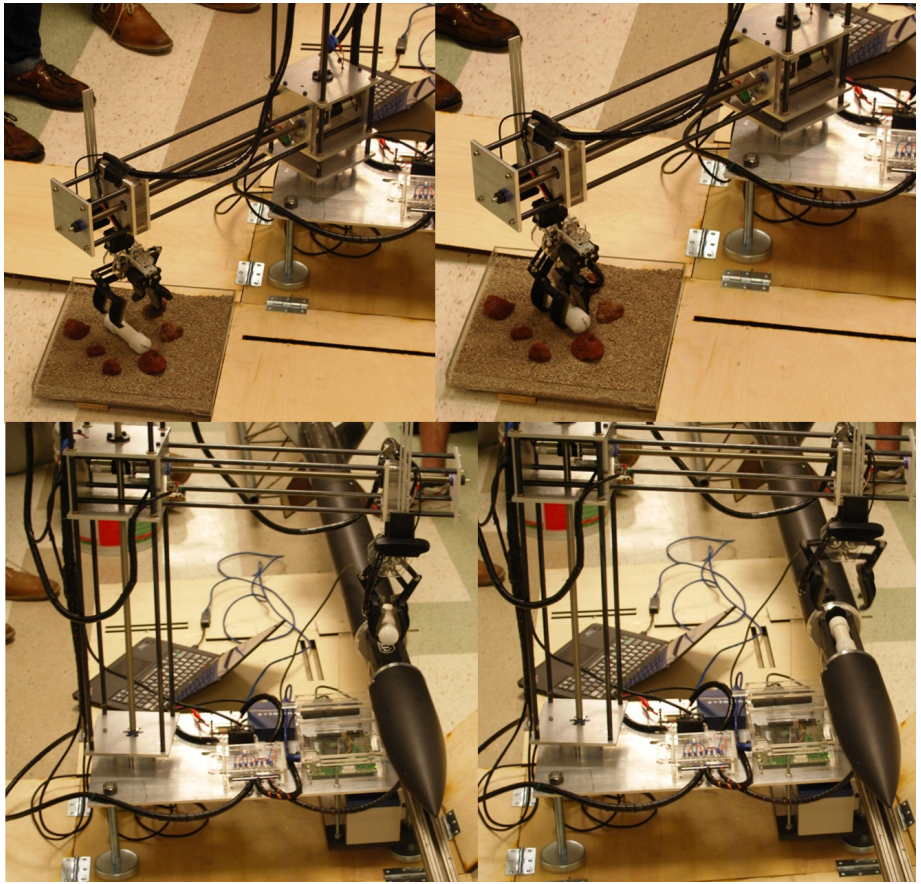


Software Rapid Prototyping

- Iterative Design-Generate-Deploy-Test cycle
- ROSMOD generated nearly 60% of the AGSE software (6,000+ 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
  - Improbable without ROSMOD

Competition Highlights

- Long Night before Competition:
  - Dynamixel AX12A Servo Failure
  - Replace with spare MX28T
  - Different 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/