A PROPOSAL FOR THE DECELOPMENT AND PRODUCTION OF A 3D PRINTER

SUBMITTED TO

NATIONAL AGENCY FOR SCIENCE AND ENGINEERING INFRASTRUCTURE

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INTRODUCTION

1.1 Background Information

A 3D printer is a machine that creates physical objects from digital designs by layering materials such as plastics, metals, and ceramics. 3D printers are built on cutting-edge technology, combining precision engineering, advanced software, and robust hardware to deliver unparalleled performance and reliability.

In recent years, 3D printing has gone from being a futuristic idea to a practical tool used in industries ranging from healthcare to architecture. Also known as additive manufacturing**,** this technology allows users to create physical objects directly from digital designs—layer by layer—using materials like plastic, resin, or even metal. What makes 3D printing especially exciting is its ability to produce complex shapes, reduce material waste, and shorten the time it takes to go from idea to prototype.

1.2 Aim and Objectives

The main aim of this project **is to** design, develop, and evaluate a functional and cost-effective 3D printer using locally available materials and open-source technologies.

The central objective of this project is to conceive, design, and develop a high-performance, cost-effective, and adaptable 3D printer that aligns with the technical, operational, and strategic needs of the organization. This development initiative seeks to create a robust additive manufacturing platform that enhances internal capabilities in prototyping, iterative design, and limited-scale production. The proposed 3D printer will be engineered to support a wide range of thermoplastic materials—including but not limited to PLA, ABS, PETG, TPU, Nylon, and carbon-fiber-reinforced composites—enabling diverse applications from basic concept models to functional, end-use components.

1.3 Justification for Project

3D printing technology has revolutionized manufacturing, prototyping, and education worldwide. However, many commercial 3D printers remain expensive and difficult to maintain, especially in regions where access to spare parts and technical support is limited. Building a low-cost 3D printer using locally available parts helps solve this problem. It makes the technology more affordable and easier to maintain, while also giving people a chance to learn new skills and come up with their own ideas. Using open-source designs and local materials also cuts costs and reduces reliance on imports, helping communities become more self-sufficient.

1.4 Statement of the Research Problem

Despite the growing importance of 3D printing technology in education, manufacturing, and innovation, many communities face challenges accessing affordable and reliable 3D printers. Commercial machines are often expensive, difficult to maintain, and rely heavily on imported parts, which increases downtime and costs. This limits the ability of students, small businesses, and makers to fully benefit from additive manufacturing technology. There is a clear need to develop a locally fabricated, cost-effective 3D printer that is easy to build, maintain, and customize to suit local needs. Addressing this gap can enhance technical skills, foster innovation, and promote self-reliance in digital fabrication.

1.5 Scope of the Research/Production

This project is focused on designing and building a simple, affordable 3D printer that works well and can be made using parts that are easy to find locally. It covers everything from putting together the frame and wiring the electronics to installing the software and testing how well the printer performs. The goal is to create a working FDM 3D printer that can handle basic printing tasks like making prototypes or simple models.

2.0 METHODOLOGY

2.1 Production Materials and Equipment.

The 3D printer uses the following materials and equipment in its development:

- Mechanical Components: Linear rails, lead screws, stepper motors and belts.

Electronic Components:

- Arduino Mega 2560, RAMPS 1.6, DRV8825 drivers, 128x64 LCD prototype.
- Commercial product (intended): SKR 1.4 Turbo (32-bit), TMC2209 drivers, BTT TFT 3.5 LCD
- Firmware: Marlin (v1.1 in prototype, v2.0 in commercial).
- Extruder and Hotend: titan extruder + E3D V3 hotend.
- Nozzle- 0.4 mm (accepts 1.75 mm filament).
- Heating Components: Heated bed (max 100ºC) and hotend (max 275ºC).
- Filaments: PLA, ABS, TPU, PMMA, HIPS.
- Software: Cura, Mattercontrol (to slice and generate G-code).
- Power Supply: 220 V AC, 12 V DC.

2.2 Methods of Production

1. Prototype Phase (Completed)

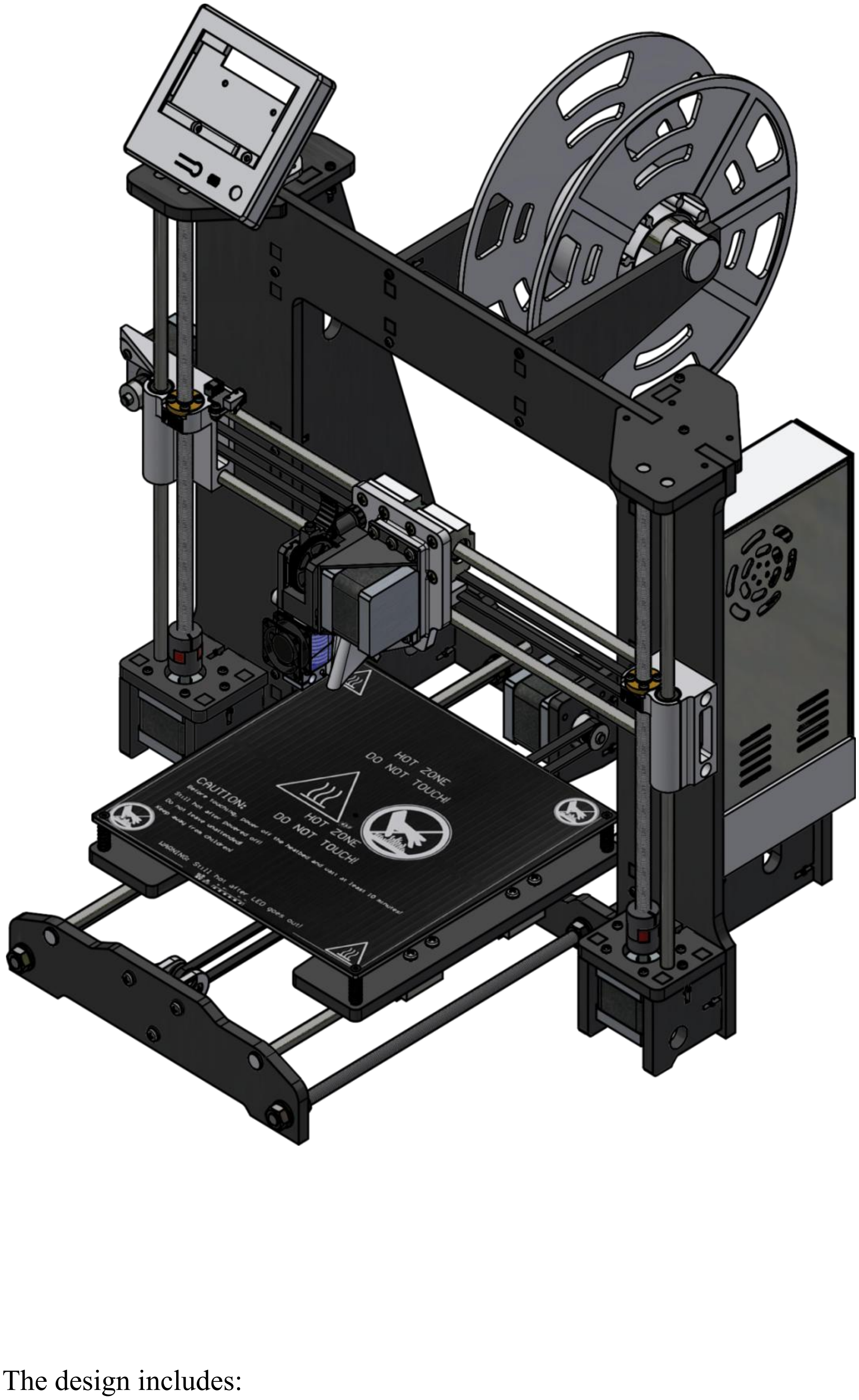
- The prototype was designed, fabricated and assembled
- Electronics were integrated using Arduino Mega 2560, RAMPS 1.6, DRV8825 drivers and Marlin 1.1 firmware.

- Calibration and testing were performed to validate the accuracy of printing (0.05-0.3 mm resolution).

2. Commercial Production (Planned Upgrade)

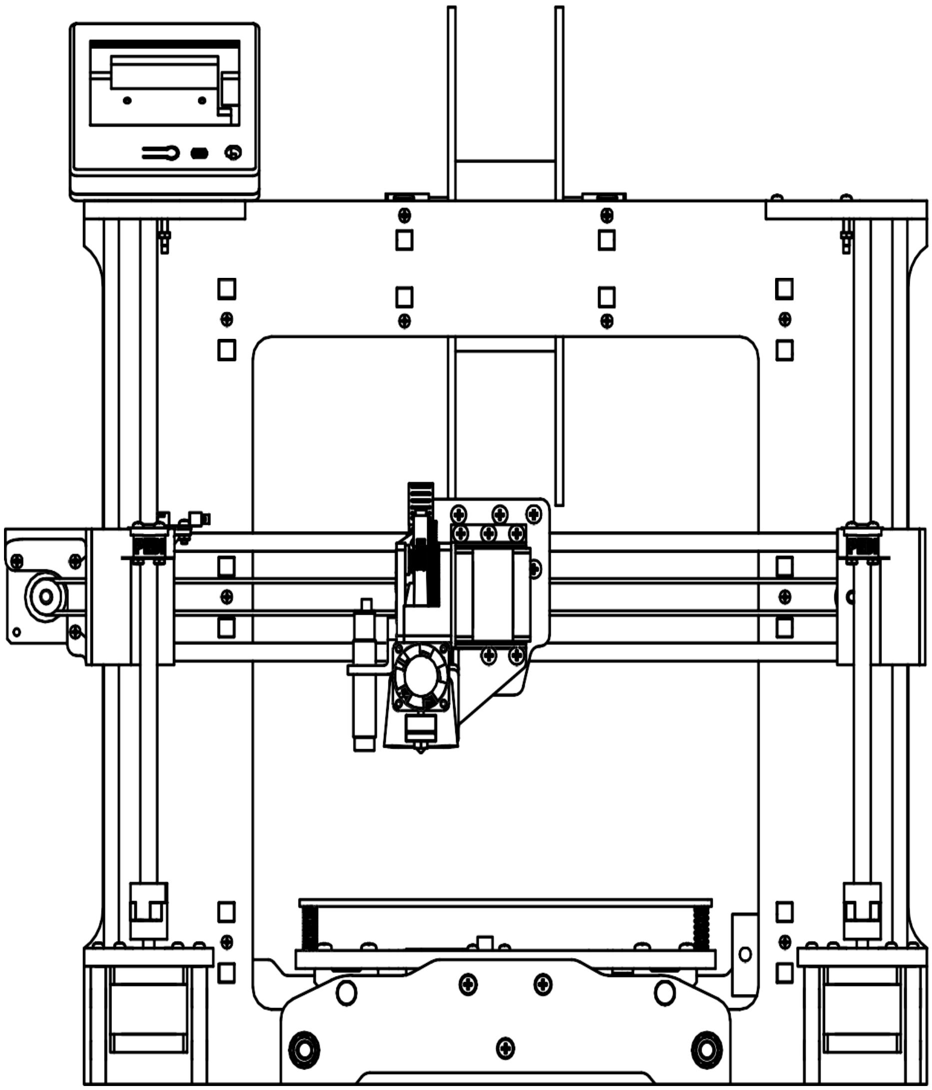
- Building on the Prototype, the commercial version will incorporate higher performance components.
- Fabrication will follow the same design principles but electronics and control systems will be enhanced in speed, precision and usability.
- Testing and Optimization will guarantee reliability in regard to continuous operation and broad usage.

2.3 Product Drawings/Graphics.

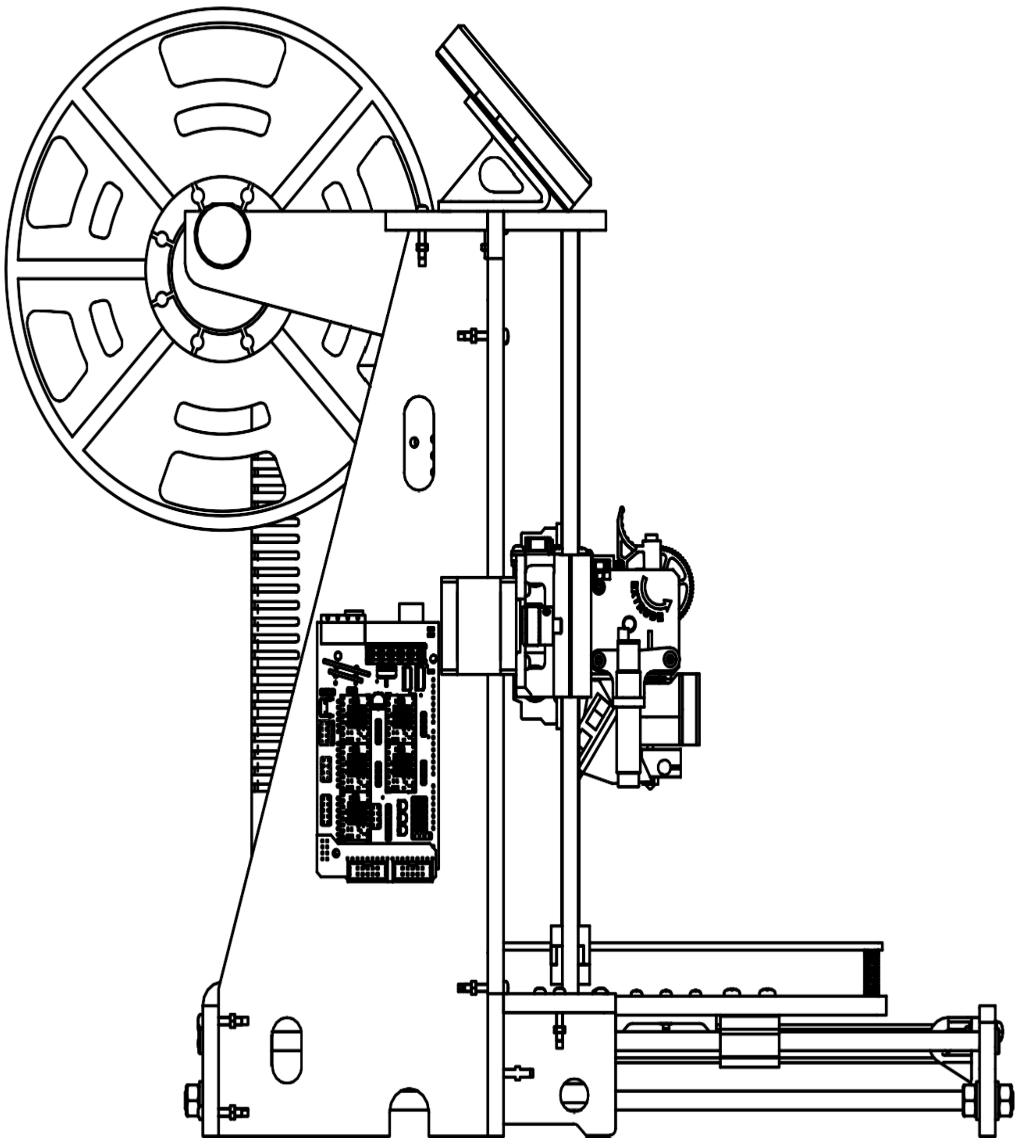


The design includes:

Front View Drawing: illustrating the frame of the machine, construction area and the location of the LCD.



Side View Drawing: movement systems (extruder, heated bed) are accentuated.



2.4 Collaboration for Production.

Collaboration will be an occasion to introduce new production techniques and commercialization in the market.

2.4.1 Prototype Production (Completed)

We have a prototype successfully produced with the following configuration:

- Arduino Mega 2560 (8-bit microcontroller)
- RAMPS 1.6 controller shield
- DRV8825 stepper drivers
- LCD 128x64 Full Graphics Display
- Titan + E3D V3 extruder
- Marlin Firmware 1.1

This version was used as the basis to complete the mechanical testing, extrusion system, and firmware control for future build. It proved functional, accurate and reliable for 3D printing.

2.4.2 Commercial Production (Planned Enhanced Version)

The prototype will be improved to a commercial production that will have the following configuration:

- SKR 1.4 Turbo main board with 32-bit ARM Cortex-M3 LPC1769 (120 MHz)
- TMC2209 stepper drivers (more quiet operation, better motion control, sensor less homing)
- BTT TFT 3.5 LCD touch screen (enhanced user interface)

- Marlin Firmware 2.0 (advanced, more processing power, greater safety)
- H_2V2S extruder (for better extrusion performance)

Added Features and Advantages over Prototype:

- Processing Power: 32 bits SKR 1.4 Turbo can runs at 120 MHz speeds, which are much faster than the 8-bit Arduino Mega, enabling faster calculations and smoother motion planning.
- Motion Precision: TMC2209 drivers provide silent operation, lower vibration and better micro-stepping precision compared to DRV8825.
- User Experience: BTT TFT 3.5 touch display offers a modern, user friendly interface, unlike the basic 128x64 graphics LCD.
- Extruder Capability: H_2V2S extruder offer an all in one light weight direct drive design with improved torque transmission and better filament control compared to the Titan+E3DV3 extruder resulting in higher precision and reduce clogging.
- Firmware Functions: The version of Marlin 2.0 gives many superior features like linear advance, thermal protection and customizable features not available in Marlin 1.1
- Reliability: The improved electronics allow long duration print, which makes the system fit for commercial and industrial applications.

This commercial version will represent a scalable and market ready upgrade of the prototype, ensuring enhanced performance, usability and efficiency.

2.5 Timeline for Production

Phase	Activities	Duration
Weeks 1-3	Procurement of upgraded materials and electronics	3 weeks
Week 4-5	Fabrication and assembly of enhanced commercial version	2 weeks
Week 6	Firmware configuration and integration of Upgraded features	1 week
Week 7	Caliberation and test printing	1 week
Week 8-9	Optimization, evaluation and final validation	2 weeks
Total Duration		8 weeks

3.0 COST ANALYSIS

3.1 Budget Estimate

S/N	CATEGORY	DESCRIPTION	ESTIMATED COST (NAIRA)
1	Components parts	Stepper motors, Threaded and plain-rods, Screw and Nuts, Bearing, Timing Belt, Pulley, Belt Idler, Coupler, Bed Spring, Cooling Fan, Switches, Power Supply, Inductive Sensor, ControlBoards (Arduino/RAMPS), H_2V2S Extruder, Heated bed, Power Supply, Frame, LCD 64128, Power cord, LED lighting,	632,745
2	Fabrication and Tools	CNC Laser Cutter,	235,000

		Hand Drill, sprayer, soldering workstation, Digital multimeter, Set of Allen keys, screw drivers set, crimping tools	
3	Software and Licenses	CAD software, Slicing Software and Firmware	8,032,500
4	Testing and Calibration	Trial prints (1kg ABS, 1kg PLA, 1kg PETG, 1kg TPU)	320,000
5	Logistics	Transportation for sourcing materials etc.	50,000
6	Administrative work	Utilities, Printing, Documentation	20,000
7	Dissemination	Prototype Demonstration, Publication Fees, Stakeholder Engagement	120,000

8	Materials and Supplies	Filaments, Electronics Components, Wiring and Fasteners	400,000
9	Contingency (5%)	Unforeseen expenses during development	490,512.25
	Total		**10,300,757.25**

1. **Justification of Cost**

    i. Components Parts: The components parts form the hearts of the 3D printer in charge of performance. These are not items that can be improvised, so they need to be improvised, so they need to be purchased at good quality to ensure the printer runs reliably. Hence it reduces the chances of breakdown and repeated replacements.

    ii. Fabrication and Tools: Cutting and finishing of frame materials which helps with Mechanical rigidityand alignment which is central to print accuracy.

    iii. Software and Licenses: The design and control of printer depend on reliable software. Some open-source tools will be used; certain features or plugins may require licenses. Hence, having access to proper tools will make the design process faster and more reliable.

    iv. Testing and Fabrication: Building the printer is only half work; making sure it prints accurately is the other half. Multiple test prints, adjustment and calibration runs will be needed. This covers the cost of the materials and simple measurement tool for fine tunning performance.

v. Travel and Field work: Sourcing materials will involve movement between suppliers. This budget allows the team to move parts and keep the supply chain smooth without unnecessary delays.

vi. Administrative Cost: This ensure the project has a functional working environment from start to finish even though routine expense like electricity, internet, and documentation may not seem significant, but they are the foundation that keeps the project running.

vii. Dissemination: Result needs to be shared at the end of the product. Which includes demonstration, printing guides or manuals, and organizing small workshop. This helps others see the impact of the project and encourages wider acceptance.

viii. Materials and Supplies: Items like filaments, wiring, screws, and connectors are vitals of this project and will be used repeatedly during assembly and testing. A steady supply of these consumables are essentials to keep the project moving without delays.

ix. Contingency: Projects usually doesn’t go as planned due to change in price, part failure, need for extra test. The contingency provides a safety net so that such issues do not derail the project.

2. Return on Investment:

The proposed budget of 10,300,757.25 is not only about building a single prototype but about laying the foundation for local 3D printing capability. The return comes in several ways:

Cost Savings in Manufacturing

Imported desktop 3D printers of same specifications typically cost between 2.5 million and ₦3 million each, excluding shipping and customs.

By designing and producing locally, the project can cut costs by at least 23.01–40.58%, making advanced manufacturing tools more affordable in Nigeria.

Revenue Generation

A locally produced printer can be sold at 1,750,000 – 2,000,000 million per unit.

With small-scale production (10 units), revenue could reach 17,500,000 – 20,000,000 almost double the initial research cost.

Capacity Building and Skill Transfer

Training during the project creates a pool of skilled people who can replicate or improve the design.

This reduces long-term dependence on foreign technology.

Market Expansion

Affordable local 3D printers can serve schools, SMEs, and Research Institutes that cannot afford imported machines. Opening this market supports wider adoption of digital manufacturing in Nigeria.

Economic Multipliers

Local fabrication shops benefit from steady contracts. Entrepreneurs can use the printer to create products, prototypes, and spare parts, leading to new businesses and job creation.

ROI Estimate:

Investment: 10,300,757.25

Cost of producing a unit: 1,422,745

Minimum Selling Price of a Unit: 1,750,000

Unit Return on Investment: 1,750,000 – 1,422,000 = 327,255 (23.01%)

Short-term Return (first 10 units sold): 17,500,000 – 20,000,000

Net Gain: 3,272,550 – 5,772,550 (23.01 – 40.58% ROI)

Long-term Return: Wider adoption and licensing of the design could multiply return beyond the initial project.

4.0 MARKETABILITY REPORT OF THE DEVELOPED 3D PRINTER

4.1 Importance of the Project

The development of a locally designed and fabricated 3D printer represents a strategic leap forward in Nigeria's quest for technological independence. Additive manufacturing, popularly known as 3D printing, is a transformative technology that has redefined production processes across the globe. By leveraging this technology, Nigeria can significantly reduce dependence on imported prototyping and manufacturing equipment, thereby conserving foreign exchange.

The project also demonstrates the capability of Nigerian engineers and innovators to provide indigenous solutions to local challenges. A locally made 3D printer not only lowers acquisition costs but also ensures that technical support, spare parts, and customization are readily available within the country. This addresses a critical barrier to the adoption of advanced manufacturing tools in Nigeria.

Furthermore, the project aligns with national development priorities, particularly the NASENI's 3Cs Agenda (Creativity, Collaboration, and Commercialization) and the Nigerian government's Renewed Hope Agenda, which emphasize local production, job creation, and industrialization. The developed 3D printer, therefore, serves as both a tool for industrial advancement and a symbol of Nigeria's capacity to compete in the global technology arena.

4.2 Market Space

The global 3D printing market was valued at over USD 20 billion in 2023 and is projected to grow at a compound annual growth rate (CAGR) of more than 20% over the next decade. Key drivers include rapid prototyping, cost-effective manufacturing, and increasing adoption across diverse industries.

In Nigeria and Africa, the 3D printing market is still emerging but with tremendous potential. The continent's youthful population, coupled with rising innovation hubs, startup ecosystems, and industrial diversification efforts, provides fertile ground for adoption. Key target markets include:

- Education Sector: Universities, polytechnics, technical colleges, and secondary schools integrating STEM and innovation programs. These institutions require affordable 3D printers for research, teaching, and student projects.
- Manufacturing & Engineering: SMEs and fabrication workshops looking for rapid prototyping, tooling, and spare parts production.
- Healthcare: Hospitals and laboratories adopting 3D printing for prosthetics, dental implants, surgical models, and customized medical tools.
- Architecture and Construction: Firms using 3D printing for model building, visualization, and experimental construction techniques.
- Entrepreneurship & Startups: Young innovators, makerspaces, and fabrication labs exploring low-cost product design and manufacturing.

Given the increasing emphasis on local production and digital manufacturing, the Nigerian market space is wide and growing. With affordability, technical support, and government backing, the developed printer can capture a significant portion of this market.

4.3. Strategy and Collaborations for Marketing

The success of the developed 3D printer in the market will depend on a well-structured strategy that emphasizes accessibility, awareness, and partnerships. Recommended strategies include:

a) Market Positioning:

- Branding the printer as a “Proudly Nigerian Technology” that is affordable, reliable, and customizable.
- Highlighting the advantages of local support and maintenance, which foreign alternatives lack.

b) Partnerships and Collaborations:

- Educational Institutions: Establish agreements with universities, polytechnics, and secondary schools to integrate the printer into their labs and curricula.
- Industry Linkages: Partner with manufacturing clusters, SMEs, and industrial associations to demonstrate the cost-saving benefits of local additive manufacturing.
- Government Support: Leverage NASENI, the Federal Ministry of Science and Technology, and state governments to promote the adoption of the printer across public institutions.
- International Collaborations: Partner with global research institutions for knowledge exchange, while maintaining indigenous production as a selling point.

c) Promotion and Awareness:

- Organize workshops, exhibitions, and seminars to showcase real-life applications of the printer.

- Engage in social media campaigns, product demonstrations, and innovation challenges to create visibility.

- Use success stories and case studies to attract interest from entrepreneurs and industries.

d) After-Sales Support and Capacity Building:

- Establish training and support centers across regions to provide user education, troubleshooting, and upgrades.

- Offer maintenance packages and warranty services to build trust and customer loyalty.

4.4 SWOT Analysis

Below is a detailed SWOT analysis of the developed 3D printer:

Strengths	**Weaknesses**
- Locally developed, customizable - Lower cost than imports - Technical expertise available - Government policy alignment - Potential for scaling	- Limited initial production capacity - Low brand recognition - Requires continuous R&D - Some imported components
Opportunities	**Threats**
- Expanding global/African market - Government push for tech - Demand for affordable prototyping - Export potential	- Competition from imports - Economic instability - Resistance due to low awareness - Risk of IP imitation

- Growing youth innovation culture	

5.0 CONCLUSION

The developed 3D printer has strong marketability potential both within Nigeria and across Africa. Its affordability, local adaptability, and alignment with government policies make it an attractive option for educational institutions, industries, and entrepreneurs. By implementing a clear strategy that combines awareness creation, partnerships, after-sales support, and continuous innovation, this project can transform Nigeria’s manufacturing landscape and position the nation as a competitive player in the global additive manufacturing industry.