# Innovative Solutions Canada

**CHALLENGE NAME:** 3D PRINTING AND ADDITIVE MANUFACTURING: METAL POWDER BED DENSITY TEST EQUIPMENT.

**SUMMARY:** This ISC challenge is sponsored by the National Research Council of Canada (NRC) and seeks new solutions to enable the testing of metal powder bed density in additive manufacturing processes.

**CHALLENGE NUMBER:** *To be determined*

**CHALLENGE CLOSING DATE AND TIME:** *To be determined*

**CHALLENGE SPONSOR:** National Research Council of Canada

**MAXIMUM CONTRACT VALUE:**

Multiple contracts can result from this Challenge.

The maximum funding available for any Phase 1 Contract resulting from this Challenge is $150,000.00 CAD (plus tax) including shipping, travel and living expenses, as applicable.

The maximum funding available for any Phase 2 Contract resulting from this Challenge is $500,000.00 CAD (plus tax) including shipping, travel and living expenses, as applicable. Only eligible businesses that have completed Phase 1 could be considered for Phase 2.

This disclosure is made in good faith and does not commit Canada to contract for the total approximate funding.

**TRAVEL:** For Phase 1, it is anticipated that up to two meetings may require the successful bidder(s) to travel to the National Research Council of Canada, 75 Boulevard de Mortagne, Boucherville, QC J4B 6Y4

**PROBLEM STATEMENT**

NRC has been involved in the development and qualification of powders for more than 30 years and supports a cluster of powder producers around Montreal. Having access to a tool capable to measure metal powder bed density would help NRC to contribute further into this research field and support the development in this area for the Canadian industry.

Producing parts of consistent quality is a significant challenge in 3D printing (i.e. additive manufacturing) and a lot of effort is being made by the industry and the research community to improve the quality and reproducibility of the technology. In metal 3D printers, parts are built layer by layer by preferentially melting powder with a laser. Each layer of powder is applied by a mobile device called a “recoater arm”. One of the key aspects of such a process is the packing density of these powder bed layers. The packing density of these layers is influenced by several factors such as: 1) powder characteristics and behavior, 2) recoater design, 3) recoated operation and 4) environmental conditions.

To optimise the recoating operation and ensure part quality, it is essential to quantify the impact of the influencing factors on the powder bed packing density. While different standards exist to quantify powder flowability and density, there is presently no equipment available to test the powder under conditions replicating the ‘recoating’ process.

**DESIRED OUTCOMES & CONSIDERATIONS**

This challenge seeks to obtain such test equipment which must be able to reproduce the recoating operation and measure the density of the resulting powder layers. Because the equipment could be used for research and development (R&D) as well as broader commercial applications (i.e. for quality control purposes), the possibility to vary the influencing factors in a controlled manner is therefore mandatory. This challenge must result in a test equipment, addressing specific R&D needs of NRC as well as broader needs for quality control in the industry.

Principle of operation:

The equipment should be equipped with a 'recoater arm' that spreads a certain quantity of powder over a working area. It is believed that a gravimetric means could be used to measure the density. The weight of the powder layer, or a portion of it, could be evaluated using a load measuring device such as a scale.

Ultimately, it should be possible to make a series of successive layers and continue to measure the evolution of the density. Optical sensors could also be considered to qualify the powder layers (ex.: thickness, presence of defects, variation of density or uniformity). Suggestions for other measuring strategies are welcome.

Sensitivity:
The equipment **must** have a sensitivity of at least 0.2% of the relative density of the metal to be coated. The powder layer has to be of constant thickness and provision shall be made in the design and the operation manual to measure its thickness and adjust the recoater arm position when required.

Versatility:
It should be possible to control the following features:
Powder layer thickness (20-200µm)
Metal powder deposition mechanism:

- coating speed/ Recoater arm speed
- Angle of attack of the blade
- Cylindrical coating blade action (rotating or not, ideally)
- Oscillating blade

Atmosphere surrounding the powder: air, $N_2$, Ar, vacuum
Static electricity (potential use of an ionization blower)
Other actions or conditions that reproduce present commercial 3D printers

Data acquisition and instrumentation:
The equipment **must** be computer controlled and all parameters must be stored in result files. Extra space above the experimental chamber should be available for a possible retrofit with a camera (or other optic system) to film the coating operation and capture the visual aspect of the bed or characterize its surface.

Health & Safety:
The equipment **must** allow a safe manipulation of powders. It **must** be easy to clean to prevent cross-contamination.

**BACKGROUND & CONTEXT**

Additive manufacturing (AM) technologies have recently generated world-wide interest as they provide flexibility and allow the production of complex parts that cannot be easily produced with other fabrication processes. These technologies have recently evolved into production processes in various industrial sectors including medical, aerospace, and automotive. In order to increase the penetration of AM technologies, a number of technical issues must be addressed. One of these is the quality and cost of the metal powder feedstock which affects the economics of the process, as well as the management and control of the quality and reproducibility of the manufactured parts.

One of the key parameters in managing the quality of the parts is the production of defect free powder layers with uniform and constant packing density during printing. This can be achieved by selecting an appropriate powder, optimising the recoating arm design and optimising recoating operation parameters. These optimisations would benefit from the measurements of the impact of fabrication conditions on the powder bed packing density. Moreover, in operations where recycling is permitted, machine users need a means to measure the quality of the powder as they are recycled.

One of the needs to improve AM processes is also the development of numerical models to predict powder deposition. The reliability of the models depend on their calibration using key powder bed attributes measured under conditions representative to those observed in 3D printing machines.

Van den Eynde et al (2015) have built laboratory equipment specifically to measure the density of plastic powder bed. Although they proposed a very inspiring design, it is not commercially available and cannot be used with metal powders. Bidare et al (2017) presented an open architecture metal 3D printer. This equipment allows characterising the powder bed using x-Ray and high speed cameras but does not allow measuring the packing density of the powder bed.

The product to be developed in this challenge must target academic and R&D institutions. The equipment will require some sophistication, with the ability to allow several parameters to be modified and should be equipped with precise instrumentation. Furthermore, it should be possible to easily modify the equipment for broader use and adoption by 3D printer users and powder manufacturers.

**ACQUISITION STRATEGY**

It is anticipated that a CFP will be posted on the Buy and Sell website in January 2018. The CFP will describe the proposal submission instructions and the evaluation procedures and criteria against which proposals will be assessed.