

# Space Decentral: A Decentralized Autonomous Space Agency

## Abstract

Space exploration has captivated humanity for decades, first as an idea and later as a reality. When space exploration initially became a reality, it did so largely due to public funding from the world's most powerful governments. While state-based actors like the US, Russia and China are and should remain important contributors to our exploration of the cosmos, as a species we (a) severely under-invest in space exploration and (b) exclude talented individuals from participating in this domain.

Recent years have seen the internet empower more people across the world to connect and collaborate - while blockchain technology promises to expand collaboration options even further by removing the need to have a centralized enforcement institution to police the activity of individual participants. We also believe that a peer-to-peer open value network is the missing link needed to conceive, fund, and implement the next generation of citizen-driven space initiatives.

In this paper we present Space Decentral, a Decentralized Autonomous Organization (DAO) whose operational protocol utilizes the blockchain to reinvigorate the push for space exploration with the public in control. Space Decentral will design space missions collaboratively, share research for peer review, crowdsource citizen science efforts, and crowdfund projects that lack national budgets.

**Keywords:** Space, Space Economy, NewSpace, Space Exploration, Decentralization, Ethereum, DAO

## 1. Introduction

Scientists hypothesize that cooperation was one of the key factors which allowed humans to develop sentience<sup>1</sup>. This same innate cooperative spirit underpinned our species' rise to dominance, the rise and fall of nations, and our first daring ventures beyond the relative safety of Earth - culminating in the lunar landings of the Apollo program. That over 400,000 people<sup>2</sup> worked together to put a dozen men on the Moon is the feather in the cap of what is arguably humanity's greatest technological achievement.

---

<sup>1</sup> McNally, Luke & Brown, Sam & Jackson, Andrew. (2012). *Cooperation and the evolution of intelligence*. Proceedings. Biological sciences / The Royal Society. 279. 3027-34. 10.1098/rspb.2012.0206.

<sup>2</sup> Thimmesch, C. (2006). *Team Moon: How 400,000 people landed Apollo 11 on the moon*. Boston: Houghton Mifflin Company.

It must be acknowledged, however, that underlying this astounding cooperation was a tremendous amount of willpower and resources allocated by a select few in the government. When resources were shifted away from space exploration, one of the most economically impactful<sup>3</sup> public projects in history was starved. Existing institutional barriers all but ensure that, barring outstanding public outcry, this new dismal *status quo* will remain until the barriers themselves can be torn down.

Current public and private initiatives could reignite the space program, and it's our hope that it will be so. The NewSpace<sup>4</sup> movement is proving to be an effective way to direct resources toward space exploration, and various syndicates of angel investors<sup>5</sup> are demonstrating interest in these kind of new private initiatives. However, to truly invest in space exploration at the appropriate scale, there must be new players in addition to governments and large, traditional corporations. In particular, it's important to find ways for unaffiliated space professionals, entrepreneurs who have unique interdisciplinary expertise, space enthusiasts, and the public at large to be actively involved. Without a broader based participation in space exploration, it is highly unlikely that we will (i) undertake enough space missions to make new materials science innovations (which would benefit humanity today) or (ii) find an effective way to become an interplanetary species (which is arguably the only way to protect the long-term survival of the human species).

To create a new niche within NewSpace, that helps make space better funded, better governed and a more positive force for humanity, we propose to create a *decentralized autonomous space agency*. We call it decentralized because no single corporation will be exclusively responsible for its management. We call it autonomous because members of the network will be in control of how work is directed, how decisions are made, which projects to fund, and what the vision for the future should be. We call it a space agency not because it should aspire to be a rival bureaucracy to the government or major aerospace corporations, but because it will enable and empower the widest possible range of scientists, entrepreneurs and visionaries.

## 1.1 The Status Quo

National space programs have been insulated from public opinion, remaining essentially unchanged by any quantitative measure for decades. The decision-making processes in these institutions are very far removed from the ballot box - and for understandable reasons. Until recently, the thought of holding elections to fill the menagerie of bureaucratic roles or perform the duties of scientific committees was logistically unthinkable at even the national level. Mustering the resources to create an international equivalent was similarly out of the question.

Much has changed on earth in the decades since Sputnik and Gagarin took to the skies. With billions of people connected to one another by the internet, coordinating activities by accurately registering the opinions of thousands worldwide is now eminently feasible. Earning the financial and social support of

---

<sup>3</sup> The Tauri Group (Ed.). (2013, April). *NASA Socio-Economic Impacts* (Rep.). Retrieved <https://www.nasa.gov/sites/default/files/files/SEINSI.pdf>

<sup>4</sup> NewSpace. (n.d.). Retrieved April 1, 2018, from <https://en.wikipedia.org/wiki/NewSpace>

<sup>5</sup> Space Angels. (n.d.). Retrieved April 1, 2018, from <https://www.spaceangels.com>

people from around the globe is not only unthinkable, but indeed commonplace - consider the popularity of Patreon, Kickstarter, and Indiegogo, among others.

In a 2009 paper published in *Futures*<sup>6</sup>, a co-author of this document proposed to create a global space agency of the people, by the people, for the people. The rise of cryptocurrencies, smart contracts, and Decentralized Autonomous Organizations (DAOs) is a powerful enabler for both the possibility for global groups of citizens to collaborate toward the space frontier, and the possibility to raise funds for new ambitious space missions that are crowdsourced and crowdfunded.

## 1.2 The Case for Space

*Since, in the long run, every planetary civilization will be endangered by impacts from space, every surviving civilization is obliged to become spacefaring--not because of exploratory or romantic zeal, but for the most practical reason imaginable: staying alive... If our long-term survival is at stake, we have a basic responsibility to our species to venture to other worlds.*

— Carl Sagan

The world is full of problems to solve - so why put space activities near the forefront? More generally, why is space important to us? We are far from the first people to articulate an answer to these questions, but it bears repeating that there are numerous quantifiable scientific and economic benefits<sup>7</sup>. Even the meager magnitude of our collective investment in this realm yields significant returns for diverse parts of society, solving needs here on Earth. It can be as clear-cut as the utility of space-based observation in disaster response effort, or as dilute as the wide-ranging impact of the Global Positioning System (GPS) integration in the world's trade and commerce networks. It can be as niche as the improvement of an aerospace engineering analytical method<sup>8</sup> or as versatile as an air filter<sup>9</sup>.

There are those who argue that, despite such strong investment prospects, there are still other problems to solve that also have their own unique returns and spinoffs. Yet space provides a rare intersection between good investment, meaningful impact, and a focal point for humanity's natural curiosity. As long as outer space remains a borderless place, it is a neutral domain for us to focus our collective efforts where we can create history together as a unified species.

The idea that we are on the cusp of exploring space as a unified species is an ambitious one. Yet it is not entirely without precedent. A recent report by Goldman Sachs entitled *Space: The Next Investment Frontier*, argues that we have already started embarking upon a Second Space Age. In this new phase of space exploration, the key organizing principle is not government funding or a flurry of enthusiasm for

---

<sup>6</sup> [http://www.academia.edu/2700115/A\\_Virtual\\_World\\_Space\\_Agency](http://www.academia.edu/2700115/A_Virtual_World_Space_Agency)

<sup>7</sup> NASA. (2013). *Benefits Stemming from Space Exploration*(Publication). Retrieved April 1, 2018, from <https://www.nasa.gov/sites/default/files/files/Benefits-Stemming-from-Space-Exploration-2013-TAGGED.pdf>

<sup>8</sup> NASA. (n.d.). Simplified Aircraft Modeling Packs Weeks of Analysis into Minutes. Retrieved April 1, 2018, from [https://spinoff.nasa.gov/Spinoff2018/t\\_5.html](https://spinoff.nasa.gov/Spinoff2018/t_5.html)

<sup>9</sup> NASA. (n.d.). Light-Induced Oxidation Cleans Air, Surfaces, Clothes. Retrieved April 1, 2018, from [https://spinoff.nasa.gov/Spinoff2018/cg\\_2.html](https://spinoff.nasa.gov/Spinoff2018/cg_2.html)

space on the part of the scientific community. Instead, the key organizing principle is the structural changes that the commercial launch and satellite manufacturing industries have gone through. Long gone are the days when governments alone accounted for all of the key innovations in these two critical industries. We are now at a point where public government-funded initiatives are being overshadowed by the innovative vision being provided by a network of well-funded, ambitious private companies.

### 1.3 A Decentralized Autonomous Space Agency

Space Decentral is a decentralized autonomous space agency, that will utilize blockchain<sup>10</sup> technology to enable collaborative, transparent and self-directed action toward building the future of space exploration. A blockchain is a distributed database that leverages public-key cryptography for decentralization and security. Blockchains utilize cryptographic tokens, which can also be used as cryptocurrencies, as a way to represent privileges and rights within a network. When actions are *tokenized*, transactions with unique digital identifiers are permanently and indelibly stored in the blockchain itself. A DAO uses these features intelligently to streamline and spontaneously coordinate workflows and business logic.

- The flow of key information through the network, and the governance of the network itself, will be facilitated by self-executing smart contracts on the blockchain and mediated by tokens.
- Aragon<sup>11</sup>, a decentralized app for DAOs, will facilitate governance and financial planning.
- Token ownership will establish voting rights on various issues, such as which projects should be added to the program and how work should be directed.

The tokens used within Space Decentral could be seen as the *cryptographic key* needed to be an integral part of the network. However, it is important to note that the token is not merely a safecode to enter a gated community, but the embodiment of the digital schema that the agency will use to run.

## 2. The Space Decentral Ecosystem

*This section provides an overview of Space Decentral's Token Ecosystem & Governance. For more details refer to the [Governance Paper](#).*

With Space Decentral, the global community can propose, debate, and implement worthy ideas. Incentives will be provided to encourage growth, where contributions to technology development or project development will be rewarded with cryptocurrency. The Space Decentral framework will be applicable beyond space exploration and aerospace, as its features will meet the needs of many organizations and research centers worldwide. One aim is for the Space Decentral Network to neatly catalog a multitude of resources that makes it easy for anyone to learn and become involved.

---

<sup>10</sup> For those new to blockchain, please review a [Blockchain Glossary](#), as unfamiliar terms may be used in this paper.

<sup>11</sup> Aragon is a decentralized application that develops governance tools for DAOs. - <https://aragon.one>

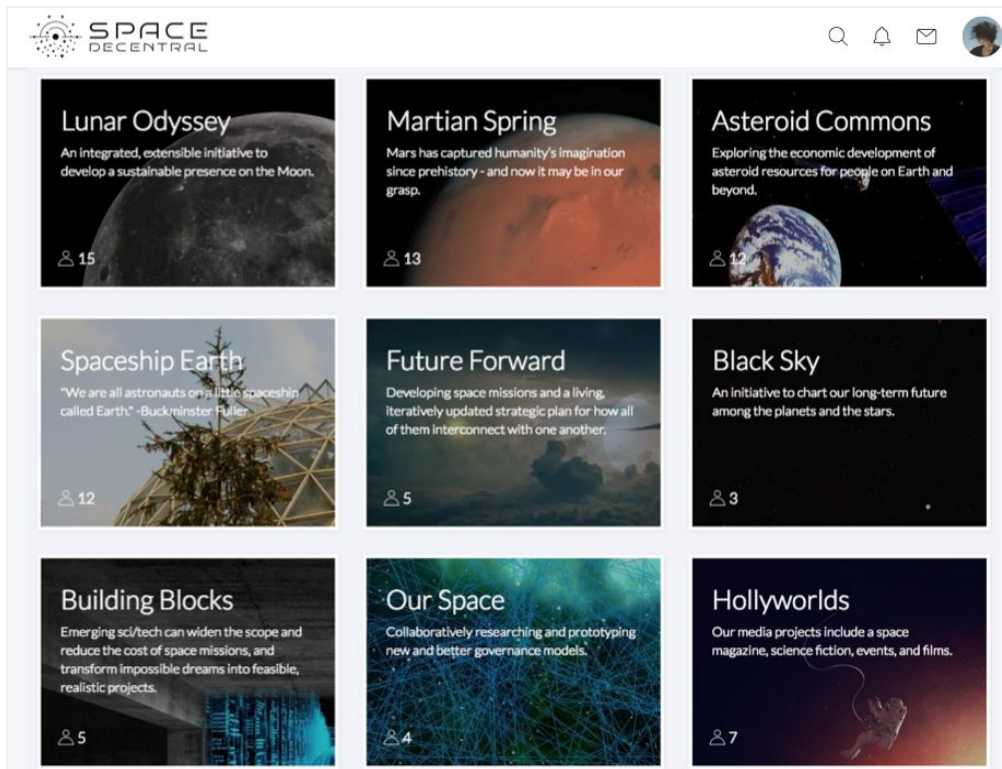


Figure 2.1. Space Decentral participants will be able to contribute toward programs that are most aligned with their skills and interests.

The Space Decentral Network includes two tokens: the Faster Than Light (**FTL**) token and the Space Decentral Network (**SDN**) token. FTL is the governing token of the network, is transferable, and can be purchased at the token generation event. SDN, by contrast, represents the relative weight of contributions to the network, is non-transferable, and can only be gained by contributing to strategic plans, open source projects, and the open knowledge base. To incentivize the development of open source space missions, rewards in FTL will be distributed to SDN holders in proportion to the amount of SDN they hold.

## 2.1. Faster Than Light (FTL) token

The token generation event for Space Decentral will raise funding by selling FTL tokens. This funding will be utilized for the development of the infrastructure and incentive structures necessary to facilitate decentralized space mission planning, peer review of solutions, and tools for distributed engineering on the Space Decentral Network. Hence purchasing FTL is also the DAO's initial vote to fund the technology roadmap described in this paper.

The primary utility of FTL is:

- The more FTL one holds, the higher influence in defining the Space Decentral program.
- Contributors collaborating on open source projects can stake FTL to become part of the Member class and receive full governance rights (assuming minimum contribution requirements are met).
- Non-members pay fees in FTL to submit proposals to be considered for the program.
- Members of the network can offer consulting services remunerated in FTL.

- FTL is the preferred currency for facilities built by Space Decentral on Earth & beyond.

## 2.2. Space Decentral Network (SDN) token

While building a thriving and intelligent ecosystem for space expansion, individuals and organizations participating in the network will receive SDN tokens, which are non-transferable tokens and used primarily as an accounting tool to measure contribution activity levels. SDN tokens are minted by Space Decentral on an as-needed basis, and are never sold by Space Decentral: their singular purpose is to be allocated against tasks and earned by contributors.

The following are considered contribution activities where SDN can be earned:

- All aspects of software development including but not limited to decentralized apps, design, flight systems software, and tool development
- Contributing to the Space Decentral wiki, including cataloging common knowledge for all projects in addition to project-specific knowledge bases
- Performing peer review on Space Decentral missions
- Design and development of solutions that are merged into to the Space Decentral program

SDN tokens will be allocated to open source tasks using smart contracts via the [Aragon Planning app](#) being developed by Space Decentral and Giveth<sup>12</sup>. The Planning app will enable FTL rewards to be distributed efficiently and fairly to collaborators via the blockchain, as each contribution will be tracked transparently with SDN. Top contributors will be also be recognized in a leaderboard, adding an element of cooperative competition.

The primary utility of SDN is:

- SDN is used as an accounting tool to determine the FTL rewards to distribute per contributor.
- For any technology developed within the network that requires a patent to protect it from trolling, SDN can be useful to determine the top inventors for filing patents.
- If any technology within the network is commercialized and generates revenue, such as offering spacecraft operation services or software subscription fees, SDN can be used to determine revenue share per contributor based on SDN holdings.

## 2.3. Network Governance

*Members* are active contributors to the development of Space Decentral and are the primary governing body that executes the majority of decisions. People can become members by:

- Purchasing and staking a minimum of **1000 FTL**
- Completing open source tasks and earning a minimum average of **10 SDN/week**, over 12 weeks

One-time use voting tokens will be generated per vote, per Member. To determine the number of voting shares, all contributors are expected to utilize a task management system where each task has an associated SDN value. Members receive 10 to 40 voting tokens, the amount of which is directly related to

---

<sup>12</sup> Giveth is an open-source platform that builds tools for distributing resources and encouraging transparency in decentralized communities.



the average SDN earned per week, over the previous 12 weeks. If a Member has earned more than an average of 40 SDN per week over this time period, only a maximum of 40 voting tokens will be allocated.

### 2.3.1. High-level funding decisions

*Explorers* are financial contributors that receive FTL, which provides privileges on high-level resource allocation decisions, such as “What percentage of our budget should we allocate toward the Moon vs. Mars?” or “What percentage of our budget should we allocate toward telerobotics vs. human spaceflight?”. These are considered program-level votes and do not require *Membership* to participate.

To become an Explorer, one must stake and lock their FTL used for voting for a minimum of one year, or have been holding it for at least one year. This will help protect programs from being manipulated by outsiders that want to “vote and dump”. Votes will be weighted based on the balance of FTL, multiplied by the length of time (in years),  $t$ , that they have held the tokens, with the maximum weight being 5. This governance model provides stakeholders who have contributed more financial capital and for longer periods of time with the privilege to influence the higher-level development of the Space Decentral program.

$$FTL_{power} = FTL_{balance} \times t$$

Equation 1. The FTL voting power is determined based on length of time held.

### 2.3.2. Project Development Process

The Space Decentral Project Development process is considered a *Curation Market* that includes a series of events that transforms an idea into a Request-for-Proposals (RFP) that seeks community solutions, which are then vetted to become projects added to the Space Decentral program. Members assist in the vetting process with peer review, and also in electing a Council that will help will validate solutions to become activated for both community crowdsourcing and crowdfunding.

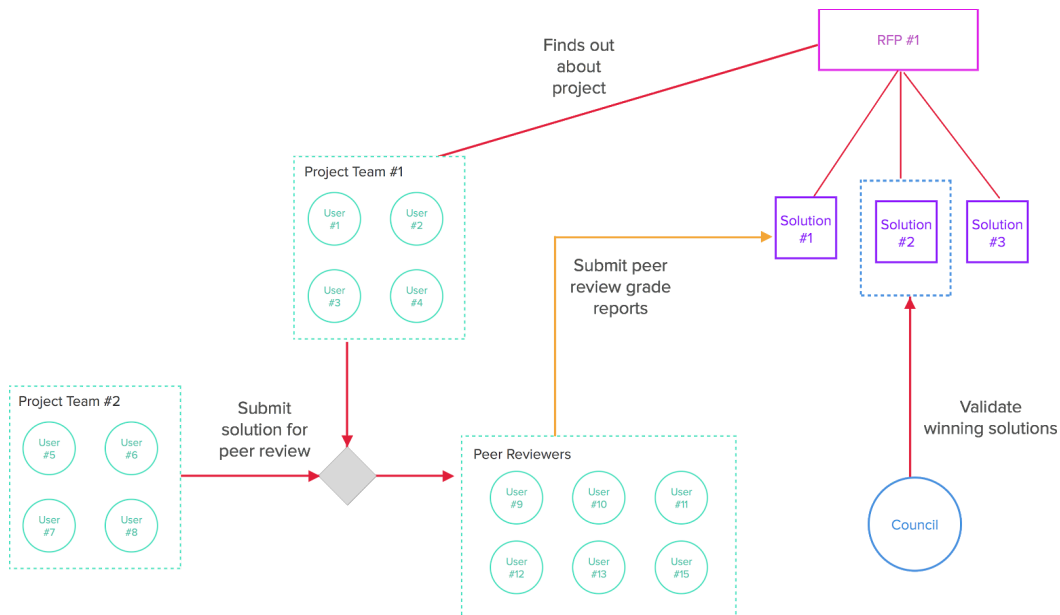


Figure 2.1. The Space Decentral project development flow.

### 2.3.3. Funding Solutions

For each vetted solution, there can be many possible paths for how it is funded for development. The best fundraising strategy will be determined per solution on a case-by-case basis. For each case, a collective decision will be made about how to proceed. Some possible scenarios are:

1. Space Decentral sells FTL in the token reserves to fund the solution.
2. Space Decentral funds the solution by rewarding project teams with FTL in the token reserves.
3. Develop child DAOs and have a separate token offering. This may be good for projects that have clear monetization or token utility strategies as opposed to purely research-driven projects.
4. Individuals directly fund the solution as a donation, using FTL, ETH, or a currency of choice.
5. The Project Team incorporates a Cooperative Corporation and offers co-ownership roles to Space Decentral members.
6. The Project Team incorporates a traditional shareholder corporation and offers early investment opportunities to Space Decentral members. (We have deliberately included this option because while Space Decentral is organized as an autonomous, decentralized organization, we recognize that some solutions and projects are best organized through a more traditional corporate form. Such solutions and projects will need to recruit and retain more traditionally-minded engineers, product managers and other contributors, many of whom require the stability of a traditional corporate form for a host of reasons.)

The point is that while token based funding seems more lucrative, there may be cases where teams want to contribute a solution or technology to the Space Decentral program, yet prefer traditional funding along with the licensing and revenue possibilities that such funding structures support and promote.

This has some important implications worth highlighting. First, Space Decentral is primarily interested in ensuring that space exploration is funded at a scale appropriate to the problem. As such, our main goal is to provide meaningful guidance and stewardship to the participants and contributors who constitute and enrich our ecosystem. Second, by providing participants and contributors with a flexible, mission-specific approach to supporting their space exploration endeavors, we will become and remain a hub to for entrepreneurs to find co-founders or seed funding for early stage, bootstrapped visions.

## 3. The Space Decentral Network

Humankind lacks a network where participants can collectively govern, develop, and fund large scale projects such as missions to the Moon or solving global challenges. The Space Decentral Network seeks to make participation in such projects more accessible by offering a suite of open source tools, data, and foundational knowledge. With a curated toolset, training material and a unified vision, being able to spend time working on our collective celestial dreams will no longer be a privilege, but a human right.

The core components of the Space Decentral Network are the Collaboration Platform and the Mission Design Kit (MDK).



- **Collaboration Platform:** The collaboration platform contains the basic social tools and knowledge repository. It will allow users to:
  - Join projects and participate in discussion boards
  - Create user profiles and share research publications
  - Find consultants or offer consulting services
  - Ideate, propose, fund, and develop projects
  - Participate in governance and decision-making
- **Mission Design Kit (MDK):** The MDK will offer scientific and engineering tools tailored towards distributed collaboration. Users will be able to develop custom apps & tools.
  - Standardized communication layer between applications and users
  - Models-based systems engineering tools
  - Integration with a tool optimized for open source hardware development
  - Integration with a space marketplace to provide seamless search for spacecraft parts

### 3.1. Social Network

A prototype of Space Decentral's social network is live at [spacedecentral.net](http://spacedecentral.net) which is the initial lobby where participants can meet and collaborate. The social network offers features such as user profiles, project discussion boards, and the ability to share and comment on research papers.

These features are part of a social utility, much in the same way that the telephone network is a social utility. This has two interlocking implications. First, Space Decentral will from time to time update its social network to make sure it facilitates efficient cooperation between users. Second, the platform will not be mined for personal information, and the activities of all Space Decentral's participants will be held in the highest confidence and never sold to third-parties for any purpose whatsoever.

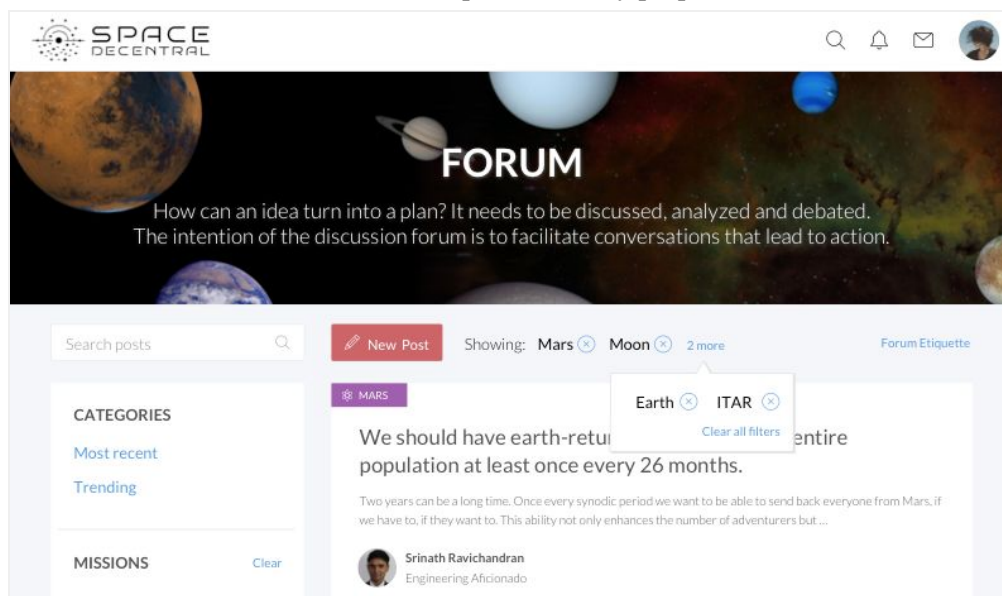


Figure 3.2. The Space Decentral forum enables the community to brainstorm and analyze ideas that can lead toward fully funded projects.

## 3.2. Aragon

Aragon is built on the Ethereum blockchain and provides the governance infrastructure to maintain Space Decentral's bylaws and operating procedures, in addition to providing collective decision making features. The tool will be capable of, yet not limited to:

- Managing voting privileges and committee creation
- Submitting and evaluating proposals for network or feature upgrades
- Approving budgets & financial transactions
- Settling disputes by utilizing arbitration services

### 3.2.1. Planning app

Aragon has developed aragonOS as a decentralized application (dapp) development framework to make it easy to develop interoperable apps belonging to their suite. Members of Space Decentral and [Giveth](#) proposed a new [Aragon Planning app](#), to tackle alternative models for incentivizing open source, and received a \$150,000 grant from Aragon for development. The Planning app will focus on a collaborative model, centered around multiple stakeholders that will enable:

- A toolkit of payout and budgeting tools for customized reward programs
- Transparent accounting for task-based payouts to either groups or individuals
- Group planning of permissionless tasks that require more complex payout structures

The grant provides funding for a minimum viable feature set, but Space Decentral plans to continue maintaining it, eventually adding complex features like gantt charts, task dependencies and kanban.

The screenshot shows a voting interface for a proposal. The proposal description is: "We have 100 ETH to allocate to our contributors this month. What percentage do we allocate per project?". The interface shows 24% voter participation (34% quorum required) and 100 voting tokens. Three options are listed: Mars (46 votes), The Moon (30 votes), and Europa (14 votes). A "Submit Vote" button is at the bottom. A red text "10 remaining" is visible at the bottom right of the options section.

DESCRIPTION	VOTER PARTICIPATION	YOUR VOTING TOKENS
We have 100 ETH to allocate to our contributors this month. What percentage do we allocate per project?	24% (34% quorum required)	100
OPTIONS		VOTES
Mars	<input type="range"/>	46
The Moon	<input type="range"/>	30
Europa	<input type="range"/>	14
		10 remaining
<input type="button" value="Submit Vote"/>		

### 3.2.2. Social Network Integration

The Space Decentral social network will be integrated with the vast open source development work occurring for the Ethereum ecosystem, especially Aragon apps. As previously described, Aragon offers many of the features needed for decentralized organizations such as financial planning, payroll, plus privilege management. Privilege and role management is at the core of Aragon, and is also a core need for operating a decentralized space agency.

## 3.3. Wiki

The Space Decentral Network will host a wiki, or knowledge base, which will enable users to collaboratively modify both a global wiki in addition to program or project specific wikis.

A global wiki will be maintained with information that can be useful for multiple projects, such as:

- **Guides:** Procedures for repetitive tasks such as securing a launch license or radio frequency allocation.
- **Foundational Knowledge:** Collegiate-level content to learn in depth, beyond Wikipedia.
- **Software:** Links and workflows for software and tools used during planning and engineering.
- **Templates:** Work is streamlined when templates are used for common project documents.

Each project (or program) on the Space Decentral Network will have a dedicated wiki that will store information such as technology roadmaps, trade studies, and literature reviews. The structure of the wiki will allow contributors to catalog project details for the public at large, displaying the status of project's progress and research. Wikis will also provide onboarding information useful for new project members, such as Project Documents, Project Plans, Technology Roadmap, Research, Datasets, and Team Information.

While most projects and programs will have wikis, some will not. As mentioned earlier, some projects and programs will elect to incorporate as a traditional corporation and seek traditional sources of funding to pursue the founders' specific goals. In those cases, whether a project or program hosts a wiki will depend upon the type of intellectual property the founders are developing, the appetite for transparency and risk of those founders (and their respective investors), and other variegated factors. Suffice it to say that Space Decentral has no immutable rule or norm with respect to the wiki hosting practices of those traditional companies incubated within our ecosystem.

### 3.4. Model-Based Systems Engineering

Adopting the Model-Based Systems Engineering (MBSE) methodology in a decentralized space agency provides both technological and financial advantages. The goal of MBSE is to provide unambiguous communication of complex systems between stakeholders and engineering project teams, improved quality in requirements and traceability, reduced risk through early/on-going verification and validation, and increased productivity across multi disciplinary teams. The benefits of MBSE are:

- Models, rather than documents, serve as the single source of truth in a project's knowledge base.
- A system model is a set of model elements which represent a system's structure, behavior, requirements, and/or parametrics, as well as the relationships between those model elements.
- Updates and changes within a model are automatically propagated to all other dependent models, allowing for consistency across the knowledge base, eliminating pain points with version control and configuration management.

SysMLpy is a Space Decentral community project to develop an open-source python package that will enable MBSE. The core of SysMLpy is an object-oriented programming paradigm for the Systems Modeling Language (SysML) - a general purpose modeling language that supports analysis, design, and verification of complex systems. The SysMLpy package is intended to serve as an extensible agile tool and language for systems engineers performing space mission analysis & design on the network. Extended use cases may include, but not limited to, automated requirements verification & validation, simulation-based testing, and failure modes & effects analysis.

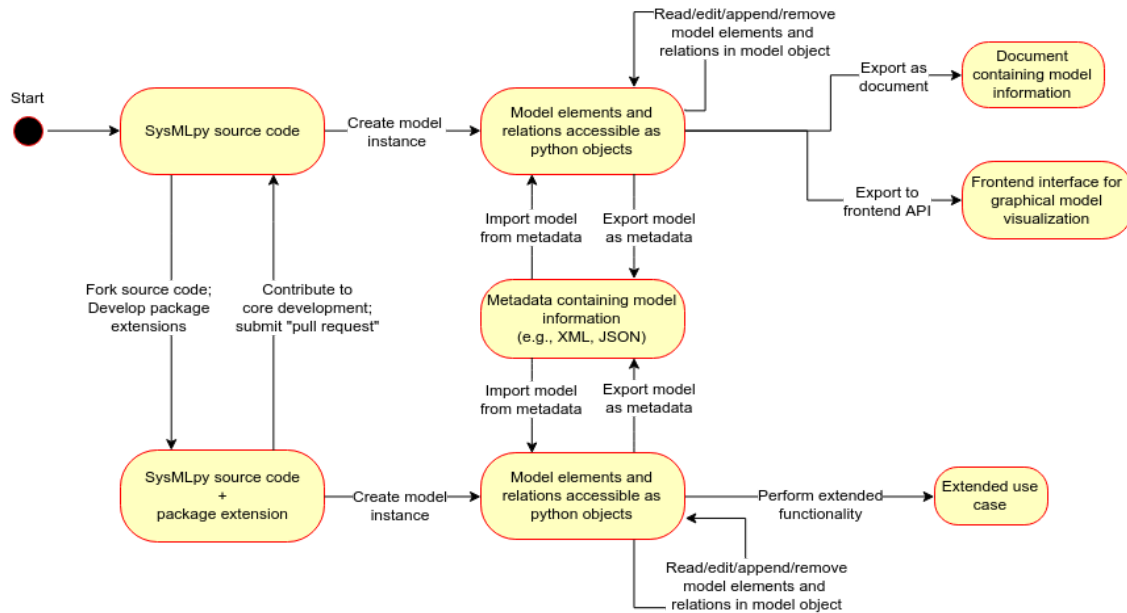


Figure 2.3 High-level state diagram of SysML.py project ecosystem

### 3.5. Open Source Hardware Collaboration

Space Decentral is collaborating with **Mach 30** to develop **Sliderule**, an open source hardware collaboration platform. The majority of hardware design takes the form of documents and users have come to expect the ability to develop documents collaboratively either in the form of wikis or the asynchronous tools like Google Docs. The goal of Sliderule is to provide a common platform capable of maintaining project integrity by storing the complete “source” of a hardware project (documents and software code) in a single storage system while providing familiar user experiences.

### 3.6. Space Marketplace

Space Decentral is collaborating with **Satsearch** to integrate a space marketplace into the Space Decentral Network. Satsearch is powered by a comprehensive search engine that indexes products and services within the space industry. Satsearch’s parametric engine integrated within the Space Decentral Network will support the development of space missions directly from project discussion forums. The engine will enable programmatic iteration through mission design concepts by matching requirements to suitable products and services. In addition to complex data querying and visualization. Satsearch’s modular open source astrodynamics library, **OpenAstro**, can also be adopted by tools built for the MDK.

## 4. Technical Roadmap

The tentative technical roadmap for Space Decentral Network is defined below. The roadmap will be open source and the community will be able to propose and prioritize features using a curatorial approach. Subsequent roadmaps will be released every 6 months in a public blog post.

<b>Table 4.1. Space Decentral Network Roadmap</b>	
<b>Release</b>	<b>Date</b>
<b>Space Decentral V0.1: Initial Prototype</b> <ul style="list-style-type: none"> <li>• Create and manage user profiles; follow and message users</li> <li>• Join programs and projects</li> <li>• Project discussion boards, with tagging and filtering</li> <li>• Share and discuss research publications</li> <li>• Collaborate on files with Google Drive integration</li> </ul>	Present
<b>Space Decentral V0.2: Aragon Integration, Search</b> <ul style="list-style-type: none"> <li>• Integrate Aragon for decision making, fund allocation, and planning</li> <li>• Ability to collect tokens by completing tasks</li> <li>• Create, manage and follow organizations/teams</li> <li>• Search by mission, person, organization, skills</li> </ul>	Q3 2019
<b>Space Decentral V1.0: Project Management Release</b> <ul style="list-style-type: none"> <li>• Ability to create and manage projects</li> <li>• Fully integrated task management solution</li> <li>• Peer review tools for project proposals</li> <li>• Manage global and project wikis</li> </ul>	Q2 2020
<b>Space Decentral V1.1: Git for Hardware Release</b> <ul style="list-style-type: none"> <li>• Open source hardware collaboration (Sliderule integration)</li> <li>• Offer or search for consulting services</li> <li>• Integrated space marketplace (Satsearch)</li> </ul>	Q4 2020
<b>Space Decentral V1.2: Systems Engineering Release</b> <ul style="list-style-type: none"> <li>• Model-based systems engineering tools</li> <li>• Wiki enhancements to support integrations Mission Design Kit apps</li> <li>• Marketplace that allows developers to monetize apps</li> </ul>	Q4 2021

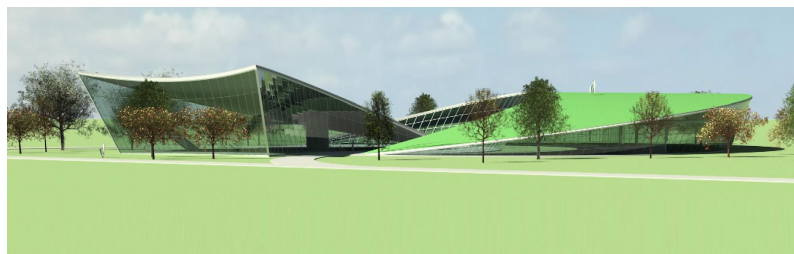
## 5. Team

For information about the people and organizations involved in Space Decentral, visit our team page:

<https://spacedecentral.net/team>

## Appendix A: Project Ideas

The following are possible project ideas that can be included in the Space Decentral program. Ultimately, the governance processes will be enacted in the Space Decentral Network to decide the focus areas, including suggesting new ideas and developing them into actionable project plans.



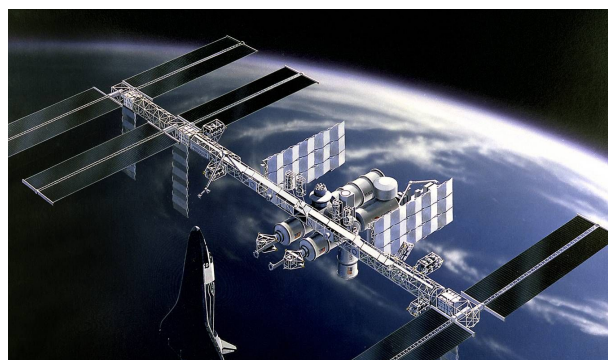
### Space Cooperative Manufacturing Labs

Space Cooperative Manufacturing Labs (SCML) is a contemporary 'fab lab' based on the latest digital machine tools intended to serve the R&D prototyping needs of Space

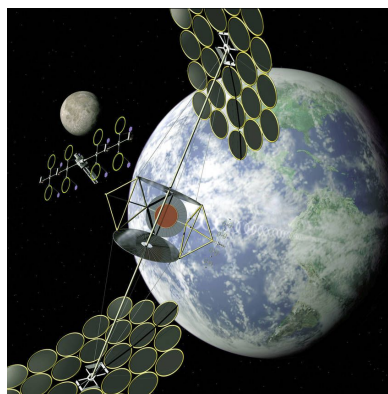
Decentral projects while supporting itself as a commercial contract fabrication facility. It would be open to the typical range of Maker-oriented services while also cultivating more advanced fabrication capability suited to aerospace and other advanced applications. It may also provide architectural fabrication services in support of Space Cooperative facilities construction and mockup development.

### Low Earth Luxury

Space stations have been envisaged since at least as early as 1869 when Edward Everett Hale wrote "The Brick Moon". The first to give serious consideration to space stations were Konstantin Tsiolkovsky in the early 20th century and Hermann Oberth about two decades later. What if there was a new space station that offered access to luxury, to all? The ride, sensations, experience, and view from low earth orbit (LEO) far



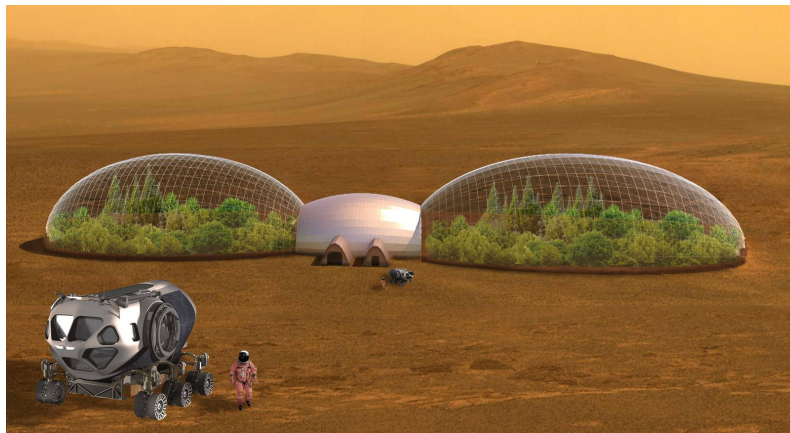
surpasses anything on Earth. In thinking through the design and comforts of this new space station, an economic plan should be created that can reduce the cost of access drastically, with each iteration. This may require serious leaps in additive manufacturing and advanced systems such as space elevators.



### Power-4-All

Space Solar Power (SSP) offers the prospect of a total renewable energy solution to global energy needs, offering social relevance to large-scale space development, the promise of open-ended growth, and the creation of a vast new space energy industry. Ultimate development of a comprehensive SSP infrastructure would be a multinational project calling for trillions of dollars and generations of work. But we propose to, at least, get things started with the practical demonstration of the concept and its principles through the creation of technology demonstrators based on conventional, smaller scale, satellite systems.





## **Martian Farms**

Agriculture is critical to both basic human survival in space and In-Situ Resource Utilization, plants and animals offering us an at-hand form of nanotechnology with which to turn space's very basic resources into useful materials with low energy. Horticulture is also crucial to the wellbeing of space settlers, both as a component of life support systems and in affording them a

means of making life in their enclosed habitats more comfortable and appealing. We anticipate this to become a central feature of space settler culture and lifestyle across the solar system. Mars presents unique challenges for this, however, with its extreme environment and toxic regolith chemistry. With manpower at a premium for early settlement, automation will also be necessary and it is likely that agriculture developed for ISRU purposes will be entire machine-managed long before settlers' arrival. New techniques, relating closely to the contemporary development of urban and vertical farming, will be necessary to make farming on the planet practical, sustainable, and productive. Through our Martian Farms program we will seek to research, develop, and demonstrate a variety of space agriculture systems for application in areas of Closed Environment Life Support Systems, industrial production, food production, and aesthetic uses suited to the types of structures anticipated for future space habitats.

## **Titanium Shores**

We propose the creation of Titanium Shores: a network of space-themed intentional villages on Earth that can showcase a life in space to actually aspire toward. We seek to explore the application of anticipated space construction and In-Situ Resource Utilization techniques to the creation of novel, beautiful, comfortable, habitats offering an appealing lifestyle. We also intend these communities to be the working facilities for our overall program, providing the workplace and workforce for the many projects and business ventures we anticipate necessary to the



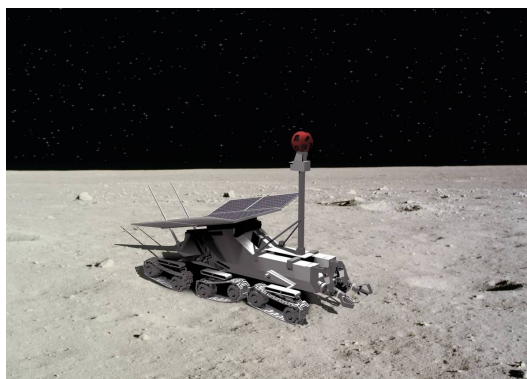
realization of this new positive vision of life in space. We will not be settling the solar system overnight. To be sustainable, that pursuit must be its own reward. And in these futuristic community settings we will seek to cultivate space development as not only a job or career but a lifestyle appealing in its own right, making it a powerful social/cultural attractors for a global space movement.

## Luna City

The establishment of a permanent settlement on the Moon is being considered by space agencies and interest groups, and some promising locations (e.g. near the lunar poles or in recently discovered large lava tubes) have been identified. We intend to participate in initial robotic and/or



crewed explorations finalized to the establishment of lunar habitats, and then in the development of Luna City, a large colony on the Moon. The Moon is the logical next step on the outer space frontier, and already identified business cases will soon unlock the funding needed for lunar settlement. Firmly persuaded that Luna City will be a reality in a few decades, we intend to play a role in all phases of its development, from conception to establishment and operations.



## LunaVeR

Advanced multi-functional units (rovers and robots) designed, built, launched, and deployed to one of the polar regions of the Moon selected for likely exploration and prospecting in view of future permanent outposts and settlement. The units will carry a range of equipment for scientific analysis, cooperative telerobotics, and resource assay, (e.g. searching for water, materials suited to ISRU, and possible exports like Helium 3). The on-board electronics will include data, image and video communications along with Artificial Intelligence (AI)

subsystems to permit partial automation. Additionally, the units will support direct teleoperation from Earth. The public will be encouraged to take part in ongoing explorations and operations with an innovative Virtual Reality (VR) system that will permit users on Earth to experience the Moon in near real-time based on returned data, images and video.

## Solar Regatta

The commercial viability of asteroid mining will depend heavily on the economy of their access. Solar sail technology potentially represents one of the most economical forms of in-space propulsion. Solar sails use the radiation pressure exerted by sunlight to move through space. Since the need for fuel is minimized, this results in cost savings due to the reduced launch weight. Solar Regatta would



seek deployment of a modest scale spacecraft to a series of accessible near earth asteroids serving as a solar sail technology demonstrator, supported by its potential as a science platform.