Lessons Learned

3D Printing and Design in the Government of Canada

Shared Services Canada
Services partagés Canada

Canada

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Introduction

The Government of Canada is increasingly integrating 3D printing and 3D design technologies to enhance operations across various departments. These technologies offer significant benefits such as cost savings, customization, and rapid prototyping. 3D printing provides advantages in developing customized solutions for government-wide services, creating prototypes for new designs, and aiding in the maintenance of critical equipment. By minimizing costs and improving operational efficiency, 3D printing supports the government's digital transformation initiatives.

Navigating the realm of 3D printing and design within a Government of Canada framework has been a journey marked by innovation, collaboration, and continuous learning. This document covers our experiences and lessons learned throughout this process, providing a roadmap for future initiatives aimed at enhancing public service delivery through the continued integration of 3D printing and design.

1. Understanding the Technology

- **Training and Skill Development**
  It is important to invest in a training program for employees. 3D printing is a cutting-edge technology that requires a specific and new skill set. Several e-learning platforms, such as Coursera, Pluralsight and Udemy, offer a wide range of structured learning paths and certifications in 3D modeling, CAD design and printing. Additionally, YouTube is a valuable resource for learning the fundamentals of 3D printing. It's an excellent free source for tutorials, demonstrations and insider tips from individuals and organizations specializing in 3D printing. Due to the hands-on nature of 3D printing, regular practice, engaging with tutorials, and participating in labs are the best ways to learn and are essential for skill development.

- **Fused Deposition Modeling**
  Fused Deposition Modeling (FDM) printing is versatile and practical for creating customized solutions, prototypes, and educational models. Unlike other methods such as Stereolithography (SLA), Selective Laser Sintering (SLS), and Digital Light Processing (DLP), FDM printing uses a straightforward extrusion process that builds objects layer by layer from thermoplastic materials. FDM offers adjustable layer heights for different print qualities and speeds, and it requires minimal post-processing. This means the printed object typically needs very little additional work.

  We chose FDM printing because it uses a variety of filament materials like Polylactic Acid (PLA), which is known for its low printing temperature, minimal warping, and biodegradability; Thermoplastic Polyurethane (TPU), which provides flexibility and durability, and Polyethylene Terephthalate Glycol (PETG), which combines strength with ease of printing. Each material has unique properties tailored for different applcations. In our use cases, FDM has been effective for creating custom protective casings for

IoT devices and sensors, mounting brackets and supports for home assistant equipment, prototyping parts for IoT wearables, and cable management solutions for IoT installations.

- **Software and Hardware Selection**
  Selecting the right tools is essential. There are many 3D design software options, such as Autodesk Fusion 360, Blender, and Tinkercad, each with its strengths and weaknesses. These software tools are used to create or modify 3D models according to your design requirements. Additionally, you will need slicer software like Ultimaker Cura, PrusaSlicer, or Simplify3D to prepare these models for 3D printing. Slicer softwares generate the necessary instructions (G-code) that instruct the 3D printer on how to build the object layer by layer. When choosing tools, ensure they are user-friendly, reliable, and compatible with your existing systems to optimize your 3D printing workflow.

  After experimenting with various design software solutions, Fusion 360 emerged as the preferred choice due to its collaborative capabilities. It allows team members to collaborate and edit designs simultaneously and it's integrated cloud storage allows for easy access to projects from anywhere.

  Regarding hardware, our preferred choice is the Bambu Labs 3D printers. These printers are popular and recognized for their affordability, user-friendly design, and high quality prints. The setup and operation are simple and straightforward. They stand out for their capability to handle up to four spools of filament simultaneously, unlike other printers that are limited to just one. Overall, these printers are the preferred choice due to their reasonable pricing, seamless setup and operation, and print job quality. Furthermore, the Bambu Slicer software enhances these benefits by optimizing the printing process for speed and precision. It's known for its efficient algorithms that improve the slicing process, reducing the time it takes to prepare models for printing while still maintaining high quality prints. The integration with Bambu Studio provides seamless workflow from design to print.

2. Pilot Projects

- **Small-Scale Implementation**
  Starting with small pilot projects helps to identify potential issues without significant investment. These projects provide valuable insights and help refine processes before scaling up. Initially, we managed print requests for our partners and senior management within our directorate. This process enabled us to gain valuable insights into fixed and variable costs, required materials, track/change management, and additional support requirements, all of which have since been documented for future reference.

- **Interdepartmental Collaboration**
  Collaboration between departments can enhance the success of projects. Sharing knowledge and resources leads to better outcomes and avoids duplication of efforts. Creating a dedicated channel for 3D

printing and design on platforms like Microsoft Teams can facilitate this collaboration and be highly beneficial.

3. Procurement and Logistics

- **Material Management**
  Proper storage and handling of 3D printer materials are essential to maintain quality. It is important to track consumable inventory to avoid disruptions. 3D printer filament should be stored in dry, airtight containers or vacuum-sealed bags. Use spool holders to prevent tangling and avoid direct sunlight or the filament can gradually degrade, the color fades and warping can occur.

4. Security and Compliance

- **Licensing and Ownership**
  Creative Commons (CC) licenses provide a structured approach, allowing others to share and adapt the designs under specific conditions. Depending on the license type, this means you can modify, adapt and build upon the designs, as long as you provide proper credit to the original creator. These licenses vary in terms of restrictions and permissions, so it's important to choose the one that aligns with your intended use and compliance requirements. Clearly defining ownership and usage rights of 3D design files within the GC helps prevent the misuse and promotes best practices.

  - **Commercial Use**: This refers to the use of 3D design files for business or profit-oriented activities. If a design is licensed for commercial use, it means that the design can be used in products or services that are sold or for any business-related purposes. For example, creating and selling custom 3D-printed components for IoT devices would fall under commercial use. It's important to ensure that any commercial use complies with licensing terms and GC policies. Creative Commons licenses that permit commercial use include Attribution (CC BY), Attribution-ShareAlike (CC BY-SA), and Attribution-NoDerivatives (CC BY-ND).

  - **Non-Commercial Use**: This encompasses the use of 3D design files for personal, educational, or research purposes without any financial gain. If a design is licensed for non-commercial use, it can be used freely for personal projects, academic research, or within non-profit organizations. For instance, using a 3D model to develop a prototype for a public service initiative or for educational demonstrations would typically be considered non-commercial use. Creative Commons licenses that restrict use to non-commercial activities include Attribution-NonCommercial (CC BY-NC), Attribution-NonCommercial-ShareAlike-International (CC BY-NC-SA), and Attribution-NonCommercial-NoDerivatives-International (CC BY-NC-ND).

5. Quality Control

- **Maintenance of 3D Printers**
  3D printers require regular maintenance to ensure consistent print quality and extend the life of your 3D printers. Over time, components such as nozzles, belts, and build plates may wear down, which may lead to print failures, degraded print quality, etc. Cleaning the build plate between prints, performing routine nozzle checks and tightening belts are key tasks that help maintain optimal performance.

  Additionally, keeping the printers firmware updated is equally important. Manufacturers regularly release updates that can improve functionality, fix bugs, and implement new features. Staying up to date with releases can prevent operational issues and help ensure that the printer functions efficiently. Implementing a structured maintenance schedule is essential to avoid unexpected downtime and reduce the risk of repairs.

  Examples of a structured maintenance schedule are as follows:
  - Clean the build plate to ensure proper adhesion for prints
  - Inspect the nozzle for clogs or buildup
  - Tighten belts to ensure proper tension
  - Check filament feed system for any blockages
  - Lubricate moving parts like rods and bearings to ensure smooth operation
  - Inspect print bed leveling to ensure it remains even for consistent prints
  - Check for any loose screws on key components like extruders, motors and frames
  - Test the cooling fan to prevent overheating
  - Clear dust or debris around printer to maintain print quality

- **Quality Assurance Testing**
  Test prints are important as they proactively identify and address issues before they escalate. Running multiple calibration and bed leveling test prints will help optimize print quality and ensure precise dimensions and layer adhesion. These tests allow for adjustments to be made early in the design process. For some designs, it can be beneficial to print a smaller version to test the concept. This approach helps in making multiple iterations without wasting too much material.

Conclusion

The integration of 3D design and 3D printing within the Government of Canada ecosystem presents significant opportunities for innovation and operational efficiency. By learning from initial implementations and continuously refining processes, departments can leverage these technologies to streamline operations and enhance public service delivery. The lessons learned outlined in this document provide a framework for successful adoption and utilization of 3D design and 3D printing. Embracing these advancements ensures that the government can meet its objectives effectively, drive innovation, and maintain a sustainable approach to evolving technology needs.

Resourceful Links

Resources like community forums, troubleshooting guides, and manufacturer materials can offer valuable solutions and insights encountered during testing and printing.

- **Thingiverse**: A popular platform for sharing and downloading 3D printable models.
- **Ultimaker Cura**: Free software for preparing and managing 3D print jobs.
- **Tinkercad**: An easy-to-use online tool for creating 3D models.
- **Printables**: Offers a variety of downloadable files among other resources.
- **Fusion 360 YouTube Channel**: A popular platform for sharing and downloading 3D printable models.
- **3D Printing Technologies**: Includes detailed articles and videos that compare FDM, SLA, SLS, and DLP printing technologies.
- **ALL3DP**: Interesting magazine for the digital maker, with compelling content on 3D printing, 3D scanning, CAD, laser cutting/engraving, CNC, SBCs, and more.
- **About CC Licenses - Creative Commons**: Creative Commons licenses give everyone from individual creators to large institutions a standardized way to grant the public permission to use their creative work under copyright law.