

**ERC Starting Grant 2023**  
**Research proposal [Part B1]**

**My project title**

**ACRO**

- Principal investigator (PI): My Name
- Host institution: My University
- Full title: My project title
- Proposal short name: ACRO
- Proposal duration: 60 months

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## Section a: Extended Synopsis of the scientific proposal [max. 5 pages]

### i DRAM in a nutshell

The main purpose of this project is to establish a blueprint methodology for the implementation of micro-chain values of distributed recycling at a urban territorial level. We seek to the achievement of a three-level target: (1) the establishment of a free-open source technical ecosystem that can be printed, 2) to establish a set indicators to possible help decision-makers and in the local implementation of these initiatives in Europe/(America?), 3) .....

### Plastics and the Antropocene: a change is needed

Plastic waste contamination is one of the relevant stratigraphic indicator of what is recently considered the Anthropocene era<sup>1</sup>. Popularized by the chemist Paul Crutzen in 2000, the antropocene recognizes humans not only as biological but as geological force acknowledging the new status of humanity given the different markups in the ecosystems that are impacting the stability of the earth system. This impact is characterized by the exponential changes in demography and economic growth since the 19th century that have led to the current climate change and biodiversity collapse. The current manufacturing activities have played a major role as motor for the economic development but also the transgression of the planetary boundaries<sup>2</sup>.

### Rethink the manufacturing approaches

The rebound effect of the mass production paradigm demands to rethink the paradigms of the means of production given current ecological degradation. Indeed, the manufacturing approaches in a post-growth economy context need to integrate the related societal issues of resource scarcity and waste accumulation in the urban lives<sup>3,4</sup>.

### Post-growth as economical logic for the urban settings

The trend is reinforced by the fact that by 2050, it is expected that about 70% of the world's population will live in urban settlements<sup>4</sup>. Likewise, it is expected that urban cities will be responsible for non-negligible environmental impact, producing about 50% of global waste, and 75% of greenhouse gas emissions which affects the sustainability of cities and the quality of city life<sup>5</sup>. Therefore, reconciling urban development and industrial development is not an easy task. **Systemic design thinking is needed to identify major feedbacks in the strategic, the tactical and the operational decisions.** Thus, the type of information that decision-makers take into account is relevant at the moment to put in place industrial systems.

### Design global / Manufacturing local approaches

A major trend in the development of production systems seeks to establish an urban production model with decentralized and distributed characteristics<sup>6</sup>. The free and open source (FOSH) and P2P approaches have been seen as potential driver to propose an alternative globalisation manufacturing paradigm<sup>7</sup>. Aiming a 'design global / manufacturing local' seems a proto-industrialization transition that is taking place given the major impact of the technological development of technologies. In that sense, the concept of urban factory is evolving as a disruptive approach and is the materialization of this manufacturing paradigm. The urban factory is defined as "*a factory located in an urban environment that is actively utilizing the unique characteristics of its surroundings*". It creates products with a focus on the local market and allows customer involvement during value creation. The Urban Factory has a minimal negative impact on its environment while positively influencing the local economy"<sup>6,8</sup>. Particularly, the recycled resources industry consists of a series of activities related to recycled resources – e.g., recycling, refining, remanufacturing, etc. – aspiring to mitigate the negative externality caused by the linear economy<sup>9</sup>. The sustainable development of the RRI has thus been highlighted on many countries' agendas to promote the circular society<sup>10-12</sup>, as well as the goals of carbon peak and carbon neutralization.

### Rebound problem: democratization of the waste

The reduction of the dependence of oil-based materials, as plastics, is a systemic endeavor challenge. However, there is an plastic waste stock of 70 years of accumulation of plastics materials. If the prot-

systems of ‘design global / manufacturing local’ continues to be democratized, **we’ll probably leading to a future with a rebound effect of waste.** Therefore, the major problem is today is how to conceived socio-technical ‘circular units’ that they will be designed in order to include the externalities that to give an broader environmental benefits.

### My implication in the State-of-the-art advancement

Since 2014, I have been working on the validation of the open source additive manufacturing as a robust manufacturing system<sup>13</sup>, but also as enabler of the mechanical recycling<sup>14,15</sup> of plastic waste material. This is and promise breakthrough in the constitution of a circular industry. From an energy and environmental perspective, the scientific literature<sup>19</sup> proves that the mechanical recycling strategy is the most suitable plastic waste management option for relatively clean and homogeneous plastic and bioplastic waste streams compared to landfilling or incineration alternatives. Also, we have proposed a closed-loop supply chain networks to possible implement distributed recycling<sup>20,21</sup>.

However, using a systematic literature review, I realize that the system maturity the technical value chain for the implementation of a community-driven of plastic recycling is ambiguous. Efforts have been in the materials and technical validation. But, the system validation remains to be difficult. In the context of a possible, we try to implement this approach in the context of an on-going European collaborative research project, INEDIT<sup>ref?</sup>. Nevertheless, the main challenge remains to make affordable the use of new secondary material applicability by the industry<sup>22</sup>.

### Distributed recycling via additive manufacturing

The purpose of this project is to give a blueprint methodology that enable to establish a distributed recycling approach in urban settlements. Considering the different specificities of AM processes, a broad field of opportunity is emerging to develop more sustainable means of production at different levels of the value chain<sup>23</sup>. DRAM seeks to the achievement of a three-level target: 1. the establishment of an open source technical ecosystem by means of open source hardware using 1. from a pluralism lens<sup>24</sup>, I aim to define principles, criteria and indicators that make synergy between industrial and biosphere systems using an ecological economics approach. 1.

### A challenging task

To appreciate the ground-breaking scientific nature of this idea, we can I like to highlight that historically, the plastic recycling has been oriented to centralized facilities in order to take advantage of economies of scale through the production of low-value products. However, it is proved to be an expensive process due to the inherent separate collection, transportation, processing and remanufacturing<sup>25,26</sup>. The consequence is for high volume and low weight polymers, the recycling of plastic is not cost-efficient in a centralized context. In fact, if we currently consider the sources of plastic waste and more specifically those from food packaging, we are faced with various limitations related to the types of material and their shaping. More specifically, sorting centres find themselves with 3 material flows to manage. The first group (G1), namely that of bottles and flasks, is well controlled with relatively distributed sorting throughout the French territory (about 150 sites) and centralized mechanical recycling in a few specialized centres by type of plastic (polyethylene (PE), polypropylene (PP), high density PE (HDPE) PET, etc.). For the second group (G2: i.e. refusal of sorting PET, PP, PET/ HDPE mixture, polystyrene polyethylene (PS)), following the many actions carried out in recent years, we find ourselves with sorted plastics but due to a lack of circuit and value chain only residual energy value is considered although their properties are still high. Finally, the third group (G3: i.e. biopolymers, polylactic acid (PLA), Polyhydroxyalkanoate (PHA)) consists of unsorted plastics that end up in landfills and on which we have very little information [17].

### DRAM: why now?

Distributed recycling fits into the circular economy paradigm<sup>23,27,28</sup>, as it eliminates most embodied energy and pollution from transportation between processing steps. Additionally, open-source investment should result in an extremely high return on investment (ROI) in free and open source hardware<sup>ref?</sup>. This makes distributed recycling and additive manufacturing (DRAM) environmentally superior to other

methods of plastic recycling.

**Axe 1: development of a open-source technodiversity for recycling**

- Joshua

**Axe 1: Systemic analysisi in function of the local territory**

- Development of methodology to identify potential urban disposal sites connecting

**Axe 3: Circular bussines model for recycled communities**

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**Axe 4: Properspective recomendation through delphi analyss?**

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## Ramdoms thoughts

- Technical challenges in the recycling process
- The use and disposal of plastics is a wicked problem characterized by high complexity and multifaceted feedback loops that calls for a systemic view of the entire plastics value chain from oil refinement to polymer production, conversion, retail, consumption, and recycling the material back into the value chain [9].
- Transitioning to sustainable plastics in the manufacturing of plastic products, parts, and packaging is influenced by the complex interconnections between polymer producers - petrochemical companies [10], converters [11], brand owners or manufacturers [12], retailers and consumers [13], and recycling operators [14], as well as the influences of policymakers in wider economic and societal changes [11]. Economic, social, political and technological barriers must be overcome for sustainable plastic management [9].
- Kawecki et al in [15] developed a dynamic probabilistic material flow analysis of seven commodity TPs identifying nine product sectors and 35 product categories, across Europe from 1950 to 2016.
- Their model revealed that “the major final compartment for plastics was landfill (48%–60%)”. Even for common consumer plastics such as polyethylene terephthalate (PET) and olefin plastics, achieving a circular economy is a major challenge [16].

towards the distributed recycling via additive manufacturing approach<sup>29</sup>, validating the open source 3D printing as a reliable technique process. This validation of the process have also include the polymer recycling process as a possible industrial vector that enables can give possible uses to this abundant material.

Studies on the technical viability of recycled materials as substitutes for conventional virgin materials are still limited to particular applications<sup>30</sup>. We have proved that for prototyping is the case<sup>ref?</sup>. We need to imagine that the use of recycled assets becomes a norm and not a exception in the industrial process. This is important given that in a post-growth approaches, the rarefication of virgin assets is a plausible scenario.

### Preliminary studies on the use of rec

- The use of recycled materials like polymer waste is going to be one of the stock that we’ll need to use given the scarcity of
  - Additive manufacturing is a potential enabler of change for manufacturing
  - the community-base recycling approach is a scale of the changes
  - major efforts in the implementation of community-driven recycling approach is needed in the urban settlements
  - the proposition of system dynamics as modelisation tool to understand the the main gap in ecosystems services are needed in the ) like a bacterias, we need to develop a industrial infrastructure that stimulus the regenerative use of products
  - Validation of open source as a means to foster the manufacturing conviviality
  - Resilience as a major backtrack for industrial processes in the future
  - Pluralism forms of evaluation needs to be developed to evaluate the implementation strategies of community-driven strategies of manufacturing.
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- Mechanical recycling is leading a path in the transformation of waste-to-ressource atoms
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## Section b: Curriculum vitae (max. 2 pages)

### PERSONAL INFORMATION

Cruz, First name:	<b>CRUZ SANCHEZ, Fabio Alberto</b>
Researcher unique identifier:	<b>ORCID:</b> 0000-0001-8529-5327
Date of birth:	06/05/1988
Nationality:	Colombian / French
URL for web site:	<a href="http://fabbiocruz.com">fabbiocruz.com</a>

### Education

2013 – 2016	Ph.D. in Industrial Engineering at the Université de Lorraine Title: <i>Methodological proposition to evaluate polymer recycling in open-source additive manufacturing contexts</i> <ul style="list-style-type: none"> <li>■ <b>Director:</b> Prof. Mauricio Camargo – ERPI, Nancy - France</li> <li>■ <i>Prof.</i> Hakim Boudaoud PERRY – ERPI, Nancy - France</li> <li>■ <i>Dr.</i> Sandrine Hoppe – LRGP, Nancy</li> </ul>
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The thesis is a result of a innovative collaboration between the Industrial Engineering Laboratory and the Chemical . I participate in the Symposium congress at Texas University. This enables the collaboration with Prof. Joshua Pearce in the domaine of Distributed recycling via additive manufacturing. This enables me to co-create the open hardware approaches fostered with the innovation multi-scale at ERPI laboratory.

### Current Position

2022	Research Associate at the ERPI Laboratory École nationale supérieure en génie des systèmes et de l'innovation –ENSGSI- Équipe de Recherche sur les Processus Innovatifs –ERPI-, Université de Lorraine, France
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### PREVIOUS POSITION

2020 - 2021	Post-Doctoral at Unievrstité Technologique de Troyes -UTT
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### Fellowships AND PRIZES

#### Main Teaching aactivities

#### Organisation of Scientific meeting

2022	Invited lecturer to the Workshop of Additive Manufacturing ". 300 Participants. ERPI - Nancy
2022	Member of the organization committee of the IEEE ICE / IAMOT joint conference on the topic of " <i>Technology, Engineering, andInnovation Management Communities as Enablers for Social-Ecological Transitions</i> ". 300 Participants. ERPI - Nancy

### INSTITUTIONAL RESPONSIBILITIES (if applicable)

#### REVIEWING ACTIVITIES (if applicable)

201? – Scientific Advisory Board, Name of University/ Institution/ Country 201? – Review Board, Name of University/ Institution/ Country 201? – Review panel member, Name of University/ Institution/ Country 201? – Editorial Board, Name of University/ Institution/ Country 200? – Scientific Advisory Board, Name of University/ Institution/ Country 200? – Reviewer, Name of University/ Institution/ Country 200? – Scientific Evaluation, Name of University/ Institution/ Country 200? – Evaluator, Name of University/ Institution/ Country

**MEMBERSHIPS OF SCIENTIFIC SOCIETIES (if applicable)**

201? – Member, Research Network “Name of Research Network” 200? – Associated Member, Name of Faculty/ Department/Centre, Name of University/ Institution/ Country 200? – Founding Member, Name of Faculty/ Department/Centre, Name of University/ Institution/ Country

**MAJOR COLLABORATIONS (if applicable)**

- Joshua Pearce, “Technical evaluation of the distributed recycling approach”, Name of Faculty/ Department/Centre, Western University / Institution/ Canada.

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- urban waste market is not separated to the existing circuits of waste management [④]
- case-based empirical research looking at how waste markets are evolving in response to resource efficiency discourses



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