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Tadeusz Uhl
Editor

Advances in Mechanism and Machine Science

Proceedings of the 15th IFToMM World Congress on Mechanism and Machine Science

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Foreword

Dear IFToMMists and Participants

Welcome to the 2019 IFToMM World Congress celebrating the 50th anniversary of IFToMM, the International Federation for the Promotion of Mechanism and Machine Science (MMS)!

This is the fifteenth congress event of the series that was started in 1965 giving the foundation of IFToMM in 1969.

The IFToMM World Congress is the main conference event of the IFToMM community not only as an open world meeting, but also for the functioning of IFToMM with the General Assembly (GA) that is scheduled in these days. Today IFToMM is composed of 48 Member Organizations (MOs) from all continents, but the participation at the World Congress collects people usually from more than 60 countries. In addition, IFToMM activity is run in specific domains through the Permanent Commissions (PCs) and Technical Committees (TCs) with meetings, conferences, tutorials, summers schools, editorial works, joint projects and so on. IFToMM works though MOs, PCs, TCs and Executive Council (EC) as based on volunteer activity of individuals both in leadership and initiatives for the success of IFToMM mission and MMS developments. For details on IFToMM and its activity and plans you are kindly invited to refer to the IFToMM webpage www.iftomm.net.

In these days of the IFToMM World Congress meetings of TCs and PCs are scheduled for discussions and plans of future activities and you are kindly invited to attend as observer also with the aim to better know the way to contribute to IFToMM and perhaps to be involved in those IFToMM bodies. Similarly, you are invited at the GA to share the IFToMM plans with your MO delegation.

As international institution in Technology and Science areas IFToMM has an important role for reference and stimulation of international collaboration and common views for MMS developments and new trends for the benefit of society and its enhancements. Each of us should be aware of this role and each of us will contribute with her/his work disseminating MMS attention and developments in all the fields of research, formation, and profession.

In this these days of the IFToMM World Congress we shall discuss many of the MMS topics with focus on the achieved new results and I wish to each of us to get the best and most satisfactory experience in sharing problems, solutions, and opinions, also with the possibility to start new international collaborations. Let's hope that this World Congress will be also the start for new horizons of our activities.

In name of leaders of IFToMM, I thank you for your presence and participation making this IFToMM World Congress a unique event, with the hope to continue the IFToMM tradition of the first fifty years with new vision and success. I wish you will like to see the poster exhibition showing the history and identity of IFToMM along time with an eye to the future, expecting even with your individual contributions.

Let's thank the Polish organizing committee in Krakow, from the leaders up to the volunteer students, who have spent great efforts to make the environment of this IFToMM World Congress efficient and friendly so that each of us can live an unforgettable experience of IFToMM with a high-level technical-scientific program and warm social events.

Let me give personal thanks to all of you for permitting me to serve once more as IFToMM President for an exciting experience whose results I hope to have been within your expectations and I will apologize for my mistakes if I have not fully worked out my original plan of visibility-activity-benefits for IFToMM.

I thank my family and my wife Brunella for having supported me and letting me to spend time and efforts for IFToMM with much of the time away from them.

Rome, italy
January 2019

Marco Ceccarelli
IFToMM President 2016–19

Preface

The 15th International Federation of Theory of Machines and Mechanisms World Congress is held during June 30 – July 4, 2019 in Krakow, Poland.

The proceedings of 15th IFToMM WC has been published by Springer in **Advances in Mechanism and Machine Science** series, which include 468 excellent papers selected from more than 550 submitted papers. The Proceedings are divided into 17 chapters, which are relevant to the Technical Committees of IFToMM. These chapters are distributed in 5 volumes of electronic book.

The conference is intended to bring together the worldwide researcher community working in different aspects of theory of mechanisms and machines. The proceedings include papers of authors from 61 countries and gives excellent review of current research topics under investigation worldwide in area of theory of mechanism and machines and their applications,

In addition to the contributed papers, the conference committee has invited Keynote papers presented by active researchers from various countries in relevant topic areas mostly covered at 15th IFToMM WC.

Much of the value of the success of the congress is due to Technical Committees Chairs who have devoted their expertise and experiences in promoting the Congress. They have spent a considerable time and energy in reviewing process. I would like to expresses great appreciation for their effort.

The reviewers of the manuscripts would remain anonymous, have been very helpful in efficiently reviewing the manuscripts, providing comments within the time frame assigned to them. Editor expresses their grateful thanks to all reviewers.

The 15th IFToMM WC is proud to dedicate this conference proceeding to the all previous Presidents of IFToMM, who were not only an outstanding researcher but also manage this organization for 50 years. Thanks to their effort and time spends to keep IFToMM organization in a good track to success.

Thanks to Organizing Committee for their hard work in choosing out manuscripts and advises in organization of the event. Current President of IFToMM prof. Marco Ceccarelli took attention to all scientific and organization aspects of the

Congress, without his engagement and effort it was impossible to organize such successful and important event for whole IFToMM community. I would like to express my appreciation for his time spends on discussions and helps. Also thanks to other staffs assisting in the various stage of the editorial work.

Tadeusz Uhl
Editor

The original version of this book was revised: Belated corrections have been incorporated. The correction to this book is available at https://doi.org/10.1007/978-3-030-20131-9_422

IFToMM: yesterday, today, and tomorrow

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Abstract. This paper is an introduction to the celebration of 50-year anniversary of IFToMM, the International Federation for the Promotion of Mechanism and Machine Science (MMS). The historical developments are outlined by reporting main facts and aspects in aggregating a world-wide community working on MMS with today 48 IFToMM national/territory organization members. The challenges of yesterday are described to explain the today significance of IFToMM as based on strong collaborations of institutions but individuals without barriers for developing knowledge and solutions in technological areas for the ultimate benefits of the mankind. The future of IFToMM is also discussed as per the challenges facing new generations on MMS in new horizons with modern systems integrating multidisciplinary aspects.

Keywords: IFToMM, History of IFToMM, challenges in MMS.

1 Introduction

Significance of IFToMM can be stressed by its history and the challenges that have been successfully experiences as well as those facing the future, as related to the worldwide community working in the broad areas of disciplines of Mechanism and Machine Science (MMS) for theoretical aspects up to practical implementations for service in the

IFToMM is an emblematic result of needs and convenience in aggregation of people with common interests and activities to strengthen their visibility and impacts both in technical-scientific collaboration aims and contractual purposes within the society, [1]. IFToMM as federation is an aggregation of national/territory communities of scientists and engineers working in MMS with a vision a world community service the welfare of the mankind, [2]. Aggregation is a natural action of humans with common interests and with the aims of achieving strong impacts in the surrounding frames. A society is an aggregation that is motivated by common cultural views and professional interests with the aim both to have a community within which is possible to share successfully

needs and interests and to have full understanding of the activity results with good visibility and influence with future trends of developments. The above aspects can be recognized in IFToMM community along its history since its foundation 50 years ago, [3, 4].

The history of IFToMM has been outlined from several perspectives mainly by the past IFToMM Presidents, as in the reports [4 - 12], very often with an eye to future trends. Those historical reports can be considered significance not only to track the history of IFToMM but to clarify the identity of IFToMM through the characteristics of peoples and achievements they reached. IFToMM can be characterized as a community that has evolved from 'a family' (as prof. Morecki was used to say, [10, 11]) up to a international organization with a large participation of individuals coming from different countries and experiences (some Technical Committee has more than 70 members representing more than 30 countries!), [3, 4]. Those President reports describe the efforts and peculiarities of IFToMM evolution and the involved people as mainly referring to leaders (posters are also available in the IFToMM webpage with names and service dates).

This year we celebrate the 50-year anniversary of IFToMM during the 2019 World Congress on MMS and a s special session is planned with speeches by living Past IFToMM Presidents, after which a commemorative plaque will be revealed for exhibition during the congress and then it will posted in the hall of the Faculty of Mechanical Engineering of AGH Krakow University.

This paper is thought as an introduction to the Past IFToMM President speeches as well as to give an overview of IFToMM significance and role through a short discussion of its history, identity, and future.

2 The Bodies of IFToMM and Their Activities

IFToMM is the International Federation of a world community working in the broad area of Mechanism and Machine Science including not only aspect of Mechanical Engineering. Its mission is clearly stated in the articles 2.1-2.8 of IFToMM Constitution as summarized by the sentence: 'To promote research and development in the field of Machines and Mechanisms by theoretical and experimental methods, along with their practical application', [2].

The bodies of IFToMM of IFToMM are defined in the Constitution as summarized in Fig. 1:

- General Assembly (GA), which is the supreme body of the Federation and determines its policy. It is composed of the Chairs of IFToMM Organization Members (MOs) (in 2019 they are 48 from countries of all the continents as national or territory associations/committees) and the members of the Executive Council with no vote rights.
- Executive Council (EC) that manages the affairs of the Federation between the sessions of the General Assembly. It is elected every four years, meets annually, and is composed of the President, Vice- President, Secretary-General, Treasurer, Past President, and six ordinary members.

- Commissions of the General Assembly (GACs) that are appointed for the basic duties relating to GA in dealing with Constitution, EC Nominating procedure, Honors and Awards.
- 14 Technical Committees (TCs) that are today active in the fields of Biomechanical Engineering, Computational Kinematics, Engines and Powertrains, Gearing and Transmissions, Linkages and Mechanical Controls, Micromachines, Multibody Dynamics, Reliability, Robotics and Mechatronics, Rotordynamics, Sustainable Energy Systems, Transportation Machinery, Tribology, and Vibrations. Additional TCs are under consideration for future activation in hot topics with an IFToMM significant community.
- Permanent Commissions (PCs) that are on Communications, Publications and Archiving; Education; History of MMS; and Standardization of Terminology.

IFToMM activity is characterized by the main aspects on collaboration and dissemination in research, application, and formation through several initiatives like meetings, conferences, editorial works, teaching technological transfers and so on, Fig.1. Main conference event is the World Congress (WC) and main student-oriented event is the Student International Olympiad on MMS (SIOMMS).

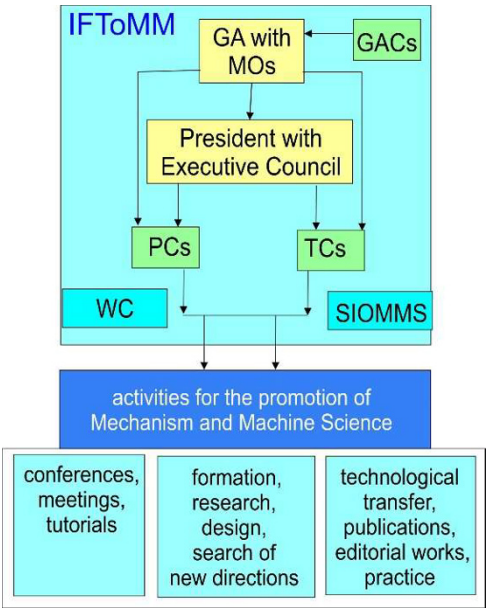

Fig. 1 Structure and activities of IFToMM

Most of the IFToMM visibility as a measure if its significance in (not only mechanical) engineering world community is achieved through conference events as forum of dissemination and discussion with direct contacts, even from industry and professional frames. In addition to several thematic conferences that every year are organized, sponsored or co-sponsored by MOs, TCs, and PCs (as advertised also in

the IFToMM webpage and communication channels), the IFToMM main event is the MMS World Congress that is organized every four years with a participation from all around the world (the last one in 2015 was participated by people from more than 60 countries), Table 1.

Table 1 – Data of the IFToMM World Congresses in MMS over the time

No.	year	location	MO host	WC Chair	No. papers	No. countries
1	1965	Varna, Bulgaria	--	Michael S. Konstantinov	64	14
2	1969	Zakopane, Poland	Poland	Jan Oderfeld	66	12
3	1971	Kupari, Yugoslavia	Yugoslavia	Todor Pantelic	198	22
4	1975	Newcastle upon Tyne, UK	UK	Leonard Maunder	230	28
5	1979	Montreal, Canada	Canada	M.O.M. Osman	350	34
6	1983	New Delhi, India	India	Jammi S. Rao	338	35
7	1987	Seville, Spain	Spain	Justo Nieto, Emilio Bautista, JaimeDominguez	417	38
8	1991	Prague, Czechoslavakia	Czechoslavakia	Laslo Pust	359	40
9	1995	Milan, Italy	Italy	Alberto Rovetta	665	51
10	1999	Oulu, Finland	Finland	Tatu Leinonen	628	50
11	2004	Tianjin, China	China- Beijing	Tian Huang	491	43
12	2007	Besançon, France	France	Marc Dahan, JeanPierre Merlet	535	52
13	2011	Guanajuato, Mexico	Mexico	Ricardo Chicurel, Josè Maria Rico	309	43
14	2015	Taipei, Taiwan	China-Taipei	Shuo Hung Chang	559	47

Main means of dissemination and collaboration results are the publications that are reported in conference proceedings, editorial works, research and teaching reports by Publishers of different levels and capabilities as well as in papers of Journals (IFToMM gave the affiliation to few ones) of different levels and capabilities. The importance of publications is recognized at government levels by requiring more and more quality and dissemination for public access that now is considered verified by the indexing values of the publication frames.

Application activity is performed with design and implementation of solutions for practical use at prototype but market levels, even with technological transfer by

patents and spin-off company from research institutions, and research consulting.

Formation is considered an independent activity but much of it comes from the design and research activities for the transfer of knowledge and skills to new generations so that it is strongly included in the dissemination mission of IFToMM with the aim to guide new generations of engineers and investigators in the realm of MMS. This is performed by a regular teaching but with new modern approaches and more specifically with tutorials and summer schools that are organized by IFToMM TCs.

3 A short Account of History of IFToMM

The History of IFToMM can be outlined look at the main facts and people who were involved in the leadership of IFToMM as per the generation that can be identified as follows, Fig.2:

- 1950's –'79 First generation with founding fathers and their friendly colleagues up to the 4-th IFToMM World Congress in New Castle upon Tyne in 1975 with prof Maunder as Congress Chair
- 1980-95 Second Generation with pupils and educated people by founding fathers and their friendly colleagues up to the 9-th World Congress in Milan in 1995 with prof Rovetta (Bianchi's pupil) as Congress Chair
- 1996-2011 Third Generation with educated people in the frames of IFToMM and within IFToMM activity with Prof. Carlos Lopez-Cajùn as General Chair for 2011 Congress.
- Today- Fourth Generation with educated people in local MMS frames that are linked to IFToMM and within IFToMM activity with 48 organizations as IFToMM members.

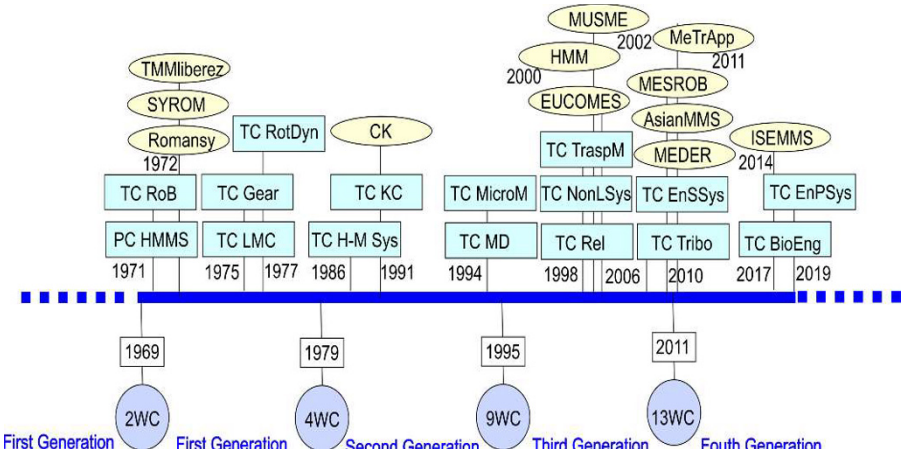

Fig. 2 A historical timeline of IFToMM with starting dates of PCs-TCs in light-green rectangles and main IFToMM conferences in light-yellow ellipses

IFToMM was founded as the International Federation for the Theory of Mechanisms and Machines in Zakopane, Poland on September 29, 1969 during the Second World Congress on TMM (Theory of Mechanisms and Machines), Fig. 3 a). The main promoters of the IFToMM World Federation were Academician Ivan I. Artobolevski (USSR) and Prof. Erskine F.R. Crossley (USA), whose principal aim was to bypass the obstacles of the time of the Cold War in developing international collaboration in TMM science. IFToMM started with a family character of TMM scientists among whom we may identify the IFToMM founding fathers, who signed or contributed to the foundation act by representing 13 Member Organizations, in the persons: Academician Ivan I. Artobolevski (USSR), Prof. Erskine F.R. Crossley (USA), Prof. Michael S. Konstantinov (Bulgaria), Dr. Werner Thomas (GFR), Prof. B.M. Belgaumkar (India), Prof. Kenneth H. Hunt (Australia), Prof. J. Oderfeld (Poland), Prof. Jack Phillips (Australia), Prof. George Rusanov (Bulgaria), Prof. Wolfgang Rössner (GDR), Prof. Zènò Terplàn (Hungary), Prof. Jammi S. Rao (India), Prof. Giovanni Bianchi (Italy), Prof. Adam Morecki (Poland), Nicolae I. Manolescu (Rumania), Leonard Maunder (UK), Douglas Muster (USA), Ilic Branisky (Yugoslavia), as in Appendix 2.

The foundation of IFToMM during the Second World Congress on TMM in 1969, Fig. 3a), finalized an intense activity of two decades for promoting international collaboration, as documented by letters that are stored in the IFToMM Archive. A first World Congress on TMM was held in 1965 in Varna, Bulgaria during which the foundation of IFToMM and started the Congress series on TMM (todays MMS) as the IFToMM World Congress, Fig. 3 b), Table 1.

The IFToMM community has grown continually and TMM has evolved to approach large engineering science, including even new emerging disciplines. This led in the year 2000 to an update of the name of the IFToMM Federation as IFToMM International Federation for the Promotion of Mechanism and Machine Science to stress a broader mission of the IFToMM community.

IFToMM activity has grown in many aspects, concerning the number of member organizations (from the 13 founder members to the current 48 members), the size and scale of conference events (with many other thematic conferences, at national and international levels, in addition to the MMS World Congress), and the number and focus of technical committees working on specific discipline areas of MMS.

In particular, Presidents and Secretaries General had significant roles in guiding the growth and success of IFToMM. Their personalities are also representative of the IFToMM community in terms of reputation and visibility worldwide. The Presidents were Ivan I. Artobolevsky (1969-1971 and 1972-1975) (USSR), Leonard Maunder (1976-1979) (UK), Bernard Roth (1980-1983) (USA), Giovanni Bianchi (1984-1987 and 1988-1991) (Italy), Adam Morecki (1992-1995) (Poland), Jorge Angeles (1996-1999) (Canada), Kenneth J. Waldron (2000-2003) and 2004-2007) (USA), Marco Ceccarelli (2008-2011) and (2016-2019) (Italy), Yoshihiko Nakamura (2012-2015) (Japan).

Fundamental is the role and the activity of the Executive Council in handling and guiding the business and activities of all the other bodies of IFToMM not only at the EC meetings with participant of other IFToMM officers, Fig.4.

a)

b)

Fig. 3 Group phot at IFToMM World Congress: a) in 1969 in Zakopane at foundation; b) in 2015 in Taipei.

The first generation (1960-1975), Fig. 2 and Appendix 1, was characterized by efforts in starting of the activities of the Federation making clear its mission, with great hopes for future success. Most of the activity were considered and experienced for the future of IFToMM. Several new initiatives were started like regular meetings and conferences as shown in Fig.2. Several EC meetings discussed long agendas with many details in even one-week of duration, as indicated in the reports that are stored in the IFToMM Archives. Significant in 1972 is the organization of the series of Romansy, CISM-IFToMM Symposium on Theory and Practice of Robots and Manipulators as the first conference event on Robotics in the world, SYROM, IFToMM International Symposium on Linkages and Computer Aided Design Methods, and TMM conference in Liberez as a continental conference. Those conference series are still very successful IFToMM events. The Journal of Mechanisms by Elsevier was affiliated to IFToMM in 1972 and was renamed as Mechanism and Machine Theory to link it clearly to IFToMM. Several textbooks were published with titles recalling TMM or even with the name Theory of Mechanisms, in several languages around the world. Those books formed a rich literature that is today of reference for teaching, design, and research in MMS. Main topics of attention were related to Mechanisms Design in aspects for Kinematics, Synthesis, Machine Dynamics, and Robotics both as emerging fields for mechanism applications and development of new integrated multi-discipline systems.

a)

b)

c)

Fig. 4 Examples of participation at EC meetings: a) at Sousse, Tunisia, in 2010; b) at Guanajuato, Mexico in 2011; c) discussion at Krakow, Poland, in 2016

Most of the efforts of the first generation of IFToMMists were also directed to advertising the just established federation and attracting new member organizations

and more individuals for new initiatives. Most of the first IFToMMists were active in IFToMM for several decades and up to their last days.

The activity of the second generation (1976-1995) is characterized by activity with a similar enthusiasm and vision to enlarge the interests and participation to the federation like by the founders with whom those IFToMMists were linked. The initiatives were enlarged both in number and participation. Other international conferences were started within the activity of the start of several TCs, like TC for computational kinematics in 1991, TC for gearing in 1976, TC for human-machine systems in 1986, TC for Mechatronic in 1994, TC for Micromachines in 1994 and TC for Rotordynamics in 1977. The participation in WCs grows continuously: one with the highest number of papers was the event in Milan in 1995 and one of the most socially participated ones was the one in Seville in 1987, Fig.3b).

The third generation (1996-2011) is characterized by a worldwide presence of the community with 48 MOs in IFToMM in 2003. This growth is reflected both in renewed and revitalized activities for the already existing TCs and PCs that have culminated in a period of relevant results in the 2008-2011 term. One characteristic operation of the third generation was an extensive use of informatics means as typical of Information Age. New TCs were established in new areas of MMS, like TC for Biomechanical Engineering and TC for Energy Sustainable Systems in 2010, and a TC on Gearing and Transmissions has been re-established with a reinvigorated group of colleagues. At the end of the period of the third generation IFToMM reaches a modern location with significant influence in the world community of engineering as consequence of clear understanding and visibility of IFToMM activities. The last decade of the period was characterized by an increase of activity and correspondingly an increase of visibility, so that most of conference initiatives, mainly under MO local organization, were stimulated to be explicitly under the IFToMM umbrella.

The history of IFToMM is also outlined in a poster exhibition during the IFToMM 2019 World Congress in Krakow, Poland (see Appendix 2 and 3).

4 Challenges for today and tomorrow

The past of IFToMM activity can also be understood as inspiration for the future developments of IFToMM not only in the well-established aspects but even to identify new horizons, needs and benefits for the IFToMM community in promoting and enhancing MMS.

The main challenges for IFToMM can be summarized in the following aspects, as coming from my experiences in the IFToMM leadership and as IFToMMist Fig. 5:

- Attraction and interest of young generation to IFToMM and its activity
- Aggregation and activity of more MOs from all continents
- Enlargements of the domains of interests, with more interdisciplinary activity, in research, formation and profession in MMS
- Start collaboration with other federations and communities, not only in engineering
- Improvement and increase of the benefits being in IFToMM for the communities and IFToMMist individuals

- To increase visibility and influence of IFToMM in scientific, professional, industrial frames at national and international levels
- To increase interest and quality of leadership in IFToMM
- To improve the participation and share of IFToMM initiatives and challenges not only within the IFToMM bodies but even with individual IFToMMists

Even if the above aspects can be well understood as challenges and plans for future activities in IFToMM leadership and MMS activities, the practical implementation of solutions and initiatives as specific issues for short-medium schedules requires flexibility in the actions as to try to satisfy all the expectations from the variety of conditions and communities which IFToMM is characterized by as coming from a world community with different cultural backgrounds. One key point is the understanding and appreciation of the benefits that IFToMM can offer or can start with a view for all IFToMM community avoiding that those benefits can be either impossible to reach or even to be considered constrains for the personal promotion. An emblematic example of such not yet common situations is in the area of publications where in some countries there is a need or even obligation to have indexed publications in well scored publication frames both for career promotion and project funding, where as in other community is already asked to have the dissemination of knowledge and results available and free for the public and not linked to those indexed frames. Therefore, although on of the mission of IFToMM is to guide towards the future for new publication frames, IFToMM should provide yet the possibilities to communities and individuals all the variety of conditions for their promotion, impact, and influence with their publications.

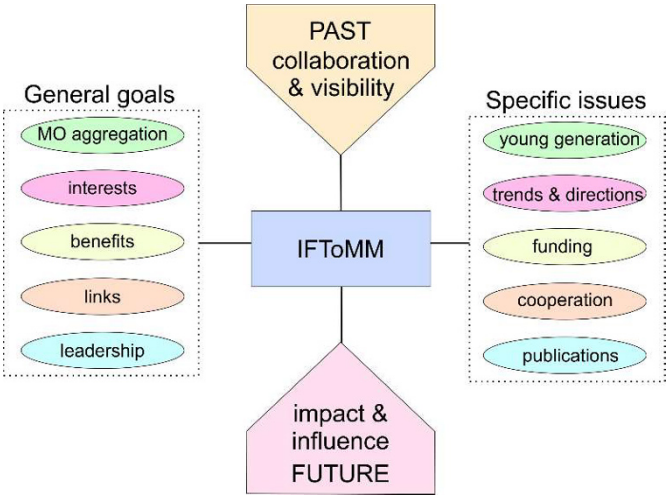

Fig. 5. Issues for IFToMM from past achievements to future challenges

One another general issue with specific impact on IFToMM even in short time is the feeling in the new generations that an aggregation in societies or entities with

common interests and targets is not useful and the fragmentation in individuals or in small groups, even only in social media, seem to give the proper sufficient benefits that young people is looking for with short horizon. This seems to happen also for the IFToMM community as also motivated by both ignorance and not-understanding the motivations and mission of IFToMM and by limited or not properly attractive benefits of being involved in IFToMM. These two last aspects can reflect also the considerably variability of situations in which IFToMM will have to act in the future.

5 Conclusions

IFToMM was founded in 1969 to overpass political barriers preventing collaboration and friendly exchanges with a vision of MMS as a means for peace and mankind development. Today the activities of 48 Member Organizations and 15 Technical Committees show a significant role of IFToMM community in scientific-technological developments in the broad areas of MMS in terms of formation, research, and application for the benefit of mankind society. New trends and innovations are the challenges facing the future of IFToMM like in the past with a fourth generation of IFToMMists working in international collaboration frames for the developments of modern (mechatronic) systems for which mechanics is still the core of activity as per the nature of the service and/or cooperation with humans.

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Appendix 1 - List of posters exhibited during the IFToMM 2019 World Congress in Krakow, Poland

1. Video of the 1969 funding act
2. Iftomm officers (from IFToMM webpage)
3. What is IFToMM? (from IFToMM webpage)
4. IFToMM History (from IFToMM webpage)
5. IFToMM Founding fathers
6. IFToMM sponsored conferences
7. IFToMM awards and Honors
8. Activity of IFToMM Executive Council
9. SIOMMS IFToMM Student Olympiad
10. All WCs
11. WC 1987 in Seville
12. WC 1995 in Milan
13. WC 2004 in Tianjin
14. WC 2007 in Besancon
15. WC 2011 in Guanajuato
16. WC 2015 in Taipei
17. IFToMM flyer

Appendix 2 – Poster of the founding fathers of IFToMM at 2019 WC

Appendix 3 – program of the IFToMM 50 anniversary Ceremony

IFToMM Celebration session: July 1, 2019 from 9.30 to 12,30
9.00- 9.30 opening of IFToMM world congress
9.30-9.35 Welcome for anniversary celebrations
by IFToMM President, Prof Marco Ceccarelli
9.35- 9.50 Congratulations
by Polish Ministry, President of Polish Academy of Science
9.50- 10.20 Keynote of current IFToMM President Prof Marco Ceccarelli
IFToMM: yesterday, today, and tomorrow
10.20-10.40 Speech of past IFToMM President, prof Bernard Roth
The Forming of International and Personal Connections Through IFToMM in Spite of a Turbulent World
10.40-11.05 Speech of past IFToMM President, prof Jorge Angeles
The Existential Question of IFToMM in the 21st Century
11.05-10.30 Speech of past IFToMM President, prof Ken Waldron
Intersections between my career and IFToMM
11.30-10.55 Speech of past IFToMM President, prof Yoshi Nakamura
Let me think about the gap between IFToMM globalism and the economic globalism
12.00-12.30 Technical keynote by Prof. Herman van der Auwearer from Siemens
Digital Twin: from concept to value creation across the product lifecycle.
12.30 -12.40 Reveal of the anniversary plaque in congress hall
(with singing the IFToMM hymn in English and Russian)
12.40- 13.00 Champagne in the congress hall

Exhibition pf poster and video on the History of IFToMM at the hall of the Congress Venue.

The Existential Question of IFToMM in the 21st Century

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http://www.cim.mcgill.ca/∼rmsl/

IFToMM, the *International Federation for the Theory of Machines and Mechanisms*, was created in 1969 as a forum that would allow the exchange of research results in the area of machines and mechanisms. This occurred at the peak of the cold war years, during which researchers from the West and their counter-parts from the East were separated by the infamous *Iron Curtain*. Let it not be forgotten that the Iron Curtain was born at the end of the Second World War, in 1945. As the old saying goes, "All things come to one end", the "curtain" came to an end in 1991, given that the spirit of IFToMM, since its birth, is to remain apolitical, I will do my best to respect this spirit, while recalling historical facts that nobody can contest.

IFToMM's birth certificate states that the federation was born in Zakopane, Poland, on September 29, 1969 during the *Second World Congress on TMM (Theory of Mechanisms and Machines)*. In the years that followed, IFToMM played a key role in bringing together, through its world congresses and its symposia, researchers from affiliated and non-affiliated communities, East and West.

With the end of the Iron Curtain, citizens of countries in the East and the West were no longer separated, which *de facto* brought about the question of the very existence of IFToMM. However, right afterwards, everybody in IFToMM looked at the new world order as something positive for IFToMM, since it would allow the unimpeded traffic of people across boundaries of all color. Alas, not all was rosy for IFToMM. During my tenure as IFToMM President, I chaired over issues unforeseen at the moment of the creation of the federation. Chairs of *member organizations* (MOs), as we decided to call the IFToMM-affiliated committees of various geographical entities, were reporting the hardship experienced by their committees in seeking financial support from both governments and industry. Various MO

chairs would complain that the "T" word (theory) in the name of the federation would make industry turn away from the activities of their committees.

The ensuing discussions, both at the meetings of the Executive Council and within MOs, led to the scrutiny of where the "T" word had come from. It soon was recognized that, as a strong participant in the creation of IFToMM, the USSR Committee exerted a significant inuence in the coining of the name. In Russian, the word "Theoriya" carries not only the meaning of "theory" in English, but also that of science, discipline or area of study. In fact, the name given to our multidiscipline in Russian can be literally translated as "theory of machines and mechanisms," with text books, monographs and periodical publications carrying this term in their title. The discussions thus culminated with the adoption of a new name for the federation. In 1999, the Executive Council decided to recognize the changing role of the organization in international collaboration and approved a new name: *The International Federation for the Promotion of Mechanism and Machine Science*. Here we borrowed the "S" word from its use in our sister multidiscipline, *Computer Science*. However, on advice of the Executive Council *IFToMM* kept this abbreviation, along with the logo, as these were already widely known.

Twenty years after the adoption of the new name, the future of the federation is not secured, yet mechanisms and mechanical systems in general have become highly sophisticated and pervasive in our daily lives, mainly in the form of robotic devices. On the other hand, the classical methods of solution of the problems of analysis, design and control of machines and mechanisms, based on deterministic numerical and symbolic algorithms, are now being replaced by heuristics. The latter are highly demanding in terms of computing resources, but their application to the solution of design and control problems has been possible by virtue of the ever-growing computer power available literally at our fingertips.

Whether heuristic are "better" than deterministic methods, only time will tell. In my own personal opinion, the popularity of the former over the latter comes from the modest demands on fundamental knowledge (system theory, dynamic programming and numerical analysis, among others). In the long run, if heuristic methods overcome their deterministic counterparts that knowledge may be lost, with unpredictable consequences for the technological development.

We can thus identify challenges coming from two fronts, from outside the IFToMM community and from within. On the outside we have a growing demand for performance and affordability of the consumer and production goods, whose design and control cannot possibly be accomplished with the sole application of the classical disciplines of mechanism and machine science (MMS)—geometry, kinematics, dynamics, continuum mechanics and control. Mastery of, or, at least, familiarity with multidisciplines like system theory and algorithmics are becoming a must.

From within, the classical TMM disciplines should be enriched with interdisciplinarity. By looking at the list of IFToMM technical committees, all areas of modern technology are already covered if, sometimes with self-imposed limited scope judging for their names. For example, the scope of "micromachines" is nowadays better described by MEMS and, even NEMS.

To conclude, I surmise that the IFToMM role in the current world community cannot be more relevant. To face the current technological challenges, we need to think “outside of the box,” i.e., beyond the classical disciplines of TMM, with the aim of enriching our multidiscipline to be better prepared to face the current challenges and those to come.

IFToMM 50th Anniversary 2019

Prof. J.S. Rao, IFToMM Founding Member
President, The Vibration Institute of India, Bangalore

It was 50 years ago in summer 1969; Varna, Bulgaria hosted a meeting led by Prof. Konstantinov in the wake of still prevailing cold war politics to form IFToMM for promoting the fundamental subject of Mechanism and Machine Science. Several nations were sent the invitations and Prof. Belgaumkar the first Indian Head of Mechanical Engineering in Indian Institute of Technology, Kharagpur was one of them. At his behest I was invited by Prof. Konstantinov and Prof. William Carnegie from University of Surrey sent me to Varna.

I immediately became a darling of several stalwarts in this field, to name a few, Prof. Artobolevski, Prof. Crossley, Prof. Meyer Zur Capellen, Prof. George Sandor, Prof. Bessanov, Prof. Luck, Prof. Boegelsack, Prof. Oderfeld, Prof. Bianchi, and Prof. Morecki amongst others. It has been great moving with them and learnt a lot about not only engineering but several other prevailing the-then politics. I didn't realize that I am participating in the draft preparation of IFToMM constitution until half the time of Varna meeting. This has been one of my learning curves that stood so long a time till today.

Besides IFToMM history, I first learnt simplicity in life and organization from Prof. Konstantinov; he made sure through several interpreters and theaters in Sofia, to catch a train leaving for Varna in the next few minutes. He then received me in Varna repairing underneath his car to transport me to Varna Beach resort from the station.

It was a great treat for me from Prof. Oderfeld, Morecki and others in Zakopane to run the sessions of formation of IFToMM before officially handing it over to Prof. Artobolevski and Crossley. I have to put on record here that my teacher, guide and philosopher Prof. Belgaumkar made me the chief delegate and give me the honor of signing the IFToMM constitution, true to the clan of great *Guru* and thinker of India.

I should also mention of Prof. de Pater from Delft with whom I shared the room in Zakopane. He took me to the border with Czechoslovakia and explained to me like a father on the II World War (I was a child then) that resulted in the Cold War era. When I raised the topic of *Zindobre*, he laughed at me saying that the waiter is greeting me *Good-day* not telling his name. He mentioned that *jesro* will be a new word in Poland meaning *good day.* He took me to Delft University to give a seminar on *Energy Methods* and also took me home for a dinner. This has been the greatest moments of my life. He then tried to make me meet my idol Prof. Biezeno and unfortunately his nurse has prohibited that day to see him as he was unwell.

My friend Prof. Bernard Roth (past President of IFToMM) took me to Prof. Timoshenko's room in Stanford, where I spent some time remembering a stalwart who initiated Engineering as we know.

Finally, I am thankful to Prof. Marco Ceccarelli who helped in my long term wish of renaming *Advances in Vibration Engineering* (2002) to *Journal of Vibration Engineering and Technology* (2014) and recognizing it as an IFToMM family of journals and then also help in co-publishing it as a Springer Journal since 2018. Let us see another 50 years and a centenary of IFToMM.

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