



Erle Robotics:

**"Linux Drones & the App Store for Drones"**

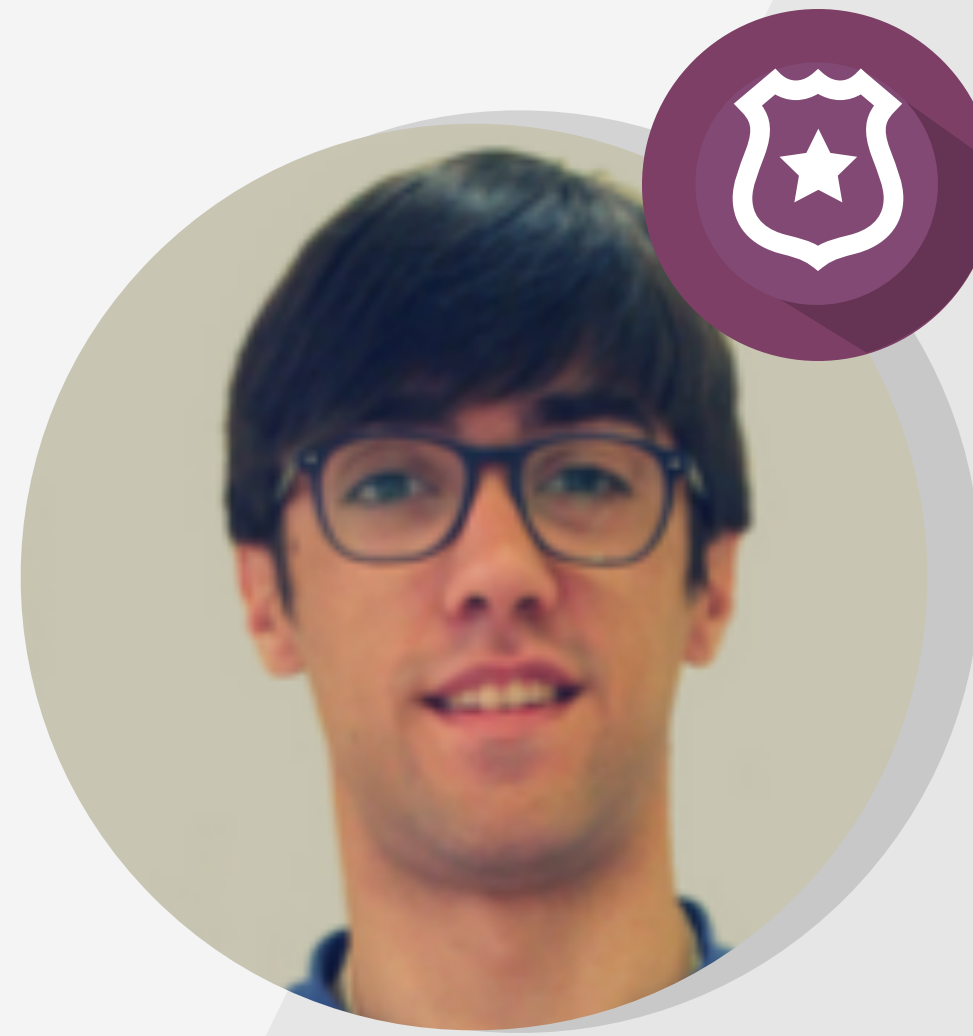
We make **artificial  
robotic brains** that power  
robots and drones.

# Today with you



**Víctor Mayoral Vilches**

Robotics  
Engineer



**Alejandro Hernández**

Robotics  
Engineer



**Iñigo Muguruza**

Robotics  
Engineer

# Erle-Brain

Brains



## A Linux-based computer for making robots and drones

Erle-Brain is an artificial Linux brain for making robots. It puts together more than 25 sensors, a 1 GHz Cortex-A8 processor and 4 GB of flash memory running state of the art algorithms.



# Erle-Brain

Brains



**PWM signals:** Motors control, PPM (radio) reception, servo motor control, ...

**UART serial:** GPS, serial console, additional sensors, ...

**Buzzer:** piezoelectric device for sound emitting

1 GHz processor running Linux distributions, several IMUs (3 axis accelerometers, 3 axis magnetometers, 3 axis gyroscopes), pressure sensors, temperature sensors, ...

**I2C bus:** How about connecting a humidity sensor or maybe a H2O one ;)?

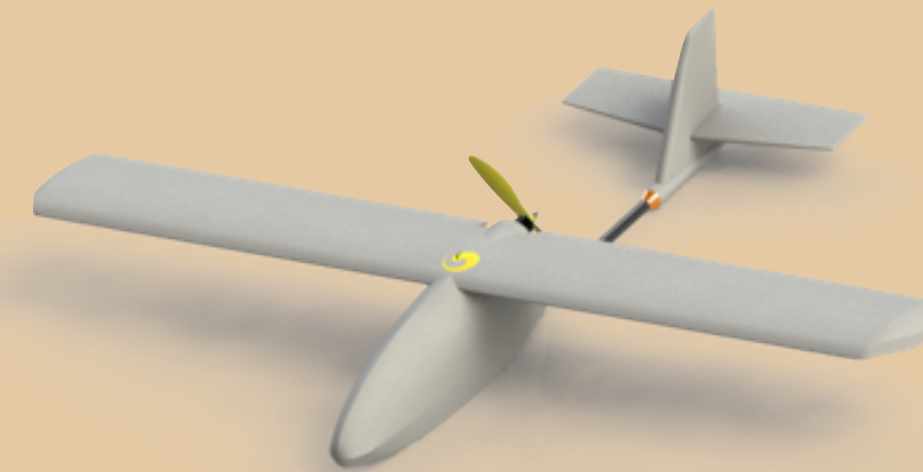
**Power module support:** Power Erle-Brain and all the sensors through traditional Power Modules

# Robots overview

Robots



**Erle-HexaCopter**  
12.2.2015



**Erle-Rover**  
20.03.2015

**Erle-Copter**  
1.1.2015



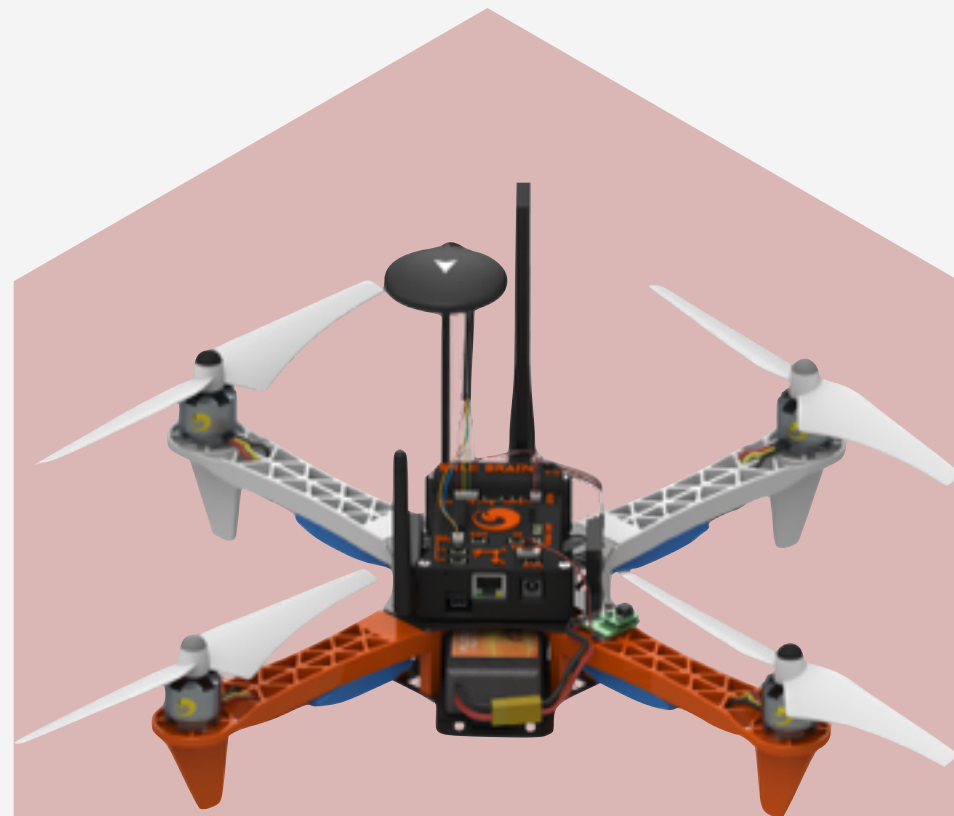
**Erle-Plane**  
07.3.2015





# Robots overview

Robots



Erle-  
HexaCopter  
Ubuntu drone  
5.5.2015

?

Erle-Copter  
Ubuntu Core  
5.5.2015



?  
30.7.2015\*

### GPS

UBlox 7M and magnetometer that includes a patch antenna

### Flight computer

A1 GHz Cortex-A8 processor that runs all the flight logic in Linux

**Buzzer:** piezoelectric device for sound emitting

**RGB LED:** Light your environment with an Erle-shaped light

**Li-Po battery**

### WiFi (2.4 / 5 GHz)

We support 802.11 ac both in *ad hoc* (hotspot) and infrastructure modes.

### 30+ sensors

accelerometers, magnetometers, gyroscopes, temperature sensors, barometers, ...

### Radio Control Link (2.4 GHz)

A traditional RC way of securing your flights.

### Power Module

A standard way of powering your drones with batteries from different sizes.

### Telemetry link (433 / 915 MHz)

Dedicated link for vehicle information and mission data

# Anatomy of a **Linux drone**



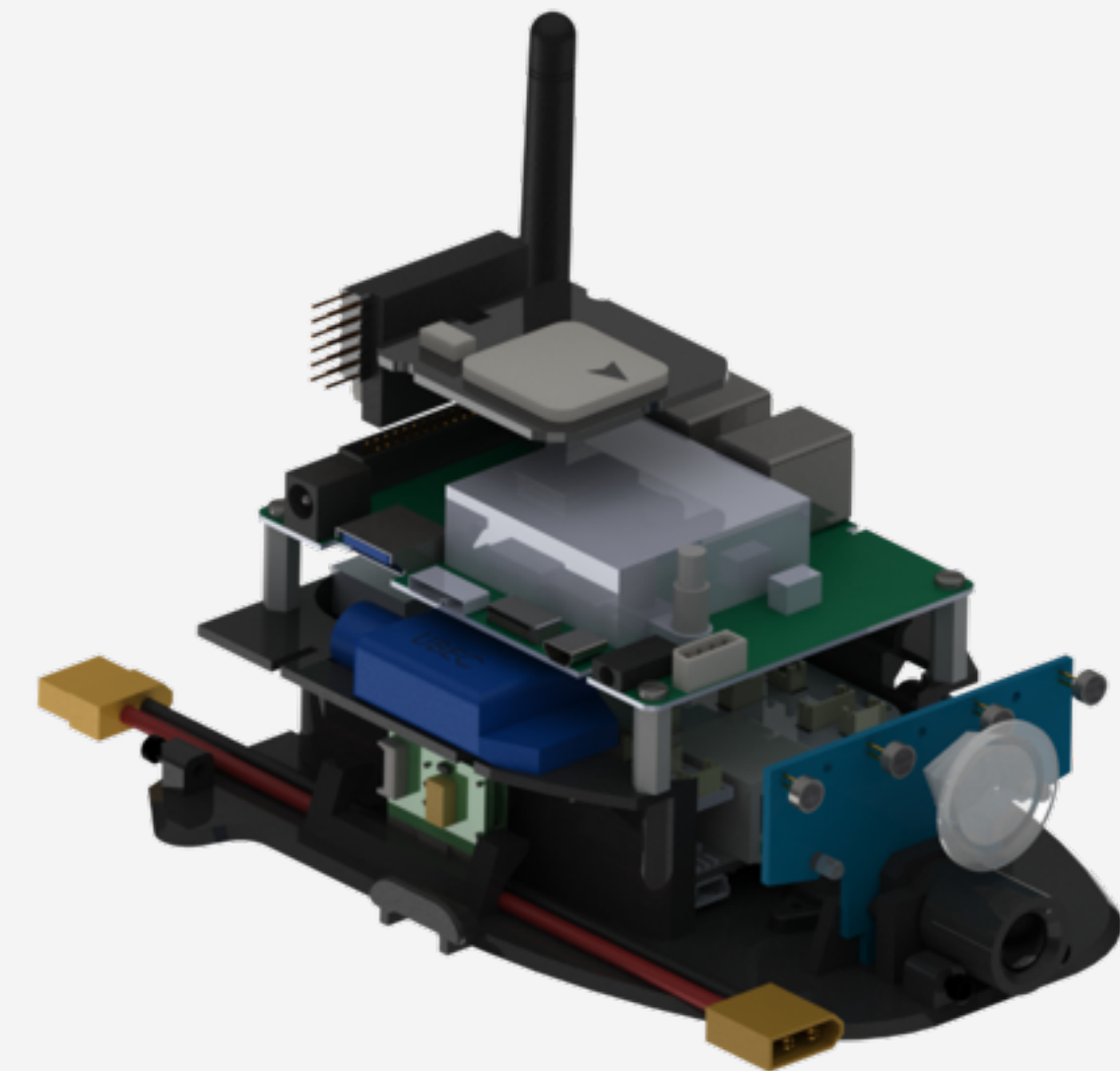
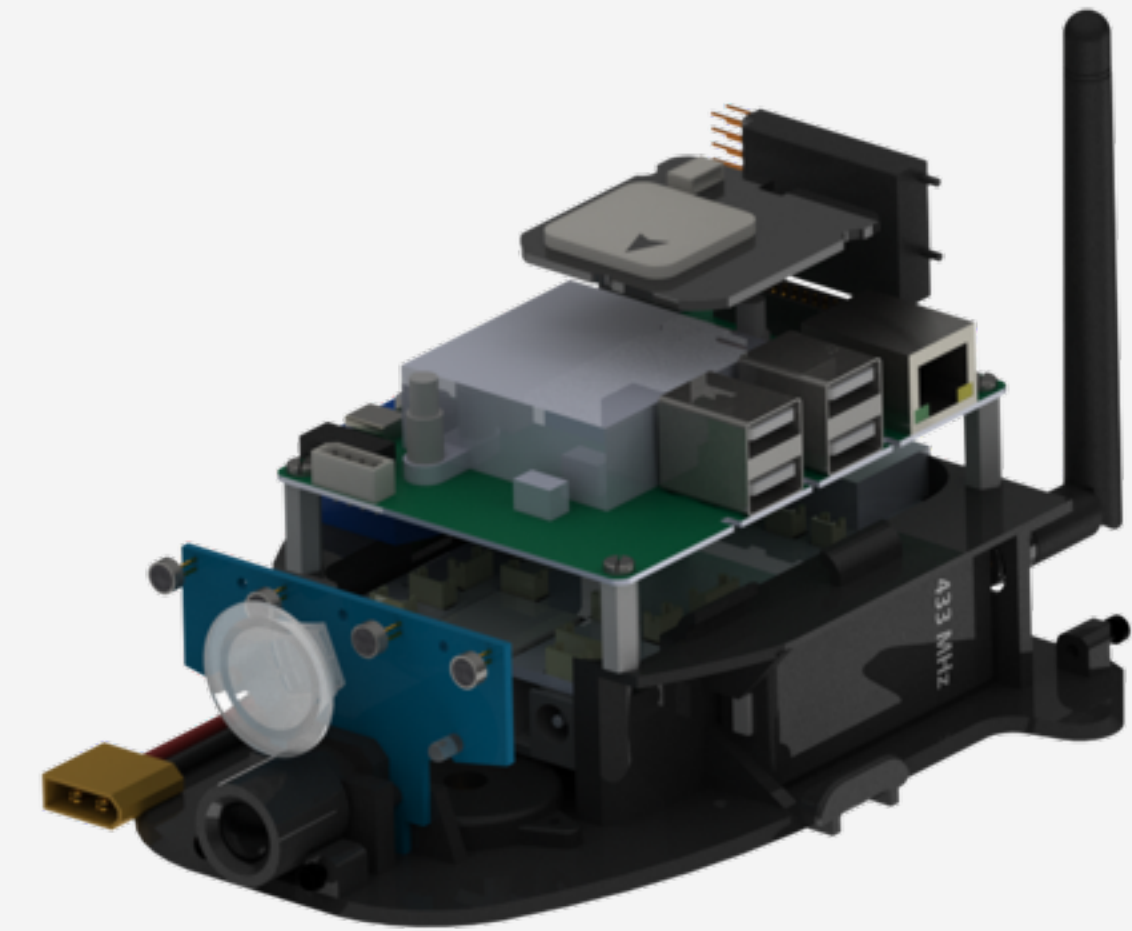
# Anatomy of a Linux drone





# Erle-Brain+

the smartest brain for drones



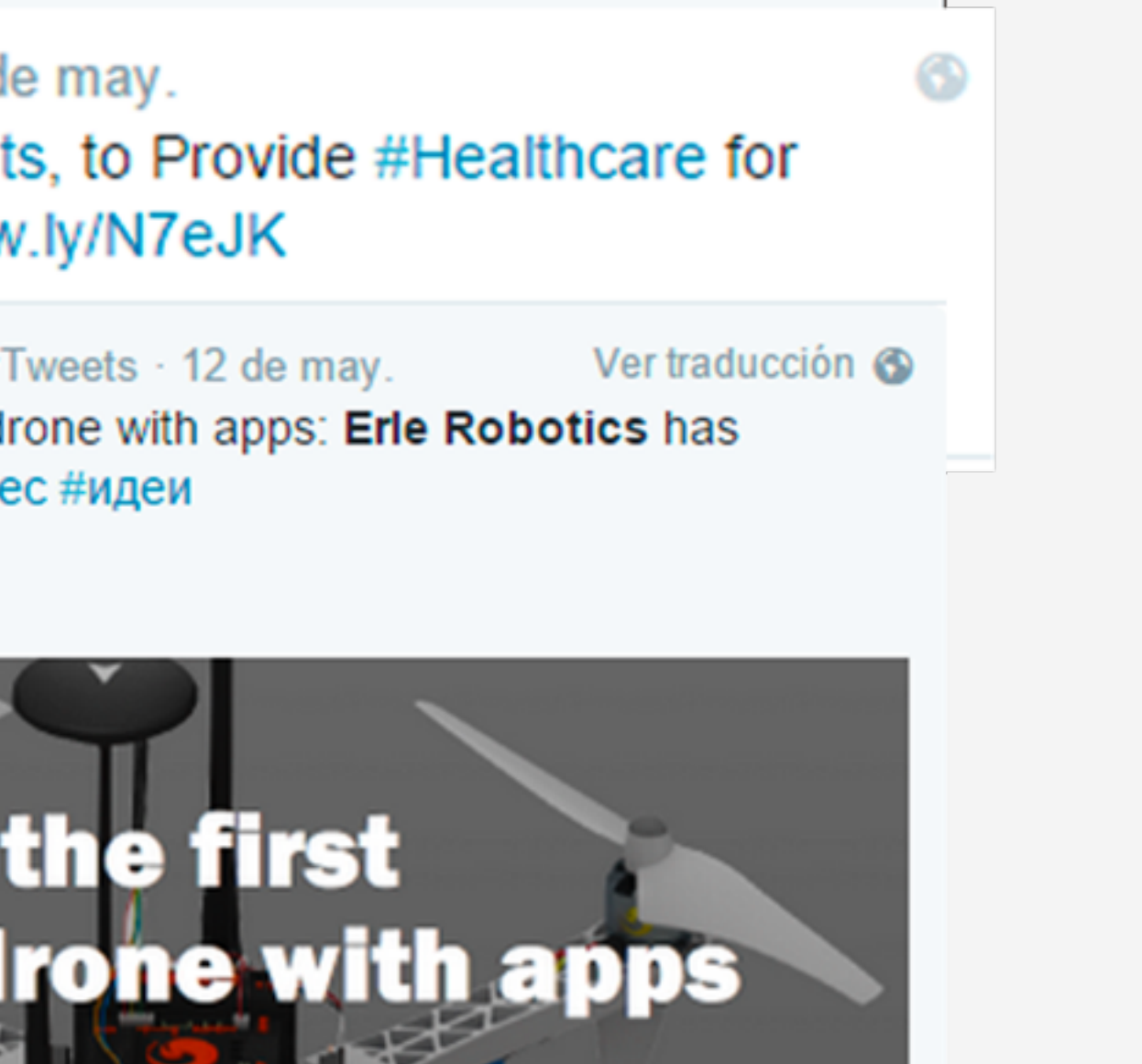
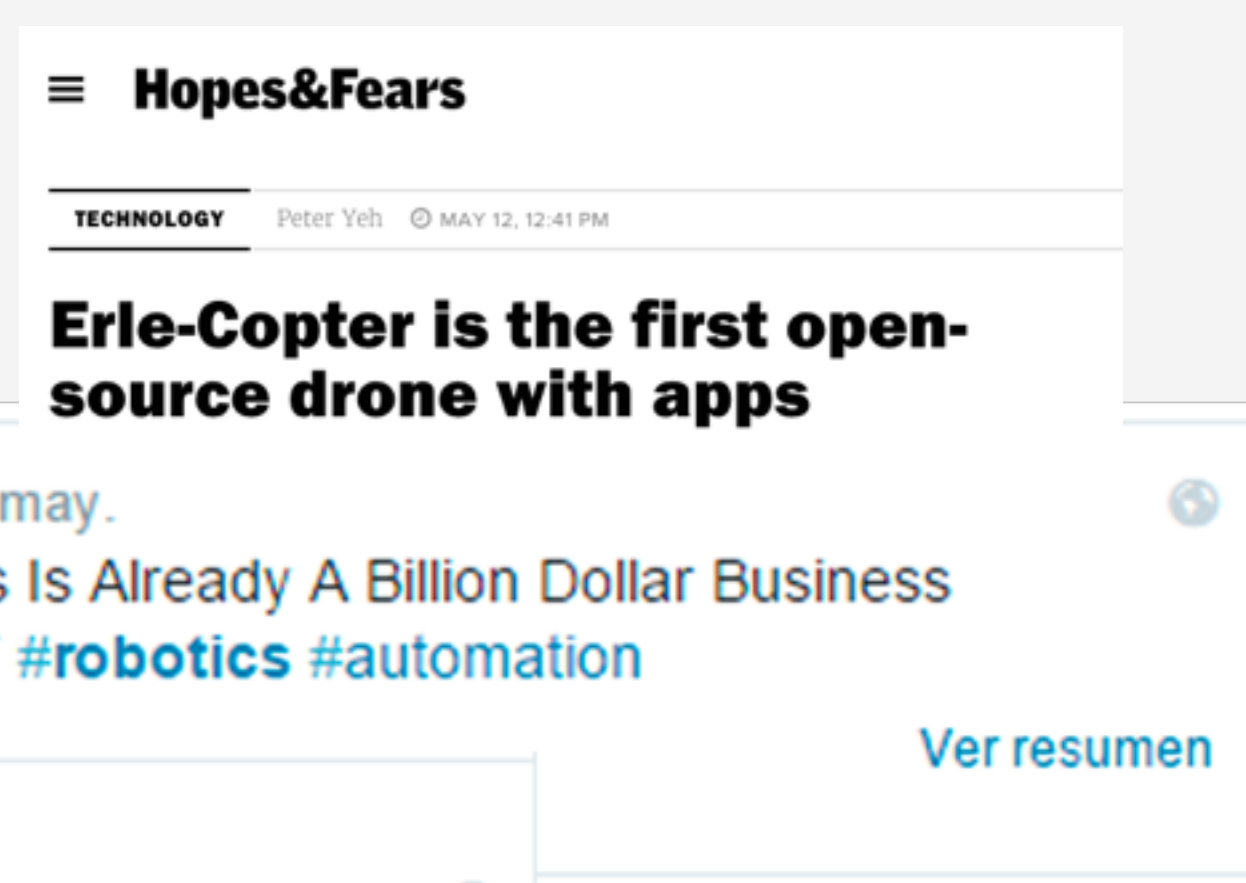
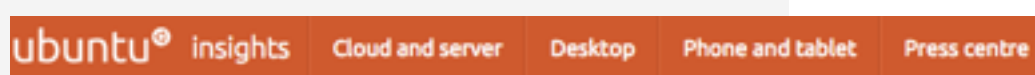
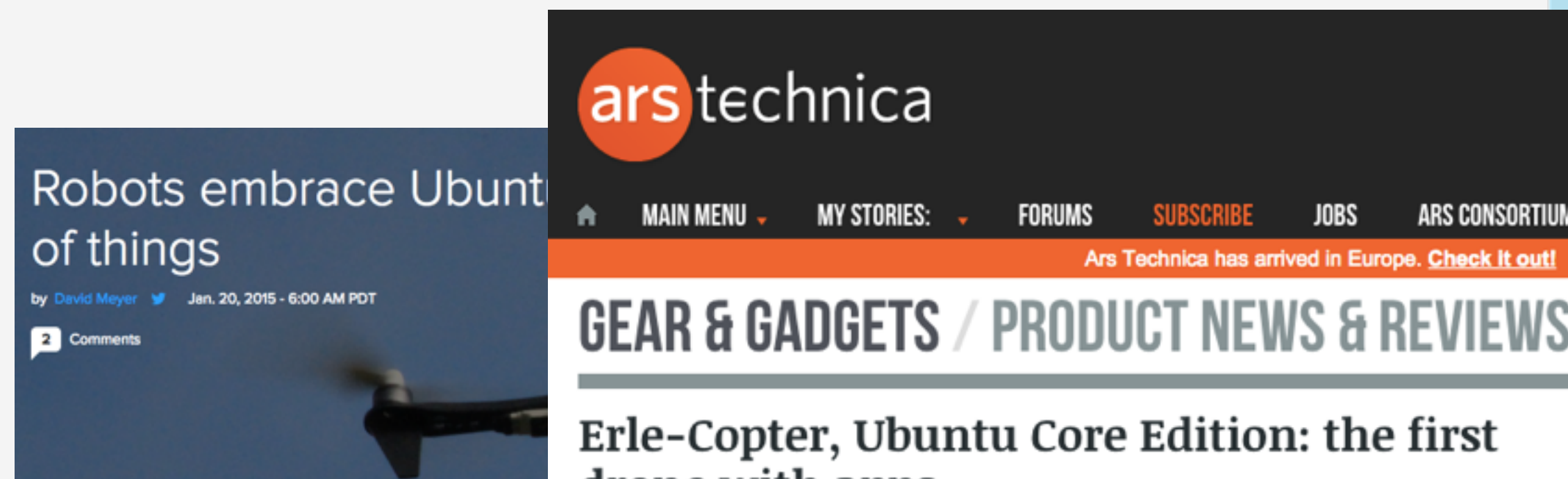
Brains

Robotics has long been a field that **overpromised and underdelivered**. We think drones are the most likely way to rectify that.

**C. Dixon**



# Why now?







Dronecode





- data on **12-15,000 flights per day**
- **200,000+** systems worldwide
- **Growth of 10,000 systems per month**

## **Last 30 days at Dronecode:**

- 150,000 downloads of the Copter code
- 30,000 downloads of the Plane code
- 300,000 downloads of the GCS
- 400,000 downloads of terrain data





Linux

SDK: ROS

App Store





# **Linux** drones and robots



# Worldwide community



**80M**  
Linux users

Out of the 3B Internet users 80M use  
Linux and 25M of them Ubuntu.





Stable OS built over  
the last **20 years**





# Embedded computers





Demo

# drone webstore

SSID: Erle-Brain+  
try [erlerobotics.com](http://erlerobotics.com)



# A toolbox for creativity







Demo

**real time visual targeting**

# Software autopilot

a.k.a. ardupilot



- 700,000 loc
- 17,000 commits
- 136 committers
- 800+ contributors
- HALs



- **APMrover2**
- AntennaTracker
- **ArduCopter**
- **ArduPlane**
- Tools
- docs
- **libraries**
  - AC\_AttitudeControl
  - AC\_Fence
  - AC\_PID
  - AC\_Sprayer
  - AP\_HAL
  - AP\_HAL\_Linux
  - ...
- mk
- modules



# Real time

Maximum latency	Task
100 ns	SPI bus transitions
1 $\mu$ s	PWM transitions, PPM-SUM and SBUS
1 ms	IMU sensor inputs (gyroscopes and accelerometers)
20 ms	Barometer, compass, airspeed, sonar (I2C, SPI and analog).
200 ms	GPS and other sensors



# Real time



## Kernel latencies

- vanilla kernel
- PREEMPT
- RT\_PREEMPT
- Xenomai



## Thread priorities

APM application threads are configured with with the scheduling policy **SCHED\_FIFO** with priorities that assure meeting the required maximum latencies. Set up has proved to be sufficient for among hundreds of flights.

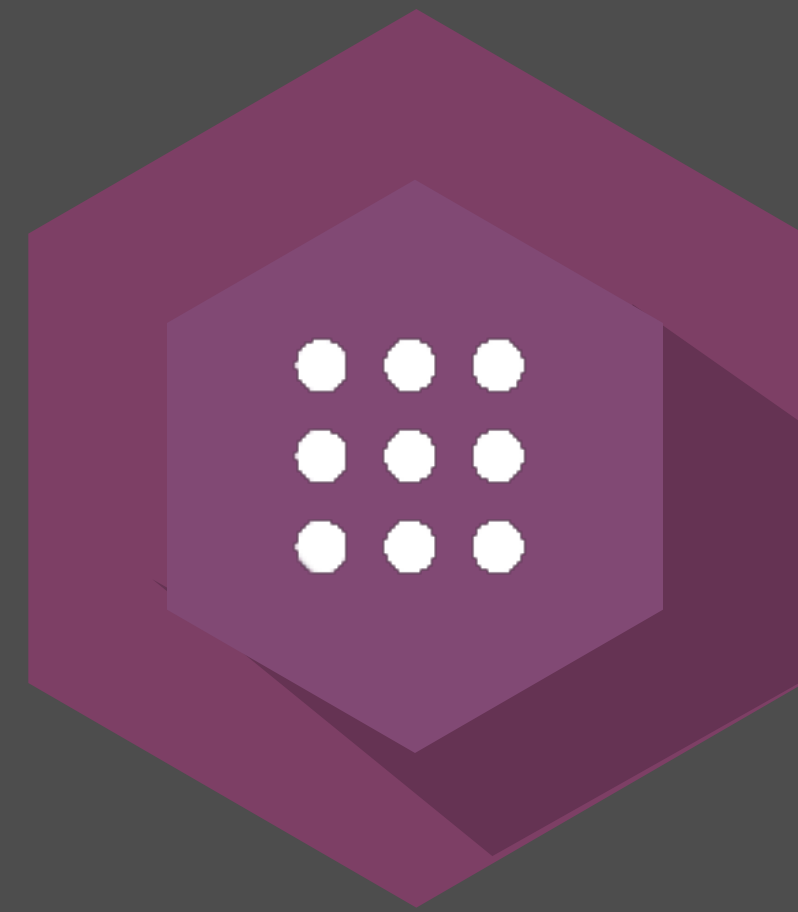




Demo

**flying while compiling**





SDK:

**Robot Operating System (ROS)**



# Robot Operating System

## **An SDK for robots and drones**

The Robot Operative System (ROS) is an open-source, framework for robot application development maintained by the Open Source Robotics Foundation (OSRF). A ROS system is comprised of a number of independent nodes, each of which communicates with the other nodes using a publish/subscribe messaging model that can be deployed over different computers.





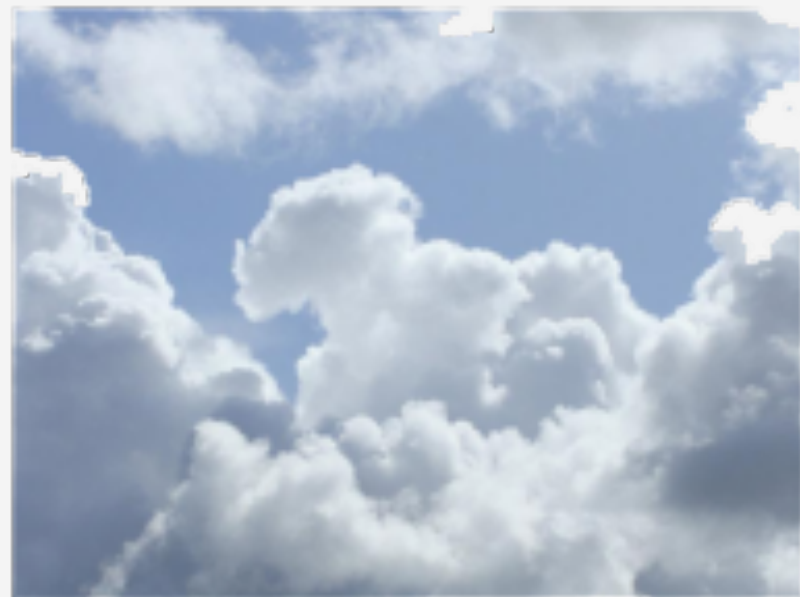
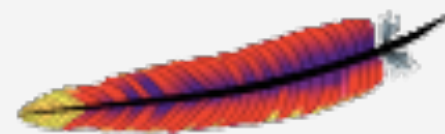
# Robot Operating System

ROS

## LAMP

Linux  
Apache  
MySQL  
PHP (Python)

## Web 2.0



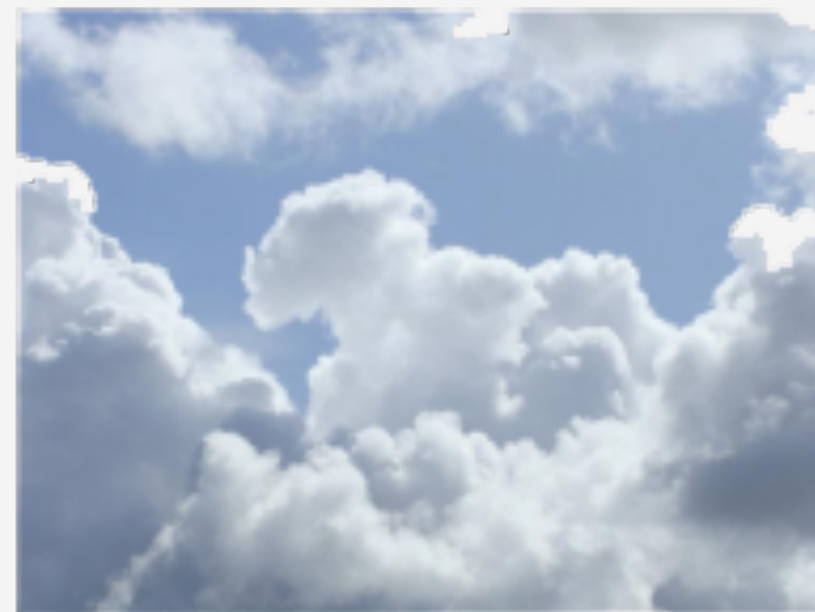
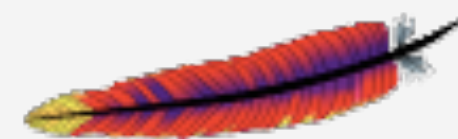
## Robotics





# Robot Operating System     ::: ROS

## Web 2.0

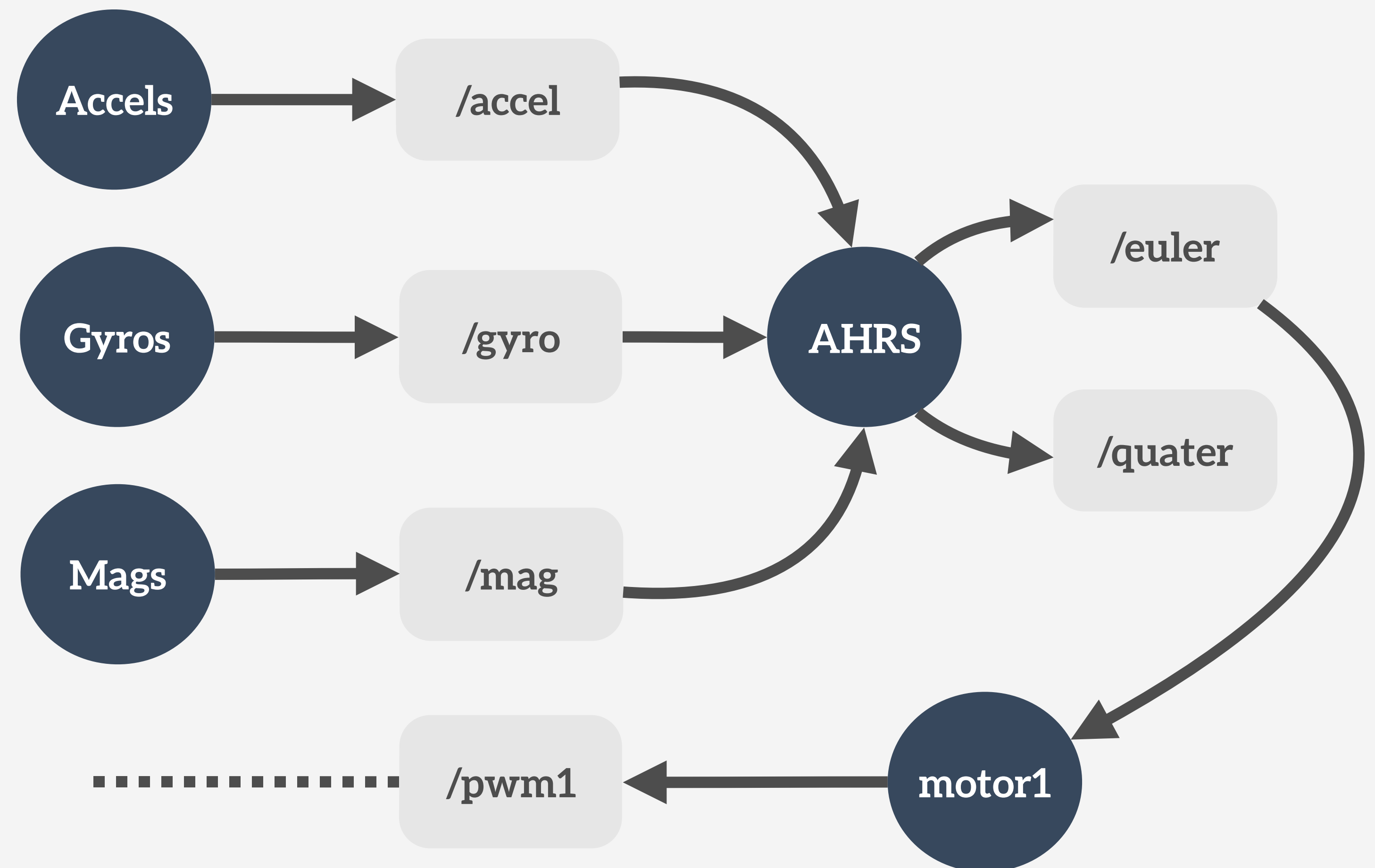


## Robotics





# ROS







# Demo

# ROS music

```
> roslaunch ros_erle_buzzer ros_erle_buzzer_writer <melody>
```



# Demo: ROS music



```
> rosrune ros_erle_buzzer ros_erle_buzzer_main  
> rosrune ros_erle_buzzer ros_erle_buzzer_writer <melody>
```





# Demo

# ROS light

```
> roslaunch ros_erle_ubled ros_erle_ubled_writer <color>
```



# Demo: ROS light



```
> rosrune ros_erle_ubled ros_erle_ubled_main  
> rosrune ros_erle_ubled ros_erle_ubled_writer <color>
```





Demo

**Autonomous flight**





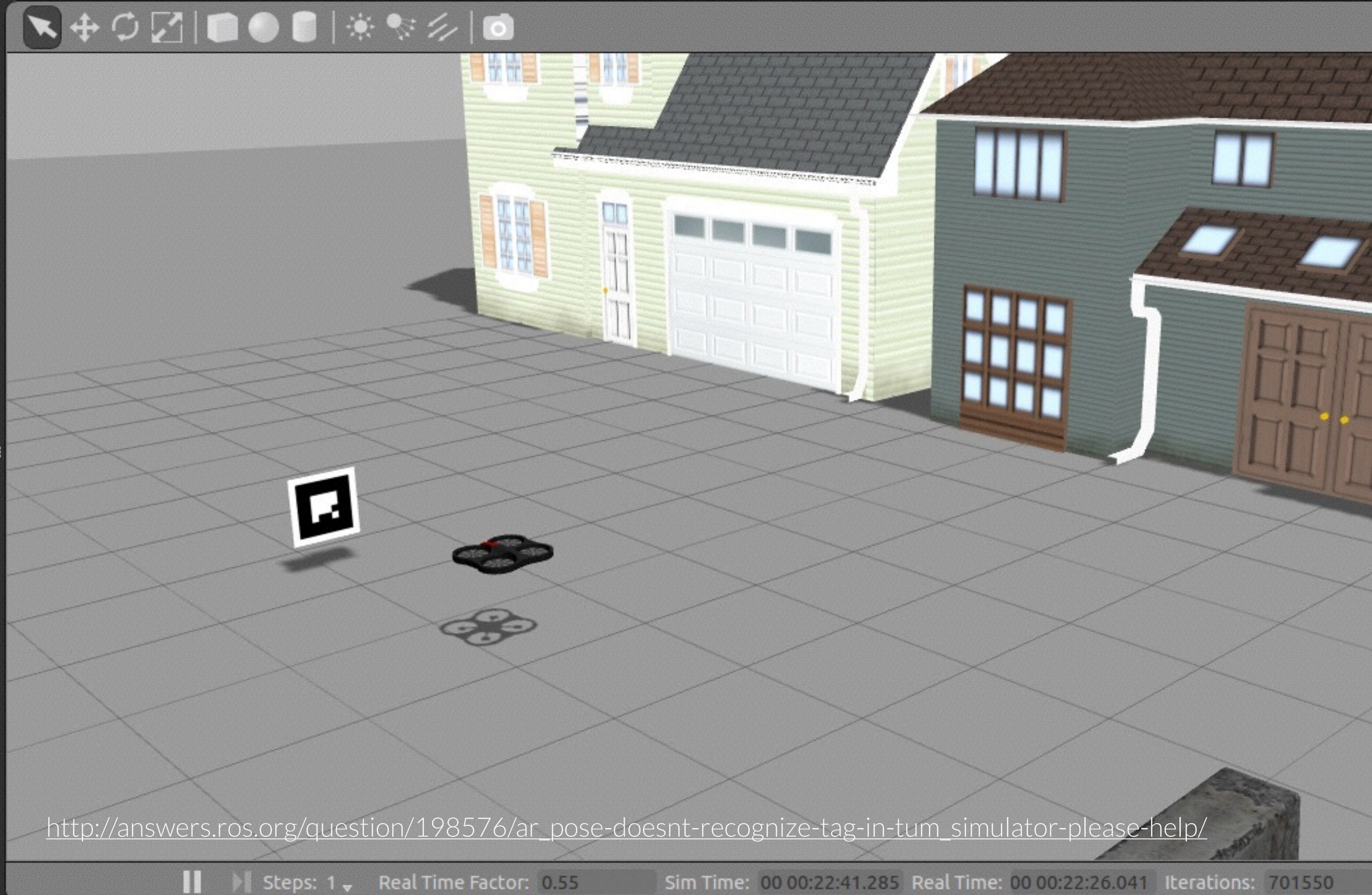
GAZEBO



World

Insert

- ▶ /home/przemek/.gazebo/m...
- ▼ /home/przemek/.gazebo/g...
  - Alpha
  - Artag\_1
  - Asphalt Plane
  - Ball Bearing
  - Beer
  - Bookshelf
  - Bowl
  - Breakable Test
  - Brick Box 3x1x3
  - Cabinet
  - Camera
  - Cart: front steering
  - Cart: rigid suspension
  - Cart: soft suspension
  - Cinder Block
  - Cinder Block 2
  - Coke Can
  - Construction Barrel
  - Construction Cone
  - Cordless Drill
  - iRobot Create
  - Cricket ball
  - Cube 20k
  - Door handle
  - Double pendulum with b...
  - DRC Practice: 2x4 Lumber
  - DRC Practice: 2x6 Lumber
  - DRC Practice: 4x4x20 Lu...
  - DRC Practice: 4x4x40 Lu...
  - DRC Practice: 135 degree...
  - DRC Practice: 45 degree ...
  - DRC Practice: Ball Valve







The next thing  
**ROS 2.0**





The next thing  
**ROS 2.0**

- lossy networks
- embedded and deep  
embedded (bare-metal)
- teams of multiple robots
- real time
- production environments





App store



# An app store for robots

App Store



The first **app store** for robots and drones in the cloud supported by **Canonical** and the **Open Source Robotics Foundation**.



# Sneak peek




CANONICAL





Open Source  
Robotics Foundation

App Store

 Erle Robotics - Erle-Brain

Store

Search 





## hello-world

By [Shared snappy store account](#)

**Version:** 1.0.5 • **Size:** 31.842 KB

Rating: 0/5

Installing...

Details

Reviews

Settings

### Details

Hello world example This is a simple hello world example.

Frameworks





# Demo

## packing a ROS app

```
> ./ros2snap ros_erle_takeoff_land
```



# Sneak peek



CANONICAL



Open Source  
Robotics Foundation

App Store

ubuntu Ubuntu

Snappy

Phone

Desktop

Victor Mayoral

Terminar sesión

## Sus aplicaciones

New application

Package name	Version	Progress			
 APM:Copter	1.4.1	 Publicado	Review	Feedback	Stats
 Erle Robotics - hello drone	1.0	 Publicado	Review	Feedback	Stats
 APM:Plane	1.1	 Publicado	Review	Feedback	Stats
 Erle Robotics - capes	1.0	 Publicado	Review	Feedback	Stats
 ROS Indigo	1.0	 AutomaticallyRejected	Review	Feedback	
 APM:Rover	1.2	 Publicado	Review	Feedback	Stats
 ros2snap	1.0	 Revisión pendiente	Review	Feedback	



# Sneak peek



CANONICAL



Open Source  
Robotics Foundation

App Store

ubuntu<sup>®</sup> Ubuntu

Snappy

Phone

Desktop

Victor Mayoral

Terminar sesión

## Sus aplicaciones

New application

Package name	Version	Progress			
 APM:Copter	1.4.1	 Publicado	Review	Feedback	Stats
 Erle Robotics - hello drone	1.0	 Publicado	Review	Feedback	Stats
 APM:Plane	1.1	 Publicado	Review	Feedback	Stats
 Erle Robotics - capes	1.0	 Publicado	Review	Feedback	Stats
 ROS Indigo	1.0	 AutomaticallyRejected	Review	Feedback	
 APM:Rover	1.2	 Publicado	Review	Feedback	Stats
 ros2snap	1.0	 Revisión pendiente	Review	Feedback	



# Sneak peek



CANONICAL



Open Source  
Robotics Foundation

App Store

## Submit your application

Your application

Drop anywhere on page or click here to select.

Required

A valid click package file for phone or Snappy, upload will begin as soon as valid file selected.

Supported releases

☐ rolling-core

☐ 15.04-core

Required

List of releases supported by your package.

Department

Required

La dirección web del sitio  
de soporte

Required

Una dirección web que los usuarios pueden visitar para obtener soporte para esta aplicación. Se permiten esquemas http(s) y mailto.



# Sneak peek



CANONICAL



Open Source  
Robotics Foundation

App Store

License

Proprietary

Required

La licencia usada para la publicación de tu aplicación.

Hacerlo gratis

☐

\$ (USD)

Required

Minimum required price \$2.99

€ (EUR)

Required

Minimum required price €2.49

£ (GBP)

Required

Minimum required price £1.99

Changelog

What changed in this version.



# Sneak peek



CANONICAL



Open Source  
Robotics Foundation

App Store

Do not distribute in the  
following countries

Afghanistan  
Aland Islands  
Albania  
Algeria  
American Samoa  
Andorra  
Angola

Your application will not be available for purchase in any countries selected in this list.

Only distribute in the  
following countries

Afghanistan  
Aland Islands  
Albania  
Algeria  
American Samoa  
Andorra  
Angola

Your application will only be available for purchase in the countries selected in this list.

Icon 256

Seleccionar archivo

Ningún archivo seleccionado

Un ícono de 256x256 que será usado cuando se liste tu aplicación. Si no es provisto, se usará el valor del campo **ícono** del manifiesto del paquete click.



“The best way to predict the  
future is to invent it”

**Alan Kay**





# Contact



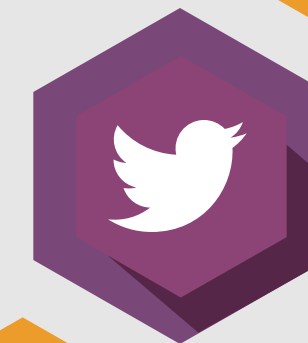
**Erle Robotics S.L.**



erlerobot



[contact@erlerobot.com](mailto:contact@erlerobot.com)



[twitter.com/erlerobotics](https://twitter.com/erlerobotics)



[facebook.com/erlerobot](https://facebook.com/erlerobot)



<http://erlerobotics.com>