

Autonomous Multiple Cycle Farming in Space



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MOTIVATION

- Space exploration expanding rapidly and the need to accommodate life beyond Earth.
- To grow food autonomously in space that can support humans reliably, without compromising valuable time, or energy, from other missions.

PROJECT GOAL

- To build an Autonomous Multiple Cycle Farming Chamber that seeds, grows, and notifies crew that crop is ready for harvest while in microgravity.
- Streamline the Growth Chamber configuration for multiple farming cycles by creating a web application user station.

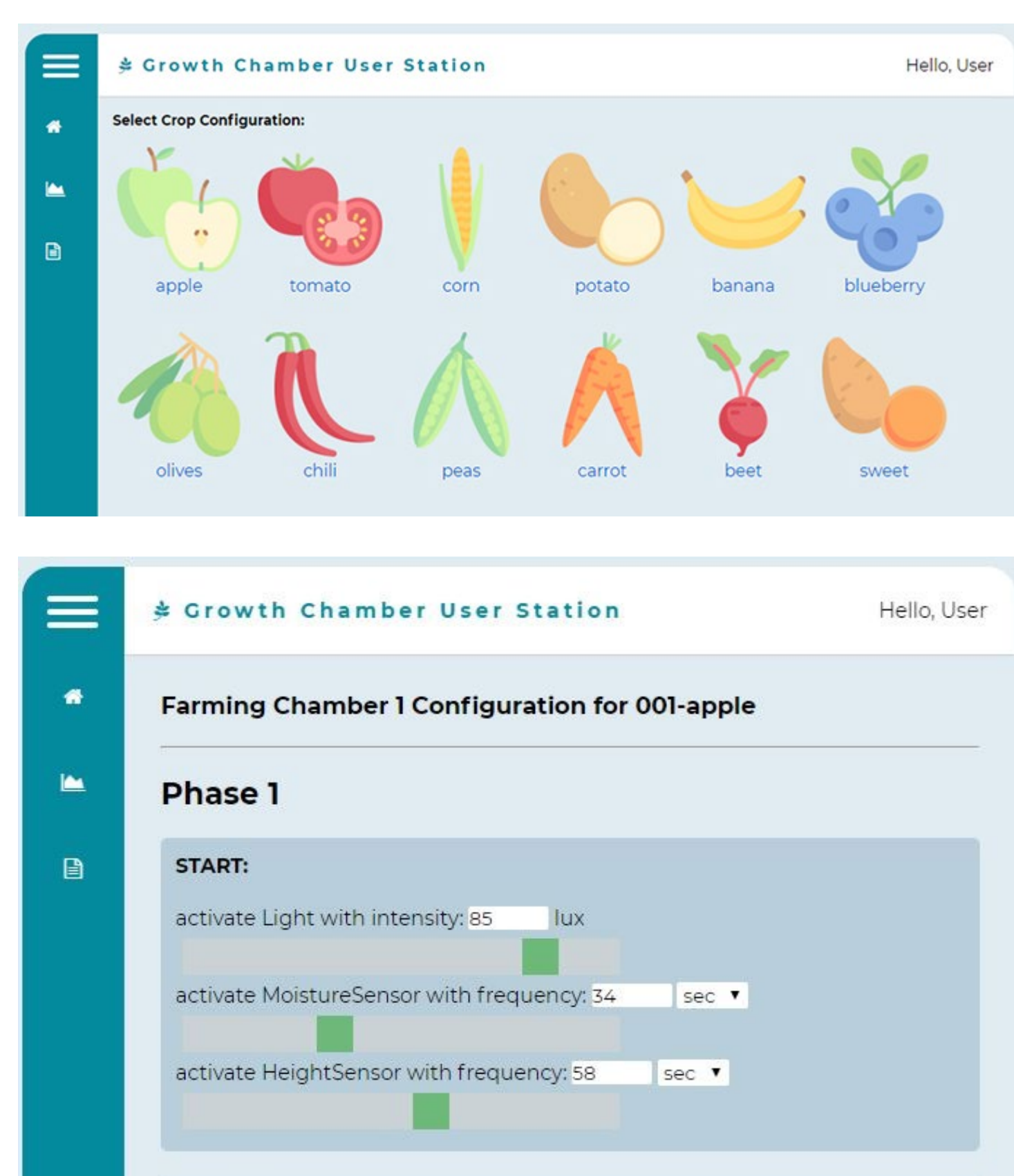
CONFIGURABLE AUTONOMOUS SCHEDULING

- Growth Chamber **runs autonomously** based on botanist and astronaut configuration files.
- Sensors and actuators can be uniquely scheduled to monitor or activate in a defined manner for any number of phases.

```
1 START:
2   - activate
3   - Light
4   - intensity: 5.3 lux
5
6   - activate
7   - MoistureSensor
8   - frequency: 5.2 sec
9
10  - activate
11  - HeightSensor
12  - frequency: 10 sec
13
14 MONITOR:
15 HeightSensor:
16 [0 cm, 1 cm]:
17   - set
18   - HeightSensor
19   - frequency: 10 sec
20
21 [2 cm, inf cm]:
22   - transition
23   - asap
```

USER STATION CONFIGURATION LIBRARY

- User Station allows many different crop configurations to be accessed and modified.
- Each may be saved and can be run on the growth chamber.



GROWTH CHAMBER DESIGN



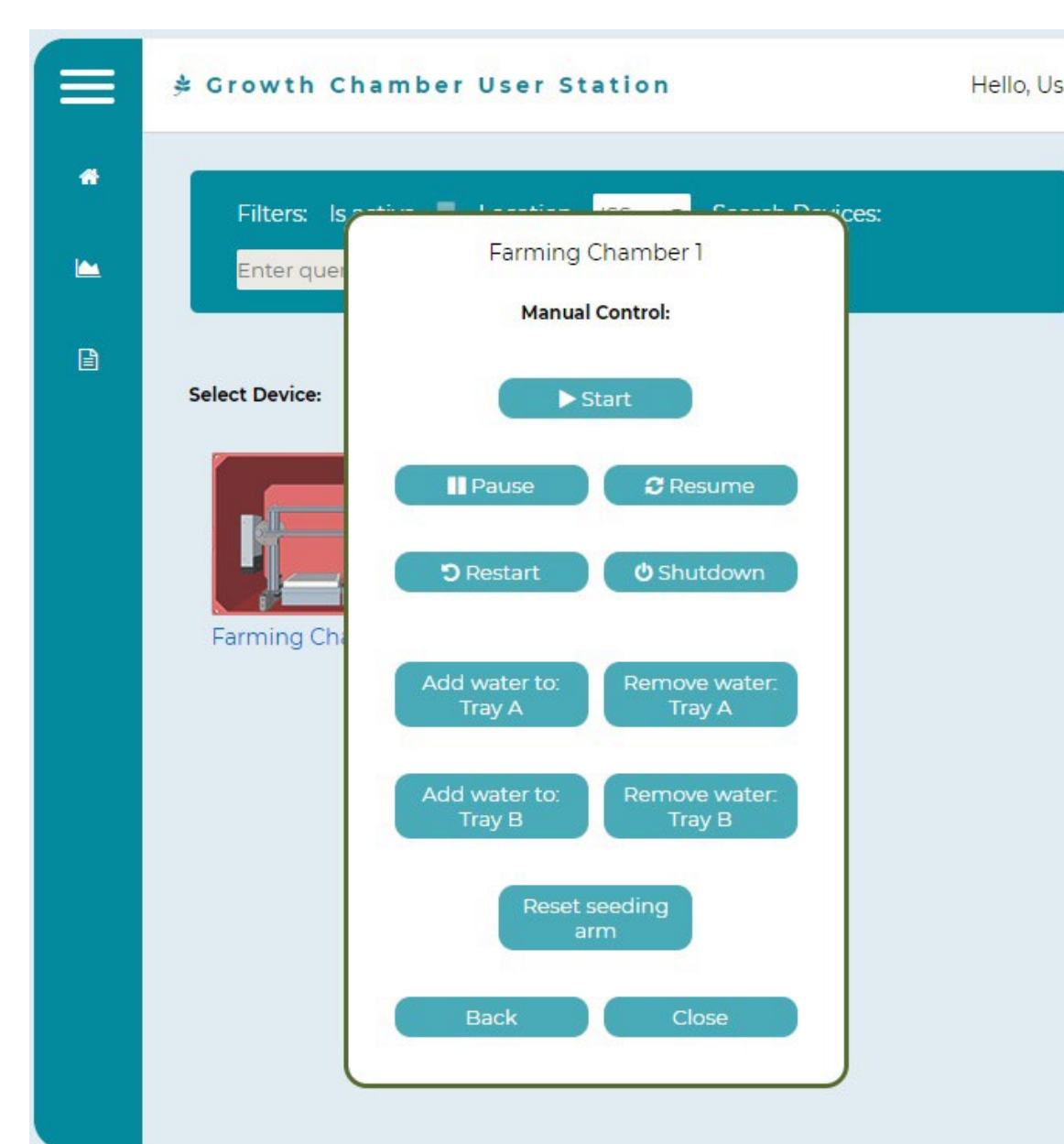
GROWTH CHAMBER FEATURES

- An aluminum tank, that controls the intake and outflow of water nutrient solution with a plunger. Solenoid valves control the direction of the water utilizing capillary action.
- The End Effector is capable of planting seeds in microgravity by forcing seeds out with filament driven by a stepper motor.



USER STATION CONTROL

- User Station allows any number of farming chambers to be selected for direct manual control or configuration.
- Users may also be alerted to important status updates, such as a signal to harvest.
- System administrators can load any number of farming chambers to the Farming User Station and control user access via Lightweight Directory Access Protocol.



TESTING & VALIDATION

- Multiple iterations of the tray were tested through growth cycles, in order to achieve the requirement of 70% harvest.
- Circuitry and software was also successfully tested over several weeks, proving the autonomous capabilities of the system.

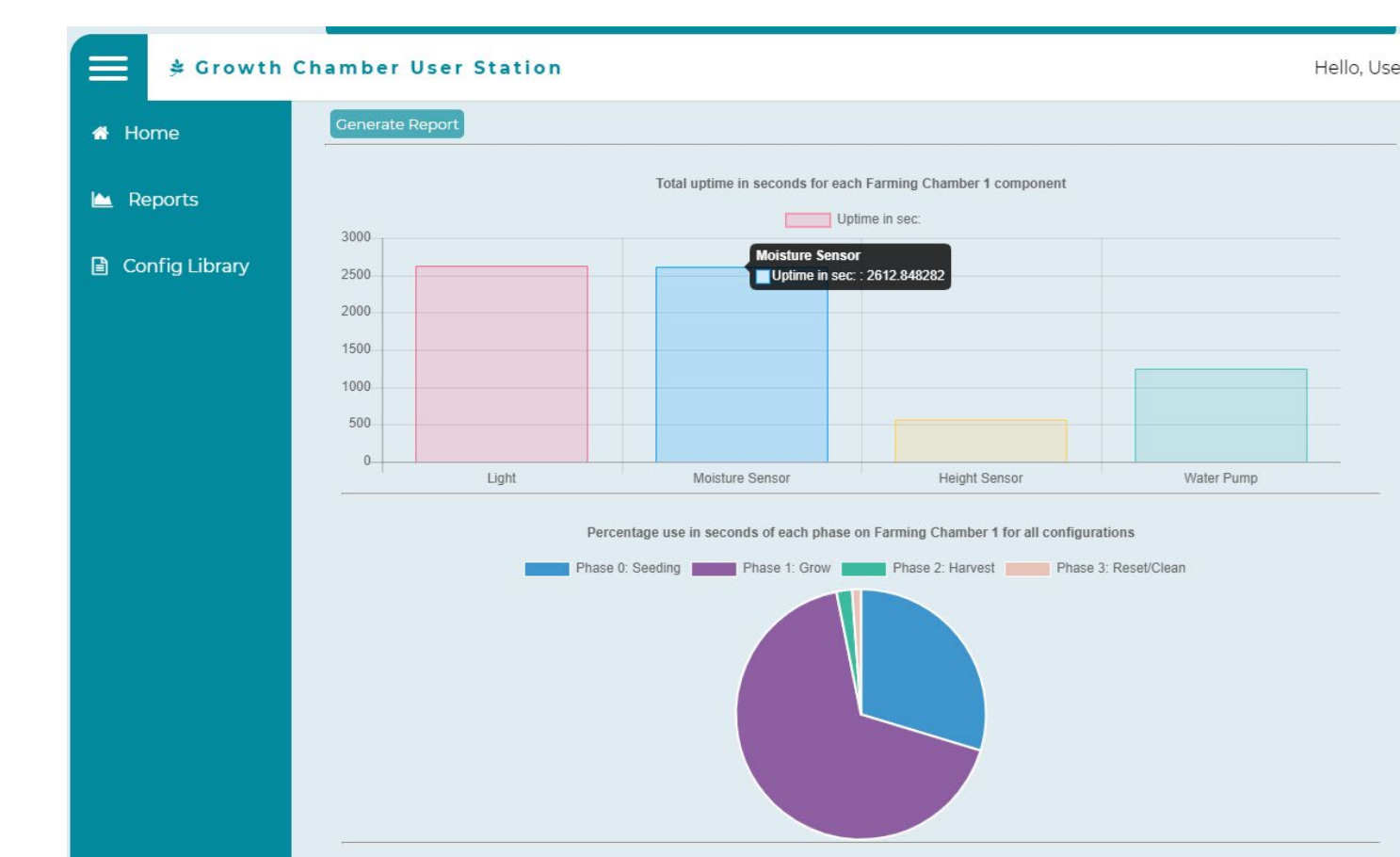


COST ANALYSIS

Planting System & End Effector	\$560.21
Water Delivery & Tray	\$329.16
Lighting & Electrical	\$83.95
Miscellaneous & Case	\$341.74
Total	\$1315.06

USER STATION REPORTS

- The User Station provides reports for each device with metrics such as component uptime and phase runtime.



CONFIGURATION VERSION CONTROL

- The history of each configuration is recorded with the appropriate metadata.
- The user may reload any previous version for modification.

File Name	Configuration Change Notes	Change Date/Time
001-apple.yml	New config	2020-04-26 22:28:35.483
001-apple.yml	Testing new phase value	2020-04-26 22:27:43.947
001-apple.yml	the reason why	2020-04-24 16:18:55.310
001-apple.yml	Testing light	2020-04-24 16:18:55.310
001-apple.yml	Testing light	2020-04-24 16:18:55.310
001-apple.yml	EL SL 7% changes to phase 0	2020-04-24 09:29:42.163
001-apple.yml	Reverting back to original	2020-04-24 09:29:42.163
001-apple.yml	Changed light to 7 lux and	2020-04-24 09:29:42.163
001-apple.yml	Moisture sensor frequency	2020-04-24 09:29:42.163
001-apple.yml	Increased light intensity and	2020-04-24 09:29:42.163
001-apple.yml	increased height sensor	2020-04-24 09:29:42.163
001-apple.yml	Threshold	2020-04-24 09:29:42.163
001-apple.yml	Testing lettuce config with new	2020-04-22 21:30:08.171
001-apple.yml	Letting seeds instead of apple	2020-04-22 21:30:08.171
001-apple.yml	updated light with intensity of 5	2020-04-22 21:30:08.171
001-apple.yml	and the plants were struggling	2020-04-22 21:30:08.171

