IRNAS – OPEN HARDWARE INSTITUTE

Modular open hardware design for electronics and 3D printing

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Presentation outline

- Overview of multiple open hardware projects
- Discussion of design choices
- Keep an eye out for lessons learned
- ASK QUESTIONS!
- Touch all the prototypes, have a good look at them.

WHO AM I?

- Luka Mustafa - Musti (MEng)
  - electronics, telecoms, hardware hacking, ...
  - Institute IRNAS Rače (non-profit development)
- Shuttleworth Foundation Fellow
- University College London: PhD student
- Also active in :
  - HAM radio S59DXX
  - wlan slovenija

Organizations

irnas

Non-profit research and development

FABRIKOR

For-profit prototyping and production

Projects

KORUZA — Wireless optical communication

GOODENOUGHCNC — Affordable manufacuring toolset

nodewatcher — Network deployment, monitoring and provisioning

symbiolab — Open hardware bio lab

VITAPRINT — Open source 3D bioprinting

KORUZA

Open source open hardware wireless optical communication system.

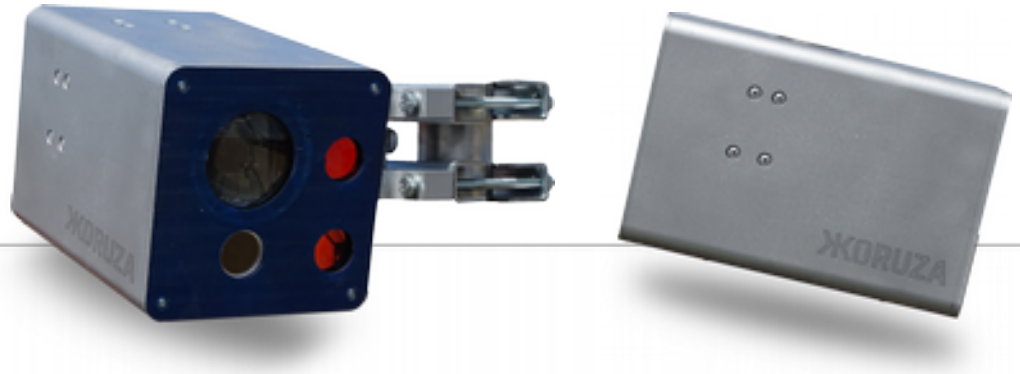
KORUZA

is a **wireless optical internet access system**, empowering an instant optical network roll-out in **high-density urban networks** with **minimal infrastructure investment** and ensures long-term **interference-free operation**.

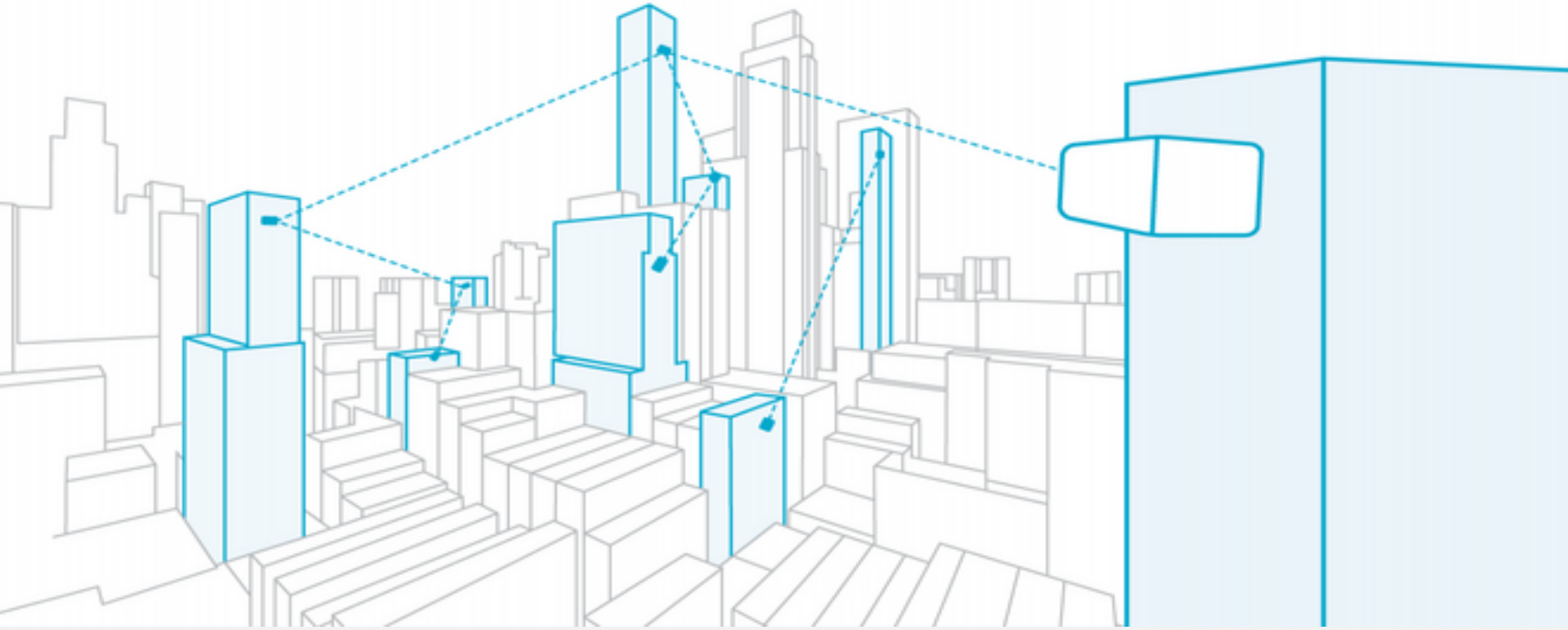
Data is securely transmitted **point-to-point** over a collimated **beam of light** at **1 Gbps or 10 Gbps** throughput at distances **up to 150m**.

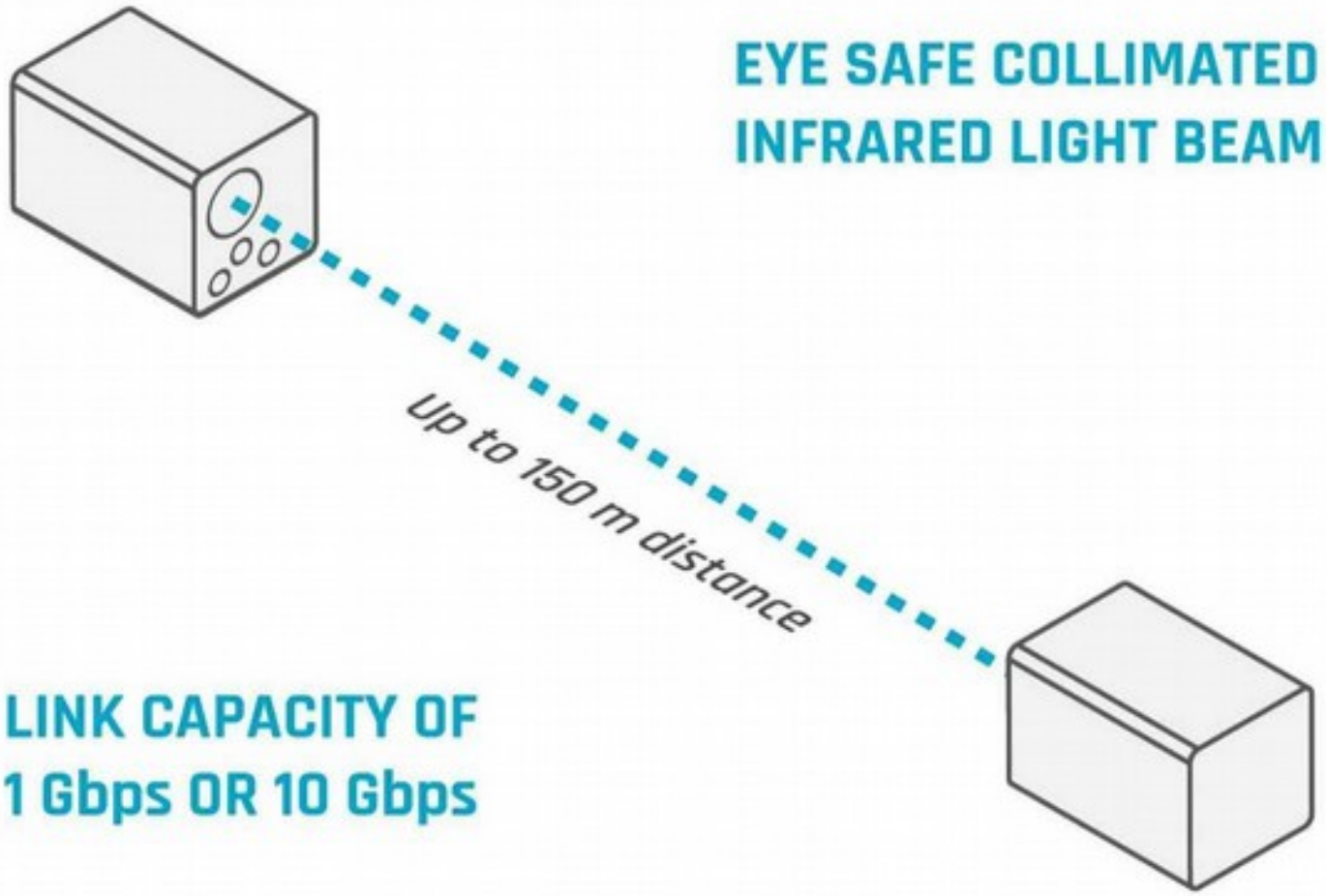
KORUZA is the first **affordable free-space optical system** (FSO), enabling **next generation last-mile connectivity** and versatile installation options.

It is **low-maintenance** and operates an **active link protection**, overall offering a **short return-on-investment (ROI)**.



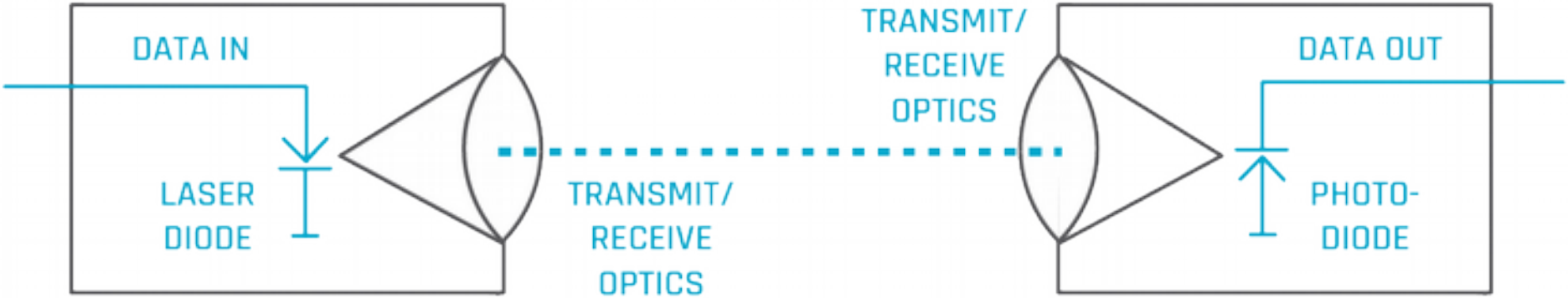
Light-speed networking.
No cables, no congestion.
Ten times cheaper.




EYE SAFE COLLIMATED
INFRARED LIGHT BEAM
Up to 150 m distance
LINK CAPACITY OF
1 Gbps OR 10 Gbps

2. Transmitter projects a small beam of light pulses towards the other unit.

3. A receiver at the other end of the link collects the light using a plano-convex lens.



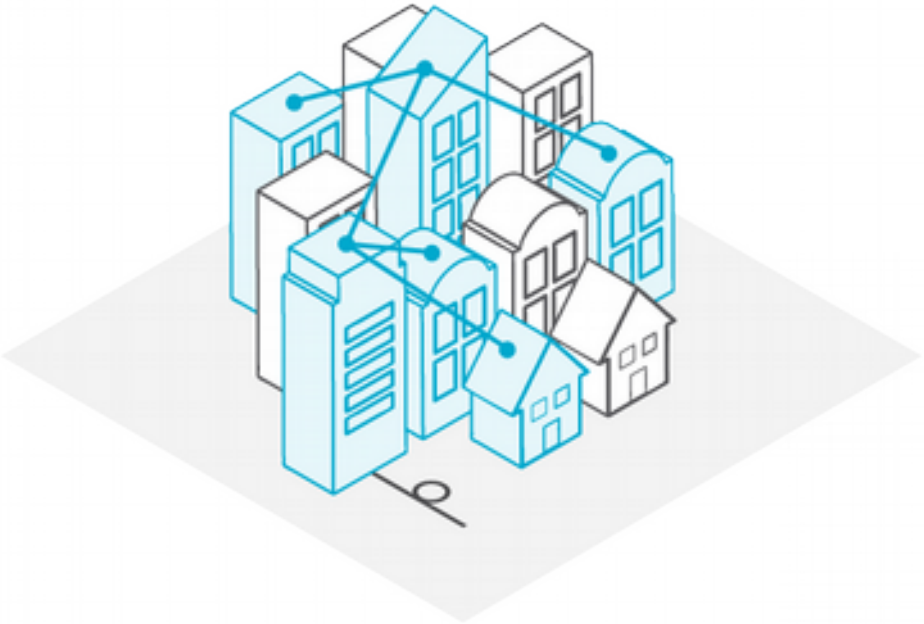
1. Network traffic converted into pulses of invisible light representing 1's and 0's.

5. Each unit can both transmit and receive, bi-directional communication occurs.

4. Received light is converted to the electrical signal and connected to the network.

Radio spectrum congestion.

Radio spectrum congestion eliminated with Koruza.



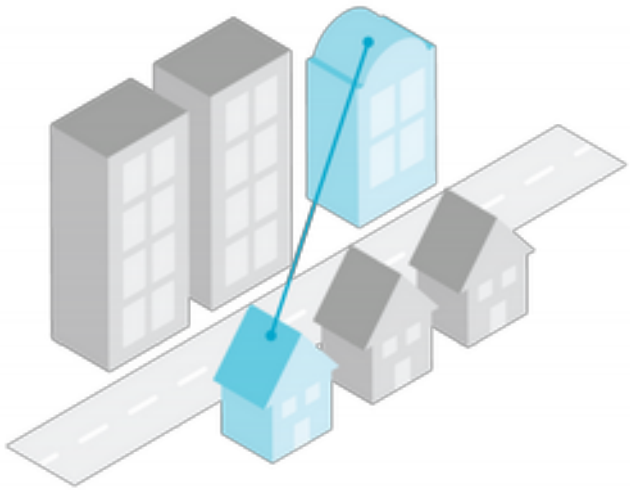
CREATING AN ULTRAFAST WIRELESS OPTICAL NETWORK

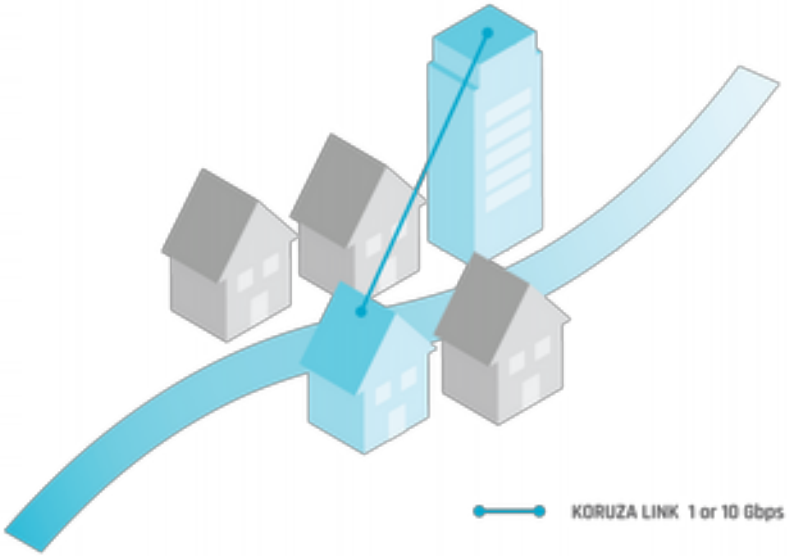
INCREASING THE CAPACITY OF COMMUNITY WIRELESS NETWORK

KORUZA Use-cases

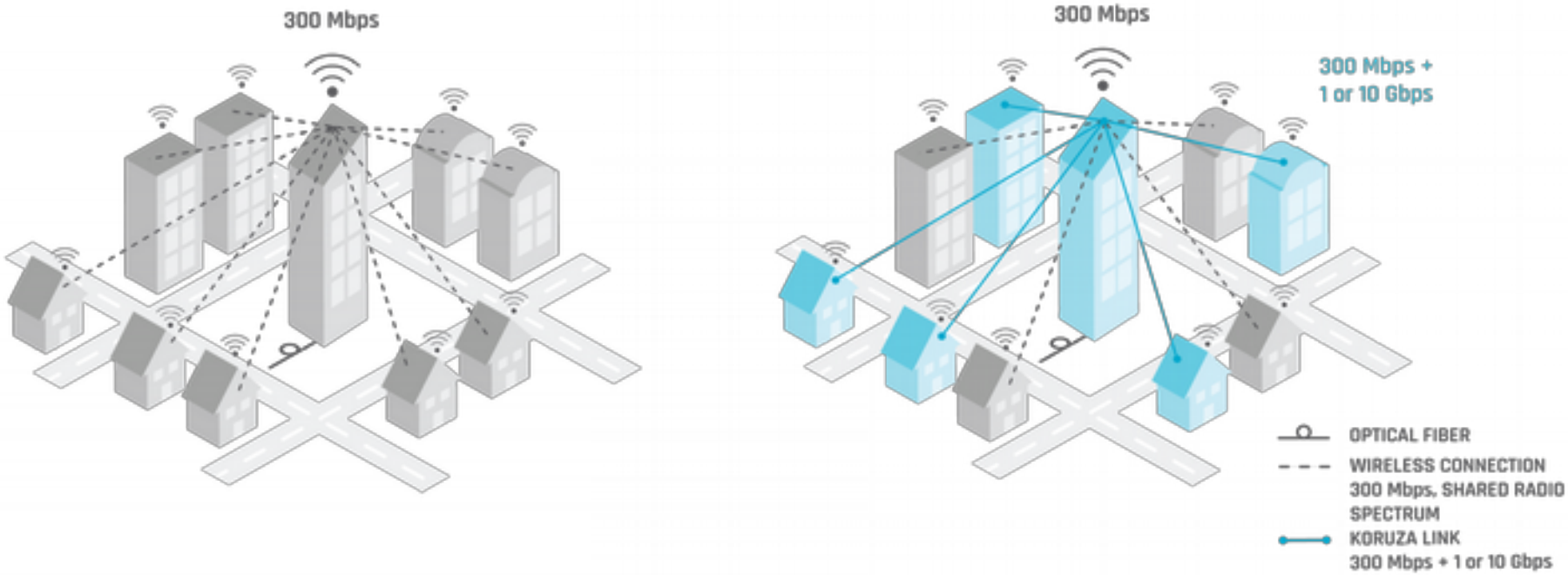
Point-to-point bridging

KORUZA is a perfect wireless communication solution to transmit 1Gbps or 10Gbps between buildings, across, the road, river or any other terrain.



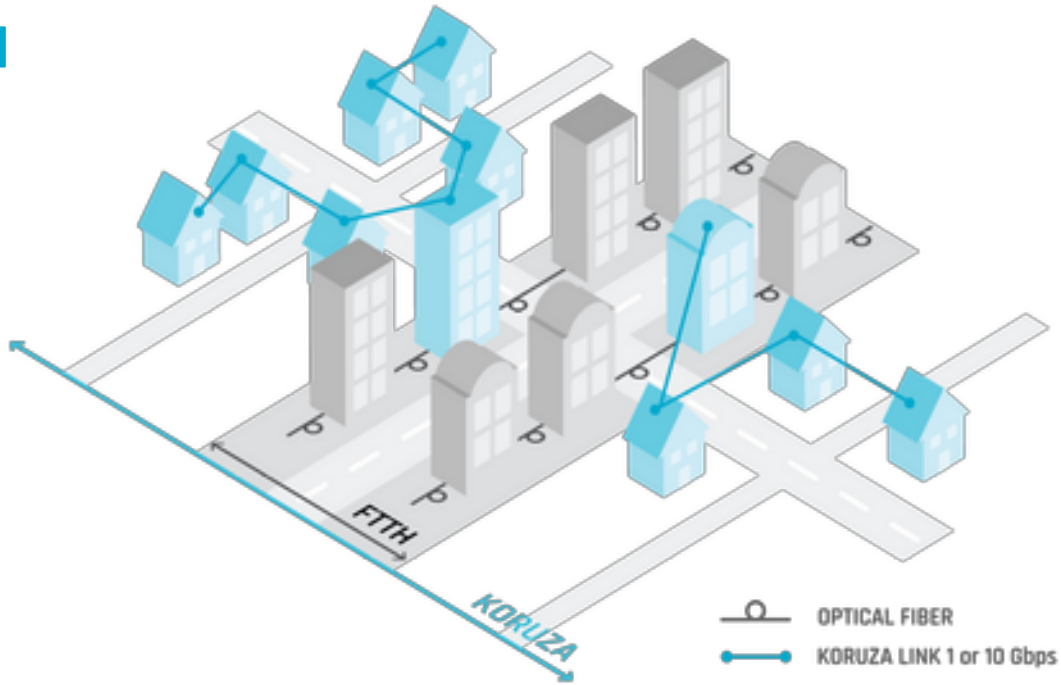


Increasing the capacity of existing networks – WiFi



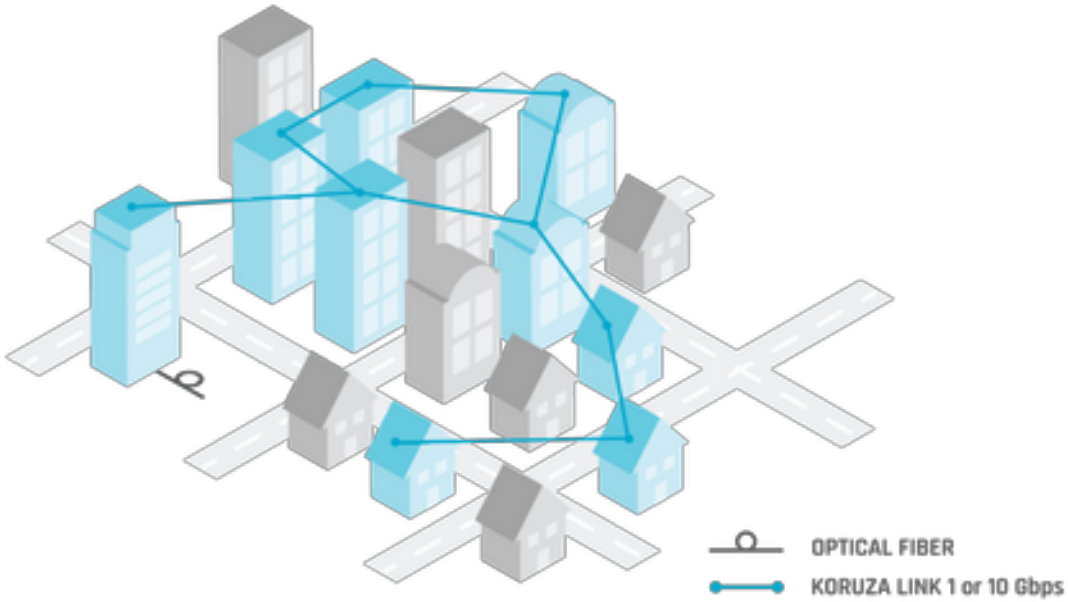
Expanding the reach of FTTH

KORUZA expands the reach of existing wired optical infrastructure by extending its reach with minimal installation costs and provides true optical connectivity to the customer.



Last-mile mesh network

KORUZA includes routing capabilities to create a mesh network between a number of buildings and enables covering a large number of buildings with fiber capacity in days. Zero interference operation enables delivery of maximum speeds even to most distant customers.

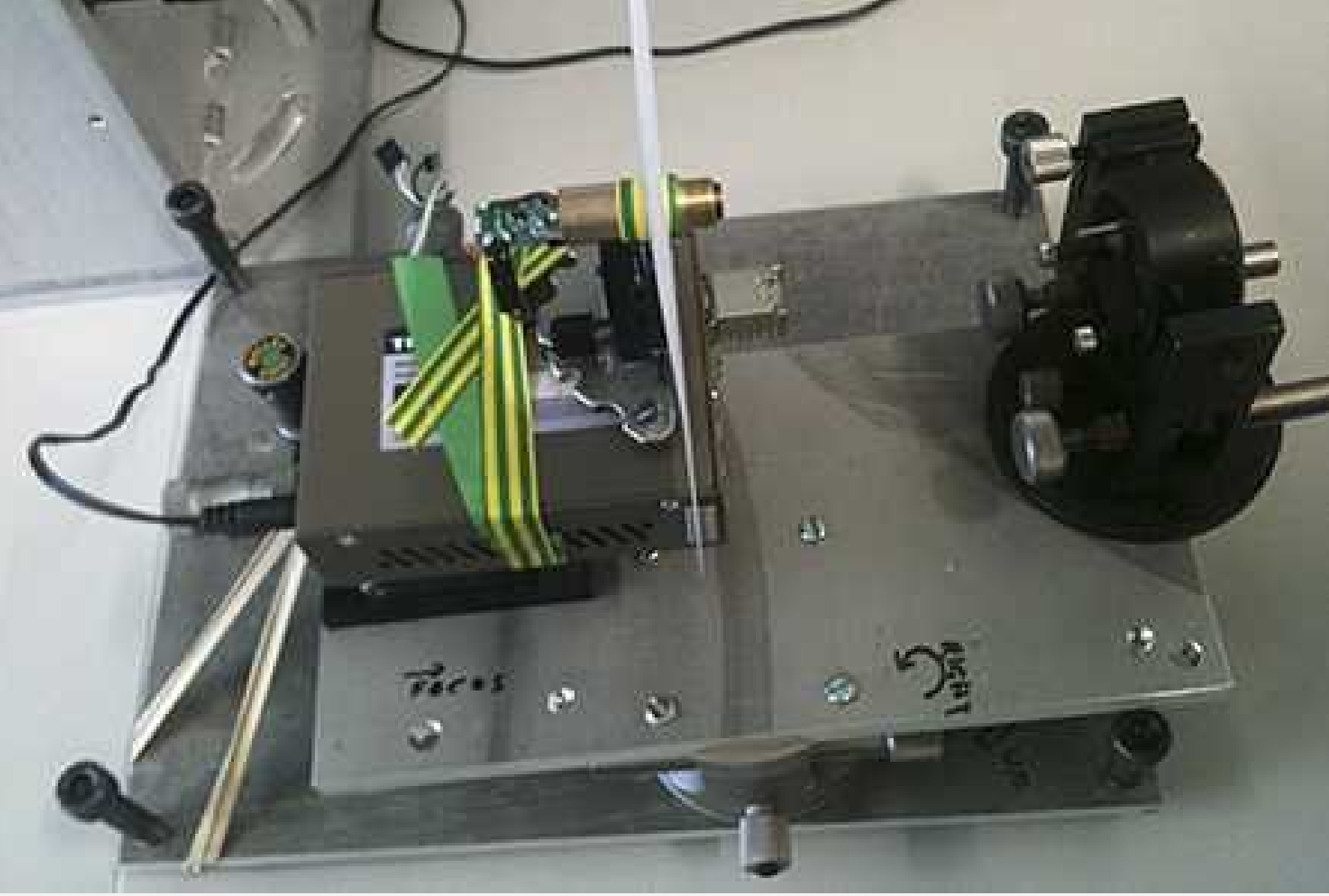


KORUZA Evolution

2012	2013	2014	2015	2016
SCIENTIFIC RESEARCH	SEVERAL GENERATIONS OF PROTOTYPES			KORUZA 1.0 SCIENTIFIC AND RESEARCH & DEVELOPMENT PLATFORM

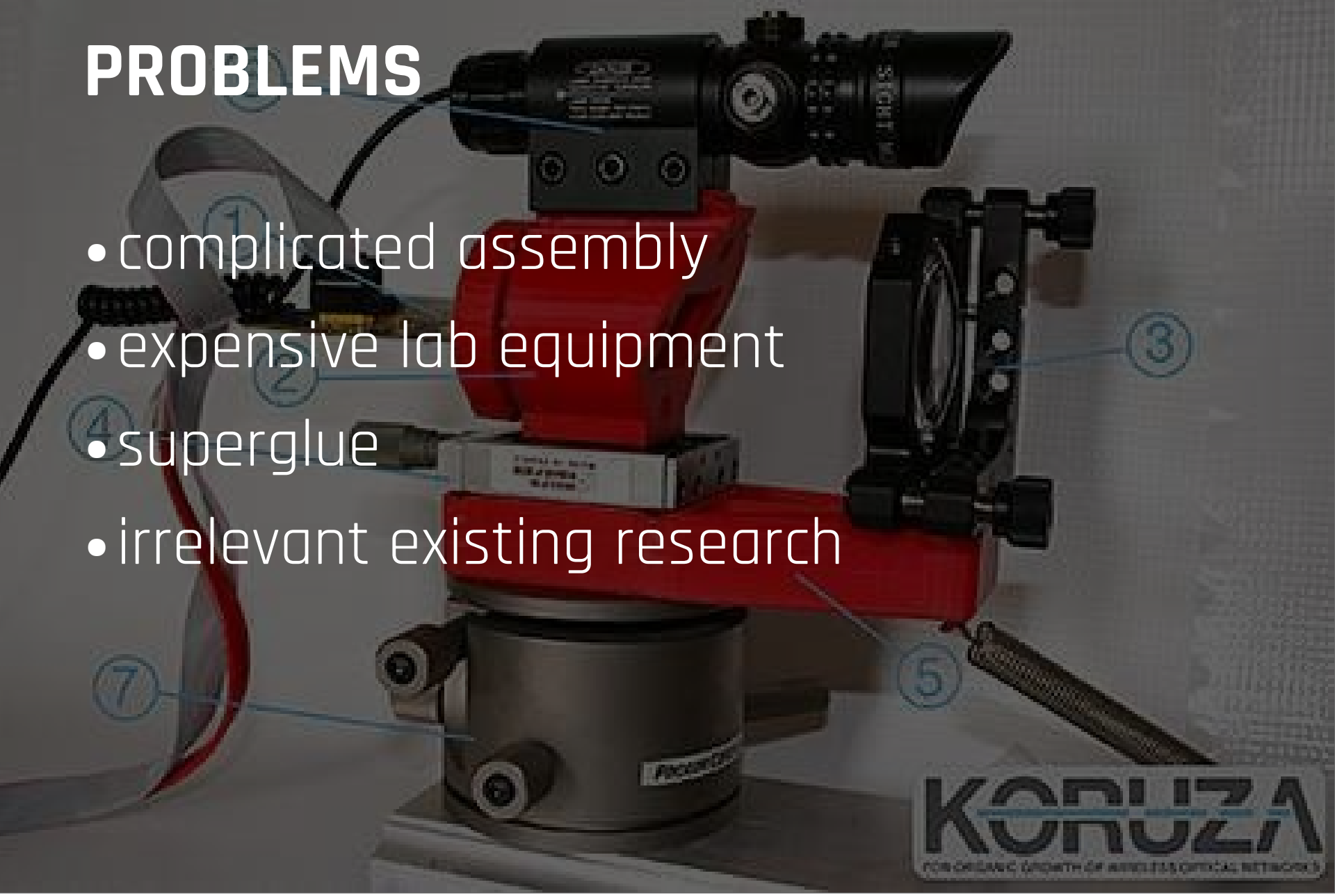
We have pioneered the use of commonly available parts to create cost effective solutions.

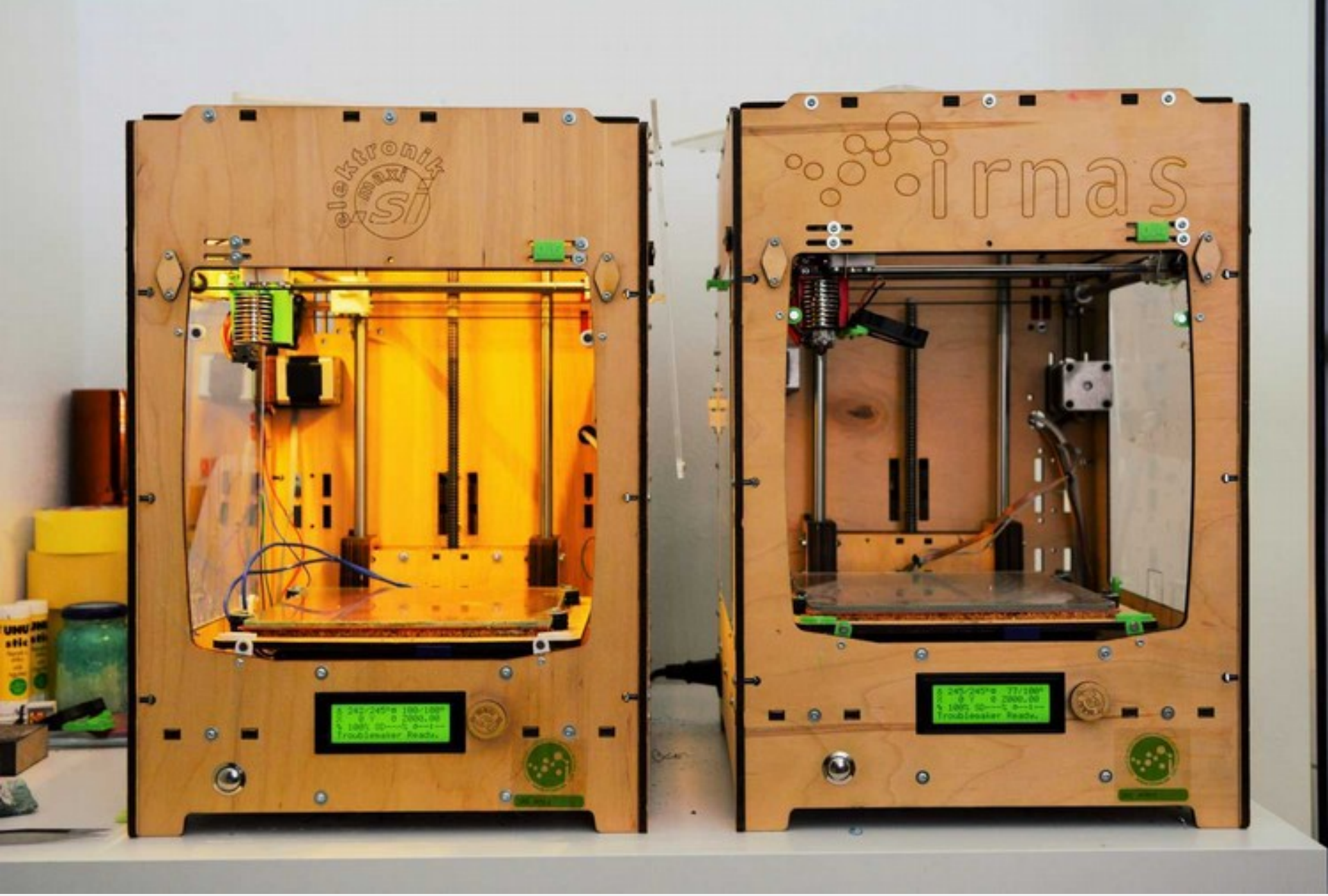
KORUZA History



PROBLEMS

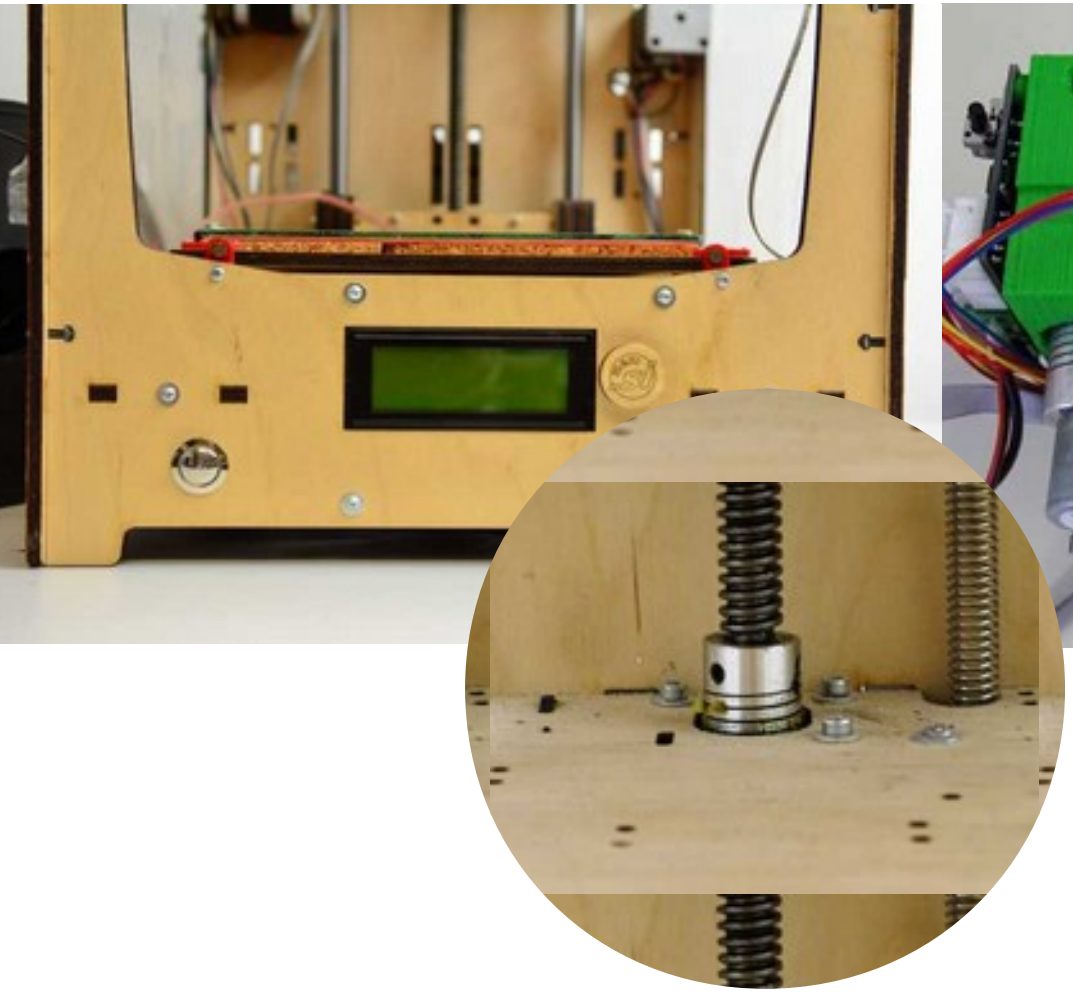
- complicated assembly
- expensive lab equipment
- superglue
- irrelevant existing research

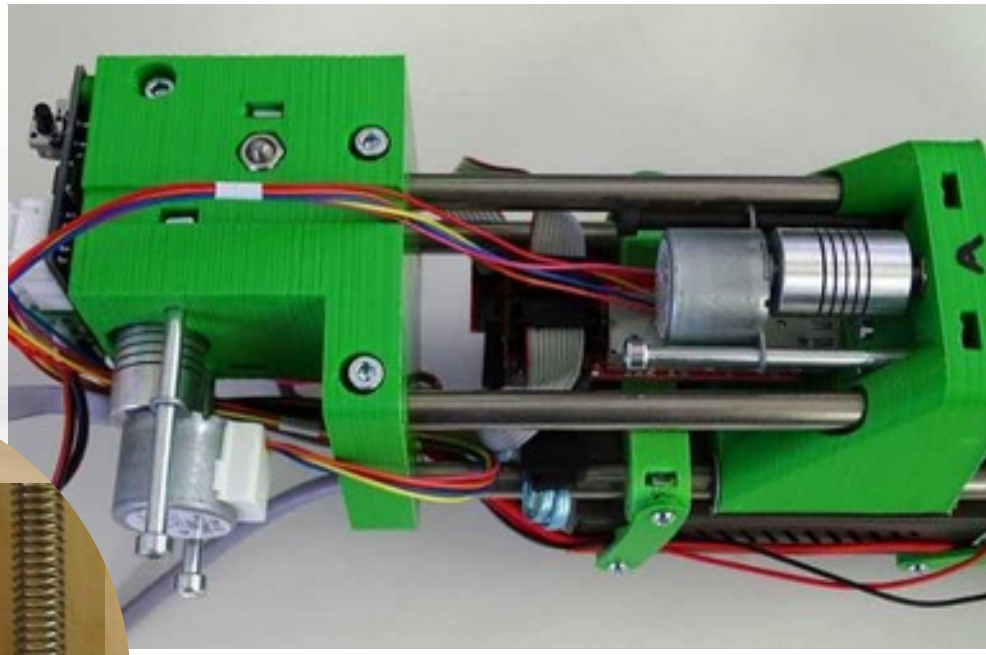




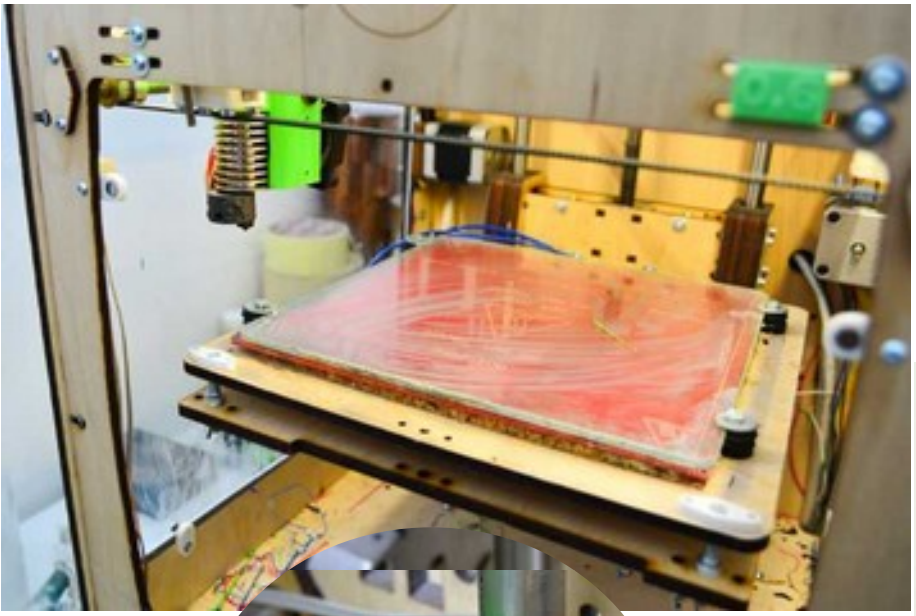
3D printing the whole KORUZA system

Using spring couplers from Troublemaker in KORUZA

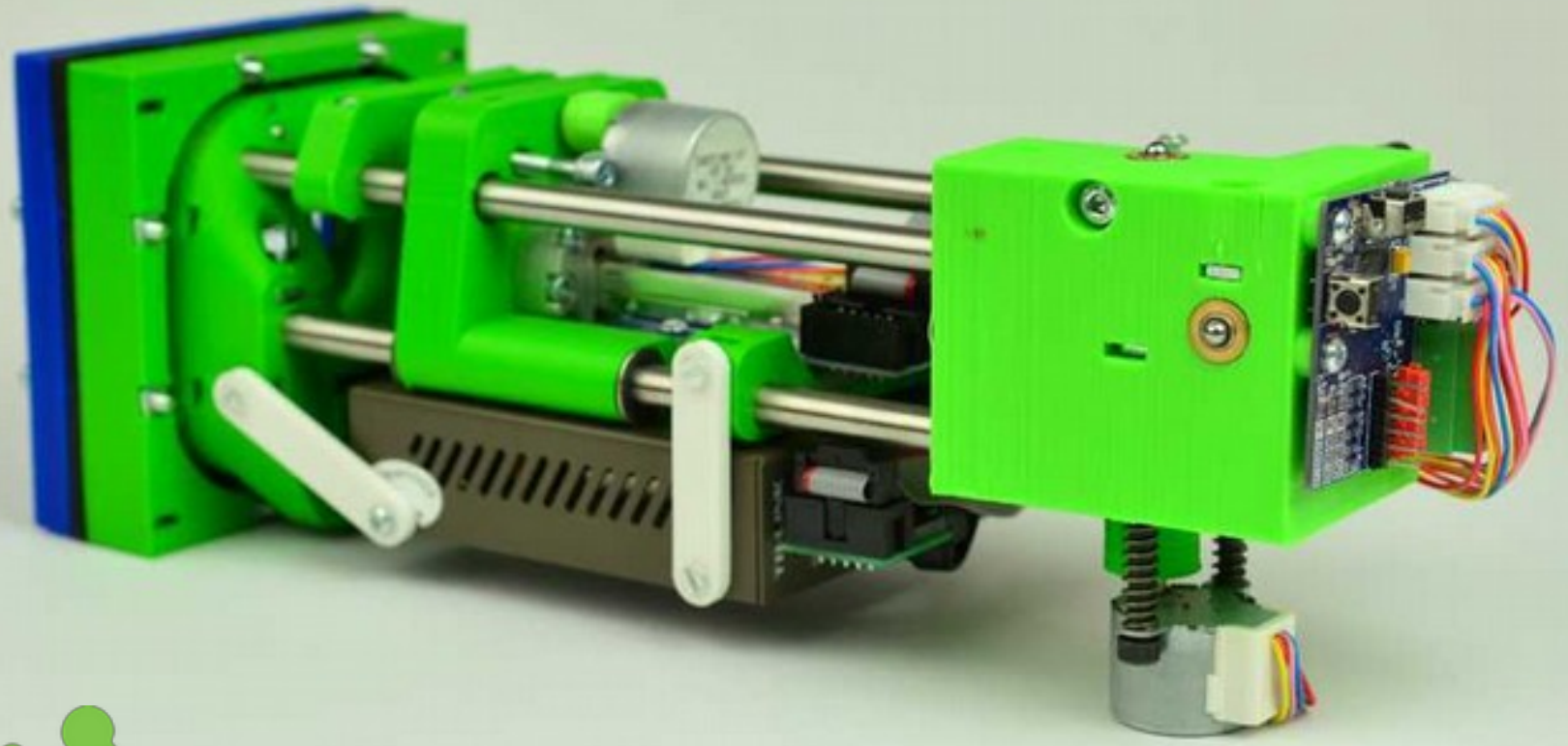




Using sliding bushings from Troublemaker in KORUZA

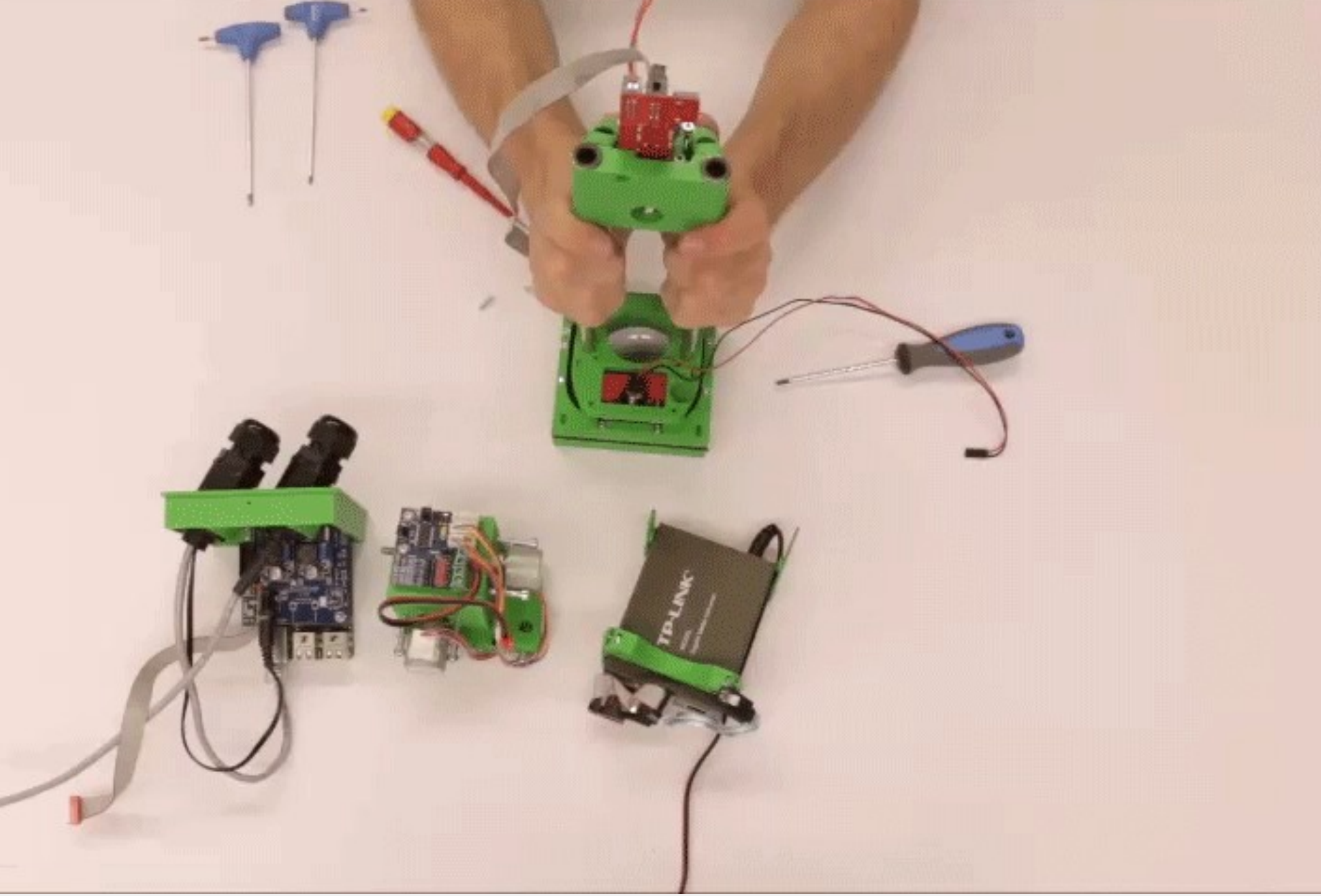


Modular design with steel rods & 3D printed components that are standalone



koruza

KORUZA 1.0




koruza
WWW.KORUZA.NET
gen 1.0
MADE IN SLOVENIA
irnas
TROUBLEMAKER
koruza
WWW.KORUZA.NET
gen 1.0
MADE IN SLOVENIA

KORUZA 1.0

- Fully modular mechanical design.
- Enables easy modification for a variety of use cases.
- Improved stability and reliability.
- 3D printed parts designed in OpenSCAD environment.
- Interconnection with stainless steel rods.
- Automatic alignment and tracking.
- Available as a DIY kit.

TESTING

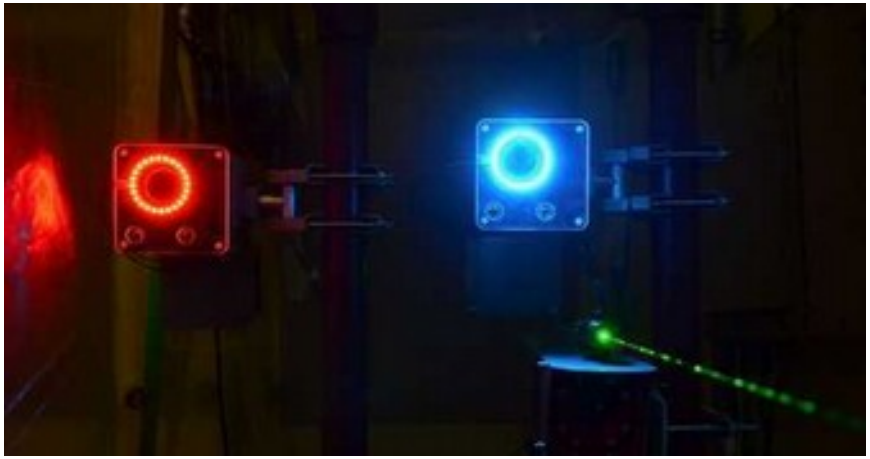
RAIN ✓

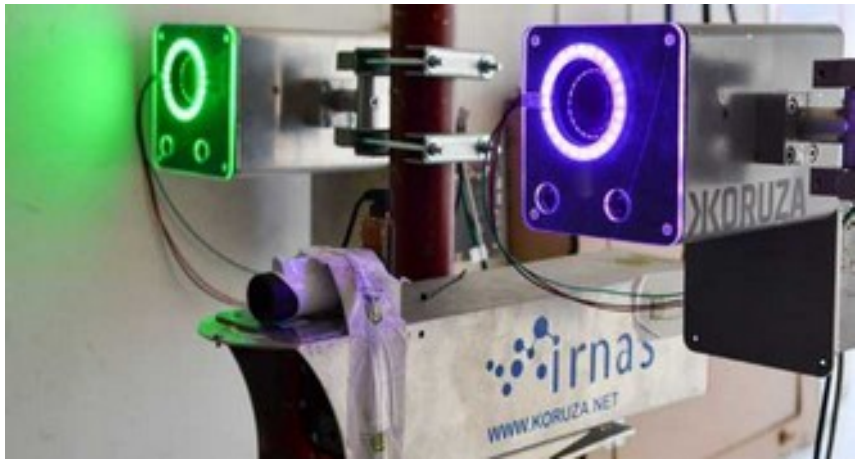
SNOW ✓

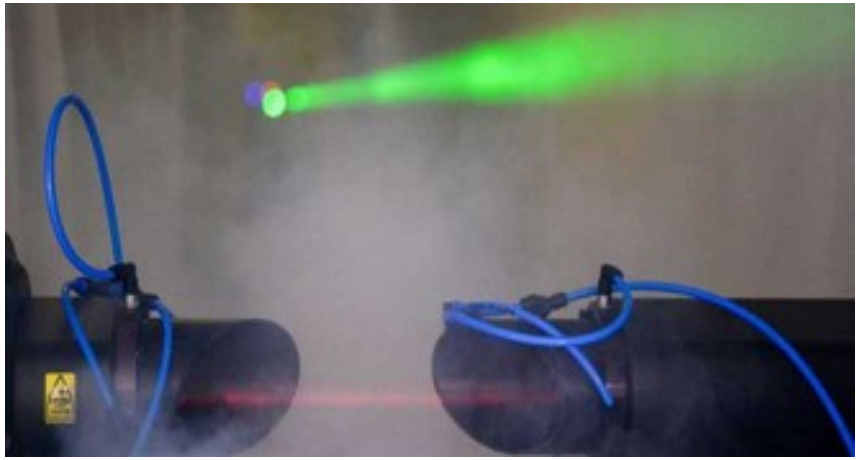
FOG ✓

Fog Scientific Testing

- Evaluation of the link performance in low visibility and presence of aerosols in the atmosphere.
- Experiment design using dry-ice, fog machine and smoke flare.
- Outdoor conditions simulated in a 50m PVC corridor.
- Green laser visibility measurement system.
- Testing facility







Fog scenarios

Moderate/typical autumn fog ~6dB/100m

Maribor Test Network

2016

KORUZA Pro

FUTURE PROOF

COLLABORATIVE DESIGN

TOTAL OWNERSHIP

FAIR PRODUCTION

WHAT IS GOOD ENOUGH FOR YOU?

GOODENOUGHCNC

Empower individuals and communities around the world to

BUILD, FIX,

HACK, MAKE

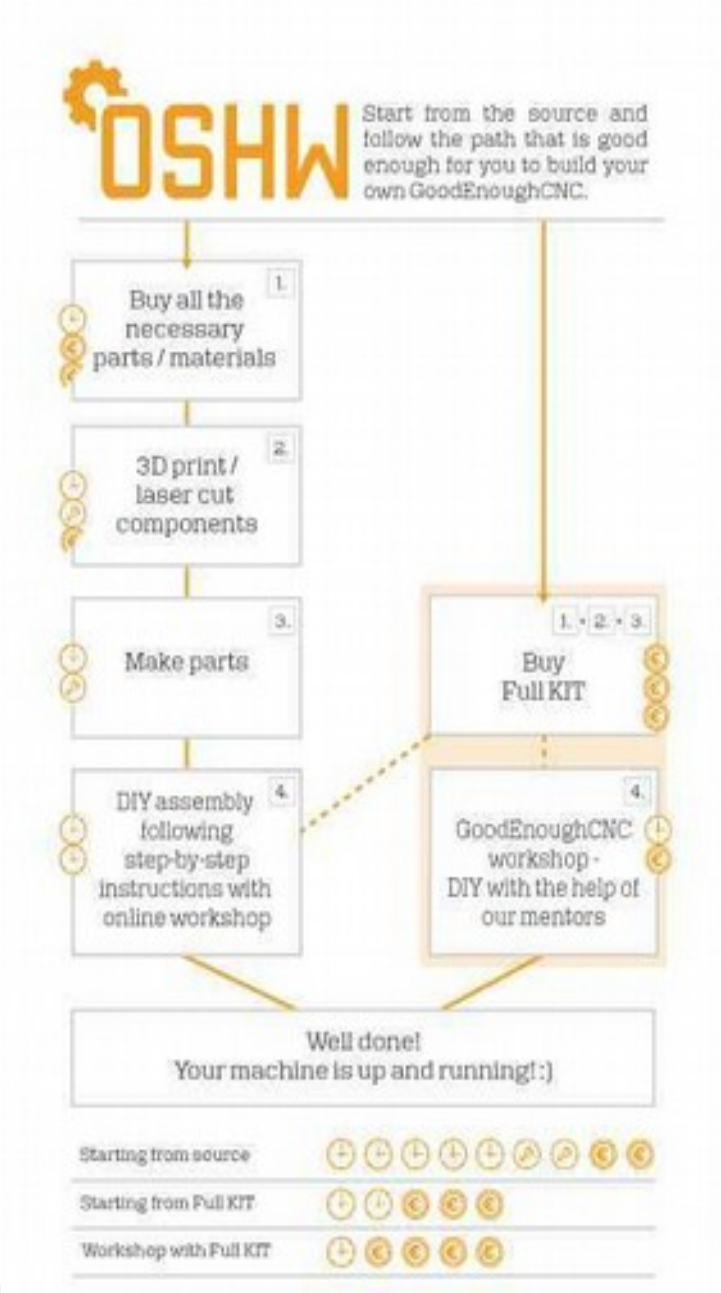
LOCALLY.

➡ **EFFECTIVELY OPEN**
Accessible

GOOD ENOUGH
➡ Affordable

MODULAR DESIGN
Sustainable

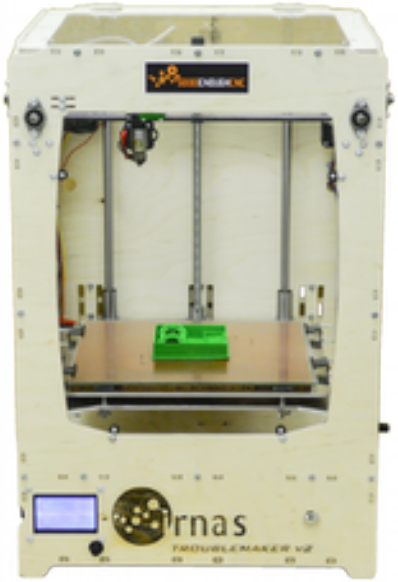
➡



Suitcase kit of essential parts.

Source heavy and big sized components locally.

Build it anywhere around the globe!



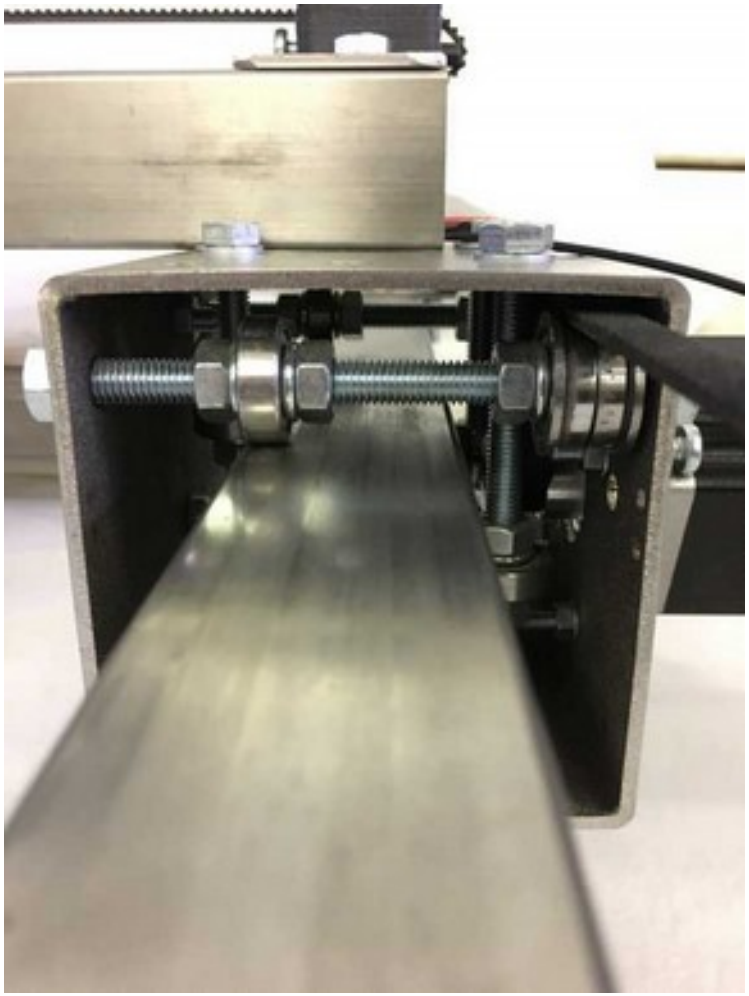
GOODENOUGHCNC

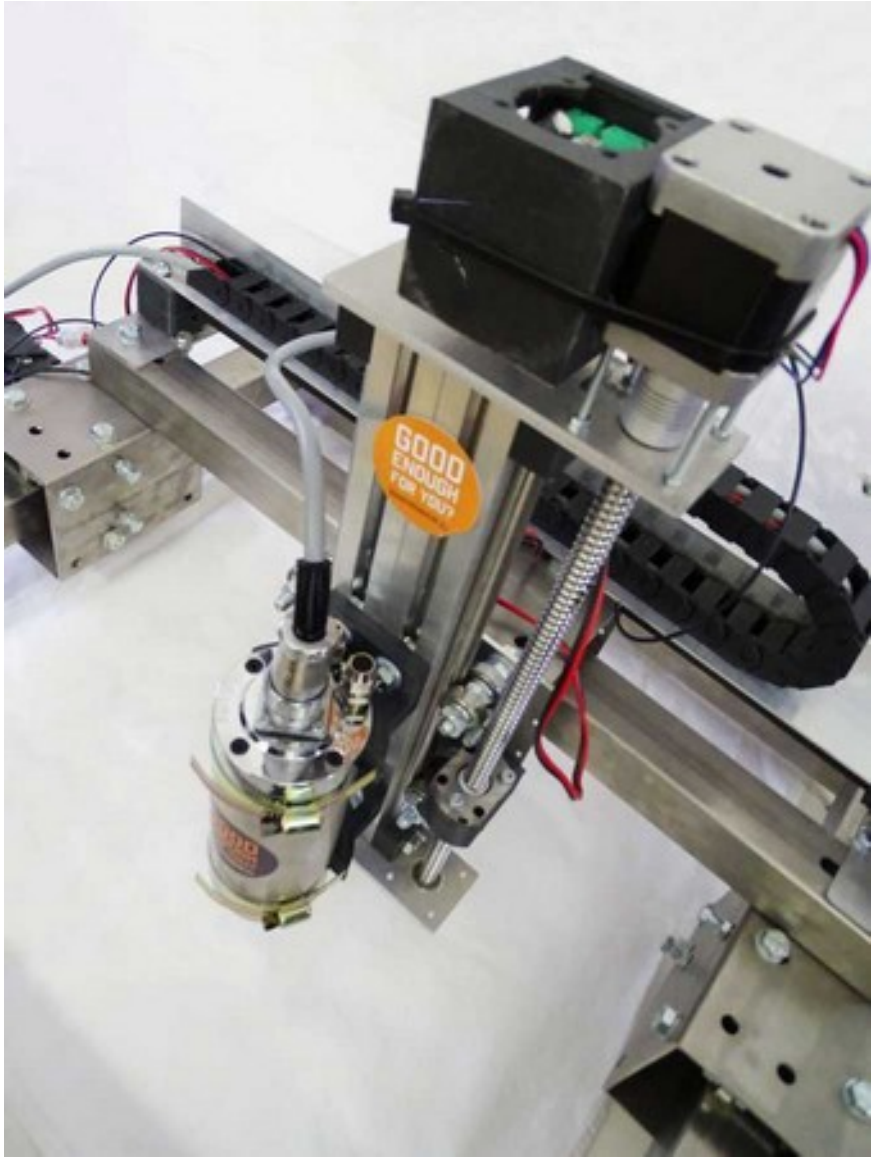
open hardware as baseline
manufacturing solution

Hybrid CNC Plasma Cutter

Hybrid CNC Mill

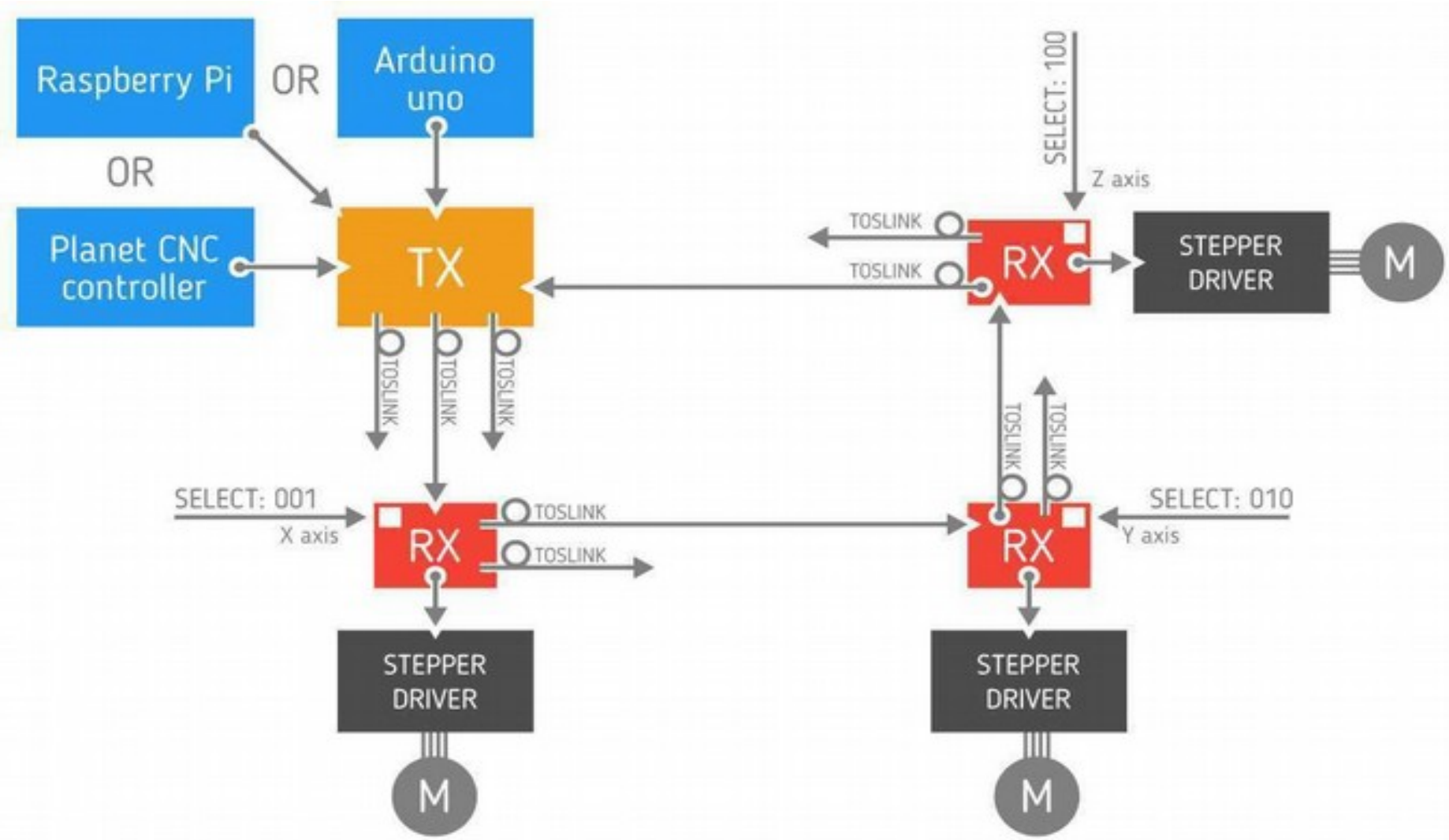
Trolley and z axis





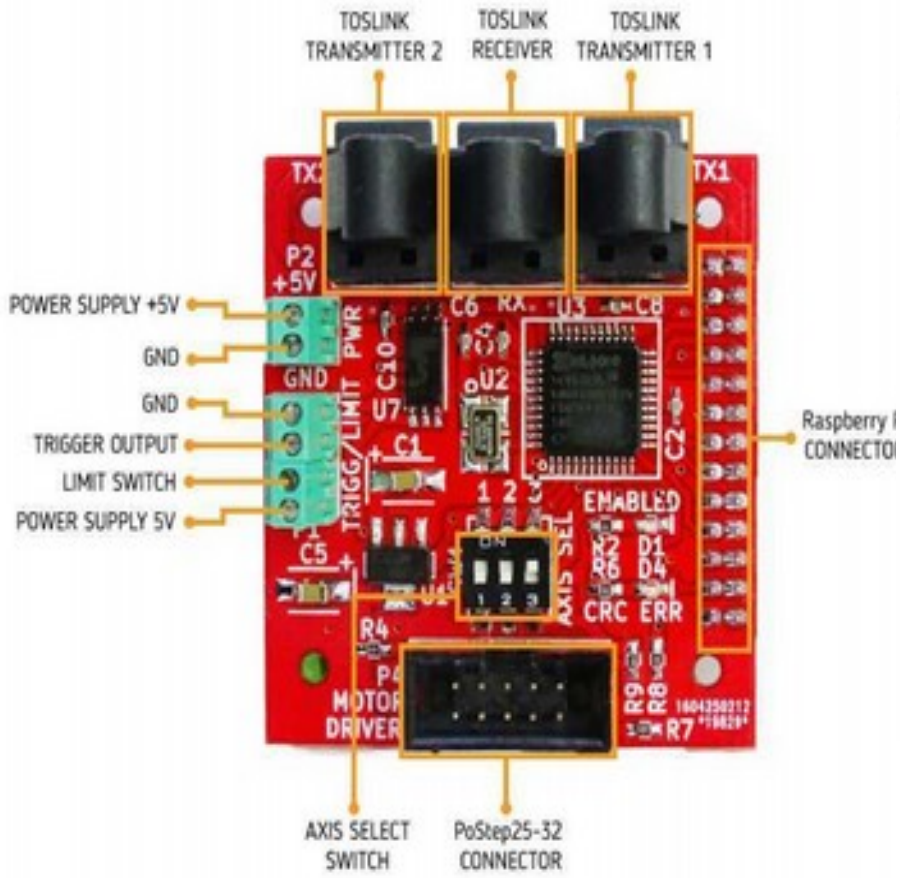
ToslinkCNC – fiber optic cnc machine control system

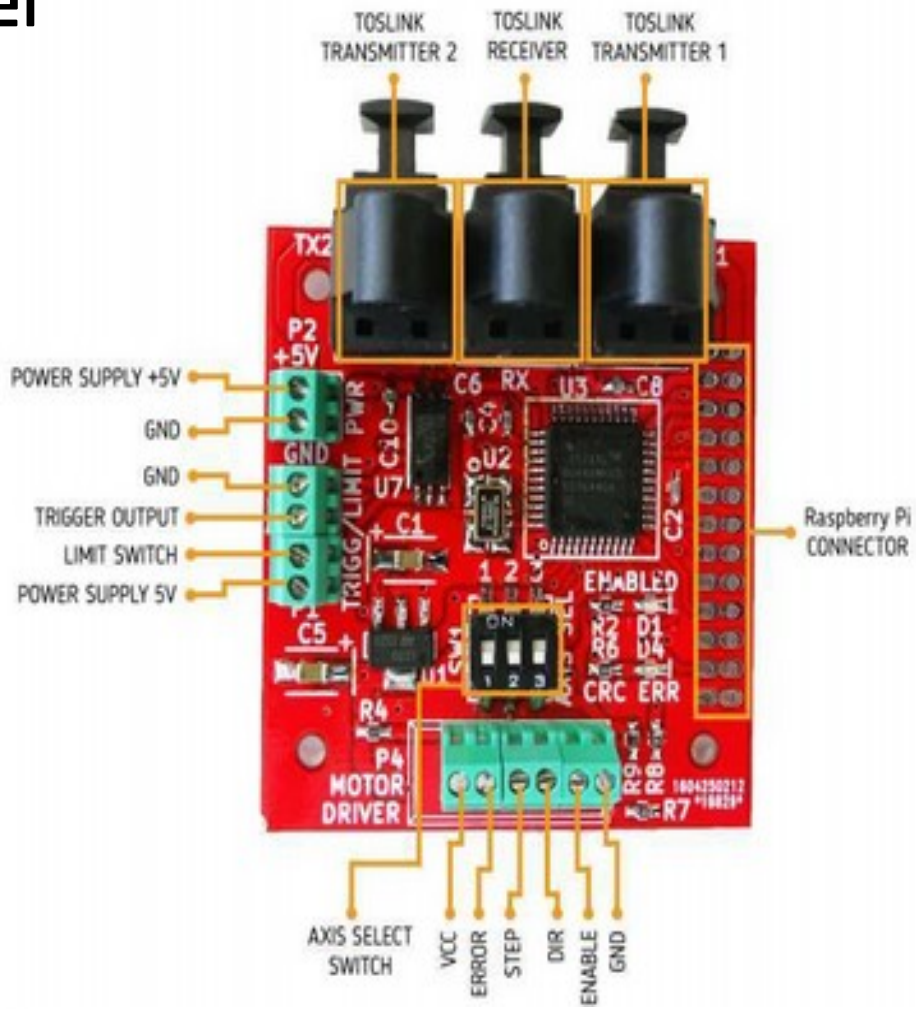
- Reliable wiring of DIY machines is often problematic
  - Ground loops
  - Intereference
- Can be solved with shielded cables, grounding and opto-couplers
- Why not use fiber instead?
- Toslink cable to every stepper
  - Driver on stepper
  - Only fiber and power required


Raspberry Pi
OR
Arduino uno
OR
Planet CNC controller
TX
TOSLINK
TOSLINK
TOSLINK
SELECT: 100
Z axis
TOSLINK
TOSLINK
RX
STEPPER DRIVER
M
TOSLINK
TOSLINK
SELECT: 001
X axis
RX
TOSLINK
TOSLINK
RX
SELECT: 010
Y axis
STEPPER DRIVER
M
STEPPER DRIVER
M

Toslink Receiver-transceiver

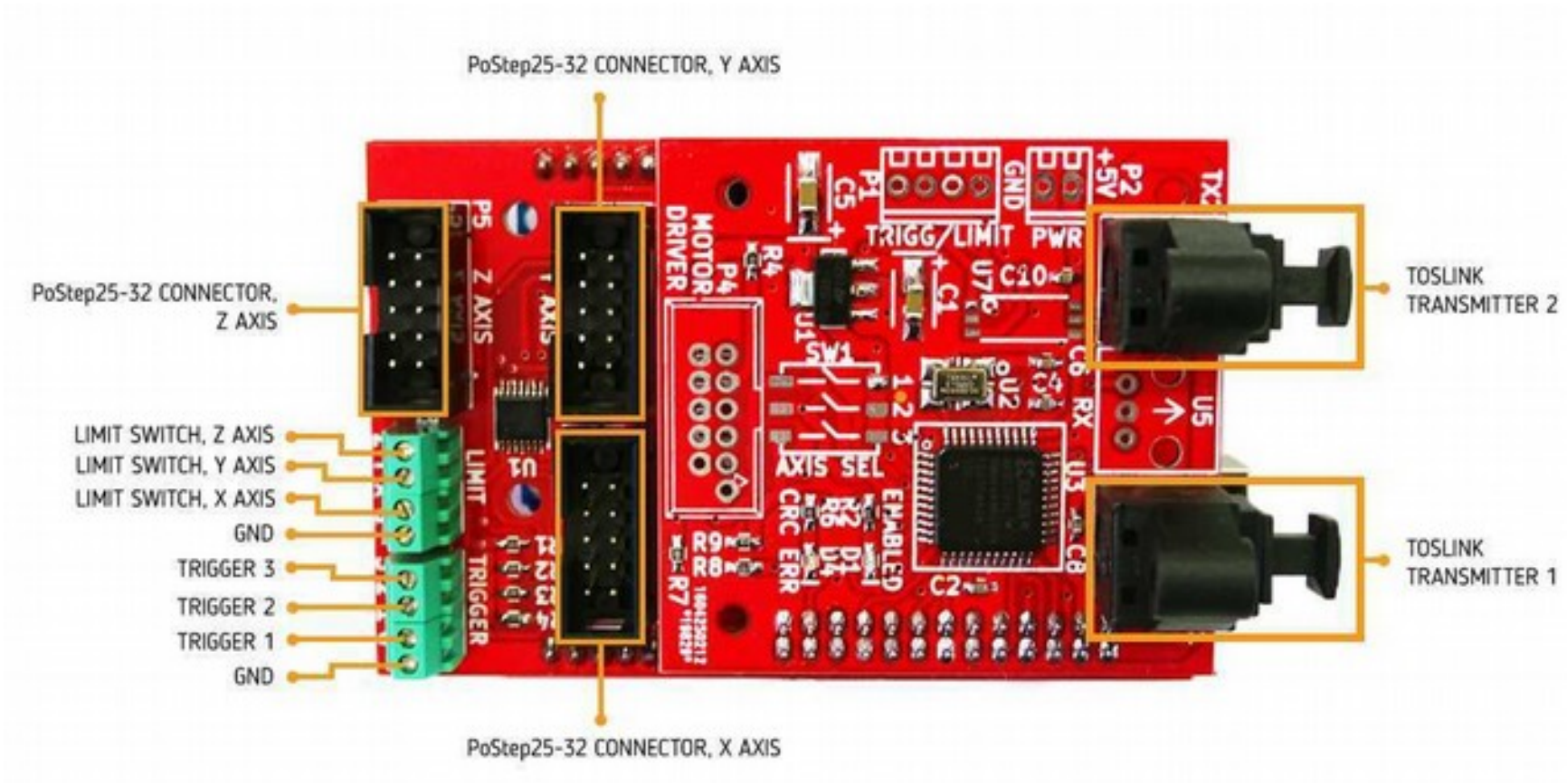
Using IDC-10 connector





Using terminal blocks

Toslink Transmitter

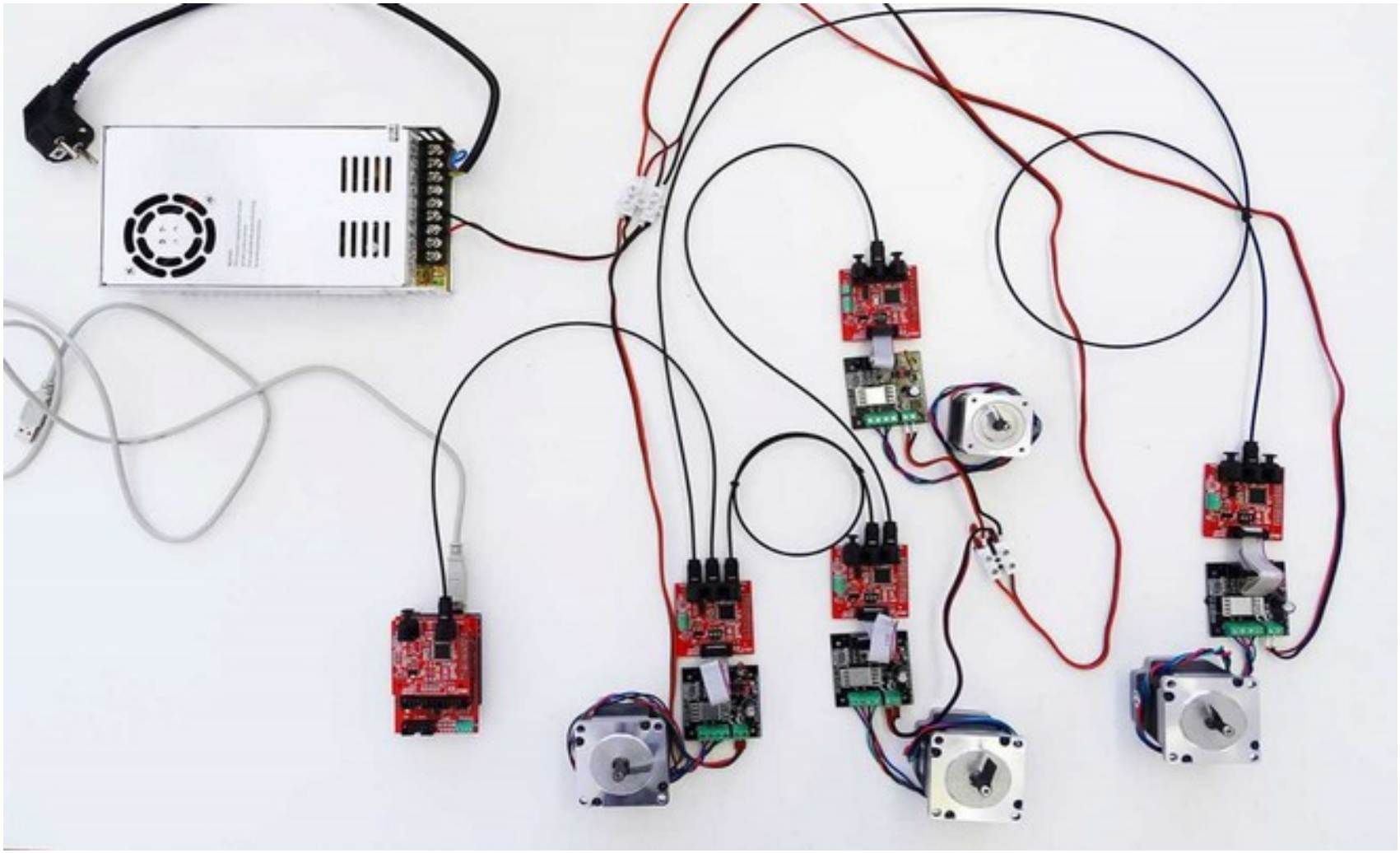


Toslink Transmitter

Arduino Shield

Planet CNC

Raspberry Pi Shield



Troublemaker 3D printer

Credit: Nepal Communitere

Collaborating with Communitere to enable sustainable disaster recovery in Nepal

Credit: Nepal Communitere

Credit: Nepal Communitere

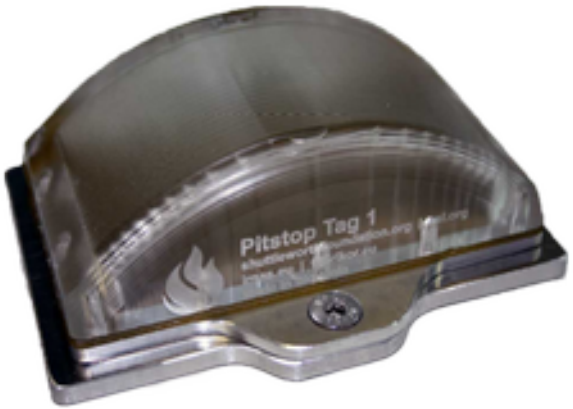
Solar powered GoodEnoughCNC

GOODENOUGHCNC
+
OPEN DESIGN
=
BUILD SOLUTIONS LOCALLY


Credit. aker.me


Credit. faircap.org

Saving endangered green turtles with open source turtle tags – **PitStop Tag**




Credit: Alais Dair

Symbiolab – open and DIY biolaboratory

- an open space for research, citizen science and bioart
- development of "good enough" DIY laboratory equipment
- educational workshops and exhibits

Fields of interest:

- urban farming
- biomaterials
- analytical biology
- sustainable development
- biomedical engineering

COLLABORATION WITH SAFECAST
Developing Solarcast

Safecast Solarcast sensor device is designed to operate off-grid and sense environmental parameters. It consists of 5 key modules designed for maximal reuse.

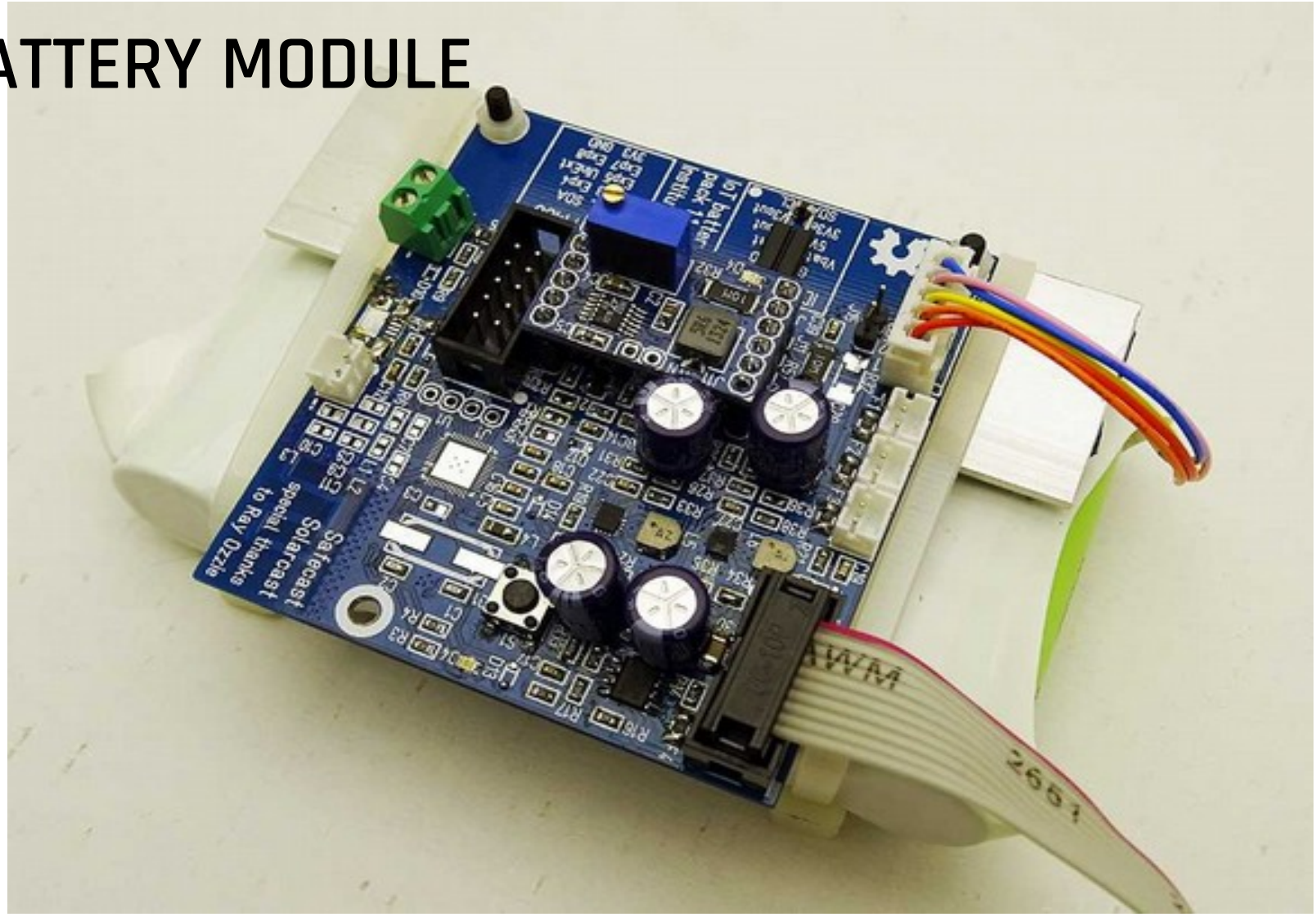
Modular design

- Air sensor module
- Geiger sensor module
- Battery power module
- Communications module
- Gateway module

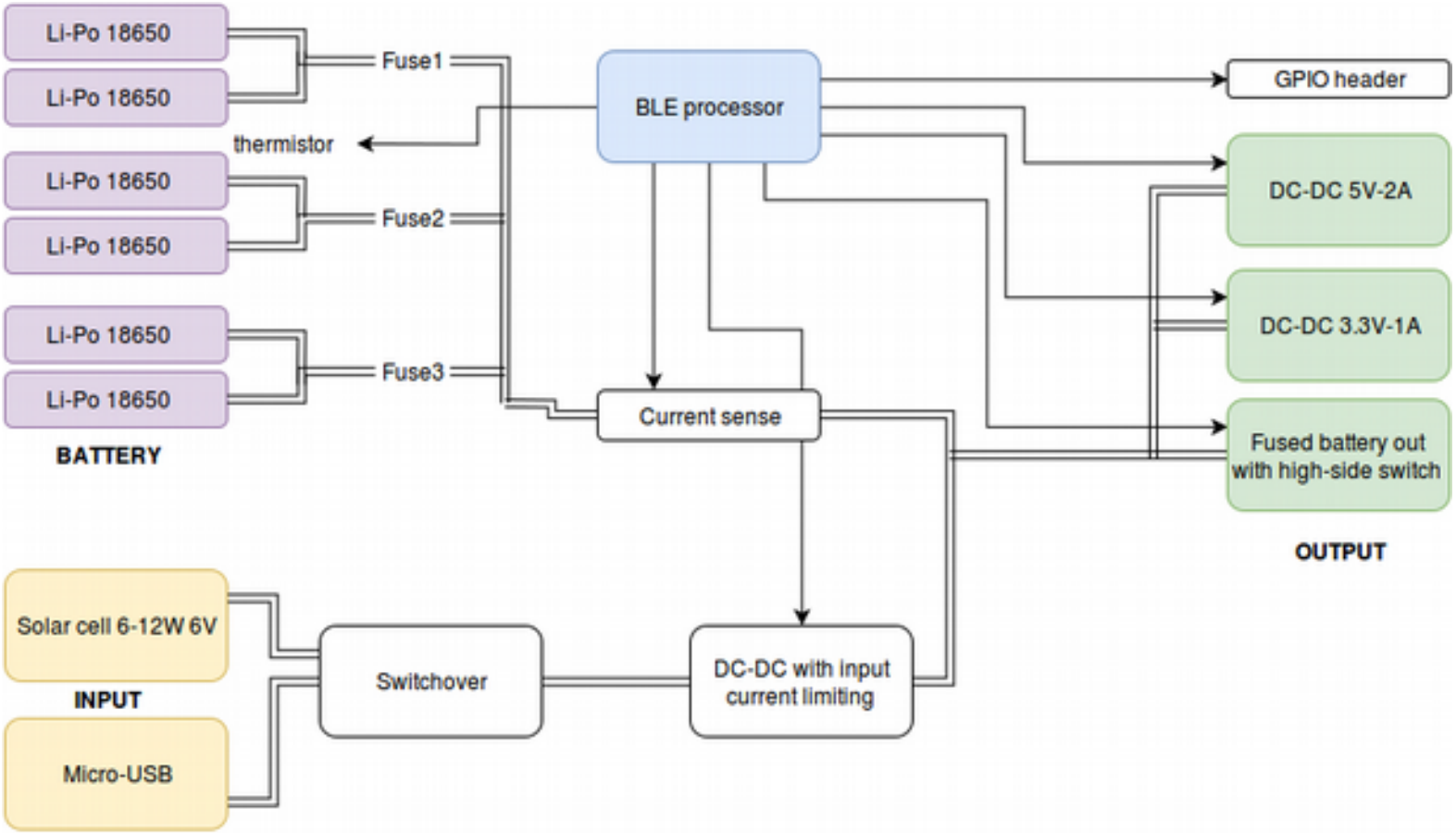
KEY DOCUMENTATION:
https://github.com/IRNAS/Solarcast

SAFECAST

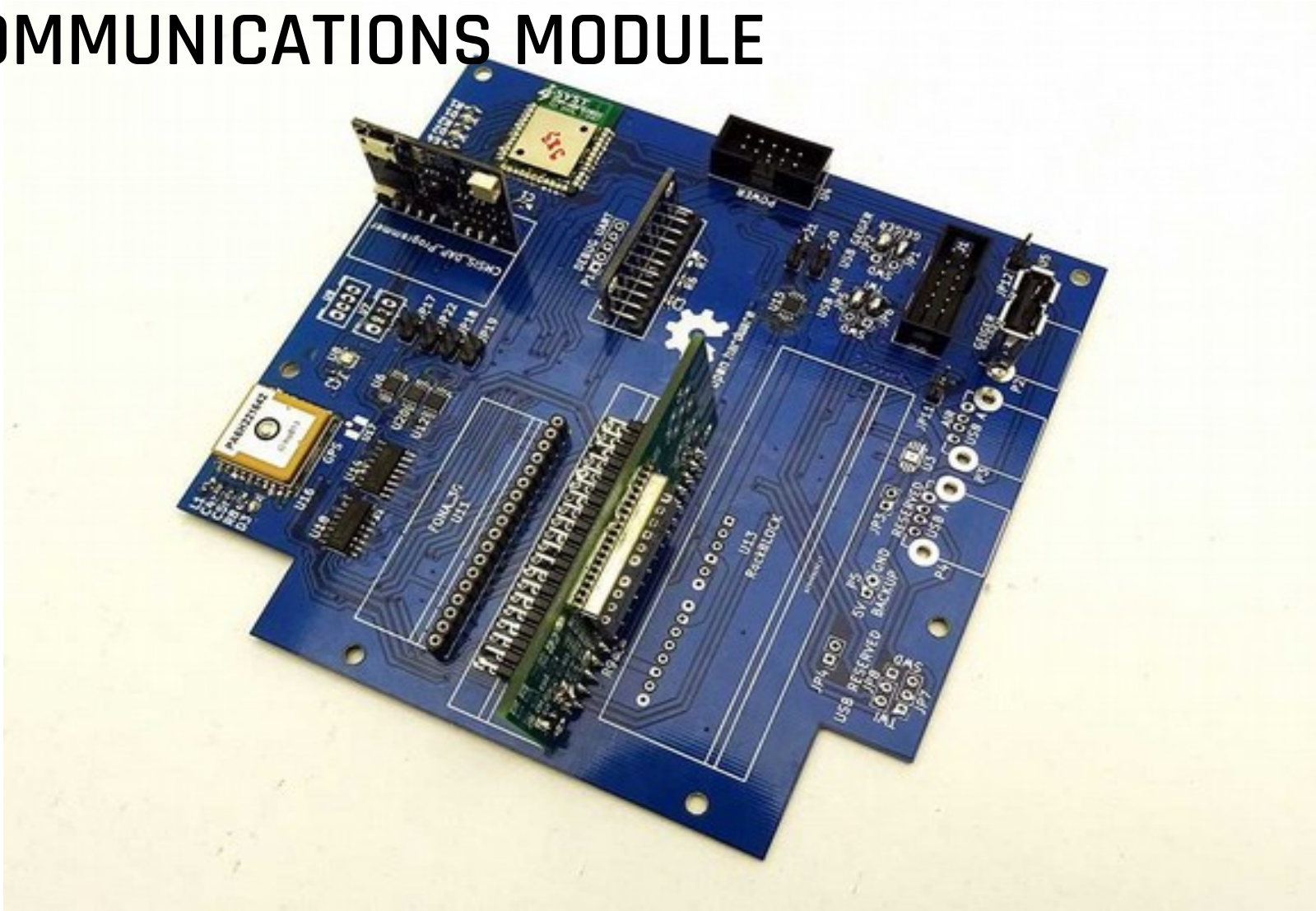
BATTERY MODULE



Battery power module – Iot Battery Pack



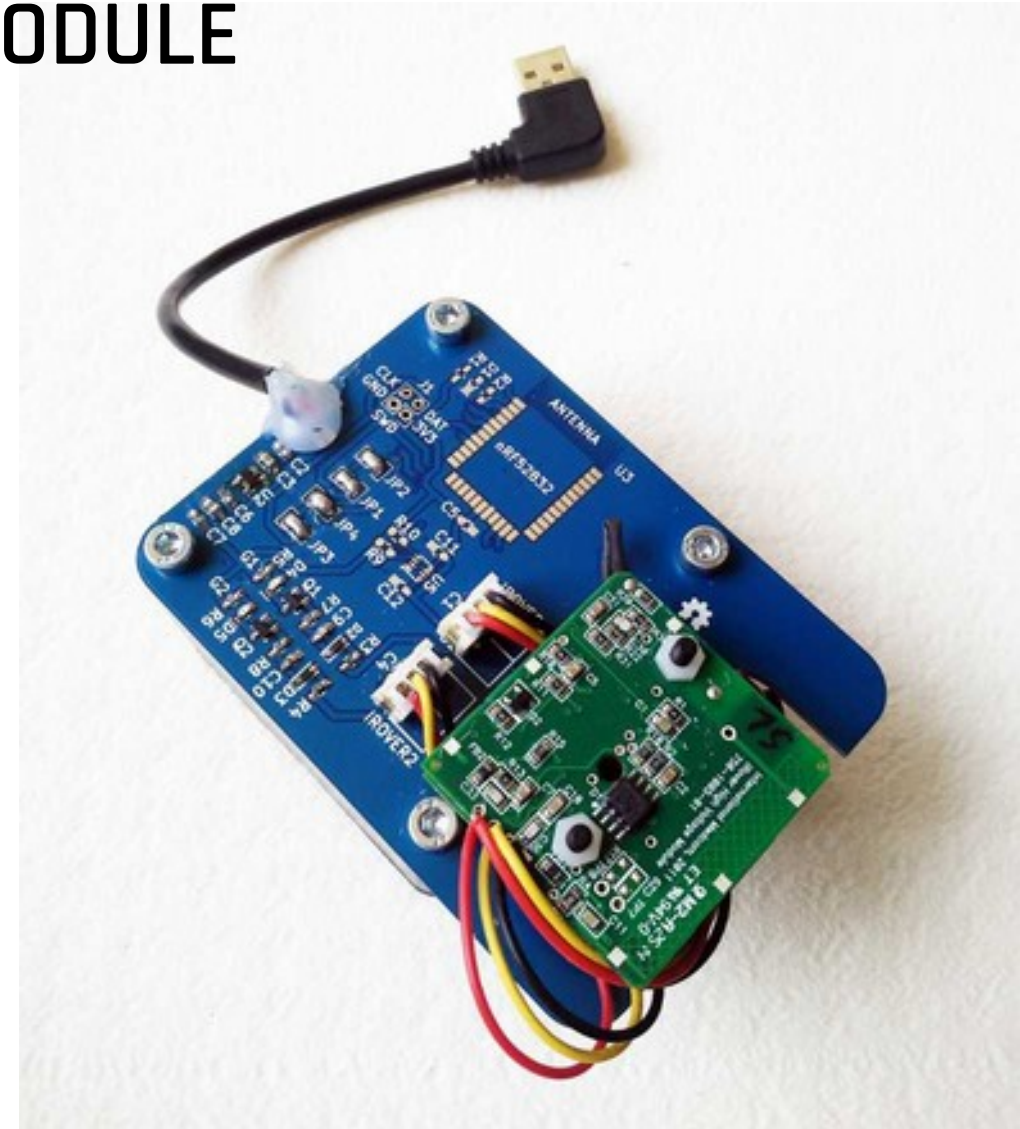
COMMUNICATIONS MODULE



COMMUNICATIONS MODULE

- Main processor: NRF module nRF52832 ANT
- GPS module
- 3G module
- Accelerometer
- Connectors for all other module (reusing USB)
- Expansion connector and lots of unused features

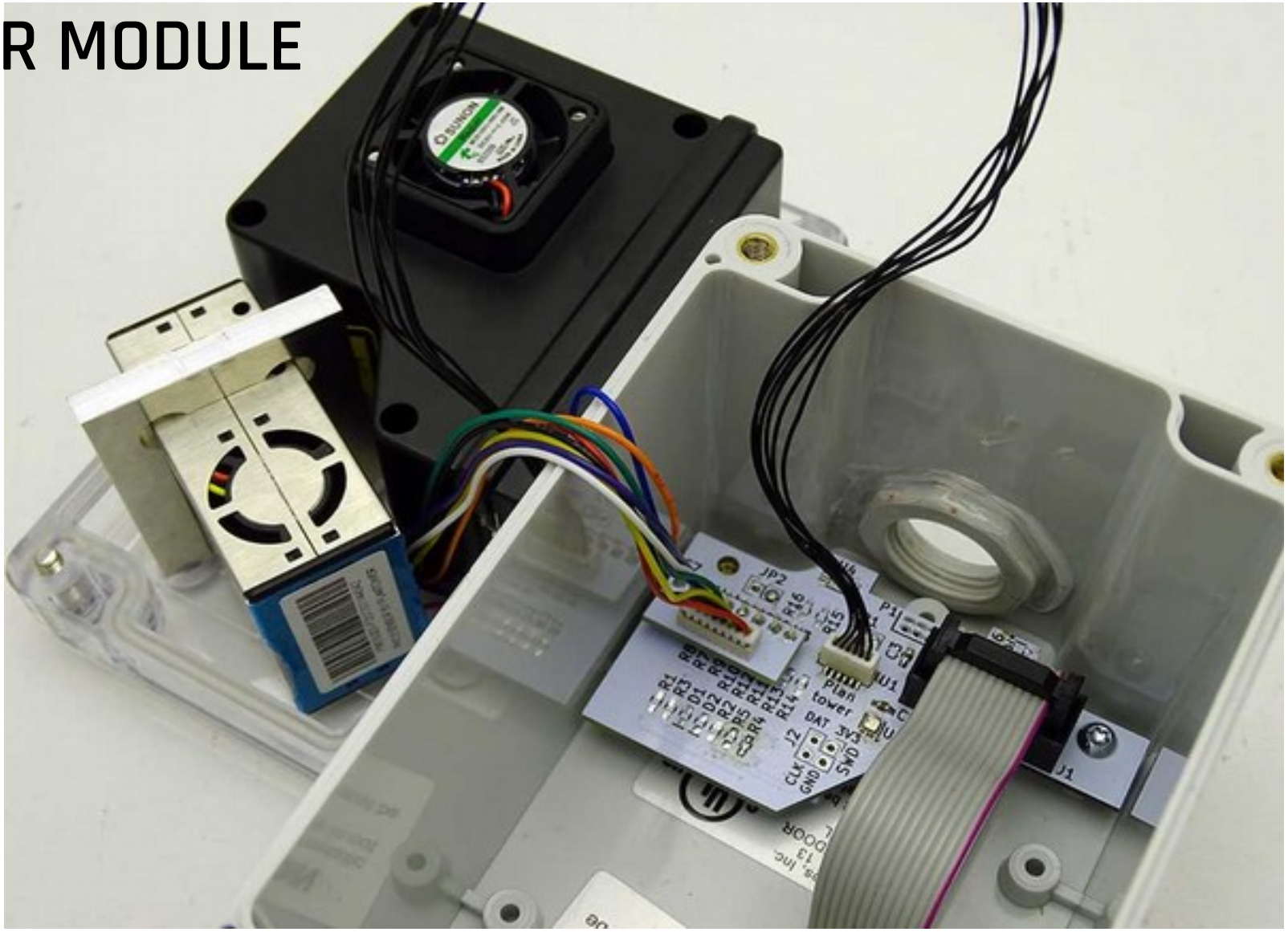
GEIGER MODULE



GEIGER MODULE

- BLE module NRF nRF52832 ANT (optional)
- Geiger pancake sensor (may be a stack of two)
- Temperature and humidity sensor (optional)
- 5V power supply via USB connector (no USB data)
- LED activity indicator

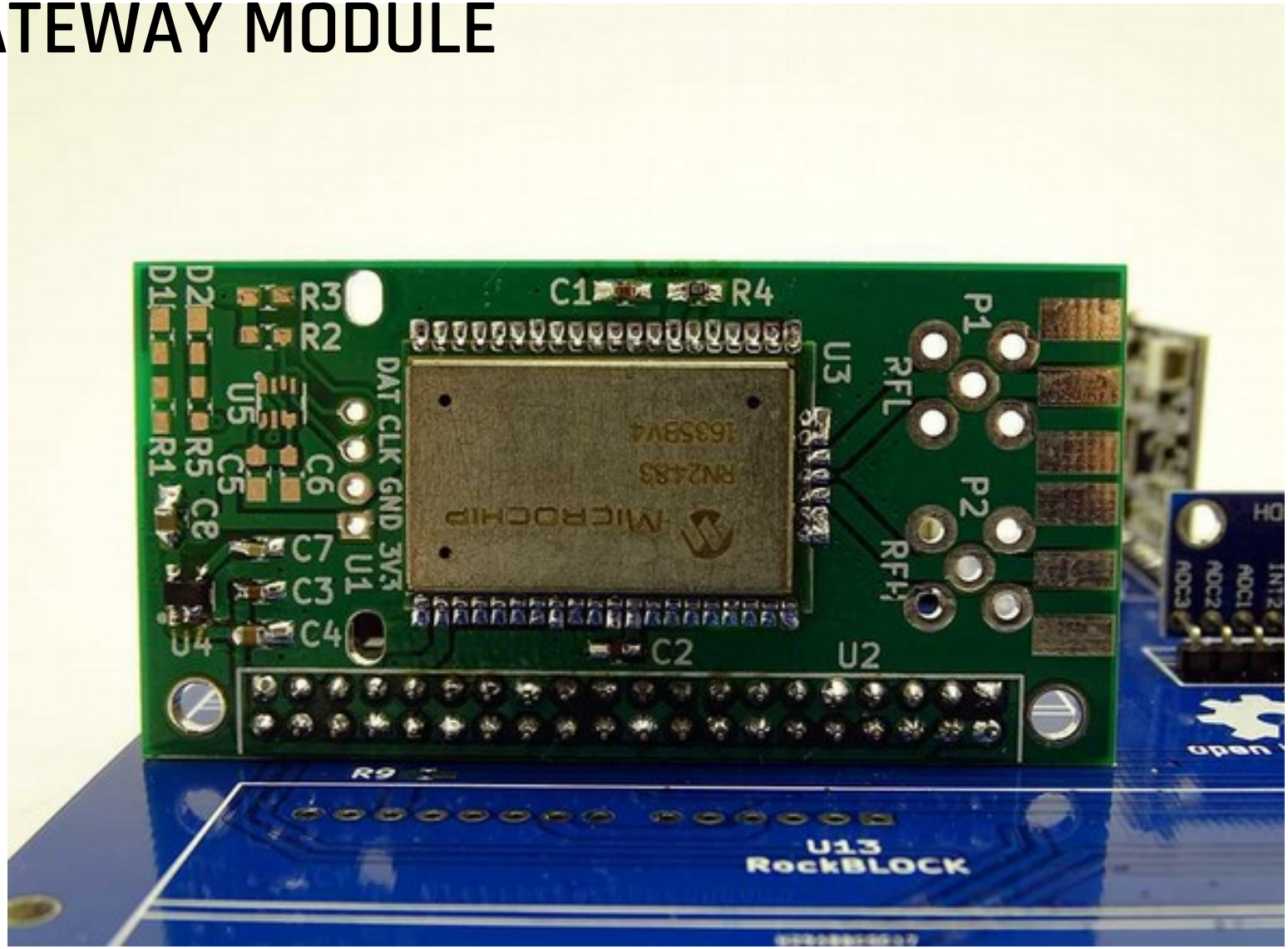
AIR MODULE



AIR MODULE

- BLE module NRF nRF52832 ANT (optional)
- Particle sensor Alphasense OPC-N2 (SPI)
- Particle sensor PM2.5 PMS 5003 (UART)
- Temperature and humidity sensor BME280 sensor (I2C SDO high 0x77)
- 5V power supply via USB connector (no USB data)

GATEWAY MODULE



GATEWAY MODULE

- LORA module Microchip RN2483/RN2903
- SMA connectors for 434MHz/868MHz
- SSD1306 i2c display (optional)
- 5V power supply and 3V3 regulator
- Status LED for each RPi and LORA module (optional)
- Temperature and humidity sensor (optional)

KEY GUIDELINES FOR OPEN HW DESIGN

- **Expect unexpected** uses and support them
- **Modularize** to simplify
- **Add debug** features, connectors and more
- **PCBs are cheap**, do not make them smaller
- **Document** iterations so others can learn
- **Serial numbers** + check lists are your friend

DEBUGGING FEATURES

- Add a header with all pins connected to them for easy access and measuring
- Add a bypass header for every switch
- Add more LEDs then needed
- Unpopulated components on a board are ok
- Add 0 ohm resistors to every power line, debugging short circuits is then easy
- Test modules individually

Connect

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THANK YOU!