

HOW TO BUILD YOUR OWN FULLY AUTOMATED LOW COST BACKYARD OBSERVATORY

CEDIC 2019

Simon Addis

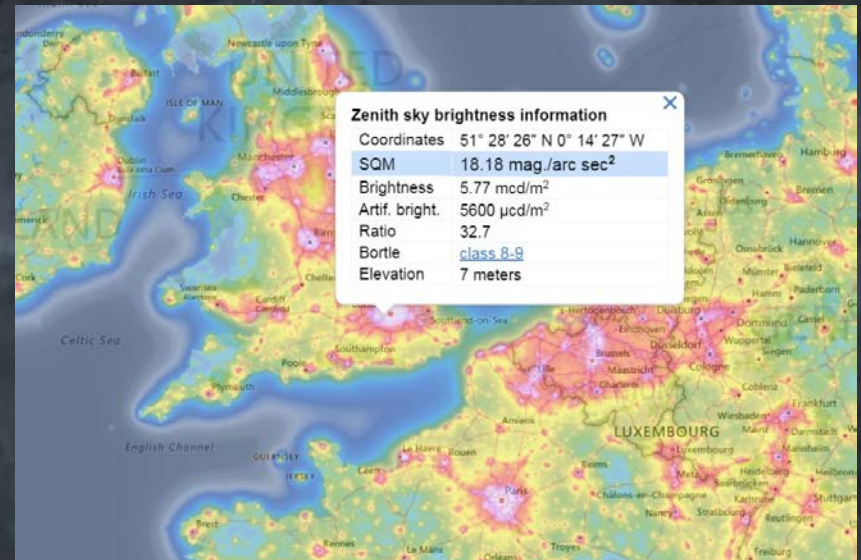
WHAT WILL WE COVER?

- Requirements & design goals
- **Hardware** design
 - Box & Roof
 - Microcontrollers
 - Other Components
- **Software** design
 - PC & Smartphone
- Demo



WHY BUILD AN AUTOMATED OBSERVATORY?

- Setup, polar align and teardown kit each night
- Poor seeing conditions
- Fun summer DIY project
- Need sleep!



www.lightpollutionmap.info

WHAT ARE THE REQUIREMENTS?

- Compact / Portable
- Weatherproof!
- Mechanical Roof
- Weather aware
- Low cost
- Remotely Controllable
- Automomous?

MY SETUP

- **Hardware**

- Takahashi FSQ106ED
- Celestron AdvancedVx Mount
- QSI 683ws CCD
- PoleMaster

- **Software**

- Sequence Generator Pro
- PHD2 Guiding
- SharpCap (Polar Alignment)



AUTOMATIC ROOF DESIGN OPTIONS

- Dome
 - -- Larger, needs azimuth control
 - ++ Simple to quickly close
- Flat Roll Off Roof
 - ++ Compact
 - -- Need to be carefully parked before close

BOX DESIGN

- Raised Bed 97x97cm
- Stackable
- Waterproof PVC
- Treated wood base
- Liner available



ROOF DESIGN

- Universal Telescopic Car Aerial (99cm) (€25)
- Attach with single screw & metal guide strip
- Connect end of antenna to roof



ROOF DESIGN

- Twin wall polycarbonate sheet (1m², 6mm)
- Angle brackets (x4)
- U-Profile Runners (x2)
- Draw Runners (x4)
- Sash Pulley Wheels (x2)



ROOF OPEN/CLOSE SENSOR

- **Reflectance** sensor to detect open/close/ajar
- Black, grey and white tape strip



ROLL OFF ROOF DESIGN

Closed Cell Foam (1.2m x1.1m)



MODULES TO BUILD:

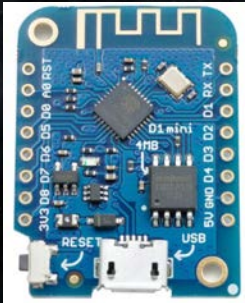
- **PC Box** – Windows PC
- **Dome** – Roof Controller
- **Safety** – Safe Conditions Monitor
- **Scope** – Power Relays
- **Switch** – Main On/Off Switch and Hub

PC BOX

- Intel Compute Stick
 - BOXSTK2M3W64CC (€300)
 - Win 10, Intel Core M m3-6Y30, 4GB DDR3, 0.9GHz
 - Auto boot on power
- 12v-5v Voltage Converter
 - 5V USBC Power
- USB hub - 7 way powered
- Mini fan to cool processor



HARDWARE MODULES



WEMOS D1 MINI

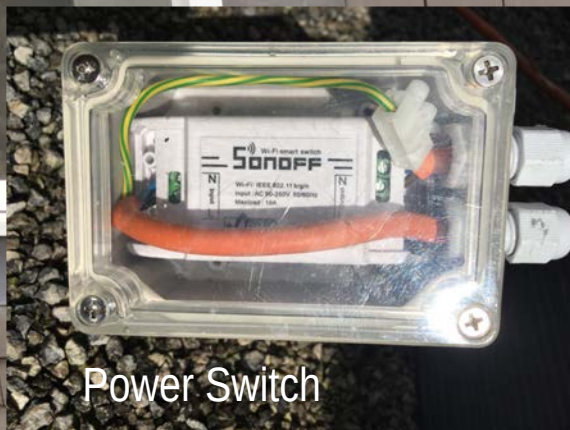
Safety Monitor



Roof Controller



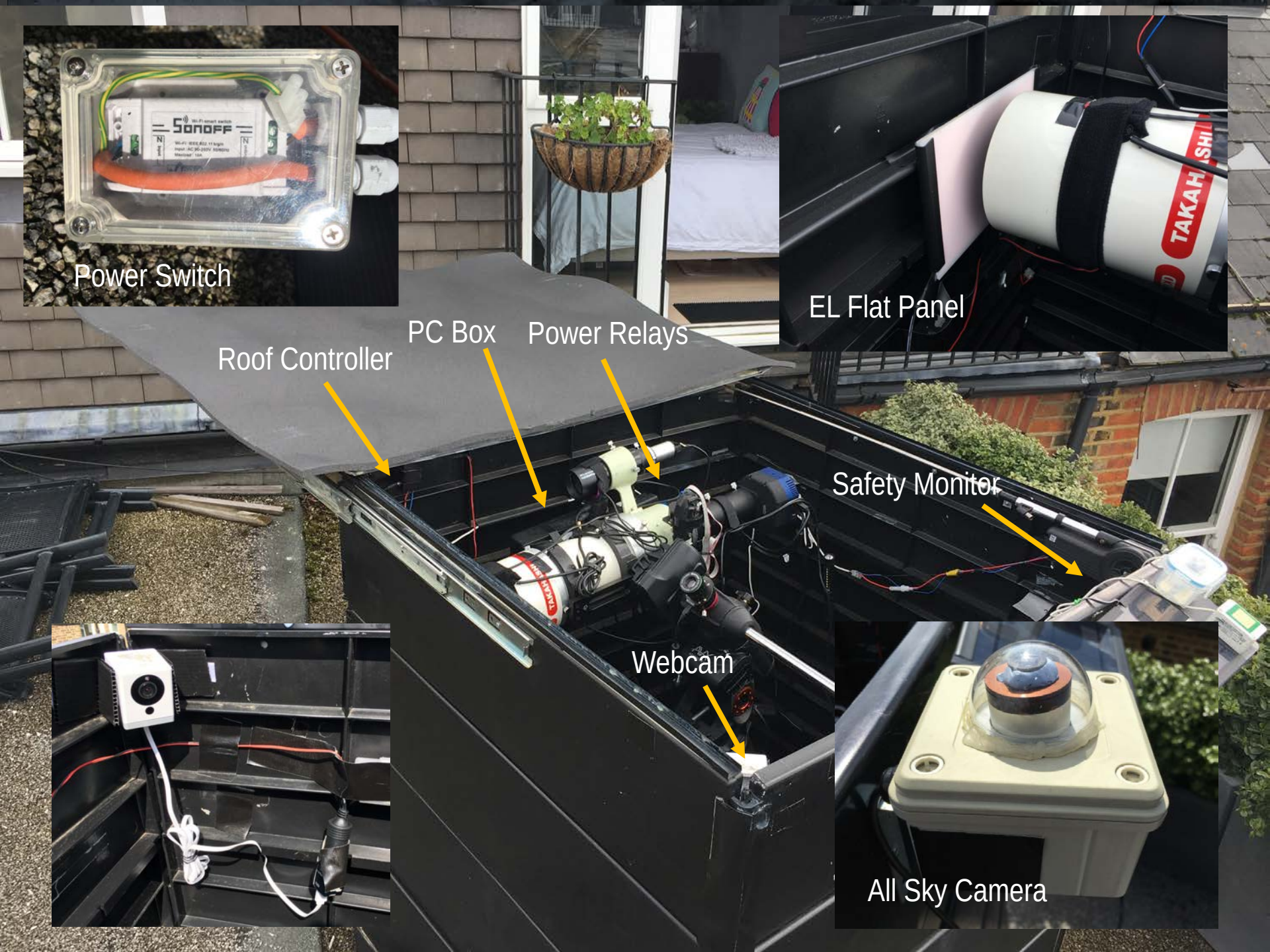
Power Relays



Power Switch



EL Flat Panel



PC Box

Power Relays

Roof Controller

Safety Monitor

Webcam



All Sky Camera

SAFETY MONITOR - SENSORS



BME280
Pressure, Temp
& Humidity



BH1750
Ambient Light
Intensity (Lux)



MLX90614
IR Thermometer
Sky Temperature
/Cloud detection



**Kemo Rain
Sensor**
Heated, 12V

SAFETY MONITOR



Transparent,
waterproof box

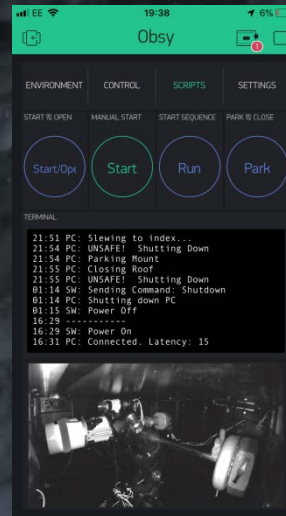
Lux, humidity,
pressure,
ambient temp,
sky temp (IR)

Heated rain
sensor



WEBCAM

- **Xiaomi Xiaofang 1s** (£20)
- 5V 1A, 1080P, colour
- Built in web server for control
- Modified firmware to allow **direct RTSP stream**
- Switch IR light on and off via URL
- **PC** access via VLC etc
- Display on **smartphone** with Blynk



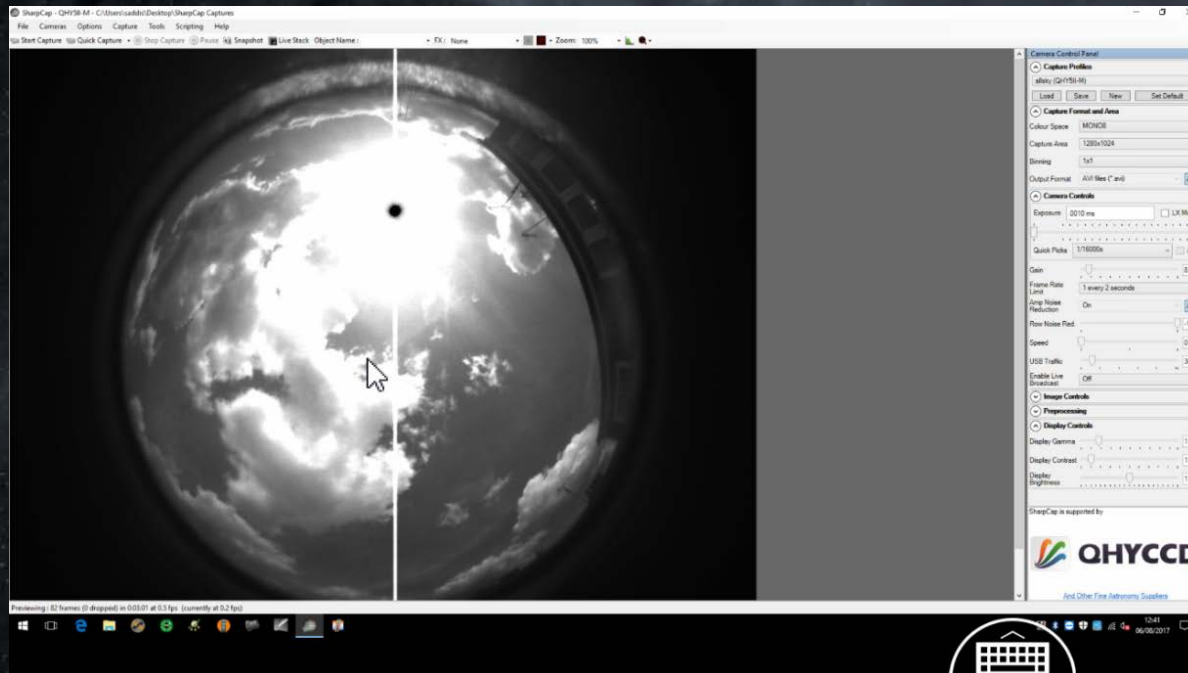
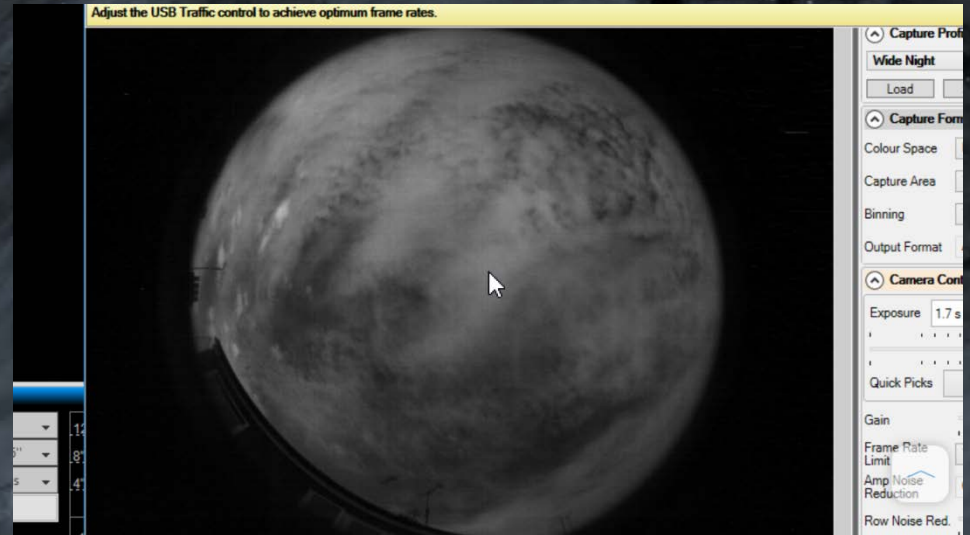
ALLSKY CAMERA

- QHY5-II Camera
- 2 inch CCTV Camera Dome (€6)
- Waterproof enclosure
- 1.8mm 170 degree Fixed Iris Lens (€5)
- C/CS Mount to M12 Adapter Ring (€10)



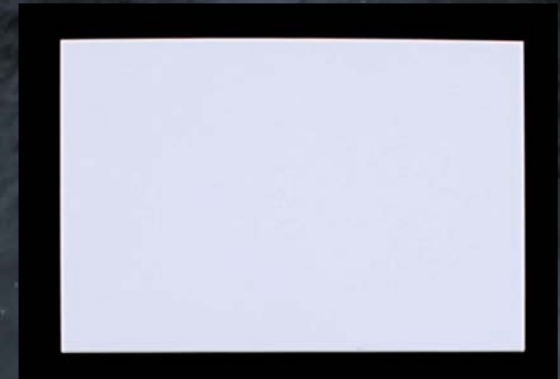
ALLSKY CAMERA

- SharpCap for live view



FLAT PANEL

- A5 Electro Luminescent (EL) Panel
 - Includes 12V power inverter
- Add white A5 acrylic sheet



SOFTWARE TOOLS



Visual
Studio



Standards for Astronomy



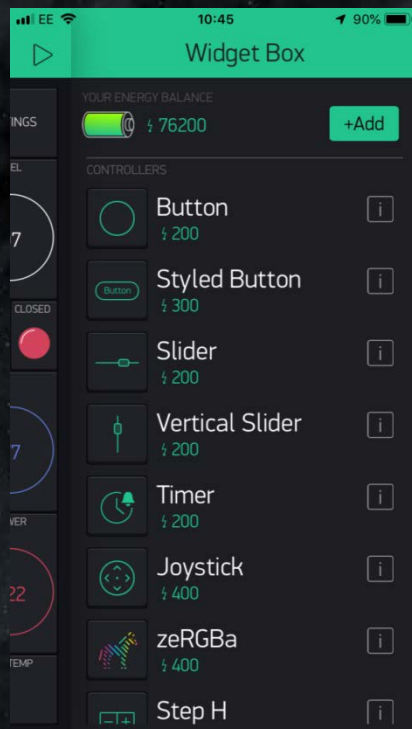
Blynk



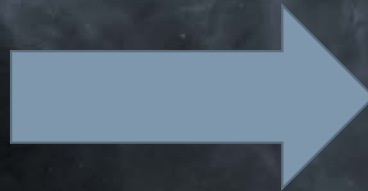
All code available at <https://github.com/simaddis>

BLYNK

- Easily build smartphone apps to control Arduino, Raspberry Pi etc.

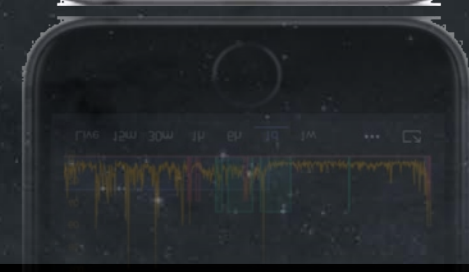


www.blynk.cc



BLYNK

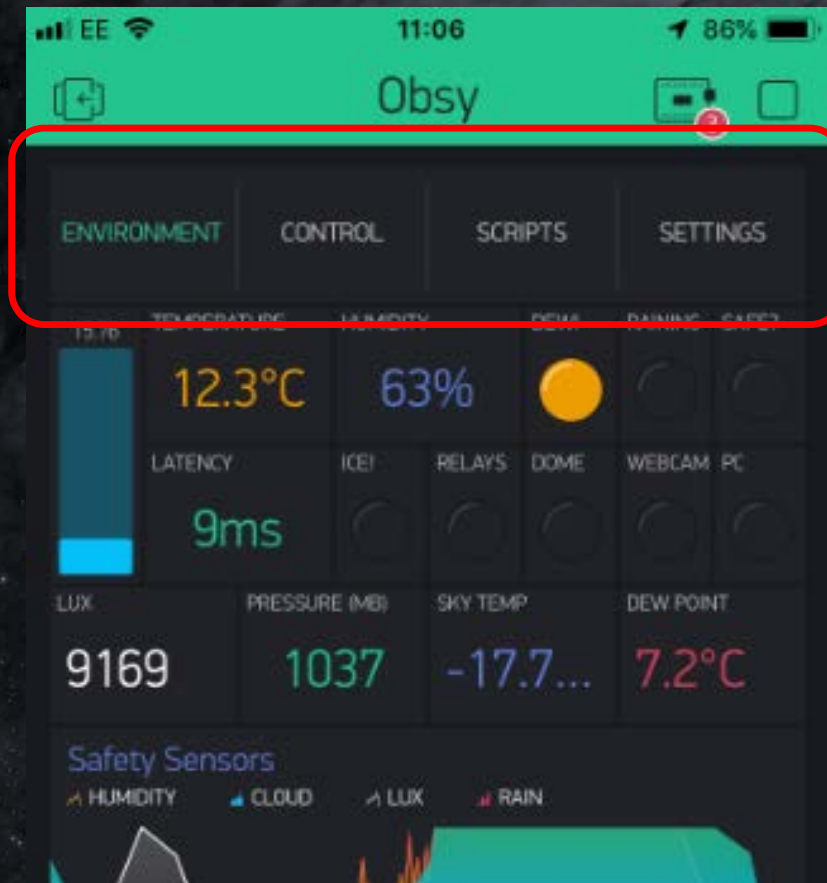
- Pay for Widgets (if Cloud Server)
- Simple client development
- Access via iPhone/Android device
- Can run on Windows also via emulator
 - E.g. **NoxPlayer**
(<https://www.bignox.com/>)
- Cloud or Local Server
 - Can run on **Raspberry Pi**



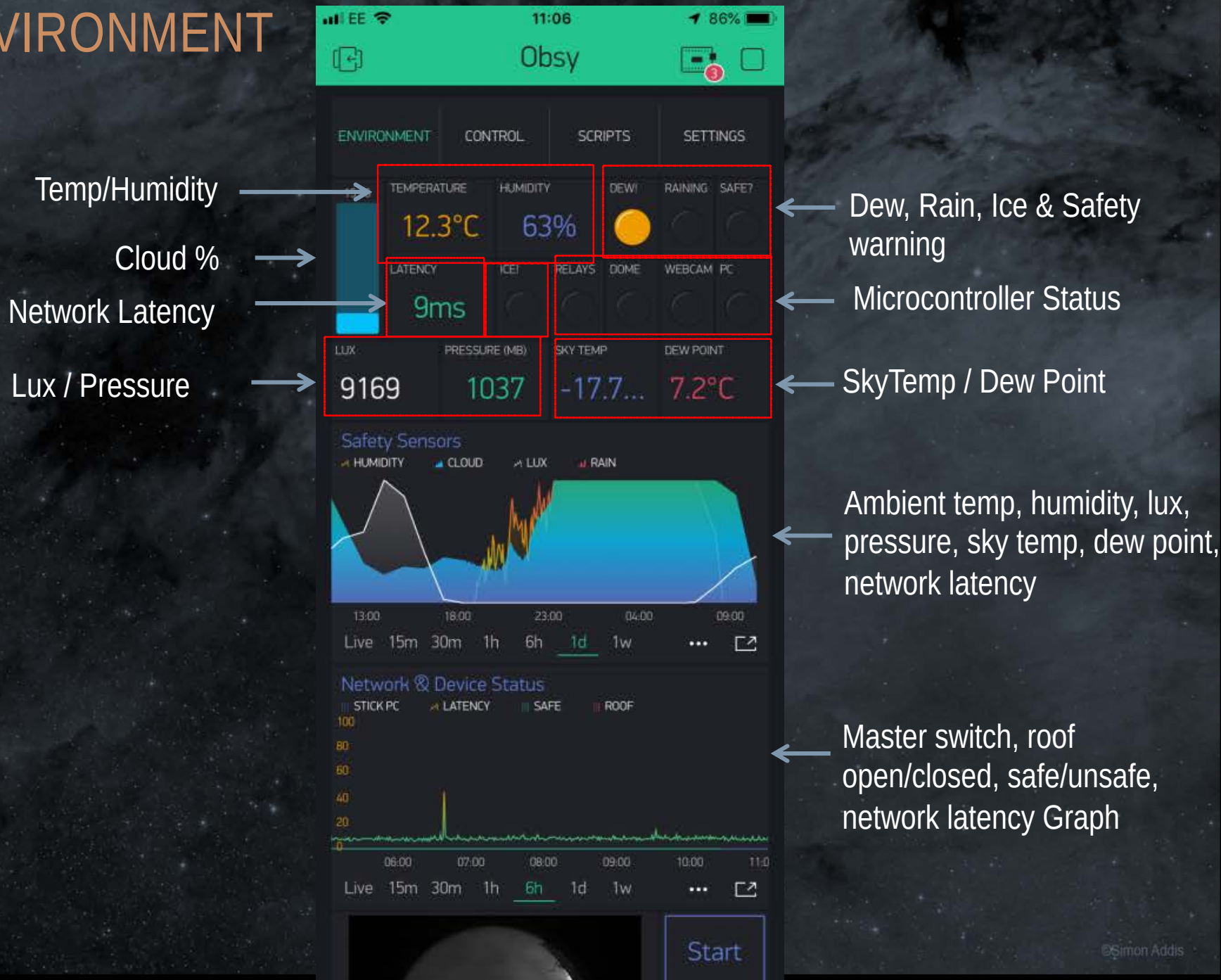


DEMO TIME...

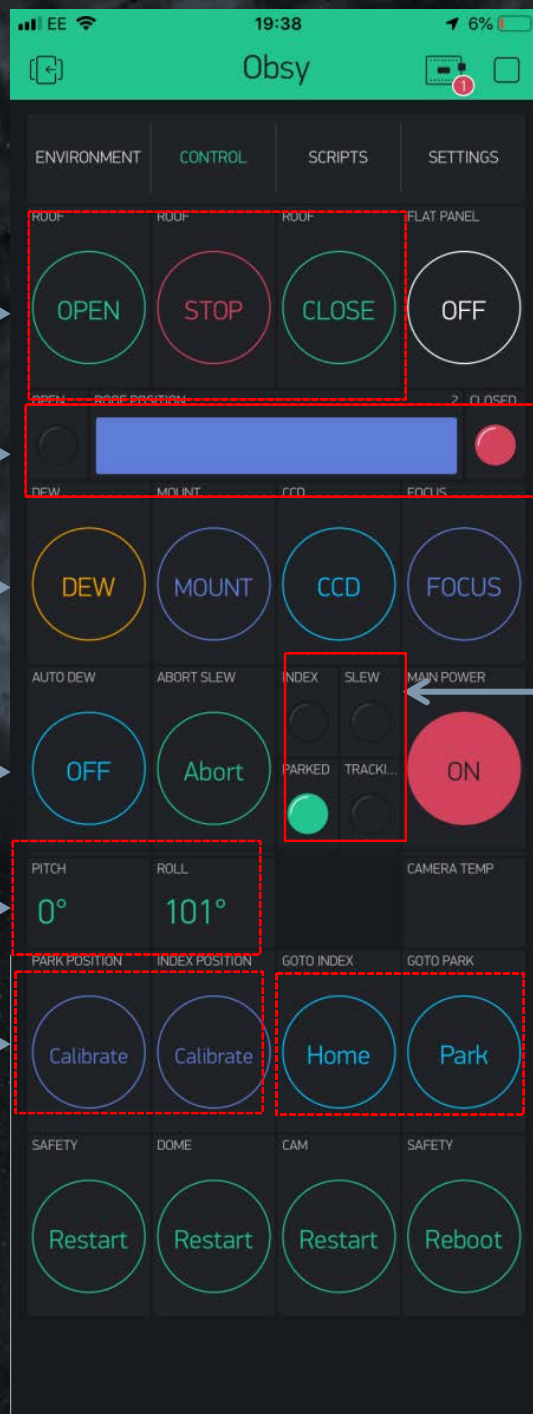
SMARTPHONE APP



ENVIRONMENT



CONTROL



Roof Controls

Roof Position

On/Off switches

Auto Dew Control

Pitch/Roll

Calibrate Home / Park

Flat Panel On/Off

Index / Slew / Parked /
Tracking Indicators

Master On/Off switch

Goto Home / Park

Reset Microcontrollers

SCRIPTS



← Startup Scripts

← Console

← Live Webcam Stream

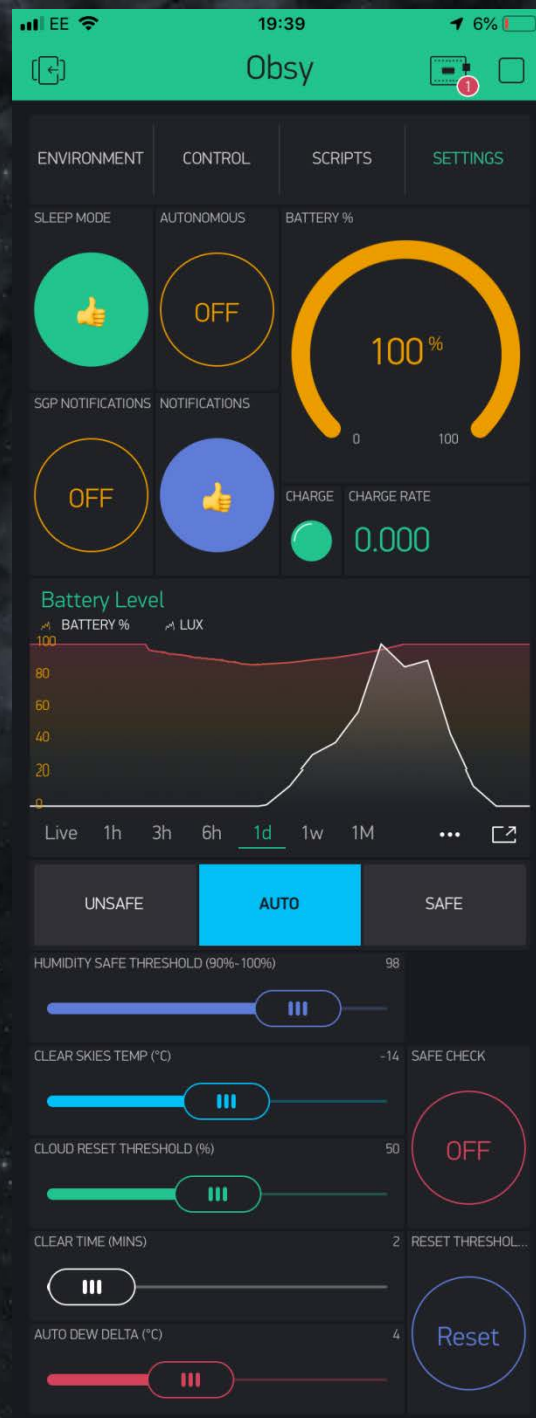
IR On/Off

← PC Controls

SETTINGS

Sleep mode
Autonomous
SGP Status Notifications
General Notifications

Threshold settings



Battery level

Charge rate

Lux, battery level graph

Safety mode

Safety On/Off

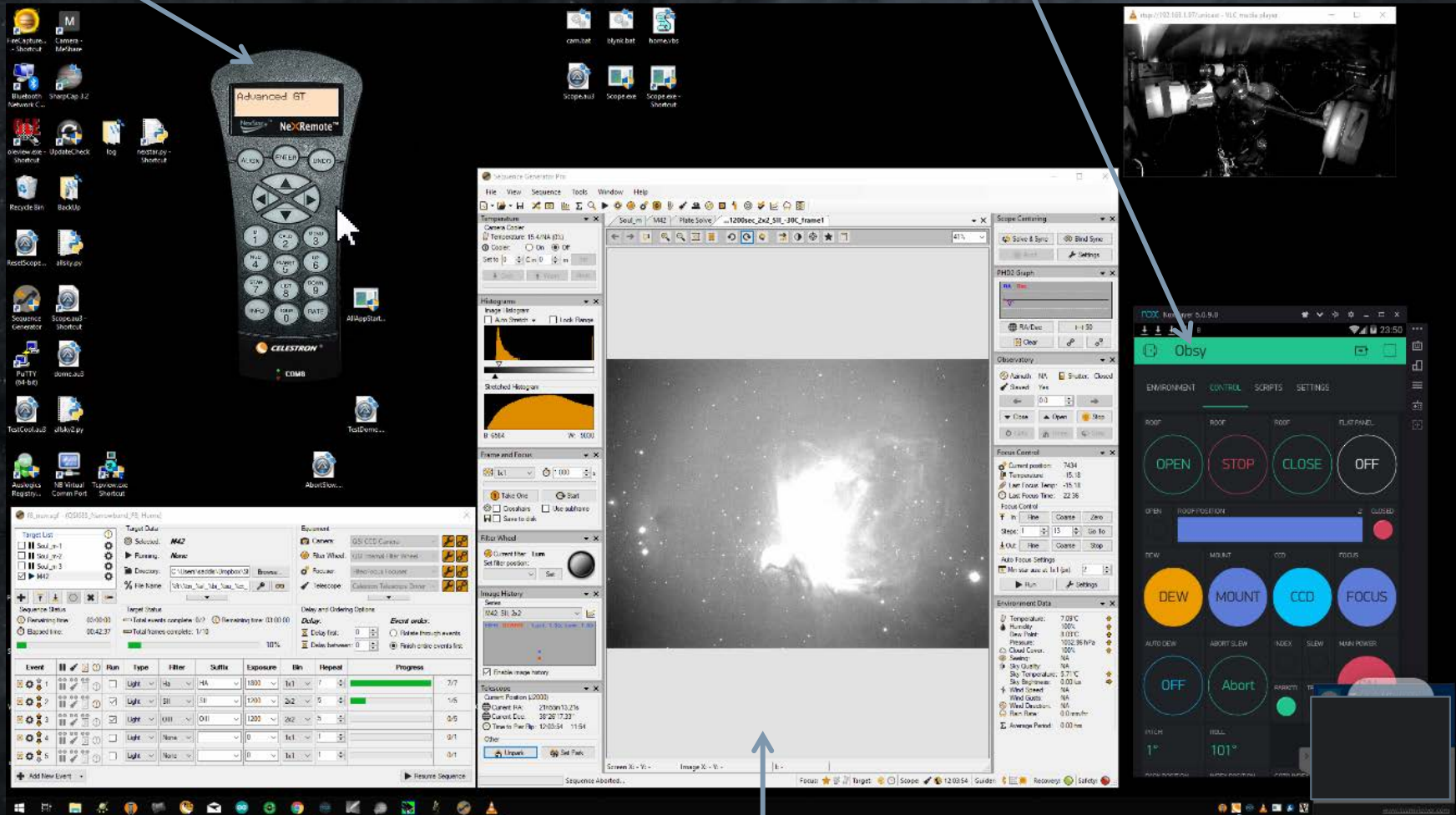
Reset thresholds

REMOTE DESKTOP VIEW

NoxPlayer

VLC

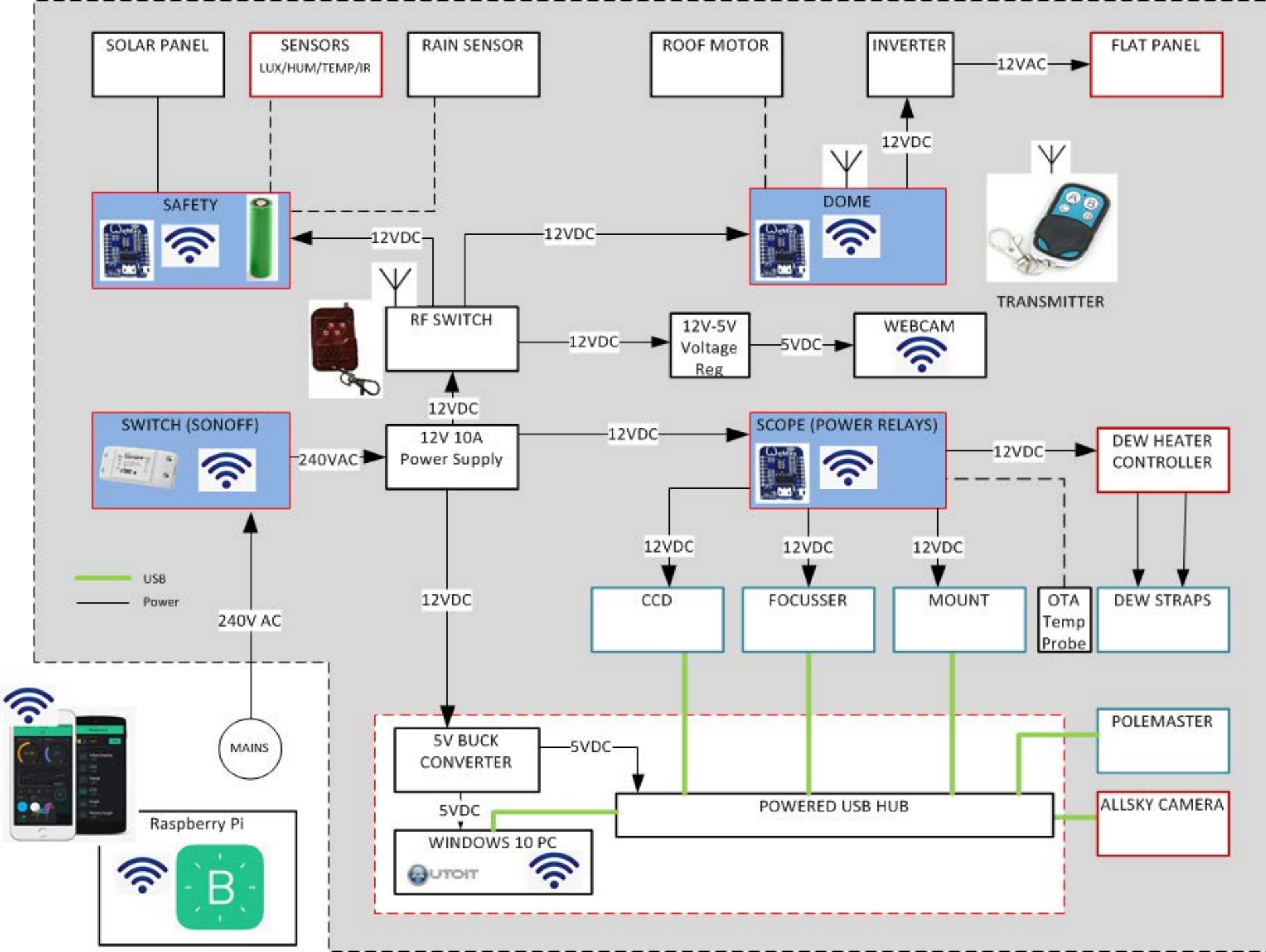
Nexremote



Images saved to Dropbox

SGP

PC Script (AutoIT)



CONCLUSION



REFERENCES

- Webcam Hack (Tomas C.)
 - <https://hackernoon.com/rtsp-hack-for-a-15-xiaomi-wifi-ip-camera-453690396691>
- ASCOM driver development video tutorials (Tom How)
 - <https://www.youtube.com/watch?v=XVlrDylBd5I>
- ESP8266 boards (Andreas Spiess, Youtube Channel)
 - https://www.youtube.com/channel/UCu7_D0o48KbfhpEohoP7YSQ
- Blynk (Youtube Channel)
 - https://www.youtube.com/channel/UCKWBP3MdpMQFdOCQ63mhC_Q
- Meteostation cloud detection formula
 - <https://indiduino.wordpress.com/2013/02/02/meteostation/>
- Accelerometer Calibration
 - <https://learn.adafruit.com/lsm303-accelerometer-slash-compass-breakout/calibration>



THE END

Thank you!

simon.addis@btinternet.com

<https://www.flickr.com/photos/22865357@N06/>

