[redacted]

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RECEIVED
OCT 31 1996
RESEARCH GRANTS OFFICE

APPLICATION FOR A GRANT
(Form 101)
PART I

October 8, 1996

cant	Given Name and Initial(s) of Applicant	Personal Identification No. (PIN)
ST	DAVID L.	[redacted]

Language of Application
[x] English [ ] French

Type of Grant Applied For (for Strategic Grants, indicate the Mission Statement)
Individual Research Grant 44 hours/month

Title of Proposal
Explosions and Shock Waves in Multiphase Media

Write a maximum of ten (10) key words that describe this proposal. Use commas to separate them.
Vapour Explosions, Fuel-Coolant Interactions, Bubble Detonations, Blast Waves

Discipline Code(s) Research Subject Codes		Area of Application Code(s)	
Primary	Secondary	Primary	Secondary
[redacted]	[redacted]	[redacted]	[redacted]

Indicate if this application will be submitted to another federal granting council. Consult Appendix "1" of the *Researcher's Guide*.
[ ] MRC [ ] SSHRC

CERTIFICATION REQUIREMENTS

Indicate if this proposal involves one of the following and, if yes, submit protocol to university certification committee

Human Experimentation	[ ] Yes	[x] No	[ ] Protocol submitted to university certification committee
Animal Experimentation	[ ] Yes	[x] No	[ ] Protocol submitted to university certification committee
Biohazard Requiring Containment	[ ] Yes	[x] No	[ ] Protocol submitted to university certification committee

Indicate if this proposal involves one of the following and, if yes, submit Appendix "D" to NSERC

Adverse Impact on the Environment, Hazardous Substances, or Field Work	[ ] Yes	[x] No

TOTAL AMOUNT REQUESTED FROM NSERC

Year 1	Year 2	Year 3	Year 4	Year 5
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

SIGNATURES

It is agreed that the general conditions governing grants as outlined in the NSERC *Researcher's Guide* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

David Frost
Applicant
(Indicate your department and university below)

Mechanical Engineering Dept.,
McGill University
Tel: (514) 398-6279
email: david@mecheng.mcgill.ca

[redacted]
Head of Department

[redacted]
President of University
(or Representative) Janine Vasseur
Director
Research Grant Affairs
Faculty of Graduate Studies & Research
McGill University

Form 101 (1995)

Canada

Voir au verso

SUMMARY OF PROPOSAL (in lay terms):

There are three major areas of investigation:

1. Vapour Explosions. An energetic propagating vapour explosion can occur if hot and cold liquids, such as molten metal and water, are suddenly mixed. Such explosions are a hazard in the metallurgical, pulp and paper, and nuclear industries. The nature of the interaction depends on the rate of energy release which is limited by the rate at which the hot liquid fragments break up, which in turn depends on the surrounding pressure and flow fields. For low flow rates, vapour bubble growth and collapse leads to drop breakup whereas for high flow rates, the drop is directly shattered by the relative flow. The objective of the present investigation is to investigate, using flash X-ray radiography, the transition from one fragmentation mechanism to another for a molten drop in water as the ambient flow velocity is increased. The results will be used to construct a more realistic model for fragmentation which will be used in models for propagating vapour explosions which are used to resolve industrial safety issues regarding the potential for and consequences of an accidental vapour explosion.

2. Reactive Waves in Multiphase Media. High-speed pressure waves have been observed to propagate in liquid/gas mixtures in which one or both of the components can sustain a chemical reaction. Such waves are a concern in a variety of chemical process industries. For example, so-called "bubble detonations" have been observed to propagate in a mixture consisting of combustible bubbles in an inert liquid. The objective of this experimental investigation is to determine the critical limiting conditions for the propagation of the wave and the mechanism for the wave failure. The use of the injection of inert bubbles to suppress the wave propagation will also be investigated, together with analytical modelling using a statistical approach for a dilute bubbly liquid.

3. Shock Waves in Heterogeneous Media. The objective of this study is to produce a quantitative model for the propagation of shock waves in laminates consisting of rigid and compressible materials. Emphasis will be placed on accurately characterizing the rate-dependent losses within the compressible layer. The model will be validated using results in which the material is subjected to an air blast wave and will be used to design a laminate to attenuate the peak pressure and impulse of the blast wave, with application to the design of protective apparel used in explosive disposal operations.

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CRSNG *Investir dans les gens, la découverte et l'innovation*

FORM 101
Application for a Grant
PART I

Date: 2000/10/24

Family name of applicant	Given name	Initial(s) of all given names	Personal identification no. (PIN)
Frost	David	L.	[redacted]

Language of application	Time (in hours per month) to be devoted to the proposed research
[X] English [ ] French	60

Type of grant applied for	For Strategic Projects, indicate the Research Area, if applicable
Research Grants - Individual	

Title of proposal
Explosions and Shock Waves in Multiphase Media

Write a maximum of ten (10) key words that describe this proposal. Use commas to separate them.
Combustion, Nanoscale Powder, Detonation, Multiphase Flow, Vapour Explosion

Research subject code(s)		Area of application code(s)	
Primary	Secondary	Primary	Secondary
[redacted]	[redacted]	[redacted]	[redacted]

CERTIFICATION REQUIREMENTS

If this proposal involves any of the following, check the box(es) and submit the protocol to the university certification committee.

Research involving humans [ ] Research involving animals [ ] Research involving biohazards [ ]

Does any phase of the research described in this proposal a) take place outside an office or laboratory, or b) involve an activity that requires a permit, licence or approval under any federal statute?

[X] No
[ ] If Yes to either question a) or b) Appendices A and B must be completed

TOTAL AMOUNT REQUESTED FROM NSERC

Year 1	Year 2	Year 3	Year 4	Year 5
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

SIGNATURES (Refer to Instructions "What do signatures mean?")

It is agreed that the general conditions governing grants as outlined in the NSERC *Researcher's Guide* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

David Frost
Applicant

Applicant's department, university, tel. and fax nos., and e-mail
Mechanical Engineering
McGill
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FAX: (514) 398-7365
david@mecheng.mcgill.ca

[redacted]
Head of department

Original signed by
Director
Research Grants Office
Faculty of Graduate Studies
and Research
McGill University

President of university (or representative)

The information collected on this form and appendices will be stored in the Personal Information Bank for the appropriate program.

Version française disponible

Canada

PROTECTED WHEN COMPLETED

Verified

Personal identification no. (PIN)	Family name of applicant
[redacted]	Frost

SUMMARY OF PROPOSAL FOR PUBLIC RELEASE (Use plain language)

This plain language summary will be available to the public if your proposal is funded. Although it is not mandatory, you may choose to include your business telephone number and/or your e-mail address to facilitate contact with the public and the media about your research.

Business telephone no. (optional): (514) 398-6279

E-mail address (optional): david@mecheng.mcgill

The proposed research program includes several projects, all of which involve multiphase systems in which one or more of the phases undergoes either i) a chemical reaction or ii) a physical change of phase, usually via a self-sustained propagating wave. The projects are primarily experimental, yet supported by analytical and numerical modelling. For the projects involving multiphase chemically reacting systems, combustible solid particles are added to an energetic material to change either the amount or the rate of chemical energy release. Applications of these projects include the design of advanced fuels and propellants. In the second major area of research, systems that undergo a rapid change of phase are investigated. These systems include molten metal-water mixtures and combustible liquids containing vapour bubbles. The motivation for these projects is to mitigate hazards in the metallurgical and nuclear industries and to define safe operating procedures for the transportation of combustible liquids.

RESEARCH ACTIVITY SCHEDULE

Refer to instructions to see if this section applies to your application. Use additional page(s) if necessary.

Milestone	Description of activities	Anticipated starting date	Anticipated completion date

Canada

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CRSNG Investir dans les gens, la découverte et l'innovation

FORM 101
Application for a Grant
PART I

Date: 2005/10/20

Family name of applicant	Given name	Initial(s) of all given names	Personal identification no (PIN)
Frost	David	D L	[redacted]

Institution that will administer the grant	Language of application	Time (in hours per month) to be devoted to the proposed research / activity
McGill	[X] English [ ] French	50

Type of grant applied for	For Strategic Projects, indicate the Target Area and Sub-Target Area, if applicable.
Discovery Grants - Individual	

Title of proposal
Explosions and Shock Waves in Multiphase Media

Provide a maximum of 10 key words that describe this proposal. Use commas to separate them.
nanoscale powders, combustion synthesis, advanced ceramics, propulsion, heterogeneous explosives, metal combustion, blast wave, shock wave, compressible foams

Research subject code(s)		Area of application code(s)	
Primary	Secondary	Primary	Secondary
[redacted]	[redacted]	[redacted]	[redacted]

CERTIFICATION/REQUIREMENTS

If this proposal involves any of the following, check the box(es) and submit the protocol to the university certification committee.

Research involving : Humans [ ] Human pluripotent stem cells [ ] Animals [ ] Biohazards [ ]

Does any phase of the research described in this proposal a) take place outside an office or laboratory, or b) involve an undertaking as described in Part 1 of Appendix B?

[X] NO [ ] If YES to either question a) or b) – Appendices A and B must be completed

TOTAL AMOUNT REQUESTED FROM NSERC

Year 1	Year 2	Year 3	Year 4	Year 5
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

SIGNATURES (Refer to Instructions "What do signatures mean?")

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

[redacted] D.L. Frost
Applicant

Applicant's department, university, tel. and fax nos., and e-mail
Mechanical Engineering
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FAX: (514) 398-7365
david.frost@mcgill.ca

[redacted]
Head of department

Dean of faculty

[redacted]
Director
Research Grants Office
McGill University

President of university (or representative)

Form 101 (2005 W)

The information collected on this form and appendices will be stored in the Personal Information Bank for the appropriate program.
PROTECTED WHEN COMPLETED

Version française disponible

Canada

Personal identification no. (PIN)	Family name of applicant
[redacted]	Frost

SUMMARY OF PROPOSAL FOR PUBLIC RELEASE (Use plain language.)

This plain language summary will be available to the public if your proposal is funded. Although it is not mandatory, you may choose to include your business telephone number and/or your e-mail address to facilitate contact with the public and the media about your research.

Business telephone no. (optional):

E-mail address (optional): david.frost@mcgill.ca

My proposed research program includes several projects which all involve multiphase systems (solid/gas or solid/liquid) in which typically one or more of the phases reacts chemically. The projects are primarily experimental, and supported by analytical and numerical modelling. Applications of the proposed work can be divided into three areas: i) the design of advanced ceramics and propellants using nanosized particles, ii) improved predictions of the performance of commercial explosives, and iii) the protection of structures and personnel against blast waves.

i) In the first project, nanosized metal oxide particles will be produced using a metal dust flame synthesis technique. Shock compaction of the powder will be explored with the objective of producing advanced high-strength ceramics. The combustion of nanosized metal particles with water will also be investigated, with the goal of producing an energetic propellant that is safe to handle for space propulsion applications.

ii) Many commercial explosives contain added metal particles to improve the performance of the explosive (e.g., the ability to crack and move rock). In order to predict the performance of such an explosive, it is necessary to have information regarding the ignition and combustion rate of the metal particles. The second project involves a study of particle ignition and reaction in high-speed flows characteristic of the flows that occur within the gaseous detonation products.

iii) There has been considerable interest in the last several years in the development of materials for the protection of personnel and structures against blast waves from accidental or deliberate explosions. To design a system to attenuate a high-pressure shock wave, it is necessary to have a fundamental understanding of how a shock wave propagates through a material and how the material responds when rapidly loaded. Experiments will be carried out to test the ability of combinations of rigid and novel compressible materials to mitigate the effects of a blast wave on a structure.

Second Language Version of Summary (optional).

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FORM 101
Application for a Grant
PART I

Institutional identifier			Date
System-ID (for NSERC use only) [redacted]			2008/10/21
Family name of applicant: Frost	Given name: David	Initial(s) of all given names: D L	Personal identification no. (PIN): Valid [redacted]

Institution that will administer the grant: McGill

Language of application: [X] English [ ] French

Time (in hours per month) to be devoted to the proposed research / activity: 50

Type of grant applied for: Discovery Grants - Individual

For Strategic Projects, indicate the Target Area and the Research Topic; for Strategic Networks and Strategic Workshops indicate the Target Area.

Title of proposal: Explosions and Shock Waves in Multiphase Media

Provide a maximum of 10 key words that describe this proposal. Use commas to separate them.
combustion, explosions, shock wave physics, detonations, multiphase flow, material synthesis, vapour explosions, condensed explosives, nanoscale metal powder, thermogravimetric analysis

Research subject code(s)		Area of application code(s)	
Primary [redacted]	Secondary [redacted]	Primary [redacted]	Secondary [redacted]

CERTIFICATION/REQUIREMENTS

If this proposal involves any of the following, check the box(es) and submit the protocol to the university or college's certification committee.

Research involving : Humans [ ] Human pluripotent stem cells [ ] Animals [ ] Biohazards [ ]

Does any phase of the research described in this proposal a) take place outside an office or laboratory, or b) involve an undertaking as described in Part 1 of Appendix B?

[X] NO [ ] If YES to either question a) or b) – Appendices A and B must be completed

TOTAL AMOUNT REQUESTED FROM NSERC

Year 1	Year 2	Year 3	Year 4	Year 5
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

SIGNATURES (Refer to Instructions "What do signatures mean?")

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

David Frost
Applicant

Applicant's department, institution, tel. and fax nos., and e-mail
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FAX: (514) 398-7365
david.frost@mcgill.ca

[redacted]
Head of department

[redacted]
Director of Ope[redacted]ns
Research Gran[redacted] Office
[redacted]
President of Institution (or representative)

The information collected on this form and appendices will be stored in the Personal Information Bank for the appropriate program.

PROTECTED WHEN COMPLETED

Personal identification no. (PIN)	Family name of applicant
Valid [redacted]	Frost

SUMMARY OF PROPOSAL FOR PUBLIC RELEASE (Use plain language.)

This plain language summary will be available to the public if your proposal is funded. Although it is not mandatory, you may choose to include your business telephone number and/or your e-mail address to facilitate contact with the public and the media about your research.

Business telephone no. (optional):

E-mail address (optional):

My proposed research program includes several project areas which all involve multiphase systems (solid/gas or solid/liquid) in which one or more of the phases typically reacts chemically. The projects are primarily experimental, and supported by analytical and numerical modelling. Applications of the three proposed areas of research include i) improvements to the performance of commercial explosives, ii) protection of personnel and structures against blast waves and ballistic impact, and iii) the combustion synthesis of advanced materials with unusual properties. A summary of the three research areas is as follows.

i) Many commercial explosives contain added metal particles to improve the performance of the explosive (e.g., the ability to crack and move rock). In order to predict the performance of such an explosive, it is necessary to have information regarding the motion and burning rate of the metal particles in the combustion gases and surrounding air. Lab-scale experiments will be carried out to determine the particle reaction mechanism and the dependence of particle combustion rate on the particle and flow properties.

ii) There has been considerable interest recently in Canada in the development of materials for the protection of personnel and structures against blast waves and ballistic impacts from accidental or deliberate explosions. Experiments are proposed to design and test a variety of novel rigid and compressible material combinations to mitigate the effects of a blast wave. For improved ballistic protection, materials that contain a shear-thickening fluid will be investigated under impact loading.

iii) In the final research area, nanosized metal oxide particles will be produced using a metal dust flame technique with applications to material science (e.g., high-strength ceramics). A related experiment will study the reaction between nanosized aluminum powder and water for the production of pure hydrogen gas to be used in a fuel cell. Finally, reactions in metal powder mixtures will be induced with a shock wave to generate solids with potentially new and useful properties.

Second Language Version of Summary (optional).

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For NSERC office use only

Form 101 - Application for a Grant

Send to NSERC with your attachments, if applicable

Reference Number: [redacted]

Applicant: David Frost
McGill

NSERC PIN: [redacted]

Program: Partnership Agreement with the Department of National Defence

Application Title: Shear Thickening Fluids for Ballistic Protection Applications

---

David Frost

Form 101 - Application for a Grant

Electronic Attachments:

- Proposal - Proposal
- References - References
- Research Support - Relationship to other research support
- Other Documents (1) - Form 183
- Other Documents (3) - Support letter from DRDC
- Contrib. from Orgs. - Explanation of in-kind contributions
- Budget Justification - Budget justification

Andrew Higgins

F100/Personal Data Form

Electronic Attachments:

- Contributions - Contributions

David Frost

Form 183A - Information Required from Organizations Participating in RPP (submitted by applicant)

Electronic Attachments:

- Letter of Support - Letter of support from PSP

Natural Sciences and Engineering Research Council of Canada

Conseil de recherches en sciences naturelles et en génie du Canada

FORM 101
Application for a Grant
PART I

Institutional Identifier

System-ID (for NSERC use only) [redacted]

Date: 2009/07/16

Family name of applicant	Given name	Initial(s) of all given names	Personal identification no. (PIN)
Frost	David	D L	Valid [redacted]

Institution that will administer the grant: McGill

Language of application: [X] English [ ] French

Time (in hours per month) to be devoted to the proposed research / activity: 30

Type of grant applied for: Partnership Agreement with the Department of National Defence

For Strategic Projects, indicate the Target Area and the Research Topic; for Strategic Networks and Strategic Workshops indicate the Target Area.

Title of proposal: Shear Thickening Fluids for Ballistic Protection Applications

Provide a maximum of 10 key words that describe this proposal. Use commas to separate them.
Shear thickening fluid, Ballistic protection, Improvised explosive devices, Fragment impact, Armour systems, Rheology, Multiphase fluid

Research subject code(s)		Area of application code(s)	
Primary	Secondary	Primary	Secondary
[redacted]	[redacted]	[redacted]	[redacted]

CERTIFICATION/REQUIREMENTS

If this proposal involves any of the following, check the box(es) and submit the protocol to the university or college's certification committee.

Research involving : Humans [ ] Human pluripotent stem cells [ ] Animals [ ] Biohazards [ ]

Does any phase of the research described in this proposal a) take place outside an office or laboratory, or b) involve an undertaking as described in Part 1 of Appendix B?

[X] NO [ ] If YES to either question a) or b) – Appendices A and B must be completed

TOTAL AMOUNT REQUESTED FROM NSERC

Year 1	Year 2	Year 3	Year 4	Year 5
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

SIGNATURES (Refer to Instructions "What do signatures mean?")

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

Applicant

Applicant's department, institution, tel. and fax nos., and e-mail

Mechanical Engineering
McGill
Tel.: (514) 398-6279
FAX: (514) 398-7365
david.frost@mcgill.ca

Head of department

Dean of faculty

President of institution (or representative)

Canada

The information collected on this form and appendices will be stored in the Personal Information Bank for the appropriate program.

PROTECTED WHEN COMPLETED

Version française disponible

Personal identification no. (PIN)	Family name of applicant
Valid [redacted]	Frost

CO-APPLICANTS

I have read the statement "What do signatures on the application mean?" in the accompanying instructions and agree to it.

PIN, family name and initial(s)	Research/ activity time (hours/month)	Organization	Signature
Higgins, A J	25	McGill	
Goroshin, S	25	McGill	

CO-APPLICANTS' ORGANIZATIONS AND/OR SUPPORTING ORGANIZATIONS (if organization different from page 1)

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors*, as well as the statements "What do signatures on the application mean?" and "Summary of proposal for public release" in the accompanying instructions, apply to any grant made pursuant to this application and are hereby accepted by the organization.

Family name and given name of signing officer, title of position, and name of organization	Signature
[redacted] Pacific Safety Products, Inc.	
[redacted] Defence R&D Canada-Valcartier	

Use additional page(s) if necessary.

Canada

PROTECTED WHEN COMPLETED

Personal identification no. (PIN)	Family name of applicant
Valid [redacted]	Frost

SUMMARY OF PROPOSAL FOR PUBLIC RELEASE (Use plain language.)

This plain language summary will be available to the public if your proposal is funded. Although it is not mandatory, you may choose to include your business telephone number and/or your e-mail address to facilitate contact with the public and the media about your research.

Business telephone no. (optional):

E-mail address (optional):

The hazards posed by shrapnel from improvised explosive devices (IEDs) are of primary concern to the Canadian Forces. In order to meet these challenges, the continued incorporation of new materials and technologies is necessary in the development of more flexible, lightweight armour systems. The integration of Shear Thickening Fluids (STF) embedded in traditional ballistic fabrics is one such technology that could be practical. The physical characteristics of STF, which consists of fine solid particles suspended in a carrier fluid, which are advantageous for protective equipment is that the materials are field-responsive. This means that the materials will behave differently under various threats. For example, under the strain involved with normal motion, the fluids are able to flow and the armour would be flexible, however upon application of a high-strain-rate force such as a ballistic event, the materials stiffen to provide protection. This enables systems involving STF to potentially be utilized in limb protection systems for soldiers to meet contemporary shrapnel threats from IEDs. Additionally, such flexible protection systems could be of interest to police forces as well as private security personnel. The proposed research program consists of a comprehensive experimental and computational investigation of the fundamental behaviour of STF under high-strain rate dynamic loading while applying the same amplitude forces that are involved in ballistic events. The ballistic response of a variety of fluid-solid particle systems will be studied using single-stage light gas guns to determine the optimum system for protecting against ballistic impact threats. The application of STF technology to develop new field-responsive armours would be invaluable to the Canadian Forces, as well as to other security personnel.

Second Language Version of Summary (optional).

NSERC Investing in people, discovery and innovation
CRSNG Investir dans les gens, la découverte et l'innovation

[redacted]

FORM 101
Application for a Grant
PART I

Date: 2003/10/27

Family name of applicant	Given name	Initial(s) of all given names	Personal identification no. (PIN)
Timofeev	Evgeny	E.V.	[redacted]

Language of application	Time (in hours per month) to be devoted to the proposed research / activity
[X] English [ ] French	70

Type of grant applied for	For Strategic Projects, indicate the Target Area and Sub-Target Area, if applicable.
Discovery Grants - Individual	

Title of proposal
Shock wave reflections in unsteady flows

Write a maximum of ten (10) key words that describe this proposal. Use commas to separate them.
Fluid mechanics, Compressible flows, High-speed flows, Unsteady flows, Shock Waves, Regular and Mach shock reflections, Transition criteria, Viscous and real gas effects, Non-continuum models, Numerical modeling

Research subject code(s)		Area of application code(s)	
Primary	Secondary	Primary	Secondary
[redacted]	[redacted]	[redacted]	[redacted]

CERTIFICATION/REQUIREMENTS

If this proposal involves any of the following, check the box(es) and submit the protocol to the university certification committee.

Research involving : Humans [ ] Human pluripotent stem cells [ ] Animals [ ] Biohazards [ ]

Does any phase of the research described in this proposal a) take place outside an office or laboratory, or b) involve an undertaking as described in Part 1 of Appendix B?

[X] NO [ ] If YES to either question a) or b) – Appendices A and B must be completed

TOTAL AMOUNT REQUESTED FROM NSERC

Year 1	Year 2	Year 3	Year 4	Year 5
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

SIGNATURES (Refer to Instructions "What do signatures mean?")

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

Applicant

Applicant's department, university, tel. and fax nos., and e-mail
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Tel.: (514) 398-4382
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[redacted]
Head of department

[redacted]
Dean of faculty

[redacted] Original Signed By
President of university (or representative)
Director
Research Grants Office
McGill University

Version française disponible

Form 101 (2003 W)

The information collected on this form and appendices will be stored in the Personal Information Bank for the appropriate program.

PROTECTED WHEN COMPLETED

Canada

Personal identification no. (PIN)	Family name of applicant
[redacted]	Timofeev

SUMMARY OF PROPOSAL FOR PUBLIC RELEASE (Use plain language.)

This plain language summary will be available to the public if your proposal is funded. Although it is not mandatory, you may choose to include your business telephone number and/or your e-mail address to facilitate contact with the public and the media about your research.

Business telephone no. (optional): 1 (514) 398-4382

E-mail address (optional): [redacted]evgeny.timofeev@mcgill.ca

The project addresses still unresolved fundamental issues of shock and blast wave reflections in unsteady gas flows. Such reflections can be of regular or irregular (so called Mach) types corresponding to different shock wave configurations. Transitions from one type to another may occur in the course of shock or blast wave propagation, leading to significant local changes in gasdynamic and thermodynamic parameters (pressure, temperature etc.). The changes may be desirable for some applications, or, to the contrary, result in harmful consequences. The project considers the phenomenon using different physical models and computer simulation. The main goal is to explain in detail the mechanism of transformation of one shock wave configuration into another and to get reliable quantitative data on the variation of gas parameters in the course of such transformations. The obtained results will lead to practical implications in many applied fields, such as hypersonic air-breathing engines (their inlets and nozzles), initiation of detonation, explosions and implosions, blast waves, hypervelocity impacts, high-pressure science and technology.

Second Language Version of Summary (optional).

Natural Sciences and Engineering Research Council of Canada | Conseil de recherches en sciences naturelles et en génie du Canada

FORM 101
Application for a Grant
PART I

Date: 2008/10/30

Institutional Identifier	System-ID (for NSERC use only)
	[redacted]

Family name of applicant	Given name	Initial(s) of all given names	Personal identification no. (PIN)
Timofeev	Evgeny	E.V.	Valid [redacted]

Institution that will administer the grant	Language of application	Time (in hours per month) to be devoted to the proposed research / activity
McGill	[X] English [ ] French	40

Type of grant applied for	For Strategic Projects, indicate the Target Area and the Research Topic; for Strategic Networks and Strategic Workshops indicate the Target Area.
Discovery Grants - Individual	

Title of proposal
Numerical modelling of unsteady high-speed compressible flows

Provide a maximum of 10 key words that describe this proposal. Use commas to separate them.
Fluid mechanics, Compressible flows, Unsteady high-speed flows, Shock waves, Computational fluid dynamics, Unstructured grids, Air-breathing propulsion, Gas/explosive systems, Nonlinear acoustics, Biomedical applications

Research subject code(s)		Area of application code(s)	
Primary	Secondary	Primary	Secondary
[redacted]	[redacted]	[redacted]	[redacted]

CERTIFICATION/REQUIREMENTS

If this proposal involves any of the following, check the box(es) and submit the protocol to the university or college's certification committee.

Research involving : Humans [ ] Human pluripotent stem cells [ ] Animals [ ] Biohazards [ ]

Does any phase of the research described in this proposal a) take place outside an office or laboratory, or b) involve an undertaking as described in Part 1 of Appendix B?

[X] NO [ ] If YES to either question a) or b) -- Appendices A and B must be completed

TOTAL AMOUNT REQUESTED FROM NSERC

Year 1	Year 2	Year 3	Year 4	Year 5.
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

SIGNATURES (Refer to Instructions "What do signatures mean?")

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

[redacted]
Applicant

[redacted]
Head of department

[redacted]
Dean of faculty

[redacted]
President of institution (or representative)

Applicant's department, institution, tel. and fax nos., and e-mail
Mechanical Engineering
McGill
Tel.: (514) 398-4382
FAX: (514) 398-7365
evgeny.timofeev@mcgill.ca

Form 101 (2008 W) | Version française disponible

Canada

The information collected on this form and appendices will be [redacted] in the Personal Information Bank for the appropriate program.

PROTECTED WHEN COMPLETED

Director of Operations
Research Grants Office
McGill University

Personal identification no. (PIN)	Family name of applicant
Valid [redacted]	Timofeev

SUMMARY OF PROPOSAL FOR PUBLIC RELEASE (Use plain language.)

This plain language summary will be available to the public if your proposal is funded. Although it is not mandatory, you may choose to include your business telephone number and/or your e-mail address to facilitate contact with the public and the media about your research.

Business telephone no. (optional): 1 (514) 398-4382

E-mail address (optional): evgeny.timofeev@mcgill.ca

The research program is concerned with essentially unsteady high-speed multi-dimensional compressible flows, which are much less explored in compressible fluid dynamics than steady phenomena and, likewise, accurate and efficient numerical methods and codes for them are few in number. New numerical methods and computer codes specifically tailored for unsteady, multi-scale, multi-fluid flows with spatially-localized features (shock waves, contact surfaces, boundary layers, vortices etc.) will be developed on the basis of the previous work by the principal investigator on locally adaptive unstructured finite-volume Euler (inviscid) solvers for non-reacting gas mixtures. Three major generalizations are to be undertaken: (1) For unsteady viscous flows at high Reynolds numbers in which viscosity effects are confined to shock fronts, boundary layers and separation zones, contact surfaces; (2) For mixtures of fluids with various equations of state (Tait, JWL etc.) (3) For nonlinear acoustics problems in heterogenous media. The research program will encompass the following application areas: (I) Basic studies of shock wave reflections, in particular on the influence of viscosity and heat conductivity on shock wave reflections; (II) Starting of air inlets of hypersonic air-breathing engines (scramjets), including recenlty proposed innovative techniques (diapgragm rupture, accelerative starting); (III) Flow dynamics in gas/explosive systems. (a) Channel effect problem (when an explosive layer is detonated inside a planar or axisymmetrical channel) which has many applications in mining, aerospace, high-pressure physics and other fields; (b) Different concepts of hypervelocity launchers in which the enormous energy densities of high explosives is used to accelerate projectiles to hypervelocities, which can be applied to high-speed impact tests (e.g. when testing satellite bumper shields); (IV) Non-linear waves in heterogenous media. In this area the developed computational method will be used for simulations of wave phase conjugation in acoustics with practical applications in echography of biological tissues, non-destructive testing, magneto-acoustics etc.

Second Language Version of Summary (optional).

Natural Sciences and Engineering Research Council of Canada | Conseil de recherches en sciences naturelles et en génie du Canada

For NSERC office use only

Form 101 - Application for a Grant

Send to NSERC with your attachments, if applicable

Reference Number: [redacted]

Applicant: Andrew Higgins
McGill

NSERC PIN: [redacted]

Program: Research Tools and Instruments - Category 1

Application Title: Photonic Doppler Velocimeter

Andrew Higgins
- Form 101 - Application for a Grant
  - **Electronic Attachments:**
    - Budget justification - Budget justification in pdf.
    - Quotations (1) - LeCroy and Tektronix Oscilloscope Quotes
    - Quotations (2) - PDV Receivers quotes in pdf.
    - Research Support - Relationship To Other Research Support in pdf.
    - Proposal - Proposal text in pdf.

Andrew Higgins
- F100/Personal Data Form
  - **Electronic Attachments:**
    - Contributions - Contributions in pdf format.

Francois Barthelat
- F100/Personal Data Form
  - **Electronic Attachments:**
    - Contributions - Contributions

David Frost
- F100/Personal Data Form
  - **Electronic Attachments:**
    - Contributions - Contributions

Evgeny Timofeev
- F100/Personal Data Form
  - **Electronic Attachments:**
    - Contributions - Timofeev[redacted]Contributions

Natural Sciences and Engineering Research Council of Canada | Conseil de recherches en sciences naturelles et en génie du Canada

FORM 101
Application for a Grant
PART I

Institutional Identifier			
System-ID (for NSERC use only) [redacted]			Date 2010/10/21
Family name of applicant: Higgins	Given name: Andrew	Initial(s) of all given names: AJ	Personal Identification no. (PIN): Valid [redacted]
Institution that will administer the grant: McGill	Language of application: [X] English [ ] French	Time (in hours per month) to be devoted to the proposed research / activity: 20	
Type of grant applied for: Research Tools and Instruments - Category 1	For Strategic Projects, indicate the Target Area and the Research Topic; for Strategic Networks indicate the Target Area.		

Title of proposal: Photonic Doppler Velocimeter

Provide a maximum of 10 key words that describe this proposal. Use commas to separate them.
laser velocimetry, shock waves, impact, ballistics, high-speed instrumentation

Research subject code(s)		Area of application code(s)	
Primary [redacted]	Secondary [redacted]	Primary [redacted]	Secondary [redacted]

CERTIFICATION/REQUIREMENTS

If this proposal involves any of the following, check the box(es) and submit the protocol to the university or college's certification committee.

Research involving : Humans [ ] Human pluripotent stem cells [ ] Animals [ ] Biohazards [ ]

Does any phase of the research described in this proposal a) take place outside an office or laboratory, or b) involve an undertaking as described in Part 1 of Appendix B?

[X] NO [ ] If YES to either question a) or b) -- Appendices A and B must be completed

TOTAL AMOUNT REQUESTED FROM NSERC

Year 1	Year 2	Year 3	Year 4	Year 5
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

SIGNATURES (Refer to Instructions "What do signatures mean?")

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors* apply to any grant made pursuant to this application and are hereby accepted by the applicant and the applicant's employing institution.

Applicant

Applicant's department, institution, tel. and fax nos., and e-mail
Mechanical Engineering
McGill
Tel.: (514) 398-6297
FAX: (514) 398-7365
andrew.higgins@mcgill.ca .

Head of department

Dean of faculty

President of institution (or representative)

Canada

The information collected on this form and appendices will be stored in the Personal Information Bank for the appropriate program.

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Version française disponible

Personal identification no. (PIN)	Family name of applicant
Valid [redacted]	Higgins

CO-APPLICANTS

I have read the statement "What do signatures on the application mean?" in the accompanying instructions and agree to it.

PIN, family name and initial(s)	Research/ activity time (hours/month)	Organization	Signature
[redacted] Barthelat, F.		McGill	
[redacted] Frost, D.		McGill	
[redacted] Timofeev, E.		McGill	

CO-APPLICANTS' ORGANIZATIONS AND/OR SUPPORTING ORGANIZATIONS (If organization different from page 1)

It is agreed that the general conditions governing grants as outlined in the NSERC *Program Guide for Professors*, as well as the statements "What do signatures on the application mean?" and "Summary of proposal for public release" in the accompanying instructions, apply to any grant made pursuant to this application and are hereby accepted by the organization.

Family name and given name of signing officer, title of position, and name of organization	Signature

Use additional page(s) if necessary.

Version française disponible

Canada

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Personal identification no. (PIN)	Family name of applicant
Valid [redacted]	Higgins

SUMMARY OF PROPOSAL FOR PUBLIC RELEASE (Use plain language.)

This plain language summary will be available to the public if your proposal is funded. Although it is not mandatory, you may choose to include your business telephone number and/or your e-mail address to facilitate contact with the public and the media about your research.

Business telephone no. (optional): 1 (514) 398-6297

E-mail address (optional): andrew.higgins@mcgill.ca

The proposed instrument to be acquired is a Photonic Doppler Velocimeter (PDV), used to obtain extremely accurate material velocity histories along two axes in high speed ballistic impact and shock wave experiments. The ability to generate this type of high quality velocity history data is essential to McGill University's continued participation in state-of-the-art research in the fields of ballistic protection, shock wave physics, and detonics. With the development of numerical modeling over the past decade, continuous data sources are necessary for the validation of new models. Experimental work involving discrete "time of arrival" data collection is now considered to be obsolete by researchers in the field. The ability to continuously record the material velocity history in an experiment will permit insights into a number of important problems. In particular, this program will use the system in evaluating novel ceramic-metal composite and shear thickening fluid armours, in simulating hypervelocity impacts caused by orbital debris, and in studying nonideal detonation propagation in commercial blasting explosives. The ability to study these processes in a high-resolution, continuous history measurement will permit models and computer simulations to be validated, which in turn can be used to predict and improve how these processes occur in applications.

Other Language Version of Summary (optional).

Fonds de recherche sur la nature et les technologies
Québec

Projet de recherche en équipe
Demande d'aide financière

ESPACES RÉSERVÉS À L'ORGANISME

Numéro de demande	Secteur	
[redacted]	Sciences naturelles et génie	

1. IDENTIFICATION DU RESPONSABLE

Nom	Prénom(s)	Mme	M.
Higgins	Andrew	◯	(x)

Établissement : U. McGill

Département : Mechanical Engineering

2. TITRE

Indiquez le titre du projet de recherche (doit être rédigé en français)

La capacité de simulation et d'essai pour l'impact de débris orbitaux

3. RÉSUMÉ

Décrivez votre projet de recherche (maximum une demi-page)

Les débris orbitaux représentent une menace persistante pour toutes les activités spatiales. Afin d'être en mesure d'évaluer ce danger, il est nécessaire d'effectuer des simulations d'impacts à haute vitesse sur des structures spatiales en laboratoire et au moyen d'outils numériques. De nouveaux matériaux doivent également être testés pour évaluer leurs capacités à résister aux impacts de débris orbitaux. Ce projet développera de nouveaux outils numériques capables de résoudre l'intégralité du problème lié aux débris orbitaux. Ce modèle numérique sera notamment utilisé pour étudier les interactions entre les éléments explosifs, métalliques et gazeux. Ce modèle sera également validé et utilisé pour développer un lanceur hyper-vitesse utilisant des moyens explosifs pour générer de très hautes vitesses essentielles à l'étude de simulations d'impacts en milieu de laboratoire. Ce lanceur sera utilisé pour tester les propriétés de matériaux composites avancés qui auront le potentiel de maintenir leurs propriétés mécaniques suite à un impact. Finalement, les impacts de projectiles sur ces composites seront modélisés aux travers de calculs numériques avancés qui seront comparés aux impacts effectués en laboratoire au moyen du lanceur hyper-vitesse. Les résultats de ce projet fourniront les outils nécessaires aux entreprises québécoise, canadienne et internationales du domaine aérospatiale pour tester et effectuer des simulations sur la menace des débris orbitaux.

5. COMPOSITION DE L'ÉQUIPE

A) Présentez la composition en identifiant d'abord le responsable, puis les membres de l'équipe dans l'ordre suivant : CHU, CHUN, CHUT, CHC et CHCT.

B) Veuillez vous assurer que les CV communs canadiens des chercheurs mentionnés ci-dessous ont été complétés.

Statut	- Nom et prénom(s) - Établissement - Département - Année d'obtention et discipline du doctorat ou l'équivalent	Numéro d'identification personnel (NIP)
CHUR	Higgins, Andrew U. McGill Mechanical Engineering 1996 Aeronautics and Astronautics	[redacted]
CHU	Barthelat, Francois U. McGill Mechanical Engineering 2005 Mechanical Engineering	[redacted]
CHU	Frost, David U. McGill Mechanical Engineering 1985 Aeronautics	[redacted]
CHU	Hoa, Suong Van U. Concordia Mechanical Engineering 1976 Mechanical Engineering	[redacted]
CHU	Timofeev, Evgeny U. McGill Mechanical Engineering 1992 Mechanics of liquid, gas and plasma	[redacted]

Agence spatiale canadienne | Canadian Space Agency

CSA Class Grant and Contribution Program to Support Research, Awareness and Learning in Space Science and Technology

Application Form - Research Component

Notice to Applicants: Please read the CSA Class Grant and Contribution Program Overview and the Sub-Component Applicant's Guide in full before completing this application form. These documents are available on the CSA Web site under Grants and Contribution tab. You must answer all fields as indicated. Your application may not be considered if there is missing or incomplete information. It is the applicant's responsibility to ensure that the application complies with all relevant federal, provincial/territorial and municipal laws.

SECTION 1 - APPLICANT INFORMATION

Legal name of the organisation (must be confirmed by the Office of Research)
The Royal Institution for the Advancement of Learning (McGill University)

Principal Investigator full name Andrew Higgins	Full name of contact from Office of Research [redacted]
Title / Position Associate Professor	Title / Position Grants Officer
Address Dept. Mechanical Engineering, McGill University 817 Sherbooke St. W., Montreal, Quebec H3A 2K6	Address Office of Sponsored Research 45 Sherbrooke St. W., Montreal, Quebec H3A 2T5
Telephone 514-398-6297 Fax 514-398-7365	Telephone [redacted] Fax [redacted]
Email andrew.higgins@mcgill.ca	Email [redacted]

Type of organisation
- [x] Canadian university or post-secondary institution
- [ ] Canadian not-for -profit organisation
- [ ] Canadian for-profit organisation
- [ ] International not- for-profit organisation
- [ ] Cluster formed by a combination of options listed above

Preferred language for correspondence
- [ ] Français
- [x] English

SECTION 2 – PROJECT SUMMARY

Name of the research Sub-Component
Space and Sub-Orbital

Proposal title
Percolating Reactive Waves in Particulate Suspensions

Total amount requested from CSA per government fiscal year (April 1st to March 31st)

Year 1	Year 2	Year 3	Year 4	Year 5
[redacted]	[redacted]	[redacted]	[redacted]	

Type of funding requested
- [x] Grant
- [ ] Contribution

SECTION 3 – SIGNATURES

Signature of Principal Investigator Date

Full name of duly authorised signatory

Title / Position

Telephone Fax

Email

Applicants must post-mail five (5) paper copies of the proposal, one with original signatures, to the address below:

Grant & Contribution Centre of Expertise
Space Science and Technology
Canadian Space Agency
6767 Route de l'Aéroport,
Saint-Hubert, QC J3Y 8Y9

Also include an identical electronic copy of the proposal on a standard media (USB Key, CD or DVD).

I declare that I am the duly authorised signatory for the organisation.

Signature Date

Version française disponible

The information collected on this form and appendices will be stored in the Personnel Information Bank of the CSA Grant & Contribution Program to support Research, Awareness and Learning in Space Science and Technology.

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Canada

CSA Class Grant and Contribution Program to Support
Research, Awareness and Learning in Space Science and Technology

Application Form - Research Component

SECTION 4 – PROJECT DETAILS

Please provide a short (maximum 100 words), summary of the proposal using non-technical language suitable for public release.

This project will study how waves of chemical reaction spread through a media that is made of point-like sources, which is often encountered in nature and technological applications, but is difficult to study due to gravity-induced settling of the particles and buoyancy disrupting the wave. This study will utilize the reduced-gravity environment on a sounding rocket to study reactive wave propagation (flames) in iron powder clouds under ideal conditions. The sounding rocket flight is being provided by the ESA. The portion of the project described here to be funded by the CSA will focus on development of the models required to interpret the experimental results and testing onboard parabolic flight aircraft to further develop the experimental concept prior to the rocket flight. The result will be the experimental confirmation of a discrete regime of reactive wave propagation, a phenomenon that is also expected to occur in a other disciplines (biology, solid state physics, etc.). The improved understanding of metal combustion will have application to the use of extraterrestrial resources as propellants and to the use of metals as zero-emission energy carriers on earth.

Please describe the project using keywords (maximum 10) separated by semi-colons

reactive waves, combustion, percolation, microgravity, dust combustion, flames, heterogeneous media, discrete media

Please specify the area of expertise

combustion, nonlinear waves

Detailed Project Description

Please attach a detailed description of the proposed research plan, including objectives, methodology and an explanation of the role and responsibilities of each person implicated in the proposed research Project. Please structure this section with subheadings corresponding to the Evaluation Criteria presented in the Sub-Component description within which your Project is submitted.

The cover page of the attachment must contain the title of the proposal, the name of the principal investigator and the legal name of the organisation requesting the grant or contribution. Please limit the document to a maximum of 20 pages in a commonly used format (.DOC, .DOCX, .PDF, .RTF, .TXT), 12pt type face, letter sized paper and 1" margins.

SECTION 5 – PRINCIPAL INVESTIGATOR AND CO-INVESTIGATORS

Please provide below the names and coordinates of co-investigators. Please complete and attach the Natural Sciences and Engineering Research Council of Canada (NSERC) Personal Data Form (Form 100) for each investigator.

Team Member 1

Full Name Andrew Higgins	Telephone 514-398-6297
Title / Position Associate Professor	Email andrew.higgins@mcgill.ca
Organisation McGill University	Role in project Principal Investigator

The information collected on this form and appendices will be stored in the Personnel Information Bank of the CSA Grant & Contribution Program to support Research, Awareness and Learning in Space Science and Technology.

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Application Form - Research Component

SECTION 5 – PRINCIPAL INVESTIGATOR AND CO-INVESTIGATORS (Continued)	
Team Member 2	
Full Name Nikolas Provatas	Telephone 905-525-9140 ext. 26897
Title / Position Professor	Email provata@mcmaster.ca
Organisation McMaster University	Role in project co-PI for modelling
Team Member 3	
Full Name Matei I. Radulescu	Telephone 613 562-5800 ext. 6720
Title / Position Assistant Professor	Email matei@uottawa.ca
Organisation University of Ottawa	Role in project co-PI for modelling
Team Member 4	
Full Name Samuel Goroshin	Telephone 514-398-6309
Title / Position Senior Research Associate	Email samuel.goroshin@mcgill.ca
Organisation McGill University	Role in project co-PI for experimental work
Team Member 5	
Full Name	Telephone
Title / Position	Email
Organisation	Role in project

* Attach an additional sheet if needed.

SECTION 6 - DETAILED IMPLEMENTATION SCHEDULE

Please attach a detailed implementation schedule for the proposal. CSA recommends presenting the schedule in both a Gantt Chart and a tabular format with the following column headings: Work Breakdown Structure (WBS) identifiers (Ex. 3.5.7), task name, task duration, start date, finish date, task dependencies (predecessor and successor task identifiers with, relationship type, and lead or lag durations), and assigned leads for main task groups.

SECTION 7 - DETAILED BUDGET AND SOURCES OF FUNDING

Please attach a detailed itemised budget in a common format indicating all sources of funding and expenditures of the project.

- Information should be allocated in accordance with government fiscal years (from April 1 to March 31)
- All funding sources and all expenditures must be included, and identified as cash or in kind
- For each expenditure, the total amount, and the breakdown by source of funding must be provided

Please refer to the Sub-Component Applicant's guide on the CSA website for a list of eligible CSA funding categories.

DTRA SUBMISSION

DTRA Phase II Proposal Submission

Electronic Receipt

Your proposal [redacted] has been submitted on 9/14/2010 1:37:51 PM.

Please print this screen and save it for your records.

Continue

FY2010 FY 2009 - 2011 Basic Research for Combating Weapons of Mass Destruction (WMD) Broad Agency Announcement (BAA) - Period 5
Proposal Cover Sheet

Proposal Number: [redacted]

Phase I Proposal Number: [redacted]
Topic Number:
Proposal Title: Dust Cloud Combustion for Defeat of Airborne Bio-WMD
DUNS: [redacted] CAGE: [redacted]
Tax ID:

Applicant:

Mail Address: McGill University
845 Sherbrooke Street West
James Administration Building, Room 429
Montreal, Quebec H3A 2T5
Canada

Website Address: www.mcgill.ca/rgo

Year 1 Cost ($): [redacted] Year 1 Duration (months): 12
Year 2 Cost ($): Year 2 Duration (months): 12
Year 3 Cost ($): Year 3 Duration (months): 12
Year 4 Cost ($): Year 4 Duration (months): 12
Year 5 Cost ($): Year 5 Duration (months): 12

Applicant Certification:

Organization Type: Academic Institution

Has a proposal for essentially equivalent work been submitted to other US government agencies or DoD components? NO
If yes, list the name(s) of the agency/DoD component and contract/grant number in the space below.
Agency 1: Contract/Grant No.:
Agency 2: Contract/Grant No.:
Agency 3: Contract/Grant No.:

Are you a current DoD Contractor or Grantee? NO
If yes, give Agency, Point of Contact, Phone Number in the space below:
Agency: Point of Contact: Phone:

Principal Investigator 1

Name: Dr. David Frost Title: Associate Professor
Phone: 1 514 398 6279 Fax: 1 514 398 7365
E-Mail: david.frost@mcgill.ca

Principal Investigator 2 (optional)

Name: Dr. Samuel Goroshin Title: Senior Research Assistant
Phone: 1 514 398 6309 Fax: 1 514 398 7365
E-Mail: sam.goroshin@mcgill.ca

Business Official 1

Name: [redacted] Title: Grants Officer
Phone: Fax:
E-Mail:

Proprietary Information (list page numbers):

Signature of Principal Investigator | Date | Signature of Corporate Business Official | Date

Technical Abstract (Limit your abstract to 200 words with no classified or proprietary information)

To neutralize biological warfare agents released into a plume we propose the use of the combustion of large-scale dust clouds of inorganic solid fuels including light metals and sulfur. The combustion of light metals such as Al, Mg, Ti, Zr, and their alloys provide the following mutually complementary mechanisms for bio-agent defeat: a) heating of large air volumes to high temperatures, b) strong thermal and potential UV radiation fluxes, c)generation of biologically-active nano-oxide particles, and d) generation of active disinfectant elements (e.g.,molecular Iodine) due to thermal decomposition of additives. The combustion of sulfur clouds is promising for agent neutralization due to the generation of a cloud of droplets of the strong antimicrobial agent sulfuric acid. The proposed scope of work aims to build on our basic understanding of the fundamental properties of propagating large-scale dust flames, while simultaneously experimentally verifying this approach for the intended application. Three research directions will be pursued, including investigating i) the hydrodynamics of dust dispersion, ii) flame speed and flame propagation limits, and iii) the radiative properties of burning dust clouds. The experimental data collected will be used to validate multiphase models for dust combustion.

List a maximum of 8 Key Words or phrases, separated by commas, that describe the Project.

Dust cloud combustion, dust dispersal, flame speed, flame propagation limits, multiphase modeling, UV radiation flux, nano-oxide particles, Iodine disinfectant

Signature not required at time of submission.