Open Source
High Performance Energy!
A digital ecosystem is a distributed, adaptive, open socio-technical system with properties of self-organisation, scalability and sustainability inspired from natural ecosystems.
We need infrastructure to support experiments, build applications, and deploy solutions.
The (Bad) Old Days
Academia

Researchers produced papers & videos, with little hope of reproducibility, much less reuse
Government

R&D programs culminated in demos, quad charts, and reports; subsequent programs rarely leveraged prior results.
Commercial progress was slowed by re-implementation of basics and friction in using those results
Can we get everyone working together?
The industry is growing dramatically

- ~15% Global robot density CAGR
- >1K global robot suppliers
- 88% companies planning robotic adoption
- 53% companies listing cost of adoption as a top 5 challenge to adoption

Source: IFR
Source: Zippia
Proposal: Leverage Open Source
Permissive open source licensing (primarily Apache 2 or BSD) ensures compatibility with commerce.
THE ROS PRODUCT FAMILY

ROS
Full stack robotics SDK
ros.org

Gazebo
Cloud-ready digital twin
gazebosim.org

Open-RMF
Interoperable fleet management
open-rmf.org
15 years of ROS development
First commercially available **ROS-based** robot

**ROS-based** humanoid robot helping astronauts on the International Space Station

Singapore catalyzes **Open-RMF** for robot interoperability

Automotive safety certification granted to **ROS-based** vehicle software system

DARPA awards $1.5M in prizes to winners of robot search-and-rescue competition running on **Gazebo** in the cloud
ROS robots are everywhere
## ROS IN EVERY MARKET

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<tr>
<th>Aerospace</th>
<th>Agriculture</th>
<th>Automotive</th>
<th>Consumer</th>
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<tr>
<td>NASA</td>
<td>John Deere</td>
<td>cruise</td>
<td>iRobot</td>
<td>prime</td>
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<tr>
<td>BLUE ORIGIN</td>
<td>IRON VOX</td>
<td>Apex.AI</td>
<td>astro</td>
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<td>ELROY AIR</td>
<td>FarmWise</td>
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<td>PIAGGIO FAST FORWARD</td>
<td>ROBOTIS</td>
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</tr>
</tbody>
</table>

GLOBAL IMPACT

2.2M
ROS installs & updates per month

>$6B
Known acquisitions of ROS-based companies

>1.3K
Contributors to ROS in 2021

>150
Organizations have sponsored ROSCon: Arm, Intel, BMW, Toyota, Google, Microsoft, and many more
The open source community builds upon us

6K
Public GitHub repositories using the topic **ros**

1K
Public GitHub repositories using the topic **gazebo**

Reference points for GitHub topic use:

- **android**: 96K ([5.9M developers](#))
- **arduino**: 25K ([30M active community members](#))
- **raspberry-pi**: 14K ([38M units sold](#))
ROS is a global robotics hub
Modern Times
Facilitated by ROS, GitHub, and other common resources, researchers commonly release code to accompany publications.

4Our code is available at https://github.com/wonderren/public_moes

2The source code for our implementation of FMCW LiDAR is available in our fork of CARLA at https://github.com/aevainc/carla.

using the classic Nesterov acceleration scheme [29]. The code to run the benchmarks is made freely available at: https://github.com/Imontaut/collision-detection-benchmark.
A TECHNOLOGY PIPELINE

From Classroom to Research to Production
Government

R&D programs build directly on earlier results and PMs expect software to be delivered in a reusable manner

International robotics competitions using Gazebo 2013-2022
NASA VIPER

Gazebo for design, development, and test

ROS for ground flight software

Scheduled to launch 2024

Inspiration for Space ROS
An explosion in commercial progress is being driven by ROS and other open infrastructure.

- **2018:** MiR acquired by Teradyne @ $272M
- **2019:** 6 River acquired by Shopify @ $450M
- **2019:** Canvas acquired by Amazon
- **2021:** Fetch acquired by Zebra @ $300M
- **2021:** Locus valued at $1B
- **2022:** iRobot acquired by Amazon @ $1.7B
COMMON CONCERNS

- ROS isn't ready for industry
- ROS isn't safe/safe OS is required to build robots
- ROS is too big/heavyweight
- ROS is too complicated
- ROS is open source, which means it's not secure
WHAT YOU CAN DO

**Academia**
- Share your code when you publish
- Demand the same when you review

**Industry**
- Set policy for open source use and contribution
- Provide open source SDKs for your products

**Government**
- Prefer (or require) open source solutions
- Test & measure with open source systems

**Everyone**
- Use ROS in your work and help us to improve it
- Be public about your use of ROS
Join us!