PERaME: Personalised polypills with programmable release made by 3D printing

SCAN ME

Ken Tam[a] , Jiongyi Yan[b], Andy Gleadall [b], Sheng Qi[a]
[a]School of Pharmacy and Pharmaceutical Science, University of Liverpool, L69 3GE
[b]Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, LE11 3TU
e-mail: c.h.tam@liverpool.ac.uk

Keywords: *Personalised medicine, polypills, additive manufacturing, tunable drug dissolution*

UNIVERSITY OF LIVERPOOL

Introduction

Personalised, segmented-release polypills fabricated via additive manufacturing offer a promising strategy to mitigate issues of polypharmacy and poor medication adherence [1].

The challenge[2,3]:

- 45% of Europeans over age 65 are taking 5 or more prescription medications.
- ~ 50% of medications are not taken as prescribed.
- Non-adherence costs the EU an estimated €300 billion annually.

The Personalised Adaptive Medicine (PERaME) project aims to deliver **a lab-scale proof-of-concept** system capable of producing personalised, segmented-release polypills at the point-of-care, such as hospital pharmacies to improve medications adherence.

Platform development roadmap

- Phase 1 — Pharmaceutical filaments development
- Phase 2 — Identify geometry-driven release control (this work)
- Phase 3 — Multi-material integration
- Phase 4 — Multi-drug compartmentalisation
- Phase 5 — Personalised dosing systems

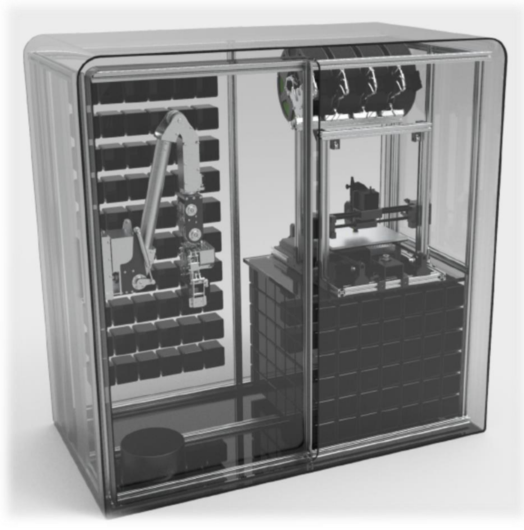

Figure 1. illustration of the conceptual PERaME printer.

Objective: To determine how tablet geometry can be used to control release behaviour in 3D-printed dual-compartment systems, as a foundational step toward personalised, multi-drug polypills.

Methods

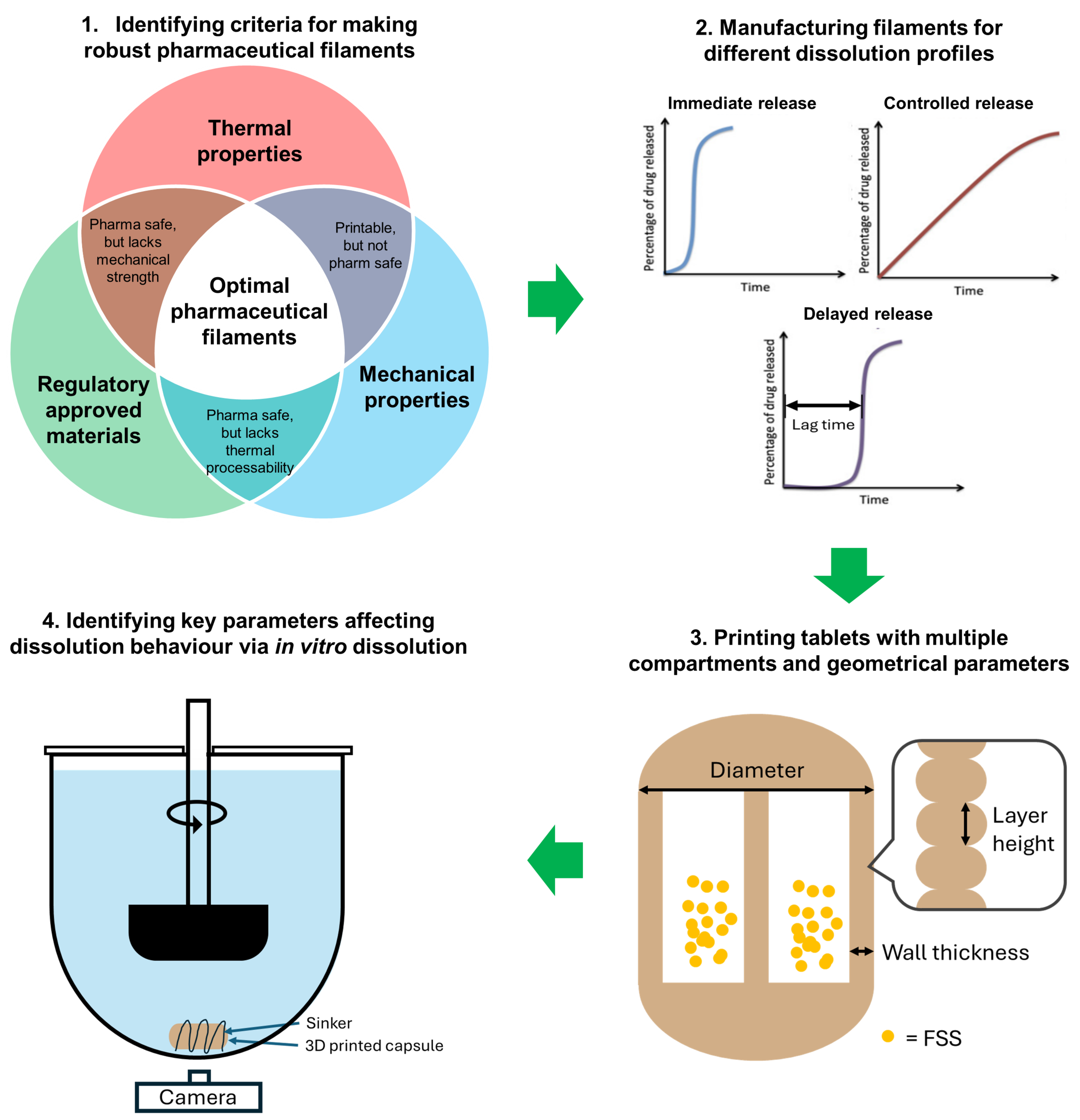

Figure 2. PERaME platform workflow: from material constraints to geometry-programmed release and dissolution testing. Phase 2 PERaME workflow: identifying key geometrical parameters governing release behaviour.

Feedstock preparation: An in-house pH-responsive polymer blend was processed into filament. Fluorescein sodium salt (FSS) was used as a hydrophilic model drug.

Tablet fabrication: Dual-compartment tablets were designed using FullControl GCODE Designer[4] and printed by the Loughborough University team. Design variables included wall thickness, tablet diameter, and layer height. Drug loading was fixed at 20 mg FSS per tablet.

***In vitro* dissolution (n = 3):** USP II (paddle) at 37 °C and 50 rpm. Stage 1: 0.2 M HCl for 2 h with hourly sampling. Stage 2: phosphate buffer (pH 6.8) with sampling continued until complete release.

Acknowledgement

The authors would like to thank the European Union's Horizon Europe Research and Innovation Programme for funding the project (Grant Agreement No 101130241).

European Innovation Council

UK Research and Innovation

Results and discussion

The pH-dependent filament was developed to resist dissolution in the stomach, protecting acid-labile medications such as peptides, or drugs with enhanced absorption in the small intestine for improved bioavailability. Figure 3 shows an example tablet under different pH conditions. The 3D-printed tablets exhibited no detectable drug release in pH 1.2 and initiated dissolution only after the pH was increased to 6.8.

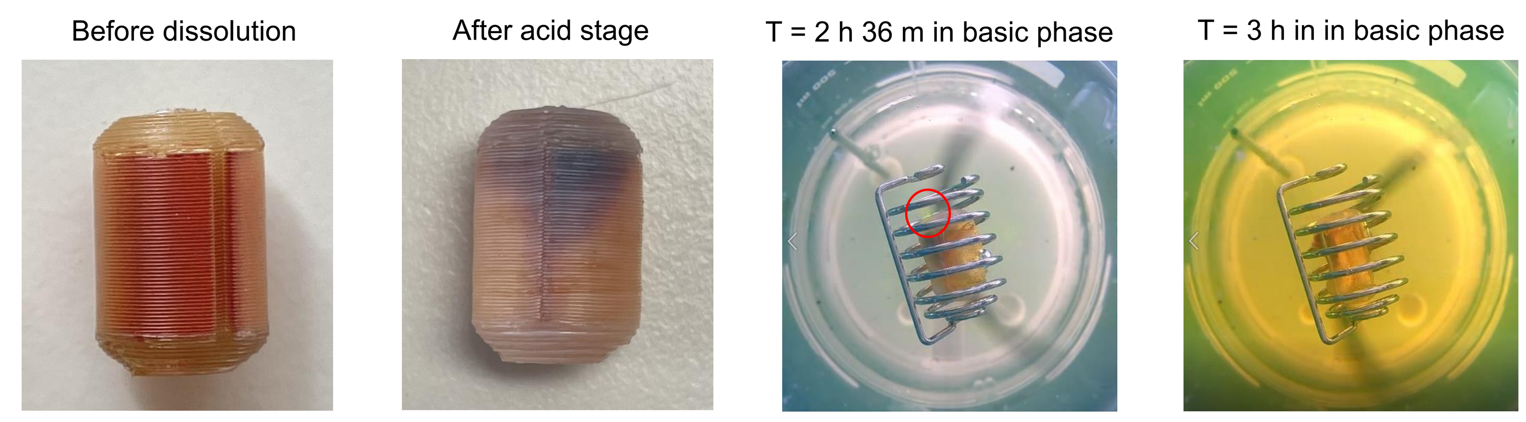

Figure 3. Example images of the delayed-release tablet with no FSS release in pH 1.2 and dissolution in pH 6.8. Red circle shows the initial release of FSS.

Tablet geometry parameters and their influence on dissolution behaviour:

- ***Wall thickness:*** Increasing wall thickness delayed the initial FSS release as shown in Figure 4A, potentially extending tablet transit time in the small intestine. While release time could theoretically be extended indefinitely, wall thickness was limited to 1.2 mm in practice to keep tablet size acceptable for swallowing and space for drug load.

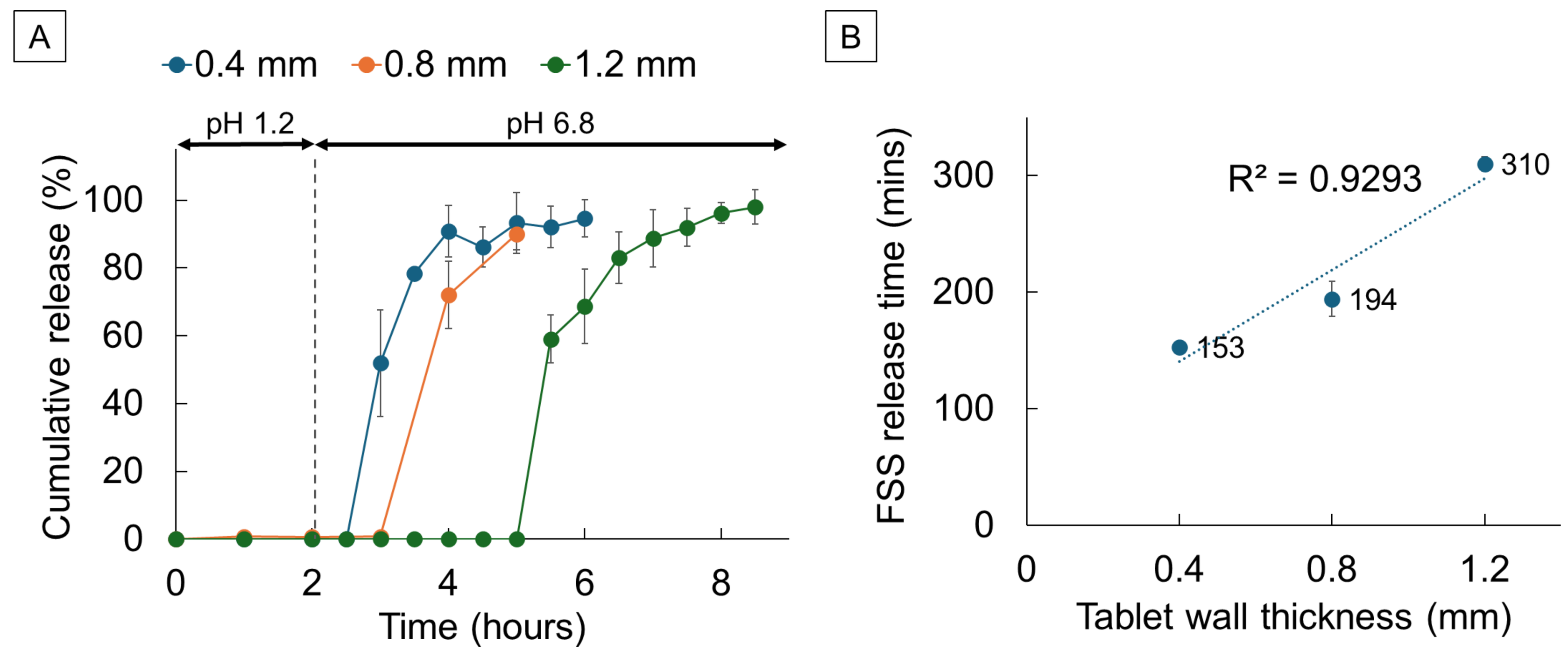

Figure 4. A) Impact of wall thickness on FSS dissolution; B) the initial release time of FSS from tablets with different wall thickness..

- ***Tablet diameter:*** Diameter changes did not significantly affect dissolution time (Figure 5A). However, larger diameters increased internal volume, allowing higher-dose drugs to be incorporated without altering release kinetics.
- ***Layer height:*** No measurable difference was observed in initial FSS release time or overall in vitro dissolution profile (Figure 5B), despite potential effects on surface area. Using a higher (thicker) layer height offers important practical advantages for manufacturing, including shorter print time and improving reliability and throughput by lowering the chance of cumulative print errors.

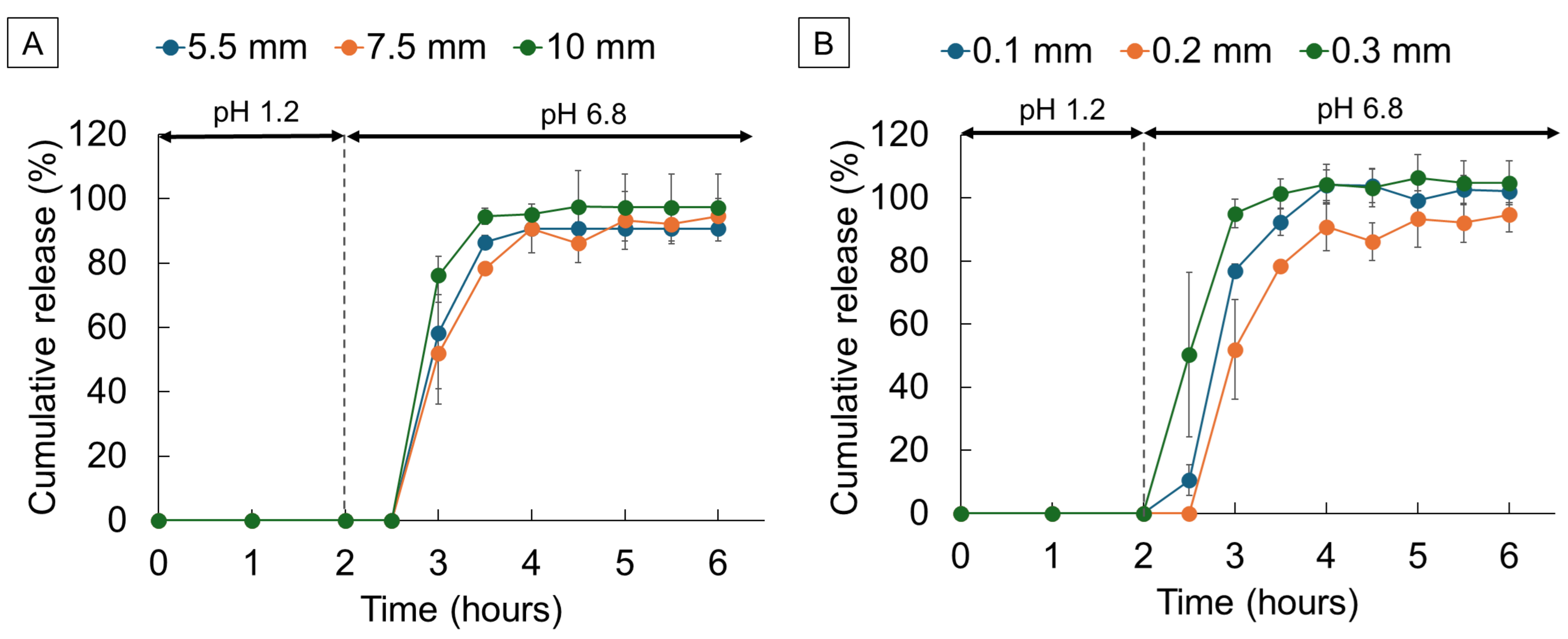

Figure 5. Impact of tablet geometry variations on FSS dissolution; A) tablet diameter, B) layer height.

Conclusion and future work

A reference dataset was generated relating dissolution behaviour to tablet geometry in a pH-dependent 3D-printed dual-compartment system. Across the conditions tested, wall thickness was most strongly associated with FSS release time, whereas diameter and layer height showed limited influence within the explored range.

Ongoing work includes long-term stability testing of feedstock materials under clinically relevant conditions, expansion of the range of drug candidates, and further system integration. Future studies will investigate the dissolution kinetics of immediate- and controlled-release formulations using the same experimental approach, with the goal of building a comprehensive reference database for the PERaME system.

References

[1] V.M. Vaz, L. Kumar, 3D Printing as a Promising Tool in Personalized Medicine, AAPS PharmSciTech 22 (2021)

[2] Eurostat, Medicine use statistics, (2019).

[3] Ballarín .E, Sabaté M, Rottenkolber M. et al. , DRUG CONSUMPTION DATABASES IN EUROPE, Barcelona, 2015.

[4] Gleadall, A., *FullControl GCode Designer: Open-source software for unconstrained design in additive manufacturing. Additive Manufacturing, 2021. 46.*