SpaceChain
White Paper

Space Exploration Program Based On Human Consensus

Version 1.0

Mission Statement

SpaceChain is creating a solutions-oriented platform to tackle our greatest challenges. With increasingly complex and difficult global challenges, we need to harness distributed intelligence to find comprehensive solutions. SpaceChain creates an open-source problem solving model that optimizes collective intelligence. SpaceChain will establish enabling conditions that incentivize the community of users, contributors and developers to strengthen the ecosystem.

SpaceChain will advance progress in these 3 areas:

1. Utilize space to better serve business and consumer needs,
2. Enhance access to space industry and technologies,
3. Accelerate the process of discovering and using space.

The SpaceChain team is led by Zuo Zheng as CEO and by former Bitcoin core developer and blockchain pioneer Jeff Garzik as CTO.

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ABSTRACT

SpaceChain aims to pioneer solutions for humanity to thrive in the coming space age. Combining blockchain technology with current astronautical resources and capabilities, SpaceChain will inspire more people to join the space community and advance the propers of space technologies together.

SpaceChain positions itself as a private space agency with an open network driven by collaboration and transparency, using blockchain based technologies. Activating the principles of decentralization and international collaboration in an already vibrant global community, SpaceChain will leverage the dynamics of tokens and private funding to accelerate space development.

SpaceChain was founded in March 2017 and has completed the development of SpaceChain Operating System (SpaceChain OS). SpaceChain OS has been successfully adapted to the Sparc V8 satellite operating system and achieved stable operations at the system level. The SpaceChain OS integrates Qtum blockchain technology and has established a platform for the development of space based applications. SpaceChain will be releasing fully functional satellites using the SpaceChain OS blockchain nodes in 2018.

By harnessing the power of tokens, private funding and leadership, SpaceChain provides on an open source platform to accelerate outer space development and settlement. We will choose and execute missions that fit this blockchain-based philosophy.

Part 1 Introduction

The Value of Blockchain & Space Technology

1.1 The Trend of of Internet Technology Innovation: Blockchain

The blockchain is a computer programming breakthrough that solved the Byzantine Generals problem. Also known as the Byzantine fault tolerance and an "error avalanche," this concept was a generalized "unsolvable" proof that led to roadblocks in software development. We have always needed a third party that demanded a payment to perform transactions or submit information to ensure that the transactions were accurate and create a reliable history. Blockchain enables trusted exchange without middleman. It creates a secure and resilient shared history which is accessible anywhere in the world. The first real-world application of blockchain is Bitcoin. Beyond cryptocurrency, blockchain allows us to program transactions and signals that allow for a decentralized, self-governing network with no middleman and executable contracts between machines called 'smart contracts.'

New technology can emerge in a manner that seems out-of-the-blue even though it is the culmination of decades of intense research and development by near-anonymous collaborators. Societies that encounter this technology when it is finally ready for users divide into two camps - idealists citing it as proof of a revolution or establishmentarians who heap scorn on and attribute harm to the technology. A small subset of society trained in technology develops, discusses, and explores its capabilities. At this point, commercial interests that look for new ways to do business usually intervene and mainstream products are built on the findings. Profound changes then occur in commerce and culture. This evolutionary arc has characterised technologies from the printing press in 1440, personal computing in 1975, the Internet in 1993 and most recently, blockchain in 2008.

Blockchain has received its share of news coverage in recent years and has captured the interest of technologists and economists since 2008. It solved the "avalanche of errors" that the open Internet presented where otherwise unrelated parties interact over an untrusted network. For the first time, information like digital signatures, digital contracts, digital keys to physical locks, digital ownership of physical assets like real estate and digital money could take place in a matter of minutes between untrusted parties with no need for a middle institution brokering history or ensuring honesty. And once the transaction is complete, it is final. Blockchains represent the Internet-wide distributed ledger (or shared history) and server for both information and commerce that cannot be rolled back (also known as immutable). Blockchain is the first true community powered super computer. Now, blockchain can power smart contracts taking complex legal, commercial, and cultural interactions programmed with no third party intervention to execute between machines like computers, sensors, or systems like grids.

1.2 Brief History of Telecommunication & Internet Evolution

The future is already here, it is up to us to equally distribute it.

A brief history of the Internet and discussion of the evolution of blockchain reveals a true revolution of our capabilities to understand, explore our world, and ultimately advance our species through technology. The combination of the Internet and the computer was a leap forward in our capacity as a species. Combining worldwide broadcasting, instant information dissemination, and platforms for collaboration without geographic location has opened new avenues for advancing a more transparent and collaborative world where breakthroughs can benefit all of humanity, all at once.

The Internet, in the context of our global telecommunications evolution, represents the most successful example of sustained, global, collaborative, decentralized development of information infrastructure. Blockchain, originated from Satoshi Nakamoto whitepaper, represents how the economic collaborative component is driving Internet evolution. The decentralized Internet today has become the widespread information and economic infrastructure and forms the true initial prototype of what has been called the National Galactic Information Infrastructure. As JCR Licklider of MIT wrote in a historic memo in 1962 discussing the concept of a "Galactic Network" of a globally interconnected set of computers through which anyone at any location could access and change data and programs, so did Satoshi Nakamoto envision a purely "peer-to-peer version of electronic cash" that would "allow any one party" to send value to anyone else they chose without a third party intermediary on a series of computers running software called nodes. Tog Ethereum protocoler, with advances in computer programming on blockchain with programming and smart contracts like Qtum, we finally have the capability to fully transform entire industries.

SpaceChain is advancing the evolution of the decentralized Internet to the next level by essentially inventing true decentralized multi-tenant software capabilities and networked space on a satellite system. SpaceChain is building a universal OS that can be used across any satellite to transform satellites into multi-use computers rather than the single use satellites that are prevalent today.

1.3 Technical Platforms Have Led to the Era of Decentralized Space Tech

Currently the international space industry has two prevailing problems that hinder the development of this industry as a whole:

- **First, are security issues, which mainly exists between countries;**
- **Second, conflicts of interest between commercial corporates and state-owned companies.**

The first issue is being addressed by diplomacy and cooperation encouraged by leaders and communities through collaboration and open source technology. SpaceChain addresses the second issue. Space technologies have always been closed source and highly guarded. The problem is that in this type of environment, it is difficult for new businesses to utilize the existing infrastructure, and access workable knowledge outside of the organization, and for countries to audit projects. Businesses have also avoided space technologies due to the high capital requirement. Unlike other software arenas, it is not possible to build space-based applications with low budgets. Lack of human capital, specialized professionals, and limited talent are also major constraints.

Current space projects are dominated by governments, so they are hindered by external factors and become inefficient. Research and innovation are under-resourced. Purely commercialized space projects like SpaceX deserve more attention and are indeed seeing high valuations from very modest upfront investments.

At the dawn of Internet age, startups benefited greatly from the traditional venture capital model. Typically, a business is owned by key members of the company and the shareholders keep working in the company and make contributions. Innovation and creativity of entrepreneurs in technology were able to thrive and succeed with the support of venture capital. However, for companies that require longer time and larger initial outlays for research and development (R&D) such as space exploration, VC model is not necessary the best option. Many technologies based on the VC model would be announced as unworkable when they need more time and capital investment to succeed and reach markets to thrive.

For example, traditional satellite research and development cycles may drag across many decades. Once the funding for research is ready, it takes months to complete research and development before teams can apply for additional funding for next stages to get technologies to market. We have seen projects spend 5 years stuck in this cycle only to have their satellite prototype unable to launch.

Tokenized fund raising provides flexibility and progressive ways to support such projects. With sufficient funding, the project can recruit the best talent, enhance internal efficiency and focus more on the long-term R&D. This is very important within space technology, where setbacks are to be expected and part of the cost of development. Hence, traditional VCs may not be willing to take the risk and leave this space to us to achieve somEthereum protocoling great under a crypto-economic model. Long-term feasibility and timeframes can be reached with smart contracts to lock and hold token sale funds with a clear roadmap and timeline for deliverables.

SpaceChain is a private space agency that will partner other organizations where crowdsourced funding can be employed on collaborative projects and smart contracts employed to lock in funds till certain software markers are met to unlock them. SpaceChain's decentralized application platform built on satellite technology will begin the opening of this industry and community. SpaceChain will promote SpaceChain OS to traditional space industry satellites, such as communication and navigation, among others. Also, SpaceChain will promote SpaceChain verification system to better aggregate and utilize current space resources in an open source, audited, and secure system. SpaceChain OS can be developed and used by different satellites and different organizations wherever they are located in the world.

1.4 Introducing SpaceChain

SpaceChain aims to establish a network infrastructure that is very much like the public telecommunication infrastructure we share globally. This network infrastructure will not involve any military or government bodies, and is only for use by the general public and by private individuals and organizations. People can access, build, and interact like they do on the Internet. SpaceChain's first application is like a mobile app development platform. With blockchain software, we provide an application sandbox or app firewall so that independent apps may be uploaded to the satellite similar to apps on a mobile application layer. Until now, inter-satellite links (satellite to satellite communications) present a fundamental hurdle to a decentralized mesh network.In order to have this resilient mesh network, you first need satellite-to-satellite communication that is blockchain based.

However, there are still security issues related to commercial satellites such as data integrity and safety of the satellite. SpaceChain invented SpaceChain OS which is a sandboxed blockchain technology that is built upon StylixOS and Qtum. This system will ensure the safety of data running on the satellite as the programs are operated at the immutable and completely public blockchain layer.

The aim of SpaceChain OS is to enhance hardware capability while maintaining security.   SpaceChain OS can adapt to global hardware systems and cater to varying satellite technologies. In order to ensure the safety features and functions of SpaceChain OS, the foundation will carefully evaluate each generation of SpaceChain OS through in-orbit testing, and it will provide the community with reliable open-source code and results. For more detailed SpaceChain OS information, please refer to "SpaceChain OS Whitepaper".

Internally, SpaceChain will tokenize and equalize technology and resources. This will optimize use of available technology and resources, and provide the space industry with an efficient and reliable consensus on value and collaboration to begin.

SpaceChain was funded in March 2017 and has already provided solutions in the space frontier. SpaceChain OS development with infrastructure design and operating system started in November 2017. SpaceChain OS has been successfully adapted to Sparc V8 satellite operating system, and has achieved stable operation at the smallest system level. The migration from Qtum blockchain technology has achieved basic sandbox function, and the EVM Virtual Machine is on track to being developed in 2018.

Part 2 path
Realizing the Value of Blockchain Tech

2.1 General Overview of the Structure of SpaceChain

2.1.1 Upcoming Milestones:

- 2018 March: complete all software development
- 2018 April: complete operating system migration from the Zynq hardware system
- 2018 September – October: complete running space verification of Zynq hardware
- 2018 December: complete the R&D of first generation space chip based on RISC-V command
- 2019 March: complete R&D of second generation hardware system and SpaceChain OS
- 2019 May: complete in-orbit testing of second generation SpaceChain OS
- Dates TBD: R&D of future generations of hardware system

2.1.2 Future Plans

SpaceChain OS smart satellite system implementation and design of SpaceChain satellite hardware standards:

- 2017 December: completed the design of first generation satellite platform based on CubeSat.
- 2018 May: complete load design.
- 2018 September: complete the production of satellites.
- 2018 October and November: launch satellites.
- 2018 November and December: complete testing of the satellite's basic functions.
- 2018 December: conduct software security test.
- 2019: launch 100kg second generation satellite equipped with latest OS, and complete function testing; publish smart satellite hardware standards with partners.
- 2020: launch one more second generation satellite, and achieve in-orbit upgrading of software without changing satellite platform; use better-performing hardware to design and build third generation satellite.
- 2021 – 2022: launch 4 third generation satellites, and form a space network with previous satellites to support application development.
- Further: move forward with the hardware and software upgrades while conducting in-orbit testing.

SpaceChain's goal is to integrate blockchain nodes on satellites to add a new dimension to the core framework of distributed ledgers. SpaceChain's node satellites will bring blockchain to space and make use of existing space technology to build a worldwide distributed application layer. We are pioneering a new layer of infrastructure for the Internet of blockchains by taking advantage of space resources. SpaceChain's platform features data collection, computing, applications, and storage. SpaceChain uses satellites as its operational nodes for realizing direct on-satellite data processing and secure in-space data storage through cryptographic technologies such as quantum communications. People everywhere will have access to this layer of infrastructure, just as they do the Internet wherever they travel with their various devices.

SpaceChain will bring satellite technology beyond a repeater model (RM).Our partner will provide better language than traditional RM. RM essentially describes how most current satellites function. They usually take a signal from the ground and then simply broadcast live satellite tv or provide GPS or one other function at a time. RM allows very little actual data processing to take place on the satellite. SpaceChain's system will change this model to a model that is multi-tenant with flexible software capabilities. Most satellites are single owner and thus single operator and single tenant. With SpaceChain, for the first time combining existing space technology and blockchain, we are able to create multi-tenant as a new user model and a new economic model for satellites.

Additionally, SpaceChain has created a system to drive down the cost of space applications to allow teams and investors to do more development with their money. SpaceChain will combine and contract the cheapest rocket launches globally with multiple payoffs per rocket. As more cheap spacecraft reach orbit, we are able to have many redundant nodes in the network launched globally. Thus, our network also self-heals. We can see a mesh network in space of many satellites where loss and replacement will enable the network to be low cost and resilient in a "many plus cheap" model. These rockets will take off from many different sites and be ensured secure by open source, auditable practices that the larger respected technology and space communities can see and support. SpaceChain will employ this mEthereum protocolod to projects we undertake in space, including asteroids or planetary bodies exploration where we can send out many remote drones powered by apps run on satellites around celestial bodies in our planetary system. Hardware design also involves internal redundancies especially as spacecraft using our 'smart' satellites will have redundancy of computing.
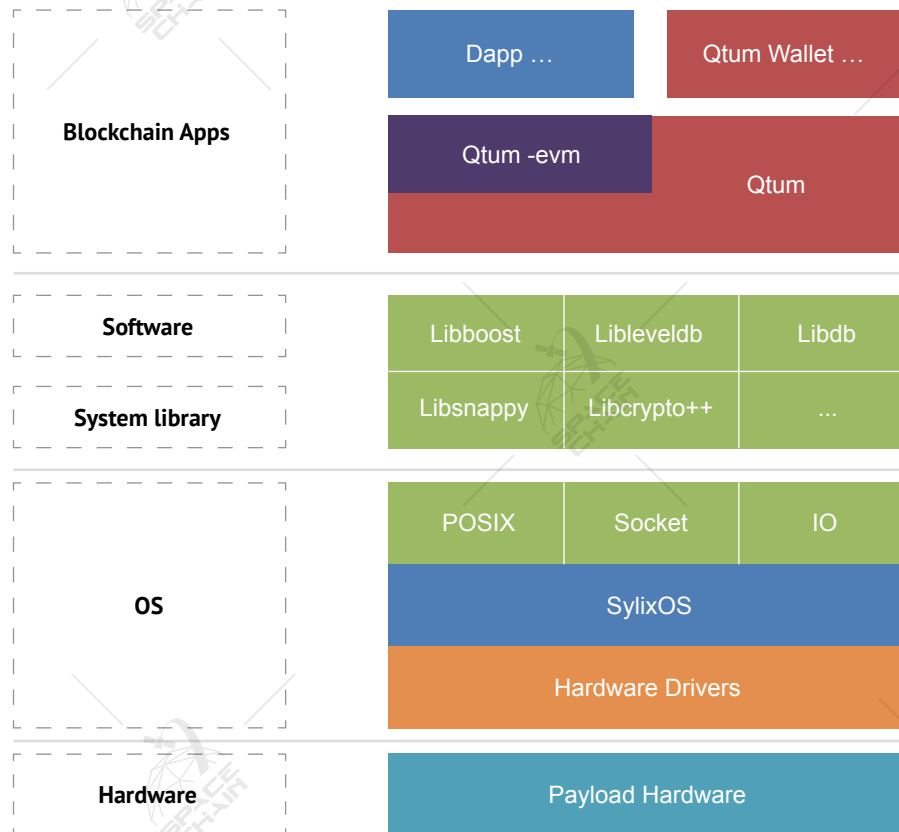
Figure of Overall SpaceChain OS Structure
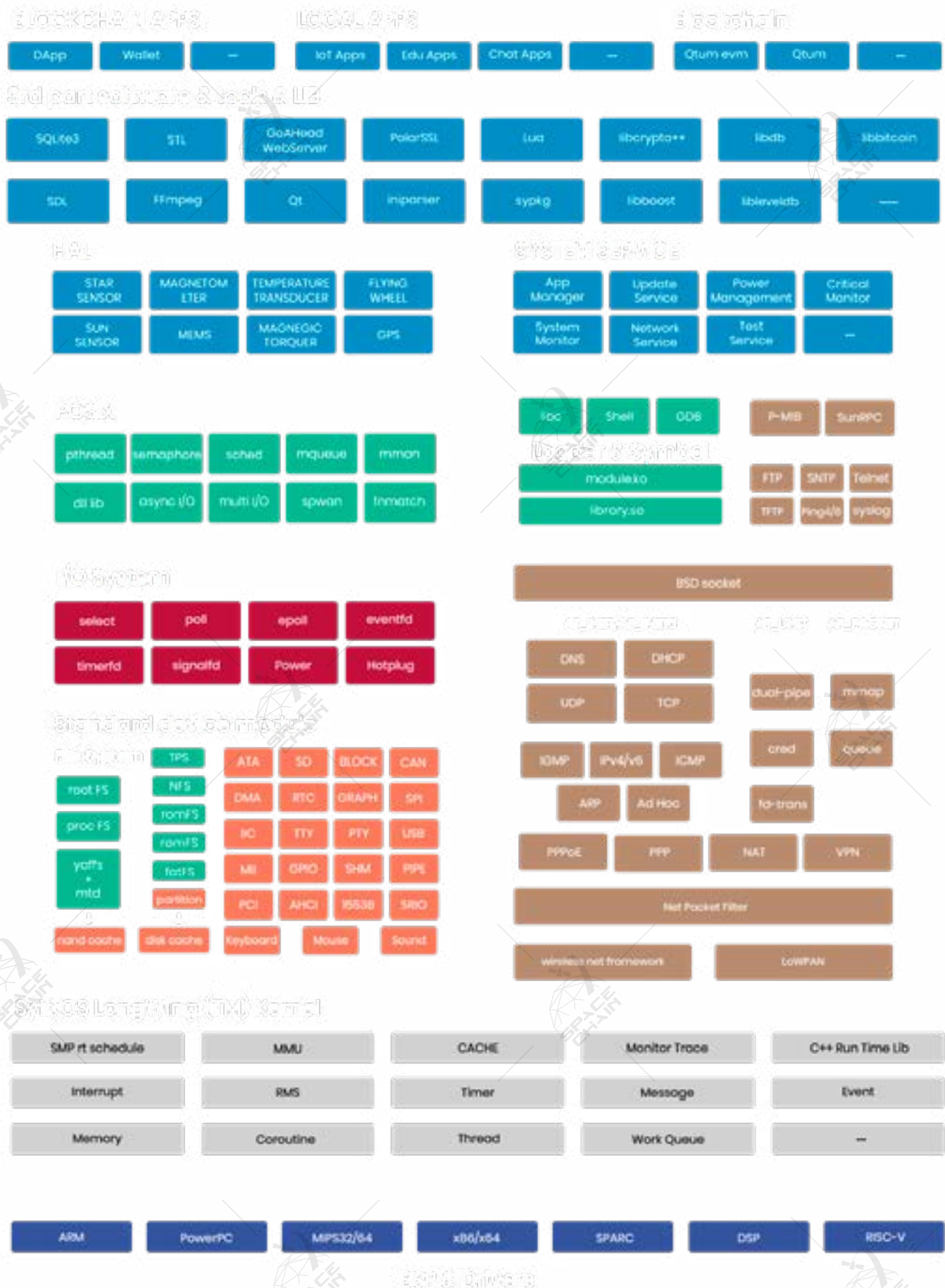
2.2 The Hardware of SpaceChain: Future of Internet Infrastructure

What follows is a technical breakdown of SpaceChain from both the hardware and software perspectives.

The key function of the blockchain payload is processing application safely on the satellite. To achieve this goal, the payload uses SpaceChain OS to provide the software environment to applications. Blockchain sandbox provides a safe environment and a high performance chip to guarantee all the software above. The main logic structure is shown below.

Blockchain Apps	Dapp …	Qtum Wallet …
	Qtum -evm	Qtum
Software	Libboost	Libleveldb	Libdb
System library	Libsnappy	Libcrypto++	…
OS	POSIX	Socket	IO
	SylixOS	
	Hardware Drivers	
Hardware	Payload Hardware	

The beta vision payload hardware is on-board CPU and FPGA.

The Payload provides a powerful processing module for Blockchain applications and OS. The module contains two main parts:

- A very powerful ARM/FPGA on-board computer (OBC) designed as an efficient system for space application
- The power system is divided into two, one for ARM and one for FPGA
- Dual ARM Cortex A9 MPCore up to 800 MHz
- 1GB DDR3 RAM/4 GB storage
- Powerful FPGA module – 125K logic cells
- Precision milled anodized aluminum heat sink to control thermal load and provide EMI shielding
- Operational temperature: -40°C to +60°C
- PCB material: 22 layer glass/polyimide
- IPC-A-610 Class 3 assembly

z7000

In the future, blockchain payload will be rapidly upgraded to meet the future demand of blockchain applications. However, the existing processors have different problems that will slow the update rate down. For example,
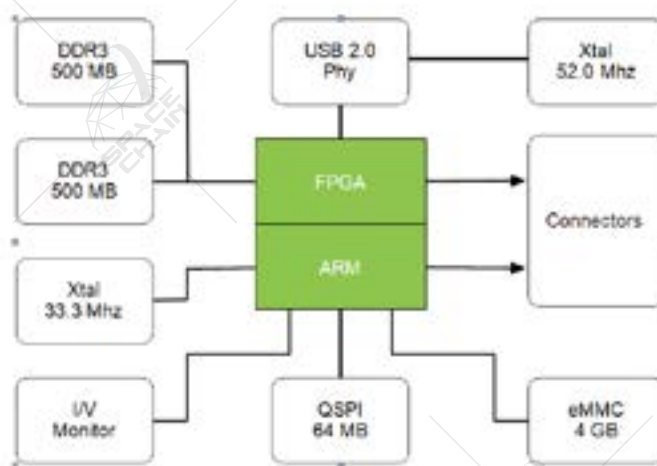
- x86 is complex and not open source, the internal structure of the processor is not clear, there may be a back door,unable to be safely controlled;
- ARM has expensive intellectual property costs that will reduce user number;
- SPARC is product of commercial companies; whole technical system has long-term sustained support risk;
- MIPS and Power belongs to commercial companies which are focused on making profits, and their business model may not promote democratisation of technology. It is easy to have conflicts of interest with upstream and downstream companies; it may lack good industrial chain ecological support.

To satisfy the update rate of blockchain payload, we need an open source processor project. In 2010, David Patterson, a distinguished professor at UC Berkeley, launched the RISC-V processor open source project, which has great properties like:

- Free authorization, no patent barriers exist
- Permanent non-profit foundation to dooperation management
- Complete alliance of upstream and downstream industry
- Two international workshop meetings each year

At present, there are 50 core member companies, 270 companies and 29 universities participating in the RISC-V open source project. In the future, SpaceChain will develop a blockchain payload processor under the open source RISC-V ISA (Instruction-Set Architecture). The blockchain payload will be updated in performanceand reliability.

Block Diagram

Functional description

Microcontroller	The OBC is based on a Zynq-7000 All Programmable SoC (AP SoC) devices integrate the software programmability of an ARM-based processor with the hardware programmability of an FPGA, enabling key analytics and hardware acceleration while integrating CPU, DSP and mixed signal functionality on a single device.
OS	The OBC has a default SpaceChain OS installed.
I2C Interface	OBC has an I2C bus supporting bidirectional data transfer between masters and slaves, multi- master bus, arbitration between simultaneously transmitting masters without corruption of serial data on the bus. Serial clock synchronization allows devices with different bit rates to communicate via one serial bus and is used as a handshake mechanism to suspend and resume serial transfer.
CAN Interface	One of the main interfaces of the OBC to communicate with other subsystem hardware is a Controller Area Network (CAN) bus interface. It is a serial communications protocol that supports distributed real- time control with a high level of security.

2.2.1 Intelligent Satellites

SpaceChain will build several LEO satellites to establish the early satellite network and a basic satellite application platform. The satellite's basic characteristics are shown below:

Characteristics	Parameters
Weight	10~100kg
Power	≤200W
Life time	5 years in orbit
Payload	≥20kg,≤100W
Orbit Height	500~2000km

Satellites will have two parts: platform and the payloads. The platform is responsible for supporting the payload in space and the payload works to realize all the defined functions.

Satellite Platform

Constitutes	Functions
Main structure & mechanism	Mechanic support for all the equipment;
Integrated management unit	Processing attitude/orbit/thermal control program to maintain the attitude/orbit state of satellite to ensure it point to appointed place and the temperature of all the equipment in a limit section;
Sensors	Collect key data to support attitude/orbit/thermal control program;Provide necessary data to payload;
Actuators	Execute the order from attitude/orbit/thermal control program
Solar panel & battery system	Provide electricity power to all the equipment and payload;
TT&C system	Send monitoring data and remote sensing data to ground station; Receive and execute the order from ground station.

Payloads

Payload	Constitutes	Functions
Blockchain payload	High performance chip(PSOC)	Provide enough calculate ability to support OS and apps
	Memories	Data storage/software code storage/ Blockchain account book storage
	Open source operation system	Provide an OS to support all the applications and smart contracts
Communication payload	Satellite-user terminal communication payload & antenna	Bi-direction communication with user terminal
	Inter-satellite communication payload & antenna	Real-time communication
	Satellite-ground station communication payload & antenna	Data transmission to ground station, OS update/applications update

Structure & Mechanism

The basic purpose of structure & mechanism design is to contain all the equipment, to guarantee the satellite's function and to satisfy the install demands of equipment. This provides a safe inner environment during launch by rocket. All of these purposes must be satisfied in limit space and limit weight. The structure shows below.

Integrated Management Unit (IMU)

The integrated management unit is the core of the satellite control components, responsible for coordination and control of all equipment to realize TT&C function, attitude/orbit control, auxiliary management of payload, and information management. Its main functions include:

A) TT&C: it receives the data directly from TT&C transponder and executive orders, sends telemetry data directly to the transponder to send down to ground station;

B) Attitude/orbit control: collect data of all attitude sensors, and perform attitude/orbit control program, control attitude/orbit actuator;

C) Auxiliary management of payload: receiving data and order from ground station to control Blockchain payload; Control the communication payloads;

D) Information management: collect and process the whole satellite's data, including attitude/orbit information, location information, parameter and state of each part, and send it to TT&C transponder.

The main parts of IMU and their functions show below:

Name	Functions
OBC	Attitude/orbit control calculation, data management, provide analog AD/DA interface, the state acquisition interface and the command output interface, temperature acquisition, analog quantity acquisition, instruction driver output; Provide power control output interface and implement active temperature control of thermal control unit;
Command and telemetry processing module	Realize TT&C communication, data interaction with OBC, direct instruction, and decryption function of upstream and downstream band;
Secondary electric power supply system	Receive premier power supply and generate the secondary power required by the DC/DC module;
Data storage & interface board	Provide the data input and output interface of sensors and actuators; Data storage and playback, software and operating system recovery.

All the IMU software is modularized and developed based on SpaceChain OS. SpaceChain OS will strengthen the operating system of the satellite platform. The main structure and their functions are:

Name	Functions
Housekeeping module	Module is responsible for: • management of application software according to the different stages of system functions and working mode, the software of the ground reconstruction instruction (by injection) for scheduling management, to complete sat-ellite task for different stages • Parameter setting and mode conversion • Payload control according to ground instructions.
Fault detection and processing module	Monitoring of other software, and when the task software is ab-normal, it can be detected and handled.
Orbital processing module	Receiving the orbital data, selecting the orbital data source, pro-cessing and extrapolating the orbital data to the Attitude/orbit control software. Orbital data sources: GPS track data and ground injection track data. Module is responsible for: 4.-GPS data analysis 5.-Orbital mode selection 6.-GPS mode processing 7.-Injection mode processing 8.-Fault mode processing is completed
Attitude/orbit control module	The Attitude/orbit control module is used to ensure the attitude orientation and orbit position to meet the mission requirements. Module is responsible for: 9.-Determine the working mode 10.-Analysis and pretreatment of sensor measurement in-formation 11.-According to the work mode of attitude control, choose the proper attitude/orbit control algorithm 12.-Call the correct control algorithm to generate control instructions and output 13.-Adjust the attitude/orbit according to the ground rail control plan 14.-Realize basic system fault handling
TT&C module	Telemetry module's task is to collect, framing, storage, sending real-time satellite sensing information frame and delayed remote sensing information frame, and to manage TT&C transporter ac-cording to the measurement and control ephemeris and work mode of information and to send telemetry data in the meas-urement and control segment.
	Tele control module is responsible for the receiving, resolving and processing of the upward data (including the indirect remote control command and injection data).

Sensors

Sensors	Data type	Functions
Gyroscope	Angle °	Attitude information
Magnetometer	Magnetic intensity T/GS	Magnetic field information
GNSS	Position	Satellite position
Star sensor	Star direction	Reference system
Sun sensor	Sun direction	Reference system
Thermal sensor	Temperature	Thermal control input

This data could also be read by any application processing on Blockchain payload of the satellite.

Actuators

Actuators	Data type	Functions
Momentum wheel	Moment	Change attitude
Magnetorquer	Magnetic induction force	Change attitude
Propulsion	Propulsion force	Change orbit
Thermal control	Heat flux	Thermal control

To secure the satellite, access to all these actuators by applications developed by non SpaceChain team is forbidden.

Solar panel & battery system

| Main part	Function	Parameters
Solar panel	Photovoltaic conversion, recharge battery	Triple junction GaAs space solar cells
Battery	Energy conservation	Lithium/60Wh
ACU	Array condition	6PV input channels, rate 2A
PDU	Power distribution	9 output channels

To secure the satellite, access to all these actuators by applications developed by non SpaceChain team is forbidden.

TT&C system

TT&C system contains two parts: transceiver machine and antenna. The main parameter shows below.

Characteristics	Frequency	Modulation
Up	VHF	AFSK
Down	UHF	BPSK

Entire Satellite Mechanism
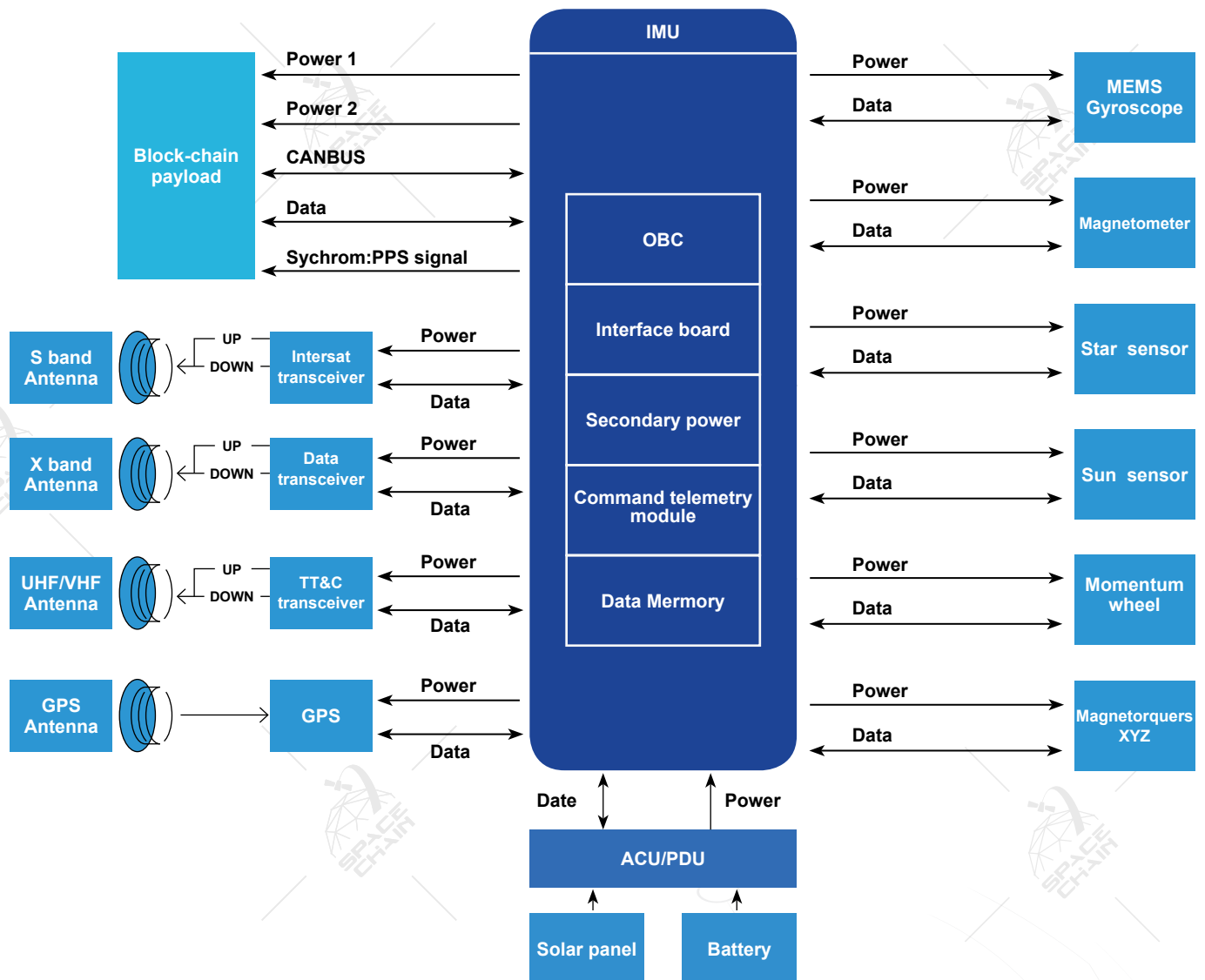
2.2.2 Mesh Networks and Satellite Installations

The SpaceChain satellite system contains 5 parts: satellites, ground station, user terminal, cloud services, core network. All these five parts take charge of their own functions:

Satellites

- Bi-direction communication with user terminal
- Data transmission to ground station, data update\TT&C from ground station
- Inter-satellite communication makes the whole system real-time
- Processing normal/blockchain applications
- Processing smart contracts

Ground station

- Receive data from constellation and send them to cloud service
- Transmit OS update code/application code to satellites
- TT&C job

User terminals
- Interface between the SpaceChain system and the end user
- Execute user's command/receive data which user demand
- Processing normal/Blockchain applications and also smart contract
- User could be human/animal/vehicle/machine/plant etc., basically everything who need and who want this network

Cloud service
- Mass data processing
- Decentralized cooperative work

Core network
- Link all the ground stations
- Link the SpaceChain network to other network (caber \ cellular network etc.)

Ground Station

The ground station is responsible for feeder link between satellite, user terminal management, channel management and operation control; as well as the operation management of maintenance system. The ground station includes the TT&C system and operation control system.

1) Operation control system

The operation control system includes: data acquisition gateway station, data acquisition center, user terminal management and user service system. The system is responsible for the preparation of satellite mission plan, completing the dispatching management of the user terminal which is responsible for monitoring the satellite. This system is also responsible for receiving, processing and distributing the user terminal data.
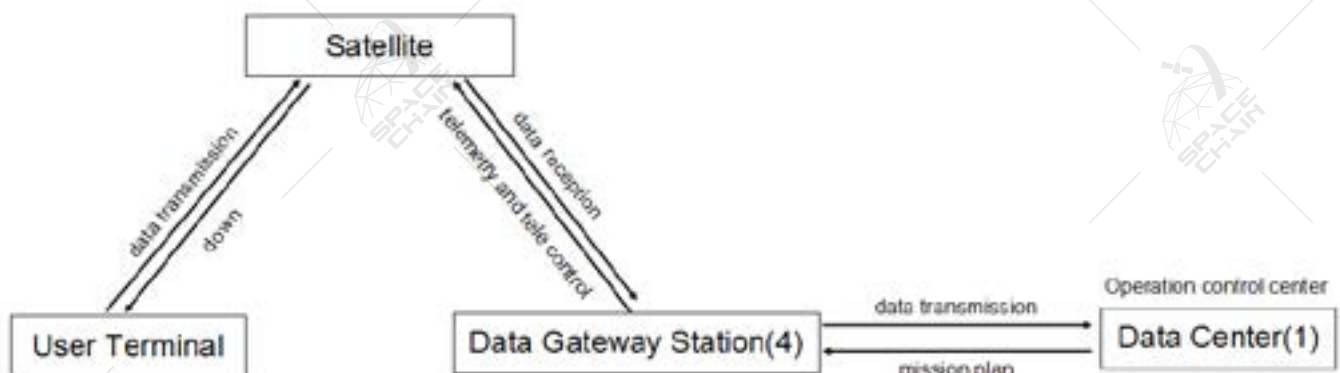
2) TT&C system

The TT&C system combines VHF/UHF frequency measurement and GPS/BD - 2 auxiliary togEthereum protocoler, isolating up/down link by TDD, using rod form as TT&C antenna, realizing auxiliary orbit measurement by GPS/BD antenna and receiver.

3) User terminals

The User terminal is the interface between the SpaceChain system and the end user. It can execute user's commands and receive data which users demand and process applications and smart contract. The User can be human, animal, vehicle, machine, plant etc.

Cloud Service & Core Network

Main Parts	Responsibilities	Description
Cloud service	-Data processing -Data base	Using Blockchain technology to realize a decentralized cloud service
Core network	-Link of ground stations -Link SpaceChain system to the other communication system	Make the SpaceChain system a whole network and to be an interface be-tween other network system, like cellule network/cable network etc.

2.2.3 Qtum & StylixOx: SpaceChain OS

SpaceChain will provide funding and support for startups in the space industry in terms of technology, resource, and human capital. At the same time, these startups will use SpaceChain's verification system so they can quickly commercialize and produce products and services thatsociety needs globally.

The most effective solution to alleviate the expense problem will be to encourage cooperation between companies while also significantly increase the usage rate per satellite. In the same way the mobile phone industry was revolutionized when Apple introduced the iPhone with its exceptionally usable iOS, SpaceChain introduces a universal space iOS for space software development. The space industry needs a stable and versatile operating system, and SpaceChain OS is the solution.

Developers can create applications using the environment provided by SpaceChain OS. SpaceChain OS greatly lowers the difficulty of developing space applications while putting the resources like infrastructure to best use. Additionally, SpaceChain OS deployed sandbox technology ensures an interference-free environment for the applications.

Our introduction of SpaceChain OS powered smart satellite system will lower application costs. Upon the success of in-orbit testing, SpaceChain Foundation will launch several customized LEO satellites with their partners that are equipped with communication, camera, sensor, gesture and orbit control functions. Please refer to "SpaceChain Satellite Whitepaper" for more details. By launching these low-orbit satellites, a simple network is formed to provide developers the platform needed to start creating software. Establishing standards for smart satellite hardware and achieving standardized production of satellite parts will make greatly reduce the cost of producing a satellite and spur organic growth of the industry. This will ensure an economically viable ecosystem.

To simplify the development process, there will be a development SDK for SpaceChain OS. It provides a modular development environment that is similar to Java Script. By being fully open-sourced, more people will join the community and create a vibrant development community.

There will be tutorials for software development, and space hardware developer board for people to try out developing application for satellites.

Partnerships with well-known universities through lab establishment, research, open courses, technical forums and other educational resources. SpaceChain Foundation will provide free resources for universities to take part in this exciting journey by providing free developer boards, hosting hackathons, and community development on SpaceChain OS globally.

SpaceChain Foundation wishes to establish an eco-system where every contributor is fairly rewarded. Through such an economic model, more resources will be attracted into the space industry and more people will join the grand adventure of space exploration.

SylixOS is an open source RTOS (Real-Time Operating System) project. SylixOS has been applied widely in various fields such as defense and security, aeronautics and astronautics, high speed railway system, smart grid, industrial automation, and motion control etc.

In the SpaceChain project, SylixOS is used in the satellite platform to manage hardware resources and in the Blockchain payload to provide standard API interface and various system features for applications.

Part 3

Tokenomics and Blockchain Structure of SpaceChain

3.1 SpaceChain Bottom Layer: Qtum

The SpaceChain OS framework is divided into a Blockchain application layer that includes these layers:

- Mainly Qtum provides the basic service API for smart contract and block chain application;
- Qtum also offers a sandbox to guarantee the safety of applications processing;
- Compatible for Ethereum protocol (ETH) ereum EVM to process Qtum smart contract；
- Open for any public blockchain and their smart contract application；

SpaceChain requires a blockchain technology with low power consumption, high stability, and strong expansibility. Qtum uses a PoS (proof-of-stake) consensus mechanism whereas most other blockchain technologies widely use PoW (proof-of-work) such as the Bitcoin blockchain and Ethereum protocol. PoW has high requirements for energy and hardware resources to work well so it is not suitable for satellite systems. Qtum has fully absorbed the accumulation of both the Bitcoin blockchain and the Ethereum protocol. Thus, Qtum technology has advantages in areas from code stability to third party support. In addition, Qtum uses UTXO technology to increase the network expansibility so that it can support a simple payment protocol SPV and the Lightning Network, and fully support the EVM smart contracts as well. So Qtum meets all the demands need to fully run blockchain technology on satellites. SpaceChain chose Quantum Chain Technology (Qtum) from the beginning after doing a complete technical assessment of both hardware and software necessary for space technology development.

In addition to the above reasons, Qtum has many unique innovations. Qtum is the first smart contract platform based on UTXO and MPoS. It has pioneered the integration of the advantages of both BTC and ETH ecosystem. It has proposed and implemented the following core technology innovation:

- Qtum uses efficient and secure MPoS consensus. As compared to Proof-of-Work(PoW) that is widely adopted by other blockchain technologies, MPoS consumes less energy and has no requirements of high-end hardwares. MPoS allows any coin holder to be able to mine the coin without wasting much electricity by staking them in the wallet. More importantly, MPoS can provide a more secure consensus and subsequently raising the cost of cyber attacking, by adjusting the height of block rewards and the allocation of transaction fees.

- Qtum combines the strengths of both Bitcoin and Ethereum, making it more stable in terms of code structure. In addition, its adaptability towards third-party applications gives it extra edge over other blockchain technologies.

- Qtum extends the UTXO technology of Bitcoin, and enhances the scalability of its network. It supports technologies such as Simple Payment Verification (SPV) and Lightning Network, as well as smart contracts that utilizes EVM virtual machines. Qtum designed and implemented Account Abstract Layer (AAL) technology, realizes conversion of UTXO model and EVM smart contract account model. Then developers can use EVM to develop smart contract without paying too much attention to the details of conversion of UTXO model.

- Qtum invented Decentralized Governance Protocol (DGP). Through the smart contract embedded in the genesis block, DGP is able to govern the blockchain network and achieve autonomous distributed processing. This allows for faster updating of the network. The current changeable parameters that Qtum supports include: Block size,Gas limite,Gas dispatch and lowest Gas price.

- Qtum is currently researching on high-performance virtual machine of new infrastructure. The innovative X86 virtual machine will tackle some problems existing in Ethereum EVM, for example, the lack of support for standard libraries and floating points, byte code of excessive size etc. Also, it will focus on building an efficient smart contract system built upon the UTXO model.

Qtum is an open source project, see **https://Qtum .org** for more information.

Qtum SpaceChain System library layer includes:

- Open source software library support, including basic library libboost, libdb, libsnappy, libcyrpto+, etc.
- Library provides services to the blockchain application layer through standard interfaces such as Posix and BSD sockets;
- System library software is all open source project.
- Operating system layer includes:
- Standard interface support such as POSIX/BSD Socket/IO
- SylixOS kernel
- Hardware driver.

3.2 SpaceChain Application Layer: Possibilities of Distributed Application (Dapp)

The SpaceChain application layer presents many blockchain use cases. For example, a cloud computing app use case is backup nodes for data recovery for the most important encrypted data. The encryption and cryptography is performed on the satellite itself. In this case, the satellite is a first class actor where the satellite decrypts data payload. This makes the data extremely secure.

In a "trusted execution environment," we provide software code and data that we digitally sign here on earth and upload to the satellite. The satellite checks digital signatures before adding anything in the application sandbox before executing the program. This system provides authentication and blockchain capability. For developers and businesses this allows a "fail-fast" make-a-change-and-try-again approach or rapid iteration in contrast to the old world approach of launching a satellite per app.

We are part of the NewSpace trend of commercialization of space. In the old world model there were only large governments deploying big satellites in space and big rockets costing billions of dollars to build, government-led and government-funded, with very little opportunity for private space companies to form to offer these services at a competitive cost. In the new model, led in part by China, we have a new space race where commercial companies from China, US, Russia, EU are competing to commercialize low earth orbit and driving the development of space technology. This is creating new markets and brings new funding into the space industry, creating possibilities for new economic models instead of one dominated by few owners and few operators. Decentralization keeps power distributed and access open for everyone.

3.3 How the SpaceChain Token Works on SpaceChain OS

In the SpaceChain economic model, the token will connect to our SpaceChain OS and allow developers to upload apps onto the SpaceChain network and thus store data and execute programs on SpaceChain satellites. SpaceChain tokens must be bought in order to execute these SpaceChain apps much like a ticket to use a SpaceChain app for a duration of time or store one megabyte on a satellite.

We are essentially building a market for space applications where a token will be a way for apps to be priced. For example, if one app is more popular than another then there will be more demand for that specific space application and thus more tokens used.

This new economic model is what led us to evolve a space app model within a broad vision of developing an inner space application and communication network first. In the private space agency model where we wire the solar system for networking, after many years and many networks, we will see satellite constellations around the moon, as well as remote data centers around planets and other celestial bodies. These constellations will communicate with each other and form a backup. This will enable human and robotic settlement of space in the long-term.

This mission to wire the solar system for networking will help realise a model called the Pony Network in Space. The Pony Network is an economic model in space for payloads and propellant technology systems whereby people and cargo travel to the moon and mars quickly and cheaply by taking a point-to-point transit approach over shorter distances. For example, a satellite being launched to the moon will not travel on a single a rocket going all the way to the moon, instead it will be launched to low earth orbit and transfer to another vehicle, using software on satellites along its path rather than having every single application running on its system. The entire network will be powered by and built on this token economic model.

3.4 Community Evolution of Collaboration in Space Exploration

Spacechain is based on a whole-of-mankind space exploration paradigm. The vision of Spacechain is to find a mechanism in the field of space exploration that can effectively mobilize the power of all mankind to meet this challenge in the face of great challenges.

SpaceChain tries to solve the following three problems:

1. International space cooperation is relatively closed and there is an urgent need in the aeronautical field for a space cooperation alliance that is open and democratic.
2. The aerospace industry is currently closed to the public, and space exploration does not harness the strength of all fields.
3. The current space project has not found a balance between government and commercial enterprise.

At present, international space cooperation is relatively closed. The reason is that security is the biggest barrier to cooperation among most countries. The other is the question of interests, which is the tension between commercial companies and state-owned companies. Therefore, establishing a cross-border, safe space security alliance that can protect the interests of participants in the field of aerospace will be the key to promoting deep cooperation in the field of space.

To establish this alliance, a collaborative mechanism must be established with other companies and blockchains. The mission of SpaceChain is to break through the existing internal barriers of the world aerospace industry by establishing such collaborative mechanisms and give us full play to existing capabilities and enable optimal integration of available resources. SpaceChain aims to reach a consensus on security and common interests.

For this purpose, SpaceChain developed SpaceChain OS, an operating system designed to create a true network in space. SpaceChain OS uses blockchain technology to encrypt the transmitted information to ensure the absolute security of information transmission, and the use of blockchain technology in the operating system and sandbox management so that each satellite can run safely.

While achieving its security, SpaceChain OS hardware adaptability is enhanced to meet the different needs of different spacecraft. Efforts are being made to promote its compatibility with different spacecraft such as satellite systems, communications, navigation and remote sensing, satellite ground systems, space stations, spacecraft, space probes and other applications, in order to achieve a seamless network.

In addition to international cooperation, the aerospace industry should not remain closed to the general public. Aerospace has always been a mysterious and opaque industry with a high barrier to entry because of its small market, high cost, and small number of qualified personnel. However, as we said before, the move towards space is a whole-of-mankind endeavour. It cannot be accomplished solely in the aerospace industry and requires widespread collaboration.

There is a need to explore a model that will allow more people and more companies in other industries take part in human space exploration. Today, the 5G era in mobile data has brought about a thriving development in the satellite communications industry. The aerospace market has been growing. The mission of the SpaceChain Foundation is to solve the remaining two problems of high cost and limited qualified personnel so that more people can by part of a global endeavor to explore space.

Data and research show that the effective way to reduce the cost of satellite applications is to increase the number of applications of a satellite. Just as a mobile phone has changed from a smartphone like Nokia to a smart phone today, the shift is based on a strong and stable operating system.

- SpaceChain OS is the operating system that can solve this problem. Developers can develop satellite applications based on the software development environment provided by SpaceChain OS and upload the program code to the satellite via terrestrial data transfer stations in a manner that is extremely simple and extremely efficient to develop.

- SpaceChain OS can therefore greatly reduce the cost of space applications. Reducing access barriers in the aerospace field and upgrading the average airspace technology are the most important ways to solve the problem of imited space personnel.

- SpaceChain OS reduces the barriers to use and simplifies the use of space. At the same time, the Foundation of Space-Chain Trust will popularize the foundation of aerospace technology in higher education and increase the potential talent pool pursuing a space exploration career.

On the basis of the collaboration mechanism, if the journey of mankind to explore space is to be sustained and the cognitive boundary of mankind to expand continuously, we must stimulate the power of a free society. This requires a more open and cooperative commercial space socio-economic and technological development model. Most current space projects cover both the government and the commercial sectors. The funds and policies of the government-led space project will be guaranteed, but at the same time they will be constrained by the government budget and government efficiency and may be hijacked by powerful interest groups.

In contrast, purely commercial space projects focus on economics, but regrettably, it is very difficult for space projects to make profits in space using conventional models. Therefore, the issue of broad-based participation in the construction of space projects needs to be solved.

The mission of the SpaceChain is to solve the above problems, establish a socio-economic model and explore a strong collaborative and win-win model in the aerospace field that can support a global collaborative and sustainable commercial space program.

The new commercial space model is already being realized by billionaires who invested in mega-rocket and orbit giant constellations to colonise space and its potential. The SpaceChain Foundation hopes to use the community incentive model to establish the ecological chain, production chain and distribution chain of aerospace wealth, so that every participant and contributor will get a fair return and attract more resources to participate in the aerospace. We aim to partner with organizations pursuing this same approach. We will build, participate in the exploration of human space, and extend human cognitive boundaries indefinitely.

3.5 SpaceChain Ecosystem Build-up

Blockchain enables new open economic models that enable new businesses, and especially for the first time ever, new space based business.

SpaceChain is similar to mobile app store you can pay a small amount of money and access a space app. This system is much cheaper than ten years ago when you needed to buy and operate an entire satellite. Now a few cryptocurrencies units can develop and put an app on a satellite; this enables whole new markets that were not possible before.

Before blockchain and cryptocurrencies, there was a large capital cost of operating a large satellite. SpaceChain already has deployed an app platform based in space, fully tested, and will be launching satellites in 2018 to achieve the base layer of a new structure. Because the SpaceChain system cost is 100x of investment versus 1000x compared to the old satellite launch mode, the economics enables many new use cases. The most important use case are the ones we have not thought of. Comparing the Internet's earliest iteration, few of us could predict global apps that would given everyone multiple choices to share a car. Opening app stores and the creativity of developers allowed ride share to begin as a viable business model that disrupted transportation. Today, we question if anyone will ever own a car in the future, solely for personal use. SpaceChain will allow this new creativity for use cases that we have no ability to predict.

Another opportunity is the ability to bring a Linux software model to space. Imagine a physically untouchable data center in space with a higher level of security because the data centre cannot be accessed without very high cost. Physical remoteness is attractive to security-conscious customers. With a non-terrestrial network we have a better diversity of nodes like Internet nodes, blockchain nodes and other application nodes. Remote nodes operating in space give us network redundancy, satellite backup, and autonomy of data and software. Autonomous software and software automation will allow us to communicate with sensors operating in the ocean engaging climate change research, among other smart contracts. Satellites will be Internet repeaters, remote sensors for telecommunications, while communicating with and tracking planes and ships around the globe, all powered on blockchain.

In 2016, the satellite industry generated more than $260 billion in revenues according to an annual report by the Satellite Industry Association (SIA). This was a 2% growth compared to 3% in 2015. Imagine the growth when this wealth can be redistributed to developers on a mesh network of a constellation of satellites. There are currently only 6 companies the "large satellites" and 16 in the "small satellite" observation categories. With SpaceChain OS, satellite capabilities will be increased and this sector will flourish alongside communication, data storage and collection capabilities, with many new companies and partnerships. In less than a few years, the numbers will be totally different with the revolutionary capabilities of SpaceChain's potential in expanding commercial interests.

3.6 incubator & Commercial Opportunities

The Spacechain Foundation will also launch an open source hardware development board and a development tutorial that runs SpaceChain OS, and promote it freely in colleges and universities all over the world to increase the number of space personnel produced by the education sector. The increase of the number of talents will greatly enhance the vitality of the industry and provide a continuous momentum of development for space exploration.

SpaceChain Foundation has been supporting startups in the space industry around the world:
- SpaceChain OSRZ Capital, an institutional investment firm.
- Beijing Jiu Zhou Yun Jian, astartup specialized in liquid rocket engine, is collaborating with SpaceChain on an engine smart control system.

Summary

In short, SpaceChain aims to accomplish the following three goals:

1. break down barriers to cooperation and integrate the existing space resources so that space can better serve the earth and serve humankind,

2. lower the industry access threshold and costs, vigorously develop education and involve more people in space exploration,

3. establish a socio-economic model to support a sustainable commercial space decentralized, distributed program that will continuously grow knowledge and expand the cognitive boundaries of humanity.

The SpaceChain Foundation hopes to take on the responsibility of pushing the boundaries of space and exploring the cosmos in which we live. SpaceChain hopes to attract more talent and resources, pool the power of all mankind, and join togEthereum protocoler in advancing space technology. We believe that the wisdom of bringing togEthereum protocoler a large number of talented people in a clear direction can lead to a unity of purpose in space exploration and the ultimate goal of a thriving human civilization.

Partners and Advisors

Partners

Qtum

Qtum Foundation is China's largest blockchain open source platform. Qtum enables the creation of decentralized applications, executable on mobile devices and compatible with major existing blockchain ecosystems. Qtum combines a modified Bitcoin Core Infrastructure with an inter compatible version of the Ethereum protocolereum Virtual Machine, and the reliability of Bitcoin's unfailing blockchain with the possibilities provided by smart contracts.

Beijing ACOINFO

The developer of SylixOS, they will co-develop SpaceChain OS based on SylixOS.

Nanoracks

A leading product and service provider for the commercial utilization of space. NanoRacks hosts a CubeSat Deployer and equipment for experiments on the International Space Station (ISS). They will join the efforts of exploring the application of SpaceChain OS on commercial international space station.

Kubos

A leading software developer from the USA,they will support SpaceChain OS on system optimization and Application development.

BeijingXihua Technology

They will be SpaceChain's partner on the reusable launch system, which will allow space exploration and commercial space utilization to be more cost efficient.

Runzhe Capital

A leading commercial space industry investor in China. They will support SpaceChain to incubate more of China's leading startups in space industry

Ruidong Capital

A leading Space industry investor in China. They will support SpaceChain to grow its eco-system and space explorer community.

Ruidong Capital

Ink is a blockchain based ledger where artists and content creators can register works and generate businesses, a trustworthy exchange where the arts can be incubated and thrive, and an ecosystem empowering anyone who creates original content. Ink provides a decentralized solution and the combined power of Consortium Blockchain, Public Blockchain and Cross-chain Interoperability for the global creative industry. Ink allows creative workers to access better ownership protection, content distribution and digitization of their creative assets.

Arch Mission

The Arch Mission exists to help humanity fulfill its purpose in the universe by preserving and transmitting our most important knowledge to the stars, via specialized archive devices called "Archs" that are designed to spread and persist across vast distances of space and time.
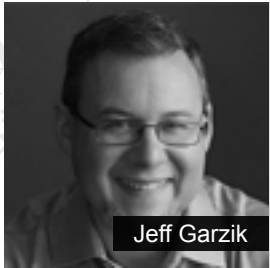
Team

Core Team

Co-Founder & CEO
Co-founder and CEO of SpaceChain. He is an early adopter in Bitcoin and Blockchain, with a strong belief that the combination of space and blockchain technology will broaden the frontier of future economy and make seamless global collaboration possible. M.A. Columbia University. Alumni of Draper University.

Zheng Zuo

Co-Founder & CTO
Key Bitcoin Core Developer who worked directly under Satoshi Nakamoto for 2 years. His work can be found in every bitcoin and miner. He is a Key Linux Kernel Engineer,on the Linux Foundation Board of Directors, and worked directly under Linus Torvalds for over 15 years. His code can be found in every Android phone, and every data center. He is also the Leader of the Ethereum protocolernet networking subsystem, and Co-Founder&CEO of Bloq.

Jeff Garzik

Core Business Advisor
Co-funder of DFJ venture capital, and renowned VC capitalist from Silicon Valley. He invested in numerous popular companies including SpaceX, Tesla, Theranos, Thumbtack. Prior to these, he also invested in Baidu, Hotmail, and Skype. He founded Draper Univer-sity in Silicon Valley to cultivate entrepreneurship talents.

Tim Draper

Core Space Advisor
CEO of NanoRacks, from 2009, Manber has steered the growth of the first company to own and market its own hardware and services on board the International Space Station. Manber has been involved in several key breakthrough commercial space projects, principally those around the commercialization of space assets as well as the integration of the Russian space industry into major space programs, including the International Space Station. Manber was with the Russian space corporation, RSC Energia, during their privatization period of the 1990s. Jeffrey Manber is regarded as one of the pioneering commercial space entrepreneurs.

Jeffrey Manber

Core Economics Advisor
Known as "the Godfather of Chinese VC", he is Chief Partner of SAIF Partners, Chief Partner of Softbank Asia Investment Fund, and President of Softbank Asia Infrastructure Foundation Investment Fund.

Andrew Yan
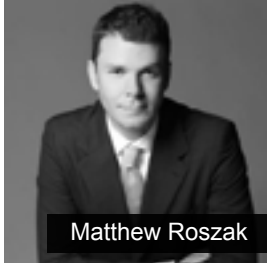
Core Strategy Advisor

Co-founder and chairman of Bloq, Mr. Roszak is also the founding partner of Tally Capital, a private investment firm focused on blockchain-enabled technology with a portfolio of over 20 investments.

Mr. Roszak is a blockchain investor, entrepreneur and advocate. Mr. Roszak is a sought after thought leader on blockchain technology, and has testified before US Congress and spoken at The Brookings Institution. Mr. Roszak has been featured on CNBC and quoted in The Wall Street Journal, Bloomberg, CoinDesk and Bitcoin Magazine. In addition, Mr. Roszak has presented at FinTech conferences worldwide, including Money20/20, CES and American Banker.

Matthew Roszak

Core Technical Advisor

Founder and CEO of China's largest blockchain open source platform Qtum quantum chain, valued at 1 billion US dollars and already attracting hundreds of developers around the world. Since 2012, Patrick has been engaging in encryption and R&D of its underlying technology, and actively promoting of blockchain technology as well as its application. He studied at the Chinese Academy of Sciences and worked at Alibaba. He is in the 2017 Forbes 30 Under 30 and a Draper University Alumni.

Patrick Dai

Core Blockchain advisor

Ryan is a well-known Chinese venture capitalist who has extensive experience in Financial technology. Ryan was the co-founder of Blockchain Global, a blockchain- focused enterprise that provides cloud data services and incubates blockchain-related startups. He is also the co-founder of ACX, an Australian- based digital currency exchange. He was named one of the blockchain leaders in 2016.
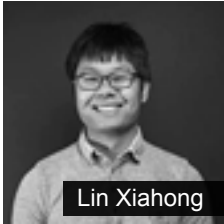
Ryan Xu

Core Industry Advisor

Founding Partner of R&Z Capital. Specialized at Space technology and industrial investment. Years of experience in digital commerce and military based technology.

Sun Bin

Advisors

Lin Xiahong

Founder of Bodhi project, Xiahong is an entrepreneur and software engineer. In 2014, Xiahong began experimenting with Ethereum protocolereum smart contracts and now is working to build a decentralized prediction market on Qtum. Previously Xiahong worked as a software engineer at Edmodo, Twitter and Tencent. He has a Master of Science Degree from Purdue University where he specialized in Statistical Machine Learning, and Master of Science Degree in Computer Science from Shanghai Jiao Tong University where he specialized in Cryptography.

Gong Ming

Founder of ICOAGE and ChainB.com, Gong Ming is widely known by his online nickname "Bao Zou Prince Gong". He was actively engaged in China's digital currency and blockchain technology development from the beginning, and is a highly reputable opinion leader in the industry. Mr Gao founded the most positively recognized blockchain new media "ChainB.com" in China and the reputable ICO platform, ICOAGE.
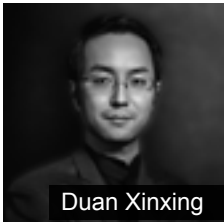
Duan Xinxing

He is co-founder of Bytom and executive president of Babbitt, winner of the Gates Foundation Scholarship, former senior engineer of Lucent Bell Labs, and vice president of the world's largest Bitcoin Exchange OKCoin (coin exchange). He has led R&D and operations in OKLink, Bytom and many other blockchain products.

Huang Butian

Founder and Chief architect of Cloud Elephant Blockchain, Huang Butian has a doctorate in computer science with Zhejiang University, is a member of IEEE, ACM and China Computer Society, and senior adviser to China New Communication magazine.
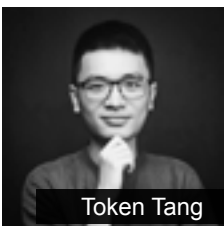
Token Tang

Token Tang is Founder & CEO of Ziggurat Tech; President of Ink Labs Foundation; Managing Partner of Jenga Blockchain Capital; initiator of Blockchain Technology and Law Innovation Research Lab of Xi'an Jiaotong University; member of the advisory committee of APEC Future College; and senior member of Silk Road Innovative Design Alliance.
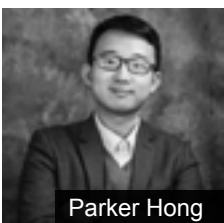
Parker Hong

Parker Hong is Partner of HQ Capital, vice president and member of the voting committee of the industry guidance fund of SDIC Hi-Tech. He worked at Iris Capital Canada and the European telecom giant Orange and Publicis VC.
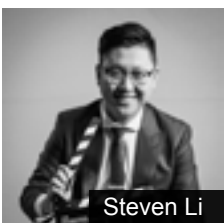
Steven Li

Steven Li is HQ Capital Partner, and Vice President of Strategic Investment of a large Internet company. He led more than twenty Internet project investments from angel to B round. He won the Ontario Youth Entrepreneurship Award, is a member of the DEMO + incubator jury, and official alumni representative for the University of Toronto in China. He has a Bachelor of Science in Economics and Management with the University of Toronto, and a Master of Finance with Queen's University.