

Keynote

## **Innovating MMS with IFToMM**

M. Ceccarelli\*  
University of Cassino and South Latium  
Cassino, Italy

**Abstract** – In this paper concepts and activities for creating and transferring innovation are synthetically presented with the aim to stress a significant role of technical contents with a specific emphasis to MMS (Mechanism and Machine Science). Examples are discussed to show past and present challenges in the areas of mechanical systems, including concerns on real novelty of today solutions. In addition, innovation of MMS is highlighted in terms of MMS community that is identified in IFToMM federation, and IFToMM activities are presented as innovation results and aims in knowledge transfer and worldwide coordination.

### **Introduction**

Everywhere is asked for innovation in technological developments.

But what does innovation mean? What does innovation mean in MMS (Mechanism and Machine Science)?

Innovation is a complex activity with multidisciplinary contents that is asked to improve technological developments with practical implementations for benefits both of their producers and users. In the last decades Science achievements have made possible new engineering developments (and vice versa!) in many fields with faster evolutions than in the past. This has produced even competition in developing solutions and innovation has raised to be fundamental for further developments within well structured frames. Those aspects and trends are today discussed and solicited from many viewpoints of innovation multidisciplinary activity and some times some aspects is overestimated as due to specific experience and expertise. A rich literature is available even from each aspect of the innovation activity. References are not included in the paper for its general character and as based on personal experience of the author.

MMS achievements are developed in theoretical, numerical, and design works that once implemented in engineering practice or in science applications they contribute to innovation or even they are innovation themselves. In this paper a synthetic presentation is attempted to clarify innovation mainly as related to technical aspects that are linked to MMS.

### **Understanding Innovation**

In general innovation can be understood as a transfer of knowledge and its applications into market sales. Fig 1a) summarizes the concept of innovation as a multi-disciplinary complex of activities and actors. Innovation is achieved not only with novel ideas but mainly when the knowledge transfer reaches successfully the real world with users' acceptance. This complex of activities includes a variety of skills and when just one is weak or fails, the whole transfer process will fail. Innovation can be started when a technical idea or solution has potential contents. Thus, initiators of innovation are designers or scientists with engineering skills, but in general the main exploiters are business experts or enterprise leaders, who produce the idea at proper levels of market valorisation and users' acceptance. But, not only new solutions make innovation, but very often is the exploitation plan that produce innovation, like for example when a product reaches the

---

\* ceccarelli@unicas.it

market sales with no other competitors. Therefore, the success of innovation requires a full understanding of what can be transferred with enterprise perspectives for market sales toward properly solicited / identified users. Summarizing: Science and Technology are the fundamentals, but Economics and Administration are the motors, and Education and Publicity are final tools of Innovation. University frames can be involved both in fundamentals and final tools when referring to technical contents. Indeed, Education and Formation are essential areas both for conceiving new ideas and preparing users to the acceptance of those new ideas.

Procedures for innovation are proposed from different perspectives but always requiring

- Technical novelty
- Production feasibility
- Operation efficiency
- Market exploitation

Technical aspects are often emphasized as due to design creativity and ingenuity for which patent production is considered the main means both of innovation defence and dissemination.

Understanding innovation can be considered fundamental for producing innovation with well aware plans.

### Innovation in MMS

All the above considerations for understanding innovation can be referred also to MMS when innovative ideas are related to machines and their operations, and users are identified not only in general users but even in stake-holders and technique developers. Thus, the general concept Fig 1 a) can be reshaped as in Fig 1 b) when it refers to the modern concept of service machines that are aimed at helping or servicing human operators in work tasks or diary life.

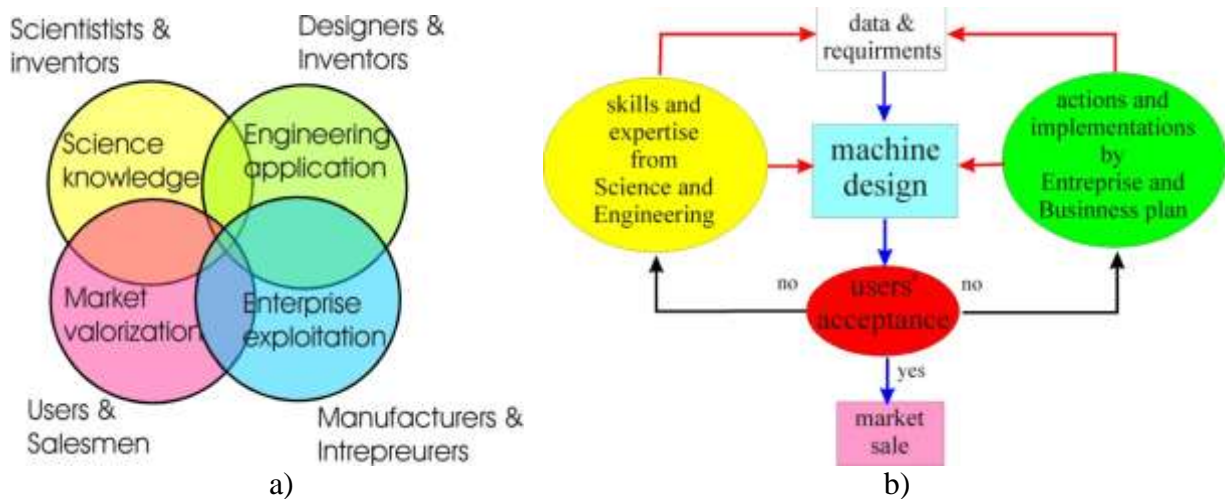


Fig. 1 Conceptual schemes for innovation: a) for a general understanding; b) in MMS areas.

In Fig. 1 b) the traditional engineering process is synthetically indicated in the central block of the diagram as the core of machine developments. But the multidisciplinary aspects can be considered very influential in the design development of machines as coming from the two lateral blocks that summarize all those other aspects that are necessary to have a machine design and an innovation proposal. The peculiarity of MMS areas can be summarized in the above-mentioned concept of service machines by which goals of MMS developments are finalized to improve and/or to solve new or evolved needs in users' activities both in diary life and technological labour.

### Examples of MMS innovative solutions

The following examples in Figs. 2 to 6 can clarify the above aspects of innovation meaning and values in MMS area with an illustrated approach.

The innovation value of achievements and results in MMS is presented through few significant examples in order to stress the variety of innovation forms that MMS can provide in terms of theory and practice of technological developments as well as in terms of knowledge acquisition and formation of next generations.

Fig. 2 refers to the design of today very famous Watt mechanism that was used to increase the efficiency of steam motors thanks to the better accuracy in piston guidance. The success led to wide application of steam motors also in the new machines for transportation and other industrial applications. Technical novelty s related to MMS of the time can be recognized in using coupler curve for motion guiding purposes. This is an emblematic example form the past in which knowledge, expertise, and ingenuity have produced and in innovation in machinery with string impacts not only in technological developments but in social and economic evolutions.

Fig. 3 shows the ABB delta robot whose parallel manipulator architecture is the core of the success in pick & place operations at high speed in manufacturing and assembling operations for industrial and non-industrial applications. In the first case knowledge was acquired with first experiences in industrial object transfer and then it was applied in further developments also in other industrial applications. In the second case theoretical works accumulated experience that has permitted the conceptions of this machine structure in new application areas. In both case the technical values was exalted by business plans and enterprise exploitations also with several versions that were developed even by others.

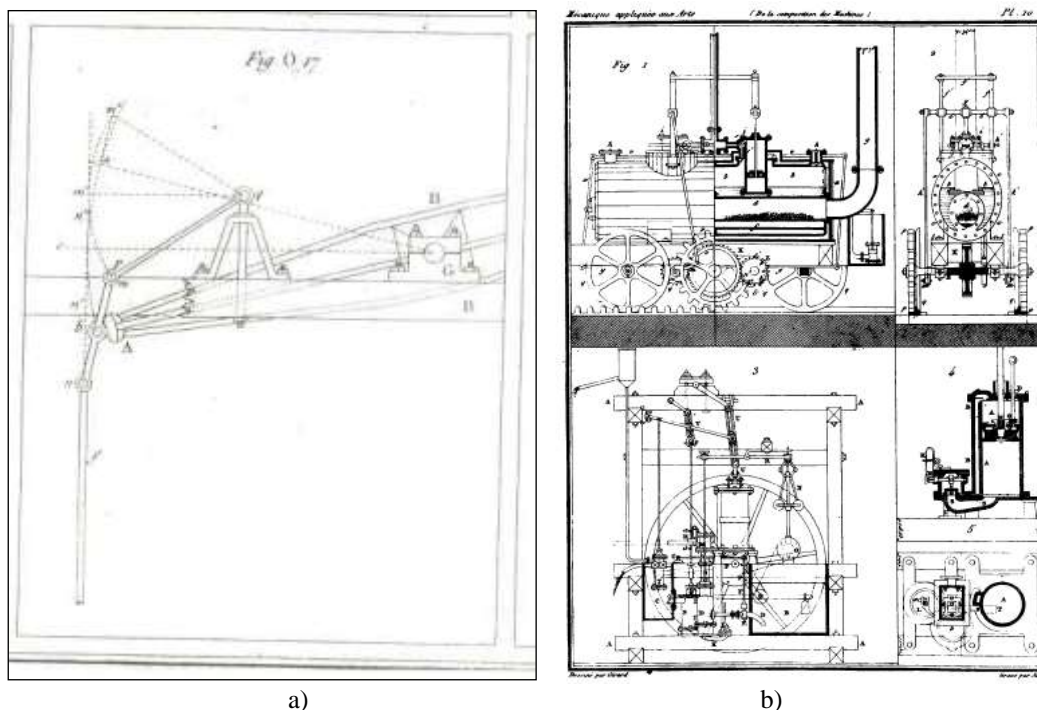


Fig. 2 Past innovation with Watt mechanism: a) early kinematic study of kinematic properties in the book by Lanz and Betancourt in 1808; b) applications for locomotives (top) and industrial plants (bottom) in the book on Composition of Machines by G.A. Borgnis in 1818.

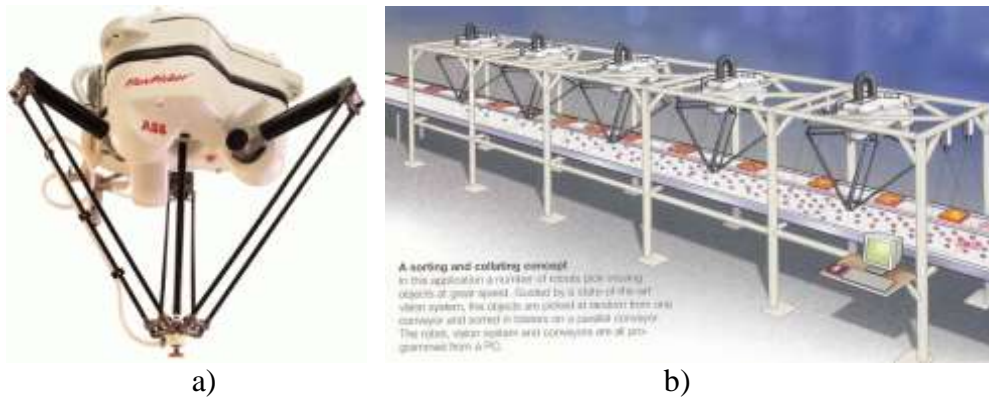


Fig. 3 Delta parallel manipulator: a) the ABB commercialized version; b) industrial application for fast pick & place packaging

While in the past technical contents were prominent in innovations with MMS values, today the commercial exploitation reduces the merit of technical valorisation. Only partially this is limited with patent protections that help to give proper significance to MMS conceptions.

Fig. 4 refers to deployable mechanisms by showing the several solutions of the innovation success. The MMS theory of deployable mechanism is still a topic of intense research activity and new design solutions are continuously conceived with or without practical applications purposes, being an emblematic example of how much a technical achievement can be a complete innovation. The examples in Fig. 4 refer to different fields of applications with specific innovation aspects. The very different fields of application can indicate how a mechanism design can contribute to innovation and technological achievements with different applications demonstrating the richness and indeed great potentiality of mechanisms.

In Fig.5 Romba house cleaning robot is shown as an example of service robot. A general scheme for designing and operating service robots is reported in Fig.5 a) to show the complexity of the service robots which includes indeed aspects of the innovation products. The current market Romba robot is shown in Fig. 5 b). It is a mobile intelligent robot with a device for house cleaning. Its design was started in 1990s' but only in the 2000s' it reached a large market success with millions of sales. Today versions are built also for other applications like garden grass cleaning and cutting. This is an example of how much users' education is influential in accepting innovation.

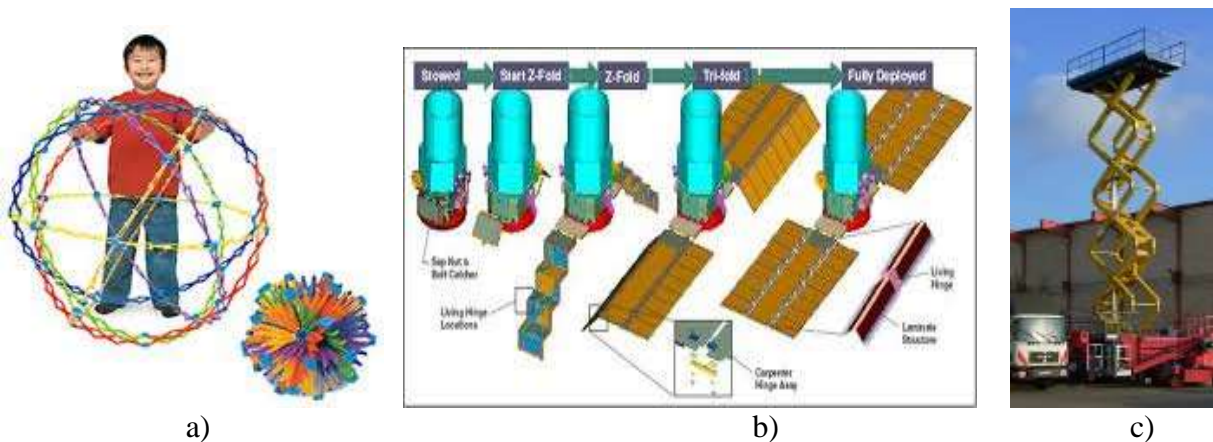


Fig.4 Deployable mechanisms in innovative applications: a) in toy design; b) for space antenna structures; c) in load lifters for civil engineering.

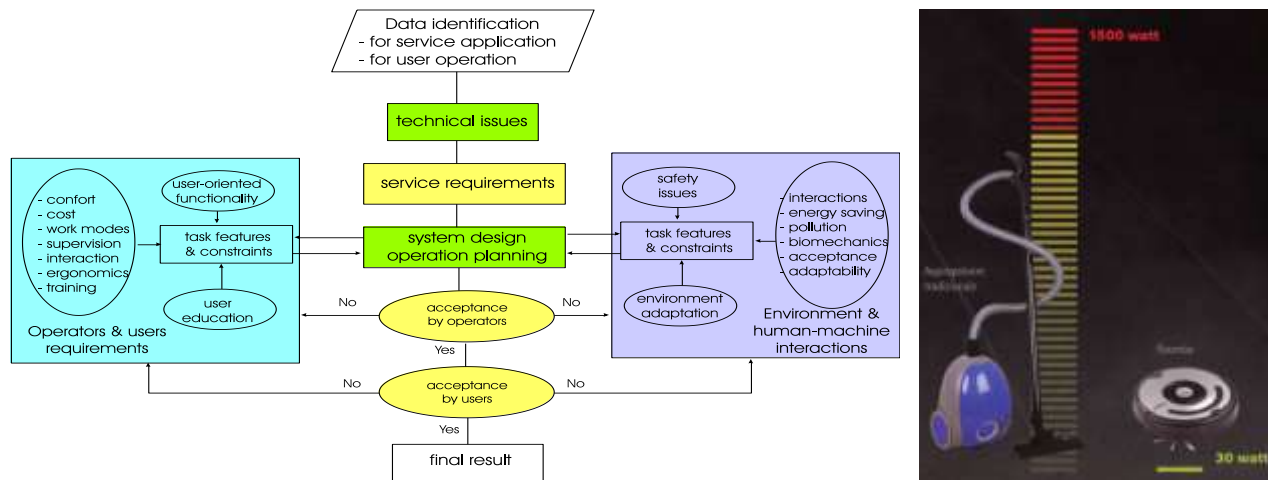


Fig.5 Innovation with service robots: a) a general scheme; b) Roomba market product.

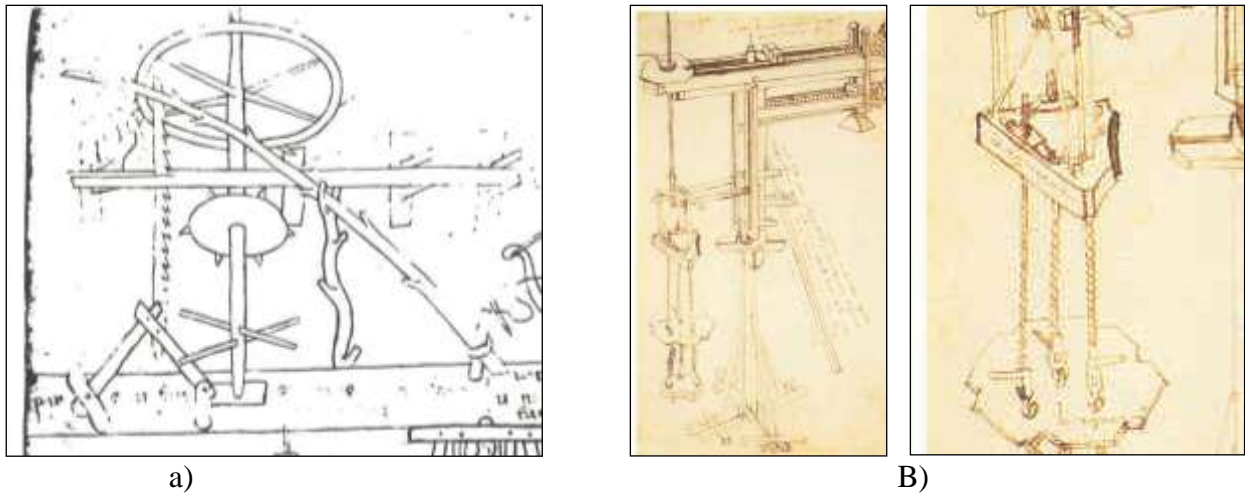


Fig. 6 Examples of modern mechanism innovations in past designs: a) 2dof linkage with coupler guiding point by Villard de Honnecourt in 13th century; b) cable-base parallel manipulators by Filippo Brunelleschi (1377-1446).

Fig.6 shows examples of past mechanism designs that were considered/recognized innovation only much later. They concern with solutions with very modern concepts, like the coupler motion guidance in Fig. 6 a) and cable-based parallel architectures in Fig. 6 b), that are today well understood and exploited in modern innovations. But the conceptual technical ideas were developed much before: this is the case for several modern inventions!

### IFToMM activities for MMS innovation

Significance of MMS innovation is produced and supported by community growth and particularly significant is the role of IFToMM, even at the level of local frames.

The current structure of IFToMM is summarized in Fig. 7 in terms of the action of IFToMM bodies that are established in the IFToMM constitution for a worldwide flow of activities. According to IFToMM mission as in the article 1 of the constitution, IFToMM activity is finalized to provide leadership for cooperation and development of modern results in Mechanism and Machine Sciences by assisting and enhancing international collaboration.

The bodies of IFToMM can be described synthetically as:

- General Assembly: it is the supreme body of the Federation and determines its policy. It is composed of the Chief Delegates of IFToMM Organization Members (in 2014 they are 46 from countries of all the continents as national or territory associations with interests and activities in MMS) and members of the Executive Council with no vote rights.
- Executive Council: it 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.
- 3 GACs (Committees of the General Assembly) that are appointed for the basic specific duty relating to GA in dealing with Constitution, EC Nominating procedure, Honors and Awards.
- 13 TCs (Technical Committees) are today active in the fields of Biomechanical Engineering, Computational Kinematics, 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.
- The 4 PCs (Permanent Commissions) are on Communications, Publications and Archiving; Education; History of MMS; and Standardization of Terminology.

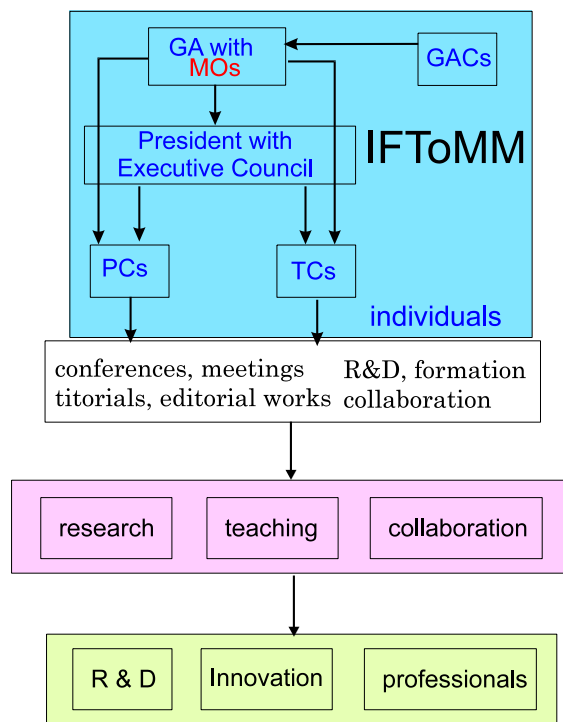


Fig. 7 IFToMM bodies and activities

Each PC and TC is composed of a Chairperson, appointed by the Executive Council, a Secretary and members, who are representatives of MOs and, once nominated by the Chairperson they are appointed by the Executive Council. A Chairperson shall not serve for more than two terms consecutively. The general goals for the work of the PCs and TCs are aimed at promoting their specific fields of interest by attracting researchers and practitioners, including young individuals, in order to:

- define new directions in research and development within their technical areas;
- establish contacts between researchers and engineers;
- initiate and develop bases and procedures for modern problems;
- promote the exchange of information;
- organize national and international symposia, conferences, summer schools, and meetings.

The mission of IFToMM is to promote research, development, and education in the field of Machines and Mechanisms by using theoretical and experimental methods, along with their practical application. This mission statement indicates the engineering aspects but also the practical scope of implementation of the activity of the community in technological developments for the benefit of the society with clear aims toward innovation.

Main activities can be summarized in, Fig.7:

- conference initiatives that are organized both for wide international participation and specific topic forums; conferences are held on local, national and international frames as organized by any body of IFToMM or by individuals, who are affiliated to IFToMM MOs under a given patronage of IFToMM; in general each TC and PC has its own specific series of conference
- meetings of the IFToMM bodies for planning the activities and indicating new trends and initiatives; all TCs and PCs have an annual meeting and some other forums
- publications that include proceedings of IFToMM sponsored conferences, editorial works, and textbooks. A special Springer book series on MMS (available in the Springer website for book series at code 8779) has been started in 2011 for book projects on MMS topics mainly from IFToMM community. Specific attention is devoted to journal paper publications that are organized mainly but not only within the 6 IFToMM affiliated Journals: Mechanism and Machine Theory, Problems of Mechanics, Open-access Mechanical Sciences, Chinese Journal of Mechanical Engineering, Advances in Vibration Engineering, Mechanics Based Design of Structures and Machines.
- knowledge transfer that is worked out through several actions including contacts and projects with professional and industrial frames, seminars, and tutorials.
- collaborations that are executed non only within the activities of PCs and TCs but also through actions for teaching, research and application among IFToMMists and institutions that are linked with IFToMM MOs; a special plan is established as Young Delegate Program to help young researchers in participating at IFToMM sponsored activities with specific grants from IFToMM budget.

Those activities are duties and benefits both for MOs and individuals, who are affiliated to IFToMM through a MO that is active in their territories.

A special attention is addressed to the IFToMM World Congress that is organized every 4 years. Last World Congress was held in Guanajuato, Mexico, in 2011 and next World Congress will be held in 2015 in Taipei, China-Taipei.

More information on IFToMM and its activity can be found in the official IFToMM website ([www.iftomm.org](http://www.iftomm.org)) that is constantly being updated.

IFToMM activity has grown in many aspects, as for example concerning the number of Member Organizations (from the 13 founder organizations to the current 46 organizations), the size and scale of conference events (with many other conferences, even on specific topics, 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. IFToMM was founded in 1969 and today a fourth generation of IFToMMists is active, who can be named as those persons working with international activity within the IFToMM community. Individuals have paid and

still pay an important role on the activity and significance of IFToMM since the federation is made of people and its bodies are just an expression of the international aggregation of persons with commonly agreed rules for functioning and perspectives of activities.

All the IFToMM activities are stimulated and directed to innovation in MMS technical filed with a clear impact also in other areas and ultimately in the society evolutions. IFToMM itself can be considered an innovation result when it is recognized as a product of new attention to a community working for technological developments of MMS.

The IFToMM community evolved in character from that of a family of a few enthusiastic pioneers/visionaries and founders into a scientific worldwide community through the following generations:

- 1950s-1975 – First generation: founding fathers and their friend colleagues up to the 4<sup>th</sup> IFToMM World Congress in New Castle upon Tyne in 1975 with Prof. Leonard Maunder as Congress Chair.
- 1976-1995 – Second Generation: pupils and people, who were educated in TMM by founding fathers and their friend colleagues; up to the 9<sup>th</sup> World Congress in Milan in 1995 with Prof. Alberto Rovetta (Bianchi's pupil) as Congress Chair.
- 1996-2011 – Third Generation: educated people with MMS activity in the frames of IFToMM and within IFToMM activity with 48 national organizations as IFToMM members, up to the 13<sup>th</sup> World Congress in 2011 in Guanajuato, Mexico with Prof. Carlos Lopez-Cajùn as Congress Chair.
- 2011 – Today – Fourth Generation: educated people working in frames that are linked to IFToMM and within IFToMM activity with 46 organizations as IFToMM members.

IFToMM officers (who are the Chairs of IFToMM Member Organizations, the Chairs of TCs and PCs, and the members of the Executive Council) have contributed and still contribute as leaders for the mission of IFToMM, which is stated in the first article of the Constitution as: 'The mission of IFToMM is the promotion of Mechanism and Machine Science'.

### **Examples of IFToMM contributions to MMS innovation**

Iftomm community works for innovation in MMS but through developments and applications of mechanical systems by means of an action of leadership and coordination of activities and trends in worldwide international frames.

Significant examples of contributions of IFToMM with innovation contents can be summarized both in community aggregation and identification as well as in specific activities such as:

- New TCs for new research subjects of large interest
- New forums and publication frames
- New demands for formation in research and profession

Innovation can be focused in new research subjects that in IFToMM can be motivation for establishing new TCs in order to focus and coordinate trends and developments. Recently TC for Sustainable Energy Systems and TC for Medical Devices have been established in those corresponding areas in which challenging activities are solicited and under developments for innovative solutions. New subjects are arising that could permit/require the creation or enlargement of TCs with a suitable groups of interested persons and institutions from Member Organizations. In addition, in each of the existing TCs activities are continuously worked out to stimulate new trends and challenges together with the usual activities of meetings, conferences, and information flows.

Similarly, innovation in IFToMM is stimulated and also disseminated through publications in international frames that can be considered themselves innovation. Thus, recently IFToMM has



more affiliated international journals with the aim to facilitate aggregation of publications of works from the IFToMM community as well as Springer book series have been started with specific focus and link to MMS.

Formation with advanced issues is of great interest since the early days of IFToMM. New results can be considered the planning of several specific tutorials, mainly as Summer schools by TCs and even a Student Olympiad that this year has been planned in its third event.

Beside the above, innovation of MMS is obtained in IFToMM through specific results in new theories, designs, and applications that are achieved for new solutions.

## Conclusions

Summarizing, achievements and solutions in MMS as well as the corresponding community can be considered important bases for innovation with technical content and background, without which no innovation is possible in machine area and even in more fields. But a full modern innovation exploitation up to users' satisfaction requires a community with more multi-disciplinary skills, even from Business and Administration areas and IFToMM community can work such an influential role in stimulating/guiding innovation activity since it was established with vision of international frames for collaboration purposes in the growth of MMS with impacts and application of technological developments for the benefits of the society.

## Basic references from author's experience

- Ceccarelli M. (Ed.), Role of MMS and IFToMM in Technology Development, Book series on Machines and Machine Science, Vol.1, Springer, Dordrecht, 2011. ISBN 978-94-007-1299-7, DOI: <http://dx.doi.org/10.1007/978-94-007-1300-0>
- Bautista Paz E., Ceccarelli M., Echavarri Otero J., Munoz Sanz, J.J., A brief illustrated history of machines and mechanisms, Science and Engineering, Book series on History of Machines and Machine Science, Vol.10, Springer, Dordrecht, 2010. DOI 10.1007/978-90-481-2512-8. ISBN: 978-90-481-2511-1
- Ceccarelli M., Problems and issues for service robots in new applications, International Journal of Social Robotics: Volume 3, Issue 3 (2011), Page 299-312, DOI: 10.1007/s12369-011-0097-8.
- Ceccarelli M., "The Challenges for Machine and Mechanism Design at the Beginning of the Third Millennium as Viewed from the Past", Proceedings of Brazilian Congress on Mechanical Engineering COBEM2001, Uberlandia, 2001, Invited Lectures, Vol.20, pp.132-151.
- Ceccarelli M., History and Challenges of Mechanism and Machine Science within IFToMM Community, in: Towards Intelligent Engineering & Information Technology, Springer, Berlin, 2009, pp. 469-488.
- Ceccarelli M., Twenty-five year of activity in IFToMM, journal Theory of Mechanism and Machine (<http://tmm.spbstu.ru>), St Petersburg State University, Vol.11.No.2, pp.3-14.
- Ceccarelli M., An Outline of History of Mechanism Design in servicing Science, In Physics, Astronomy and Engineering: critical problems in the History of Science and Society – Proc. of SISFA 2012, The Scientia Socialis Press Siauliai, (Invited lecture) pp.1-10.
- Ceccarelli M., A short account of History of IFToMM and its role in MMS, Mechanism and Machine Theory, 2015, 10.1016/j.mechmachtheory.2014.09.007 (in print)

## About the author

Marco Ceccarelli is Full Professor of Mechanics of Machinery and Director of LARM, the Laboratory of Robotics and Mechatronics at Cassino University (<http://webuser.unicas.it/web/larm>). He has been President of IFToMM, the International Federation for the Promotion of Machine and Mechanism Science for term 2008-2011 and Secretary General in 2003-2007. He is editor of the Springer book series on MMS and History of MMS. His research interests cover aspects of Mechanics of Mechanisms and Robots, History of MMS, and Mechanism Design. He authored more than six hundred papers, and he has authored 4 books and has edited 20 books for proceedings and specific topic issues.