

Carlos López-Cajún (1948–2020)



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Abstract Prof. Carlos López-Cajún has been a prestigious figure, who has been admired worldwide also for his unique attitude to combine friendships and scientific activity in working the true spirit of IFToMM for collaboration, sharing, and improving the technology for the benefit of the society in the welfare of human beings. Prof. Carlos López-Cajún has been a great IFToMMist contributing and significantly supporting activities of the Permanent Commission of History of MMS in organization of events and exploration of the history of IFToMM and MMS with very valuable publications. Prof. López-Cajún devoted his acquired knowledge and expertise to the mechanical design, mainly on kinematic optimization of mechanisms, robotics and synchronization of mechanical systems publishing valuable results in papers in recognized journals, books and proceedings of international congresses. He served IFToMM as Member of the PC on History of MMS, member of the Executive Council and also as Secretary General. Moreover, he participated in the organization of the 13th IFToMM World Congress in 2011, and many among many other initiatives he also organized the HMM2016 Symposium in his city Queretaro in 2016.

1 Biographical Notes

Carlos Santiago López-Cajún, Fig. 1, (he used in general only the given name Carlos) was born on January 18, 1948, in Campeche, Mexico and passed away on Sunday 20

The original version of this chapter was revised. The Author name has been corrected from “Juan Carlos Juaregui Correa” to “Juan Carlos Jauregui Correa”. The correction to this chapter can be found at https://doi.org/10.1007/978-3-031-18288-4_8

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M. Ceccarelli and A. Gasparetto (eds.), *Distinguished Figures in Mechanism and Machine Science*, History of Mechanism and Machine Science 41, https://doi.org/10.1007/978-3-031-18288-4_4

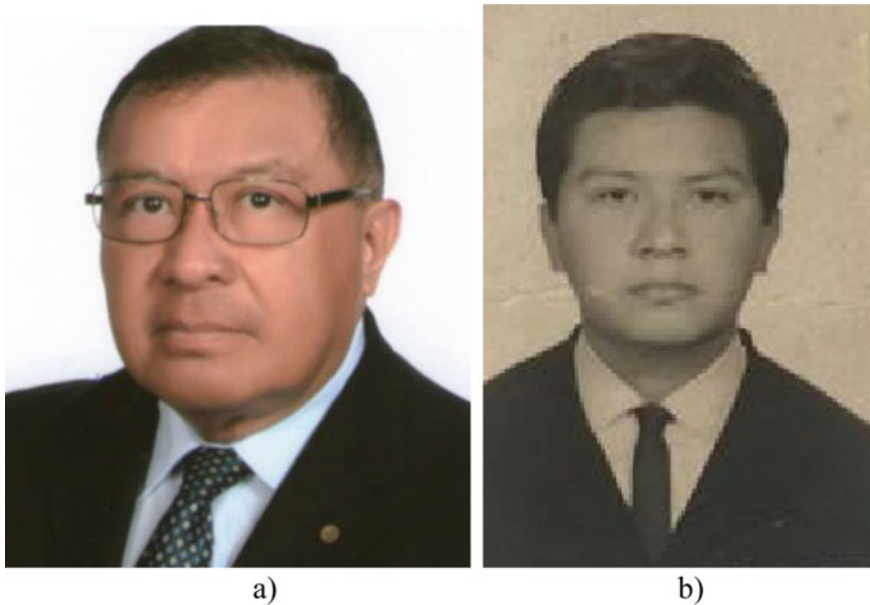


Fig. 1 Prof. Carlos S. López-Cajún (1948–2020): **a** in his maturity as professor at University of Queretaro; **b** when student at UNAM in Mexico City

December 2020 in hospital in Queretaro, Mexico (López-Cajún 2018, 2022; Acevedo and Ceccarelli 2022).

Prof. López-Cajún spent his childhood in Campeche where the family is still based, Fig. 2. There he formed his warm character with a calm behavior as always available to interact and help people, while starting to have interest in technology and particularly to machinery.

Prof. López-Cajún got his Bachelor and Master degrees on Mechanical Engineering in 1969 and 1977 from Universidad Nacional Autónoma de México (UNAM) in Mexico City, Fig. 1b, and his Ph.D. from Case Western Reserve University, USA in 1982. After the bachelor's degree he worked from 1969 to 1972 at the companies Panamerican Valves and from 1972 to 1975 at the Mexica Bus Company in Mexico City getting a strong experience of industry frames and relationships. During the period of strong dedication to studies and formation at the Department of Mechanical Engineering of UNAM in Mexico City he had the chance to meet and collaborate with Professor Ricardo and Enrique Chicurel who were later his mentors and supporters in promoting internationalization of the Mexican community, not only with links to IFToMM. In this period, he also started a long-life friendship with Jorge Angeles, who was at that time senior student in UNAM attending the same department of the professors Chicurel, and later with him he had strong long scientific collaboration mainly in the topics of mechanism and particularly cam transmissions, while Jorge Angeles became professor at McGill University in Montreal, Canada. The experience in USA for his Ph.D. degree was also formative in having not only been formed



Fig. 2 Prof. López-Cajún with his grandmother in Campeche, Mexico

in other fields than mechanisms, but also to have experiences in USA with a first international vision.

After returning from USA to Mexico with the Ph.D. degree, Prof. López-Cajún worked from 1988 to 1995 in Industry at Mexican Institute of Transportation in Queretaro acquiring a professional experience, also as leader positions, that gave him also a better practical view of the need of academic formation with practical engineering aspects. During this period, he also had the chance to know the professional and industry communities with whom he maintained the contacts for long time. This experience was also useful to have a clear motivation to return to the academic frames.

While employed in Industry he was also part-time Professor at the Faculty of Engineering of UNAM in Mexico City. Then upon invitation by Jorge Angeles he spent sabbatical leaves in 1986–87 as Visiting Researcher at McGill University, Quebec, CA, and at University of Notre Dame, USA.

Then in 1996 he moved to Universidad Autónoma de Querétaro, campus San Juan del Río, where he got the position of Full Professor in Mechanical Engineering in same year starting there regular and continuous activity in teaching and research. He remained very active there until his last days, with increase of activity not only on local and national frames but also at international levels and mainly in IFToMM community.

Since the beginning of his long academic career, Prof. López-Cajún gave mainly courses on Mechanics of Transmissions and Mechanism Design, both on basic formation and advanced topics for bachelor, master, and Ph.D. students at the most in his university but also with invited lectures and seminars abroad all round the world.

He was also interested in many other subjects of MMS in which he also gave many other courses always with special attention to Mechanism Science even in the fields of Robotics, Automation, diagnostics of machinery, and History of mechanical engineering. This last was his passion outside of regular teaching frames but he always tried to give history hints in his lectures to make the students aware not only of the past efforts and invention but to show that the advances in technology and particularly in MMS are due to the efforts and dedication of persons, inventors, academics and professionals, during several years of works.

In particular his passion and clarity in teaching together with his kindness and humanity made him as a very appreciated teacher by the students among them he is still remembered also as a great teacher. In his teaching activity he was well dedicated not only in lecturing but also in assisting the students with tutorials and meetings for better explanation of the subjects helping the students to have a clear understanding of the concepts with a practical application with numerical examples if not possible experimental practice. His attitude made him like a father for those who were in strict relationship with him because of thesis projects and even more as Ph.D. students. He was also well open to share his teaching with plans to combine his lectures, regular or invited, with lectures by other colleagues with the aim to give experience to students to appreciate not only the local teaching but even to learn topics with different viewpoints and cultural backgrounds. With the students he was never aggressive, and he always tried to accommodate the students to have the time for their understanding, although at the time of exams he was rigorous and objective in the evaluations.

While being Profesor Universidad Autónoma de Querétaro he was living in Querétaro where he was taking care of his nephew who lost both the parents quite early so that he could not make his own family. But then in 2008 he got married with Maria Agueda Amador after many years of relationship with her. At their wedding Prof. López-Cajún wanted to have his friends from IFToMM even as wedding wisdom as a sign of the IFToMM spirit that the IFToMM community is like a family. In Fig. 3 the photo shows the just married Carlos and Maria together with Ineke and Teun Koetsier (from Netherlands), and Brunella and Marco Ceccarelli (from Italy).

The participation of colleagues from the IFToMM community in his marriage is emblematic to indicate the spirit of Prof. López-Cajún of how to live and participate in the IFToMM community by combining technical-scientific activities with social relationships that undoubtedly improve and give satisfactions of long-term personal sociality in such collaborations, including international ones.

With this attitude of personal involvement, was an effective promoter of aggregation in various national and international contexts. This communicative capacity and sharing of community aggregation was also carried out with cordial meetings around a table during a lunch both in congress and non-congress environments. Figure 4 shows an example of such meetings in which the Prof. López-Cajún brought together Mexican colleagues also including his former Ph.D. students now professors, together with fellow foreign visitors, both to discuss and plan greater incisiveness of the Mexican community in the national academic and research programs as to plan adequate participation and visibility in international frames, especially in IFToMM.



Fig. 3 Wedding memory photo of Carlos López-Cajún and Maria Agueda Amador with Ineke and Teun Koetsier (at their right) and Marco and Brunella Ceccarelli (at their left)



Fig. 4 A meeting organized by Prof. Carlos López-Cajún with Mexican colleagues in Mexico City in 2018 (from the left to right: Carlos López-Cajún, Marco Ceccarelli—invited guest, Eusebio Hernandez and Ivan Valdez from IPN-Ticomán, Mario Acevedo from Panamericana University, and Prof. Christopher Torres from IPN-Zapeteco)

Within his activity it is to note his strong actions as promoter of IFToMM Mexico, beside being a very active member of ASME. In Mexican national frames he was a Founder Member of the Mexican Society of Mechanical Engineering (SOMIM) as a national aggregation of a community well recognized within Mexico and abroad.

Because of his reputation was appointed a member of the Mexican Academy of Engineering and awarded with several honors by local, national, and international institutions, among which it may be highlighted the Mexican National Researcher award.

Prof. López-Cajún had an intense international activity with regular and continuous participation not only in congress events but also in promotion and management of activities of international community institutions. As an ASME member he has been very active in participating in international congresses in the American continent and in the activity of the association. As a member and co-founder of SOMIM he has always been active and proactive in the growth of the community both academically and professionally with interactions at international levels. But the most significant activity was carried out within the IFToMM, International Federation for the Promotion of Machine and Mechanism Science, since the beginning of his academic career, evolving from simple participation in congresses to leadership roles.

He served IFToMM as Chair of Mexico IFToMM member organization, member of the Permanent Commission on History of MMS, member of the Executive Council and also as Secretary General in 2008–2011. Moreover, he proposed and contributed to the organization of the 13th IFToMM World Congress held at Guanajuato, México in 2011 and he also was Chair of the HMM2016 Symposium on History of Mechanism and Machines held at Querétaro, México in 2016.

Prof. López-Cajún was recruited for the Commission for History of the MMS during the 1999 IFToMM World Congress in Oulu, Finland, by Teun Koetsier and Marco Ceccarelli, past and current Chair of the Commission (Ceccarelli and Koetsier 2004; Gasparetto and Ceccarelli 2022), having appreciated his interest and vision on the history of mechanical engineering as also important in the training of a modern engineer and researcher in MMS fields. Since the first days of his appointment as a member of the commission, the Prof. López-Cajún has been active and reactive by participating in the activities both in meetings and interactions, also through media and Internet, and in the specific research and interpretation of inventions, events, and personalities in the history of mechanical machinery. In fact, it has always contributed since the first HMM symposium with significant contributions that have always received great attention from the participants and subsequently from the experts of the subject in finding documentation and published works.

Figure 5 shows examples of his participation in the commission's statutory meetings during which he made substantial contributions in the discussion of the commission's issues and plans to meet the IFToMM constitutional requirements for the commission's activities but also to promote a greater incisiveness of the commission with a wider international participation of colleagues (fundamental characteristic of the commission) not only from the member organizations of IFToMM but also from other communities interested in the history of the machines. In this active participation in the meetings of the commission as well as in the work of the HMM symposium, Prof. López-Cajún has also established relationships and collaborations at an international level, promoting the interest in the history of mechanical machinery by also young researchers in MMS areas. In particular, his works presented and published in the HMM symposium range from historical and interpretative studies of machines also of the recent past to theoretical and design analysis for the reconstruction of machines not only coming from the history of Mexican technology.

This continuous and prolific activity on the history of mechanical engineering also saw him as an always present actor also in the activities of the commission's



a)



b)

Fig. 5 Examples of participation of Prof. Carlos López-Cajún in the meeting activities of the IFToMM PC for History of MMS: **a** PC meeting in 2000 during HMM2000 symposium in Cassino, Italy; **b** PC meeting in 2011 during IFToMM World Congress in Guanajuato, Mexico

Workshop which was proposed precisely as a meeting frame to stimulate collaborations and research on local aspects and personalities that were not known or not sufficiently detailed for an international awareness. Figure 6a documents the participation of Prof. López-Cajún in the 2004 Workshop in Dresden, Germany, in which, among other things, the commission started an initiative to attract attention from wider communities, even from a general public to the cultural heritage that mechanical engineering has produced in the past in terms of models and technical-experimental documentation for training and teaching. Figure 6b shows an example of the cordial interaction that Prof. López-Cajún established to start friendly collaborations and partnerships referring to his last attendance at the HMM symposium in 2018 with a convivial meeting with his friend and colleague Prof. Baichun Zhang, organizer of the symposium in Beijing, China.

One major contribution of Prof. López-Cajún in the activities of the Permanent Commission, after having actively participate to all the HMM symposia since the beginning 2000, was the organization of the 2016 HMM symposium in Queretaro, as also in his capacity of member of the scientific committee for HMM. The 2016



a)



b)

Fig. 6 Examples of participation of Prof. Carlos López-Cajún in the activities of the IFToMM PC for History of MMS: **a** PC Workshop 2004 in Dresden, Germany; **b** meeting with Prof. Baichun Zhang in Queretaro during HMM2016 symposium

Symposium was very well participated with 23 papers presented by authors from all around the world and published in the Springer book series on History of MMS (López-Cajún and Ceccarelli 2016). The program was organized also with a very interesting social cultural program, as in the tradition of the HMM symposia, that permitted the participants to strengthen or start their friendship with more plans of collaborations that gave results in more findings in history of machines and mechanisms with better technical characters as per the engineering background of the HMM symposium community.

Prof. López-Cajún worked a significant role in IFToMM in different positions, starting as simple IFToMMist since he participated in the IFToMM activity initially in the thematic congresses and mainly in the world congresses that have allowed him to know the institutional and operational characteristics of the IFToMM community as well as to know members of this community. After being an active member of the IFToMM Member Organization Mexico, he was elected President of it in 1999, activating for a greater participation of Mexican colleagues in the IFToMM technical committees and mainly giving a more international breath to the Mexican community referring to the Mexican association of mechanical engineering SOMIM

of which he was also vice president as well as a founding member. In this promotional activity of the Mexican community, it should also be remembered its commitment which led to the proposal to host the IFToMM World Congress in 2011 in Mexico which was well accepted by the IFToMM General Assembly in 2007 as programmatic in allowing direct experiences of the surrounding communities. Initially, the proposal agreed within the Mexican community was to host the Congress at the University of Querétaro, the seat of Prof. López-Cajún who, after having quickly checked the efficiency and the possibility of suitable infrastructures (a large convention center promised in Queretaro was postponed by the Mexican local government), was able to involve his Mexican colleagues to find an optimal solution in the city of Guanajuato, with characteristics of social and tourist attractiveness combined with a network of surrounding technical universities to which the University of Querétaro also referred. Even though he was part of the organizing committee, the professor left the responsibility of organizing the Congress to the president of the Mexico IFToMM Member Organization of the moment Professor Riccardo Chicurel with a committee composed of members also from nearby universities. However, his active participation and interest in successfully planning the 2011 IFToMM World Congress led him to a continuous commitment and presence as shown in the example in Fig. 7.

Thus, with the experience of participation at all levels and therefore of leadership as Chair of an IFToMM Member Organization, Prof. López-Cajún was then elected a member of the IFToMM Executive Council for the 2003–2007 term, making significant contributions to the improvement and growth of the IFToMM activities, with regular participation in the meetings of the IFToMM Executive Council chaired by Professor Kenneth Waldron, Fig. 8.

During this period Prof. López-Cajún coordinated well with the members of the IFToMM Executive Council, receiving appreciation and recognition for his commitment and results in promote IFToMM especially in the South American world, also involving the Iberoamerican Federation of Mechanical Engineering FebIM which



Fig. 7 Meeting for planning the 2011 IFToMM World Congress on 23 September 2010 (from the left): Adolfo Pamanes, Marco Ceccarelli Ricardo Chicurel, Juan Carlos Jauregui, and Carlos Lopez-Cajun



Fig. 8 Meeting participation of Prof. Carlos López-Cajún as EC member at the meeting of the IFToMM Executive Council in 2005 in Besancon, France

in those years established a bilateral agreement with IFToMM to activate concrete collaborations in synergy. A first result of this agreement should be remembered in the activation of the MUSME Congress sponsored by both federations on the issues of Multibody Dynamics and Mechatronics, which began in 2002 in Mexico City. In this context, the two federations also shared the activities of their technical committees on Robotics and Mechatronics, being Prof. López-Cajún the liaison person for many years.

The interest and dedication of Prof. López-Cajún have given results of appreciation so much so that at the General Assembly of the IFToMM in 2007 he was unanimously elected General Secretary of IFToMM by the present Chairs of the IFToMM member Organizations. He carried out this position with continuous and regular activity with efficient coordination with the president Marco Ceccarelli and the treasurer Joseph Rooney who, together with the past president Kenneth Waldron, formed the Presidential Desk which coordinated the activities of the IFToMM Executive Council, also gathering the enthusiastic participation and contribution of all its members. These activities and the relative results are summarized in numerous documents which are mainly archived at the IFToMM archive at the CISM in Udine, Italy, and by the publications (López-Cajún 2008–2011; Ceccarelli et al. 2011; Ceccarelli 2013, 2022) which give a synthetic summary.

As General Secretary, Prof. López-Cajún carried out fully and with excellent results also recognized in the final report presented at the 2011 IFToMM General Assembly during the World Congress in Guanajuato, Mexico, regarding his constitutional tasks as a point of reference for the management of IFToMM affairs, editor of the official documents of the IFToMM, manager of relations and communications with the bodies (PC, TC, Chair of GA) of the IFToMM and with the IFToMM community in general, and collaborator of the president in coordinating the activities

and above all in presiding over the meetings of the Executive Council in presence and in telematic form.

Figure 9 shows the group photos at the end of the Executive Council meetings with the participation of all the members of the Executive Council and some other officers of the IFToMM as chairperson or representatives of the technical and permanent commissions as well as Chair and representatives of the Member Organizations. As can also be noted from the photos Prof. López-Cajún has always carried out his duties as secretary general with discretion and never without exaggerating in a leading role but leaving plenty of space, in agreement with the president, for the discussion of those present at the meetings and also as can be seen from the photos giving a greater visibility to all the representatives of the IFToMM bodies.

In Fig. 9a the meeting held at Waseda University, in Tokyo, Japan, with professor Atsuo Takanishi (last on the right), local organizer, is documented, with the aim of giving greater international visibility to IFToMM on the occasion of the Executive Council meetings, with the possibility also for the young Japanese researchers to be able to attend the discussions and the planning of the activities. This approach continued throughout the mandate as documented by the fact that the Executive Council meeting was held with the prescribed annual regularity, being hosted in the various continents where the IFToMM has Organization Members.

Figure 9b shows the meeting held in Mexico at the site of the Congress of 2011 as required by the constitutional requirements in the duty of the Executive Council in its collegiality to verify the organization in the World Congress and the structures provided for it. Prof. López-Cajún on that occasion was particularly involved being also in the organizing committee and remembering that he was the proponent of this Congress. In this role he has made a considerable commitment which ensured, together with the congress organizers, a success, as expected, at the 2011 Congress with appreciation already during the 2009 visit. On this occasion in 2009, it was also possible to celebrate the fortieth anniversary of the IFToMM with an event limited to a single day and a few interventions by the past presidents and the few founding fathers still alive. Thanks to the organization of Prof. López-Cajún, the ceremony took place at the historic site of the University of Guanajuato with contributions also online by guests from all over the world with an efficient coordination by Prof. López-Cajún.

Figure 9c shows the meeting that was held at the University of Sousse in Tunisia as the first event of the IFToMM official body on the African continent and at the same time at a recently affiliated Member Organization. The local organizer Professor Lotfi Romdhane (third from the left) with the Rector (near him) enthusiastically welcomed the IFToMM delegation composed of the Executive Council members and other IFToMM officers, also proposing an interesting social program with an excursion to the neighboring territory to learn about the culture and history of the country with visits also to archaeological sites from the Phoenician, Roman, and Arab eras. Figure 9d shows the group photo of the official meeting of the executive council at the beginning of the 2011 World Congress with a program that included a second session at the end of the Congress to allow the new Executive Council to share discussion, problems and programming between the two bodies to ensure continuity



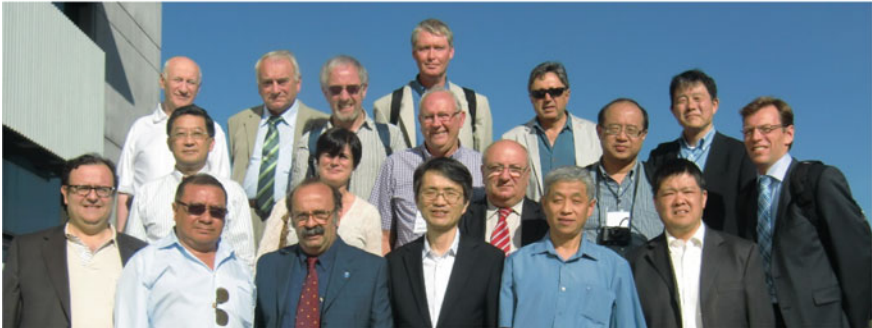
a)



b)



c)



d)

Fig. 9 Examples of participation of Prof. Carlos López-Cajún in the meeting activities of the IFTToMM Executive Council: **a** in 2008 in Tokyo during CISM-IFTToMM Romansy Symposium; **b** in 2009 in Guanajuato, Mexico, checking the 2011 World Congress site; **c** in 2010 in Sousse, Tunisia; **d** in 2011 during IFTToMM World Congress in Guanajuato, Mexico

in the guidance of the IFToMM. In this last aspect Prof. López-Cajún together with the president collaborated closely especially in the early days with the new general secretary Veniamin Goldfarb and with the new president Yoshiko Nakamura to allow them to have a regular and efficient performance of their activities in their mandate 2012–2015.

Figure 10 shows examples of the management of Executive Council meetings in which Prof. López-Cajún carried out his role with great efficiency also in complying with the timing of a timed agenda with a high density of topics to be discussed. He can be noted in Fig. 10a while recording the interventions alongside the treasurer and the president. In Fig. 10b Prof. López-Cajún at the center of the coordination table between the president and the treasurer coordinates the interventions assisted with multimedia systems and projector allowing interventions also online for those who had not been able to come in attendance. Also noteworthy is Prof. López-Cajún’s ability to coordinate with an open and understandable language to all listeners from all continents and also with different linguistic skills in sustaining conversations and discussions in English as prescribed by the IFToMM constitution.

Figure 11 shows moments of the activities that Prof. López-Cajún following the meetings of the Executive Council with photographic indication of the aforementioned precision and scrupulousness in carrying out the institutional tasks envisaged in his role as secretary general. Figure 11a shows the presidential desk meeting, also



a)



b)

Fig. 10 Prof. Carlos López-Cajún as IFToMM Secretary General, recording the discussion at the meeting of EC meeting: **a** in 2008 in Tokyo after CISM-IFToMM Romansy Symposium (first in the left); **b** in 2011 during IFToMM World Congress in Guanajuato, Mexico (at the center of chair desk)



a)



b)



c)

Fig. 11 Prof. Carlos López-Cajún at work as IFToMM Secretary General: **a** in 2011 meeting of the Presidential Desk during IFToMM World Congress in Guanajuato, Mexico; **b** in 2007 preparing documents for EC meeting with the IFToMM President; **c** in 2011 revising the minutes of the 2011 EC meeting with the IFToMM President

held in a convivial form, to adequately prepare an Executive Council meeting with a preliminary view shared by the members of the presidential desk to efficiently deal with all discussions and issues not only included in the agenda. In this task Prof. López-Cajún has played an important role, always being punctual in the preparation of the agenda points but also in the cordiality of the discussion of each point even in critical terms. In Fig. 11b and c, on the other hand, moments of work with the president are reported in order to better take care of the drafting of reports and official documents following not only the meetings of the Executive Council but also to produce suitable and complete documents for the IFToMM archive as well as prescribed by constitutional obligations, but also for an awareness of the importance of maintaining a historical memory of the activities and their evolution.

Prof. López-Cajún was member of several scientific committees for international conferences and journals as result of his reputation from an intense scientific activity that is documents by papers, books (for teaching and with research results), and patents. Significant are the book on Cam Transmissions (Angeles and López-Cajún 1991), co-authored with Prof. Jorge Angeles and the book on Mechanism Design (in

Spanish) (López-Cajún and Ceccarelli 2008), coauthored with Prof. Marco Ceccarelli. He contributed to many projects in different topics, beside Mechanism Design, like in Robotics, Biomedical devices, Space systems, and History of Engineering and Machines with achievements in highly disseminated publications, that can be still easily found (not only in Google).

Throughout his life, Prof. López-Cajún has combined professional scientific activity, characterized by dedication and intelligence, with an aptitude for relating to people, be they students or fellow researchers, with an empathy that has made his figure attractive both on a scientific and didactic level, leaving an imperishable memory of his spirit and his results both in scientific and social relations.

2 List of Main Works

The prolific scientific activity of Prof. López-Cajún covered many aspects of mechanical engineering and especially in the areas of MMS with particular interests and significant results especially in analysis and synthesis of mechanisms, cam transmissions, design of service robots, machine diagnostics, vehicle mechanics, vibration mechanics, and history of mechanisms and machine. The most significant contributions are documented in more than 500 papers (and still available not only in Google) that are published in international journals and international conferences with a significant number of citations by other authors documenting a significant impact in their respective thematic areas. Furthermore, significant contributions have been collected in book chapters and especially in co-authored books among which it is to note:

- Optimization of Cam Mechanisms del 1991 (Angeles and López-Cajún 1991), Fig. 12a
- Mechanisms (in Spanish) del 2008 (López-Cajún and Ceccarelli 2008), Fig. 12b

In addition, remarkable is the volume of proceedings of the 2016 HMM symposium on History of Machines and Mechanisms (López-Cajún and Ceccarelli 2016), Fig. 13, which the Prof. López-Cajún organized in Queretaro with a successful international participation and still today in of interest not only for investigators on the history of mechanical engineering as documented by the more than 20,000 downloads received to date.

From the very prolific publication activity reporting results and their enhancements the following main papers listed in References can be indicated as representative of main works of Prof. López-Cajún on:

- mechanism design and cam transmissions: (Angeles and López-Cajún 1988; Angeles et al. 1994a, b, c; Carbone et al. 2001; Lanni et al. 2006)
- machine diagnostics and vibration mechanics: (Lozano-Guzmán et al. 1993; Rafael et al. 2009; González-Cruz et al. 2014, 2015; Figueroa et al. 2004)

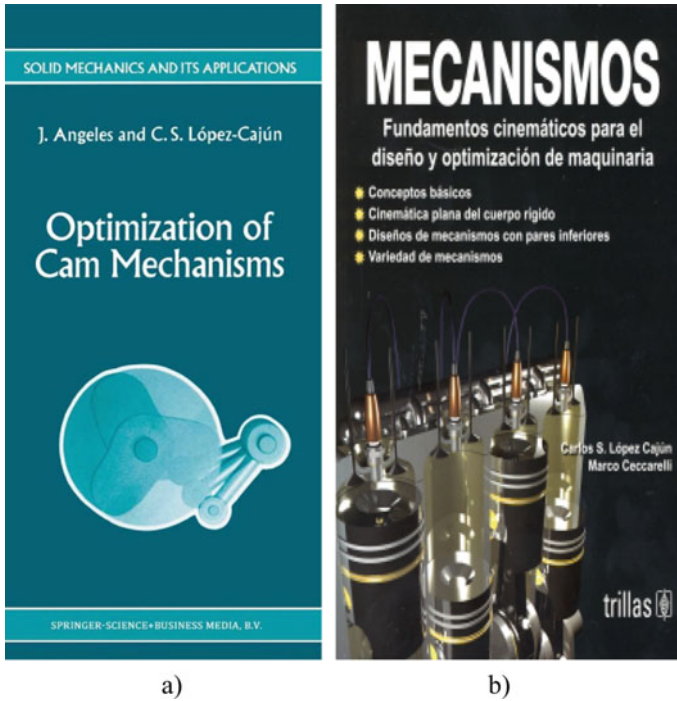


Fig. 12 Books co-authored by Prof. Carlos López-Cajún: **a** with Jorge Angeles on Cam Mechanisms in 1991 (Angeles and López-Cajún 1991); **b** with Marco Ceccarelli in 2008 on Mechanism teaching (López-Cajún and Ceccarelli 2008)

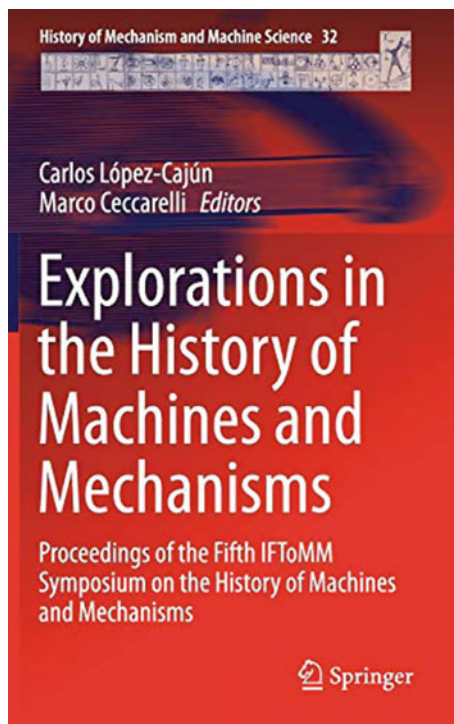
- analysis and design of robots: (Angeles et al. 1988; Angeles and López-Cajún 1992; Hernández-Martínez et al. 2010a, b; Jáuregui-Correa et al. 2013, 2015; López-Cajún et al. 2015)
- history of mechanisms and machines: (Figueroa et al. 2000; López-Cajún et al. 2004; López-Cajún 2010)

However, during his long activity Prof. López-Cajún authored and/or coauthored more than 400 papers in international journals and conferences, most of them are still of reference and background for the last advances in specific topics.

3 Review of Main Works and Contributions

The main contributions by Prof. López-Cajún can be recognized mainly in mechanism design and cam transmissions, machine diagnostics and vibration mechanics, analysis and design of robots, and history of mechanisms and machines.

Fig. 13 Proceedings volume co-authored by Prof. Carlos López-Cajún with Prof. Marco Ceccarelli on the 2016 HMM symposium held in Queretaro, Mexico (López-Cajún and Ceccarelli 2016)



In the following, examples and most significant aspects of those achievements are summarized using the original publications by Prof. López-Cajún.

Referring to mechanism design and cam transmissions, papers (Angeles and López-Cajún 1988; Angeles et al. 1994a, b, c; Carbone et al. 2001; Lanni et al. 2006) and the books (Angeles and López-Cajún 1991; López-Cajún and Ceccarelli 2008) can summarize the contributions of by Prof. López-Cajún in the main aspects of analysis and design aspects for procedures and solutions including activity of prototyping and testing for experimental validation.

Figure 14 from works in Carbone et al. (2001) and Lanni et al. (2006) summarizes the most significant issues in modelling for design and analysis. Figure 14a shows an efficient model for performance evaluation via simulation that can be used also in testing characterization and Fig. 14b the numerical results using the model. Figure 14a shows an example of the great synthetic modeling ability of Prof. López-Cajún in recognizing the fundamental aspects of transmission mechanics in cam systems, either fairly simple or very complex. The example refers to the generation of an equivalent slider-crank mechanism regarding a circular-arc profile. The same scheme can be used for analyzing any cam profile by using a circular arc as a corresponding portion approximated by the osculating circle at the profile point under evaluation. The equivalence of the slider-crank mechanism is valid up to the second order kinematic characteristics since the osculating circle describes second order

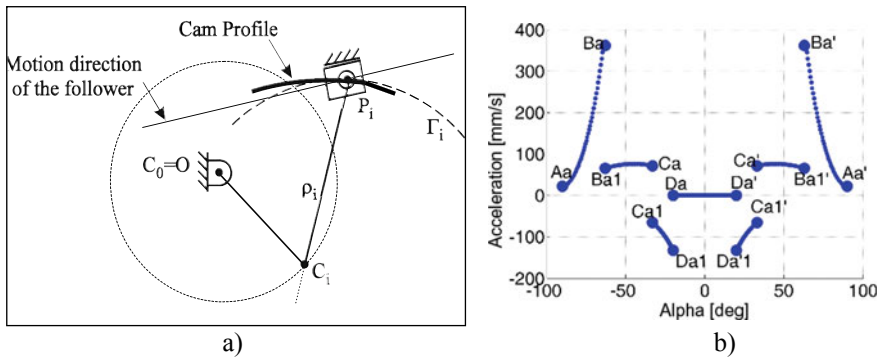


Fig. 14 An illustrative example of kinematic analysis of the circular-arc cam transmission (Carbone et al. 2001; Lanni et al. 2006): **a** identification of equivalent slider-crank mechanism; **b** results of the kinematic analysis in term of point acceleration

contact with the osculated profile, for a proper straightforward kinematic analysis (López-Cajún and Ceccarelli 2008). The crank-slider mechanism can be determined by using the center C_i of the circle Γ_i and the direction of the follower motion as reported in Fig. 14a. In particular, the coupler link is determined as the link connecting the center C_i with the point P_i of the osculated profile and the crank is the link connecting the frame joint to the ideal joint at point C_i . Thus, the coupler length coincides with the radius ρ_i of the circular-arc. The equivalent mechanism method of analysis has two advantages: first, it permits the analysis of cams and follower of any form moving in any manner; then, it provides a pictorial concept of the relative movement of the members.

The method is applicable to any cam profile since a profile can be considered as composed of a series of small-length circular arcs that are related to osculating circles that can be identified by using normal lines to the profile to determine centers of curvature (López-Cajún and Ceccarelli 2008). Once the equivalent slider-crank mechanism is determined, the cam behavior can be analyzed by looking at the kinematics of the slider point of the slider-crank mechanism that is related to each circular-arc portion of the cam profile with results like those in Fig. 14b.

Similarly, Prof. López-Cajún proposed models that were very efficient for dynamic analysis and the transmission of forces in cam transmissions with procedures that were also implemented in research and experimental characterizations of the dynamic behavior of the cam transmissions as reported in the example of publication (Lanni et al. 2006).

Relevant contributions of Prof. López-Cajún in cooperation with other authors are reported in the works (Angeles and López-Cajún 1988; Angeles et al. 1994a, b, c) and in the book (Angeles and López-Cajún 1991) concerning procedures and design solutions for cam transmissions using algorithms of optimized design using the characteristics of the cams and their operational purposes.

In the fields of machine diagnostics and vibration mechanics of several types of machine design including vehicles, prosthesis, and other machine aspects related to materials, papers (Lozano-Guzmán et al. 1993; Rafael et al. 2009; González-Cruz et al. 2014, 2015; Figueroa et al. 2004) give an overview of wide interest and achievements obtained also for practical implementations.

Referring to Vehicle Dynamics, Vibrations, and Complex Systems, the contributions of Prof. López-Cajún in the area of complex systems are the results of previous works on dynamics and vibrations. He noticed that to understand modern mechanical systems' dynamic behavior; it was necessary to include other disciplines. He explained multi-body dynamics as complex mechanical systems comprising many interconnected individual components. He assumed that these interconnections could be modeled as weak springs and dampers for explaining synchronization. In his publications, he proposed to analyze complex systems to understand the synchronization of different elements. This analogy allowed him and his coauthors to locate long-time variations by analyzing the coupling among different elements. One of the first attempts to analyze the effect of the surroundings was an experiment with 24 blades (static condition) subject to an axial airflow. The vibration motion was recorded with 24 accelerometers mounted on the tip of each blade. The experimental data were analyzed with the Kuramoto parameter, the correlation coefficients, the cross-correlation function, and the recurrence plots. They found that the foreground components determined the dynamic response of each blade, and the background conditions the coupling response. He and his coauthors also studied experimental data obtained inside an automobile. For the analysis, they applied various techniques, and the data were obtained through a set of accelerometers mounted on the dashboard and one door (González-Cruz et al. 2014, 2015).

His contributions to the analysis of vibration field data included also a methodology for determining horse movements. This analysis's results helped specify the required movements for designing a mechanism that emulates hippo-therapy for children. The data were obtained by setting accelerometers on horses and converting the data into planar and tilt movements (López-Cajún et al. 2015).

Regarding vehicle dynamics analysis, Prof. López-Cajún worked on several topics as in the following short summary. He also determined the effect of the type of suspension on the load carried by heavy trucks. He and his coauthors instrumented different vehicles with a data logger and a set of accelerometers and measured the vibration levels on the truck. They compared both suspensions and found that the air-spring suspension transmitted 48% of the vibration energy than the leaf suspension (Lozano-Guzmán et al. 1993). He also worked on optimizing the truck's fuel consumption by analyzing the powertrain system and optimizing the gear shift to operate the engine at its lower fuel consumption regime (Rafael et al. 2009).

One of his main topics of interest was Robotics. His contribution covered modeling, analysis, and practical applications. In this field, he has contributed to developing parallel robot kinematic and dynamic models. He gave a fundamental contribution to the development of the kinematic model of the parallel robot that controls the position of the secondary mirror of the Large Millimetric Telescope

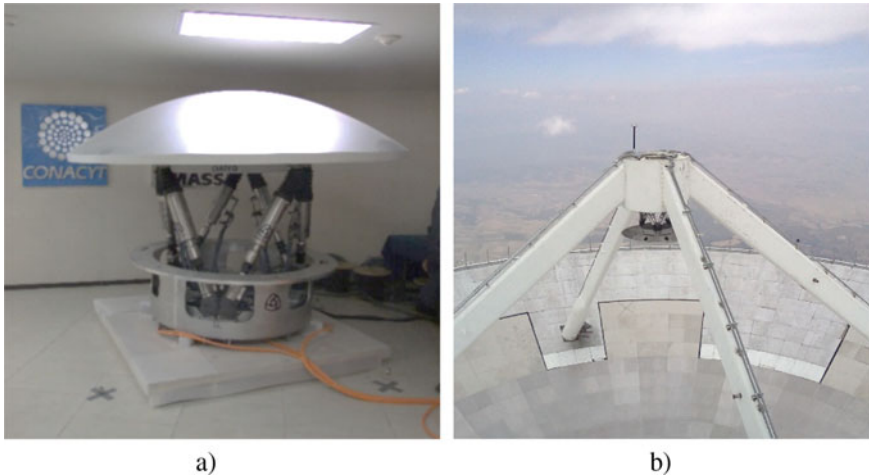


Fig. 15 The designed parallel robot for the secondary mirror of the Mexican Large Millimetric: **a** the built unit; **b** installed in the large telescope

(famous up to be in https://es.wikipedia.org/wiki/Gran_Telescopio_Milimétrico, as a fundamental astronomic instrument installed in the Mexican State of Puebla), Fig. 15.

He also contributed to the determination of the pose accuracy considering joint individual errors and overall errors, as reported for example in Jáuregui-Correa et al. (2013, 2015). In this area, he also worked on estimating the end-effector pose errors of the cable-base manipulator Milli-Cassino Tracking System (Milli-CaTraSys), developed at LARM at the University of Cassino in Italy (Hernández-Martínez et al. 2010a). The results of this development were also applied for determining displacements and orientation variations of other robots, such as CaPaMan 2bis. To characterize the system, he and his coauthors made ADAMS simulations and experimentally validated the results as in Hernández-Martínez et al. (2010b).

Regarding serial robots, Prof. López-Cajún defined the conditioning index in terms of the reciprocal of its minimum condition number, or other words, the condition number of its Jacobian matrix. The Jacobian quadratic norm is needed to determine the condition number. In the publication (Angeles and López-Cajún 1992), it was defined that a robot with a 100% conditioning index is isotropic, meaning that a robot with all its angles between neighboring revolute axes at 90° and all its distances between neighboring axes identical is isotropic. On the topic of serial robots, another important work was the paper dealing with trajectory planning (Angeles et al. 1988). In this work, they derived a systematic procedure in the configuration space by referring to the orientation of the end-effector to a unique orthogonal frame. The orthogonal frame was defined at every point along the end-effector's path. The Darboux vector and its time derivative determined angular velocity and acceleration.

He also contributed to revising the state of the art in robotic vehicle technologies and their implementation for monitoring road infrastructure, as results of several invited lecture on this and other topics.

The wide interest on history of mechanisms and machines of Prof. López-Cajún is summarized in the sample papers (Figuroa et al. 2000; López-Cajún et al. 2004; López-Cajún 2010) attaching the historical-technical analysis of a past machine and highlighting attention to past distinguished figures with the aim not only to record the past values but also to reevaluate the past achievements for a past-aware modern vision of further developments.

Figure 16 (Figuroa et al. 2000) shows the historical-technical study that Prof. López-Cajún made on the typically Mexican machine for the production of tortillas. The machine examined is a fairly recent machine but with a cultural and technical history that Prof. López-Cajún wanted to highlight as an example of how much a design and construction of a machine can hide or contain even in broader cultural aspects. The analysis carried out included the historical study of the tortillas and how they were produced as well as the reasons that led to the design of an automatic machine of which the one investigated is an emblematic example that he had available. The historical study of Prof. López-Cajún with his co-authors has deepened the motivations and the design choices as well as analyzed the functioning of the machine in functional terms related to the tortilla culture in Mexico.

The interest in the history of machines has led Prof. López-Cajún also to research and understand texts from the past that are the basis of modern mechanics. Together with a team of international authors as reported in the publication (López-Cajún et al. 2004) he rediscovered and reevaluated the classification of machines according to Monge’s concepts by the two students Augustin de Betancourt and José María Lanz y Zaldívar (in short Lanz) of the Polytechnic school of Paris and among other things, he discovered that Lanz was a fellow citizen of Campeche. Therefore, this discovery gave him a further historical-technical problem to investigate which, together with the author of this chapter, in several years he tried to solve in relation to the personality of Lanz as defined finally in the publication (López-Cajún 2010). His passion was

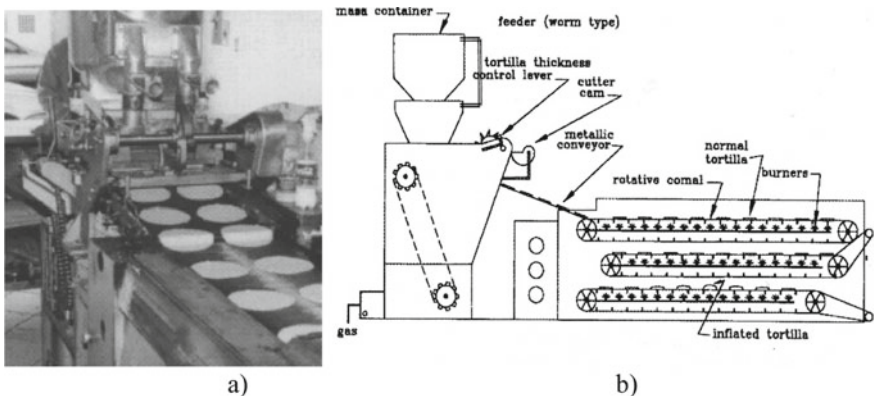


Fig. 16 The automatic machine for production of Mexican tortillas investigated by Prof. López-Cajún with results in Figuroa et al. (2000): **a** the sample of the investigate machine; **b** a scheme of the historical-technical analysis

not purely technical but also of wide-ranging culture and in fact on several occasions he met with the great-grandchildren of Lanz to better understand the life and the human and technical-scientific figure also with the intention of looking for a portrait (without being successful in this last search). Nevertheless, he managed to clearly delineate in López-Cajún (2010) the figure and the historical-scientific contribution of his fellow citizen of Campeche who, similarly to him in his technical-professional activities, was a citizen of the world having had activities and experiences in various parts of the world.

4 Legacy and Today Interpretation of Contributions

The legacy that Prof. Carlos López-Cajún left as a technical cultural heritage and teaching values as a reference for the next generations can be summarized mainly in three aspects:

- achievements of impact also for future developments in the aforementioned fields of his interest and activity
- methods of teaching and interacting with students
- sociability with kind character open to consolidate scientific-technical collaborations and to promote greater aggregation and dissemination of the importance of a technical-scientific community

The impact of the results obtained from the technical-scientific activities of Prof. López-Cajún are still today a reference for the community not only for the specific results obtained which have advanced knowledge and specific applications in the subjects of mechanisms, cam transmissions, machine diagnostics, vibration technology, applied biomechanics, robotics in mechatronics fields, and a historical awareness of the past, but also for the methodologies and approaches used to reach them with an engineering vision with characteristics of dissemination to wider areas. The attitude of Prof. López-Cajún is also significant in trying to disseminate the results of his research and design activities with presentation of activities and with a non-aggressive attitude, typical of today, with a spasmodic and excessive interest in citing his own works. In fact, an important aspect of the legacy that left us also consists in the fact that the further dissemination of the results, published in important and appropriate editorial frames, can be obtained through presentations and contacts with specific interested communities without the spasmodic attention and production of a valorization through indexes and citations obtainable through informatic means. Prof. López-Cajún has always given considerable importance to direct interaction that can allow not only a faster understanding of the results but also a subsequent if not immediate participation in further developments.

No less unforgettable are the events, facts, collaborations and interactions that Prof. López-Cajún lavished on the IFToMM community, making him a reference figure also for future generations, having fully embodied the original spirit of

IFTToMM in the mission of promoting the science of the machines of the mechanisms not only for the improvement of technology but mainly for the well-being and peace in human society.

The legacy left by Prof. López-Cajún in the field of teaching and academic training is evident above all from the good memory that students and those who have had the opportunity to have the professor as mentor or supervisor for a long time. As already mentioned, of reference and therefore a legacy is the attitude with which Prof. López-Cajún transferred his knowledge in teaching with passion and dedication, paying attention to that students were attracted and made their own the attention required to what was discussed in the lessons. Another aspect of reference for the future is also the kindness in the interaction with the students or with those who collaborated with Prof. López-Cajún in the activities of mutual transfer of results and problems.

The aspect of empathy in carrying out the activities of his academic and scientific commitment is even more an aspect of inheritance on a social and personal level that makes Prof. López-Cajún a reference to be indicated for a correct attitude in the academic world and in society in general in order to ensure dignity to the activities of a community to which one refers without excessive self-centeredness. Still appreciable are the kindness and open-mindedness with which Prof. López-Cajún used to interact and accept new scientific and technical challenges but also to work involvement and collaboration with colleagues with different technical formation and even with a different cultural background coming from distant geographic locations. In this Prof. López-Cajún well embodied the spirit of the IFTToMM which sees no barriers of any kind except the technical-scientific problems to start and sustain collaborations that can be useful for mutual cultural and technical growth as well as for the promotion of areas and structures that are less capable or less structured, also due to lack of funds.

Prof. López-Cajún had great teaching skills, he taught many years and every student remembered him as an excellent teacher. When his former students knew he passed away their expression was: “Oh, what terrible sad news! He was a great teacher and I will always remember him...”.

In conclusion, Prof. Carlos López-Cajún will be remembered as a distinguished figure with multifaceted skills and significant results of activity not only in the history of IFTToMM and of the disciplinary areas of Mechanisms and Machines Science.

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