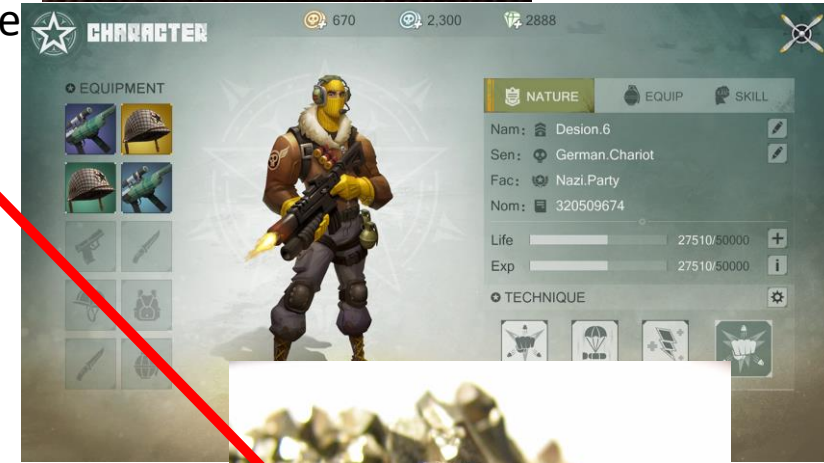


“One ring to rule them all.”

NanoLab Software GUI

Glenn Johnson with Gene Gordon

Develop a simple to use software package using Raspberri Pi or Arduino that will reside in each of the NanoLabs and control the different hardware for a 30 day mission with minimal command and control from the ground and no assistance from the astronauts. Data will be downloaded on a regular basis so researchers can track the progress of their experiments.



Ag NanoLab—control a NanoLab that will allow researchers to grow seeds and/or small plants for a 30 day mission without any assistance from the astronauts.

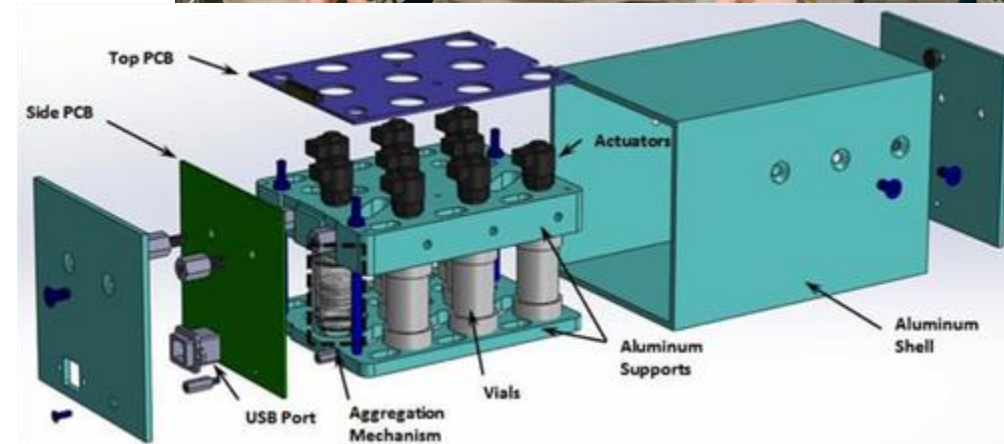
Fermentation NanoLab—control a NanoLab that will allow researchers to ferment either a liquid, fruit or blob of dough for a 30 day mission without any assistance from the astronauts.

Fungus NanoLab—control a NanoLab that will allow researchers to grow mycelium and/or mushrooms for a 30 day mission without any assistance from the astronauts.

Crystal Growth NanoLab—control a NanoLab that will allow researchers to grow crystals for a 30 day mission without any assistance from the astronauts.

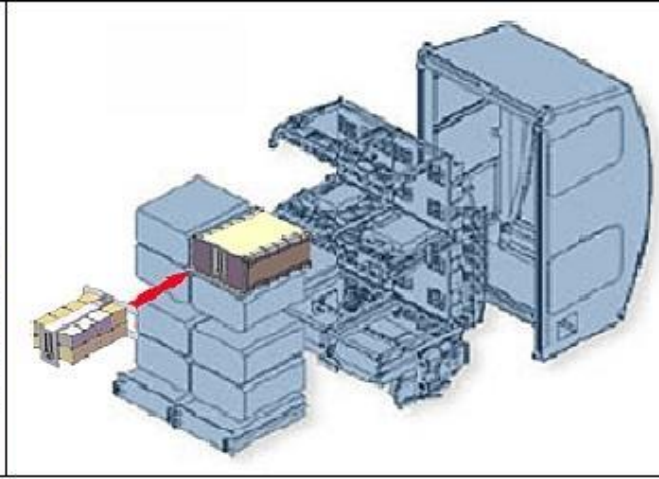
Nanolabs

- Nanolabs are small, autonomous, powered experiments that fit inside a specialized ISS Locker that are sent to the International Space Station for testing effects of microgravity on materials, processes, living organisms and many other experiments. These experiments are meant to be relatively cheap so many people and organizations can afford to develop an experiment for the space program. There are specific sizes and power requirements that the experiments have to meet. These are not new and many high schools, colleges and industries have participated in Nanolabs already.
- So far most of these Nanolabs have been specially designed for a very specific experiment. That will probably remain so for many future experiments. However, there are a lot of groups interested in doing an experiment in space but are daunted from doing it because they have to first develop the Nanolab platform for their experiment. This development can take a long time especially if you don't understand all the requirements related to zero-g and the ISS.
- NanoRacks would like to partner with HUNCH students to develop a more generic Nanolab that would allow for a variety of experiments so people could concentrate more on the experiment they want to do rather than on the development of the Nanolab cube for their experiment.

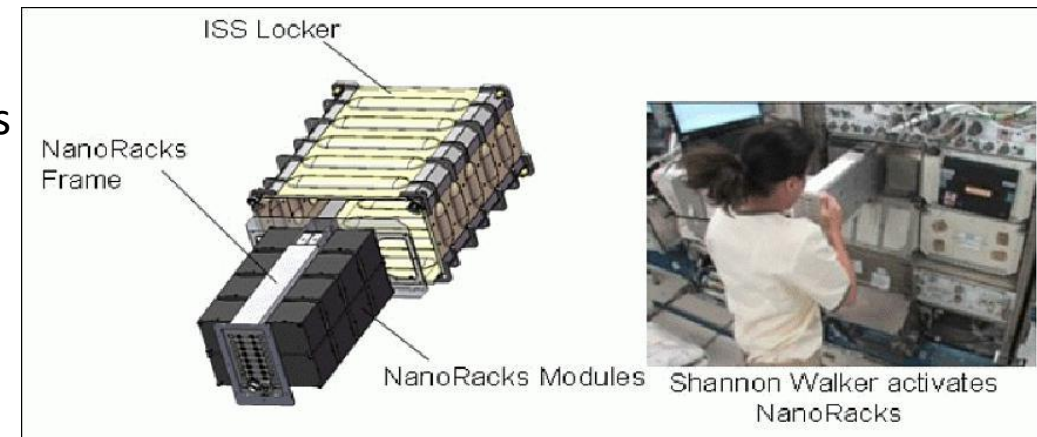


Important General information about all Nano Labs

- All Nano Labs (modules) will be installed into a NanoRacks frame —up to 16 Nano Labs to an ISS Locker. This ISS Locker will travel up to the ISS on a supply vehicle and will be removed from the supply vehicle by an astronaut and placed in one of the EXPRESS racks on the ISS where it will be turned on by the astronauts. All of the Nano Labs inside the Experiment box will run autonomously or have some command and control from the ground for about 30 days. After that time, the astronauts will remove the Experiment box with all of the NanoLabs inside and place the Experiment box into a vehicle where it will be returned safely to the ground or be burned up in the atmosphere. You should expect that your NanoLab will never be touched by the astronauts. All of the actions inside the Nano Lab will happen with out human hands. All of the data must come from the NanoLab and pass through Space Station computers without human hands.



- All Nano Labs have to be sealed to prevent any contents of one experiment from contaminating another experiment or the living space for the astronauts. This also means there is little if any air exchange between the Nano Lab and the astronauts atmosphere.
- All electronics give off heat when in use. Heat transfer does not happen as fast in zero-g since there is no convection without fans to move the air. Heat transfer by conduction (contact between objects) works well. All of the NanoRacks modules will be cooled by air being blown into the ISS Locker from the EXPRESS rack. The exterior of the Nano Lab is made of aluminum and is a good heat conductor but the more plastic against the interior walls of the Nano Lab the slower the heat will transfer.

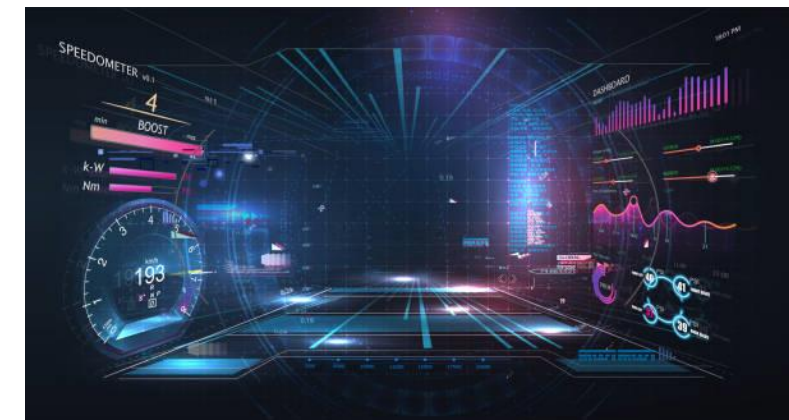
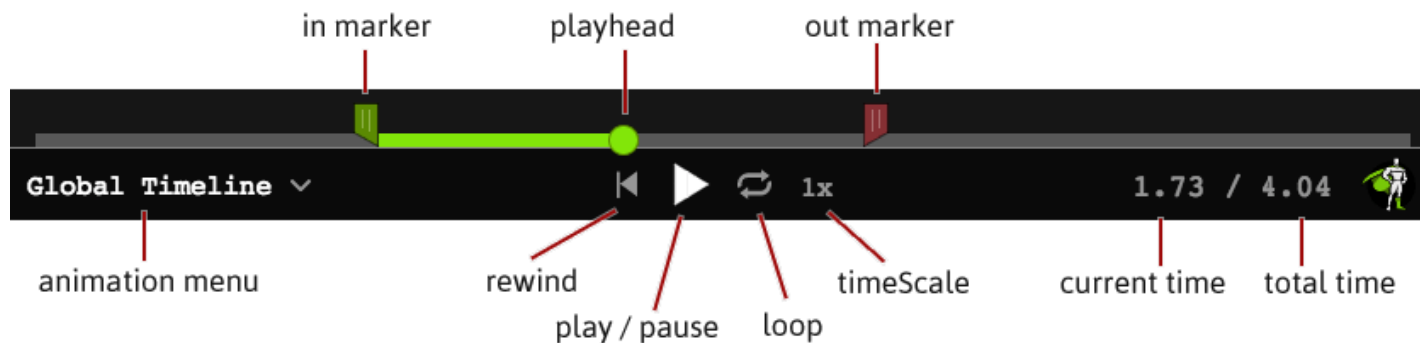


NanoLab software GUI

Problem:
Scientists and Researchers are wanting to send up experiments to the ISS but they don't have enough experience designing labs. HUNCH wants to make it easier for Researchers to do their science without having to do all of the engineering by making a generic lab that is easier for them to work with. There are 4 generic labs HUNCH is aiming for—Agriculture, Fungus growth, Fermentation and Crystal Growth. Last year we had students developing a Generic Ag Lab with good results and great ideas. We would like to expand the kinds of labs that could be made generic to include more researchers needs. We would also like to make the interface to all of them very similar so that there is a consistent style of controlling the instrumentation (potentially different sensors, cameras and equipment) that would be in each of the generic labs.

Objective:
Develop software for the Raspberry Pi or Arduino that would control a large number of Sparkfun hardware and make it easy enough that a 5th grader would be able to be able to do the setup but a college professor would be able to get the data they are looking for.

- Requirements:**
- Uses a Raspberry Pi or Arduino
 - Interfaces easily with several Sparkfun sensors, motors, cameras.
 - choose your coding language but likely to be python
 - screens or windows that help select down to specific equipment to the desired lab.
 - Consistent style throughout software between each lab.
 - Interfaces with NanoRacks downlink for data retrieval
 - Operate without internet connectivity
 - Able to operate for a minimum of 30 days with minimal interaction with the ground
 - Arrangement that will allow a compact volume for the boards, cables, connections without retaining too much heat. Contact with aluminum NanoLab shell?



The Project

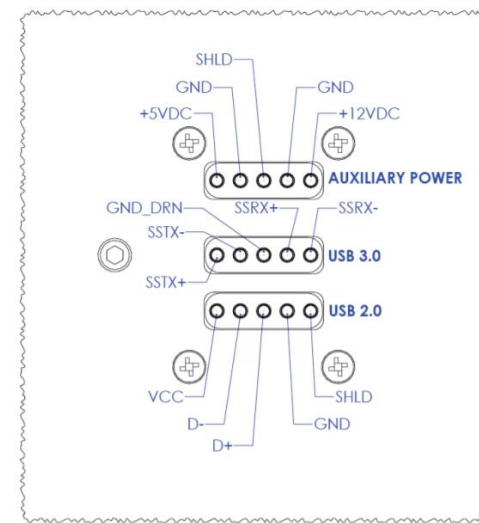
- Most researchers spend most of their time and effort concentrating on developing the questions they need to answer and how to get the data for their experiment. They would like to spend less time developing the software and hardware to control the experiment. HUNCH wants to make it easier for Researchers to do their science without having to do all of the engineering by making a group of generic labs that are easier for them to work with.
- HUNCH is looking for an easy-to-use Graphic User Interface (GUI) that will make it easy for experimenters to
 - Choose the experiment box they are outfitting
 - Plug in and set up the desired sensors and hardware
 - Choose settings and times for that hardware to be on/off
 - Collect photos and data
 - Export data so scientists can get the information they need
- Depending on the experiment and available volume in the box, only some of the sensors and hardware will be used for an experiment—expect that each experimenter will want to use a different set of sensors and hardware.
- Although the software will be set up on the ground where there is internet access, once the lab is prepared for launch, there will be no internet available. The software you write should be able to run independently for the whole 30 day mission however, it may be possible to send and receive some commanding through NanoRack ground control. Although some researchers may come home after the experiment, it is possible that some experiments will be burned up after the 30 day mission. This means that the photo and data retrieval from orbit is especially important.
 - What is the maximum number of sensors and hardware that can be plugged in at one time?
 - What kind of pull down menus or selectors make it easy to choose the on/off times and the ranges?
 - What kind of buttons make it easy to choose the hardware that will be plugged in?
 - Are there sounds that can help the user during set up of software and hardware?
 - Make it easy to choose when the camera and lights are on for different types of pictures. (some pictures may be taken with different colors on or off)
 - Assume that there will only be one data dump in 24 hours.
 - How is the data packaged and transmitted so it is easy for the user to see the photos and the data collected over a 24 hour period.—spread sheet form?
 - Assume the first versions will be in English—we may expand the languages later to include researchers in other countries.



Nanolab requirements

Your team will need to be aware of the requirements of the NanoLab, Nanode (the locker that the NanoLab will sit in) as well as the requirements for the International Space Station. This sounds like a lot but all of the information is available on the NanoRacks web site. The aluminum box that all of your electronics, lights, camera, support structure... will be provided by Nano Racks (once the design has been finalized) allowing you to concentrate on fitting your materials into the box. This means you don't have to worry about how the box fits into the experiment holding rack.

- Most of this is pretty obvious: Your NanoLab can not be flammable, or off gas stinky or poisonous fumes, we don't want it to electrically short out anything or make a rattling or squeaky sound that bothers the astronauts.
- Use the links below to download and print out the Nanode Interface Document, Standard Materials and Processes, Flammability and Offgassing and Acoustic Noise Control and Analysis.
 - <https://nanoracks.com/>
 - <https://nanoracks.com/products/nanolab/>
 - <https://nanoracks.com/wp-content/uploads/Nanoracks-Nanode-IDD.pdf>
 - This is a video that shows you some of the make up of the ARISE Nanolab.
 - <https://www.youtube.com/watch?v=M72qjfMBaU>
 - Example of an agriculture experiment that went to space.
 - <https://nanoracks.com/the-chicks-are-going-to-the-iss/>



TOP VIEW - NANODE CONNECTOR PIN-OUT
Figure 3.2-1: Pin Layout of the 3 Nanode Connectors

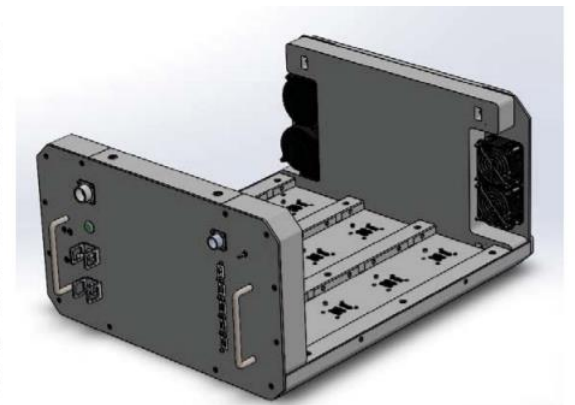


Figure 3-1: Nanoracks Nanode (Mainframe) Assembly

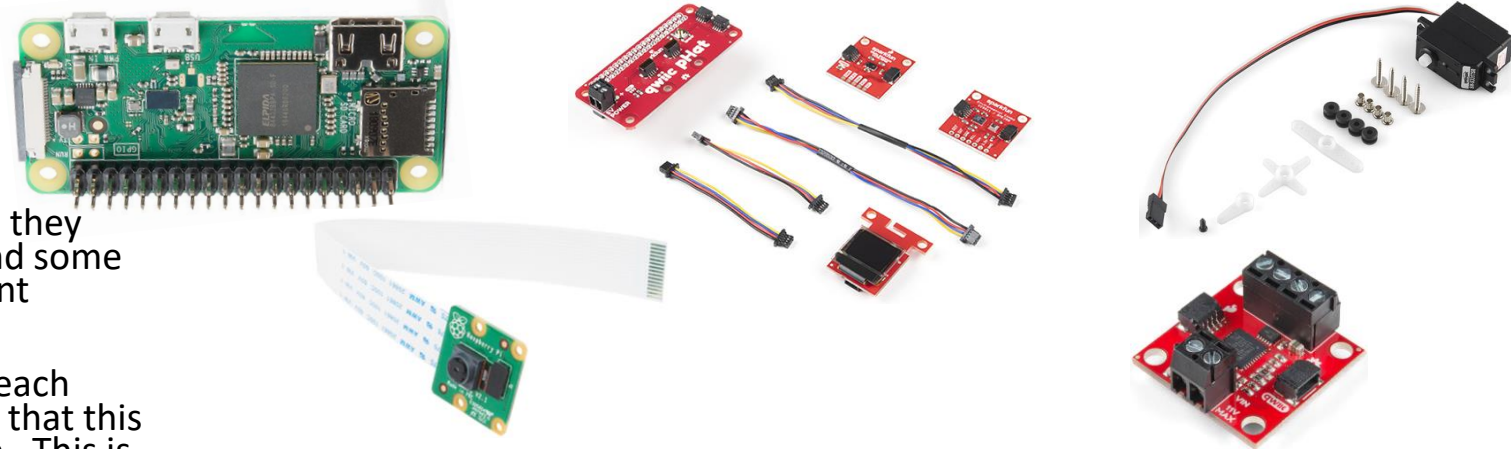


Figure 3-2: Nanoracks Nanode (Mainframe) Assembly Installed in ISS Locker

3.4.3.3 Experiment Operations page 14

- During experiment operations, the Payload Provider will be able to update their experiment via file uplink and downlink experiment data on a semi-frequent basis. The Nanoracks Operations team will be responsible for performing the necessary commanding, file uplinks, and data downlinks as required by the Payload Provider. The standard service for commanding to the payload and uplink/downlink of data is as follows:
 - 30 days of on-orbit payload operations support – NTE 1 hour every business day
 - File downlink limited to 2 GB per day
 - Total file downlink per week limited to 10 GB
- The exact timing and frequency of payload operations support will have to be coordinated with the Nanoracks Operations team and documented in the ICA. If the payload requires more interactions on-orbit or larger size file downlinks, it will have to be negotiated and agreed to with the Nanoracks Operations team and documented in the ICA. The following operational specifications must be defined in the ICA for assessment with Nanoracks to be assured the requirements can be met by the current Nanode performance and ISS environment:
 - Frequency and lead-time for updates and data downlink;
 - Data format and size;
 - Whether the payload or some parts of the payload need to be returned to the ground;
 - Thermal constraints pre/post operations (refer to previous sub-section on Thermal Constraints which provides information for on-orbit as well as for transport).
 - Thermal or humidity constraints/limits for the science while operating.
- 3.4.3.3.1 Ground to Payload Communication page 15
- Communications to/from Nanode is accomplished through NASA managed Ku-band Internet Protocol (Ku-IP) at the Nanoracks BRIDGE in Houston. Ku-IP provides the Nanoracks Operations team with a Linux Virtual Network Computing graphical interface to Nanode and any connected modules. File transfer rates are dependent on many different factors. Payload required file sizes and downlink frequency will be documented in the ICA. All communications with the Nanolab while on orbit are conducted by Nanoracks Operations team only.

Sparkfun Connection



- HUNCH recommends using SparkFun components because they have a wide range of easy to use electronic components and some of them have already flown to space on a variety of different experiments.
- HUNCH will supply one kit with the following hardware to each school participating in the GUI Project. I am not suggesting that this list is the correct or only set of components you should use. This is a set of parts that will give you a good start on finding what you need. Please think deeper. If you already have electronic components you want to use, that is ok also.
- This is a representative set of hardware to give you a good idea of what to program for. As we get closer to a final product some of these parts may change but these should put you on a good path.
- To help you develop your electronics packages, SparkFun suggests using their Qwiic System that uses small cables and connectors to help avoid soldering and loose connections.

https://www.sparkfun.com/qwiic?_ga=2.245661252.1112341652.1631552334-35476676.1624479033&_gac=1.193005279.1631552334.CjwKCAjw7fuJBhBdEiwA2ILMYWnnhB_f_XKUHzoZbmDLC9TDCPON_A_T9HM8uRWSsHu6a6_hreX0jxoC2HYQAvD_BwE

- They also have Python code that is already written that will help your team move forward with your ideas. This means you should not have to wait until you have the kit to get started.

<https://www.sparkfun.com/news/3947>

- We are not looking for the NanoLab with the most expensive parts. **We are looking for the most versatile NanoLabs that the most researchers could use and afford so more people can do an experiment on the International Space Station.**

| SparkFun Part Number | description | Qty | Notes |
|----------------------|--|-----|---------------------------------------|
| PRT-08430 | Jumper Wires Premium 6" F/F Pack of 10 | 1 | 155mm +/-5mm long, 26 AWG |
| TOL-13831 | 5.1V DC 2.5A Wall Wart (USB Micro-B) | 1 | AC to DC power supply |
| DEV-14028 | Raspberry Pi Camera Module V2 | 1 | 25mm x 23mm x 9mmc, 15cm ribbon cable |
| PRT-14272 | Pi Zero Camera Cable | 1 | |
| CAB-14274 | MiniHDMI | 1 | |
| CAB-14276 | USB OTG MicroB Cable | 1 | |
| PKG-14011 | Large Red Box (9.25x6x2) | 1 | box it comes in |
| COM-15052 | SparkFun Noobs card Raspberry Pi | 1 | |
| DEV-15470 | Raspberry Pi Zero WH | 1 | 65mm long x 30mm x20mm |
| ROB-15451 | SparkFun Qwiic Motor Driver | 1 | 25.4mm x 25.4mm x 12.5mm |
| PRT-16662 | Jumper Wires Premium 6in. M/M Pack of 2: Red and Black | 1 | |
| WS2812B | SparkFun RGB LED Breakout - WS2812B w/ Headers | 1 | 24 mm x 22mm x 5mm |
| KIT-16841 | SparkFun Qwiic Starter Kit for Raspberry Pi | 1 | 65.00mm x 30.5mm x 10mm |
| ROB-10189 | Servo - Generic Continuous Rotation (Micro Size) | 1 | 42.8mm x 33mm x 16.5mm |

Expected hardware for different Labs

Agriculture Lab

Temperature sensor
Humidity sensor
O2 sensor
CO2 sensor
Lights
Camera(s)
Motor(water distribution)



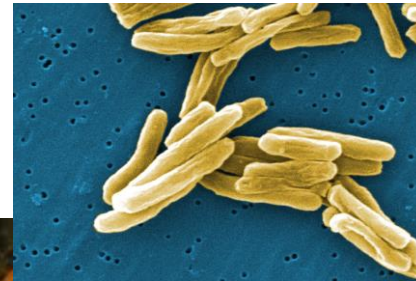
Fungus Lab

Temperature sensor
Humidity sensor
O2 sensor
CO2 sensor
Infrared Lights?
Infrared Camera(s)?
Motor(water distribution)
Motor (cut cap off mushrooms)



Fermentation Lab

Temperature sensor
Humidity sensor
O2 sensor
CO2 sensor
Lights
Camera(s)
Motor(water distribution)
Motor (agitation)



Crystallization Lab

Temperature (internal temp)
Thermocouple (experiment temp)
Humidity
O2
CO2
Lights
Camera(s)
Motor (2)
pH sensor (2)
Infrared camera
H2 sensor
Voltage
Resistance
Amperage
USB heater



Keep it simple

If a 5th grade teacher gets a grant for her class to grow a sunflower seed on the ISS, I want her class to be able to pick up an Ag Nano Lab with your hardware and software and be able to have her students set it up. They will probably buy two—one for flight and one to run on the ground while the other is in space so they can do a comparison.

Here are examples of what might be appropriate for pull down menus and text boxes (you are welcome to make it better):

- Choose the experiment box are you using?(Icon)
- pull down menu of the hardware that they may want to plug in
- instructions of where on the board it needs to be plugged in (photos of board with arrows)
- prompts asking when it needs to be turned on/off, how many times per day/hour/min/sec. (select times from a dial)
- Select camera—(camera types from pull down) (Picture format options)
 - Make sure lights are on when camera is taking pictures (what color of lights for picture?—color option selection)
- Lighting for plant growth—color selection—time on/off
- Select another sensor and repeat.
- Data download format options?
- When the experiment is over, is there a shut down procedure so it is safe? If the scientist is paying to have it come home is there a different safe mode for shut down?
- Think of what makes your phone and a good web pages easy to use. There are clearly labeled icons that help you figure out what you need. There are pull down menus that make it easy to find information and set up your app or fields that pop up to lead you into filling in the correct information.
- This needs to be simple enough that a 5th grader can set up the lab but it needs to be versatile enough that a college professor can get the data that they are looking for.
- Can you display the actions the researcher has chosen in a timeline or other graphic so it is easy to see what will happen in what order in the program?
- Can there be a reset button for all the data to be wiped so they can make small changes in their set up and send the same box up a second time?
- This is about making it easy to use **not necessarily futuristic.**

