Smart Irrigation
ECE Capstone

Austin Morlan, Dylan Johnson, Bryan Martin, Taylor Griffin

intel

Portland State
UNIVERSITY

Problem

- Water is precious
- Current irrigation methods are wasteful
- Need more efficiency without lowering crop yield
- Existing irrigation controllers require:
  - Frequent calibration
  - Array of costly sensors
  - Frequent sensor replacement

Problem

- There is a need for low cost, low maintenance controllers
- Should work in any location, terrain, and local climate
- Should contain few sensors for minimal cost

Solution

- Water-budgeting & irrigation scheduling
- Tracks amount of water entering and leaving soil
  - Evaporation of water from soil to environment
  - Transpiration of water from crops to environment
  + Precipitation of water from environment to soil
  + Added water from water source

Hargreaves Reduced-set Method

$$E_{to} = HC \cdot R_a \cdot (T_{max} - T_{min})^{HE} \cdot (\frac{T_{max} + T_{min}}{2} + HT)$$

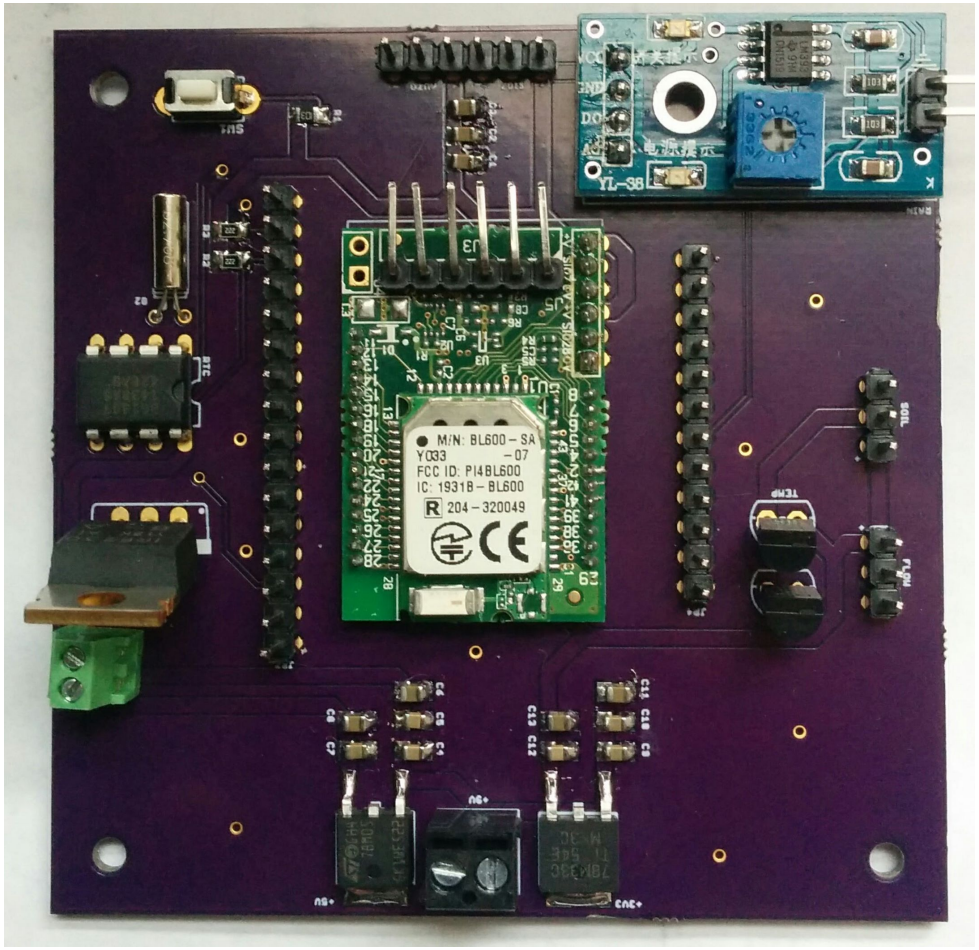
- Estimates evapotranspiration w/ ambient air temperature, latitude, and day of the year
- Requires two sensors: temperature and precipitation
- Latitude and calendar day supplied by app
- Calculates how much water has left soil
- Amount that has left is resupplied by water source

$$Irr = E_{to} - P$$

Irr - amount of water to be applied (mm)
E_{to} - crop evapotranspiration (mm)
P - precipitation (mm)

Device Technology

- MCU:
  - BL600 - nRF51822 (Cortex M0) with smartBASIC added
- Sensors:
  - Temperature, rain - for evapotranspiration algorithm
  - Soil moisture - to check calculations against reality
  - Flow - to measure amount of water distributed
- Enclosure
  - Waterproof
  - Snazzy

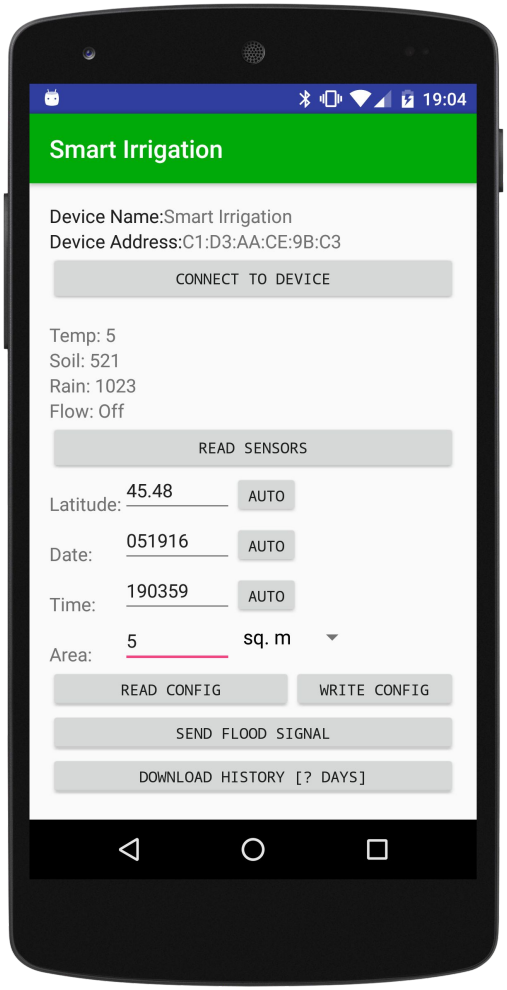

M/N: BL600-SA
FCC ID: PI4BL600
IC: 19318-BL600
204-320049
YL-38
TEMP

Functionality Overview

- Samples temperature and precipitation sensors hourly
- Track wet or dry precipitation readings throughout day
- E_{to} calculations performed once per day with daily high and low temperature values
- E_{to} multiplied by crop area to find volume of water leaving soil
- Solenoid activated to actuate water flow
  - Flow sensor calculates how much water has been distributed

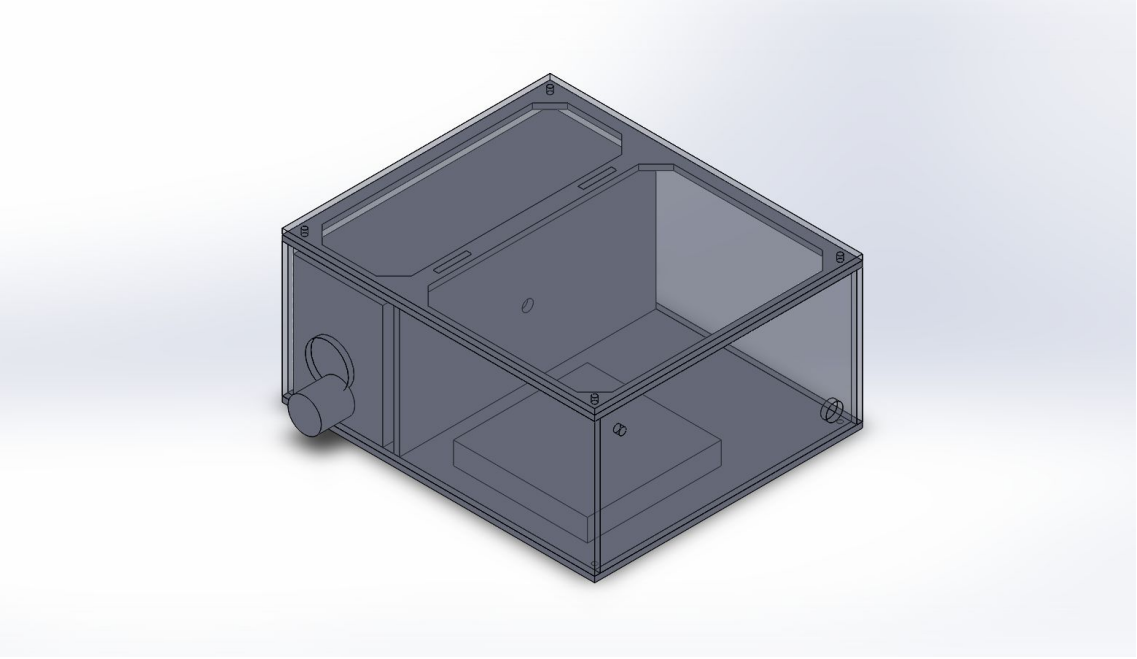
Android App

- Communicates with device via Bluetooth Low-Energy (BLE)
- Sends configuration info for irrigation policy (time, date, latitude)
- Downloads 32 days of irrigation statistics (max temp, min temp, etc)
- Receives and displays live sensor readings



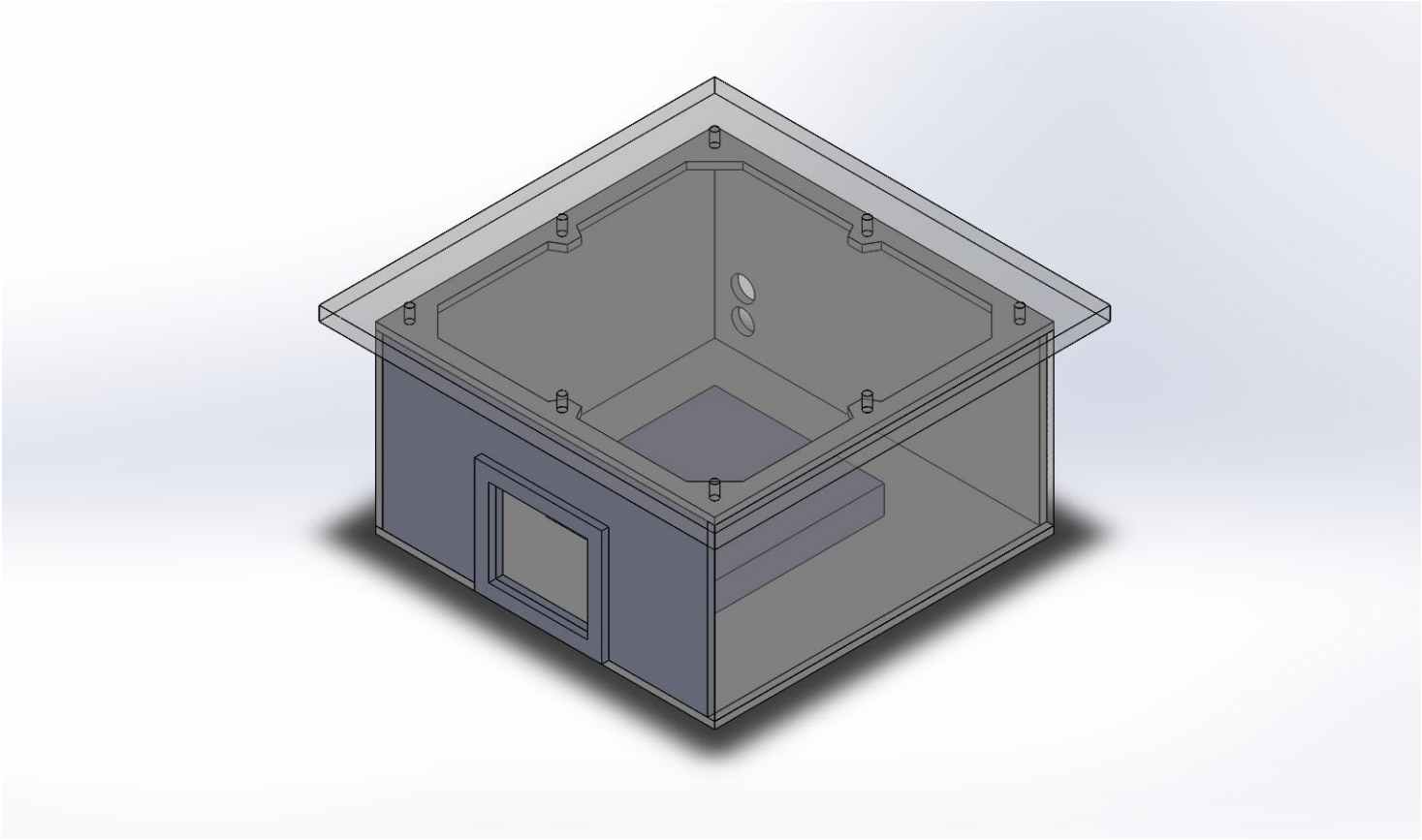
Case Design

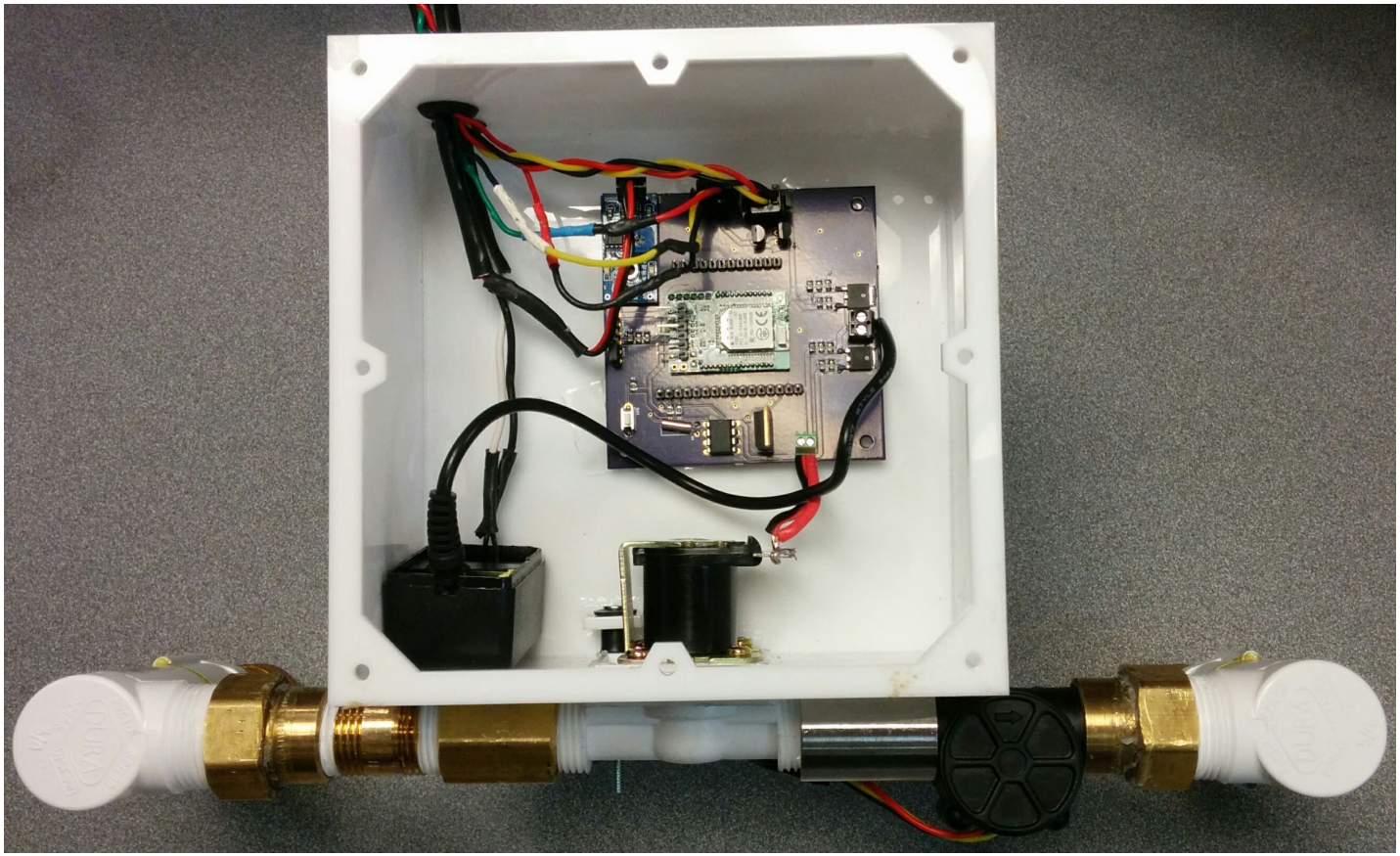
- Modeled in SolidWorks
- Laser cut in L.I.D.
- Ver. 1 built with ¼ inch clear cast acrylic
- Housed both the PCB and hose connections



Case Design

- Ver. 2 built with ¼ inch white cast acrylic
- Hose connections moved outside box





Results

- Field tested from May 4th-23rd
- Area to be irrigated was $3m^2$
- Total evapotranspiration calculated at 67.91mm
- Irrigated 46.3 gallons total
- Precipitation provided 10.6 gallons
- Together: 56.9 gallons of water supplied to vegetable bed

Date	Tmax (°C)	Tmin (°C)	Eto (mm)	Gallons
05/04/16	17	12	2.44	1.93
05/05/16	22	12	3.59	2.85
05/06/16	27	13	4.49	3.56
05/07/16	30	13	5.02	3.98
05/08/16	18	12	2.73	2.16
05/09/16	21	12	3.34	2.65
05/10/16	26	10	4.53	3.59
05/11/16	29	10	5.01	3.97
05/12/16	28	12	4.79	3.80
05/13/16	33	12	5.67	4.49
05/14/16	16	13	1.99	0
05/15/16	15	12	1.93	0
05/16/16	17	12	2.47	0
05/17/16	24	13	3.89	3.08
05/18/16	22	13	3.47	2.75
05/19/16	14	10	2.11	1.67
05/20/16	18	9	3.07	0
05/21/16	13	11	1.57	1.24
05/22/16	16	10	2.59	2.05
05/23/16	20	12	3.21	2.54

Historical/Rule of (Green) Thumb Comparison

- Historical
  - 10-year evapotranspiration for Forest Grove, OR: 84.4mm
- Rule of Thumb:
  - 1” of water per week
  - Additional 0.5” of water per week for avg temp above 70 ^{o}F
  - Using this: 63.4 gallons needed by either irrigation or rain

Conclusions

- An overall success!
- Water-budgeting and evapotranspiration estimates work
- Compares favorably to historical data & rule of thumb guidelines
- Future Improvements:
  - More testing data
  - Sites varying in location, soil quality, and crops grown
  - Possibly adjust constants in calculations
  - Different rain detection

References

1. FAO Irrigation and Drainage Paper 56
2. USGS, Oregon Water Science Center, HYDRA Rainfall Network
3. US Department of Interior, Bureau of Reclamation, Cooperative Agricultural Weather Network
4. Bonnie Plant Farm, “How Much Water Do Plants Need?”