

Ultra-Deep Mining Network (UDMN)

Think Deep Program – CALL FOR PROPOSALS 2014

Open Call Guidelines

Context

Deep underground metal mines are the source of the specialised metals including nickel, chrome, molybdenum, lead, zinc, platinum, gold and palladium – that are essential for the modern industrial economy. While the supply of commodity metals such as iron, aluminum and copper generally come from very large open pit mines, the specialised metals are largely produced by deep underground mines (> 2.5 km below surface).

The pressing need for a fundamental shift in how we design, develop and operate underground metal mines is driven by three converging factors:

- the need for many of the large open-pit copper mines in the world to go underground while sustaining unchanged production levels
- the need to pursue specialised industrial metals to ever greater depths and
- the need to attract a new generation of well educated, socially diverse employees.

The Ultra-Deep Mining Network (UDMN) is a **\$46 million business-driven network** (\$15 million from the Networks of Centres of Excellence of Canada leveraged through partner cash and in-kind contributions), founded by members of the mining and oil & gas industries, with the active participation of small to medium sized enterprises, industry agencies, research facilities and academia.

UDMN is a distinct collaborative network that approaches innovative R&D in the ultra-deep mining environment as a joint business model where all members contribute to the cost and benefit from the network's successes. A family of leading experts is dedicated to advancing deep mining and will ultimately be known for driving the innovative solutions for the mining industry, making deep mining financially feasible for the future.

The objective of the Ultra-Deep Mining Network is to help the mining industry by developing commercially viable research and development projects that result in proven, innovative technologies with high impact.

The Scope of the Program

The UDMN *Think Deep Program* aims to support solution-providers capable of creating the industry-needed tools and technologies that will help ultra-deep mines (below 2.5kms) to operate more effectively and safely, generate more value, improve the human environment and enhance mine productivity in the short term.

Working to amplify and expedite commercial value and enhance ultra-deep mining innovations in Canada, this program is intended to directly help the mining industry to accelerate research and development, increase investment in R&D and deploy proven innovative and advanced technologies. This program is not intended to support fundamental research, but rather apply new forward-looking technologies to mining at depth (below 2.5kms).

This program seeks solution-providers to collaborate with industry (private organizations), Canadian academia, and research institutions to implement solutions for ultra-deep mining. Successful applicants will have a project that is industry-supported; addressing a specific industry challenge to advance development in ultra-deep mining environments.

Research Agenda

Within the Ultra-Deep Mining environment (below 2.5kms), there are four strategic themes (see Theme Description for details):

Theme 1: Rock stress risk reduction; improve the control of stability in deep underground excavations

Theme 2: Energy reduction & optimization: the 40% Mine; improve the energy consumption profile and cooling of deep mines

Theme 3: Novel methods of **material transport and productivity;** increase the rates of development and production in mines

Theme 4: Improved human health; use a human-centered approach to improve environment in deep mines

Only projects with a well defined, near term application deemed to optimally impact the ultra-deep mining field will be invested in under this program.

Program Requirements (Selection Criteria)

This program is deliberately intended to enhance collaboration and advance innovations with Canadian academia and/or private organizations.

Each project proposal must meet the following criteria:

- ✓ Make a compelling case that it will have optimal impact on deep mining and is within one of the four ultra-deep themes: rock stress risk reduction; energy optimization; material transport and productivity; and improved human health (see detailed theme descriptions for more information)
- ✓ Address specific needs/challenges identified in the mining industry
- ✓ Convincingly demonstrate commercial outcomes. Demonstrate a project's path to commercialization
- ✓ Involve collaborations with industry and/or academia
- ✓ Generate clear deliverables and a sound sense of expected value-added
- ✓ Be based/take place in Canada and be led by Canadian solution-providers
- ✓ Have a maximum project duration of 2 years
- ✓ Successful applicants will be expected to become a Network Member
- ✓ Every Network Member will contribute to the Network with cash and in-kind contributions

Timetable

Call for Proposal	October 27, 2014
Submission Deadline for (letter of Intent) LOI	November 10, 2014
Announcement of the Selected LOIs	November 17, 2014
Submission Deadline for Initial Application	December 8, 2014
Announcement of the selected Initial Applications	December 18, 2014
Submission Deadline for Full Application	January 15, 2015
Announcement of the Selected Applications	March 2015

Eligibility and Proposal Process (Overview)

Description	Applicants in Canada with a project that focuses on applied solutions to ultra-deep mining
Eligibility	Must be Canadian or a resident of Canada
Project Timelines	Within 2 yrs of start date
Application Requirements	Letter of Intent Initial Application Full Application
Submission	Submit to submissions@miningdeep.ca
Contact for questions and	Diane Lepage

comments on application process	UDMN Administrative Coordinator submissions@miningdeep.ca 705-673-6568
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The project proponent must operate from a Canadian base and demonstrate clear intentions and capacity to further develop project results. Start-up companies may be considered, provided that they meet the requirements. In all cases, proponents must demonstrate the ability to exploit the project's results and to be eligible the research must be performed in Canada.

The applicant will bear all of its own costs and expenses associated with or incurred through the preparation of a proposal to the Call for Proposal (CFP) process. Including, without limitation, any costs and expenses arising out of or incurred in:

- (a) the preparation and issuance of the CFP;
- (b) the preparation and making of a submission; or
- (c) the conduct of interviews, negotiations or other activities related to the CFP process.

Submission Procedures

1. Applicants must submit a letter of intent that fulfills the selection criteria for the LOI to submissions@miningdeep.ca by **November 10, 2014 at 5pm EST**.

Subject Line in email must read: **Letter of Intent and Project Proponents name**

2. Successful applicants from the LOI phase will receive and must submit the Initial Application form to submissions@miningdeep.ca by **December 8, 2014 at 5pm EST**.

Subject Line in email must read: **Initial Application and Project Proponents name**

3. Successful Initial Application Applicants must submit using the Full Application form provided to submissions@miningdeep.ca by **January 15, 2015 at 5pm EST**.

Subject Line in email must read: **Full Application and Project Proponents name**

Upon submitting an application a no-reply back email will be sent confirming receipt.

Withdraw from Call for Proposals:

Applicants who wish to withdraw from the program application process at anytime can contact Diane Lepage, at submissions@miningdeep.ca

Funding Specifics

Detailed eligible expenses and financial information will be made available with the initial application forms.

Review and Decision Process

The program will select successful applicants following a competitive process.



For all applicants who are not currently UDMN Network Members who qualify under the Program Requirements/Eligibility. See Program Requirements section for details.

1. Letter of Intent



Applicants must submit a Letter of Intent by **November 10, 2014 at 5pm EST**.

The LOI must include the applicant's name, contact information, project working title, and the applicable theme(s). The length of the LOI should be no longer than 2 pages with size 11 font, preferably in pdf format.

The selection of the letters of Intent will be reviewed by the UDMN staff and Management Committee based on the binary measure of the selection criteria. Successful candidates will

receive a notification and a request for the completion of the Initial Application. All LOI applications and their contents will be treated as confidential information.

Selection Criteria for LOI:

- ✓ Make a compelling case that it will have optimal impact on Deep Mining and is within one of the four ultra-deep themes: Rock Stress Risk Reduction; Energy Optimization; Material Transport and Productivity; or Improved Human Health (see detailed theme descriptions for more information)
- ✓ Be an innovative idea
- ✓ Project proponent has to demonstrate relevant capability and expertise
- ✓ Project must address specific needs/challenges identified in the mining industry
- ✓ Project must demonstrate the potential for commercial outcomes
- ✓ Project must take place in Canada and be led by Canadian solution providers
- ✓ Maximum project duration 2 years

If an LOI does not meet the above criteria, a referral may be made to the appropriate department at the Centre for Excellence in Mining Innovation (CEMI) for other potential funding and partnering opportunities.

Only applicants whose LOI is selected will be invited to participate in the initial application phase.

2. Initial Application



Applicants who successfully pass the LOI phase will be provided further instructions and the initial application form which is comprised of specific questions addressing the issue, previous efforts, value proposition and solution, benefits to the Industry, partners, and overall budget.

The completed form (max 4 pages), must be submitted by **December 8, 2014 at 5pm EST** to submissions@miningdeep.ca.

The selection of the Initial Application will be overseen by the UDMN Management Committee and will include an independent third party review. Initial Applications decisions and feedback will be delivered by **December 18, 2014**.

Only applicants whose Initial Application is selected will be invited to participate in the Full Application and to start a dialogue with the appropriate UDMN Theme Leader.

3. Full Application



The Full Application is to be completed by applicants who have successfully passed the Initial Application.

At the Full Application phase, applicants must provide confirmation that they have secured funds (including cash and in-kind) in the form of a signed letter of commitment. The Full Application, including a research method, comprehensive scope of work, detailed budget, timelines and scheduling, must be submitted by **January 15, 2015 by 5pm EST**. Applicants are encouraged to collaborate with Theme Leaders for the opportunity to gain valuable feedback about overall fit to that theme.

Further information including the form will be provided to the finalists.

Approval Process for Full Application



Full proposals will be evaluated in a formal review process by the Management Committee. The committee members are chosen for their specific scientific and/or industrial expertise in the field of ultra-deep mining. This Committee will present recommendations based on program requirements to the UDMN Board of Directors who will decide on the final list of approved applications and the necessary budgetary allocations to deliver on these applications.

Successful applicants will be contacted in **March 2015**.

If the application does not meet the above criteria, a referral may be made to the appropriate person/department at the Centre for Excellence in Mining Innovation (CEMI) for other potential funding and partnering opportunities.

UDMN Theme Descriptions

Theme 1: Rock Stress Risk Reduction

Resource extraction in Canada is occurring at ever greater depths and geotechnical risks are increasing significantly, particularly as they relate to stress within the rockmass. The challenges associated with this, in both the mining and oil and gas sectors, need to be addressed as failing to do so will foster unacceptable project risks. This in turn will impact investment and will jeopardize Canada's competitiveness.

a) **Induced Seismic Hazard Mitigation in Ultra-Deep Mines**

The Challenge: Rock stress and stress-change management when mining at depth are absolutely critical to minimize geomechanics-related risks which can impact operational productivity, cost management and safety.¹ Further, when rock stress-related ground failures occur, entire sections of mines can become inaccessible, with serious negative economic impacts and potential mine closures due to sterilization of ore reserves. Mine sequencing and de-stress blasting are currently used to modify the stress field and reduce the seismic hazard in deep mines but these techniques are often insufficient to adequately reduce rockburst potential and related risks in mines—in particular near vulnerable underground excavations. Thus, further complementary and innovative R&D methods are required.

The *Think Deep Program* is targeting proposals that will explore ways to better measure, anticipate, mitigate and manage and even modify built up stresses in the rockmass, resulting in more intelligent rock mechanics design protocols and advanced approaches (in part built upon experience from the Oil & Gas sector).

b) **Extraction of Oil & Gas in tight shale rock at depth in non-conventional Hydrocarbon Reservoirs**

¹ These factors are also important from an investors' (internal and external to a company) confidence perspective.

The Challenge: The ability of the Oil & Gas (O&G) industry to extract hydrocarbons from tight shale rock deposits at extreme depth can be improved through cross-sectoral R&D involving Canada’s deep mining industry. Techniques applied to lower rock-related stress in underground mines are strongly applicable to the O&G industry and both sectors have a need to generate closely spaced fracture networks— for hydrocarbon release and transportation in the case of the O&G sector and caving/fragmentation/stress management purposes in the case of the deep mining industry.

Despite the vast inventory of microseismic information that has been collected and interpreted by the O&G sector to understand fracture and reservoir stimulation (including information on the orientation, density and half-lengths of fractures), stimulated rock volumes are often poorly understood and can be difficult to reconcile with ultimate hydrocarbon production output. Difficulties are encountered in relating the stimulated volumes to the “geophysical observables”. Understanding these parameters is extremely important to ensure efficient and effective exploitation of trapped reserves.

Cross-sectoral R&D proposals will look at ways to make mines safer by reducing geotechnical risks through a broader understanding of these same parameters while also helping to ensure Canada’s ability to supply hydrocarbon-based energy resources into the future.

Successful *Think Deep Program* proposals will provide the underpinning of technology development and new knowledge to aid in tackling what are anticipated to become two of the more significant technical challenges for the O&G and ultra-deep mining sectors in the next ten years.

Theme 2: Energy reduction & optimization

The 40% Mine; Improve the energy consumption profile of deep mines

The Challenge: The 40% Mine is an initiative that aims to reduce the energy consumed by mines to 40% of their current consumption levels by 2040. This theme of the UDMN will work toward this goal specifically for Ultra Deep Mines.

The energy required to power underground mine operations is extensive and can be equivalent to that used for a small city of a few thousand people. For the average Canadian underground hard rock mine, the energy input costs to production alone are 18%. This fraction has been steadily increasing for the last 50 years and this trend continues. For underground mines in soft rock the average is closer to 22%. According to some empirical models for all fuels energy consumption (electricity, heating, cooling, transport fuel) 97% of the variance in the models can be explained with just three variables: i) production rate, ii) heating degree days and iii) production depth. Proposals in the following areas will be particularly welcomed, but this

theme of the UDMN aims to support research, development and innovation/commercialization activity in the field of energy that focuses on, or specifically relies upon, 'extreme-z'.

- Innovation arising from enhanced understanding of the psychology of energy consumption in all types of stakeholders in ultra deep mines. Such works should be commercializable and may rely on behaviour change mechanisms.
- Measurement, Auditing, Benchmarking and Optimization of energy systems for ultra deep mines. Innovations are particularly welcome in the fields of energy measurement systems, audit methodologies and consumption metrics, realized in hardware, firmware or software that specifically address the needs of ultra deep mines. This includes application to potentially non-obvious energy flows in the sub-surface, including thermofluid distribution such as ventilation air flows, and power transmission such as compressed air distribution.
- Alternatives to diesel powered loading and haulage systems that offer substantial cost savings or operational benefits relative to conventional practice for ultra deep mines.
- Deep mine cooling technologies that will deliver a discounted cost of a MWh_r that is at most 50% of that of a conventional vapour compression refrigeration solution.
- Development of vertical transportation of ore and waste with an energy efficiency of greater than 66% relative to the potential energy of raising that mass to the surface from depth an ultra deep mine.
- Energy storage technology and development in or for ultra deep mines. This could include (flow) battery technology, pump storage (including the deferral of ore and waste rock haulage), liquefaction of gases, safe installation of flywheels, supercapacitors and superconductors, and Compressed Air Energy Storage systems.

Theme 3: Improved Mine Productivity and Novel Transportation Methods

The Challenge: Mining companies continuously strive to improve each of the processes involved in getting their product to the mill. As their operations expand further underground, it becomes more critical to find these improvements, because it will take longer to transport workers and materials into the mine and to the work place. Similarly, the transportation of ore, waste and fill material into and out of an ultra deep mine present an ever-increasing challenge as mines go deeper.

The main research areas of interest for the *Think Deep Program* focus on improving Mine Productivity and introducing novel transportation methods are about improving the individual steps involved in:

1. the mine development process – more efficient drilling, loading/blasting, mucking, ground support, transport of material, ventilation.
2. the mine production process – production drilling, loading/blasting, mucking, filling, sizing and transport of material.
3. the supply of support and services – ventilation, pumping, mine planning, communications, surveying, slimes management.

Successful proposals will focus on these main research areas.

Theme 4: Improved Human Health

The Challenge: There is a direct relationship between working in extreme environments and decreased workforce productivity. Physiological stressors are common for workers in deep mining environments, and even more so within the ultra-deep mine setting. There is a need for the development of effective personal protective gear that will help keep people working within appropriate occupational conditions. Normalizing temperature and environmental condition extremes such as hot and cold masses of air including oxygen levels and high concentration of diverse contaminants are required. One must meet ambient air quality standards so as to not alter or impact human health or performance. Biophysical inputs and outputs of working in Ultra Deep Mining conditions require solutions that will address psychological, physical and social health and safety issues which affect worker performance. Working at depth is synonymous with remoteness and isolation which is known to influence worker wellbeing and productivity. Developing systems and technologies that improve communication, navigation and the overall wellbeing of the ultra-deep workforce is a priority.

The main research areas of interest for the *Think Deep Program* focus on improving human health in ultra-deep mining environments are:

1. Workplace ergonomics and human Factors for Ultra-Deep Mines;
2. Workplace safety and industrial hygiene;
3. Thermal Control – to design novel systems and technologies that regulate the temperatures to which workers will be exposed
4. Communication and Navigation – to improve systems of communication and navigation to effectively communicate with workers over a wide geographical area underground.

The *Think Deep Program* seeks proposals that develop sound and resilient technologies to tackle occupational health and safety challenges in ultra-deep mines. Coordinating and seamlessly combining these technologies together are essential to the advancement of Ultra Deep Mining.

UDMN Theme Lead Contacts

UDMN Research Themes	Theme Leader	Email
1. Rock Stress Risk Reduction Improve the control of stability in deep underground excavations	Damien Duff	dduff@miningexcellence.ca
2. Energy reduction & optimization The 40% Mine; improve the energy consumption profile and cooling of deep mines	Dean Millar	dmillar@mirarco.org
3. Novel methods of material transport and productivity Increase the rates of development and production in mines	Harvey Parsons	hparsons@miningexcellence.ca
4. Improved human health Use a human-centered approach to improve environment in deep mines	<u>Academic lead</u> Sylvie Nadeau <u>SME lead</u> Allan Akerman	Sylvie.Nadeau@etsmtl.ca aakerman@miningexcellence.ca

Sponsors and Affiliates

Centre for Excellence in Mining Innovation (CEMI)

The Centre for Excellence in Mining Innovation (CEMI), located in Sudbury, Ontario, is continuing its R&D efforts to facilitate the delivery of step-change research initiatives which are deemed critically important to the mining industry. It strives to establish excellence in strategic areas of research: deep mining, mineral exploration, integrated mine engineering, environment

and sustainability. Please visit CEMI's website at www.miningexcellence.ca to review CEMI's 2014 Annual Report and project catalogue highlighting the achievements of its team of innovators.

Business Led Networks of Centres of Excellence

The BL-NCE program is a federal program overseen by a tri-agency NCE Steering Committee composed of the Deputy Minister of Industry (or delegate), the Deputy Minister of Health (or delegate); and the Presidents of the three federal granting agencies: the Natural Sciences and Engineering Research Council of Canada (NSERC), the Social Sciences and Humanities Research Council of Canada (SSHRC), and the Canadian Institutes of Health Research (CIHR), with the President of the Canada Foundation for Innovation serving as observer.

The goal of the BL-NCE program is to address private sector research and development (R&D) challenges in Canadian research priority areas through the creation of business-led research networks that increase private sector investment in R&D, innovation and competitiveness. For more information, please visit the Networks of Centres of Excellence of Canada website at www.nce-rce.gc.ca.

Contact for Call for Proposals

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