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Final Report: Twelfth International Symposium on Special Topics in Chemical Propulsion (12-ISICP), 20-22 October 2020, Santander, Spain

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W911NF-20-1-0229

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER
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Pennsylvania State University
Office of Sponsored Programs
110 Technology Center Building
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14. ABSTRACT

15. SUBJECT TERMS

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UU	UU	UU	UU		19b. TELEPHONE NUMBER 814-863-6375

RPPR Final Report
as of 03-Jan-2022

Agency Code: 21XD

Proposal Number: 77181EGCF **Agreement Number: W911NF-20-1-0229**
INVESTIGATOR(S):

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Principal: Y

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Address: Office of Sponsored Programs, University Park, PA 168027000
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Report Date: 31-Oct-2021 Date Received: 30-Dec-2021
Final Report for Period Beginning 01-Aug-2020 and Ending 31-Jul-2021
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Phone: (814) 863-6375
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STEM Degrees: **STEM Participants:**

Major Goals: To promote technical communication and to encourage further advancement in new energetic materials development, as well as characterization of the combustion behavior of energetic materials for propulsion applications, the Twelfth International Symposium on Special Topics in Chemical Propulsion was held as a virtual conference from 23-25 March 2021. The focus of this three-day Symposium was Recent Progress in Energetic Materials & Chemical Propulsion, covering a variety of experimental, theoretical, and numerical investigations. Six invited lectures along with three panel sessions covering interesting, relevant, and developing topics were important parts of the symposium. In addition, sixty-two scientific presentations were given. Selected papers from the Symposium are now being submitted to the International Journal of Energetic Materials and Chemical Propulsion and published upon further review as refereed papers. These papers serve to archive the technical information from the meeting and are useful reference documentation to both scientists and engineers now and in the future. The funds provided by the US Army Research Office paid for the registration fee of 25 people, who were mostly US graduate students.

The International Symposium has several major objectives. These are: 1) to promote communication between researchers, designers, and manufacturers regarding state-of-the-art approaches in the field of propellants and combustion; 2) to discuss new and improved safety techniques in the combustion of energetic materials; and 3) to recommend future directions for research in combustion and chemical reaction systems. The Symposium also addresses pressing global issues such as: a) the resolution of environmental issues in the combustion of energetic materials; b) the need for economical utilization of finite fuel resources; c) the production of power using existing or newly synthesized energetic materials; and d) the development of adequate techniques for disposal of surplus propellants and explosives for demilitarization purposes.

Accomplishments: The International Symposium on Special Topics in Chemical Propulsion is a unique conference that brings together scientists and engineers from academia, research laboratories, and industry to exchange knowledge on relevant topics in energetic materials and chemical propulsion. The symposia address recent advances in various areas of ignition and combustion of energetic materials, including the areas of novel diagnostics and experimentation; synthesis, manufacturing, and materials; theory, modeling and simulation; nanotechnology; safety enhancement; environmental impact; and commercial applications. These advancements cover experimental, theoretical, and numerical areas. A goal of the symposia is to address technological gaps that still exist in the combustion of energetic materials. The first symposium was held in 1970 in Athens Greece and the next eleven followed on a nearly biannual schedule. The Twelfth International Symposium on Special Topics in Chemical Propulsion (12-ISICP) was originally planned to take place in Santander, Spain from 20-22 October 2020.

However, because of COVID-19, the steering committee made the decision to delay the meeting and convert it to a virtual meeting, which was held from 23-25 March 2021. Funds from the Army Research Office were originally requested for support of registration and travel of students and invited speakers and of meeting materials, such as a book of abstracts, etc. Since the meeting was converted to a virtual meeting, the travel funds were not necessary, and the registration fee was lower allowing more students to be supported and attend the meeting.

The organization of the meeting was established through a Steering Committee, an International Organization Committee, and a Scientific Board. The organizer and host was Jim Fleming (FCIT2, UK). Pro One Media was selected as the company that produced the symposium and streamed the event. Information and updates for the Symposium were maintained on the Internet at: www.isicp12.com. The meeting was advertised through several avenues. These included: the meeting website, mass emails to previous attendees of the ISICP meetings, distribution emails through the author and reviewer database of the International Journal of Energetic Materials and Chemical Propulsion, and emails sent to attendees of other related meetings. The supporters of the 12-ISICP were all from the USA and included the Army Research Office, Day & Zimmerman, PacSci EMC and Resodyn.

The topics covered were of importance to Army interests in the areas of energetic materials and chemical propulsion. Both basic science and applied engineering issues were presented and discussed at the meeting. Furthermore, the bringing of new researchers into the field of energetic materials and chemical propulsion was an important goal of the symposium. The meeting provided students entering these fields an opportunity to interact through the web with international scientists and engineers that are experts in the subjects of energetic materials and chemical propulsion, thus providing them with a unique educational opportunity.

Approximately 175 people participated in 12-ISICP. This number exceeded the attendance at the previous ISICP meetings. The 10-ISICP which was held in France in 2010 had 135 participants plus 16 ENSMA students. The 11-ISICP was held in Germany in 2018 and had 120 participants. The maximum attendance previously was 140 people, which occurred both at the meetings held in Japan (2007) and Canada (2012). The regions as determined by time zones that represented the attendees for 12-ISICP included 37% of the attendees from the Americas with 31% of the total from the USA, an “expanded” Europe, which included the UK, South Africa, Israel, and Turkey accounted for 42% of the attendees. Asia accounted for 21% of the total people with half of this amount from India. There were approximately 85 different speakers including panelists. The Army Research Office funding supported registration for approximately 25 people, who were mostly US graduate students.

The meeting began on Monday March 22, 2021, with a welcome message and a discussion of the meeting organization and structure. During the following three days, the meeting began with two invited lectures and was followed by three streaming sessions.
Three panel discussions were also given. The first panel technical area was “3D printing of energetics and RAM: what new applications are expected by 2025?” The second panel technical area was “High throughput experimentation and research with energetic materials, artificial neural networks (ANN) for combustion, etc.” The third panel topic was “What can be done to sustain energetic materials and/or increase the uptake of greener materials.” The panel discussions were successful events at 12-ISICP meeting program and will be continued in future meetings. In addition to the invited seminars and panel discussions, sixty-two technical presentations were given covering the 18 technical areas listed above.

Selected papers from the Symposium have been recommended for submission to the International Journal of Energetic Materials and Chemical Propulsion (IJEMCP) and are being published upon further review as refereed papers. Publication of the papers in IJEMCP maintains their high quality and makes them archival for future reference. Finally, awards were given for Lifetime Achievement, Best Invited Paper, 12-ISICP Best Paper/Presentation Award, Best Student Paper, and 12-ISICP Best Student Presentation.

The 12-ISICP was concluded with an email request for feedback on the meeting and a washup/lessons learnt Zoom meeting on March 26, 2021. The positives from the meeting included the high standard of papers overall, the record virtual attendance to the meeting, and the participation of new countries to the meeting, e.g., Brazil, and an increase in the number of papers from regular country attendees, e.g., 17 from South Africa, 10 from the UK and 7 from Lithuania. Generally, very positive feedback from the participants was obtained. Some examples were “Excellent web site for the conference, best I have seen,” and “very good technical standard of papers, best for a conference of this type.” Technical challenges that occurred during the first day (such as audio feedback, poor Tech Checks in advance, and making sure there was sufficient time for finding questions on Chat and addressing them) made a very good recovery by the second and third day. Noting that the meeting was converted from an in-person to a virtual meeting within a few months, the conclusion was that 12-ISICP was a great success.

RPPR Final Report
as of 03-Jan-2022

Training Opportunities: Nothing to Report

Results Dissemination: Nothing to Report

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: PD/PI
Participant: Richard A Yetter
Person Months Worked: 2.00 **Funding Support:**
Project Contribution:
National Academy Member: N

Partners

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I certify that the information in the report is complete and accurate:
Signature: Richard A. Yetter
Signature Date: 12/30/21 3:35PM

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13. SUPPLEMENTARY NOTES

14. ABSTRACT
To promote technical communication and to encourage further advancement in new energetic materials development, as well as characterization of the combustion behavior of energetic materials for propulsion applications, the Twelfth International Symposium on Special Topics in Chemical Propulsion was held as a virtual conference from 23-25 March 2021. The focus of this three-day Symposium was Recent Progress in Energetic Materials & Chemical Propulsion, covering a variety of experimental, theoretical, and numerical investigations. Six invited lectures along with three panel sessions covering interesting, relevant, and developing topics were important parts of the symposium. In addition, sixty-two scientific presentations were given. Selected papers from the Symposium are now being submitted to the International Journal of Energetic Materials and Chemical Propulsion and published upon further review as refereed papers. These papers serve to archive the technical information from the meeting and are useful reference documentation to both scientists and engineers now and in the future. The funds provided by the US Army Research Office paid for the registration fee of 25 people, who were mostly US graduate students.

15. SUBJECT TERMS
International Symposium, Chemical Propulsion, Energetic Materials

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a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**		14	Richard A. Yetter
					19b. TELEPHONE NUMBER *(include area code)* 814-863-6375

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Table of Contents

Introduction

The International Symposium on Special Topics in Chemical Propulsion is a unique conference that brings together scientists and engineers from academia, research laboratories, and industry to exchange knowledge on relevant topics in energetic materials and chemical propulsion. The symposia address recent advances in various areas of ignition and combustion of energetic materials, including the areas of novel diagnostics and experimentation; synthesis, manufacturing, and materials; theory, modeling and simulation; nanotechnology; safety enhancement; environmental impact; and commercial applications. These advancements cover experimental, theoretical, and numerical areas. A goal of the symposia is to address technological gaps that still exist in the combustion of energetic materials. The first symposium was held in 1970 in Athens Greece and the next eleven followed on a nearly biannual schedule. The Twelfth International Symposium on Special Topics in Chemical Propulsion (12-ISICP) was originally planned to take place in Santander, Spain from 20-22 October 2020. However, because of COVID-19, the steering committee made the decision to delay the meeting and convert it to a virtual meeting, which was held from 23-25 March 2021. Funds from the Army Research Office were originally requested for support of registration and travel of students and invited speakers and of meeting materials, such as a book of abstracts, etc. Since the meeting was converted to a virtual meeting, the travel funds were not necessary, and the registration fee was lower allowing more students to be supported and attend the meeting. A description of the meeting organization and of the program is provided below. Appendix A includes a detailed listing of the program.

Meeting Organization

The organization of the meeting was established through a Steering Committee, an International Organization Committee, and a Scientific Board. The Steering Committee of the Symposium consisted of:

Chairman: *Professor Richard Yetter*, Penn State University, USA
Vice-chairman: *Professor Keiichi Hori*, JAXA/ISAS, Japan
Vice-chairman, *Dr. John Zevenbergen*, NTO, Netherlands
Vice-chairman/organizer: *Jim Fleming*, FCIT2, UK

Jim Fleming, the meeting organizer and host, was also co-organizer of the first ISICP meeting held in 1970 along with *Professor Kenneth Kuo* who was the founder of the ISICP meetings. The International Organizing Committee (IOC) assisted in the selection of the web company for managing the virtual meeting and matters concerning its structure. The members of the IOC were:

Mr. Jim Fleming, FCIT2, UK
Mr. Martin Sloan, UK
Dr. Rodrigo Caro, Quinetic, Chile
Prof. Pang Weiqiang, Xi'an Modern Chemistry Research Institute, China
Mr. Nicolas Rumeau, Ariane Group, France

Dr. Helmut Ciezki, German Aerospace Center Institute of Space Propulsion, Germany
Dr. John Zevenbergen, TNO, The Netherlands
Mr. Steve Dart, Day & Zimmerman, USA
Mr. James Ponzo, Raytheon Missiles & Defense, USA
Dr. Eric Boyer, Penn State University, USA

The Scientific Committee consisted of 38 international scientists and engineers. Pro One Media (*Ruzica Markovic*, Scottsdale, AZ, USA) was selected as the company that produced the symposium and streamed the event.

Information and updates for the Symposium were maintained on the Internet at: www.isicp12.com. The meeting was advertised through several avenues. These included: the meeting website, mass emails to previous attendees of the ISICP meetings, distribution emails through the author and reviewer database of the International Journal of Energetic Materials and Chemical Propulsion, and emails sent to attendees of other related meetings. The supporters of the 12-ISICP were all from the USA and included the Army Research Office, Day & Zimmerman, PacSci EMC and Resodyn.

Meeting Program

The International Symposium has several major objectives. These are: 1) to promote communication between researchers, designers, and manufacturers regarding state-of-the-art approaches in the field of propellants and combustion; 2) to discuss new and improved safety techniques in the combustion of energetic materials; and 3) to recommend future directions for research in combustion and chemical reaction systems. The Symposium also addresses pressing global issues such as: a) the resolution of environmental issues in the combustion of energetic materials; b) the need for economical utilization of finite fuel resources; c) the production of power using existing or newly synthesized energetic materials; and d) the development of adequate techniques for disposal of surplus propellants and explosives for demilitarization purposes. Specific technical areas included the following:

1) Nano Technology and Innovative Methods in Energetic Material (EM) development
2) Synthesis and Characterization of EMs
3) Formulation, Processing, and Manufacturing of EMs
4) Insensitive Munitions
5) Hazard Reduction and Safety Aspects
6) Theoretical Modelling and Numerical Simulation for CP (Chemical Propulsion) and EM
7) Performance Evaluation of EMs
8) Aging, Stability, and Compatibility
9) Recycling, Disposal, and Environmental Aspects
10) Test Methods and Diagnostic Techniques in CP and/or Combustion of EMs
11) Ignition and Initiation Processes
12) Detonation and/or Deflagration Processes
13) Enhanced Blast and Thermites

14) Innovative Rocket Propulsion Techniques
15) Rocket Thermal Protection Materials, which may include associated liner &/or bonding with propellant
16) Environmentally Friendly "Green" Propellants
17) Commercial Applications of EMs
18) Performance of Advanced Propulsion Systems

The topics above cover many subjects of importance to Army interests in the areas of energetic materials and chemical propulsion. Both basic science and applied engineering issues were presented and discussed at the meeting. Furthermore, the bringing of new researchers into the field of energetic materials and chemical propulsion was an important goal of the symposium. The meeting provided students entering these fields an opportunity to interact through the web with international scientists and engineers that are experts in the subjects of energetic materials and chemical propulsion, thus providing them with a unique educational opportunity.

Approximately 175 people participated in 12-ISICP. This number exceeded the attendance at the previous ISICP meetings. The 10-ISICP which was held in France in 2010 had 135 participants plus 16 ENSMA students. The 11-ISICP was held in Germany in 2018 and had 120 participants. The maximum attendance previously was 140 people, which occurred both at the meetings held in Japan (2007) and Canada (2012). The regions as determined by time zones that represented the attendees for 12-ISICP included 37% of the attendees from the Americas with 31% of the total from the USA, an "expanded" Europe, which included the UK, South Africa, Israel, and Turkey accounted for 42% of the attendees. Asia accounted for 21% of the total people with half of this amount from India. There were approximately 85 different speakers including panelists. The Army Research Office funding supported registration for approximately 25 people, who were mostly US graduate students.

The detailed program is provided in Appendix A. The meeting began on Monday March 22, 2021, with a welcome message and a discussion of the meeting organization and structure. During the following three days, the meeting began with two invited lectures and was followed by three streaming sessions. The invited lectures were given by:

Professor Ellen Mazumdar from Georgia Tech (USA) "Optical diagnostics for multiphase combustion of propellants and energetic materials,"

Mr. Ronald Veraar from TNO (The Netherlands) "Ramjet propulsion for projectiles – An overview of world-wide achievements and future opportunities,"

Prof. Sergey Rashkovskiy from Ishlinsky Institute for Problems in Mechanics (Russia) "Non-one-dimensional combustion modes of solid homogeneous energetic materials,"

Prof. Luigi DeLuca from Politecnico di Milano (Italy) "Nano aluminum for solid rocket propulsion: illusions and reality,"

Prof. Pengwan Chen from Beijing Institute of Technology (China) "Experiments, simulation, and prediction on impact ignition and safety of polymer bonded explosives," and

Dr. Denis Spitzer from ISL: French-German Research Institute (France) "From spray flash evaporation to spray flash synthesis: the case of ADN."

All the invited lectures are expected to be published in the International Journal of Energetic Materials and Chemical Propulsion. The 12-ISICP Session/Stream Chairs were: *Dr. Helmut Ciezki* (German Aerospace Center, Institute of Space Propulsion, Germany), *Prof. Alon Gany* (Technion, Israel), *Prof. Charles Kappenstein* (University of Poitiers, France), *Prof. P.A. Ramakrishna* (Indian Institute of Technology, India), *Prof. Kenichi Takahashi* (Nihon University, Japan), *Dr. Bryce Tappan* (Los Alamos National Laboratory, USA), *Prof. John Wen* (University of Waterloo, Canada), *Prof. Jack Yoh* (Seoul National University, Korea), and *Prof. Greg Young* (Virginia Tech University, USA). The meeting ended on Thursday March 25, 2021.

Three panel discussions were also given. The first panel technical area was "3D printing of energetics and RAM: what new applications are expected by 2025?" The panel members were *Dr. Eric Beckel* from the US Army, *Mr. Lawrence Farrar* from Resodyn Corporation, *Prof. Lori Groven* from the South Dakota School of Mines, *Prof. Steven Son* from Purdue University and *Dr. Kyle Sullivan* from Lawrence Livermore National Laboratory. The second panel technical area was "High throughput experimentation and research with energetic materials, artificial neural networks (ANN) for combustion, etc." The panel members included *Dr. Victor Abrukov* from Chuvash State University, *Dr. Brian Barnes* from the US Army, and *Dr. Mark Johnson* from the US Army. The third panel topic was "What can be done to sustain energetic materials and/or increase the uptake of greener materials." The panel members consisted of *Dr. Jamie Neidert* from the US Army, *Dr. Uwe Schaller* from ICT, and *Dr. Guy Jacob* from Ariane Group. The panel discussions were successful events included in the 12-ISICP meeting program and will be continued in future meetings. In addition to the invited seminars and panel discussions, sixty-two technical presentations were given covering the 18 technical areas listed above.

Selected papers from the Symposium have been recommended for submission to the International Journal of Energetic Materials and Chemical Propulsion (IJEMCP) and are being published upon further review as refereed papers. Publication of the papers in IJEMCP maintains their high quality and makes them archival for future reference. Finally, awards were given for Lifetime Achievement, Best Invited Paper, 12-ISICP Best Paper/Presentation Award, Best Student Paper, and 12-ISICP Best Student Presentation.

Summary

The 12-ISICP was concluded with an email request for feedback on the meeting and a washup/lessons learnt Zoom meeting on March 26, 2021. The positives from the meeting included the high standard of papers overall, the record virtual attendance to the meeting, and the participation of new countries to the meeting, e.g., Brazil, and an increase in the number of papers from regular country attendees, e.g., 17 from South Africa, 10 from the UK and 7 from Lithuania. Generally, very positive feedback from the participants was obtained. Some examples were "Excellent web site for the conference, best I have seen," and "very good technical standard of papers, best for a conference of this type." Some issues occurred for some of the speakers with joining the streams due to incomplete technical checks with Pro One Media or speaker issues (no

audio, camera, wrong name so not able to be admitted). Technical challenges that occurred during the first day (such as audio feedback, poor Tech Checks in advance, and making sure there was sufficient time for finding questions on Chat and addressing them) made a very good recovery by the second and third day. Noting that the meeting was converted from an in-person to a virtual meeting within a few months, the conclusion was that 12-ISICP was a great success.

Lastly, the next meeting, 13-ISICP, was discussed. With the continuance of COVID-19, various formats were considered including a hybrid meeting. It was recognized that virtual meetings are just as demanding to organize, if not more, than a physical meeting. A hybrid meeting would only increase the complexity and cost. Other much larger organizations are moving in this direction; however, it is yet to be seen if this will be the standard for large organizations.

Appendix A Program

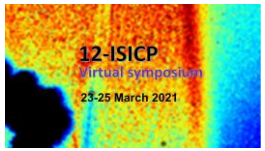
12th International Symposium on Special Topics in Chemical Propulsion & Energetic Materials (12-ISICP)

Preliminary Technical Program/Agenda, Issue E dated 19th March '21

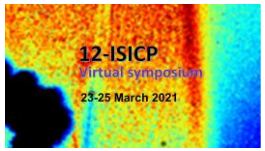
Virtual Symposium

23-25 March 2021 (with a short Welcome on 22nd March)

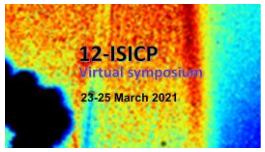
CET Start Time	Monday, March 22, 2021 (Day "0")		
2:00 PM to 2:30 PM	**Welcome** **Prof. Richard Yetter**, Penn State University (USA)		
	Tuesday, March 23 (Day 1)		
12:00 PM	Invited Speaker **Asst. Prof. Ellen Mazumdar,** Georgia Tech (USA) **Optical diagnostics for multiphase combustion of propellants and energetic materials**		
12:30 PM	Invited Speaker **Mr Ronald Veraar**, TNO (The Netherlands) **Ramjet Propulsion for Projectiles - An Overview of World-Wide Achievements and Future Opportunities**		
	Stream 1 **Chair: Prof. Alon Gany** Technion (Israel)	**Stream 2** **Chair: Prof. Charles Kappenstein** Uni. of Poitiers (France)	**Stream 3** **Chair: Dr. Helmut Ciezki** German Aerospace Center, Institute of Space Propulsion (Germany)
1:00 PM	Technical Area: 16 Paper № 70671 **Study of the combustion wave structure in a GAP/AP propellant** Tamiaki Takasago, Kazuki Nagao, Yutaka Wada, Kaiichi Baba, Tatsuya Oda	Technical Area: 18 Paper № 70646 **Enhancement of Combustion of a solid fuel ramjet for its application in an artillery shell** Yogeshkumar Velari, R. V. Reji, Prof P. A. Ramakrishna	
1:20 PM	Technical Area: 16 Paper № 65863 **Investigation and production of hexaaluminate-ceramics** Dr. Tijen Seyidoglu, Robert Jan Koopmans,	Technical Area: 18 Paper № 70659 **Unsteady Combustion in Hybrid Rocket with Liquefying Fuel** Jina Kim, Wonjeong Hyun, Changjin Lee	Technical Area: 12 Paper № 70638 **Reduction of Pyro Shock in Stage Separation Mechanism by use of Gas Generator Systems** A.Chakraborty, N. Rathi, Prof P. A. Ramakrishna, M. Haradanahalli, R Srinivasan A.



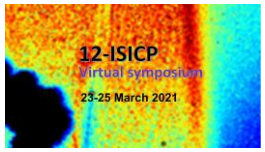
1:40 PM	Technical Area: 1 Paper Nº 70663 **Combustion Performance of the Nanosized Nitrocellulose and Its Nanocomposites Produced by the Supercritical Antisolvent Processing** Nikita Muravyev, Dimitri B. Meerov, Mikhail N. Zharkov, Ilya V. Kuchurov	Technical Area: 17 Paper Nº 70692 **Scientific misconducts from retracted or corrected articles - Case studies including energetic materials** Prof. Charles Kappenstein	Technical Area: 8 Paper Nº 70806 **The Effects of Accelerated Aging with High Relative Humidity and Temperature on the Boron Potassium Nitrate (BPN) Pyrotechnic Composition** Beril Dumalilar Tabak, Dr. Nil Ezgi Dincer Yilmaz
2:00 PM	Technical Area: 3 Paper Nº 70627 **Printable Energetic Materials** Levi Gottlieb, Yoav Eichen, Yuval Zertal, Avishai Levi, Matthew Young	Technical Area: 6 Paper Nº 70630 **Effect of the melt viscosity on regression rate of low-melting solid fuel in hybrid rocket engines** Sergey Rashkovskiy, Sergey Yakush	Technical Area: 14 Paper Nº 70658 **Testing Water-Augmented Rocket Motor** Nachum E. Eisen, Prof. Alon Gany
2:20 PM	Technical Area: 3 Paper Nº 70805 **Solventless Extruded Double Base (EDB) propellant charges - a review of the properties, technology, and applications** Jim Fleming, Martijn Zebregs, Chris van Driel, Dr. Werner Rousseau	Technical Area: 6 Paper Nº 66492 **Understanding burning of heterogeneous solid propellants through mesoscale modeling** Stany Gallier, Mathieu Plaud	Technical Area: 14 Paper Nº 70675 **Recent Advances in Gel Propulsion Technology at DLR Lampoldshausen** Christoph Kirchberger, Maxim Kurilov, Sophie Ricker, Dominic Freudenmann
2:40 PM	Technical Area: 3 Paper Nº 70679 **Formulation Design – An Integrated Approach** Prof. Adam Cumming	Technical Area: 10 Paper Nº 66552 **Optical Investigation on the Hypergolic Reaction of Green Liquid Ionics with Highly Concentrated Hydrogen Peroxide** Dr. Robert Stützer, Jakob Balkenhohl, Felix Lauck, Michael Oschwald, Stefan Schlechtriem	Technical Area: 15 Paper Nº 70443 **Analysis of the Multistep Degradation Kinetics of EPDM-based Thermal Protection System** Ramin Shilav, Dr. Levi Gottlieb
3:00 PM	**Panel 1** Technical Area: 3 **3D printing of energetics & RAM: what new applications are expected by 2025?** Chair: Prof. R Yetter Dr. Eric Beckell, US Army Lawrence Farrar, Resodyn Corp Prof. Lori Groven, South Dakota School of Mines Prof. Steven Son, Purdue University Dr. Kyle Sullivan, US Army	Technical Area: 11 Paper Nº 70321 **Ammonium nitrate - Thermal vaporization vs catalytic decomposition: recent results into an old field** Prof. Charles Kappenstein, Yann Batonneau PhD, Romain Beauchet	Technical Area: 15 Paper Nº 70678 **Influence of Nozzle Radiation on Solid Rocket Motors Tail-off Thrust** Prof. Fabrizio Ponti, Mini Stefano, Luca Fadigati, Adriano Annovazzi, Michela Archi



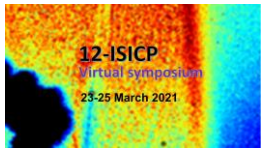
3:20 PM	(Note that Panel 1 will finish at 4 PM)	Technical Area: 11 Paper № 70693 **Participation of Poitiers to European Programs on Space Propulsion GRASP, PRECISE, RHEFORM and GRAIL: an Overview** Prof. Charles Kappenstein, Yann Batonneau, PhD	Technical Area: 2 Paper № 70297 **Development and Performance Evaluation of "Green" Primary Explosives for Use in Electro-explosive Devices and Detonators** Euan McLean, Dr Alistair MacCuish, Prof. David K. Harrison, Dr Rob P. Claridge, Patrick McMaster
3:40 PM			Technical Area: 2 Paper № 70647 **A Novel Method of Assessing Impact Sensitivities of Energetic Materials** Patrick McMaster, Dr David M. Williamson, Olivia J. Morley
	March 24 (Day 2)		
11:00 AM	Invited Speaker **Prof. Sergey A. Rashkovskiy,** Ishlinsky Institute for Problems in Mechanics (Russia) **Non-one-dimensional combustion modes of solid homogeneous energetic materials**		
11:30 AM	Invited Speaker **Prof. Luigi DeLuca,** Politecnico di Milano (Italy) **Nano aluminum for solid rocket propulsion: illusions and reality**		
	Stream 1 **Chair: Prof. Kenichi Takahashi** Nihon University (Japan)	**Stream 2** **Chair: Prof. P.A. Ramakrishna** Indian Inst. of Technology (India)	**Stream 3** **Chair: Prof. Jack Yoh** Seoul National University (Korea)
12:00 PM	Technical Area: 10 Paper № 70662 **Methods of Analysis of T-burner Experimental Data** Ganesan S, S. R. Chakravarthy	Technical Area: 14 Paper № 66622 **Combustion mechanism of uncured polyethylene glycol and glycidyl azide polymer mixture fuel** Yutaka Wada, Kazuki Nagao, Tamiaki Takasago, Shintaro Hatano, Kaiichi Baba	Technical Area: 1 Paper № 66493 **New Insights in the Energetic Materials Performance Enhancement Through Synergistic Effect of Hybridized Carbon-Based Nano-Additives Properties Modification by Electrostatic Field** Alexander Lukin, Yutaka Wada
12:20 PM	Technical Area: 10 Paper № 70665 **Residue oxide particle size distribution studies of aluminized solid propellants using plume collection** Robin Rathi, Hiteshkumar Zinjala, Satyanarayanan, R. Chakravarthy	Technical Area: 14 Paper № 66623 **Flight demonstration of GAP/N2O direct injection gas-hybrid rocket system using a small rocket** Shintaro Hatano, Yuri Matsumoto, Tamiaki Takasago, Yutaka Wada, Kaiichi Baba	Technical Area: 1 Paper № 70555 **Nanocomponents as a Source of Increasing the Energy Potential of Chemical Propellants** Valery Babuk



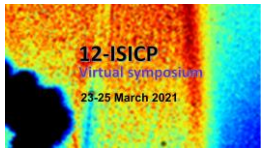
12:40 PM	Technical Area: 10 Paper № 70667 **Acoustic Admittance of the Aluminized Composite Solid Propellant by Laser Doppler Velocimetry at Low Pressure** Rajendra Rajak, Satyanarayanan R. Chakravarthy	Technical Area: 14 Paper № 70563 **Photosensitive propellants applied to the laser-controlled combustion behavior** Haonan Zhang, Ruiqi Shen, Lizhi Wu, Prof. Luigi T. DeLuca, Buren Duan	Technical Area: 1 Paper № 70640 **Green and MEMS-Compatible Energetic Composites with High Electrostatic Safety: Copper Azide Embedded in Oriented Carbon Nanotubes Arrays Grown on Silicon Substrate** Xuwen Liu
1:00 PM	Technical Area: 10 Paper № 70668 **Determination of Steady State Mean Burning Rate of Composite Solid Propellant Combustion under Open loop and Closed loop with Servo-Mechanism by Laser Doppler Velocimetry** R Rajak, S. R. Chakravarthy, B.S. Subhash Chandran, H Zinjala	Technical Area: 14 Paper № 70569 **Design and Testing of Miniature Rocket Motors for control Applications** Raj Alexander Y., Nikunj Rathi, R Srinivasan, Prof P. A. Ramakrishna	Technical Area: 11 Paper № 66566 **Watching the ultrafast hot spots dynamics of PETN/FOX-7 under a tabletop microscope** Wei Zhang, Meysam Akhtar, Lawrence Salvati Dana D. Dlott, Ruiqi Shhen
1:20 PM	Technical Area: 10 Paper № 70674 **Quantification of Binder melt: Aluminized Composite Propellants with RDX** K Nagendra, P. A. Ramakrishna, Rekha Sangtyani, Arvind Kumar	Technical Area: 14 Paper № 70657 **Combustion of 5-Aminotetrazole Propellant for Laser-Augmented Chemical Propulsion** Nianbai He, Ruiqi Shen, Prof. Luigi T. DeLuca, Lizhi Wu, Wei Zhang	Technical Area: 11 Paper № 70621 **Energetic initiators realized by Al/CuO reactive multilayer films in metal-interlayer-metal structures** Fu Shuai, Prof. Ruiqi Shen
1:40 PM	Technical Area: 10 Paper № 70680 **Revisiting Combustion of Ammonium Perchlorate with Burn rate Modifiers** Mahesh S Ingole, Dr. Nagendra Kumar, Prof P. A. Ramakrishna		Technical Area: 11 Paper № 70681 **Ignition Transient Study: Igniter Jet Impingement** Sumit Sarma, Prof P. A. Ramakrishna, Dr. Nagendra Kumar
2:00 PM	Technical Area: 10 Paper № 70802 **Mechanical response of composite solid propellant under uniaxial loading** Rajeev Ranjan, H. Murthy, V.S. Sadavarte, S.M. Pande, Debdas Bhowmik	Technical Area: 14 Paper № 70664 **Phase-Transition Process of Paraffin-added Thermoplastic Elastomer for Hybrid Rocket Fuel** Ayana Banno, Yutaka Wada, Yuji Mishima, Takahisa Tsugoshi, Nobuji Kato	Technical Area: 7 Paper № 66531 **Ignition and Combustion Behavior of Al-Mg-Zr in Composite Propellants** Zhao Qin



2:20 PM	**Panel 2** Technical Areas: All **High Throughput Experimentation and Research with Energetic Materials, Artificial Neural Networks (ANN) for combustion, etc.** Chair: Dr J Zevenbergen, TNO Dr. Victor S Abrukov, Chuvash State University Dr. Brian Barnes, US Army Dr. Mark Johnson, US Army	Technical Area: 3 Paper № 66471 **Effect of hydroborate iron additives (BH-Fe) on the properties of composite solid rocket propellants** Prof. Wei-Qiang Pang	
2:40 PM		Technical Area: 3 Paper № 70633 **Coating Viton on Flake Aluminium and Its Effects on Performance of the Solid Rocket Motor** Gaurav Marothiya, Prof P. A. Ramakrishna	
	March 25 (Day 3)		
2:00 PM	Invited Speaker **Prof. Pengwan Chen,** Beijing Institute of Technology (China) **Experiments, simulation and prediction on impact ignition and safety of polymer bonded explosives**		
2:30 PM	Invited Speaker **Dr. Denis Spitzer,** ISL: French-German Research Institute (France) **From spray flash evaporation to spray flash synthesis: the case of ADN**		
	Stream 1 **Chair: Prof. Greg Young** Virginia Tech (USA)	**Stream 2** **Chair: Dr. Bryce Tappan** Los Alamos National Laboratory (USA)	**Stream 3** **Chair: Prof. John Wen** University of Waterloo (Canada)
3:00 PM	Technical Area: 2 Paper № 65736 **Alternatives to existing Primary Explosives** Michael Williams	Technical Area: 5 Paper № 70614 **The fragmentation test results for hybrid rocket fuels in an oxidizing atmosphere** Akiyo Takahashi	Technical Area: 6 Paper № 66461 **Structural integrity analysis of viscoelastic low-melting-point thermoplastic fuel for hybrid rocket systems** Yo Kawabata, Yutaka Wada, Takeshi Yasuda, Ryo Nagase, Nobuji Kato
3:20 PM	Technical Area: 2 Paper № 70654 **Effect of Piezoelectricity on the Burning Rates of Fluoropolymer and Nanoaluminum Composite Energetic Materials** David Drewniak		Technical Area: 6 Paper № 70670 **Comparative Study of Numerical Schemes for Granular Combustion** Annie Rose Elizabeth, Dr. T. Jayachandran



3:40 PM	Technical Area: 16 Paper Nº 66269 **Combustion of HAN-based Propellants and Decomposition of their Components** Robert E. Ferguson, Alan A. Esparza, Steven D. Chambreau, Ghanshyam L. Vaghjiani, Evgeny Shafirovich	Technical Area: 14 Paper Nº 70804 **Experimentation of a Large Lab-Scale Hybrid Rocket Engine Utilizing Paraffin-Based Fuels Containing High-Energy Materials** Dillon J. Over	
4:00 PM	Technical Area: 16 Paper Nº 66633 **Performance Enhancement and Ignition Delay Suppression of TMEDA using Amine-Borane Additives** Michael Baier, Andrew Noel, Steven Son	Technical Area: 13 Paper Nº 70803 **Ignition and Combustion of TNT-Dispersed Aluminum Powder** Asst. Prof. Ryan W. Houim, Jacob Posey Swagnik Guhathakurta	
4:20 PM	Technical Area: 16 Paper Nº 70687 **Characterization of Dense Green Oxidizer Formulations for Propulsion Applications** Dillon J Over	Technical Area: 14 Paper Nº 70363 **Effect of Electrical Stimuli on Combustion Behaviour of Solid Oxidizers** Bradley Gobin, Sean Whalen, Gregory Young	Technical Area: 6 Paper Nº 70631 **Comparison of Reactive Molecular Dynamics Simulation of HMX with FTDO Explosive** F. Batista Mendonça, R.F. Boschi Gonçalves, José A. Fritz Fidel R., M. Galizia Domingues, G. S.Urgessa
4:40 PM	Technical Area: 16 Paper Nº 70695 **Electrocatalytic Decomposition of Hydroxylammonium Nitrate Aqueous Solutions** Eric Crisp, Richard Yetter, J. Eric Boyer	Technical Area: 18 Paper Nº 70362 **Improved Hybrid Rocket Performance by Additively Manufactured Gel-Infused Solid Fuels** James Meier, John Reynolds, Sean Whalen, Michael J. Bortner, Associate Prof. Greg Young	Technical Area: 6 Paper Nº 70648 **Analysis and Comparison of the Performance of Paraffins Based on Reactive Molecular Dynamics** R.F. Boschi Gonçalves, E.C. Rosa Araújo, José Atílio Fritz Fidel Rocco, Marcela Galizia Domingues
5:00 PM	**Panel 3** Technical Area: 16 **What can be done to sustain energetic materials &/or increase the uptake of Greener materials** **Chair: Prof. Keiichi Hori, JAXA** Dr. Jamie Neidert, US Army Dr. Uwe Schaller, ICT Dr. Guy Jacob, ArianeGroup	Technical Area: 2 Paper Nº 70807 **Exploring new techniques for the analysis of nitrocellulose** Dr. Ruth Tunnell, Dave Tod, Dan Pearce, Richard Moore, Richard Johnson	Technical Area: 3 Paper Nº 70304 **Continuous Acoustic Chemical MicroReactor** Joe Mayne, Lawrence C. Farrar, Bradley Sleadd, David Boruta



5:20 PM	(Panel 3 will finish at 5:40 PM)	Technical Area: 10 Paper Nº 70645 **Hybrid Rocket Motor thrust modulation by GOX flow rate control** Bruno T. Rocco, M. Galizia Domingues, L. Rocco Junior, José Atílio Fritz, Fidel Rocco, Koshun Iha	Technical Area: 3 Paper Nº 70308 **Safer and Cleaner Continuous ResonantAcoustic® Production of Energetic Material** Mike Miller, Lawrence C. Farrar, Dr. Andrew Nelson, Michael Siirila
5:40 PM	**Prof. Richard Yetter** **Prize Awards & Closing**		
6:00 PM to 6:20 PM	**Jim Fleming** **13-ISICP & Santander (Spain)**		

Note that the Excel version of the Programme/Agenda (that can be downloaded from here) includes the author's organisations.

Key to technical areas: -

Nº	Technical Area	Nº	Technical Area
1	Nano Technology and Innovative Methods in Energetic Material (EM) development	10	Test Methods and Diagnostic Techniques in CP and/or Combustion of EMs
2	Synthesis and Characterization of Ems	11	Ignition and Initiation Processes
3	Formulation, Processing, and Manufacturing of Ems	12	Detonation and/or Deflagration Processes
4	Insensitive Munitions	13	Enhanced Blast and Thermites
5	Hazard Reduction and Safety Aspects	14	Innovative Rocket Propulsion Techniques
6	Theoretical Modelling and Numerical Simulation for CP (Chemical Propulsion) and EM	15	Rocket Thermal Protection Materials, which may include associated liner &/or bonding with propellant
7	Performance Evaluation of EMs	16	Environmentally Friendly "Green" Propellants
8	Aging, Stability, and Compatibility	17	Commercial Applications of Ems
9	Recycling, Disposal, and Environmental Aspects	18	Performance of Advanced Propulsion Systems