

# Open Source Hardware

Portland Science Hack Day

*October 7, 2016*



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**OSH Park**

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@oshpark / @pdp7





# Open Source Hardware



Design is made  
**publicly available**

so that anyone can

**study,**

**modify,**

**distribute,**

**make**

**or sell**

designs or

hardware based on that design



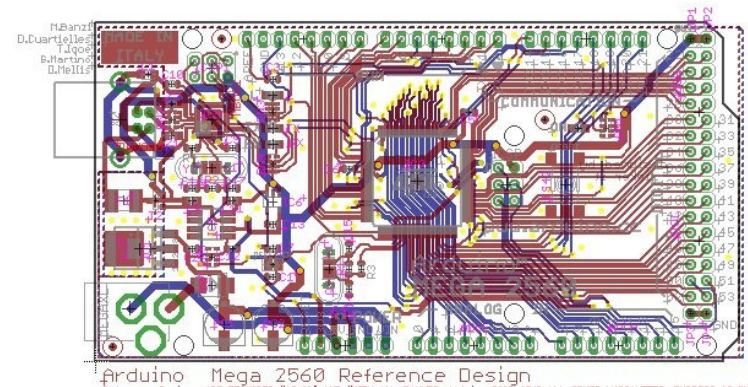
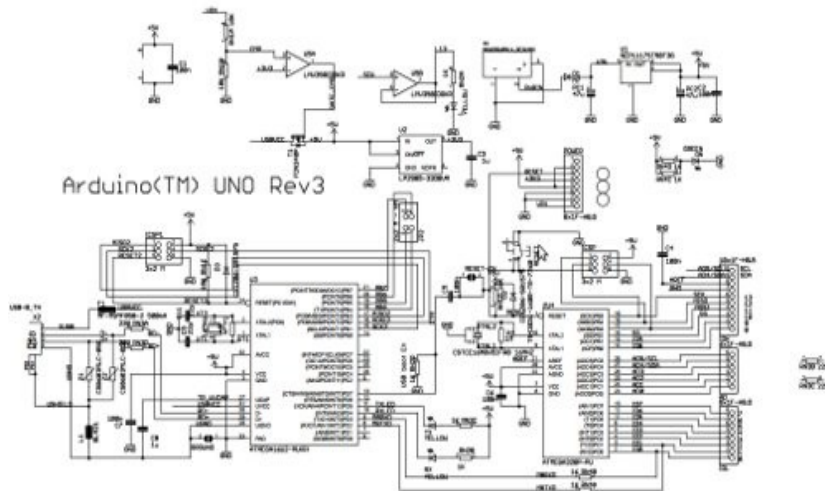
# Open Source Hardware



Documentation required for electronics:

Schematics

Board Layout



Editable source files for CAD software (*KiCad, EAGLE, Altium, etc*)

Bill of Materials (*BOM*)

*Best practice:* all components available in **low quantity distribution**



# Open Source Hardware



Publish documentation with an  
**Open Source license:**

- Creative Commons Share-Alike: **CC-BY-SA**
  - Non-Commercial (NC) clause is NOT acceptable
- Copyleft: **GPLv2, GPLv3**
- Permissive: **Apache, BSD, MIT**
- OSHW inspired: **CERN OHL, TAPR, SolderPad**



# CERN Open Hardware Licence

- Originally written for **CERN** designs hosted in the **Open Hardware Repository**
- Can be used by **any designer** wishing to **share design** information using a **license compliant** with the **OSHW definition criteria**.
- **CERN OHL version 1.2**  
Contains the license itself and a guide to its usage



# CERN Open Hardware Licence

Myriam Ayass, legal adviser at CERN and author of the CERN OHL:

- **OHL** is to hardware what **GPL** is to software
- Similar principles to Free or Open Source software
- Anyone should be able to:  
**see the source\***, **study it**, **modify it** and **share it**

*\*the design documentation in case of hardware*

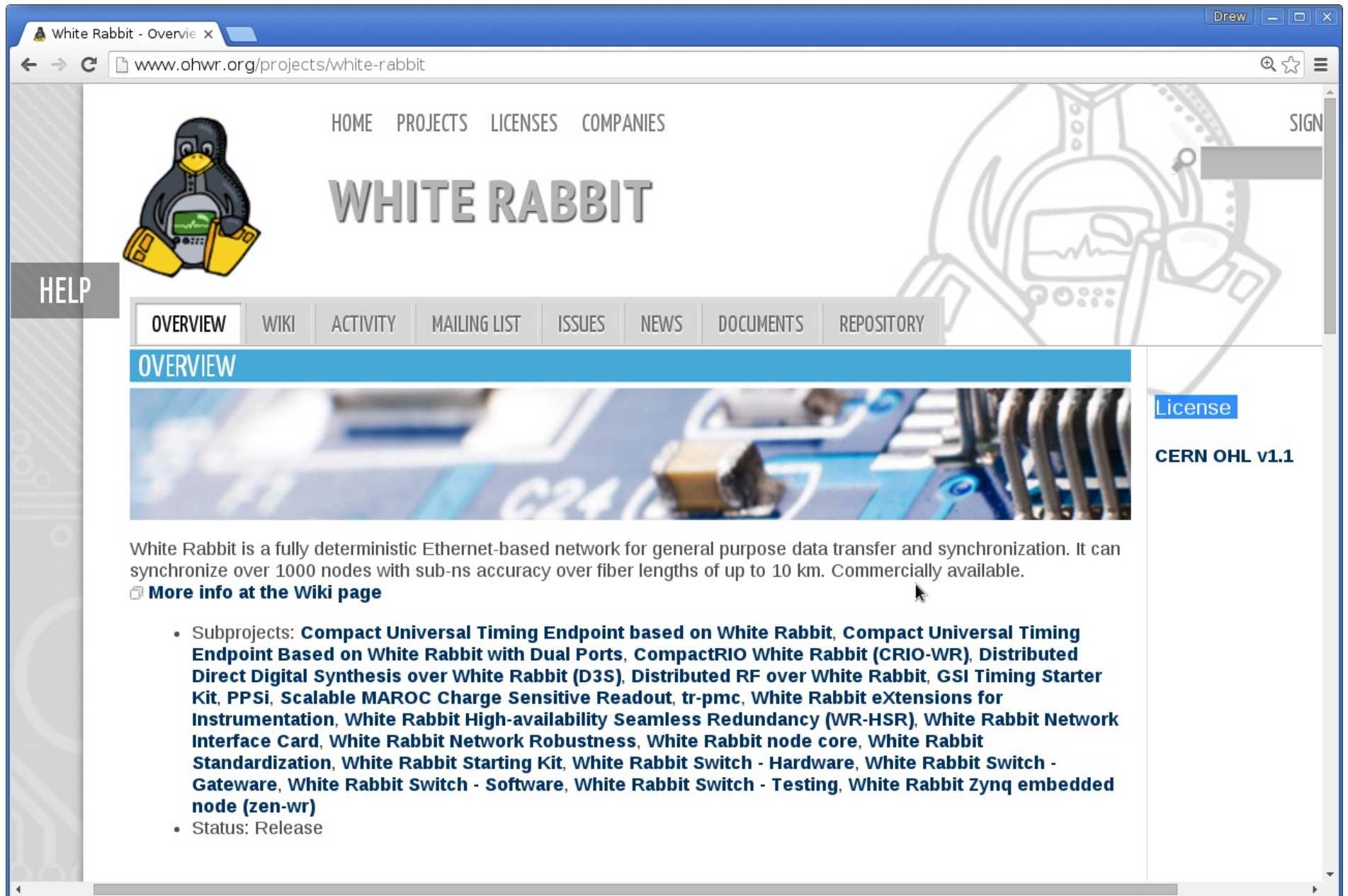
# Open Hardware Repository



- **Collaborate** on Open Hardware designs
- **Peer review** for small teams or solo designers
- Origins in **experimental physics laboratories**
- Enable teams to **work together** to solve problems
- **More fun** than isolation & results in **better hardware**



# Example: White Rabbit



White Rabbit - Overview x

www.ohwr.org/projects/white-rabbit


HOME PROJECTS LICENSES COMPANIES

WHITE RABBIT

HELP

OVERVIEW WIKI ACTIVITY MAILING LIST ISSUES NEWS DOCUMENTS REPOSITORY

OVERVIEW



License

CERN OHL v1.1

White Rabbit is a fully deterministic Ethernet-based network for general purpose data transfer and synchronization. It can synchronize over 1000 nodes with sub-ns accuracy over fiber lengths of up to 10 km. Commercially available.

[More info at the Wiki page](#)

- Subprojects: **Compact Universal Timing Endpoint based on White Rabbit**, **Compact Universal Timing Endpoint Based on White Rabbit with Dual Ports**, **CompactRIO White Rabbit (CRIO-WR)**, **Distributed Direct Digital Synthesis over White Rabbit (D3S)**, **Distributed RF over White Rabbit**, **GSI Timing Starter Kit**, **PPSi**, **Scalable MAROC Charge Sensitive Readout**, **tr-pmc**, **White Rabbit eXtensions for Instrumentation**, **White Rabbit High-availability Seamless Redundancy (WR-HSR)**, **White Rabbit Network Interface Card**, **White Rabbit Network Robustness**, **White Rabbit node core**, **White Rabbit Standardization**, **White Rabbit Starting Kit**, **White Rabbit Switch - Hardware**, **White Rabbit Switch - Gateway**, **White Rabbit Switch - Software**, **White Rabbit Switch - Testing**, **White Rabbit Zynq embedded node (zen-wr)**
- Status: Release



# Javier Serrano, Open Hardware at CERN



- Physicist and Electronics Engineer at CERN
- co-author of the **CERN Open Hardware License**
- creator of the **Open Hardware Repository**



**Open Source Hardware**



**Licenses, Copyright and Patents  
can get confusing!**

## **Review of Popular OSHW Licenses**

*Talk by Ari Douglas at OHS 2014*



# Open Source Hardware



## What is the spirit of Open Source?

- Publish everything that will:

**enable collaborative development**

- The goal is NOT to just check a box on a marketing flyer or add keywords to a Kickstarter campaign

# Open Source Hardware Association

- US Federal 501(c) non-profit
- Hosts the **OSHW definition**
- *“aims to be the voice of the open hardware community, ensuring that technological knowledge is accessible to everyone, and encouraging the collaborative development of technology”*



**OSHW**  
OPEN SOURCE HARDWARE ASSOCIATION



# Open Source Hardware



- **Best Practices**
- **Quick Reference Guide**
- **May and Must attributes** *(PDF)*

# Open Hardware Summit (OHS)

- **OHS 2016**: Portland, Oregon



- **6 prior summits:**
  - **2010, 2011**: New York Hall of Science
  - **2012**: Eyebeam (NYC)
  - **2013**: MIT (~Boston)
  - **2014**: Roma, Italia!
  - **2015**: Philadelphia



# Open Hardware Summit (OHS)

## 2015 videos:



**2015 Summit Late Afternoon Sessions**

4 months ago



**2015 Summit Early Afternoon Sessions**

4 months ago



**2015 Summit Late Morning Sessions**

4 months ago



**2015 Summit Early Morning Sessions**

4 months ago

# Open Hardware Summit (OHS)

## 2014 videos:

OSHWAs Videos on Vimeo - Iceweasel

Slides | Linu... | LinuxCon + ... | Donate » Lib... | Premier Farn... | Linux/includ... | Open Sourc... | Inbox - Outlook... | fustini oshw... | OSHW | oli... | fustini "osh... | About | OSHWA's... x

https://vimeo.com/user14106369/videos/sort:date/format:detail

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Upload

### OSHWAs Videos

47 Videos | 0 Appearances | 47 Total

Sort: [Date](#) / [Alphabetical](#) / [Plays](#) / [Likes](#) / [Comments](#) / [Duration](#)

**Closing Remarks by Simone Cicero and Gabriella Levine** 11:48  
from OSHWA Added 10 months ago | ▶ 30 ♥ 0 💬 0  
+ More details

**John Dimatos - The Open Source Advantage on Kickstarter (2014 OHS)** 11:45  
from OSHWA Added 10 months ago | ▶ 55 ♥ 0 💬 0  
Session: Implication of Open Source in Business and Culture 2014 Open Hardware Summit <https://twitter.com/ohsummit>  
<http://www.2014.oshwa.org/> <http://www.oshwa.org/>  
+ More details

**Tristan Copley Smith - EcoHacking the Future (2014 OHS)** 15:13  
from OSHWA Added 10 months ago | ▶ 362 ♥ 2 💬 0  
Session: Implication of Open Source in Business and Culture 2014 Open Hardware Summit <https://twitter.com/ohsummit>  
<http://www.2014.oshwa.org/> <http://www.oshwa.org/>  
+ More details

**Ari Douglas - Review of Popular OSHW Licenses (2014 OHS)** 13:10

#### BROWSE VIDEOS

Here are all of the videos that OSHWA has uploaded to Vimeo. Appearances are videos that OSHWA has been credited in by others.

Follow

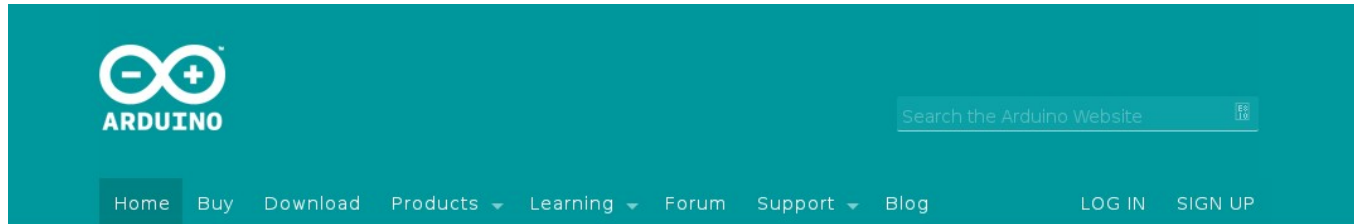
#### ALSO CHECK OUT

More stuff from OSHWA

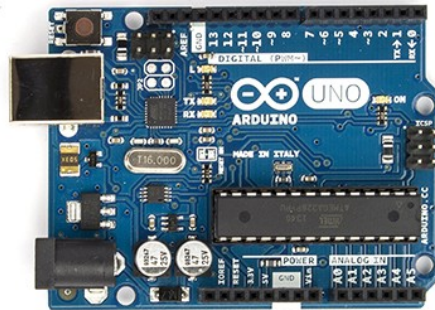
- 47 Videos ▶
- 1 Like ▶
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OSHWAs Videos

# Achieved Critical Mass by Sharing: Arduino



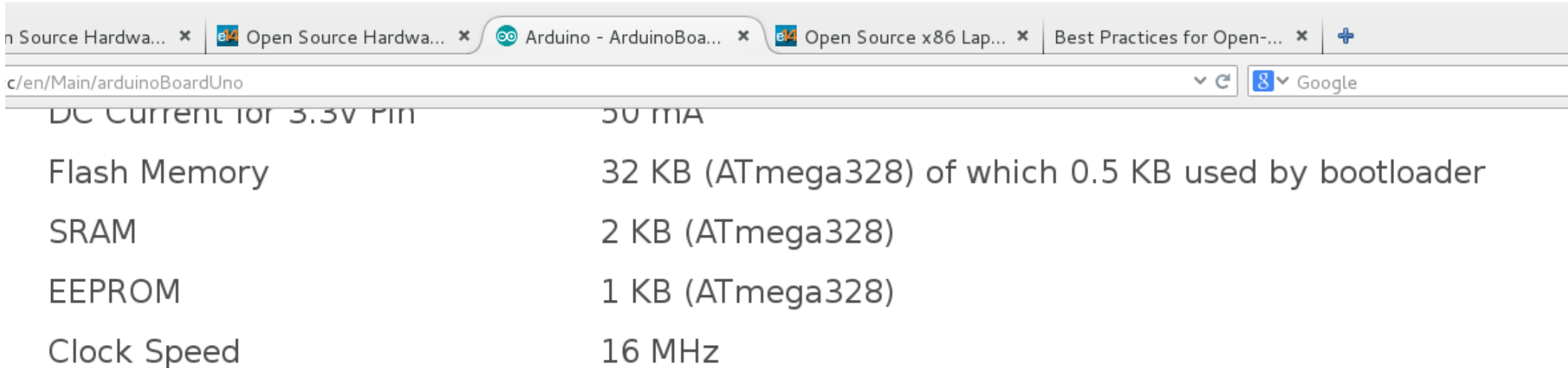
## Arduino Uno



*How did it come to be?*

**Arduino: The Documentary**

# Example: **Arduino UNO Design Files**



The image shows a browser window with several tabs. The active tab is titled "Arduino - ArduinoBoa...". The address bar shows "c/en/Main/arduinoBoardUno". The page content lists the following specifications:

DC Current for 3.3V PIN	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

## Schematic & Reference Design

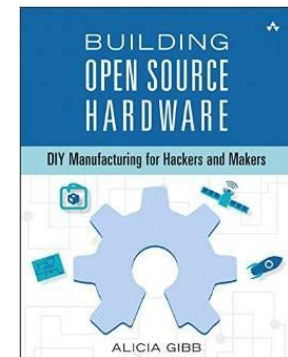
EAGLE files: [arduino-uno-Rev3-reference-design.zip](#) (NOTE: works with Eagle 6.0 and later)

Schematic: [arduino-uno-Rev3-schematic.pdf](#)

Note: The Arduino reference design can use an Atmega8, 168, or 328, Current mode logic, or ATmega328, but an Atmega8 is shown in the schematic for reference. The pin configuration is the same for all.

# OSHW Resources

- Join OSHWA
- Subscribe to the mailing list
- Follow on Twitter:
  - @OHSummit
  - @oshwassociation
- Building Open Source Hardware  
by Alicia Gibb



*Section:*  
LINUX on OSHW



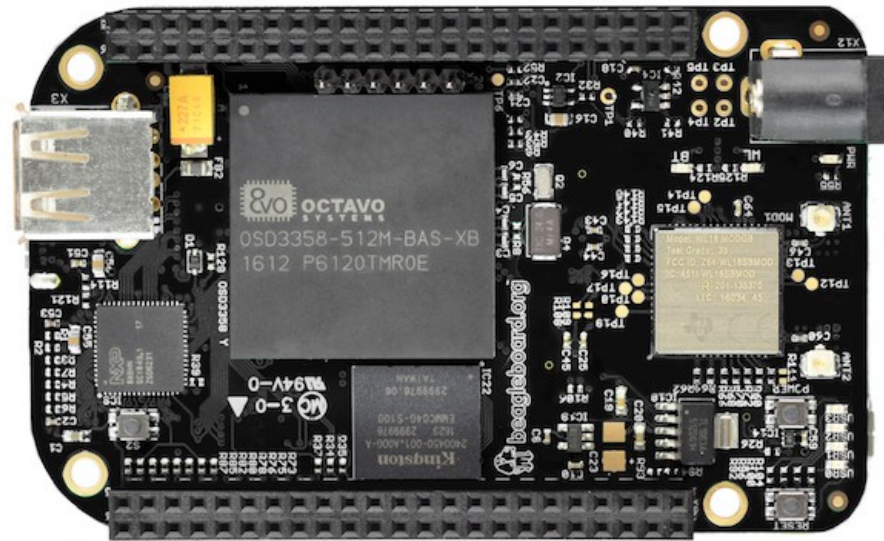


- ARM Linux on Open Source Hardware
- Developed by [BeagleBoard.org Foundation](#) and [BeagleBoard.org Community](#)
- Manufacturers: [element14](#), [GHI](#), [Seeed](#)





# BeagleBone Black Wireless



- 1 GHz ARM processor, 512 MB RAM
- 2x 32-bit PRU microcontroller for hard real-time
- 4GB eMMC with Debian GNU/Linux installed
- WiFi 802.11 b/g/n, Bluetooth 4.1 with BLE
- HDMI / USB / 65 GPIO pins / 8 PWM outputs
- 7 analog inputs / 4x UART / 2x I<sup>2</sup>C / 2x SPI

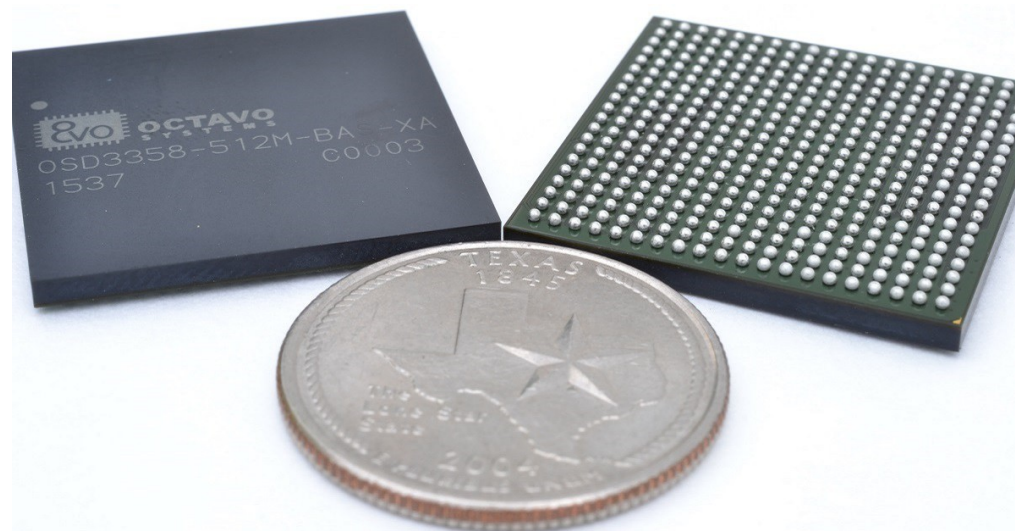


# BeagleBone Black Wireless

*(ships November 2016)*

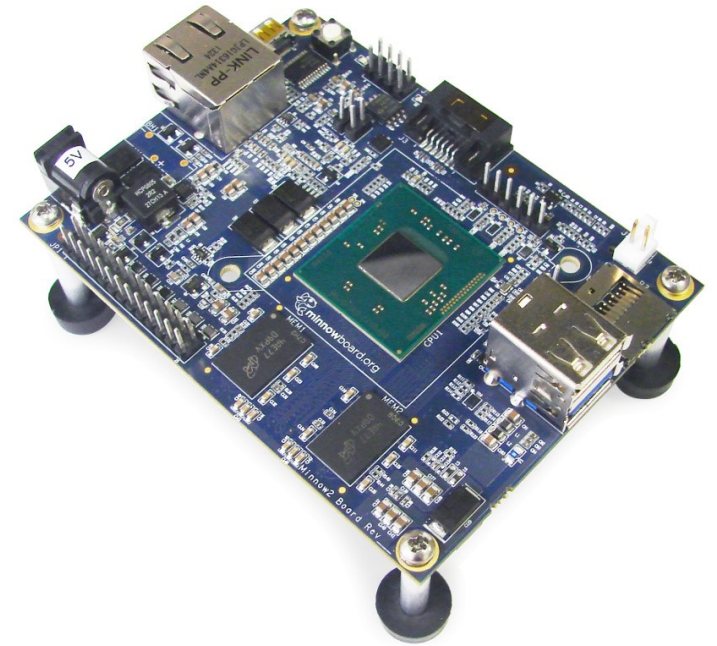


- CadSoft EAGLE design files hosted on GitHub
- Bill of Materials: every part available in qty 1
- Octavo System-in-Package (SiP) large pitch BGA simplifies PCB layout and assembly





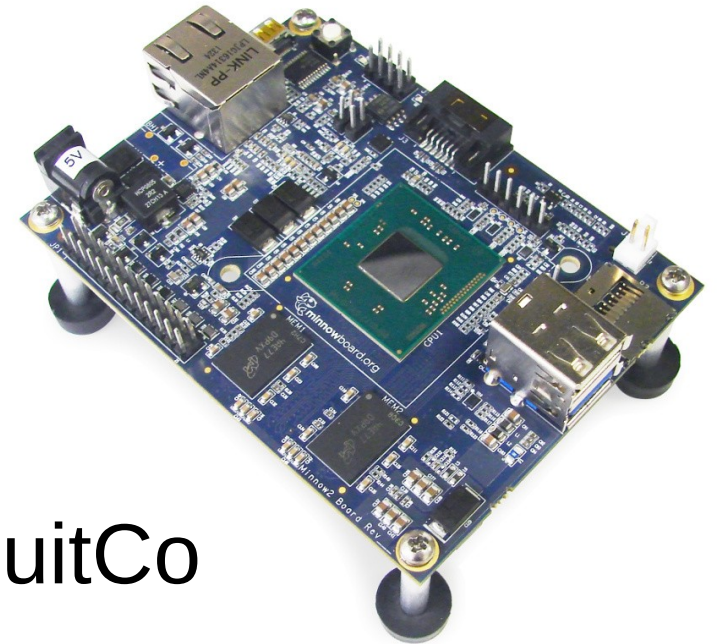
# MinnowBoard



- 64-bit Intel Atom “*Bay Trail*”
- **MinnowBoard Turbot**
  - \$135: E3826 (dual-core, 1.46 GHz)
- USB 3.0, SATA, PCIe, Gigabit Ethernet, HDMI
- Integrated Intel HD Graphics
  - Open Source Mainline Linux drivers!



# MinnowBoard



- Manufactured by **ADI** and CircuitCo
- Released under Creative Commons **CC-BY-SA**
- **Download:**
  - **[x] Schematic** (Orcad DSN & PDF)
  - **[x] Board Layout** (Allegro BRD & Gerbers)
  - **[x] Bill of Materials**



# OLinuxino



- Low cost OSHW Linux computers
- Designed and manufactured by **Olimex** in **Bulgaria**
- **Blog post:**  
*“Open Source Hardware, why it matters and what is pseudo OSHW”*

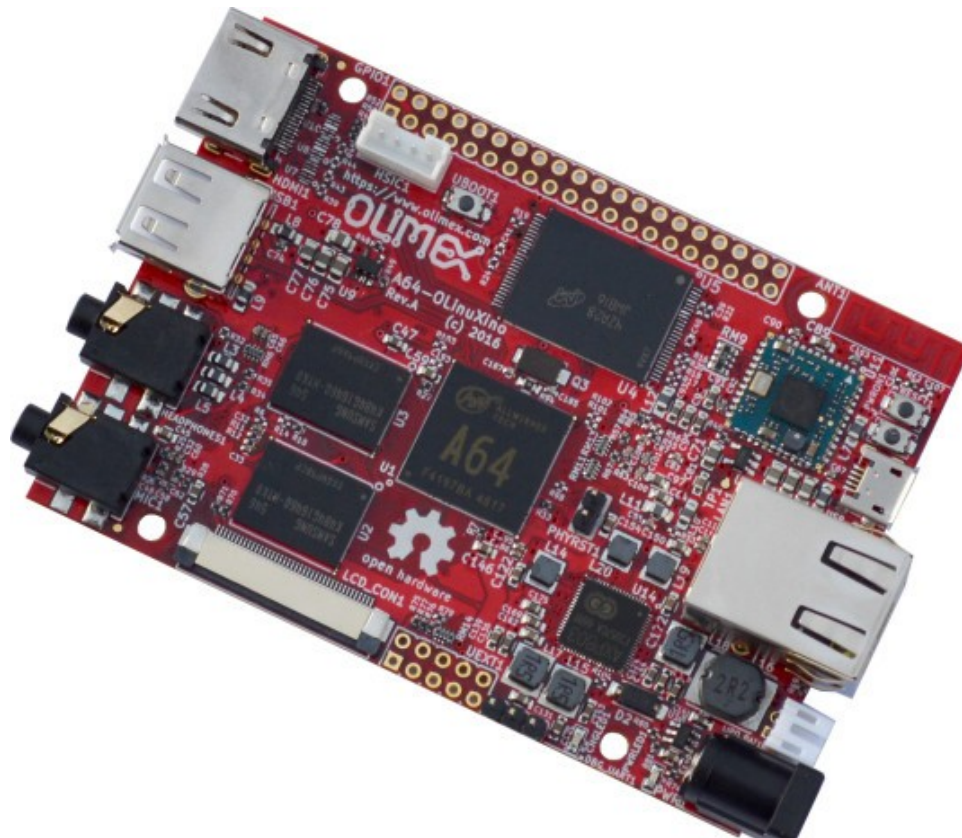




# A64-OlinuXino



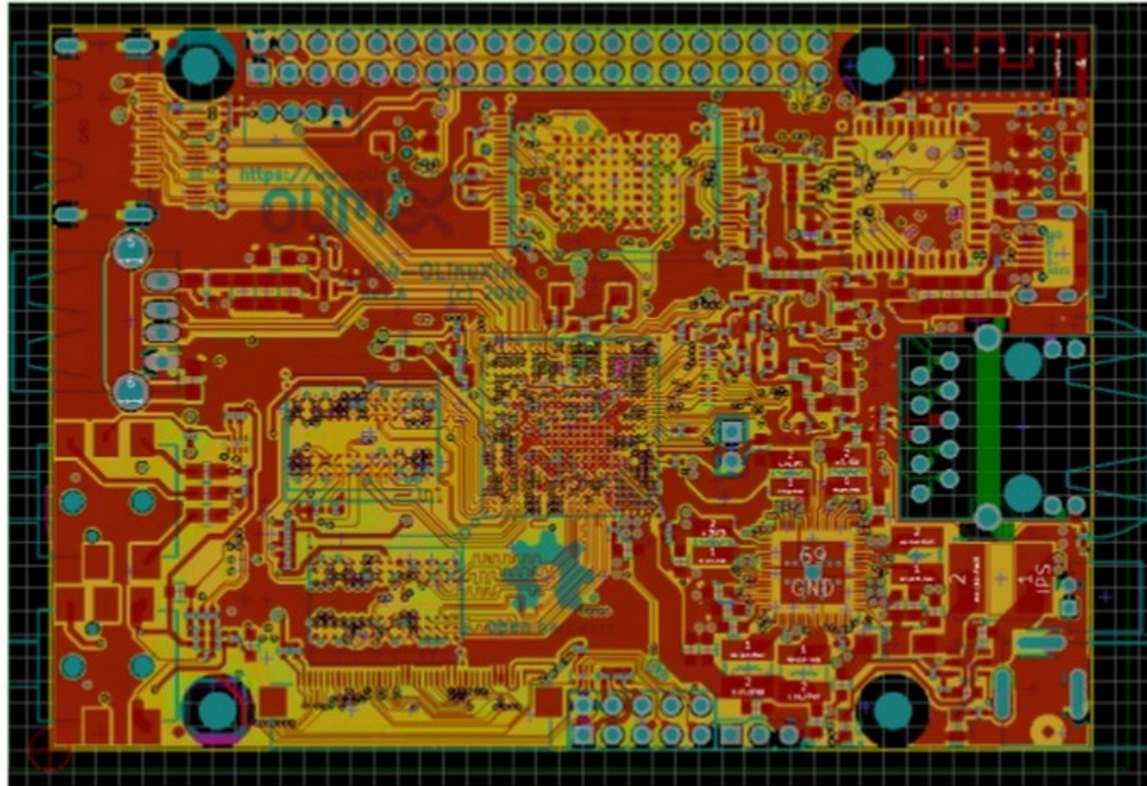
- Allwinner A64: Quad Core **64-bit ARM**
- Designed with Open Source **KiCad**
- 1GB RAM, 4GB eMMC, WiFi+BLE4.0





Using FOSS tools for OSHW project

## Designing with KiCAD of 64-bit ARM board

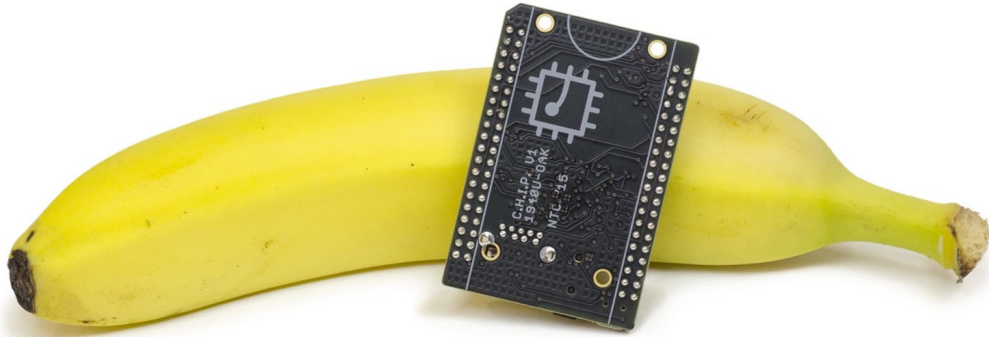


Tsvetan Usunov, OLIMEX Ltd

FOSDEM 2016

<http://www.slideshare.net/olimexbulgaria/designing-with-kicad-of-64bit-arm-board>

# CHIP



*The World's First \$9 Computer*

- [getchip.com](http://getchip.com)
- Next Thing Co. in Oakland
- Kickstarter in 2015:
  - 39,560 backers
  - \$2,071,927 pledged







# 1GHz + 512MB + 4GB

processor

ram

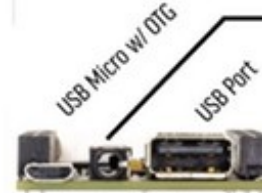
storage

60mm/2.3"

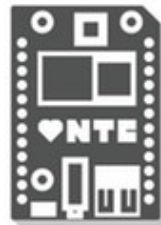
40mm/1.5"



1GHz Allwinner A13 Compatible SoC  
Mali400 GPU w/ OpenGL ES 2.0 & OpenVG 1.1  
512MB DDR3 Ram  
4GB NAND Flash Storage



Composite Video  
HDMI & VGA Out via adapter  
Headphone Audio Out  
Mic In



C.H.I.P. is built with Making in Mind

Realtek 2-in-1 Bluetooth 4.0 + WIFI B/G/N  
I2C + SPI + UART + 8 x GPIO  
Camera Sensor Support (MIPI-CSI)  
Native LCD Support 4.3-8"  
Battery Power & Charging



Fast Boot Debian Based Linux OS  
Over The Air Updates  
OpenGL ES 2.0  
OpenVG 1.1



## WIFI & Bluetooth

802.11B/G/N



4.0

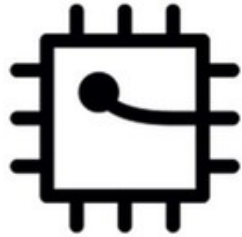


*Battery Power  
& Charging  
Built In!*



*Run CHIP for  
Hours with a  
Single Cell Lipo.*

# C.H.I.P. is OSHW



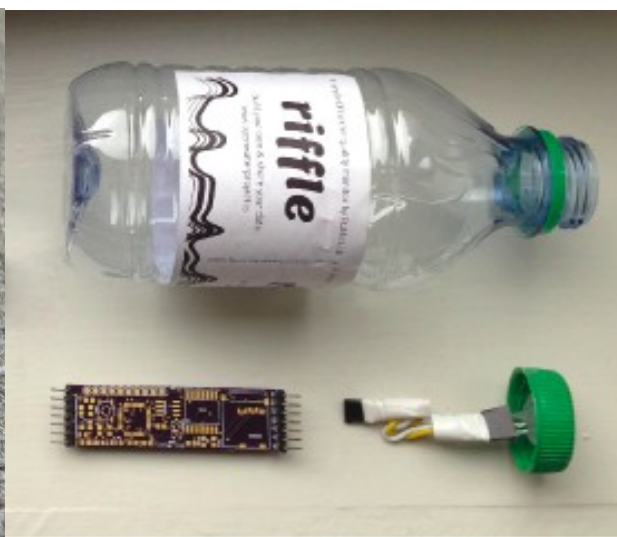
- **GitHub: [NextThingCo/CHIP-Hardware](#)**
  - Schematics
  - PCB Layout
  - Bill of Materials (*BoM*)
- **License:**
  - Creative Commons Attribution-ShareAlike (*CC-BY-SA*)

*Section:*  
OSHW in Science

*Suggestions from the OSHWA mailing list*

# Public Lab

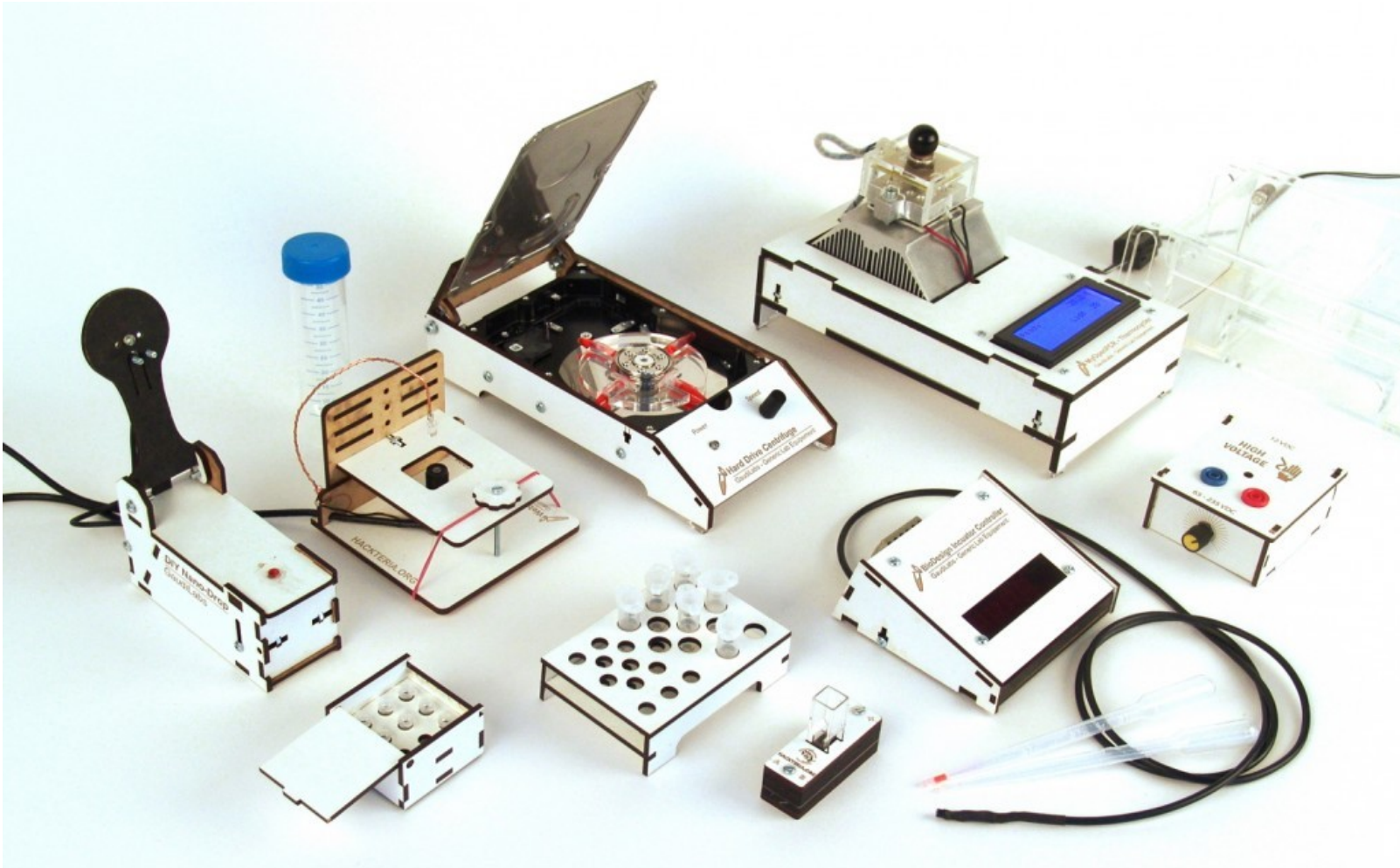
- “Using inexpensive DIY techniques, we seek to change how people see the world in environmental, social, and political terms.”
- Office in Portland!
- Riffle: Open Source Water Monitoring
- Desktop Spectrometry
- Balloon Mapping Kit





# Generic Lab Equipment

- GaudiLabs in Lucern, Switzerland
  - part of the [hackteria.org](http://hackteria.org) open source biology art network



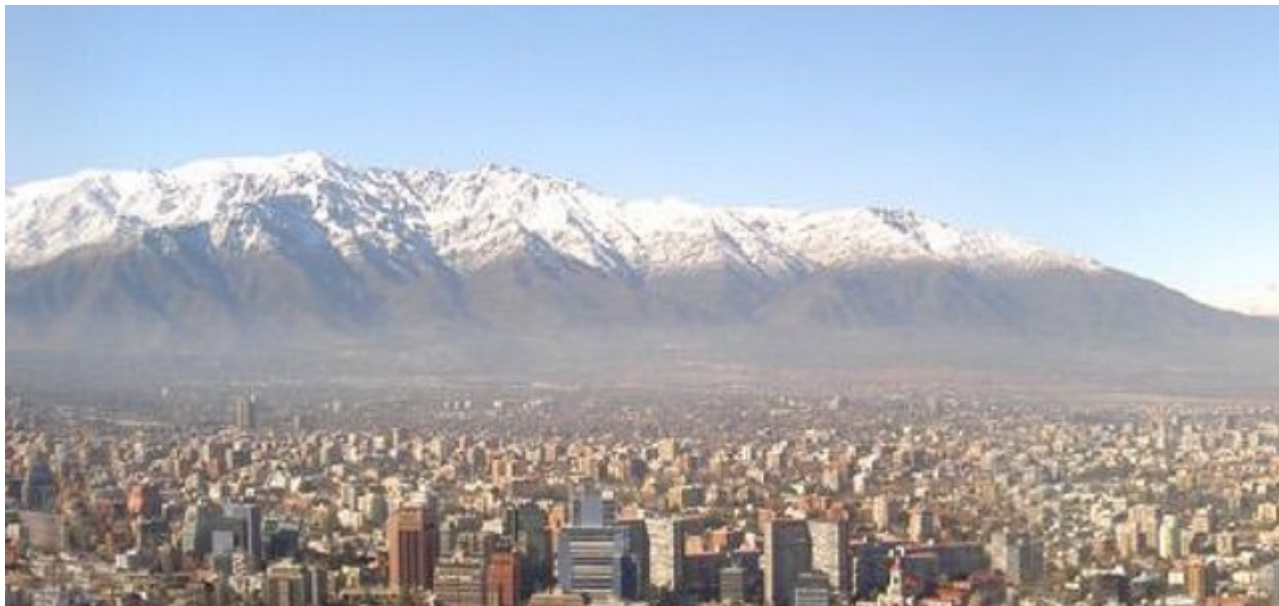


# Generic Lab Equipment

- WebCam Microscope
- Hard Drive Centrifuge
- Incubator Controller
- Gel Box and High Voltage Supply
- Turbidity Meter Kit
- DIY Microvolume Spectrometer
- My Open PCR
- Tube Racks

# GOSH 2017

- Gathering for Open Science Hardware
- Santiago, Chile. March 22-25, 2017.
- “growing number of people around world are developing and using Open Science Hardware, and we want to help build self-organising community to drive change in open science”

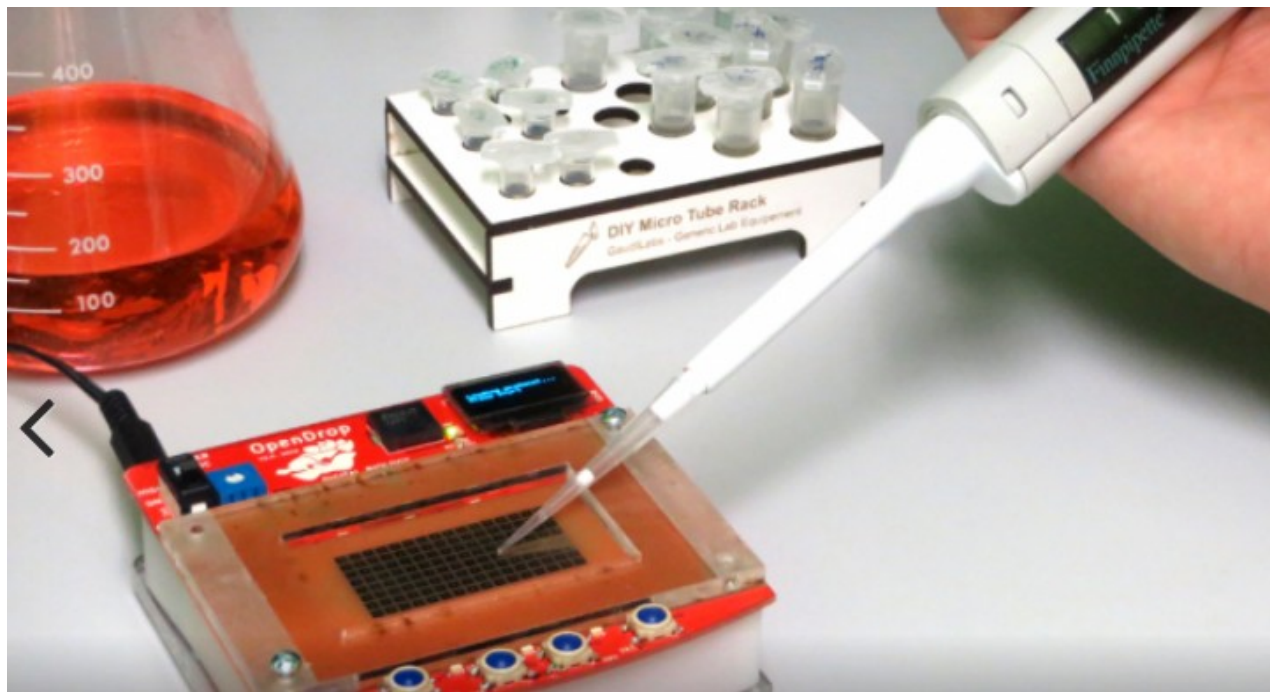


# OpenDrop



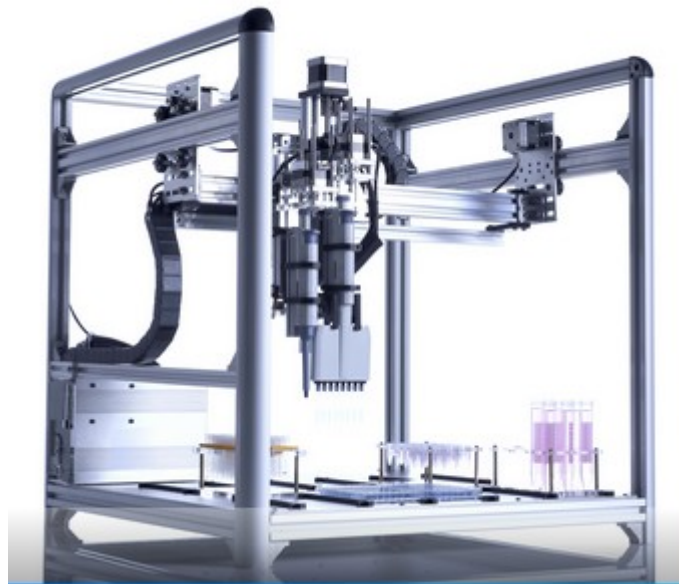
**OpenDrop**

- “Desktop Digital Biology Laboratory”
- digital microfluidics platform for research
- part of a bigger ecosystem around digital biology with the aim of making personal lab-automation accessible to more people



# OpenTrons

- **Robots for Biologists**
- “We think biologists should have robots to do **pipetting** for them.”
- “They should be able to spend their time designing experiments and analyzing data.”



# OpenPCR

- **PCR is a method of copying DNA molecules.**
- OpenPCR is a project to develop open source hardware, software, and protocols to perform PCR and Real-Time PCR reactions
- community dedicated to openess in science and applying the fundamental technologies of PCR to global problems





# Open Source Imaging (MRI)

- Open Source Magnetic Resonance Imaging
- [Opencore NMR](#) is an open-source toolkit for implementing an NMR spectrometer
- [LukasW log](#): “COSY Magnet: Single ring results look fantastic! Less than 2% difference to simulation”



# Hackteria.org

- Collection of DIY Biology, Open Source Art Projects that use Biology, LifeSciences, Biotechnology.





# Digital Naturalism

- Investigates the role that Digital Media can play for Biological Field Work
- Uphold the naturalistic values of wilderness exploration, while investigating the new abilities offered by digital technology
- Theory and Guidelines by Andrew Quitmeyer



# MOST research group

- Joshua Pearce Research Group at Michigan Tech in Open Sustainability Technology (*MOST*) focuses on open and applied sustainability
- Exploring the way solar photovoltaic technology can sustainably power our society



# Libre Space Foundation

- Non-profit for Open Source HW & SW in Space
- **UPSat**: first open hardware satellite bound to be launched to the International Space Station in late December
- **SatNOGS**: open source hardware satellite ground-station network



*Section:*  
BONUS SLIDES

# *What about silicon?*

## **LowRISC:**

“lowRISC is producing fully open hardware systems. From the processor core to the development board, our goal is to create a completely open computing eco-system”



# Novena laptop

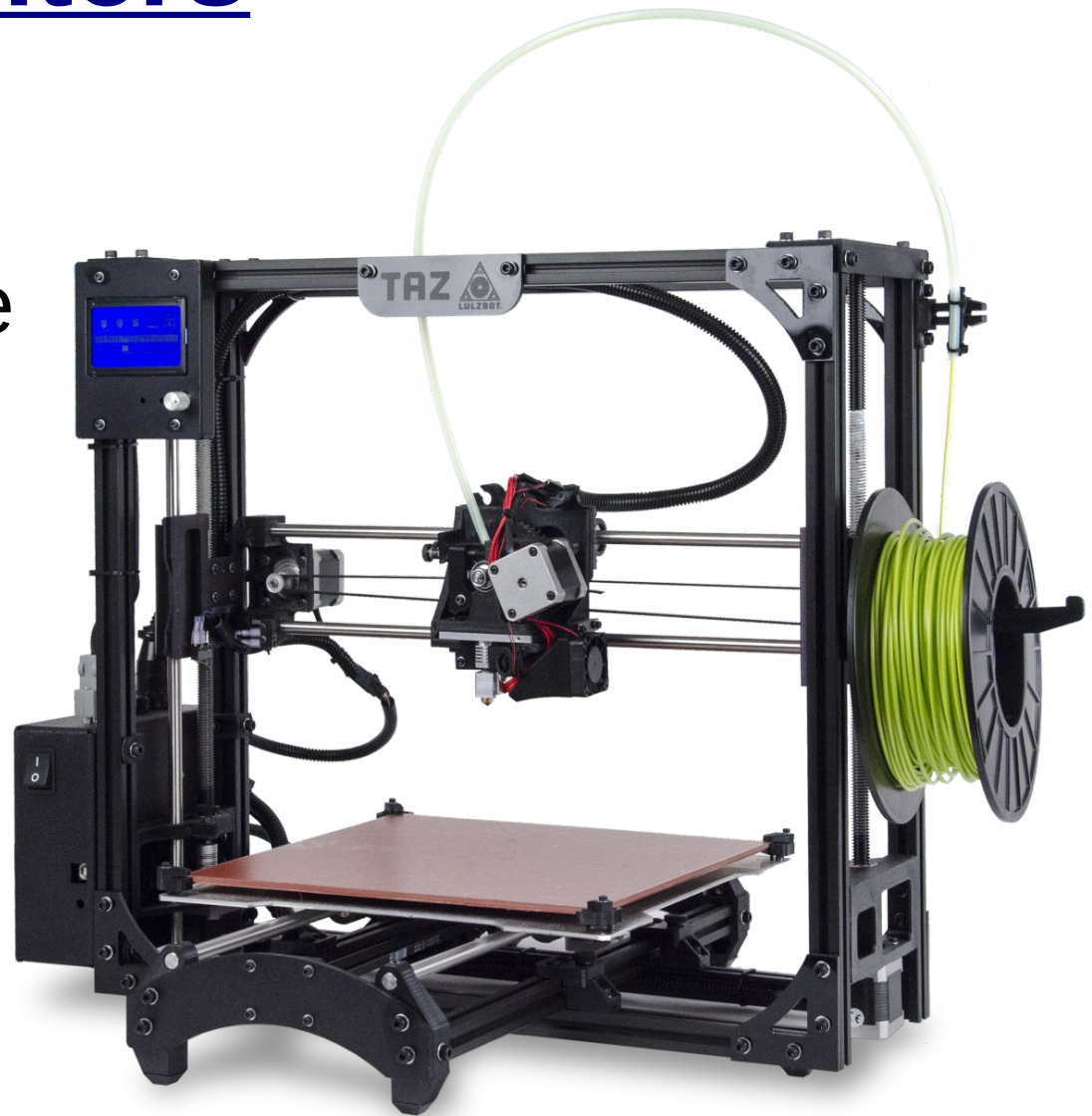
- Created by **Bunnie & xobs!**
  - Chumby! Hacking the X-Box! Amazing reverse engineers
  - *The Exploration and Exploitation of an SD Memory Card*
- **100%** Open Source Hardware laptop
- **Quad-core 1.2GHz Freescale ARM CPU**
- **FPGA!** 4GB RAM, WiFi, **2x Ethernet**, SSD





# Lulzbot 3-D Printers

100% Open Source  
Hardware & Software



- FSF Respects Your Freedom certified



# Thanks

- **Suggestions** from the [OSHWA mailing list](#):
  - Abram Connelly
  - Andrew Plumb
  - Andrew Quitmeyer
  - Eleftherios Kosmas
  - Marcin Jakubowski
- **Jeena Lee** for first telling me of Portland Science Hack Day
- **Max Ogden** for asking me to speak

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- [OSH Park Blog](#)