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KORUZA 1.0

Wireless optical system for community networks and research applications

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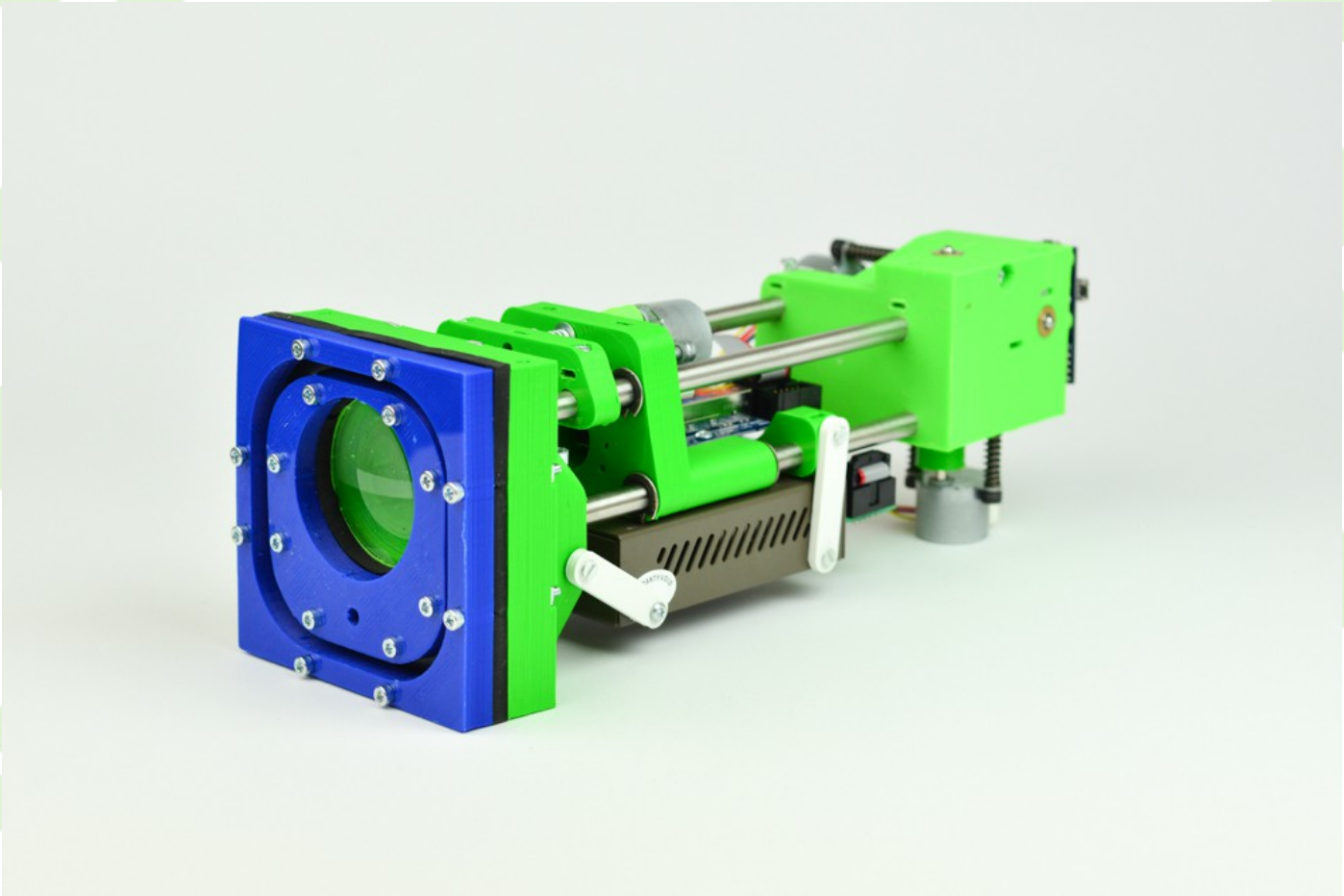
KORUZA 1.0

1Gbps networking connectivity for locations up to 100m apart, using an eye-safe infrared light beam.



KORUZA wireless optical

- Alternative for RF congested areas
- End-user deployed last-mile networks
- Open-source open-hardware for anyone to build
- DIY kit and documentation in finals stages of release

Creating an ultrafast wireless optical network.

Increasing the capacity of community wireless.

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

RADIOKLUB ŠTUDENT S59DXX

wlanslovenija

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Institute IRNAS Rače

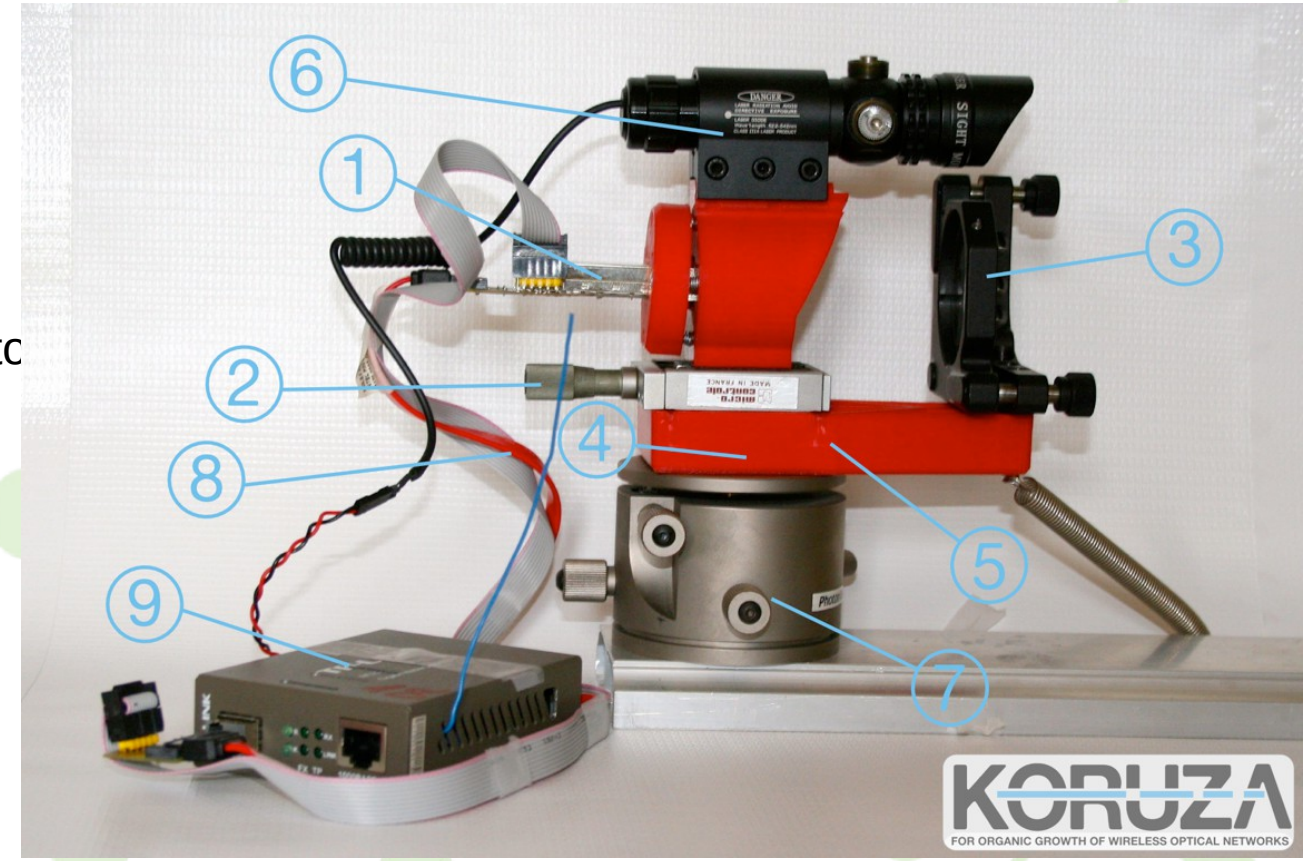
- Non-profit development lab focusing on open technologies with 4 full-time developers
- KORUZA – wireless optical communication system for 100m/1Gbps links
- GoodEnoughCNC machines for low-cost manufacturing
- Troublemaker 3D printer
- Various tools, measurement devices...
- DocuBricks - a useful source approach to documenting open hardware

History

- Early 2012: Idea
  - *Very Affordable Laser Ethernet Transceiver* (VALET) by Luka Mustafa, Dr. Benn Thomsen, UCL, London
- Early 2013: Working prototype
  - Published a paper: *Reintroducing Free-space Optical technology to Community Wireless Networks*
- Mid 2013: Scientific presentation
  - Crowdfunding campaign to present the paper at AMCIS2013 in Chicago
- Late 2013: 3D printing
  - IEEE ComSoc Student competition Second prize to Luka Mustafa for VALET
  - Shuttleworth foundation Flash Grant to Luka Mustafa for development
- Early 2014:
  - NLnet foundation grant to IRNAS for development of KORUZA
  - Working outdoor prototype for long term testing
- Late 2014:
  - World Wide KORUZA experiment, 10 sites globally
- Early 2015:
  - Shuttleworth Foundation Fellowship, active development with a dedicated team

Prototype generation 1

1) Infrared laser source and detector
2) Kinematic mount for aligning the source to the lens (3D printed)
3) Plano-convex lens in the kinematic mount for aligning it to the source
4) Linear translation stage for adjusting focus/collimation
5) Mounting bracket (3D printed)
6) Visible laser for alignment purpose
7) Rotational mount for aligning the unit to its pair at a distance
8) High-speed communication extension
9) 1 Gbps ethernet media converter



Tested at 180m, very expensive design.

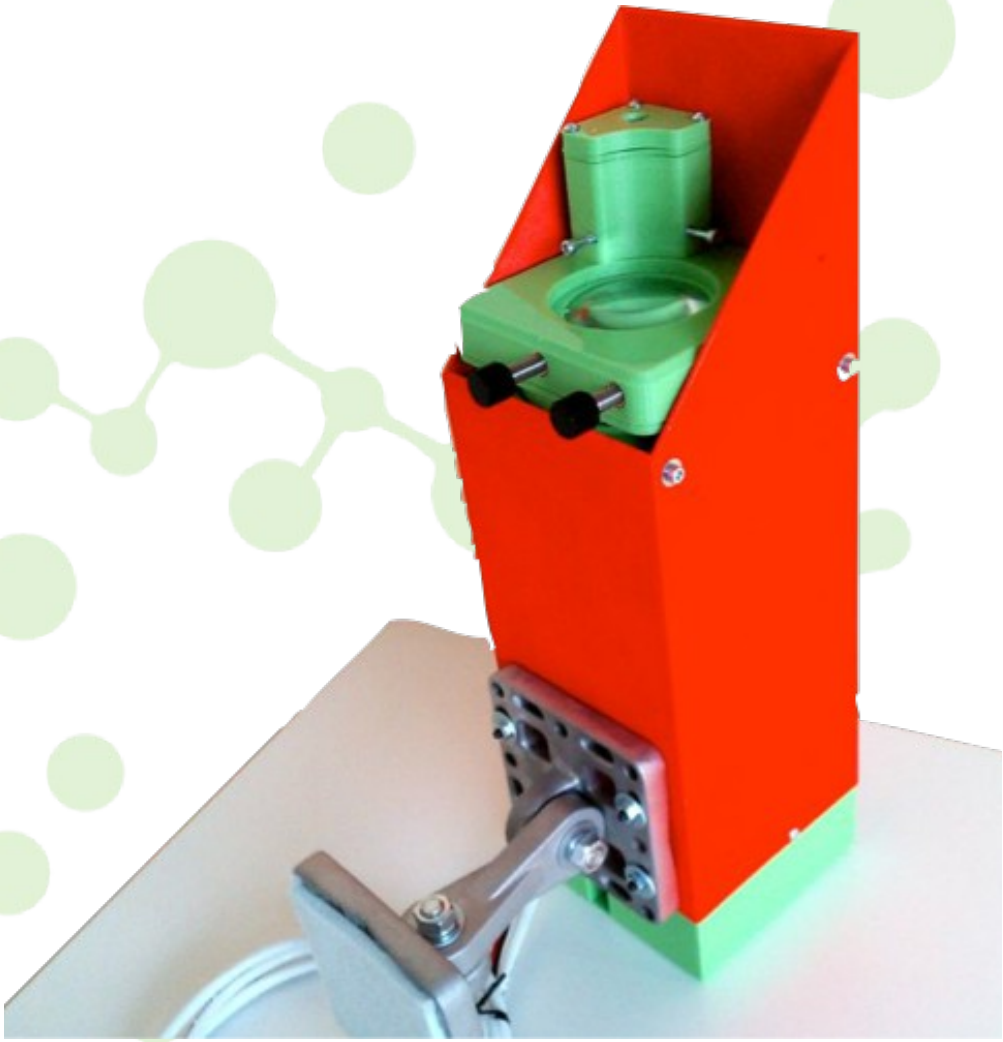
Prototype generation 2

1) Infrared laser source and detector
2) Kinematic mount for aligning the source to the lens
3) Plano-convex lens in the linear two axis translational mount for aligning the lens to the detector
4) Linear translation stage for adjusting focus/collimation (prototype sourceavailable)
5) Indoor desktop mounting system, that is to be upgraded to the outdoor version
6) Visible laser for alignment purpose
7) 3D printed kinematic mount for pointing at its pair at a distance (resolution 10urad / 0.6mm at 100m)
8) High-speed communication extension
9) 1 Gbps ethernet media converter

Tested at 100m, insufficiently stable, unsuitable for outdoor.

Prototype generation 3

- Implements visible laser pointer alignment with 3D printing
- Water-resistant
- Tested at 180m
- Long term instability due to thermal expansion
- Complicated assembly
- Control based on Energia and MSP430F5529
- Motorized alignment in X,Y and focus

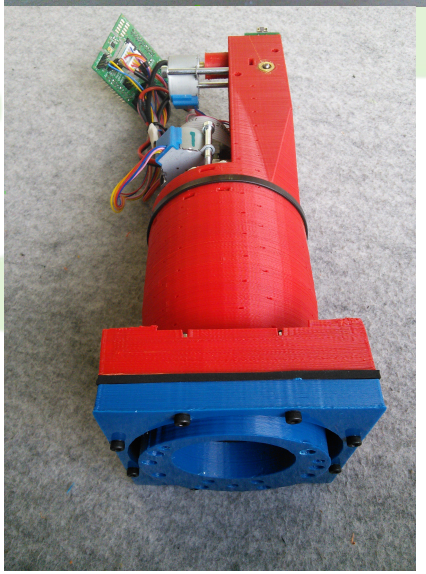


Prototype generation 4

- Simplified design
- Improved focus alignment accuracy
- Reduced material cost
- Integrated visible laser source
- ARM based control electronics TI Launchpad Tiva C + Energia
- Low-power diagnostic communication between units
- Automatic alignment and tracking under development
- 180m range tested, 1dB loss at 25m

Prototype generation 5

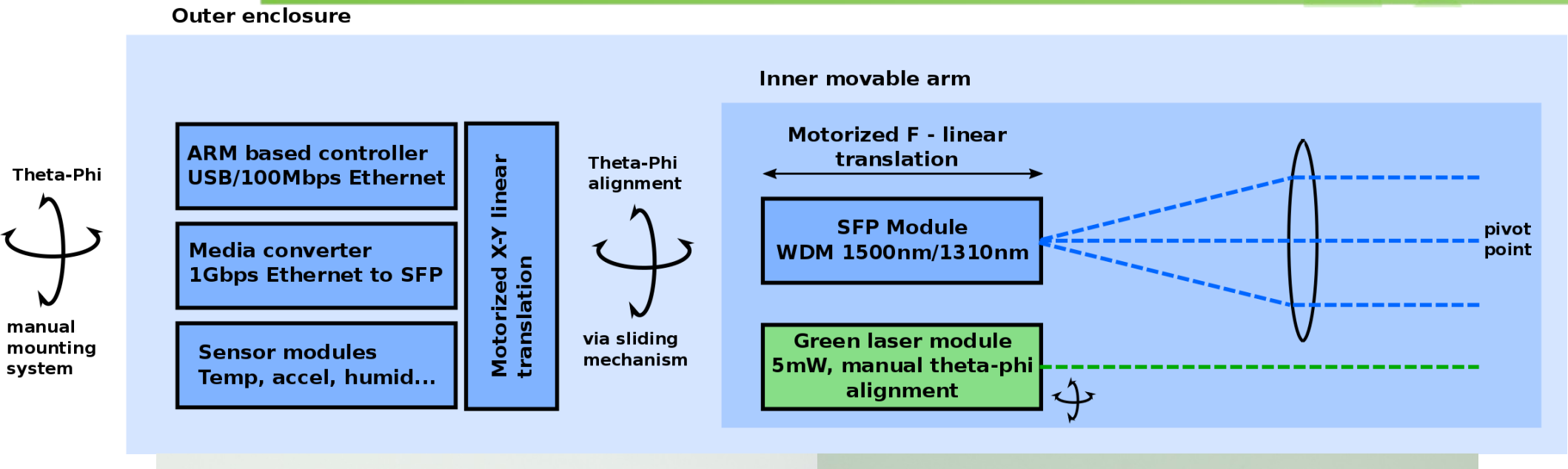
- Optimized design
- Complete redesign in OpenSCAD
- Reduced material cost
- Improved stability and realiability
- Sensors + measurement and testing system
- Automatic alignment and tracking under development
- SFP module improvement, 30dB link margin

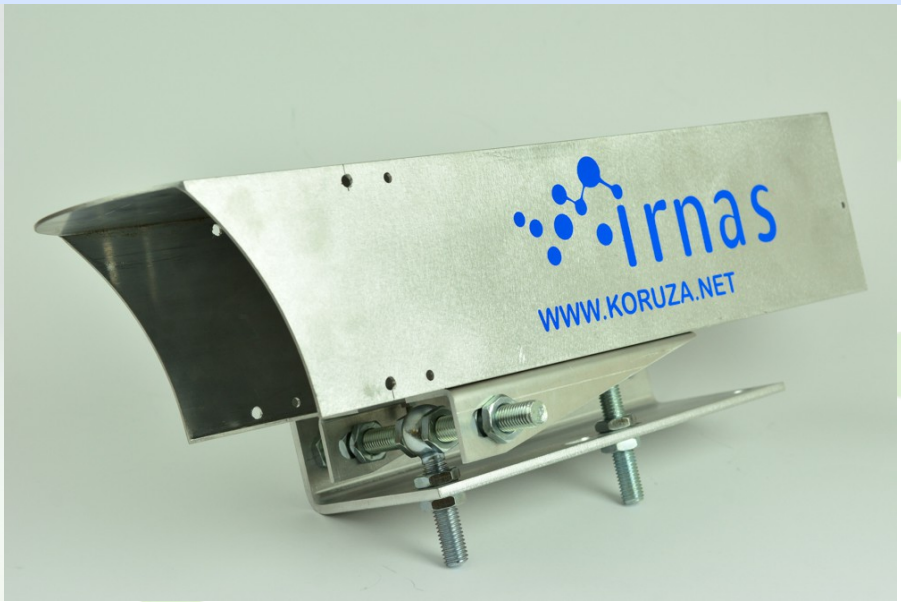


KORUZA 1.0

- 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.
- Soon available as a DIY kit.

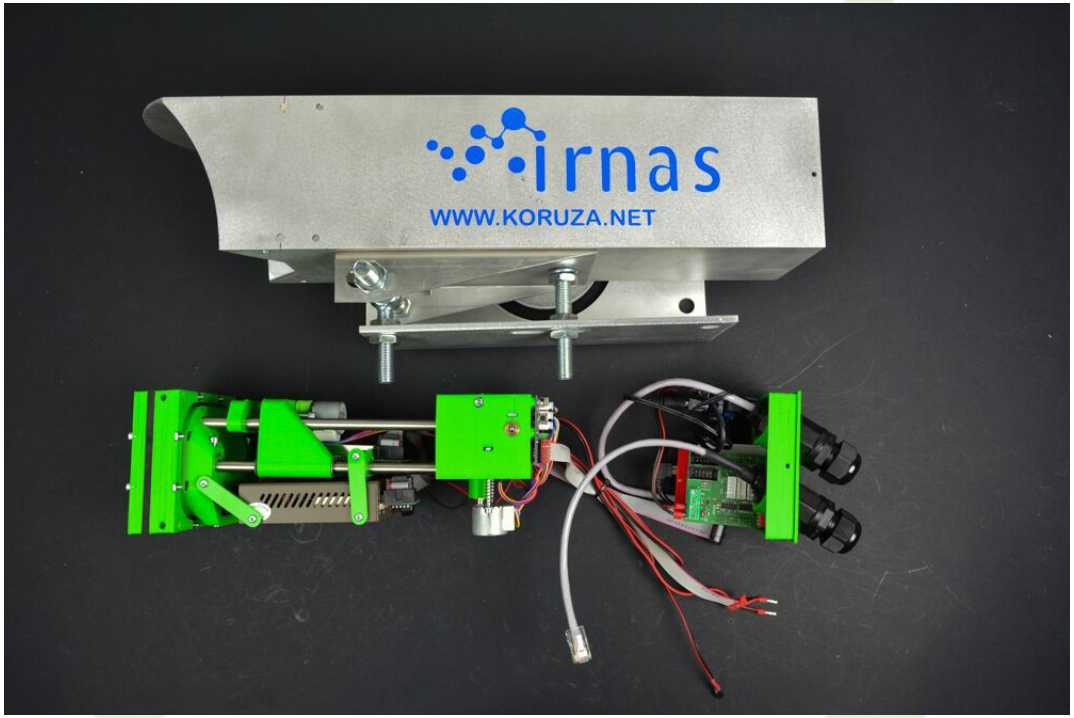
KORUZA system





KORUZA modular assembly

- 12 different 3D printed parts
- Precision alignment system
- 4 modular electronics boards
- SFP optical module
- DPSS green laser
- WiFi router and expansion board



We aim for researchers to be able to replicate the system, understand operation and be able to modify it.

DESIGN

- Innovates on the use of SFP modules for wireless optical
- Modularity enables quick integration in many applications
- Refined through several hardware versions
- Replicable design in hackspaces

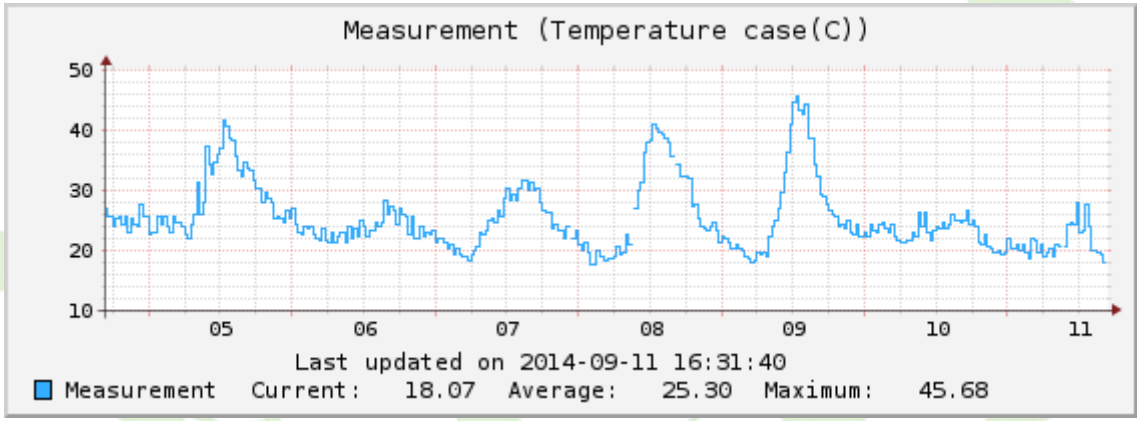
World-wide experiment

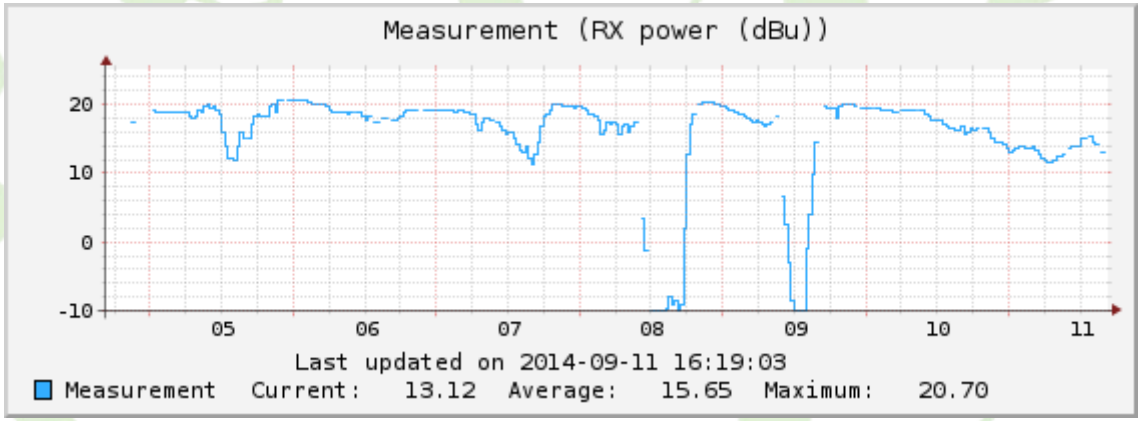
- Observing FSO system performance in real-time over 12+ months
- Observing micro-climate and environmental parameters on the spot
- A number of deployments (20+) world-wide
- The creation of an open data set for future studies
- Correlation of performance measurements with national meteorological data
- Used for carrying community network traffic

Current deployments

What have we learned

- Thermal expansion mis-aligns the system significantly
- Rain and snow do not significantly affect operation
- Fog can be a problem if poorly aligned





FOG experiment

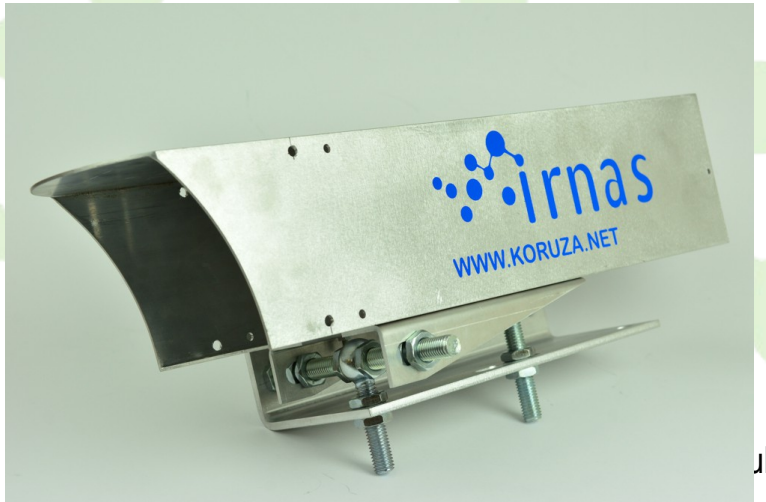
- Evaluation of the link performance in low visibility and presence of aerosols in the atmosphere.
- Experiment design using dry-ice, fog machine and smoke flare.
- Outdoor conditions simulated in a 50m PVC corridor.
- Green laser visibility measurement system.

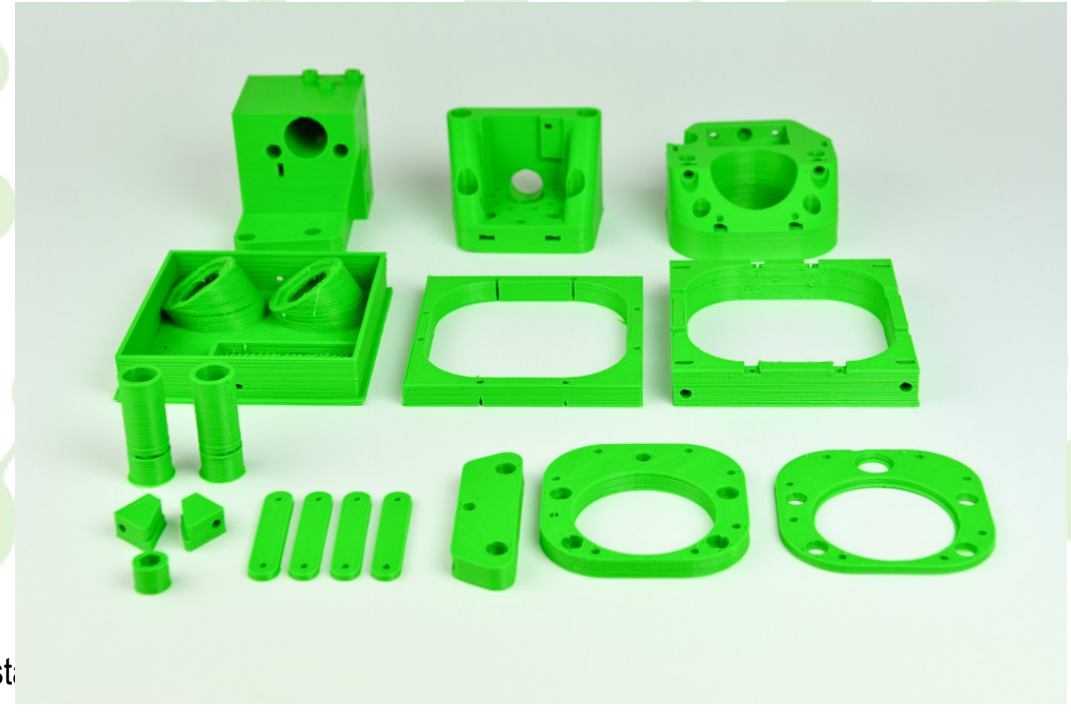
Future of KORUZA

- Release of full documentation and DIY kit by the end of August
- To be replicated by hackers, developer and people interested
- Design optimization for lower cost and easier assembly
- Expansion of WorldWide KORUZA experiment
- Establishment of global micro-manufacturing network for open hardware
- Open-hardware release of toolset

DIY KIT

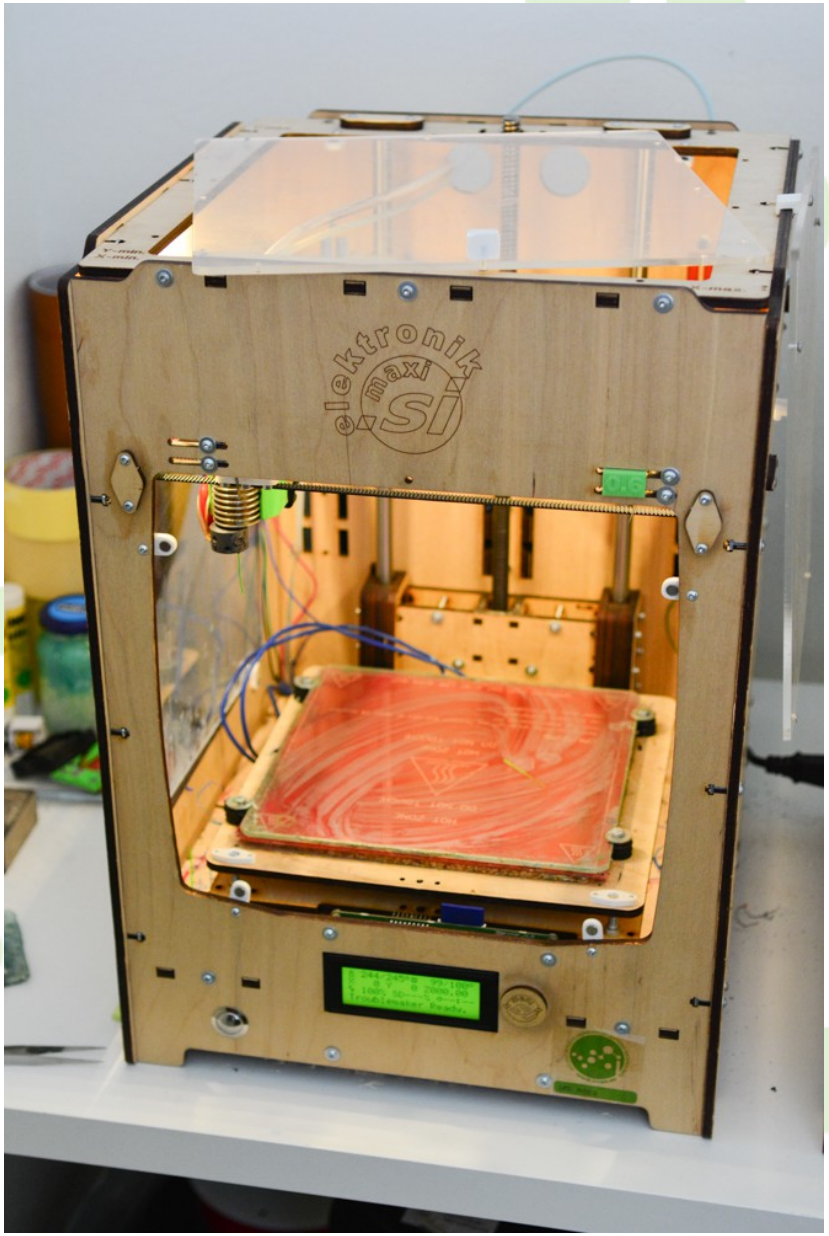
- 3D print the parts yourself
- Get a KIT from IRNAS
- Assemble the unit following instructions
  - About 8h of work per link
  - Test and calibrate
- Deploy links





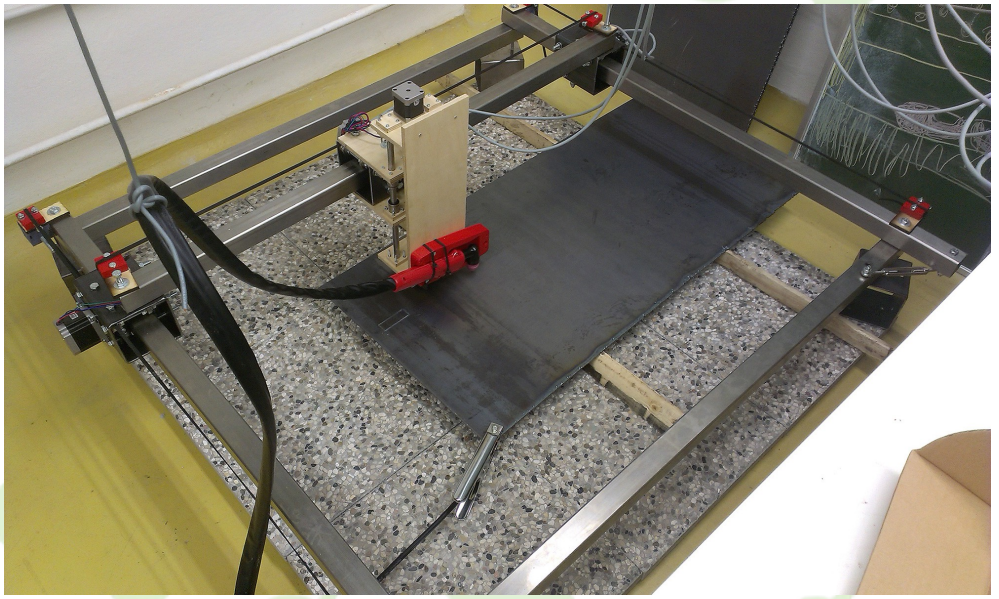
Troublemaker 3D printer

- http://www.thingiverse.com/thing:263814
- Ultimaker Classic derivative
- Reworked enclosure
- Heated bed/chamber upgrade
- Effectively open-source
- 80+ built in society Društvo Elektronikov Slovenije
- **Next generation under development**



GoodEnoughCNC Plasma cutter

- Based on stock steel profiles
- Low-cost with sufficient performance
- Innovative fiber optic control and torch height control operating even with lowest cost cutters
- Complete machine in 700GBP range
- **Close to release**



Under development 10k fab:

- **Plasma cutter**
- **CNC mill (2x3m)**
- **Laser cutter 100W (2x3m)**
- **3D printer**
- **Waterjet cutter**

State of open hardware today

- A large number of projects
- Questionable quality
- Difficult to replicate
- Difficult to document
- Open hardware focused on modifications and hacks not replication
- Of limited use for scientific applications
- Most replicated systems are not calibrated and results can not be compared

DocuBricks
http://docubricks.com/

- Implementation of useful source proposal
- Tree-structure of “bricks” consisting of
  - Functions (logical parts)
  - Implementations (physical parts or design files)
  - Multi-level
- Documentation builder application under development
- Envisioning a companion mobile phone app for seamless documentation

Future of docubricks

- Online system/database of open hardware stable releases
- DOI for releases
- Collaboration with open hardware journals
- Documenting/referencing experimental equipment
- Enable sharing of kits for assembly
- API for including projects into other websites

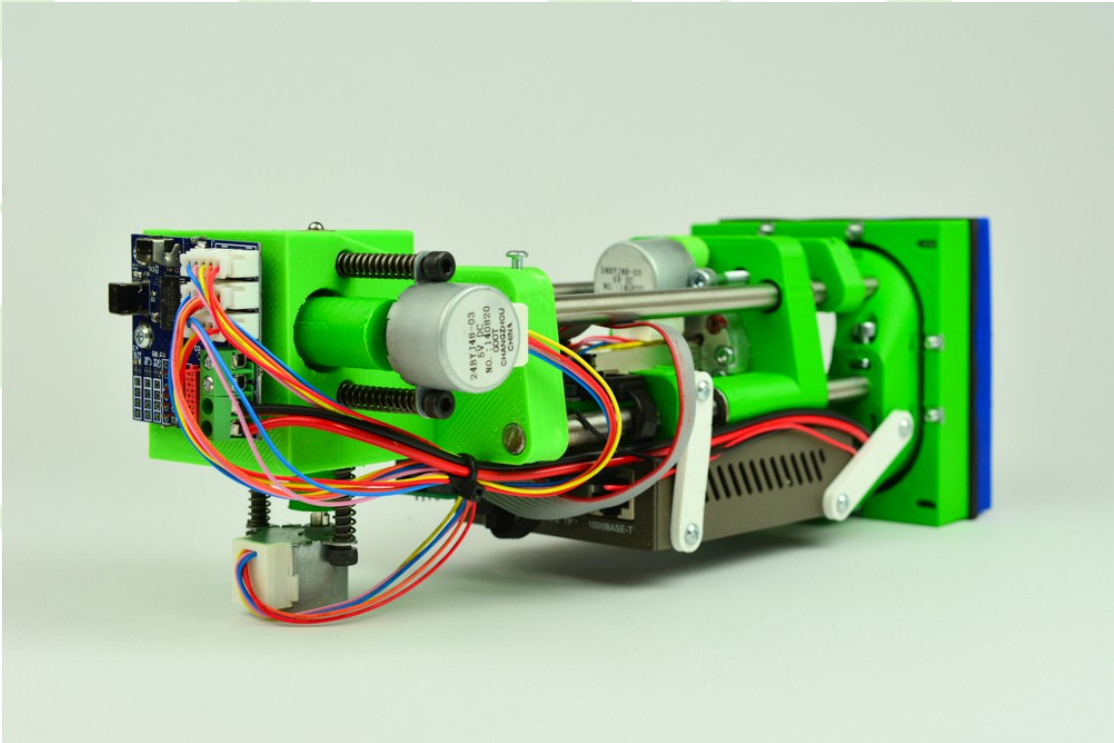
Developed by:

Tobias Wenzel, Dr. Carlos Lugo, Dr. Johan Henriksson, Luka Mustafa

UNIVERSITY OF CAMBRIDGE · John Innes Centre · TSL · EMBL-EBI · SHUTTLEWORTH FELLOW

KORUZA practical session

- Tonight and tomorrow evening
- Establishing an outdoor link
- Learning how to use it
- Ask first hand questions



Visit www.koruza.net

Questions? *musti@irnas.eu*