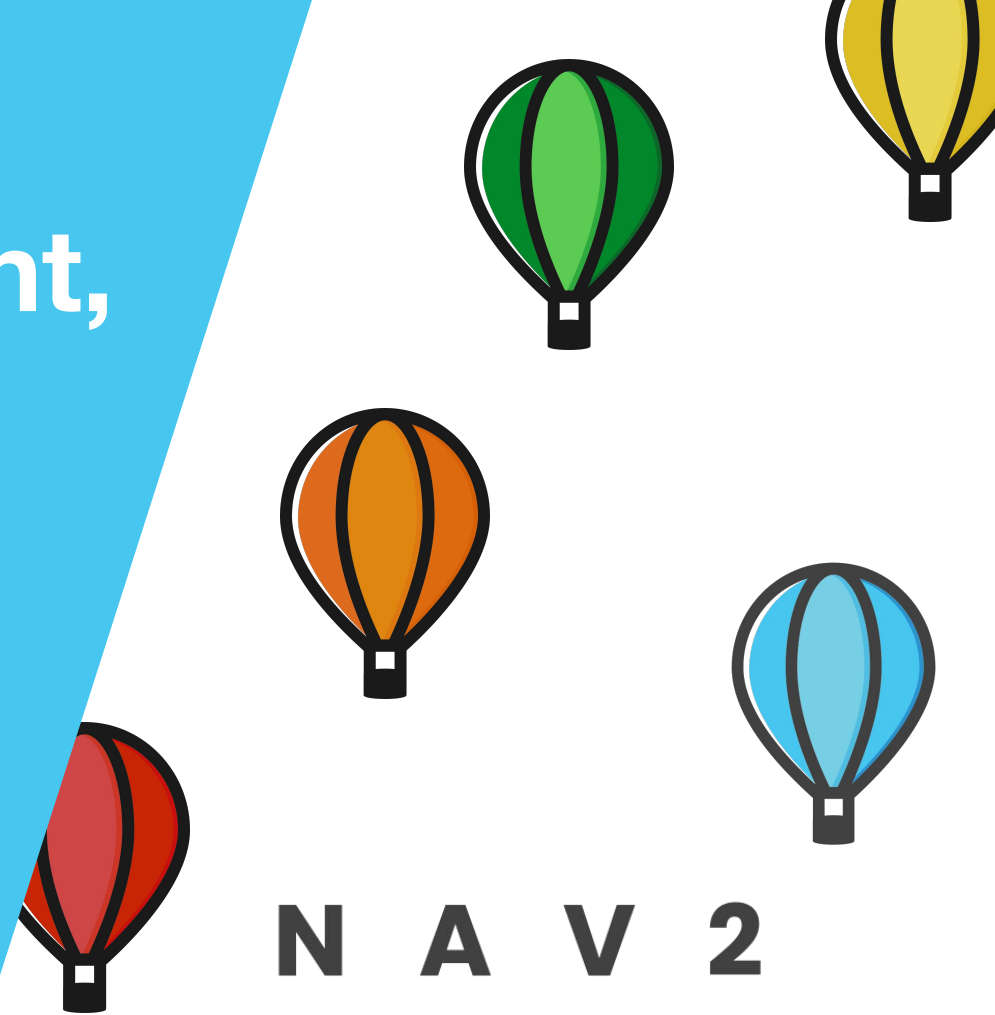
The Past, Present, and Future of Navigation

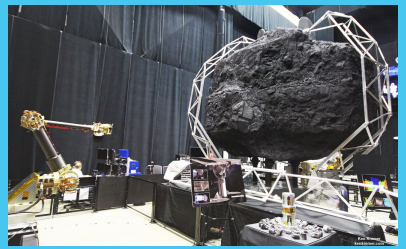
Steve Macenski, Samsung Research America



Steve Macenski

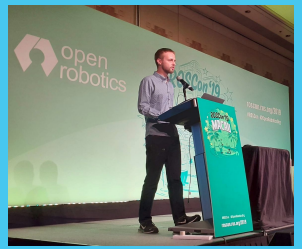
Open-Source Robotics - Engineering Lead

- Your Friendly Neighborhood Navigator!
- ROS Technical Steering Committee Member
- Navigation Working Group & Project Lead
- Developed 50+ ROS & ROS 2 Packages



NASA Goddard (2015 - 2017)

Simbe Robotics (2017 - 2019)

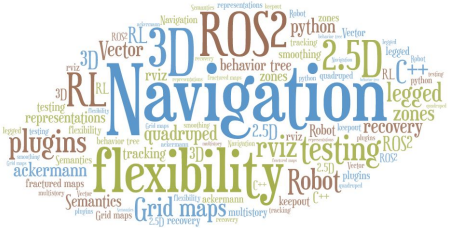


Samsung Research America (2019 - Present)

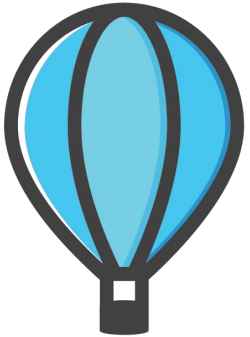
Overview

History of ROS Navigation

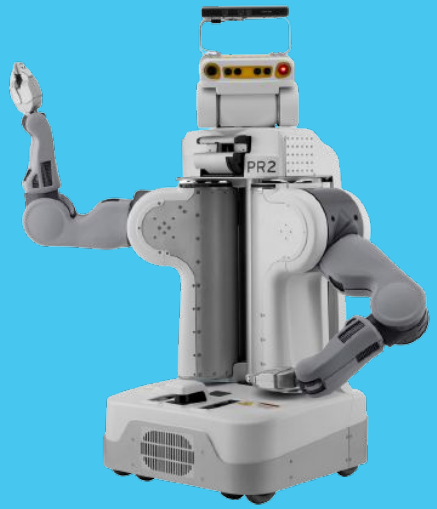
Motivations for Nav2

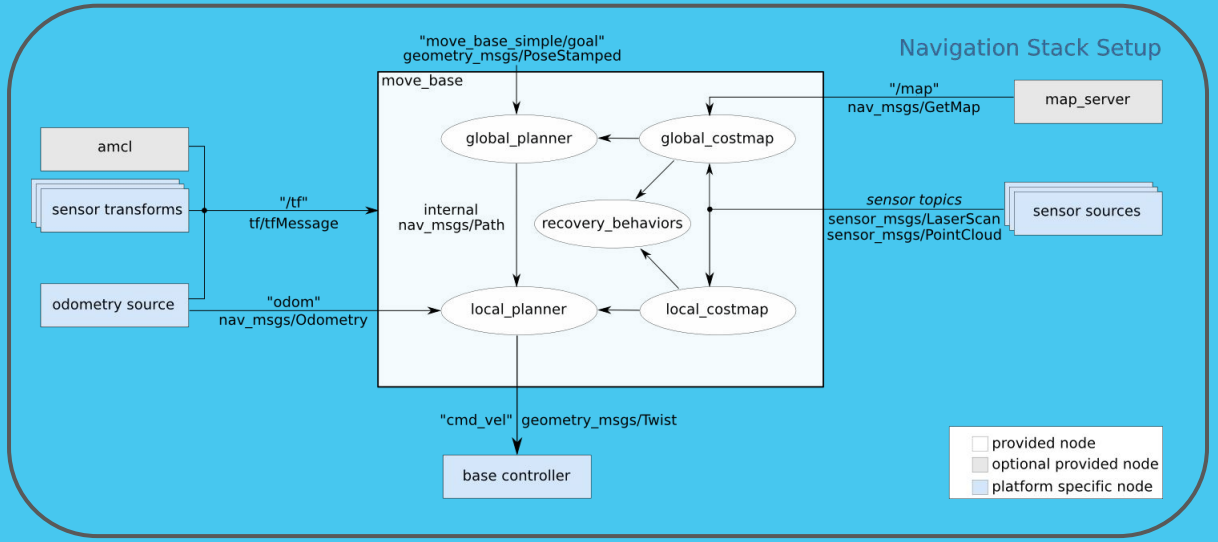


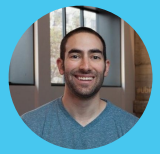
Nav2 and Current Users



History of ROS Navigation - Initial Creation






Eitan Marder-Eppstein

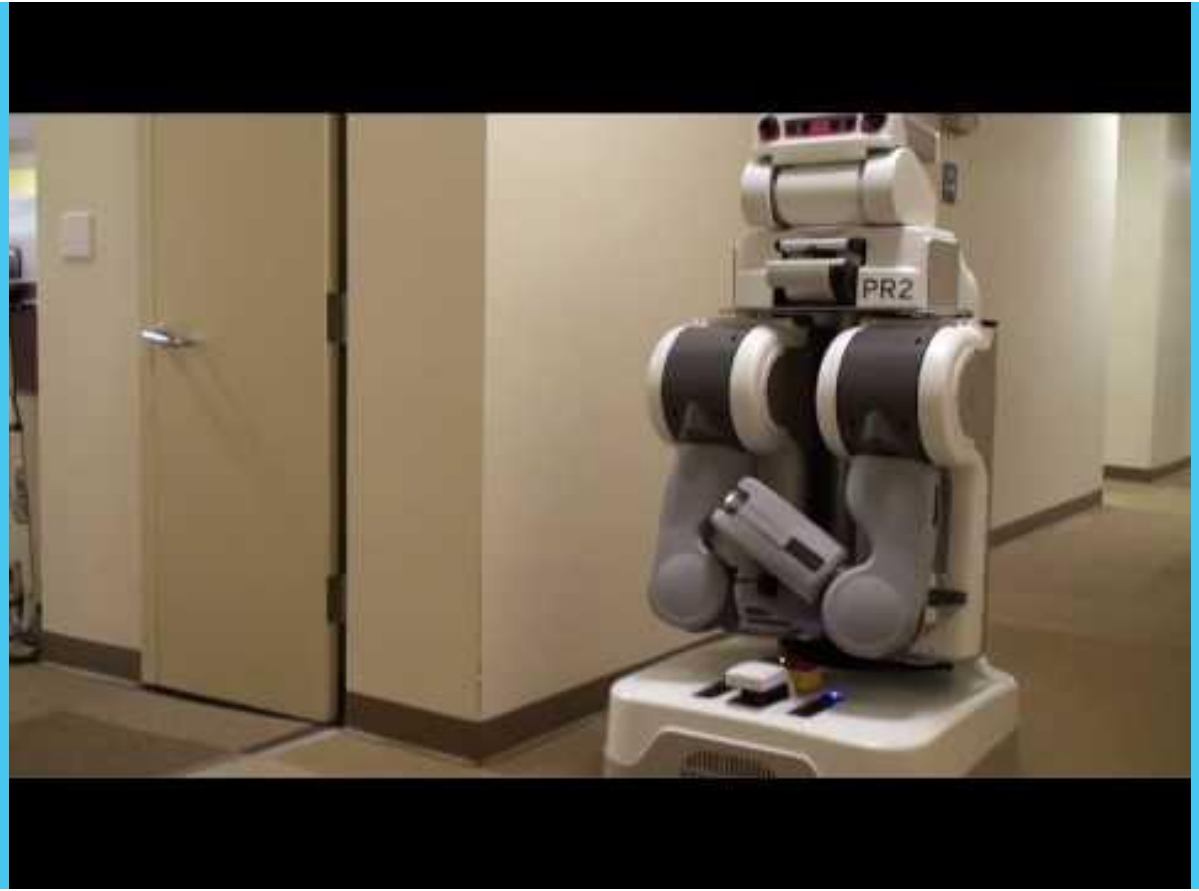
Kurt Konolige

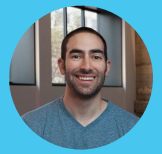
Brian Gerkey

Sachin Chitta

Conor McGann

History of ROS Navigation - Marathon Reliability

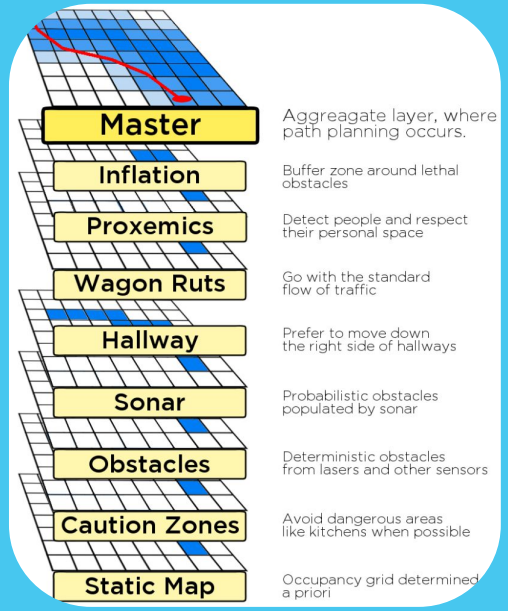




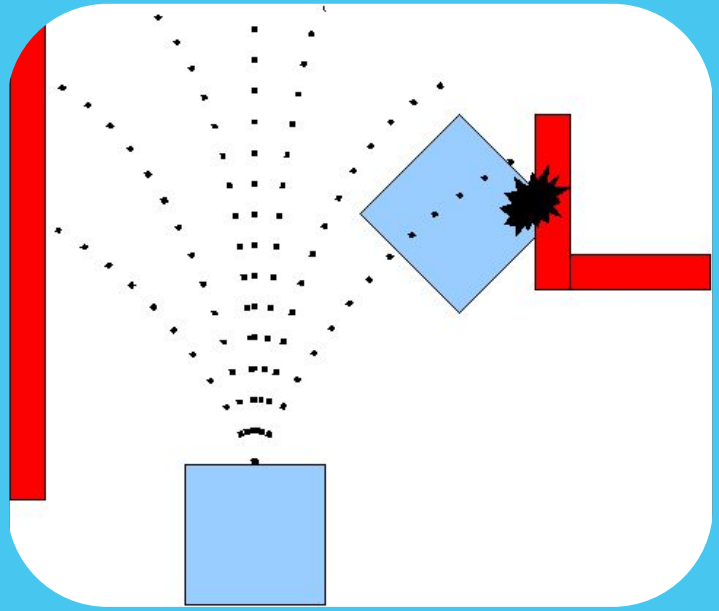
Eitan
Marder-Eppstein

Conor McGann

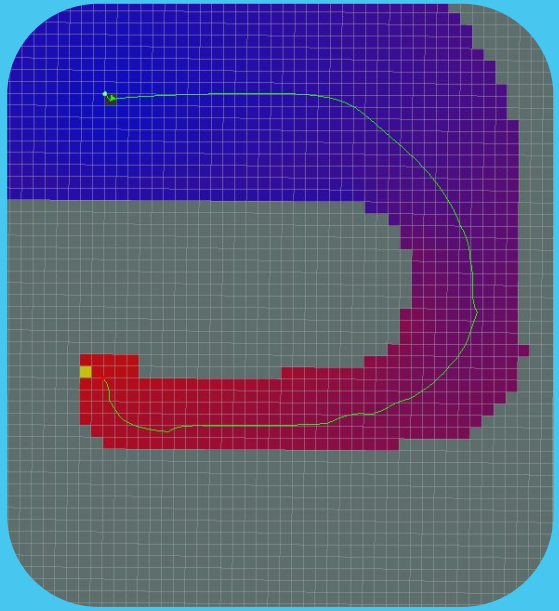
History of ROS Navigation - Focus on Modularity



Costmap Layers



Base Local Planner → DWA



NavFn → Global Planner

Dave Hershberger

David Lu!!

History of ROS Navigation - Willow Closing

Willow Garage

savioke

Unbounded Robotics™

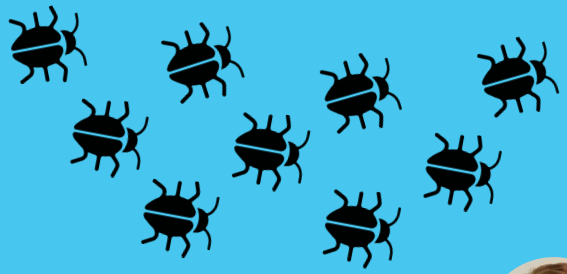
beam®

...

Mike Ferguson

David Lu!!

History of ROS Navigation - Fergs ‘n Fetch



History of ROS Navigation - 2015 to Present

2015

2016

2017

2018

2020

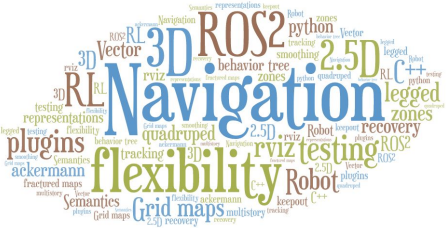
Mike Ferguson

David Lu!!

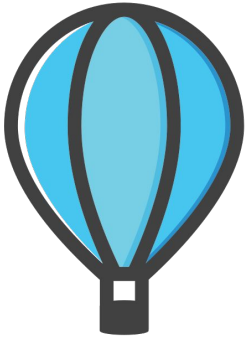
Overview

History of ROS Navigation

Motivations for Nav2



Nav2 and Current Users



Motivations for Nav2 - ROS 2

ROS2

- Lessons Learned in 10+ Years
- Product Ready Middleware
- Quality and Reliability Focused
- Embedded / Real-Time Support
- Multi-Robot Teaming Capable
- Best in Class Security

Courtesy of DARPA: https://www.digitaltrends.com/cool-tech/darpa-subt-challenge-feature/

Motivations for Nav2 - What's Changed?

Motivations for Nav2 - What's Needed?

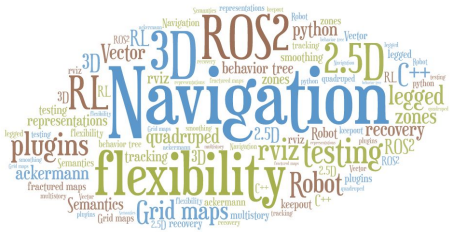
Quality and Modernization

- Testing, Confidence, Reliability, Safety
- Professional Support and Documentation
- Leverage ROS 2 Features & Philosophies
- Re-Centralize Navigation Development
- More Independence In The Framework
- Updated Algorithms (Localization, Planning, Perception, etc)
- Product Features (docking, keepout zones, map editing, etc)

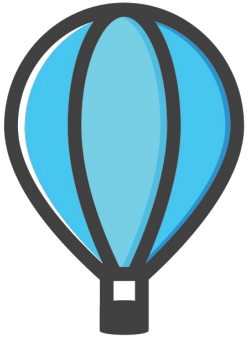
Overview

History of ROS Navigation

Motivations for Nav2



Nav2 and Current Users

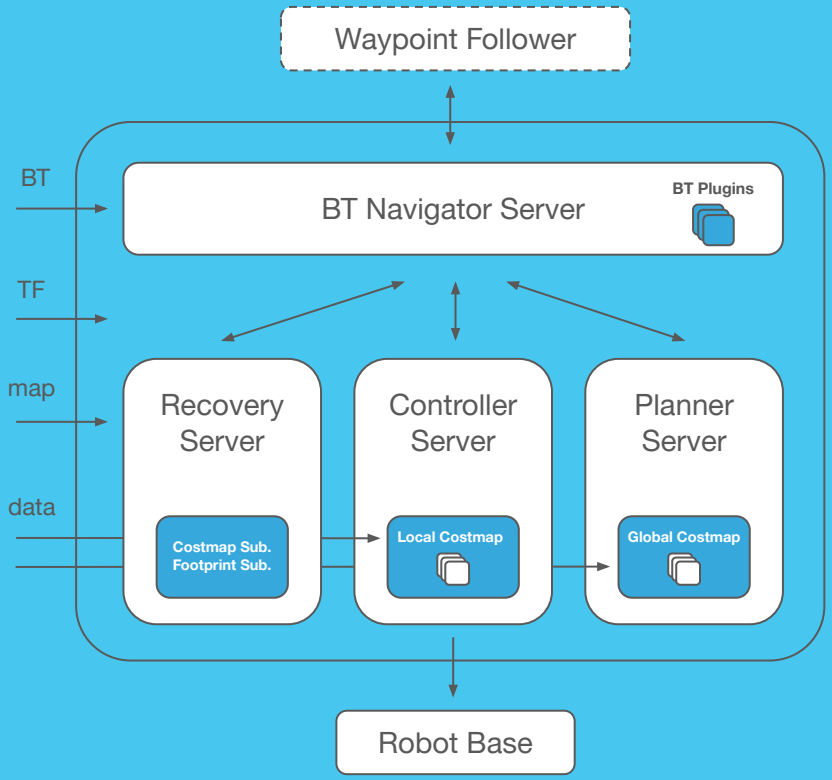


Nav2 Overview

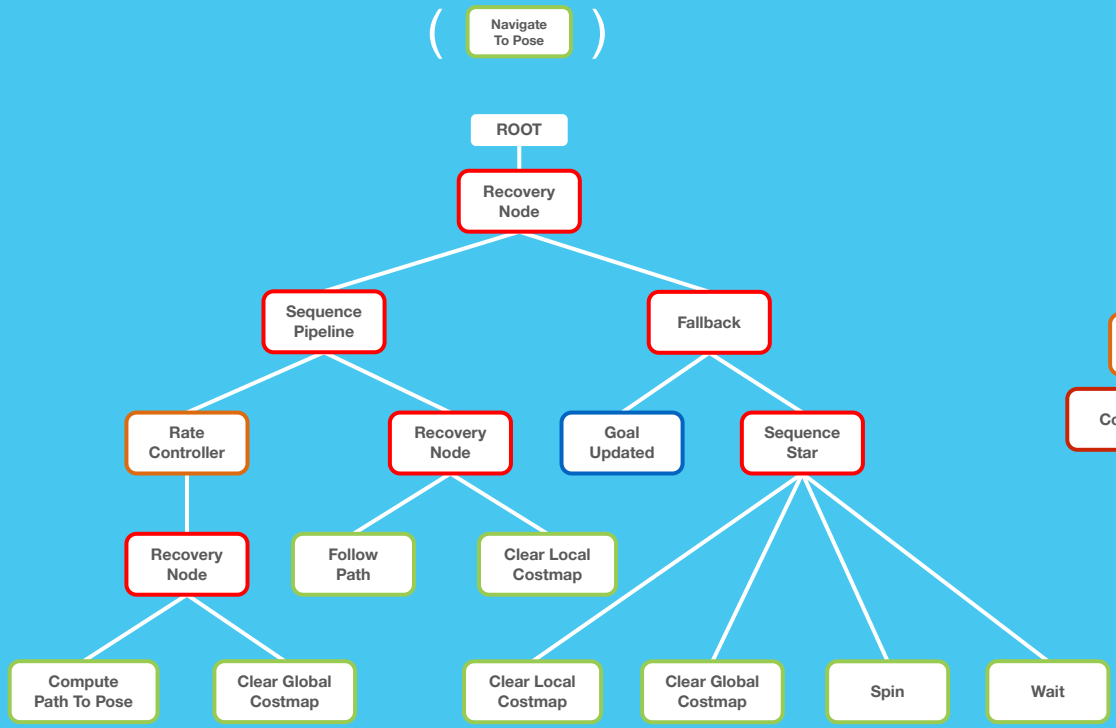
Star 639 Fork 429

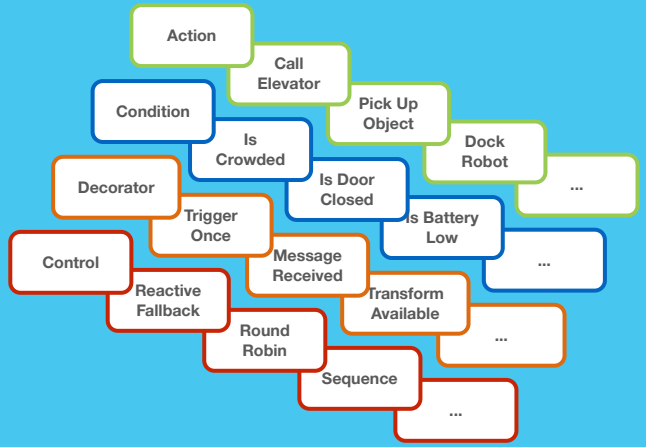
ROS 2's Production Solution

- Behavior-Tree Navigator
- Designed on Modular Servers
- Growing Features and Algorithms
- More Run-Time Selectable Plugins
- Support for All Robot Types
- Focus on Quality & Testing
- Easily Extensible



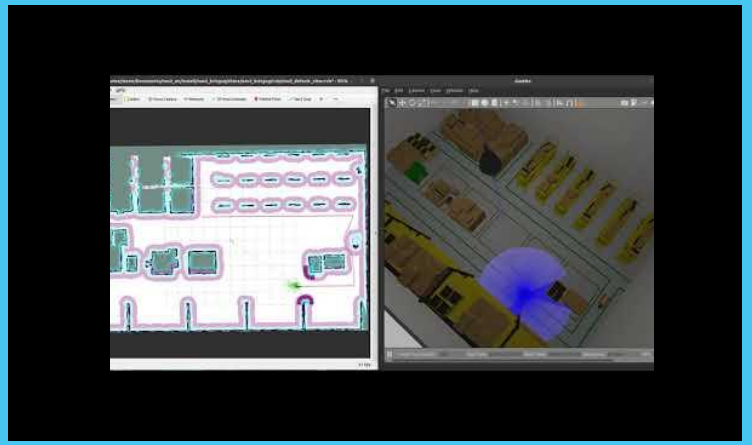
Behavior Trees





Ported From ROS (1)

- Costmap 2D
- AMCL / SLAM Toolbox
- NavFn Planner
- Map Server



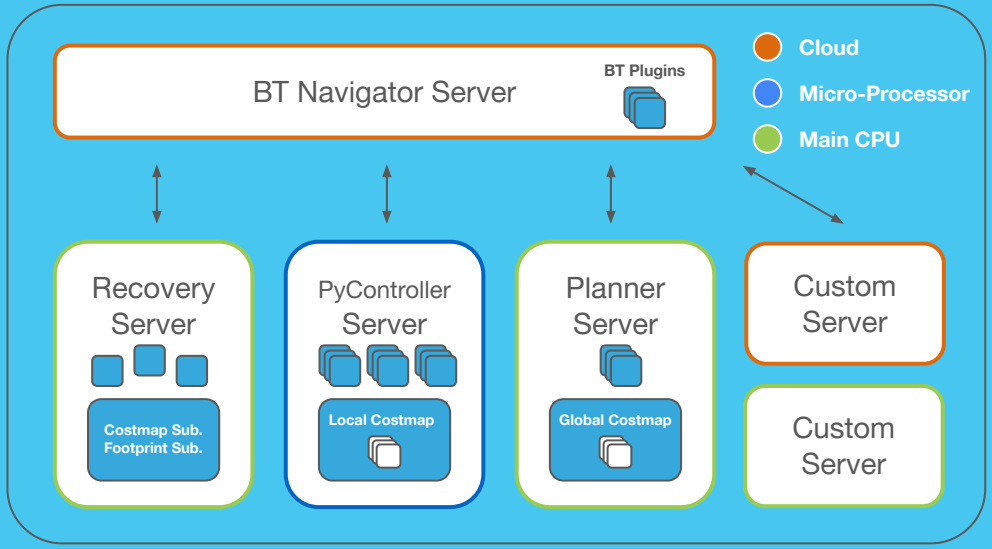
From ROS | Design | Algorithms | Features | Ease of Use | Quality

Design Characteristics

XML Behavior Tree Logic
- Behavior Tree Plugins

Easy to Swap Task Servers
- Multiple CPUs, Cloud, etc

More Plugin Interfaces
- With Multiple Instances
- Independent Recovery API

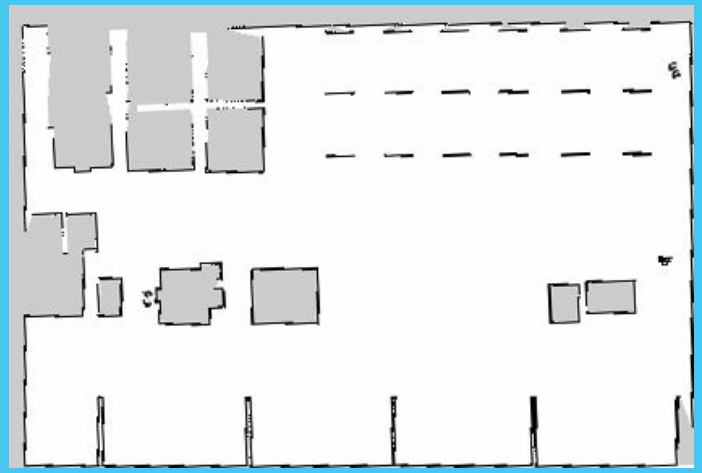


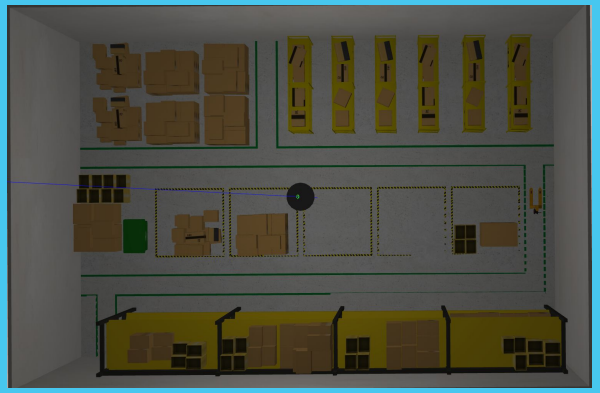
New Plugin Algorithms

Differential	Omni	Ackermann	Legged
RPP | DWB | TEB	DWB TEB	RPP TEB	RPP TEB
Theta Star Smac 2D | NavFn Smac Hybrid Smac Lattice	Theta Star Smac 2D NavFn Smac Lattice	Smac Hybrid Smac Lattice	Smac Hybrid Smac Lattice

From ROS | Design | **Algorithms** | Features | Ease of Use | Quality

New Product Features





From ROS

Design

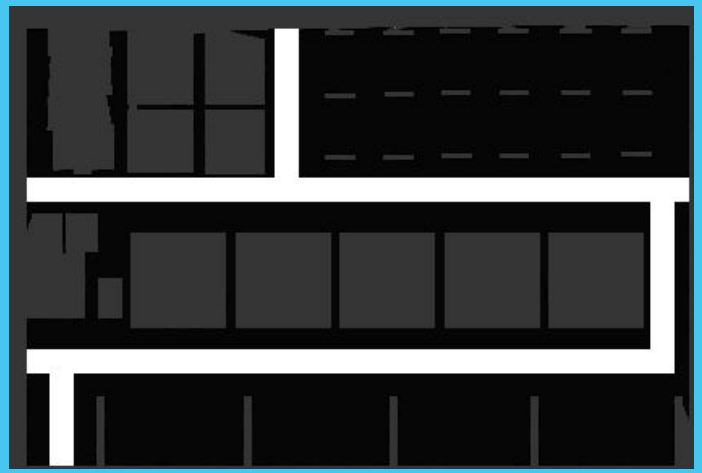
Algorithms

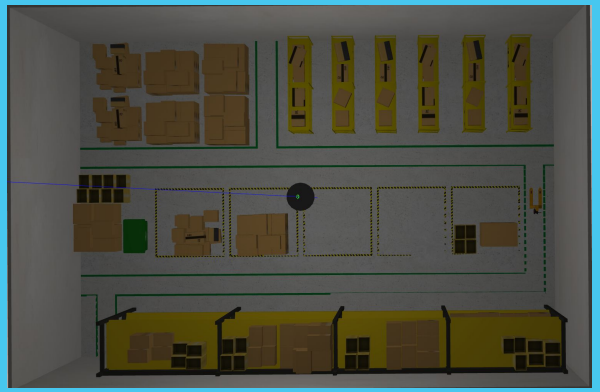
Features

Ease of Use

Quality

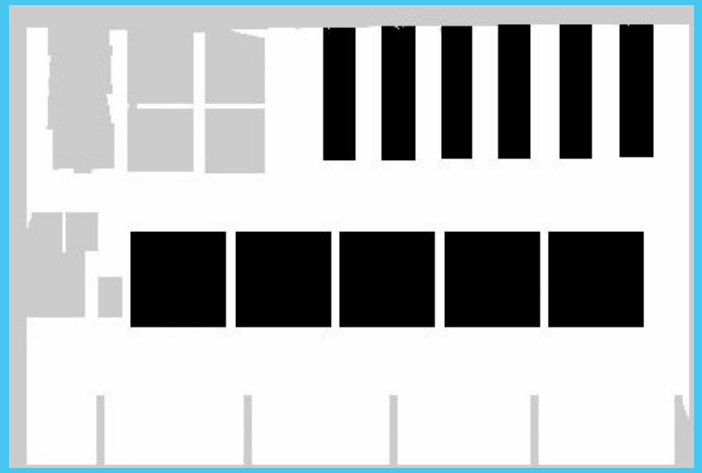
New Product Features - Speed Zones

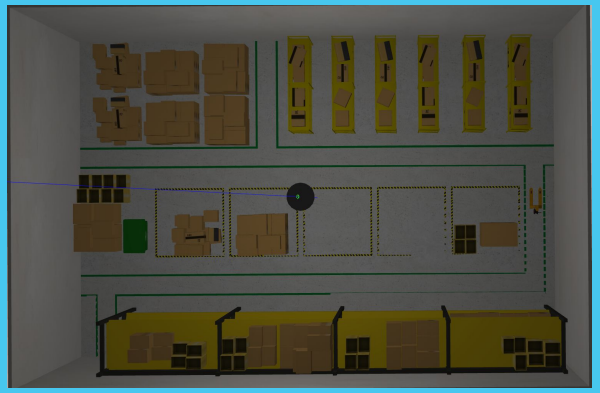




From ROS | Design | Algorithms | **Features** | Ease of Use | Quality

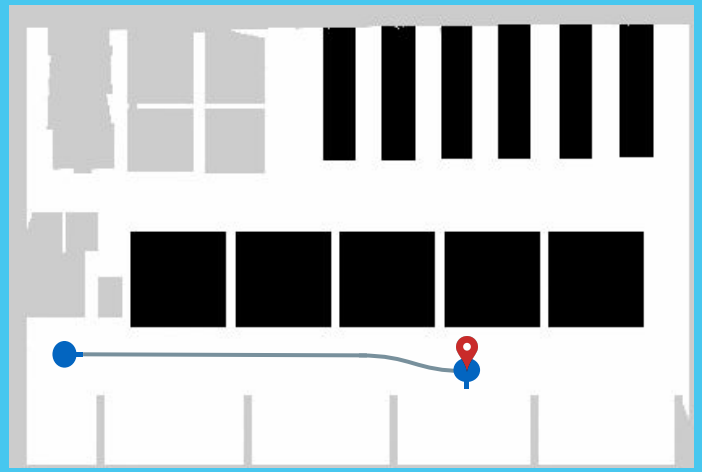
New Product Features - Keepout Zones

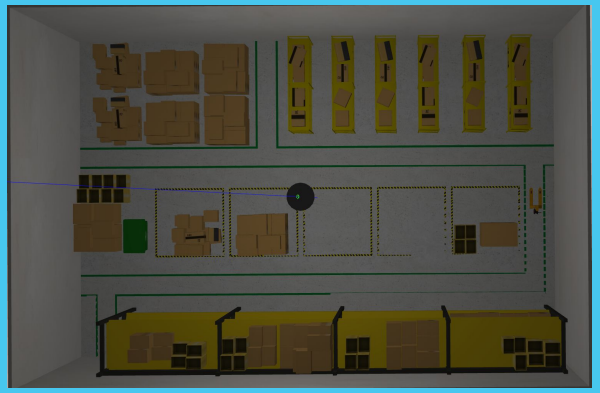




From ROS | Design | Algorithms | **Features** | Ease of Use | Quality

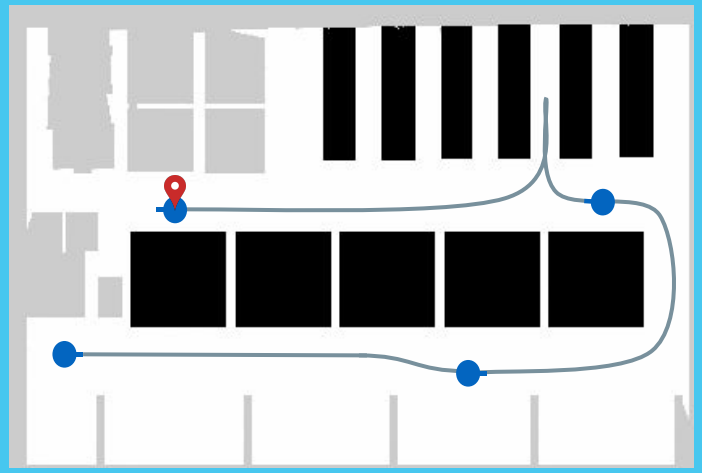
New Product Features - NavToPose

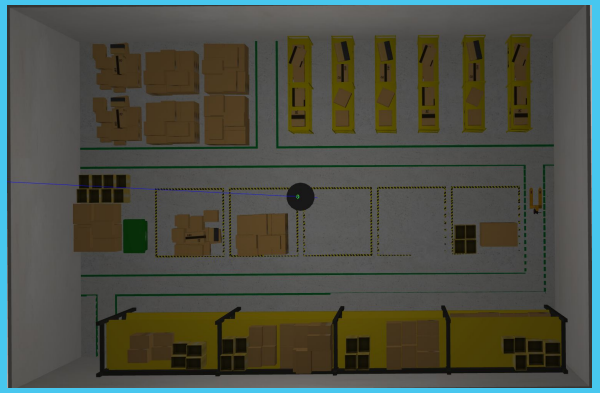




From ROS | Design | Algorithms | **Features** | Ease of Use | Quality

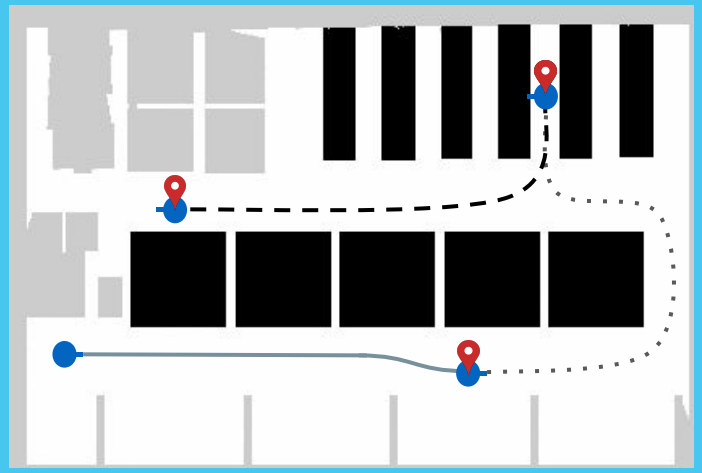
New Product Features - NavThroughPoses

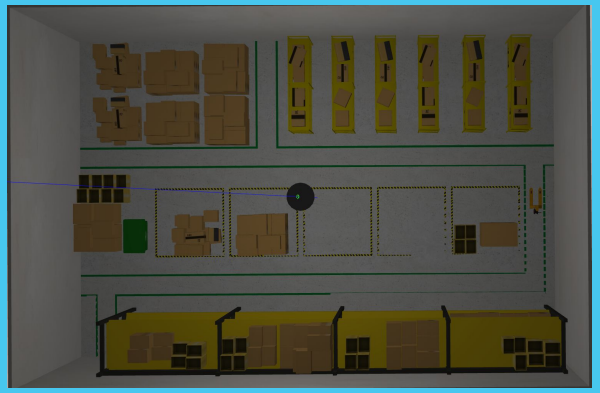




From ROS | Design | Algorithms | **Features** | Ease of Use | Quality

New Product Features - Waypoint Follower + Task Executors





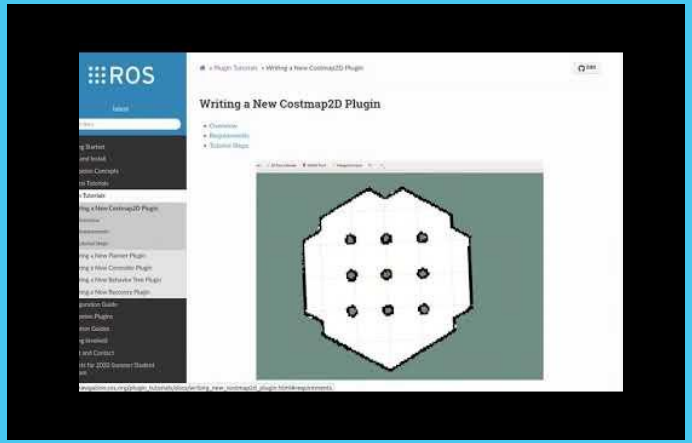
From ROS | Design | Algorithms | **Features** | Ease of Use | Quality

Application Developer Resources

Rviz Testing and Basic Operations Panel

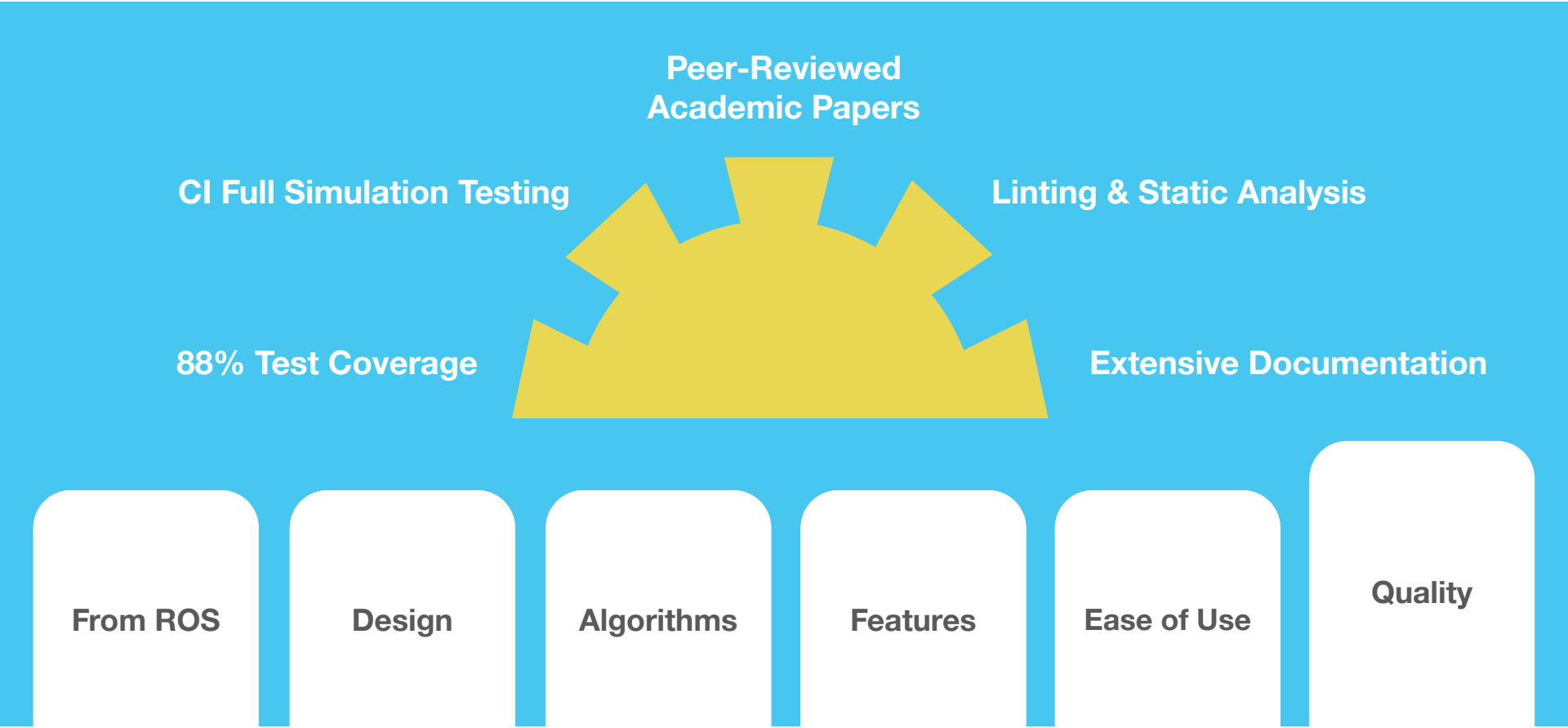
Python3 Simple Commander API

Documentation
- Build, Install, and Configuration Guides
- Plugin Creation and General Tutorials
- First-Time Robot Setup Guide
- Central List of Known Nav2 Plugins



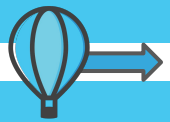
From ROS | Design | Algorithms | Features | **Ease of Use** | Quality

Software Quality



Nav2 Roadmap

1. ~~Basic Service Robot Capabilities~~ ✓
   The Marathon 2: A Navigation System.
   IROS 2020, Finalist RoboCup Best Paper
2. ~~Expand Support for All Bases~~ ✓
   Circular and Non-Circular Differential, Omnidirectional, Ackermann and Legged
3. **Create Modern Product Features**
   Keepout, Speed Zones, Assisted Tele-Op, Safety Nodes, Docking, Dynamic Obstacle Processing, IPC, Demos & Documentation, etc
4. **Extend Support for 3D and VSLAM**
   Support high-quality and improved 2D, 3D, and Visual SLAM and Localization systems
5. **Retool Terrain Models for Outdoor**
   Create swappable environmental models, including cost and height maps for planar, urban, non-planar, and outdoor environments



Nav2 Community

Navigation Working Group
- Bi-Weekly Meetings
- 7-20 People Per Meeting
- 115 Contributors
- 500 People on Slack

Why Get Involved?
- Professional Growth
- Reduced Risk
- Collaborate on Development
- Power to Steer the Project

Interested in Getting Involved?
Join our Slack: https://bit.ly/3ssxidP

Repository, Documentation, and Issue Tracker:

https://github.com/ros-planning/navigation2

https://discourse.ros.org/c/navigation

https://navigation.ros.org

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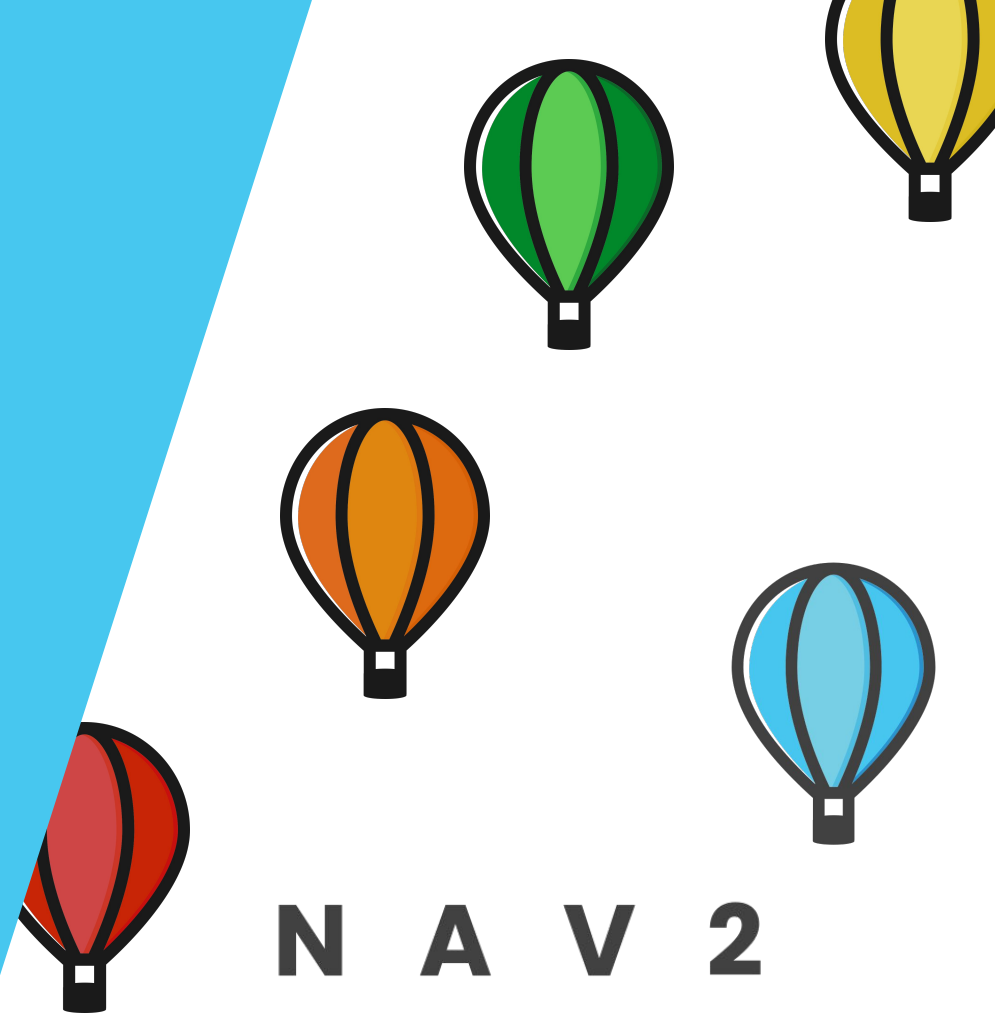
Steve Macenski

Open Source Robotics - Engineering Lead
s.macenski@samsung.com
stevenmacenski@gmail.com



History of ROS Navigation - PR1

Motivations for Nav2 - Early Development Team

Matt Hansen

Carlos Orduno

Brian Wilcox

Mohammad Haghighipanah

Carl Delsey

Michael Jeronimo

Steve Macenski

Ruffin White