CLAIMS

What is claimed is:

1. A method for verifying and authenticating additive manufactured products utilizing extraterrestrial communication, the method comprising:

receiving, from a customer, at least one customer requirement for a product;

developing, from said at least one customer requirement, at least one manufacturing requirement for said product;

generating, from said manufacturing requirement, a product geometry file and at least one printer parameter;

recording, by a first computing device, to a distributed transaction register stored on a server network having a plurality of node servers, a first transaction reflecting said product geometry file, said first transaction having a first output that is associated with said first transaction, said first output including a blockchain address;

transmitting, from said first computing device to a second computing device, said first output from said distributed transaction register that is associated with said first transaction, said product geometry file, and said at least one printer parameter, said transmitting said first output includes transmitting between a terrestrial transceiver that is communicatively connected to said server network and an extraterrestrial transceiver that is communicatively connected to said terrestrial transceiver, said second computing device being configured to communicate with said server network having said plurality of node servers storing said distributed transaction register by at least said terrestrial transceiver and said extraterrestrial transceiver;

printing, with a 3D additive printer that is connected to said second computing device, said product that meets said at least one printer parameter and utilizes said product geometry file;

generating, by said second computing device, a unique product code reflecting said first output of said first transaction;

recording, by said second computing device, to said distributed transaction register, a second transaction reflecting said printing of said product and said first output, said second

transaction having a second output that is associated with said second transaction, said second output including a blockchain address;

embedding, by a mechanism, said unique product code reflecting said first output within or affixing to said product;

wherein said product geometry file and said printing of said product is verified with said unique product code and said second output from said second transaction such that said product is authenticated.

2. The method set forth in claim 1, wherein said at least one customer requirement for said product is selected from a group consisting of quality parameters, material composition requirements, product definitions, manufacturing requirements, and an IP artifact, and wherein said at least one manufacturing requirement for said product is selected from a group consisting of product size, product weight, product strength, product geometry, a computer aided design (CAD) file, and an IP artifact.

3. The method set forth in claim 1, wherein said extraterrestrial transceiver is located on a space colony, a space station, a spacecraft, a planet, a moon or an asteroid.

4. The method set forth in claim 1, wherein said terrestrial transceiver and said extraterrestrial transceiver are communicatively connected via a deep space network.

5. The method set forth in claim 1, wherein said distributed transaction register comprises a blockchain, said recording said first transaction comprises recording said first transaction to a first block of said blockchain, and said recording said second transaction comprises recording said second transaction to a second block of said blockchain.

6. The method set forth in claim 5, wherein said first transaction further comprises a first transaction datum and said second transaction further comprises a second transaction datum.

7. The method set forth in claim 6, wherein said first transaction datum comprises a cryptographic hash digest reflecting said product geometry file and said second transaction datum comprises a cryptographic hash digest reflecting said printing of said product.

8. The method set forth in claim 1, wherein said embedding said unique product code reflecting said first output comprises printing said product with said unique product code or etching said product with said unique product code.

9. The method set forth in claim 1, further comprising:

generating, from said manufacturing requirement, at least one 3D additive printer material parameter and at least one 3D additive printer calibration parameter; and

printing, with said 3D additive printer meeting said 3D additive printer calibration parameter, said product using said at least one 3D additive printer material parameter,

wherein said first transaction reflects said at least one 3D additive printer material parameter and said at least one 3D additive printer calibration parameter, and

wherein said at least one 3D additive printer material parameter and said at least one 3D additive printer calibration parameter is verified with said unique product code such that said product is authenticated.

10. The method set forth in claim 9, wherein said at least one 3D additive printer calibration parameter is selected from a group consisting of speed, power, scan rate, and feed rate, and wherein said at least one 3D additive printer material parameter is selected from a group consisting of aluminum, titanium, stainless steel, cobalt chrome, inconel, maraging steel, hastalloy-X, and copper.

11. The method set forth in claim 9, wherein said distributed transaction register comprises a blockchain, and wherein said recording said first transaction comprises recording said first transaction to a first block of said blockchain.

12. The method set forth in claim 11, wherein said recording said first transaction comprises recording to said first block an entry reflecting said product geometry file, said at least one 3D additive printer calibration parameter, and said at least one 3D additive printer material parameter.

13. The method set forth in claim 1, further comprising:

recording, by a third computing device, to said distributed transaction register, a third transaction reflecting said at least one customer requirement for said product;

obtaining a third output from said distributed transaction register that is associated with said third transaction;

recording, by a fourth computing device, to said distributed transaction register, a fourth transaction reflecting said at least one manufacturing requirement for said product;

obtaining a fourth output from said distributed transaction register that is associated with said fourth transaction;

wherein said fourth output reflects said third output and said first output reflects said fourth output;

wherein said at least one customer requirement for said product and said at least one manufacturing requirement for said product is verified with said unique product code such that said product is authenticated.

14. The method set forth in claim 13, further comprising:

recording, by a fifth computing device, to said distributed transaction register, a fifth transaction reflecting said embedding said unique product code reflecting said first output;

obtaining a fifth output from said distributed transaction register that is associated with said fifth transaction and said second output;

inspecting said product;

recording, by a sixth computing device, to said distributed transaction register, a sixth transaction reflecting said inspecting of said product;

wherein said embedding said unique product code and said inspecting of said product is verified with said distributed transaction register.

15. The method set forth in claim 14, further comprising:

obtaining a sixth output from said distributed transaction register that is associated with said sixth transaction and said fifth output;

delivering said product to an end user;

recording, by a seventh computing device, to said distributed transaction register, a seventh transaction reflecting said delivering of said product to said end user;

wherein said delivering of said product to said end user is verified with said distributed transaction register.

16. The method set forth in claim 15, further comprising:

obtaining a seventh output from said distributed transaction register that is associated with said seventh transaction and said sixth output;

installing said product for end use;

recording, by a eighth computing device, to said distributed transaction register, an eighth transaction reflecting said installing of said product for end use;

wherein said installing of said product for end use is verified with said distributed transaction register.

17. The method set forth in claim 16, wherein:

said distributed transaction register comprises a blockchain;

said recording said first transaction comprises recording said first transaction to a first block of said blockchain;

said recording said second transaction comprises recording said second transaction to a second block of said blockchain;

said recording said third transaction comprises recording said third transaction to a third block of said blockchain;

said recording said fourth transaction comprises recording said fourth transaction to a fourth block of said blockchain;

said recording said fifth transaction comprises recording said fifth transaction to a fifth block of said blockchain;

said recording said sixth transaction comprises recording said sixth transaction to a sixth block of said blockchain;

said recording said seventh transaction comprises recording said seventh transaction to a seventh block of said blockchain; and

said recording said eighth transaction comprises recording said eighth transaction to an eighth block of said blockchain.

18. The method set forth in claim 1, further comprising generating a transaction record reflecting said first transaction and said second transaction from said distributed transaction register.

19. The method set forth in claim 16, further comprising:

scanning, by a ninth computing device, said unique product code embedded within or affixed to said product;

verifying, by said ninth computing device, that said unique product code is associated with said second output of said distributed transaction register; and

obtaining, by said ninth computing device, at least one transaction datum; and

determining, based on said verifying and said at least one transaction datum, that the product is authentic.

20. The method set forth in claim 1, further comprising training an artificial intelligence module for closed loop control of said 3D additive printer, the training of the artificial intelligence module including:

inputting to the artificial intelligence module additive manufacturing build parameter configuration files corresponding to a plurality of parts;

inputting to the artificial intelligence module sequential time-based parameter data collected in-process by the with a 3D additive printer;

inputting to the artificial intelligence module build layer image classification data generated by a convolutional neural network configured to evaluate build layer images captured in-process;

inputting to the artificial intelligence module post-process image classification data generated by at least one other convolutional neural network configured to evaluate images of a part captured post-process; and

evaluating the additive manufacturing build parameter configuration files, the sequential time-based parameter data, the build layer image classification data, and the post-process image classification data by means of the artificial intelligence module.

21. The method set forth in claim 20, further comprising:

inputting to the artificial intelligence module melt pool data collected in-process by the additive manufacturing machine; and

evaluating the melt pool data by means of the artificial intelligence module.

22. A system for verifying and authenticating additive manufactured products utilizing

extraterrestrial communication, the system comprising:

a server network having a plurality of node servers storing a distributed transaction register;

a first computing device being configured to communicate with said server network having said plurality of node servers storing said distributed transaction register, said first computing device being further configured to record to said distributed transaction register a first transaction reflecting a product geometry file generated from at least one manufacturing requirement for a product, said first transaction having a first output that is associated with said first transaction, said first output including a blockchain address;

a terrestrial transceiver communicatively connected to said server network to transmit and receive data;

an extraterrestrial transceiver communicatively connected to said terrestrial transceiver to transmit and receive data;

a second computing device being configured to communicate with said server network having said plurality of node servers storing said distributed transaction register by at least said terrestrial transceiver and said extraterrestrial transceiver;

a 3D additive printer being configured to communicate with said second computing device and to print said product, said 3D additive printer being further configured to print said product using said product geometry file; and

a mechanism being configured to communicate with said second computing device and to embed or affix a unique product code reflecting said first output to said product;

wherein one of said first, second, or a third computing device is configured to generate said unique product code that reflects said first output of said first transaction,

wherein said second computing device is further configured to record to said distributed transaction register a second transaction reflecting printing of said product and said first output, said second transaction having a second output that is associated with said second transaction, said second output including a blockchain address;

wherein said product geometry file is verified with said unique product code and said second output from said second transaction such that said product is authenticated.

23. The system set forth in claim 22, wherein said 3D additive printer comprises said mechanism for embedding or affixing said unique product code to said product.

24. The system set forth in claim 22, wherein said 3D additive printer is configured to build a part layer-by-layer according to an additive manufacturing build process, the 3D additive printer including:

a powder bed and an energy source, wherein a beam of energy from the energy source is scanned relative to a layer of powder in the powder bed to build each layer of the part by fusion;

a build parameter configuration file storing an initial set of build parameters for building the part in the 3D additive printer, wherein the initial set of build parameters is based at least in part on a geometric model of the part;

a closed-loop control structure for adjusting the initial set of build parameters in-process, the closed loop control structure including a slow control loop having a trained artificial intelligence module; and

a build layer image sensor arranged to acquire layer images of the part layers in-process;

wherein the initial set of build parameters, a time-based sequence of adjusted build parameters corresponding to the build process, and the layer images are transmitted as inputs to the trained artificial intelligence module.

25. The system set forth in claim 24, wherein the 3D additive printer further comprises:

a fast control loop having a state machine; and

a melt-pool monitoring system arranged to acquire real-time melt pool data representative of a melt pool formed by the energy source in-process;

wherein the melt pool data is transmitted as an input to the trained artificial intelligence module and as an input to the state machine.