

Mechanisms and Machine Science

Jaroslav Beran
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Petr Žabka *Editors*

Advances in Mechanism Design III

Proceedings of TMM 2020




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Mechanisms and Machine Science

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Miroslav Václavík · Petr Žabka
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Preface

The International Conference on the Theory of Machines and Mechanisms has been held since 1973 in regular four-year intervals. The expert agenda of the conference focuses on a wide range of problems, including theoretical and practical findings related to theories pertaining to machines and mechanisms. The person involved in the creation of this conference was an important personality and leading expert in mechanics and mechanism theories doc. Ing. Jaroslav Charvát, CSc. He was not only a renowned expert regarding mechanism theories, but he was also an excellent teacher and promoter of mechanics for the professional and lay public. He impressed students with his lectures and boosted their enthusiasm for the study field. His scientific and research activities were focused to a great extent on the mechanisms of textile machines. He regularly contributed to expert magazines. He was the author of many monographs and scripts, and he actively attended conferences and seminars. He was responsible to a significant extent for the development of young technical intelligence and contributed to the development of the field of textile machine mechanics.

The 13th International Conference on the Theory of Machines and Mechanisms was held from September 7–9, 2021, at the Technical University of Liberec, Liberec, Czech Republic. The conference was organized under the auspices of the Czech National Committee for Theories of Machines and Mechanisms IFToMM, the Czech Society for Mechanics and the VUTS a.s. The lectures focused particularly on the areas of analysis, synthesis of linkages, cam, planar and spatial mechanisms.

A major part included a focus on problems related to the dynamics of machines and mechanisms as well as mechatronic and biomechanical systems. Robotic systems were another major focus of the conference.

In this book, contributions from the conference have been included into five main sections.

- General theory of machines and mechanisms, analysis and synthesis of planar and spatial mechanisms, linkages and cams.

- Dynamics of machines and mechanisms, computational mechanics, rotor dynamics, biomechanics, vibration and noise in machines.
- Robots and manipulators.
- Mechatronics, control and monitoring systems of machines, accuracy and reliability of machines and mechanisms
- The mechanisms of textile machines, optimization of mechanisms and machines.

As it has for more than 48 years, this volume of proceedings offers both a broad perspective on the state of the art in the field and an in-depth look at its leading-edge research. It is our privilege to be able to offer this collection and we express our sincere thanks to the contributing authors for making this series a continuing success.

We appreciate the interest in this conference and believe it will bring many suggestions for further extension of knowledge in the field of machines and mechanisms theory and will provide new ideas for international cooperation in this field.

Jaroslav Beran

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**General Theory of Machines
and Mechanisms, Analysis and Synthesis
of Planar and Spatial Mechanisms,
Linkages and Cams**



Experiences in Leadership IFToMM: Achievements and Challenges

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Abstract. The paper presents a recent history of IFToMM from personal experiences in leadership positions of IFToMM bodies during the last twenty years. A community is characterized by its activities, but also by the leaders guiding /super-*vising*/stimulating it. The peculiarities of IFToMM mission are discussed with the challenges attached during leadership positions up to reach results indicating new goals and trends in MMS developments, without ignoring open issues for future attention. In the last years it is possible to recognize an evolution of IFToMM community with activities with more multidisciplinary aspects enforcing also the international collaborations. Limits are experienced in the organization structure that has not always been able to react properly and in due time. Based on the past experiences a challenging future of IFToMM is also outlined with main targets to be worked out by next leaders and whole IFToMM community.

Keywords: History of IFToMM · History of MMS · IFToMM leaderships · IFToMM Presidents · Marco Ceccarelli

1 Introduction

A scientific community is generally recognized in the history of the community's evolution [1], but also by the personality of its leaders within the professional and scientific evolution of the leaders with their activities in addressing the challenges for the community and in achieving planned objectives.

Significance of IFToMM can be stressed by its history and the challenges that have been successfully experienced 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 and benefits in the society [1–7].

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 [2–4]. IFToMM as federation is an aggregation of national/territory communities of scientists and engineers working in MMS with a vision a world community servicing for the welfare of the mankind [5, 7, 8]. 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 [9].

This work aims to summarize the author's experiences within the IFToMM international community in his leadership activity with a gradual evolution from a simple congress participant up to reaching the maximum representative authority of president, as partially presented in [10]. The paper presents the challenges that the author has faced especially in leadership positions and the results achieved by not renouncing to indicate the aspects still to be addressed and which can be considered future challenges for the next generations of the IFToMM community, as reported in IFToMM documents like [11–15]. The work therefore presents a historical survey regarding the author's experiences but with a perspective referring to the historical development in the IFToMM community with its peculiarities as an international community present in all continents within a wide spectrum of disciplines that are synthetically grouped in the domain of Mechanism and Machine Science with aspects of theory, training, design, research, and application.

2 A Timeline of History of IFToMM

My life in IFToMM frames started with a participation at the 1985 CNIM national Spanish conference in Gijon, at the 1987 IFToMM World Congress in Seville and then at SYROM in 1989 organized by prof Manolescu, who showed me enthusiasm in IFToMM confirming the passion that prof Vinciguerra transmitted me during my PhD formation [10]. A timeline of my experience in IFToMM is shown in Fig. 1 within a historical outline of IFToMM with main events [9].

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). 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 [8] as: 'To promote research and development in the field of Machines and Mechanisms by theoretical and experimental methods, along with their practical application'. The bodies of IFToMM of IFToMM as per the Constitution are General Assembly (GA), Executive Council (EC), 3 Commissions of the General Assembly (GACs), 14 Technical Committees (TCs), and 4 Permanent Commissions (PCs). 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, Main conference event is the World Congress (WC) and main student-oriented event is the Student International Olympiad on MMS (SIOMMS).

The history of IFToMM has been outlined from several perspectives mainly by the past IFToMM Presidents, as in the reports [3–6], very often with an eye to future trends

[9]. The history of IFToMM was also outlined in a poster exhibition during the IFToMM 2019 World Congress in Krakow, Poland, celebrating the 50th anniversary of IFToMM. The History of IFToMM can be outlined looking at the generation that can be identified as follows, Fig. 1:

- 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 Leonard 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 Alberto Rovetta 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
- 2012 – today: Fourth Generation with educated people in local MMS frames that are linked to IFToMM and within IFToMM activity with 44 organizations as IFToMM member organizations.

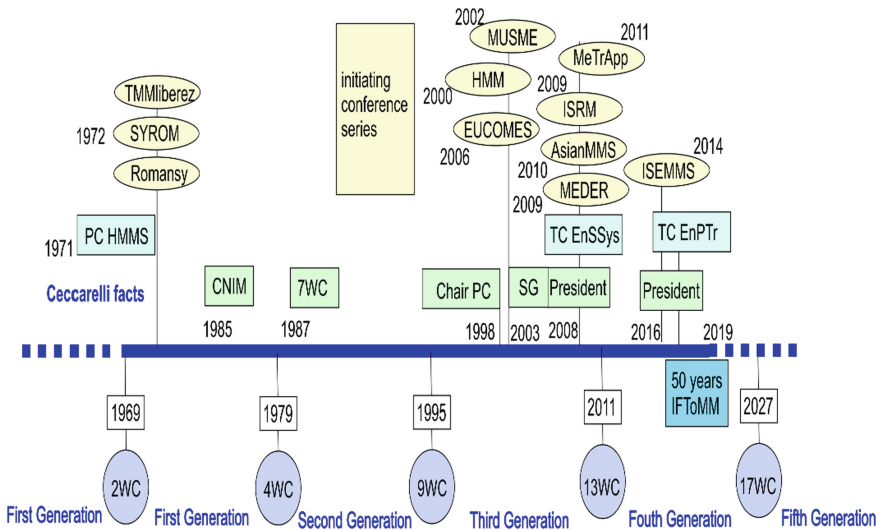


Fig. 1. A historical timeline of IFToMM with Ceccarelli experiences in light-green rectangles, starting dates of PCs-TCs in light-blue rectangles and main IFToMM conferences in light-yellow ellipses

The IFToMM community has grown continually and TMM has evolved to include even new emerging discipline leading 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 [7]. 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), and today Andres Kecskeméthy (Germany).

The first generation (1960–1975) was characterized by efforts in starting and advertising the activities of the new Federation making clear its mission, with great hopes for future success. Several EC meetings discussed long agendas with many details in even one-week of duration with reports that are stored in the IFToMM Archives. Significant in 1972 is the start of the conference 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 Liberec 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. 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) was characterized by activity with a similar enthusiasm and vision as being the pupils the first generation to enlarge the interests and participation to the federation. The initiatives were enlarged both in number and participation. Other international conferences were started with several TCs, like TC for Computational Kinematics in 1991, TC for Gearing in 1976, C for Rotordynamics in 1977, TC for Human-Machine Systems in 1986, TC for Mechatronics in 1994, and TC for Micromachines in 1994. The participation in WCs grew continuously and 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.

The third generation (1996–2011) was 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.

The Fourth generation (2012 – today) is characterized by an intense international activity with collaboration in teaching, research and technological transfer of MMS results with challenging trends in confirming the significance of traditional subjects in emerging mechatronic approaches for new and update solutions of systems with less and less mechanical parts.

The next Fifth generation is expected with interests and no barriers in looking and developing systems that, although with more and more aspects in non-mechanical traditional aspects, will be conceived with innovations but still for helps and benefits of human users, thanks still to solutions from MMS.

3 Leadership Experiences

The author's leadership experience can be summarized in the following periods with the relative roles, Fig. 1:

- 1998–2004: chairman of the permanent committee for history of MMS [11, 16]
- 2004–2007: IFToMM general secretary [12]
- 2008–2011 and 2016–2019: IFToMM president [13, 14]
- 2012–2015 and 2020–2023: chairman of IFToMM nominating committee as past president

The leadership activity has been carried out by interaction with individuals (IFToM-Mists or not) through initiatives with achievements and challenges that are presented in the following short accounts whereas details are available in the reports [11–15].

The activities of Chair of the PC for History of MMS were centered on a program agreed also with the previous Chair Professor Teun Koetsier to increase the number of members of the commission and to develop an activity related to the analysis of the history of technological and cultural development of machines from a technical point of view by MMS researchers in the IFToMM fields. The main effort in the early years of chairmanship was to recruit new members for the commission with the indication of sharing and developing a vision of the history of machines from a specifically technical point of view in the sense of understanding and interpreting the historical developments of the machines from a technical point of view even if endured from a cultural point of view typical of the history of science and technology. These activities have given rise to a rapid growth of the PC also following a periodic meeting activity between the members which began at the beginning of 1998 with only four people and with 48 members at the beginning of 2004, as shown in the example in Fig. 2. Figure 3 briefly shows the result of the activities of increased interest in historical analysis from a technical-scientific point of view with the start of the HMM symposium in 2000 which also produced conference proceedings with publication for international dissemination and a more informal meeting with the HMMS workshop to facilitate collaboration and the beginning of collaboration between the members of the commission. Figure 4 emphasizes the results of these activities even after the period of chairmanship with the periodic organization of the HMM symposium and the corresponding publication of the proceedings, [18], which then have also determined the beginning of the Springer book series on the history of machines (<http://www.springer.com/series/7481>) as well as the beginning of an encyclopedia of distinguished figures in MMS, Fig. 4a) and finally the success of being able to obtain an adequate number of works from which to extract also Journal special issues such as the recent one reported in Fig. 4b).

In summary, the period of the chairmanship of the PC was characterized by an intense activity of initiatives to attract the attention of people interested in the historical developments of the machinery of mechanisms in all its aspects referring to both inventors and inventions as well as theoretical works and to the schools that led to the development of MMS. Although this activity was essentially of leadership, it also had aspects of sharing especially with the past chair prof Koetsier and collaboration with all the members of

the PC who from time to time were recruited by sharing programs, expectations and initiatives as obtained also in the following years after chairmanship thanks to a continuous collaboration with the next chairs of the commission that still characterizes the success of the PC, despite the diminished interest on the past by the new generations.



Fig. 2. Examples of leadership activity as Chair of PC for History of MMS in chairing PC meeting in 2004.



Fig. 3. Examples of leadership activity as Chair of PC for History of MMS in conference initiative HMM symposium series since 2000 [17]

As Secretary General during 2004–07, [12], the activity has been focused in dealing with the handling of IFToMM business in coordination with the President, prof. Kenneth Waldron referring mainly to:

- forwarding information on IFToMM activity and stimulating opinion exchanges among IFToMM officers and with contributions of IFToMMists



Fig. 4. Examples of later achievements following leadership activity as Chair of PC for History of MMS in publications initiatives: a) volumes on Distinguished Figures in MMS [19]; b) a special journal issue [20].

- assisting and collecting information for EC meeting, Fig. 5a), and GA and preparing minutes for distribution and archiving in the reinforce IFToMM archive
- working to finalize the actions that have been decided at EC meetings
- updating information on the organization of IFToMM MOs for a correct visibility of the Federation nature of IFToMM
- asking nominations for representatives of IFToMM MOs in the PCs and TCs
- contributing in the IFToMM Taskforce for Journals for plans of better publications frames with correct liaisons
- collecting material for IFToMM Archive
- contributing in IFToMM Working Group for a campaign of information with proposals on posters and flyer, Fig. 5b) [21], and on improve of the clarity of the IFToMM webpage
- cooperating for regular payment of annual fee from IFToMM MOs
- working out email postal ballots in EC on matters identified with the President
- promoting actions for new IFToMM MOs
- representing IFToMM in conference events and meetings with presentations on general MMS topics and IFToMM mission.

During the term 2008–2011 the presidency activity has been focused on guiding IFToMM activity within president planned candidature program for Visibility-Activity of IFToMM by also improving the functioning of the IFToMM bodies. The Visibility-Activity plan has been intended to increase the visibility of IFToMM and its activity



a)

<p>How IFToMM can be reached</p> <ul style="list-style-type: none"> • Through your local Member Organization, to become active in IFToMM • Through an IFToMM Technical Committee Chairperson, to participate in a specific activity • Through the IFToMM Executive Council • Through the IFToMM Secretary General: Prof. Marco Ceccarelli, LARM: Lab. of Robotics and Mechatronics DiMSAT, University of Cassino, Via Di Biasio 43, 03043 Cassino (Fr), Italy <p>IFToMM Presidents at a meeting in 2000</p> <p>From left to right (the years in brackets indicate the terms of the Presidents' mandates): Giovanni Bianchi (1984-1987 and 1988-1991), Arcady Bessonov in substitution of Ivan I. Aronbolevsky (1969-1971 and 1972-1975), Bernard Roth (1980-1983), Jorge Angeles (1996-1999), Kenneth J. Waldron (2000-2003 and 2004-2007), Leonard Maunder (1976-1979), Adam Morecki (1992-1995), and Marco Ceccarelli (IFToMM Secretary General 2004-2007).</p>	<p>Main activities of IFToMM</p> <ul style="list-style-type: none"> • 47 IFToMM Members of territory and national Organizations • 13 Technical Committees: Computational Kinematics Dynamics of Multibody Systems Gearing Human-Machine Systems Linkages and Cams Mechatronics Micromachines Nonlinear Oscillations Reliability Robotics Rotor dynamics Transportation Machinery Tribology • 5 Permanent Commissions: Communications Education History of MMS Publications Standardization of Terminology • 3 Journals: J. of Gearing and Transmissions Problems of Applied Mechanics Electronic Journal of CK • 1 affiliated Journal: Mechanism and Machine Theory • A World Congress every 4 years 	<p>IFToMM <i>International Federation for the Promotion of Mechanism and Machine Science</i></p> <p>The mission of IFToMM is stated as in Article 2.1 of IFToMM Constitution:</p> <p>To promote research and development in the field of Machines and Mechanisms by theoretical and experimental methods, along with their practical application</p> <p>IFToMM webpage: http://www.iftoimm.org</p> <p>-December 2006</p>
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b)

Fig. 5. Examples of leadership activity as IFToMM Secretary General: a) assisting EC meeting in 2005; b) (first) IFToMM flyer in 2006 [21]

by promoting new and existing activities with an explicit mention of IFToMM and to facilitate new and existing initiatives under the umbrella of IFToMM.

During the term 2008–2011, results are achieved in increasing main aspects of meetings, exchanges, publications, teaching, and international collaborations, as prescribed for the mission of IFToMM in the IFToMM constitution.

New significant initiatives were the start of SIOMMS: IFToMM Olympiad of MMS (thanks to the late prof Veniamin Goldfarb) and affiliation of more journals and book series on MMS. Functioning of the IFToMM has been improved with better functioning the Executive Council also through specific activity of newly established EC Working

Groups in attaching specific matters with active role of EC members. New MOs have been accepted from Turkey, Portugal, Egypt, Denmark, after preliminary negotiations for proper candidature submissions reaching 48 MOs with presence in all continents.

A new TC has been started on Sustainable Energy Systems and a TC on Gearing and Transmissions has been re-established with a reinvigorated group of colleagues, although still few TCs were with a weak activity. Particular mention for a continuous dedication to IFToMM is deserved to the Secretary General late prof. Carlos Lopez-Cajùn, the Treasurer Joseph Rooney, but also to late prof. Veniamin Goldfarb working continuously also thanks to telemeetings that have been started in 2010. The important new means of EC work has been successfully experienced with Working Groups (WGs) following procedures in new-established EC regulations. The 40-th year anniversary of IFToMM was organized and celebrated with a ceremony in foundation city Zakopane, Poland.

The second Presidency period in 2016–19 addressed attention not only referring to the plans as proposed in the candidature in terms of Visibility-Activity-Benefits but also problems and trends that were brought to the attention to the President and EC during this term, even coming from the previous terms. In particular, one of the essential services as President has been spent with almost a diary dedication in planning, coordinating, soliciting, summarizing, email exchanges and communications, and chairing problem discussions and solution proposals with indications coming not only within the EC but also from the IFToMM community, even at the level of individual IFToMMists. A measure of this dedication (also for most of the EC members) can be indicated by the number of EC tele-meetings and face-to-face meetings (in total 16) that have been worked out during the term with a plan to have EC discussions every three-four months and the number of Working Groups (WGs) (in total 21) that were established to attach specific problems to have well studied proposals for the EC also in EC tele-meetings. Special care and time have been devoted to assist IFToMM Member Organizations (MOs), Technical Committees (TCs), and Permanent Commissions (PCs) in critical situation (with weak activity and irregular status).

Matters for Activity were discussed to increase the quantity and quality of the initiatives for the IFToMM aim of promoting MMS in technological-scientific frames for the benefits of mankind and peace (as per the 1969 founding principles still valid).

Results were obtained in reinvigorated action of TC/PC also with increased TC/PC members representing MOs; start of a new TC on Engines and Powertrains; new IFToMM MOs; new affiliations of publications frames; support (also with presence) to old and new initiatives (conferences, summer schools, Olympiads, meeting); considerations and solutions for better activity and new matters (like procedures for IFToMM functioning as in the Manual for IFToMM procedures, and ethical issues); improved participation of individuals and MOs in IFToMM activity and its planning. Open issues were recognized in coordination of activities to avoid overlapping of time schedule and topics; influent action of EC on IFToMM bodies, influent action of PCs and TCs in the worldwide community; influence and representative of IFToMM in funding programs; coordination with other federations in engineering; efficient response and interaction from IFToMM bodies with respect to EC indications.

Matters for Visibility were attached to make IFToMM well known and well reputed in the scientific community and even in the general public. Results were achieved with increased number of IFToMM events as conferences, meetings, tutorials and schools at local and international levels; improvement of visibility means (webpage, call for papers), preparation of posters and flyers. But it was noted that IFToMM is still unknown in several (scientific and professional) frames and countries; IFToMM is not fully understandable to the young generations; newsletter readability is not accepted; publicity of IFToMM is weak in technical-scientific and public frames.

Matters for Benefits were worked out to increase quantity and quality of benefits for communities (MOs, TCs, PCs) and individuals, especially for young generations; to reinvigorate the Student MMS Olympiad; to identify new benefits of interest and attraction towards IFToMM. Results were obtained in terms of increase of publication frames and conference events with desired aspects and benefits for individuals; reduced fees for conference participation and for publication of papers and proceedings; attention to ethical issues; conference Best paper Awards in 3 categories (research, application, student) and possibly in 3 levels (gold, silver, bronze); establishment of IFToMM fellow grade. However, understanding and planning proper benefits with significant values for young and senior IFToMMists and MOs are not yet at satisfactory levels requiring new and update proper benefits for individuals and MOs; attraction of individuals from professional and industrial worlds; continuous attention to new needs and benefits for the IFToMM community; participation of individuals and TC/PC representatives to WGs.

Figure 6 show examples of President acts during the two presidency terms.

In addition, the President was involved as chair of the Committee for Honors and Awards with activity in increasing interest and visibility of IFToMM awards with establishing BPA and fellow grade; soliciting nominations; chairing the evaluation of the nominees; participating personally at the award ceremonies; working and writing on the updates of the manuals. Several new honorary members were elected thanks to proper nominations and several recipients received Award of Merit and Dedicated Service Award.

As Past President, although still in the EC as member without vote right, the leadership role is influential as reference person for the recent past and experience in handling the IFToMM business, that however not very often is fully exploited, like in the current term. Additionally, as Past president the role of Chair of IFToMM Nominating Committee still requires dedication to IFToMM community in searching and stimulating proper nominations from IFToMMists in the roles of future leaders in the IFToMM bodies, for which is still experienced lack of interest and proper awareness.

Summarizing, the commitment as IFToMM leader in the various roles was to fulfill with the obligations as established by constitution, but also to improve and increase the activities and impact of IFToMM first in its IFToMM community as well as to greater dissemination and influence also in neighboring communities and more generally for public visibility in society, not neglecting to emphasize aspects that, despite having been carefully addressed, have not worked out with expected results and therefore remain as future challenges and targets for future leaders.



a)



b)



c)

Fig. 6. Examples of leadership activity as IFToMM President in chairing: a) EC meeting at Sousse, Tunisia, in 2010; b) EC meeting discussion in 2017; c) General Assembly in Krakow, Poland, in 2019

4 Challenges for Today and Tomorrow

The main challenges for IFToMM can be summarized in Fig. 7 for the following aspects, as coming from my experiences in the IFToMM leadership (as also presented at the 2019 IFToMM GA), [15]:

- Attraction and interest to IFToMM and its activity from young and senior MMS scientists
- Aggregation and activity of more and more MOs from all continents
- Increase of domains of interests, with more interdisciplinary activity
- Collaboration with other federations and communities, not only in engineering
- Improvement of benefits for communities and individuals in IFToMM
- Increase visibility and influence of IFToMM in scientific, professional, industrial frames at national and international levels
- Increase of interest and quality in leadership of IFToMM
- Share of IFToMM initiatives and challenges not only within the IFToMM bodies but even more and more with individual IFToMMists.

Even if the above aspects can be well understood as challenges and plans for future activities by IFToMM leadership in MMS activities, the practical implementation of solutions and initiatives as specific issues for short-medium programs requires flexibility in the leader actions as to try to satisfy all the expectations from a large variety of conditions and communities in IFToMM that is a world community with different cultural backgrounds. One key point is an understanding and appreciation of the benefits that IFToMM can offer or can start avoiding that those benefits can be either impossible to reach for someone or even to be considered constrains or obstacles for personal promotion. An emblematic example of such a benefit differentiation can be considered in the area of publications where in some countries there is a need or even an obligation to have indexed publications in pre-defined publication frames both for career promotion and project funding, whereas in other national communities is already asked to have the dissemination open-source free for the public and not linked to those mentioned indexed frames. Therefore, although a 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 in all kind of frames.

One another general challenge for IFToMM even in short time can be considered in the fact that in general, for the new generations an aggregation in societies or entities with common interests and targets is not felt useful like in the past and the fragmentation in individuals or in small groups, even only in social media, seems to give sufficient benefits for a required short horizon. This seems to happen also towards IFToMM community since both ignorance and not-understanding of the motivations and mission of IFToMM give limited or not properly attractive benefits of being involved in IFToMM. These two last aspects can be reflected also in the considerably variability of situations in which IFToMM will have to act more and more in the future.

A peculiar aspect for aggregations and communities to which the IFToMM community is particularly sensitive, is related to communication and information within the community and mainly from the leaders. It is strategic that the leaders such as especially the IFToMM president, as official representative of IFToMM towards outside of the community, and the members of the EC maintain continuous and constant communication and information with the community through direct channels, as well as with the periodic meetings of the EC, and characteristic ways of IFToMM through the Chairs of

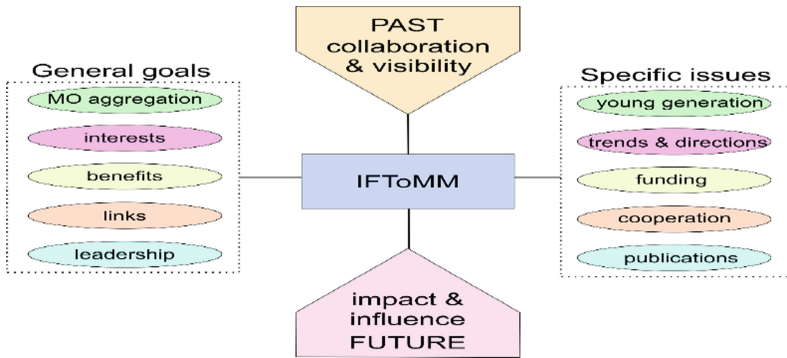


Fig. 7. A summary of issues for IFToMM future challenges

member organizations, not neglecting the possibility of direct contacts with IFToMM individuals.

5 Conclusions

This paper presents a brief historical account of the activity of IFToMM from a personal perspective of the author in his leadership roles that he has lived in the last twenty years allowing not only an analysis of the historical development but also a critical analysis of the evolution of the IFToMM community and its activities. In particular, the positive character of IFToMM is emphasized as a structure that allows an aggregation and collaboration of communities in common interests for research, training, and technology transfer in the broad domain of the science of machines and mechanisms. The author has had the honor and responsibility of contributing to the growth of the IFToMM community over the past 20 years in the role of permanent committee chair, general secretary, president, and then past president.

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Minimization of Shaking Moment in Fully Force Balanced Planar Four-Bar Linkages

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Abstract. This paper deals with a solution of shaking force and shaking moment balancing of planar four-bar linkages. The shaking moment balancing is realized by displacement of the axis of rotation of the counterweight connected with the input link. The conditions for balancing are formulated by the minimization of the root-mean-square value of the shaking moment. This approach is well known. However, the paper describes another of its properties. It is about the choice of the shaking force balancing solution, which significantly affects the minimization of the shaking moment. It is well known that the shaking force in four-bar linkages can be balanced in various ways. The aim of this paper is to show that the choice of the balancing scheme of shaking forces can influence the minimization of shaking moment. To show this difference, two balancing schemes are compared: by two and three counterweights. It is shown that the application of the mentioned balancing technique for minimization of the shaking moment is more efficient for shaking forces balancing by three counterweights. Numerical simulations carried out via ADAMS software illustrate the mentioned observations.

Keywords: Shaking force · Shaking moment · Dynamic balancing · Planar four-bar linkage · Inertia forces · Minimization · Root-mean-square value

1 Introduction

The balancing of mechanisms is a well-known problem in the field of high-speed machinery because the variable dynamic loads cause vibration and noise of the machines. The resolution of this problem consists in the balancing of the shaking force and shaking moment, fully or partially, by internal mass redistribution or by adding auxiliary links [1].

A reliable and simple way to balance shaking forces is to redistribute the mass of the moving links of the mechanism by adding counterweights. It is widespread and quite attractive for industrial applications.

However, balancing of the shaking moment is more challenging and can only be reached by a considerably complicated design of the initial mechanism or by unavoidable increase of the total mass.

R. Berkof [2], Ye and Smith [3], Arakelian and Smith [4], Feng [5] have proposed methods for complete shaking moment balancing by planetary gear trains. Esat and Bahai [6] used a toothed-belt transmission to cancel the shaking moment in four-bar linkages. Kochev [7] proposed to balance shaking moment by a prescribed input speed fluctuation achieved by non-circular gears or by a microprocessor speed-controlled motor.

Moore, Schicho and Gosselin have proposed all possible sets of design parameters for which a planar four-bar linkage is balanced: both shaking force and shaking moment [8]. Briot and Arakelian [9] used this approach for complete shaking force and shaking moment balancing of four-bar linkages.

The complete shaking force and shaking moment balancing of four-bar linkages via copying properties of pantograph systems formed by gears was also considered [10].

A comparison of various shaking moment balancing principles has been carried out by van der Wijk, Herder and Demeulenaere [11]. This overview summarizes, compares and evaluates the existing principles of complete shaking force and shaking moment balancing regarding the addition of mass and the addition of inertia.

As was mentioned above, the complete shaking moment balancing can often be achieved by a considerably complicated design of the initial mechanism and by unavoidable increase of the total mass. This is the reason why methods of partial dynamic balancing of mechanisms have also been developed.

Freudenstein, J.P. Macey, E.R. Maki [12] derive the equations for minimizing any order of combined pitching and yawing moments by counterweighting the driveshaft or a shaft geared to the driveshaft. The equations are given directly as a function of the harmonic coefficients of pitch and yaw and apply to any plane machine configuration. J.L. Wiederrich and B. Roth [13] proposed simple and general conditions for determination of the inertial properties of a four-bar linkage that allow partial momentum balancing. Dresig and Schönfeld [14, 15] examined the optimum balancing conditions for various structural forms of planar six and eight-bar linkages. A last-square theory for the optimization of the shaking moment of fully force-balanced inline four-bar linkages, running at constant input angular velocity, is developed in the studies of J.L. Elliot and D. Tesar [16] and R.S. Haines [17].

V.A. Shchepetilnikov [18] suggested the minimization of the unbalance of shaking moment by transferring the rotation axis of the counterweight mounted on the input crank. In his works the first harmonic of the shaking moment is eliminated by attaching the required input link counterweight, not to the input shaft itself, but to a suitable offset one which rotates with the same angular velocity. This approach is original in that, while maintaining the shaking force balance of the mechanism, it is possible to create an additional moment, reducing thereby the shaking moment. The similar studies have been developed in [19, 20].

This paper represents the further development of shaking moment balancing technique based on the last mentioned principle, i.e. by parallel displacement of the rotation axis of the counterweight mounted on the input crank. The improvement of the known approach resides in the fact that the choice of the scheme of the shaking force balancing essentially influences at the level of the shaking moment minimization.