



PROJECT SHATTERSTAR

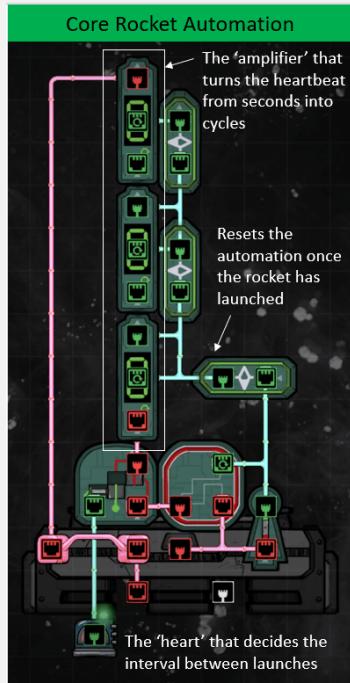
VOLUME 1 OF GUIDE TO THE ONI-VERSE

OXYGEN
NOT INCLUDED

SPACED
OUT!

By-
the stormfather

CHAPTER 16 : Hydrogen Rockets and the Late Game



Hydrogen Rockets should be called Hellfire rockets, for the amount of heat they spew out. I don't think we'll be able to fully control them... not yet anyway.

Highlights :

- We make some liquid hydrogen and Oxygen
- We test out our hydrogen rockets
- We show the future of our hydrogen rocket silo
- We expand our stormlink network



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CH 16: Hydrogen Rockets and the Late Game



Disclaimer-

Oxygen Not Included is a sandbox game limited only by the player's imagination. I can assure you that no player (including me) has figured out the 'right' way to play the game.... No matter how many hours they may have put into the game.

That's because there is no right way. What you do depends on what you want to achieve. Some love building ridiculous and elaborate builds, while others are more efficient and practical. Both are perfectly acceptable ways to play. What matters is that you enjoy what you do.

The following document is a guide and not a gospel. Like every other player, I have my unique style of play. What I intend to do is to share my playstyle and start a conversation with the community. This document will take you through a real and typical game, showcasing my approach to things. The playthrough will not be perfect. But it will be enlightening and entertaining. I hope my readers will use this series to modify their own unique style rather than copy mine.

Feel free to skip, ignore or modify any of the recommendations given in the series.

All Game art has been taken from the game files and is the property of Klei (if that wasn't obvious enough). I've used them only to make the document more engaging.

While this guide is quite simple, It's not meant to spoon-feed you. You may have to do a bit of additional research if you are a new player, and I'm happy to answer any specific questions.

The easiest way to find me is on Reddit. My handle u/Storm-Father. Please feel free to drop me a message or tag me in a post.

The series will use the following mods. These are quality-of-life mods and do not affect core gameplay

- Wounded go to Med bed
- Blueprints fixed
- Bigger Building Menu
- No 'Long Commutes'
- Suppress Notifications

- Geyser Calculated Average Output tooltip
- Critter Inventory
- Queue for Sinks
- FreeCamera
- MaterialColor
- Show industrial Machinery Tag

Game Coordinates – ‘SNDST-C-360860549-0’



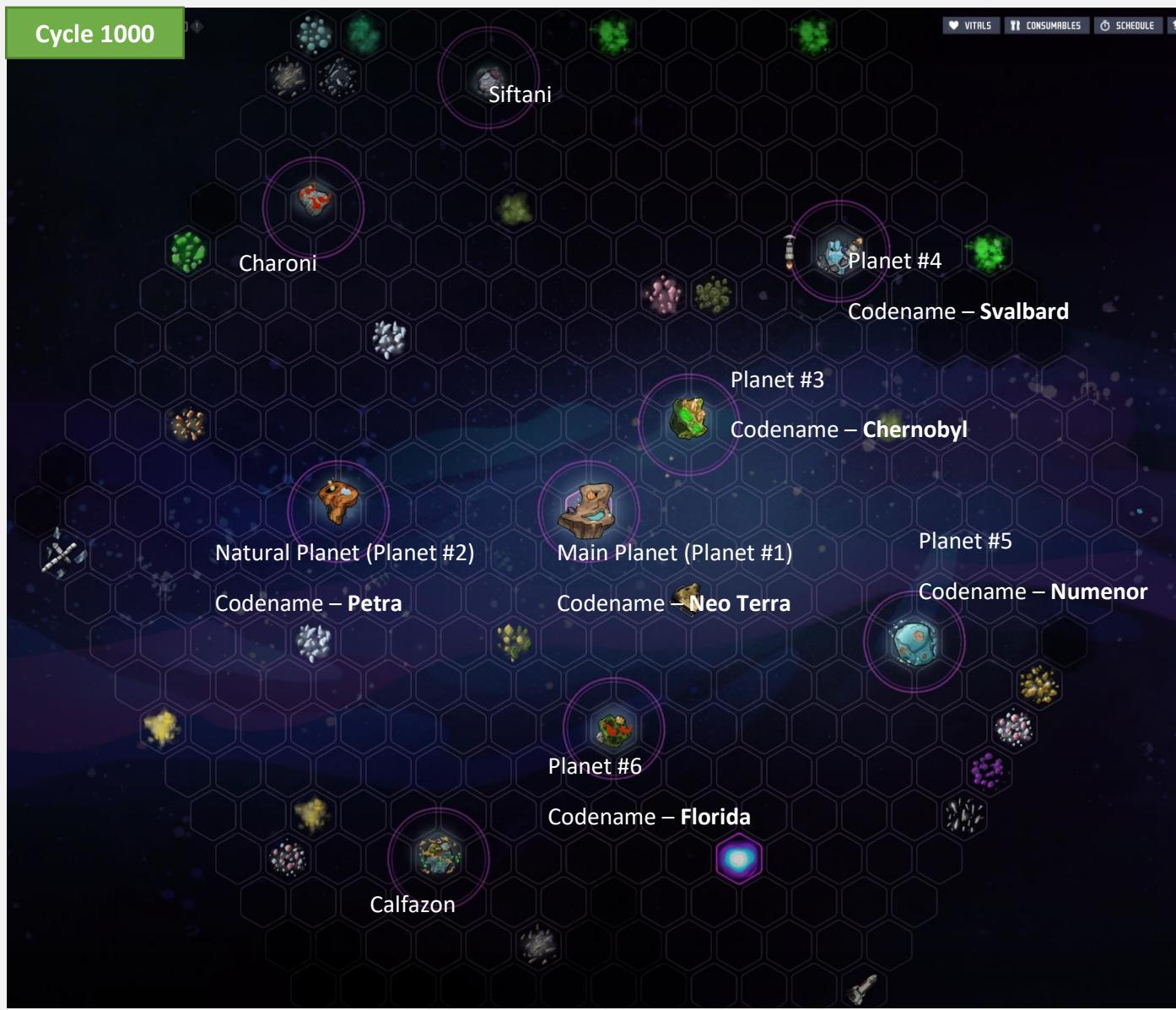
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The Starmap



The layout of the introduction has been changed to accommodate the increase in information that comes from having multiple planets. If you have any suggestions on alternate layouts or additional information, feel free to let me know on Reddit.



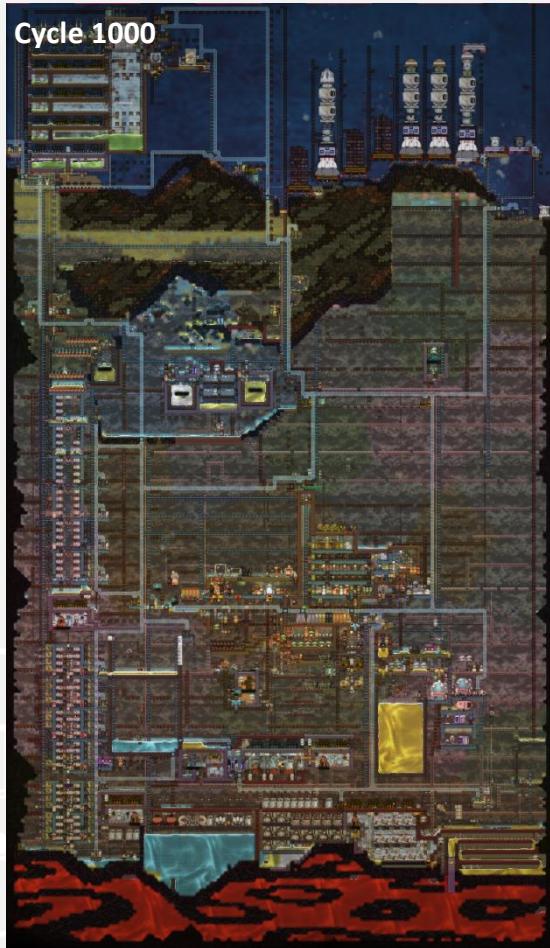
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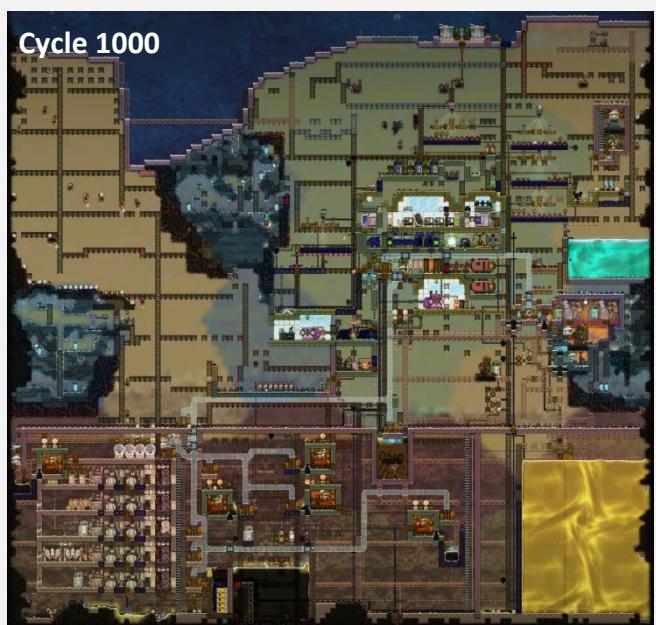
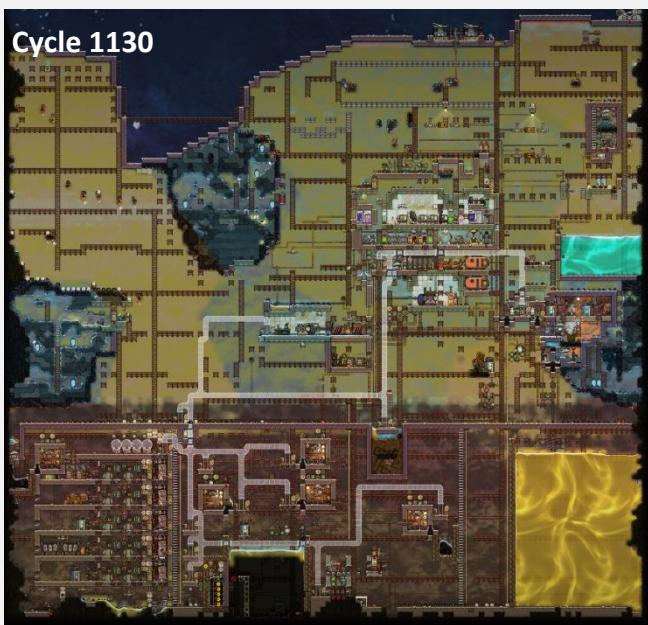
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Neo Terra



Petra



StormFather



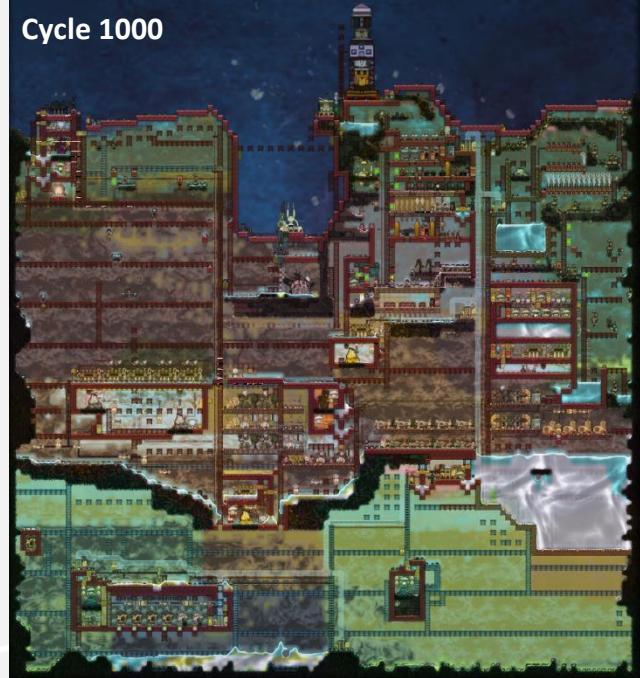
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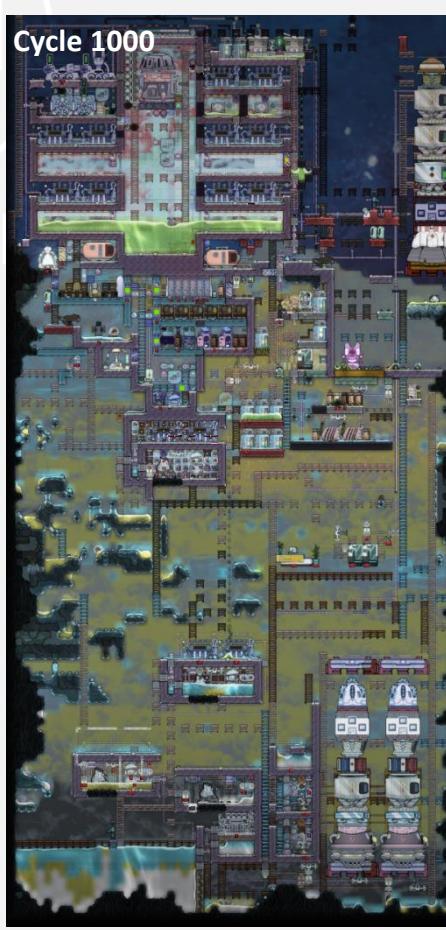
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Chernobyl



Svalbard



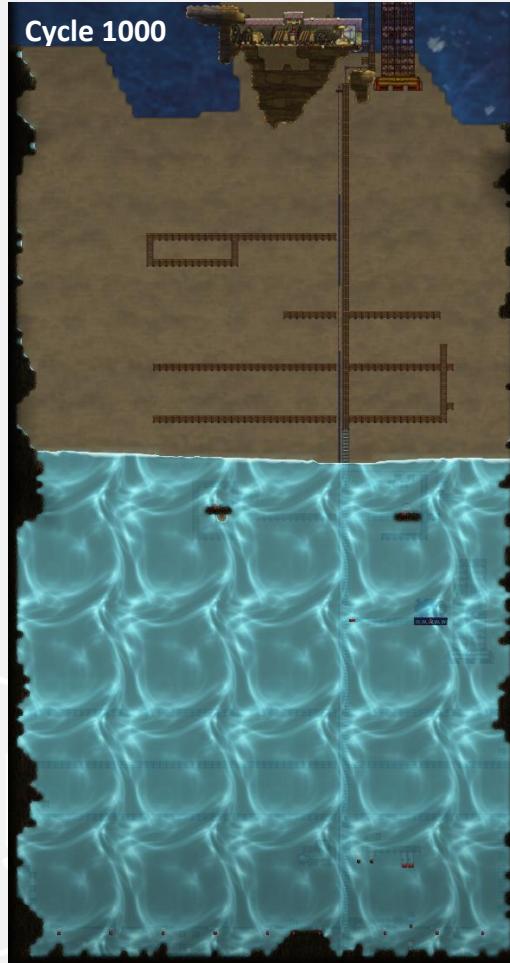
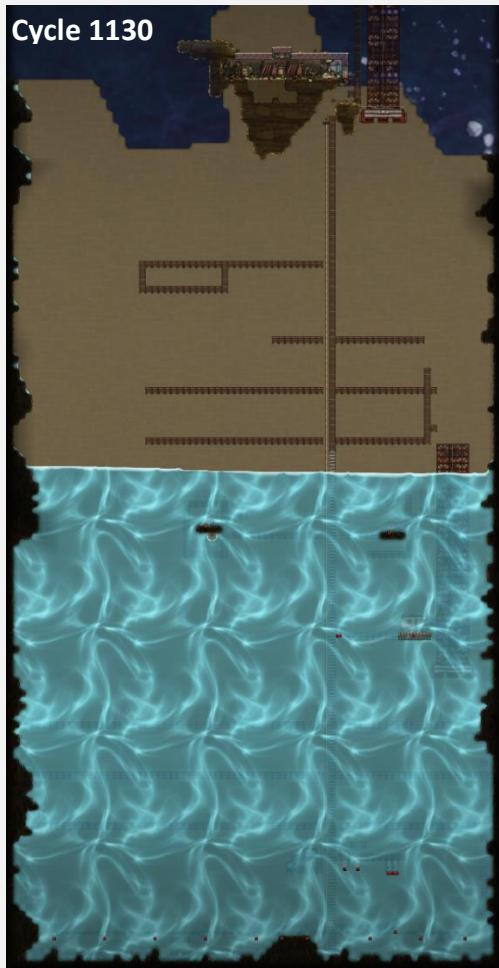


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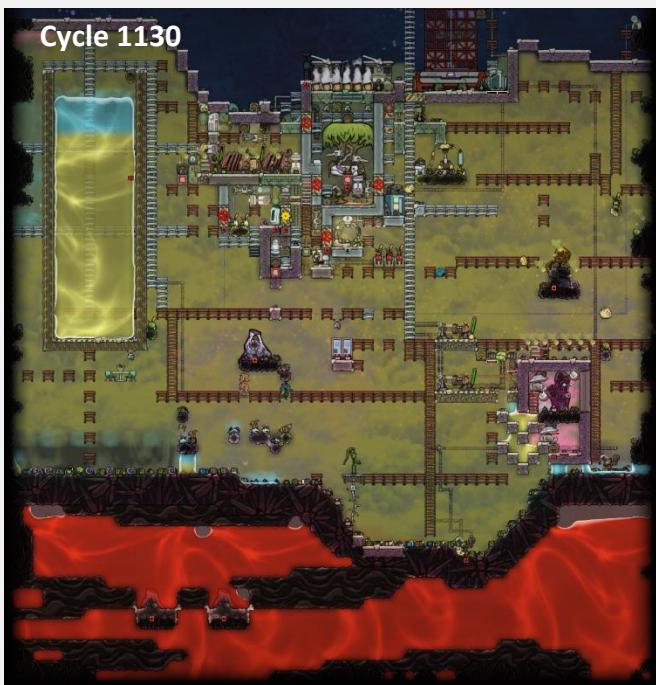
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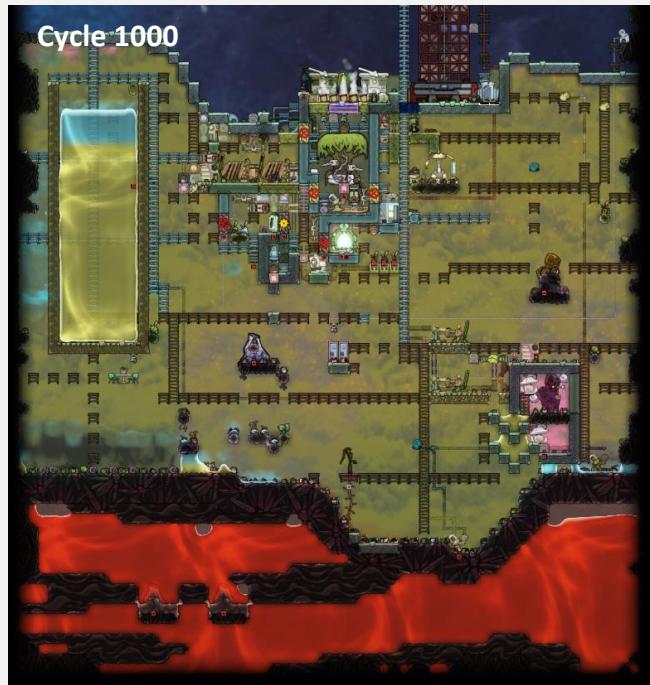
Numenor



Florida



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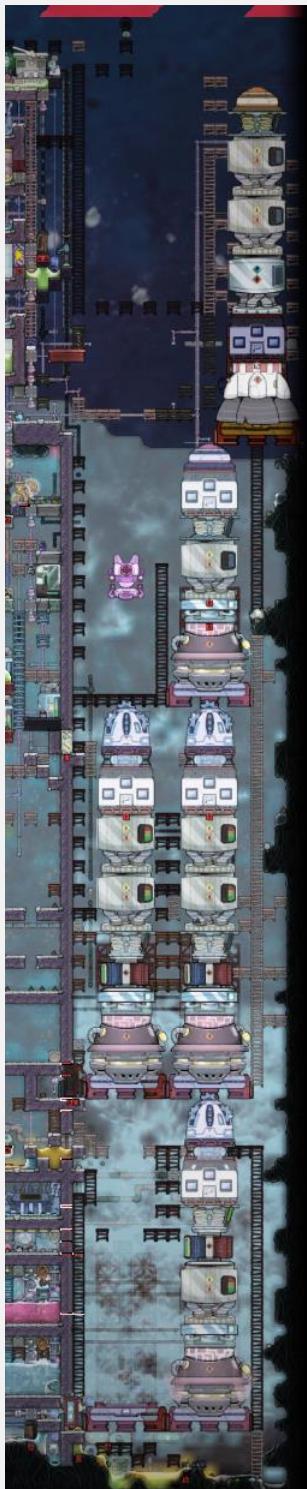


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1) Remote rocket base



So, we seem to be building a bunch of hydrogen rockets on Svalbard. The question is, why?

So I'm building hydrogen rockets mainly for one thing – mining space objects. As you might know, in spaced out, we can mine certain POIs (Points of Interest) that give us materials in return. We use drill cones full of diamond, with each drill cone able to mine 20 tons of material before all the diamond is used up and the rocket has to come back home.

While there are many materials I can mine from space that I need right now- such as metal ore or sand, what I really need a steady supply of in the long term is uranium ore.

As of cycle 1130, I have around 5 tons of refined uranium and around 2 tons of uranium ore. This will be enough to run a nuclear reactor for about 680 cycles. That sounds like a lot of time, right? Well, I have 2 nuclear reactors and the plan is to build a third, at minimum. That means my stock would last me about 225 cycles. 225 cycles is still a lot, but uranium ore has to be refined, so the input is not instantaneous. Also consider the fact that I am completely dependent on uranium both for energy and interplanetary transport, meaning I have to build up a very large and healthy buffer ASAP. If for whatever reason I do not sort out my uranium situation, the game is over.

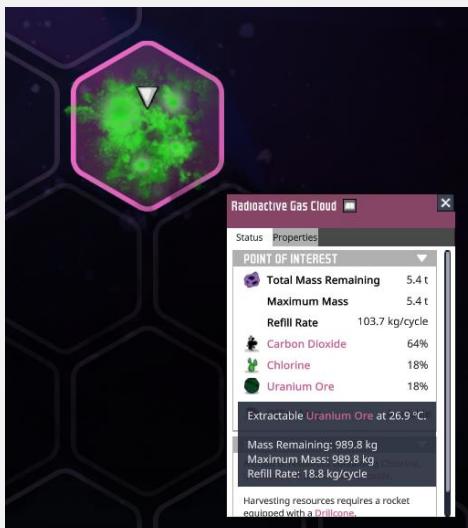
The way the uranium is distributed, 3 uranium clusters are very close to Svalbard, with the 4th being far, but reachable. We also have a full nuclear reactor on Svalbard, but not much to consume all that power. So a liquid hydrogen and oxygen facility could be run here with no extra energy cost. And with stormlink, getting materials onto the planet is not an issue.



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As a side note, the game does not show the regeneration rate of the asteroid materials, only the artefacts. I did not realise this initially, but around cycle 2000 I start using a mod called ‘Space POI additional Info’ that shows us regeneration rates.

Based on the regeneration rates of the Uranium POIs we can get 78 kilos of Enriched Uranium per cycle. This means we could run up to 7 nuclear reactors sustainably in this playthrough, though going any higher than 4 would make me a bit nervous.

2) Playing with Hellfire

Full disclosure, this was my first experience with Hydrogen rockets. Or liquid oxygen/hydrogen for that matter.

By builds at this point were experimental, but this playthrough has survived to cycle 3400 as of now, so I guess I did all right. That being said, this rocket silo is pretty crude, and If I were to make this again, I would probably change a few things.

In any case, this build served me quite well for about 1000 cycles before I started seeing frequent issues, so not complaining too much.



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I don't think I was prepared for how insanely hot hydrogen rockets get. While this silo works well, it scalds my dupes constantly. I do end up building cooling loops into it, but they were not sufficient to cool the silo enough. The rocket plume of a hydrogen rocket can melt steel. STEEL! Tungsten is the only refined metal that can handle the heat of a hydrogen rocket, so be sure to tame some tungsten volcanos if you want to automate your rockets right away.

Hydrogen rockets also melt igneous rock, btw. So build all your pipes and ladders with obsidian only. Insulated tiles made of igneous rock are fine though.

3) Liquid Hydrogen and Oxygen

The only way to make liquid hydrogen and oxygen is a supercoolant cooling loop, as they have very low liquefaction temperatures. Liquid hydrogen is harder to make though. One, because the liquefaction point is lower, and second because the gap between its liquefaction point and freezing point is 7 degrees.



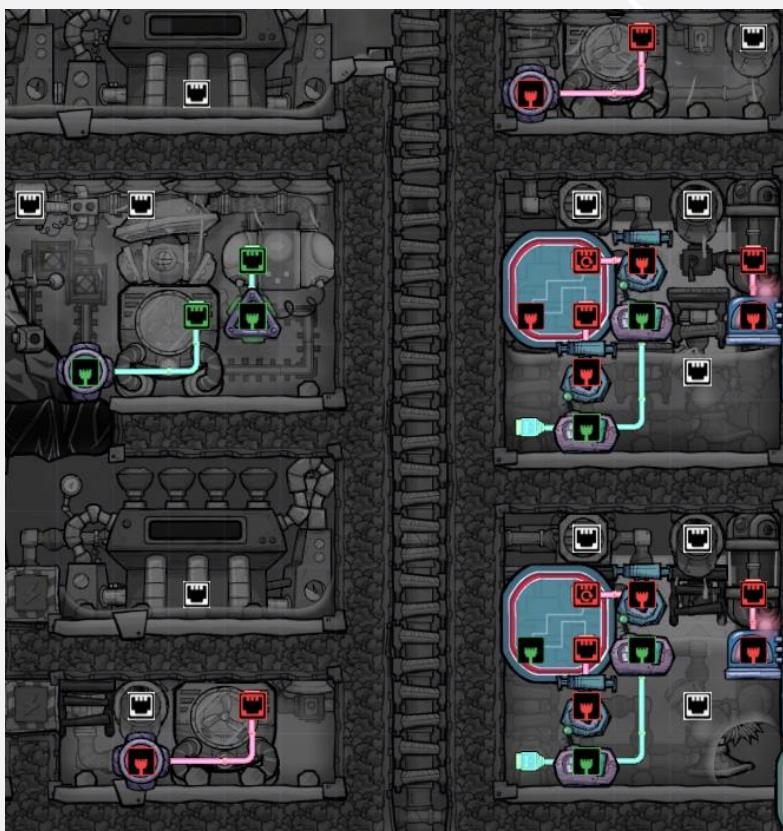
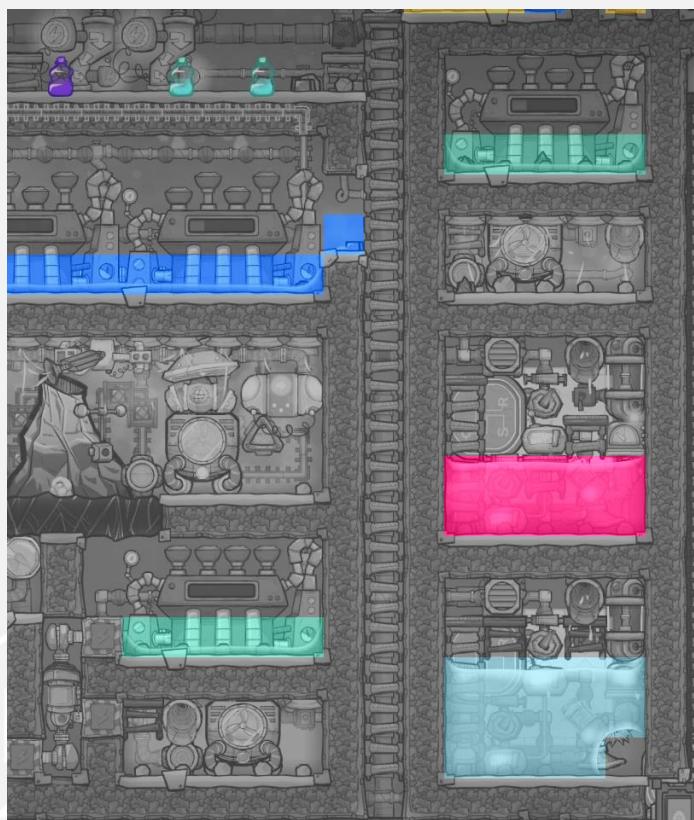
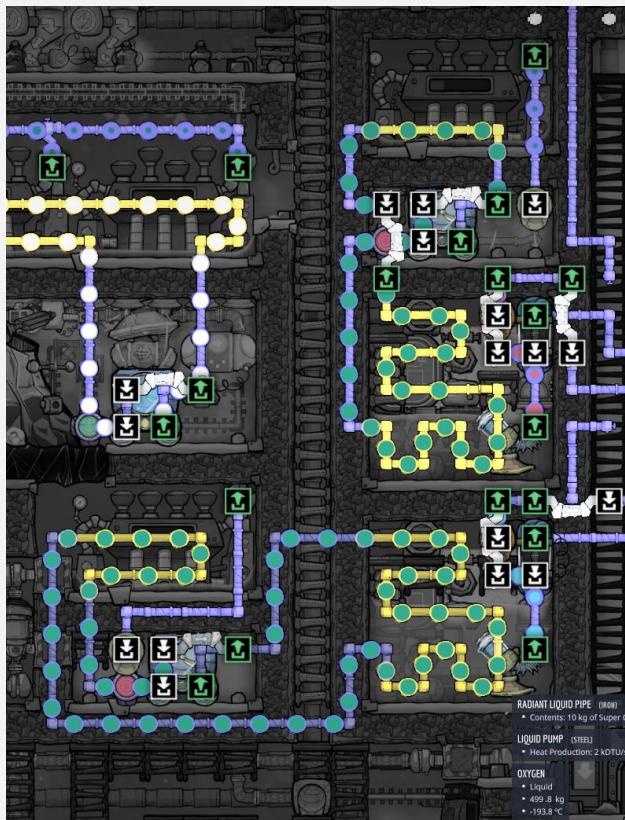
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In such a case, you could easily end up freezing your hydrogen instead of liquifying it. This is the biggest issue you may come across.



This cooling design is very straightforward. A simple cooling loop with aquatuners, with a target temperature of -192 for oxygen and -255 (or -256) degree Celsius for Hydrogen. The ideal place to make these cooling boxes is in space, to control heat transfer and all that, but this is a small planet and we do not have that luxury.

Gaseous oxygen and hydrogen are pumped into the respective chambers, and the cooling loop is allowed to do its work.



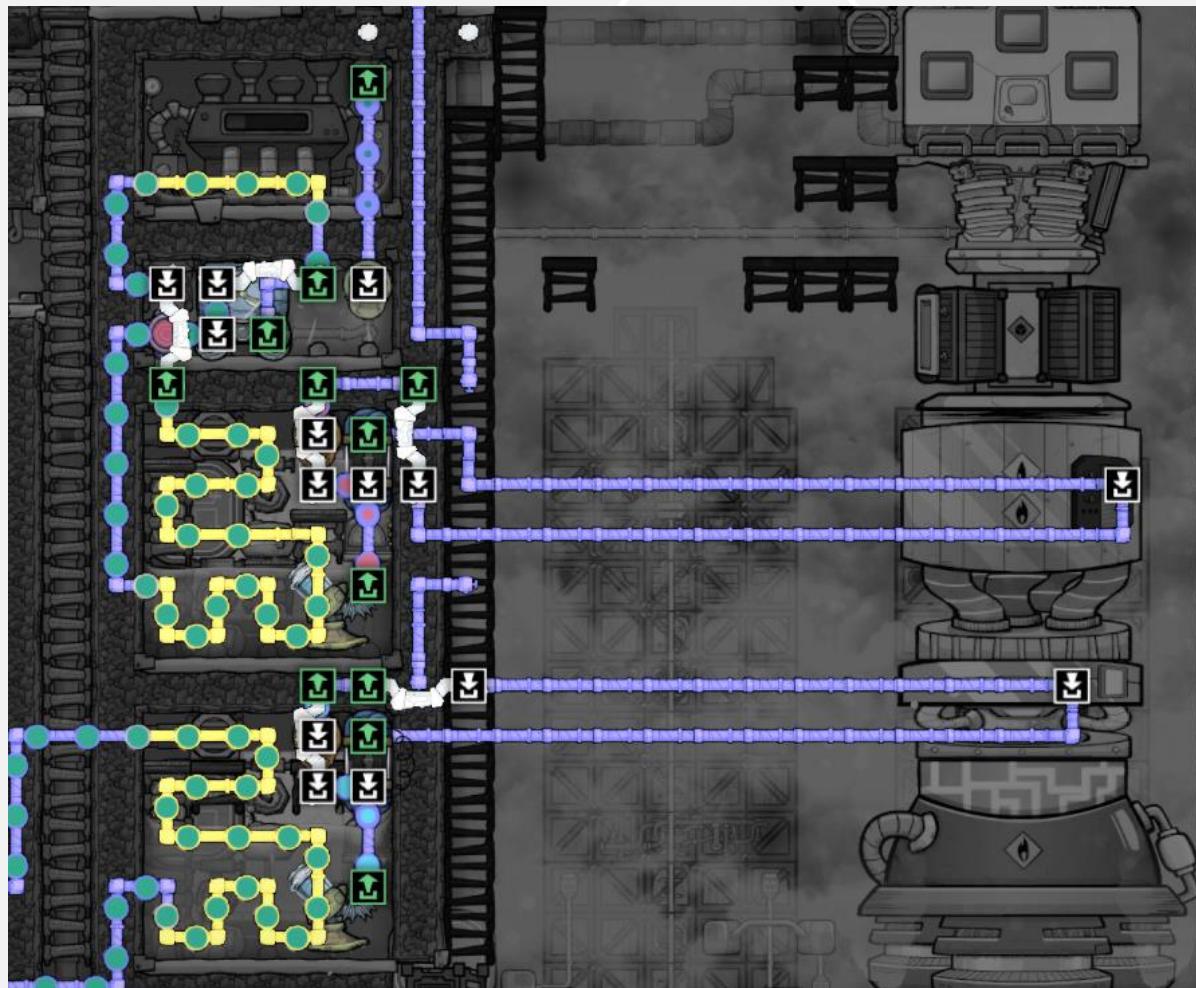
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The startup takes time, as the supercoolant is at room temperature and takes some time to come down, but when it does, the gas will start to liquefy. We have automation for the gas input such that if the amount of liquid is below a certain level, a green signal is sent, which turns red once a 2nd level is reached. This is a simple level sensor made from 2 hydro sensors and a memory toggle. Here the lower sensor is set to above 500 and the top sensor is set to below 50. At this point, I haven't connected this automation to the gas pumps, but I will in time.

Those thermosensors are redundant. I thought they would be useful but they weren't. For the liquid output, I have a pump constantly running, where it picks up liquid from the tank and drops it back. This keeps the liquid dynamic and prevents freezing. When required to fuel rockets, I manually give a green signal to the shutoff, which diverts the liquids to the rockets. The reason I don't have the liquid constantly running in a loop across the rockets is that the liquids will vapourize on the way and break the pipes. I do have a return pipe though, to ensure any unused liquid comes back to the tank. Even so, a pipe does break occasionally, so make sure all pipes are ladder accessible (You may have to build ladders when the rocket is not on the platform, to achieve this).





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I've found insulation to be the only material that can be used for rocket piping, but we are far from getting our hands on those, so let's work with what we have.

For now, I have a Rodriguez built on the planet to supply hydrogen and oxygen, but the ultimate goal is to import them both via stormlink from Neo Terra. That's for the next episode.

Oh and always remember to put a little layer of supercoolant on your steam turbines before you seal them up. Otherwise, your turbine will overheat and your build is busted.

4) Rocket design –

Now let's talk about the considerations for the actual design of the rocket. A hydrogen rocket has a maximum one-way range of 8 tiles with one fuel tank, and 16 tiles with 2. Simple enough. With the way the 4 uranium POIs are set up, I need 3 short-haul rockets and 1 long-haul rocket.

Also, let's look at the POIs themselves. At the moment, I only need Uranium. The gas clouds also have liquid chlorine and gaseous CO₂ in them, which I don't need. If my rocket only has solid storage, I will be able to mine only the solids. The same goes for gas and liquid storage. Just to be clear though, It does not mean that if I only have solid storage the liquid and gas will not be mined, it means that any excess material will be wasted. So when possible and useful, always try to retrieve whatever material a POI has.

StormFather



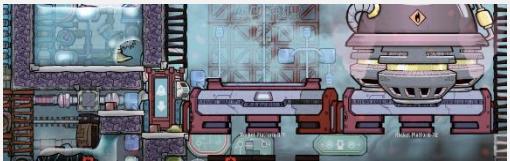
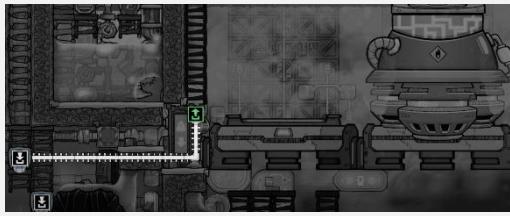
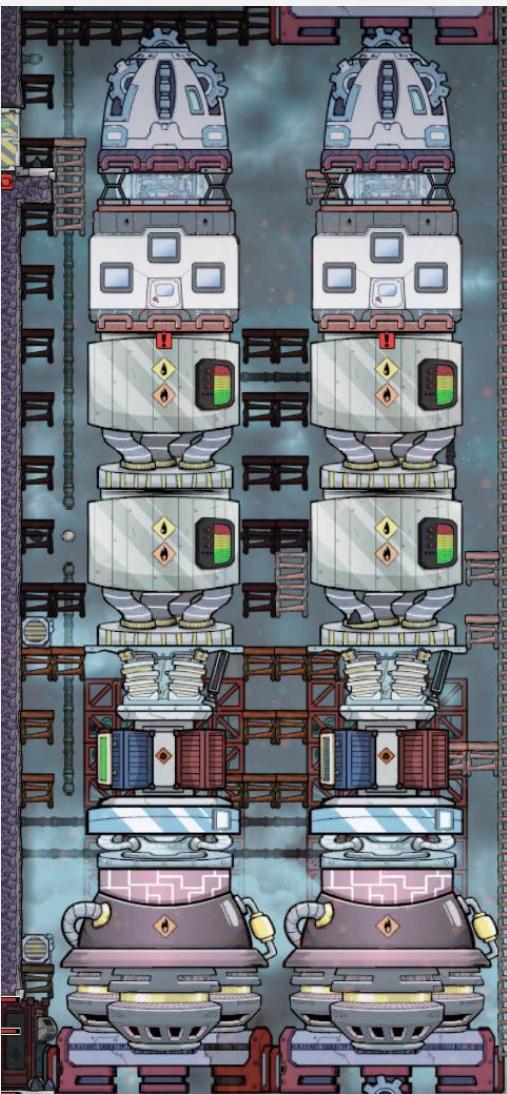
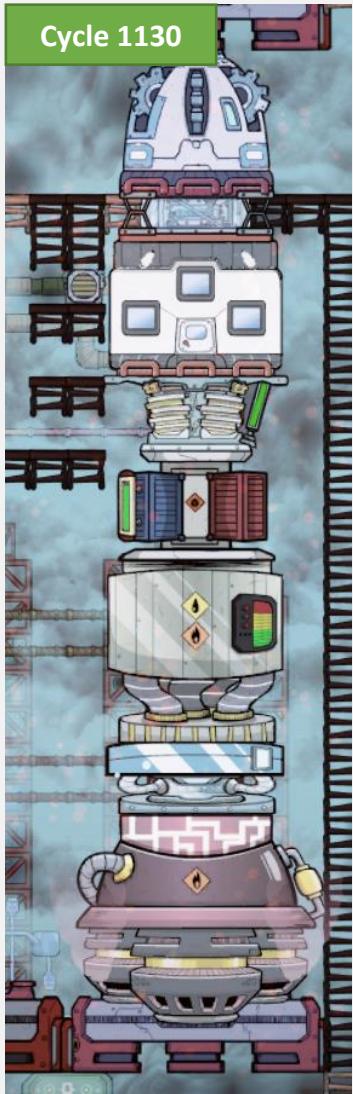
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The asteroid field is only made of solids, so no issues there. Solid storage will be enough to get everything back. The other 3 have solids liquids and gases. The liquid is useless to me as I don't use chlorine in any way, and I have no use for CO₂ right now. So I will just put it in solid storage for now.

So the way the POIs are designed, if the materials in the asteroid hit 0, the mining will automatically stop, and if you have enabled the round trip function, the rocket should return automatically once the mining is done. I didn't know this in the beginning, so I prime my storage with other materials, but that is not something we need to worry about,

Initially, I had designed rocket interiors with the intent of letting dupllicants remove their atmosuits, but this turned out to be a bad idea. In such a situation, you have to keep all your rockets plugged into power at all times, or there is a chance your dupllicant could get stuck inside and die. You would also have to keep a spare atmosuit inside, to ensure that if an atmosuit wore out, the dupllicant always had a spare.

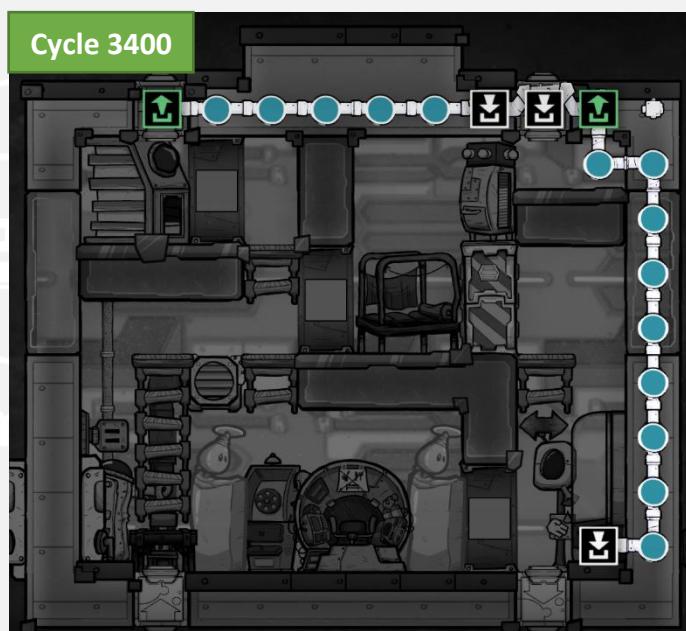
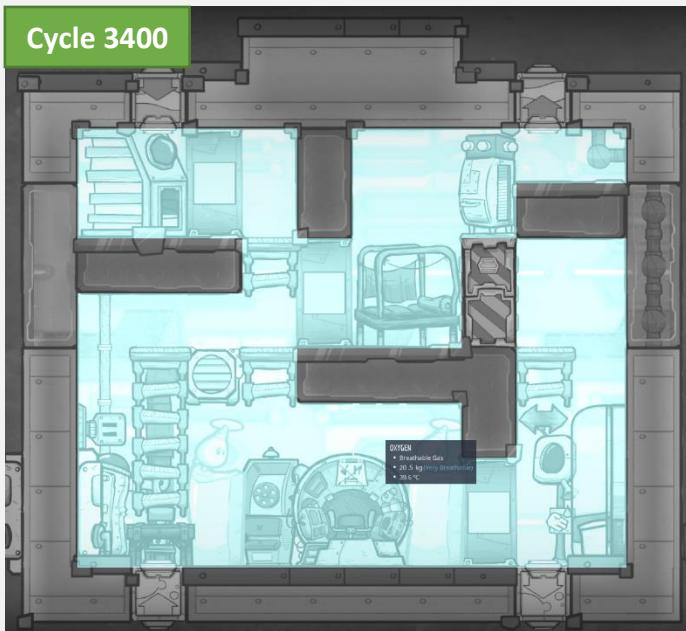


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Over time I realised that a duplicitant could live just fine in their atmosuit. Let's look at the pros and cons of such an arrangement

- 😊 Rockets don't have to be connected to the grid. Any electrical requirements are handled by the on-board engine
- 😊 We do not require any system to pump out CO₂, as duplicitants in atmosuits do not expel any CO₂, even when there is no air in the atmosuits
- 😊 There is enough space in the rocket interiors to keep a battery, meaning the rocket battery is not required.
- 😊 No chance of your idiot duplicitants getting stuck and dying



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- 😊 You don't need to rely on oxylite for oxygen. You can just overpressurize the whole place with gaseous oxygen and the dupllicants will get no popped eardrums. I keep a bin of oxylite only as a backup

- 😢 Your dupllicants will get out of breath every now and then, and this may interrupt their piloting action.

So many pros and just one con. I think I'm good with this arrangement.

5) The rocket Silo -



On a practical level, it's a lot easier to make rockets out in space than deep in an asteroid like this. Rockets in space have a natural heat dissipation system, whereas silos like this get real hot real fast.

I would eventually build in a bunch of cooling for my dupllicants, but it would never truly be enough. I may have to come up with a better design eventually, but this is more than enough for now.

As of now we only have one LOx and one LH tank, which supplies 2 rockets. I'm going to build another set of tanks and cooling loops for the rockets above. We will discuss the automation etc in a future episode, but if you're impatient I've put some posts on Reddit that you can check out.



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6) The ultimate Silo –



Probably a good time to go into the future and see what the silo evolved into. I could have just gone chronologically, but no point in keeping you all waiting I think. The following pictures are from Cycle 3400.

You may also notice that I end up moving the silo to the main planet. You may also notice that we have a bunch of rockets, whereas ONI only allows a maximum of 16.

So I used a mod, called rocketry advanced, which has a bunch of cool features and buildings, but I've disabled all of them. I use it for only its passive feature – the ability to build many many more rockets.

How it does that is simple – the rocket interiors actually take up a lot of space, with a grid size of 32x32 I believe. This is the reason some people mult the walls and make full bases in their rockets.

This mod shrinks that extra space, and only the bare minimum area is used. It is a shortage of physical grid space that limits the number of rocket interiors. With that limit gone, we can make so many more.



This silo is fully serviceable by duplicates, has a much more stable cooling system, and features a lot of automation.



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The liquid cooling tanks are now double-walled, to prevent the occasional overpressure damage, and the supercoolant loop now has an intermediary tank. This tank evens out the output temperature, thus reducing thermal shocks for the cooling system. Even though the aquatuner changes temps by 14 degrees at a time, the output temperature does not fluctuate more than a degree or so.



The tanks typically have around 2000 kg of liquid in them, but you can reduce this if you don't have too much supercoolant available. We've also changed the cooling loop automation such that the aquatuner turns only if the steam box is under 200 degrees AND the output liquid from the liquid reservoir is above the target temperature (-217 for Oxygen and -260 for hydrogen)

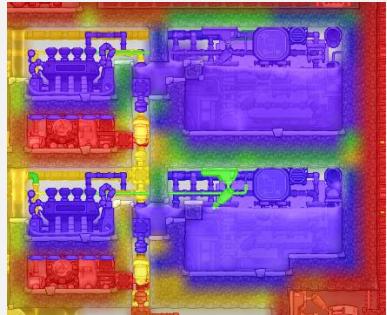
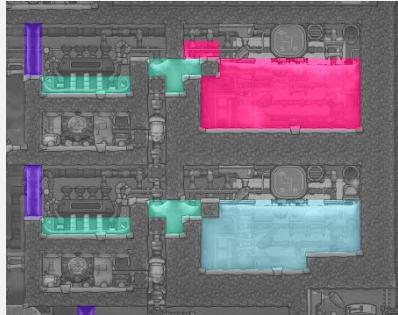
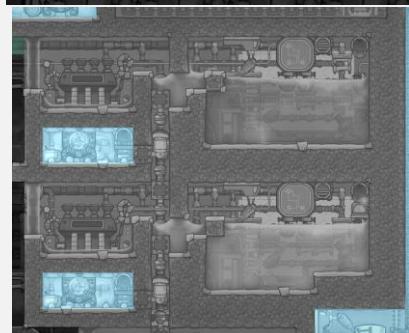
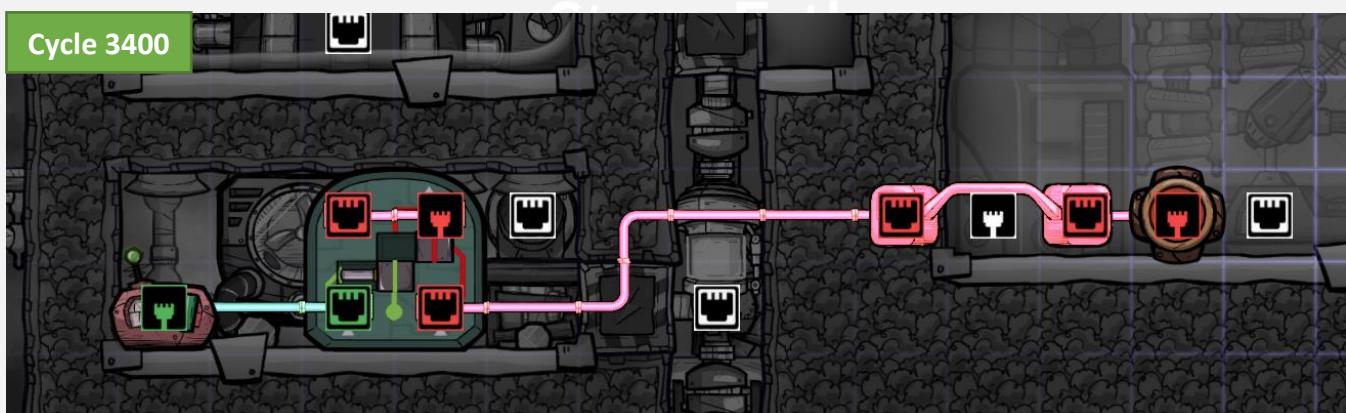
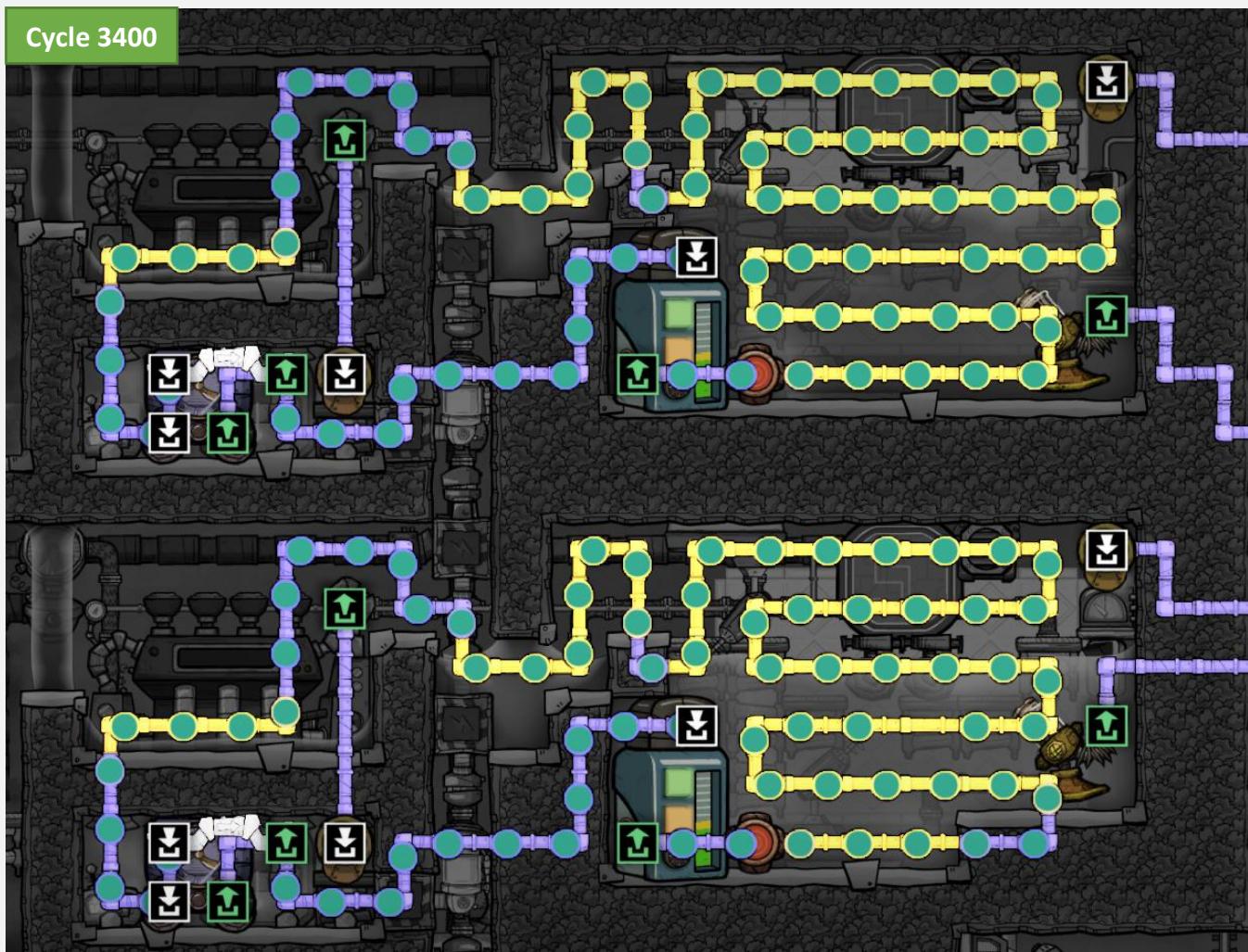
We have 2 airlocks, one is a full water lock made of supercoolant and one is made using viscogel. The area between them is gasless. A layer of supercoolant helps in the cooling of the turbine, and the cold from the liquids does not escape to the outer world. Simple.



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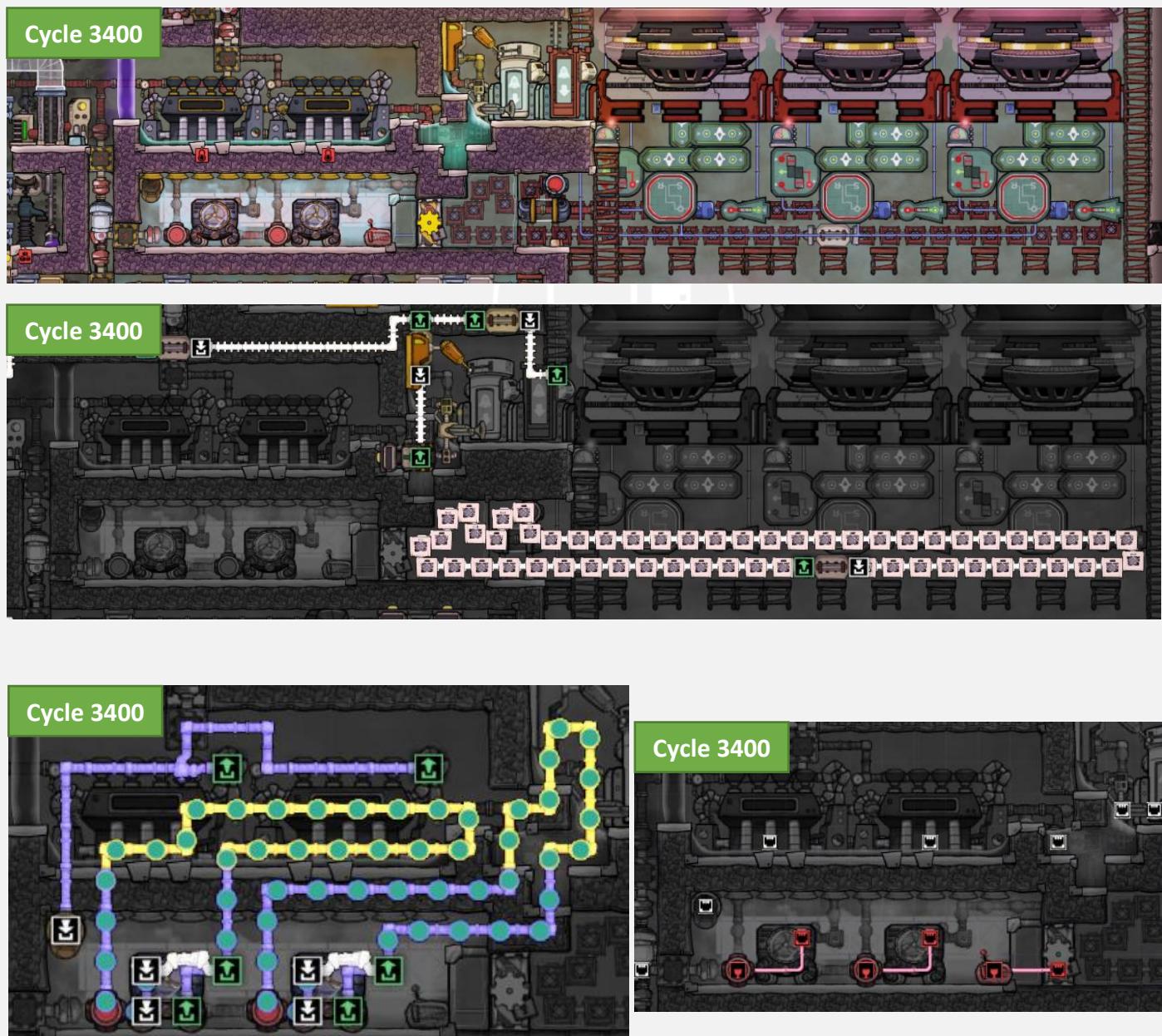
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And to control the extreme heat in the silos, we have some cooling systems in place, let's look at them.

One is a hybrid cooler, where the primary task is cooling the supercoolant liquid lock that provides duplicant access to the silo. When the steam box temperature goes below 200 degrees, the steel door closes. And the heat from the diamond conveyor rail loop dumps its heat into the steam box. Every level of rockets has its own LOx and LH tanks, as well as this hybrid cooler. The cooling loop also keeps the thermium robo-miner, autosweeper and conveyer loader cool. The steam turbines are also in a vacuum, with a layer of supercoolant for cooling, to prevent a leak of the temperature to the outside world.





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Shout out to **u/shafi83** on Reddit, for suggesting the use of a conveyer rail for cooling. That was the seed that germinated into the 2 cooler designs that I made.

The second cooler design is a dedicated space cooler, with a single conveyer rail for cooling. Instead of limiting the amount of heat, this is more concerned with ensuring all temperatures can be handled.



The diamond in the base speeds up the transfer of heat into the steam room, and I have doors on top that will block inputs to the steam turbine when the steam gets too hot. If you don't understand this input blocking concept, you may have to do a bit of googling, because I understand it well, but not well enough to break it down for you.

7) Automation max-

In case you haven't figured it out already, I love automation. And I wanted to keep my rocket system as automated as possible.

The main issue with rockets for POI mining is that many of them could take almost 40-50 to fully regenerate. And there is nothing in the game that lets you set a timer for that long. Also, I would need a timer that only starts after a rocket lands, and no timer in ONI can be triggered to start at any given time.



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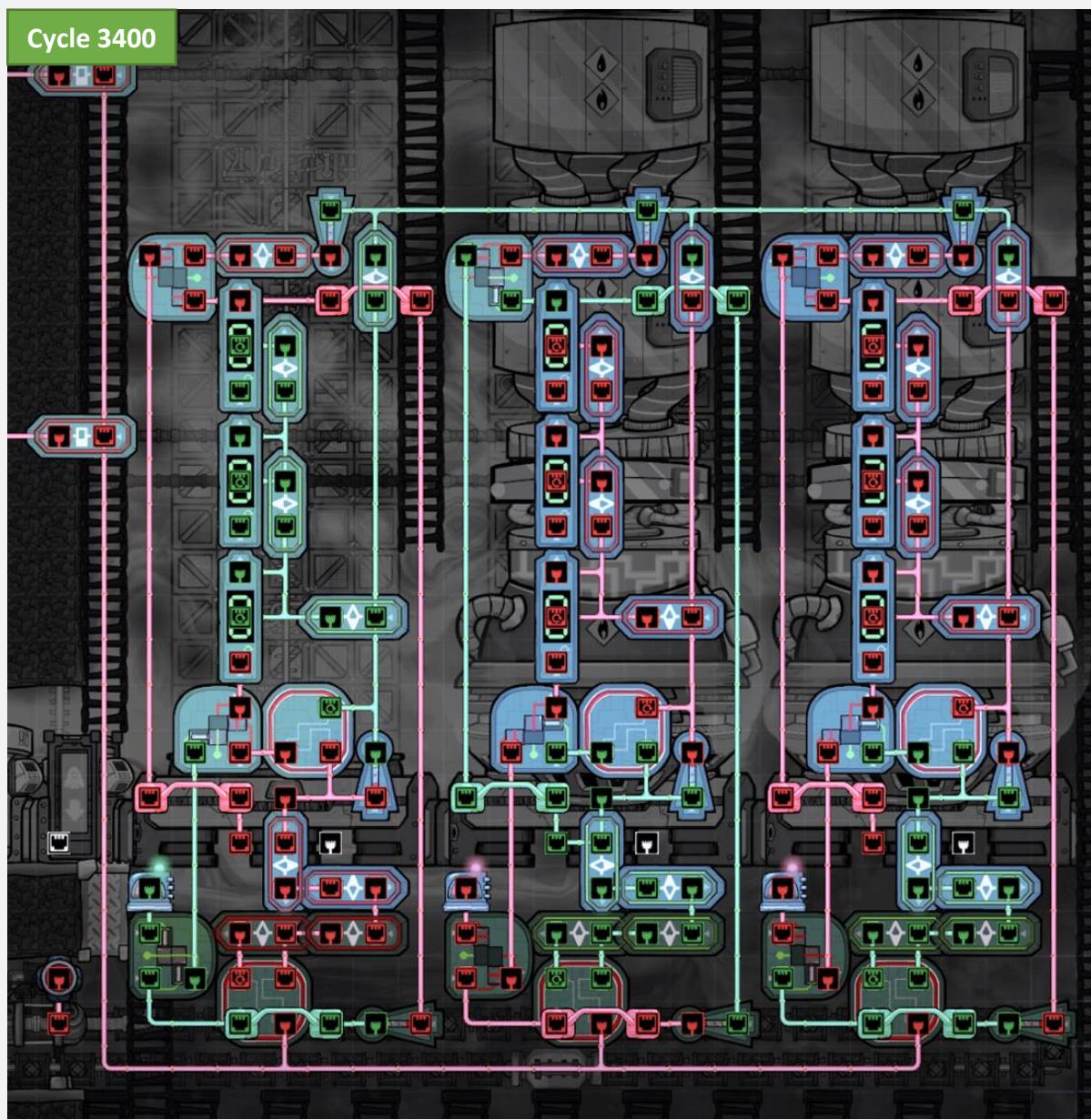
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My requirements were simple and clear –

- Make a timer that can be triggered by rocket return, and relaunch rockets at a fixed time.
- Allow rockets to be refuelled automatically on their return
- Top up the rocket's oxygen supply
- Top up the rocket's toilet water supply
- Diamond and food supply will continue to be manual

With these principles in mind, this is what I came up with. I've already posted this on Reddit before, but here is the recap



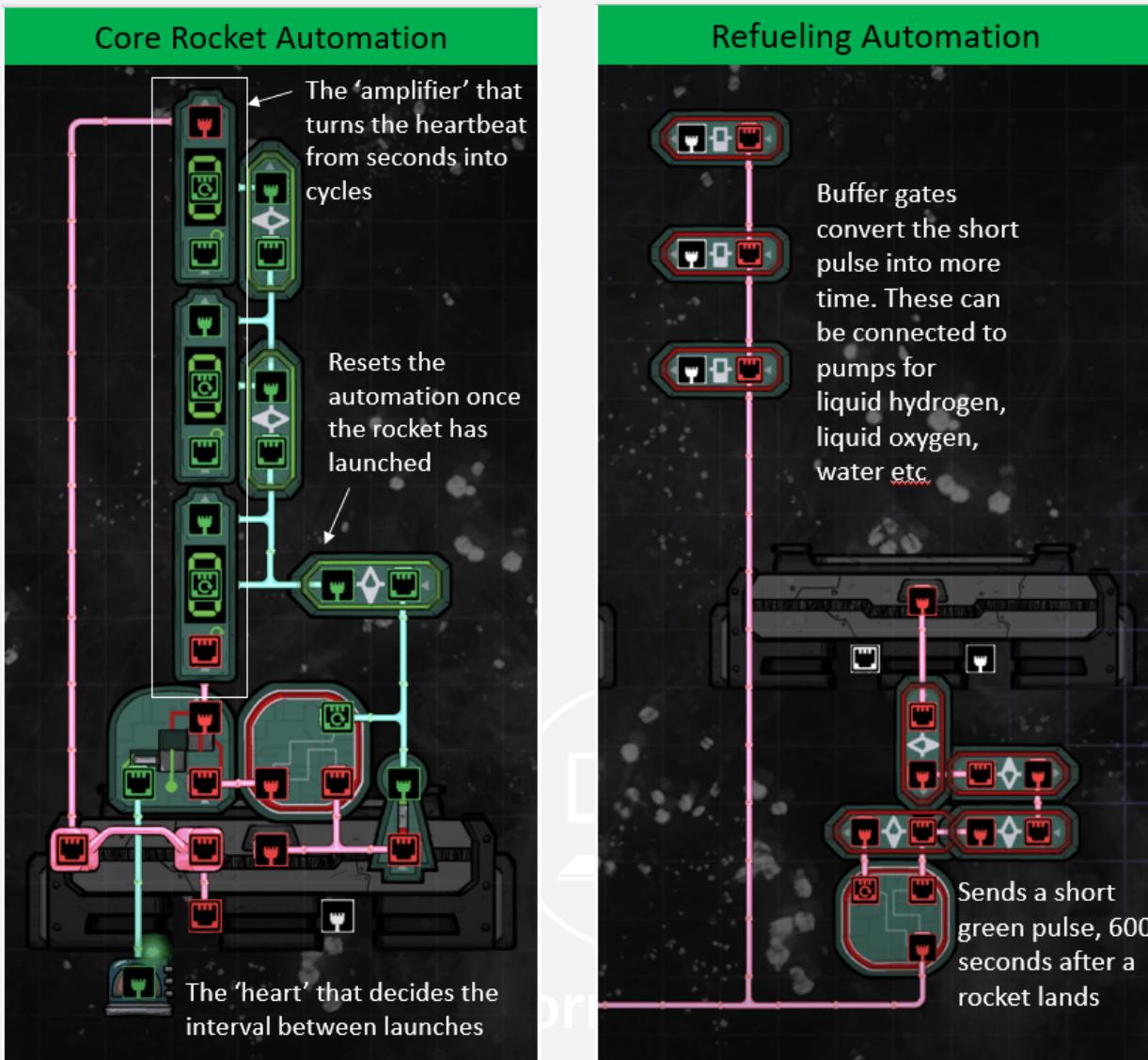


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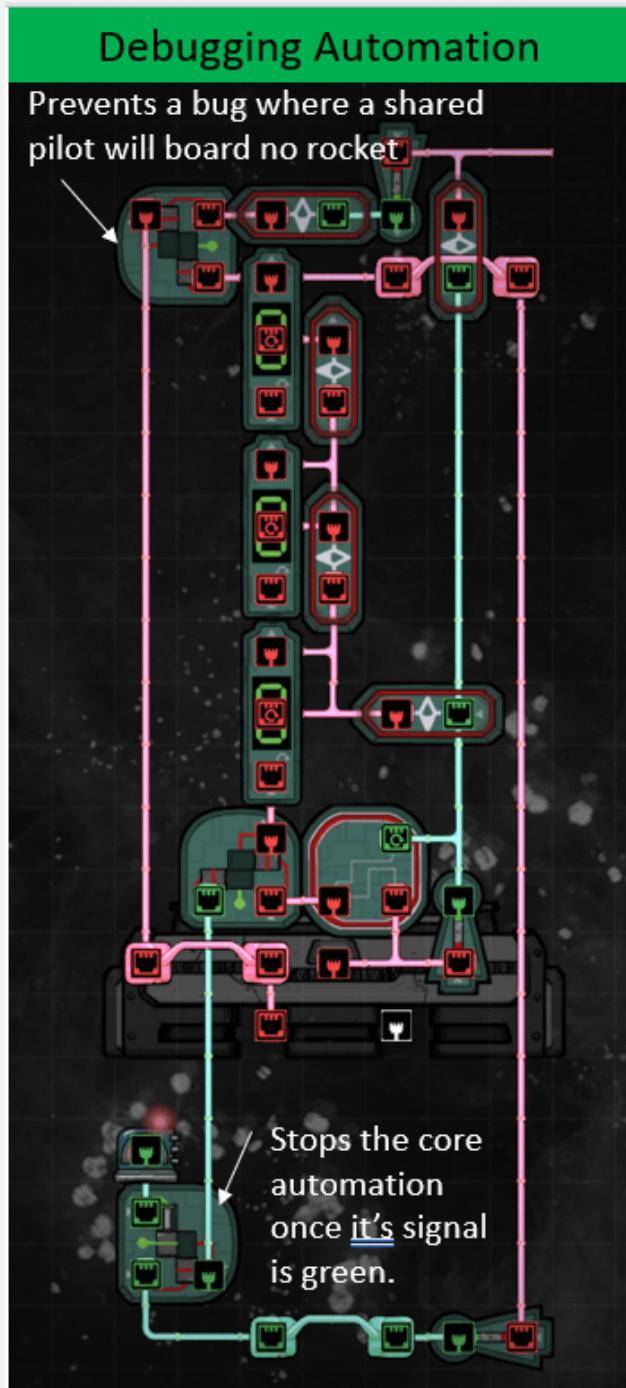
I think the automation is self-explanatory, but a bit complex. The core automation amplifies seconds to cycles. Every time the sensor goes green, it adds to the count of the first signal counter. Once the count on the first signal counter is 10, it sends a green signal to the second one, which again requires a count of 10 to increase the count of the third signal counter by 1. This basically means that the timer sensor must flash green 1000 times ($10 \times 10 \times 10$) for the final signal to be green. So, a timer with 6 seconds on green and 6 on red will launch a rocket once in 12000 seconds, which is 20 cycles. It also has a margin of error of only 12 seconds.

The refuelling automation is much simpler. Once the rocket lands, it creates a short green pulse which can be amplified using buffer gates to fill a pre-determined amount of material. I use this to fill fuel, oxidizer, water and



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oxygen as well. Only the diamond for the drill and berry sludge is delivered manually. The debugging automation does 2 things –

- Once the signal to launch a rocket is given, it stops the core automation.
- It allows the launch go-ahead to be given only if all 3 platforms have a rocket on them.

The short pulse output is connected to a buffer gate, which controls the pumps for liquid hydrogen and oxygen. For the pumps, you can keep the buffer gate at the max oxygen capacity of the storage, divided by 10.

So for a single tank of hydrogen, you can set it at 90 seconds. For 2 tanks, you can keep it at 180 seconds. Oxygen can either be kept at 45 seconds, or hydrogen capacity divided by 4 (so 23 seconds or 45 seconds). There will always be some excess, so make sure there is a way for the excess liquid to move back to the tank.

If you have more questions, let me know.

8) Base Check-

- We are suffering from major and crippling material shortages, but I suppose that's more a function of how I like to play. Most people in my position would be pretty happy with what they have, but I tend to build big and build fast, so that's my perpetual state of existence. I am short on ore, sand and obsidian. I now realise I should have imported all these materials from Petra in large quantities, instead, I



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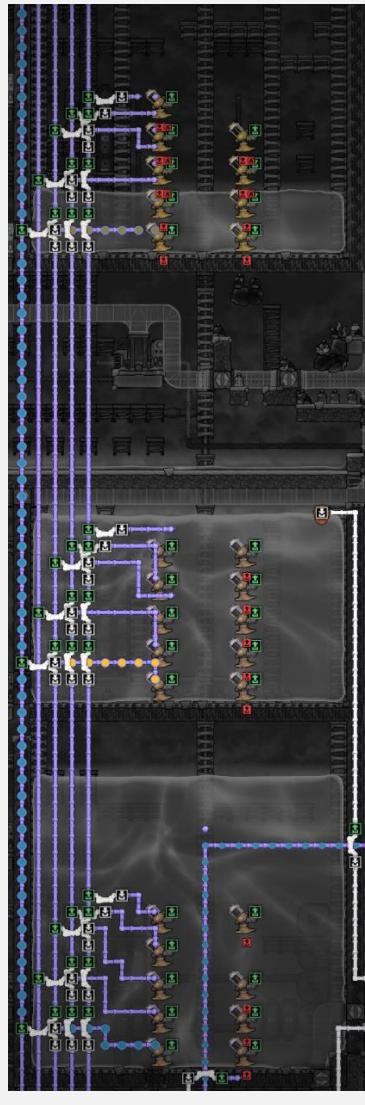
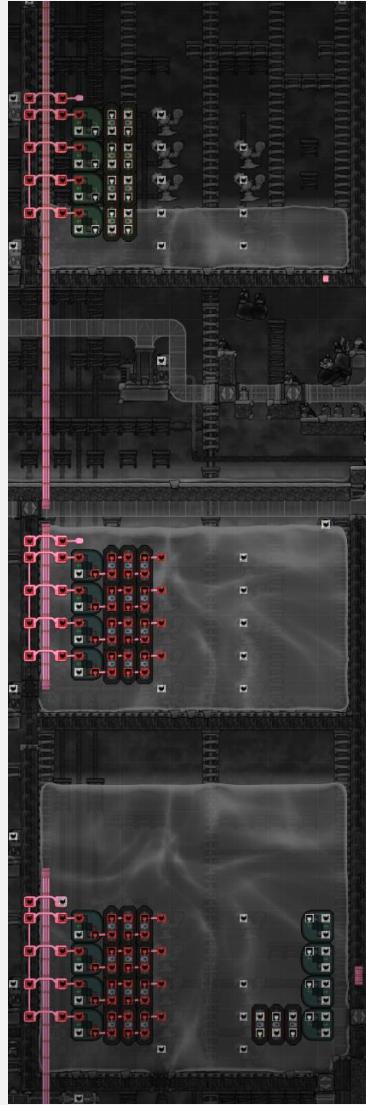
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OXYGEN
NOT INCLUDED

SPACED
OUT!

only took in small amounts and kept sizable buffers on Petra, and Chernobyl. Tips to improve next time I guess.

- We've built a bunch of liquid tanks. These tanks will be filled with liquids and the water and petrol tanks will be connected to stormlink.



- Our main base is now full of CO₂. We might have to do something about that.
- We're sweeping, cleaning and consolidating resources on all 3 planets.



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Author's Note –

Thank you for taking the time to check out Project Shatterstar. I hope this helps you to up your game. Each episode will be updated when necessary, so do keep an eye on the change history.

This series is a labour of love and an attempt to create quality written content. It does take up a lot of effort, though, so If you do like the work, please share and recommend it actively. You can also support me directly if you are willing and able.

There is always scope for improvement and new perspectives, so I encourage you to reach out to me if you have any specific thoughts on the work, be it good, bad or ugly. Reddit is the best way to get a hold of me. Do follow me there to keep up to date with the latest on what I do.

Check out the 'Stormfather's Guide to the Galaxy' and 'Academy Not Included', both of which are series that I built on Reddit. SGG is now scrapped, thanks to some complications when Spaced Out came out of Beta. But ANI will continue in some form or another.

Reddit is also the perfect place to point out any errors in the file. Due credit will be given to those who find errors or provide feedback that is incorporated into the file.

To check out any past or future work, or to support or follow me, do check out the following link-

<https://linktr.ee/Stormfather>

Until next time



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Change History –

Date	Version	Change	Credits
7 th July '23	0	New Release	-



StormFather