



Integrated project delivery, an alternative to the usual form of construction work in Spain

Métodos colaborativos, un cambio para la construcción en España

MIGUEL ÁNGEL ÁLVAREZ

Arquitecto, PMP, CEO de Ag Arquitectura S.A
 maalv@agararquitectura.com

ALFONSO BUCERO

Ingeniero en Informática, PMP, PMI-RMP, PfMP, PMI Fellow, CEO de Bucero
 PM Consulting alfonso.bucero@abucero.com

CARLOS J. PAMPLIEGA

Arquitecto, PMP, CEO de Salinero-Pampliega PM
 carlos@salineropampliega.com

- ◊ The productivity of construction in Spain is lower than that of other sectors.
- ◊ IPD is applied in other countries improving the experience of construction players.
- ◊ Take advantage of BIM and IPD in search of greater efficiency in construction sector.
- ◊ IPD is a Lean methodology that has a positive impact on the construction process.
- ◊ A change of mentality is necessary in the way in which construction takes place in Spain.

The productivity of the construction sector in Spain is very low, as compared to other economic sectors, as with other countries in our environment. It takes us to a deep reflection on whether we are doing things right and what improvements can we introduce to increase production. These improvements must necessarily be technological and methodological, since there is a good training of the equipment both at the managerial level, as well as at the technical and in most of the labour levels, it is to exploit the full potential of new IT tools, especially Building Information Modelling (BIM) and the new methodologies that, from the industry, look for greater efficiency of the process and the elimination of all type of losses, like Lean Construction. A change of mentality, necessary to rethink the way of work in which we have been working for so many centuries, as the only possible paradigm, to replace confrontation as a way of producing construction through collaboration between all the agents involved in the work. We will speak in this article about Integrated Project Delivery (IPD), as one of the Lean methodologies that enable a profound improvement, we will see its definition, its essential components, and how its application can positively influence the construction process in Spain as it has already demonstrated in others.

Integrated Project Delivery (IPD); Lean Construction; Building Information Modelling (BIM); Project & Construction Management (P&CM)

- ◊ La productividad de la construcción en España es menor que la de otros sectores.
- ◊ IPD se aplica en otros países mejorando la experiencia de los agentes del proceso constructivo.
- ◊ Aprovechar BIM y metodologías como IPD buscando una mayor eficacia en la construcción.
- ◊ IPD es una metodología Lean que incide positivamente en el proceso constructivo.
- ◊ Es necesario un cambio de mentalidad en la forma en que se produce la construcción en España.

La productividad del sector de la construcción en España es muy baja, tanto comparativamente con otros sectores económicos, como con la de otros países de nuestro entorno. Se hace necesaria una profunda reflexión sobre si estamos haciendo bien las cosas y qué mejoras podemos introducir para incrementar la producción. Estas mejoras han de ser necesariamente tecnológicas y metodológicas, ya que existe una buena capacitación de los equipos tanto a nivel directivo, como en la escala técnica y en muchos casos en la laboral, es decir, se trata de aprovechar todo el potencial de las nuevas herramientas informáticas, especialmente Building Information Modeling (BIM) y de las nuevas metodologías que, provenientes de la industria, buscan una mayor eficacia del proceso y la eliminación de todo tipo de pérdidas, como Lean Construction. Un cambio de mentalidad necesario, que pasa por replantearnos la forma de trabajo en la que llevamos tantos siglos empeñados, como único paradigma posible, sustituir el enfrentamiento, como forma de producir la construcción, por la colaboración entre todos los agentes intervinientes en la obra. Hablaremos en este artículo de los Métodos Colaborativos en construcción, que en inglés se han denominado Integrated Project Delivery (IPD), como una de las metodologías Lean que posibilitan una profunda mejora, veremos cuál es su definición, componentes esenciales, y cómo su aplicación puede incidir positivamente en el proceso constructivo de nuestro país al igual que ya lo ha demostrado en otros.

Integrated Project Delivery (IPD); Lean Construction; Building Information Modelling (BIM); Project & Construction Management (P&CM)

1. INTRODUCTION

Among the various productive sectors of Spain, construction has traditionally been one of the most important, for several reasons: We are a great tourist power as well as for

our climate, our history, our monuments, our natural beauty, our gastronomy, etc. for our built infrastructure that we must maintain, improve and expand. We also have a very old built heritage, and we are not only referring to our innumerable monumental buildings, but to everyday buildings such as houses, which require a permanent rehabilitation.

On the other hand, construction has been, is, and will be a locomotive sector of the economy that not only creates many jobs, but has a multiplier effect in many other sectors, contributing in an exceptional way to our economic growth.

Consequently, we should be mostly interested in the effectiveness of this sector and in a continuous improvement of the methods by which it occurs.

Instead, we continue to build in the same ways we did centuries ago, we have legislation in the field that faithfully reproduces those obsolete methods, both in terms of building management and public contracting, we consider that the only possible paradigm with which a building can be built is that, and contracting down is the great invention to make public works, and in most cases private ones, in Spain [1].

We will develop in this article some of our errors in the methodology we apply, how there is another way of working, another approach to the constructive fact much more effective and that allows us to leave them, improving a sector so important to our economy and our well-being.

As for all changes, it is required an open mind, breaking down paradigms is not easy, or comfortable, it requires courage and be convinced of the possible improvements, Einstein said we cannot expect new results if we continue doing the same.

Construction can, and must, be more efficient in Spain, we can build better, cheaper, with less means and meet deadlines, but we must look forward, we must recognize our mistakes and be willing to implement new methodologies persevering in them until we will master them. In other countries of our environment this is already a reality, let's do not be late again.

2. PRODUCTIVITY IN SPAIN AND CURRENT STATE

Productivity rates in the construction sector in Spain can be vastly improved when compared to the industrial sector. It seems, however, that at least before the real estate crisis the operating construction system itself in Spain did not call for any change in the use of building systems and working methodologies in the construction sector.

The main reason why there has not been a need for a change so far is its economic impact. The incidence of constructions costs on the price formation of a building was abnormally low (around 25%) compared to the ground costs (40%) and the rest of the financial costs, taxes, marketing, etc. (35%). Thus, any investment intended to enhance the construction process and its management did not imply a solid improvement on the final cost of the real estate product.

The cost of labour also influences the implementation of more advanced construction systems. In countries with a lower labour cost, more industrialized and higher quality processes are less used.

Years before the real estate crisis, the labour force in the construction sector in Spain was extensive and low-skilled, with cheap hiring costs that made unprofitable the

implementation of more productive construction systems that require less skilled and better-paid labour [1].

In the last few years, we have noticed how this distribution of the percentage of the final price has changed, and the construction cost is reaching up to 60% of the final product.

Our construction sector and its labour market are approaching the average of countries surrounding ours, by implementing more modern systems with a more skilled workforce. Therefore, it is urgent to increase the productivity in the sector as it significantly improves the final product.

There are other aspects that need to be improved as much as productivity, aiming at looking for alternatives and new procedures: The delays in the execution times, cost overruns, lack of planning, reworks, ineffective logistics, unnecessary consumption of raw materials, CO₂ emissions, maintenance costs and the lack of quality in a sector with a traditionally under-trained labour and under-industrialized systems, especially in Spain [1].

3. INDUSTRIAL EFFICIENCY

As it has happened so many times, construction must learn from industry, although there are many differences in the way both sectors are produced, it is obvious that the great methodological changes under construction have always come from the application of improvements in the industrial processes, which have then been transferred to it [2].

After World War II a defeated and wounded in its pride Japan wanted to return to occupy the position that corresponded to him among the industrialized nations, but it could not be done using the same methods, the same forms of its competitors, especially of the United States, who saw in the chain of production the paradigm that had made them powerful and had contributed to their success in the War.

In the American industries, the prophecies of Henry Ford, published in his 1926 book "Today and Tomorrow", continued to resonate: To produce and produce, to create a large stock of products that the commercial departments of the companies would care in the market.

They are firstly Kiichiro Toyoda and then Taiichi Ohno, who study their competition thoroughly residing in the United States for a while. Both oversaw the Toyota automobile company and understood that their success had to be based on other principles.

Very impressed by the large parking lots in which hundreds of finished cars were waiting for a customer's order, they realized that this was a major failure of the American industry, a large unproductive immobilizer that in many cases had no outlet and was directly lost.

It was in the improvement where they could give the battle of effectiveness, and above all Ohno was applied to it with the greatest interest, structuring it in the basic principles that would be the Toyota Production System or TPS.

Walking the years, in the eighties, Japan began to flood the

United States with its cars, lighter, less fuel consumers, with good quality, less defects and cheaper than Americans. In this country, many managers began to think that they were the ones who now had to learn from the Japanese and reversed the journey which Toyota managers had made in the 1950s.

What they found was a clean production of everything that did not contribute to their development and improvement, with the focus on the customer, without losses, without useless stocks, without immobilization, a continuous and open collaboration of the work teams and a maximum fixation on quality. It was the TPS, those were the principles that Taiichi Ohno had applied at Toyota.

"The Machine That Changed the World" by professors James P. Womack, Daniel T. Jones and Daniel Roos, is the title that leads to the Massachusetts Institute of Technology or M.I.T. these principles. From that point on, industrial production in the United States revolved around hundred and eighty degrees, and it began to be fixed in improvement as a goal. Japan had understood that competition lay in the lack of defects and in obtaining it with the least possible means.

A good word to define this way of producing was "Lean", which means: Clean, without superfluous elements, to do things with just, but to do them well. This is how the Toyota Production System is renamed the United States Lean Production System or LPS.

There are many titles which from that moment begin to be published there on the Lean philosophy and Toyota heritage, inevitably come loaded with principles and even Japanese words.

For us it stands out above all of them "kaizen" which derives from two words: Kai (change) and zen (good), change to better, something that pervades everything, a principle on which teamwork is based, the collaboration in the search for continuous improvement, in a permanent way, that was the idea force that the TPS printed to production, everything was based on it [3].

It was another way of naming the W. Edwards Deming Cycle: Plan, Do, Check, Act or PDCA, who through his teachings in Japan in the 1950s on continuous improvement, had influenced the TPS too.

4. LEAN CONSTRUCTION

The LPS is implemented and developed in the North American industry for the manufacture of all types of products, the losses are reduced to a minimum, the production chain is balanced, it is produced based on the demand of the customers, not to sell what has been manufactured, but manufacture what has been sold.

"Just in Time" or JIT is the new way of making production profitable, everything has started from Toyota, but has been internalized in the United States as its own, it has been researched and deepened in improving, achieving very positive results that still exist today.

It is in the year 1992 when Finnish professor Lauri Koskela

presents a scientific paper at Stanford University, United States, which in 2000 will develop as Doctoral Thesis at Helsinki University of Technology, Finland: "An exploration towards a Production theory and its application to construction" [4].

This research will lead to the application of Lean's industrial production methodology to construction. Professors Glenn Ballard and Greg Howell of the University of Berkeley in California, USA, were investigating along the same lines.

From the confluence of this knowledge is born Lean Construction, later joining to this group the professor Luis Fernando Alarcón of the Pontificia Universidad Católica de Chile, together they will constitute the International Group for Lean Construction or IGLC, and from their work will be born a whole series of techniques that will develop Lean methods in construction [5].

The substrate that have all these techniques is common sense, collaboration between work teams and focus on people rather than processes. The phrase of Fujio Cho, one of the presidents of Toyota: "Before we make cars, we make people", is a good definition of the methodology.

Over the years Lean Construction work techniques have been growing and have been refined, as well as demonstrating their effectiveness with positive results in concrete works [6].

The most important ones are:

- ◆ Last Planner System.
- ◆ Value Stream Mapping.
- ◆ Target Value Design.
- ◆ Integrated Project Delivery.

All these techniques would require a concrete study of each one of them, since they can contribute to an improvement in the construction processes in Spain (Pons Achel J.F., 2014) [7], but in this article, we want to focus on Integrated Project Delivery or IPD.

5. INTEGRATED PROJECT DELIVERY

We assume that the Spanish construction has a single form of development: Design, Bid, Build, this is our paradigm, a truth assumed as if there was no other alternative, just consult our Legislation in the matter to realize how far it is. It does not matter that this way of working does not leave us satisfied neither with the process itself, nor with the results.

A work is undertaken by the confrontation from the zero minute between the main actors of the same: The Property, The Constructor, The Design Technicians and the Directors of Work. Each one of them will defend a plot against the others, and for this they will not exchange his information with the others, but will use it privately for his own benefit.

The designers will develop the project without taking into account the construction company, or many times the property, and once finished they will realize a budget which they know that will not be fulfilled, but that will serve to summon a

competition between constructing companies, which again will go to falsify the data by offering to do the work at such a low price and with such short deadlines that it will only serve for the property, delighted with that misleading offer, awards them the work.

In the execution phase, all this will explode, in the first place, the construction company will start trying to lower the quality and or present contradictory prices that allow it to balance its accounts. A very important weapon that they will use for this purpose will be the project, which will most often be poorly defined or poorly projected.

The project planners-directors by their part will defend their project, but rather from an aesthetic point of view, thinking about the publication of the photos of the building in the corresponding magazines, to enhance their ego and increase their future commitments, but not so much from the quality, the price or the execution period of the work, since they are aspects that in the bottom they worry less.

Who is going to pay the broken dishes of all this mess is the property, who trying to defend itself from that expensive "party", will hire a Project Manager that will help to put a little order in the chaos, but who won't be able to achieve all its objectives because what is badly designed is the system itself.

IPD [8], completely returns to this process, and what it proposes is that from the very beginning of the design the main actors, mentioned above, work collaboratively in a single team, and that all the information of the project and of the work will be always available to all members of the same. Open books are the formula.

By being open the information the property, the constructor and the technicians will also be able to give an opinion on the development of building issues. This ends the surprises, but also ends up taking advantage of them to cover incompetence or defects of their own.

To work as such, IPD includes that the benefits of the professionals involved are obtained based on the degree of success or failure achieved, measured in terms of price compliance, execution time and quality of the building [9]. There is a prior recognition of costs for the builder and the design team, but the profits will be based on what I mentioned before. This creates a true team spirit, a real interest in things to go well, is what is commonly said in football: "To kick all for the same goal", and not going each one by his side, his own interests, to the detriment of the fulfilment of common objectives.

Advancing the decision making constituting the team at the beginning, contributes to a greater efficiency of the process. There are many studies that attest to this, such as those of Patrick Mac Leamy for HOK (Hellmuth Obata and Kassabaum, one of the most important architectural studies in the world) presented at the American Institute of Architects (AIA): "As early you make a decision on the project it will be cheaper and more effective".

Leamy points out the cost of the decision making and changes caused by the projects throughout their life cycle. Statistics show that we can positively influence the project in its starting phases by making decisions that also have a lower economic impact whereas when construction is advanced, decisions and changes over the project imply overruns (Fig. 1).

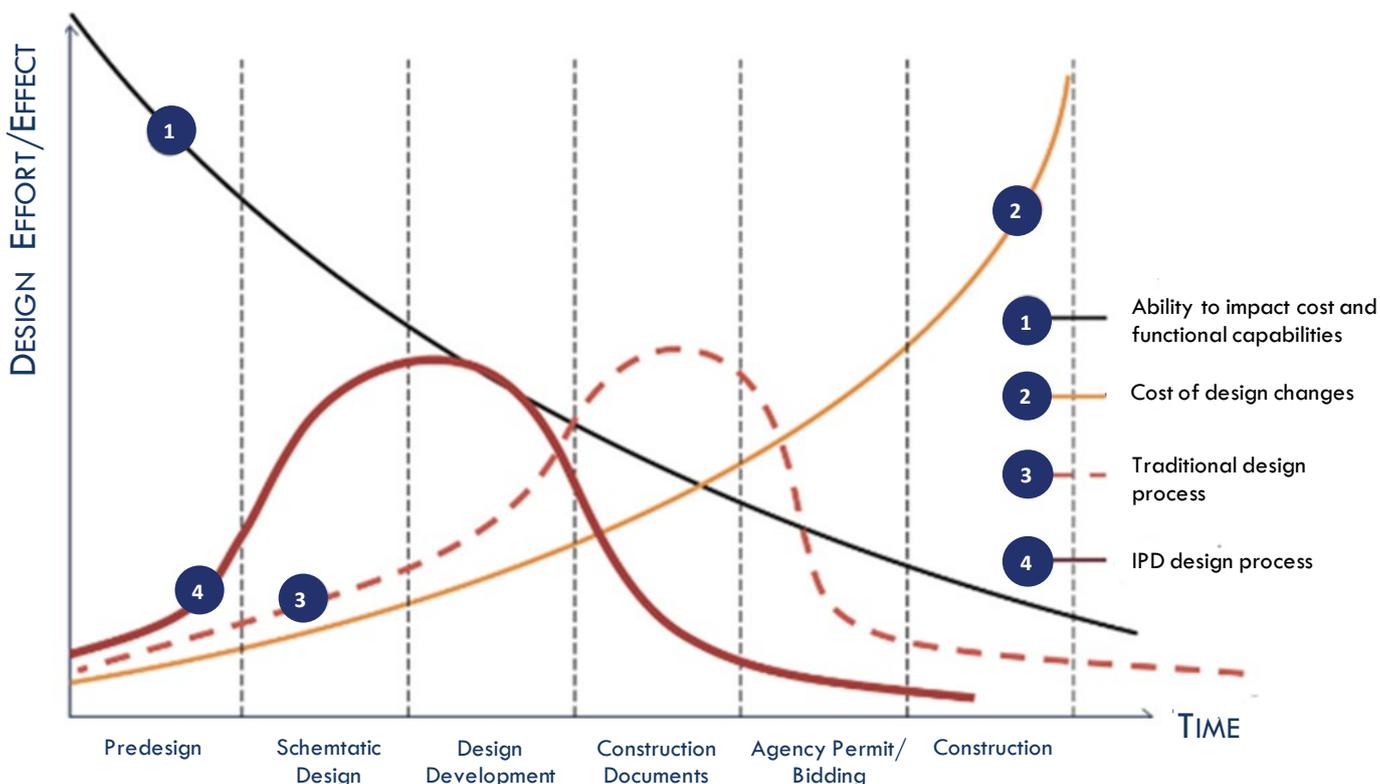


Figure 1: The MacLeamy Curve (Pons Achell, J. F. Introducción a lean construction. Available at: www.fundacionlaboral.org).

This particular fact about the construction projects might be what separates us the most from other industries, especially those related to knowledge and information technology (IT). In construction, prototypes are made of concrete and steel, and any modification on site implies overruns which are much time unfeasible. This factor inevitably determines the management process of the project.

As a result, it is necessary for the future agents of the project to be involved in it since its early phases, so that we can benefit from their experience and knowledge during its design and we can avoid modifications and reworks during the construction phase.

By doing so, technicians from the construction companies will carry out a re-engineering work by providing their expertise and adapting the design to their own working needs. In practice, this calls for a lower cost of the work, higher quality, and greater choices for the client-promoter to adjust the early design of the project to their needs. As outlined below, by involving the agents who are going to perform certain tasks from the beginning, the risks to the property will greatly reduce [10].

An important point in this methodology is the drafting of the agreement under which all parties will relate and share their interests and risks, but there is already in the United States a basis for action in the matter that is: Integrated Form of Agreement or IFOA, such as ConsensusDoc 300, signed by AIA, IGLC and the Associated General Contractors of America (AGCA), which can serve as a model for Collaborative Contracts [11]. It opens here a great field of action for offices of Spanish lawyers who can become experts in this matter, as is already happening in America.

The construction practice shows that 85% of the chances to manage the outcome of the project arises before the awarding of the construction contracts. The involved agents must work together from the beginning to set the strategy for the design management, costs and the subsequent work procurement.

Using IFOA contracts, the main involved agents develop and validate together the objectives of the project by sharing its risks and rewards, based on each one's abilities. During procurement, the company executing the work must make emphasis on who is going to take on those known risks and look for procurement formulas to share the risks of the project.

The risk is allocated through a contract based on procedures defined by the principals (owners of the construction project) which should obey the good practice that says: "Allocate the risk to those who can manage it the best". This means that each risk must be allocated to the party that can best manage, control and mitigate the risk and can withstand its consequences.

This way, the risk management, the decision making and the project control will be executed in collaboration based on the

Collaborative Contract itself that involves all of them [11].

A key factor derived from the Lean philosophy is the importance of the relationship with the client throughout the entire process. In the IPD approach and the Collaborative Contracts between different agents, it states that the work of the team in charge of the development of the project firstly focuses on the client's needs.

The main point of a Collaborative Contract will be to define what the client wants clearly and to define the objectives of the project, the focus that must guide any decision or change on the design. Beyond the quality obtained, the schedule and the cost of the work and the client's needs will be the key points on which the rewards of each part are based [12].

The client's relationship with the rest of the parties benefits from the use of IPD, taking advantage of the experience of architects, technical-architects, engineers, construction companies and suppliers capable of providing solutions that enhance the performance of the project while saving costs and improving deadlines.

The new technologies increasingly facilitate this interaction and the collaborative participation of all parties. The customer is evidently the centre of the IPD process, and there are examples worldwide where new technologies support the inclusion of the customer's needs, whether the promoter or the end customer. Big Data technology is already being used to monitor the usage and habits of building users, gaining valuable information that improves the design and subsequent maintenance of buildings.

Further examples, such as virtual reality, allow us to include the client in the design process in a real and inclusive way. Based on the client's experience, we will create virtual twins, or digital models, that will facilitate communication with the rest of the technicians and suppliers [13].

Accordingly, the development of this tool is contributing as no other to the implementation of IPD: Building Information Modelling or BIM.

The fact that the whole team can work on a single virtual model of the building using BIM has been the biggest step that technology has taken to facilitate this way of working. Also, the use of the cloud for the exchange of information allows the relocation of the equipment and a degree of flexibility that enhances the team work as it had never happened before BIM.

The use of digital models produced with BIM will not only be key during the planning and design of the project but also for communication and re-engineering during the work and subsequent maintenance in a much more advantageous way [14].

The BIM Commission of the Spanish Ministry of Development has announced that from 2020 its use will be mandatory in Spain; therefore, we must catch up on this methodology which

strengthens like never the collaborative work.

6. WHAT DO WE NEED TO CHANGE IN OUR SECTOR?

The construction process in Spain is governed by a general law: LOE, based on very specific procedures and roles, which do not facilitate the implementation of new management methodologies such as IPD.

Artificially, the relationship with other agents that are not reflected in the LOE is based on the jurisprudence reinterpreting this law. The inclusion of new agents involved in the construction project will force the administration, insurers and legal departments of companies to establish norms and protocols adapted to the law.

In Spain, the management of public contracts is based on an obsolete legislation that encourages the previous situation of confrontation between the parties we are criticizing. It is possible to make possible different types of contracts, such as Integrated Project Delivery, Construction Management or Design and Build, whose main difference with Spanish public contracts is the margin left for collaboration between the parties and those who assume the responsibility and risks of the project.

To that effect, our companies are accustomed to carrying out projects with these forms of public-private collaboration contracts when they compete for international contracts. The Directive 2014/24 of the European Union on Government Procurement; the FIDIC international contracts; or the World Bank contracts; include aspects related to proposals for changes, modifications to the project, risk sharing, which facilitate the management of projects and expedite the treatment with the contracting administration [15].

Another key element of our sector, which we can extend to the rest of the national economy, is the lack of a collaborative business culture. Many hours of education and training in the various tools related to Lean Construction will be necessary, starting with IPD. But knowledge of these methods will be useless if there is no culture that favours collaboration. That has necessarily to do with the legal part reflected in the contracts, the process of rewards, remuneration, civil liability, and trust building among all agents.

In this credibility building process during the project, the Project Manager [16], a job not efficiently used in Spain, should be converted into a change agent in organizations that fosters a collaboration culture. The "Project Manager" role is key as the main responsible for the IPD project. His/her role is the change leader, he has to believe in the project, convince the rest of stakeholders and sell it to them focusing on "why IPD".

The Project manager needs to be somebody who has good technical skills but mainly very good soft skills, because he/she will have to deal with many obstacles within organizational storms. Skills like effective communication, conflict

management, adequate delegation, internal Project selling, negotiating and even the adequate use of good humor and politics, adequate decision making and influence, are absolutely necessary for good project performance. Knowing how to swim in turbulent waters, popular sentence used by elder people, is the product of wisdom and experience. For instance, all things related to management, monitoring, control and influence about Project stakeholders is a skill the Project Manager needs to know better than nobody and it is crucial for organizational success [17].

Fostering and always practicing a positive attitude from IPD conception to implementation is key for project success. 3Ps development (Passion, Persistence and Patience), necessary skills to develop and practice for all implementation projects, are indispensable for an IPD project too.

Passion is the enthusiasm that the Project Manager needs to develop and maintain, persistence is the perseverance to obtain stakeholders support during the whole project life cycle. And patience is to understand that not all the Project stakeholders follow the same pace that a project manager needs to have.

Knowing how to play with technical and soft skills and having a positive attitude are fundamental keys for project and organizational success. The Project Manager needs to keep the credibility title very high. Credibility is finally the result of some actions and details that we do among Project stakeholders and it takes time, but it is not impossible [18].

7. CONCLUSIONS

It is not an utopia; it is being applied with flying colours in Anglo-Saxon countries where many buildings are constructed in this way, and many companies have been long using it: Sutter Health, Autodesk, Biogen Chemicals, etc. with great results in cost, term, quality and satisfaction of stakeholders [19].

Technology is boosting the implementation of more industrialized and productive models of management and construction. The construction sector is not an island separated from the rest of the economy and will not remain oblivious to what is happening in other sectors.

Technology and innovation that is permeating all industries will also influence construction, mainly in three areas. The first one will be the way of producing: The sector will be industrialized, adopting more industrialized construction systems. The second segment that will undergo changes will be demand, as the customer will become the centre of the entire management process, and will call for more from the builders. And finally, the transformation will also influence a finished product with higher quality.

Other sectors of the economy have long been adapting to a more liquid and collaborative society. In other industries, collaborative methods such as Agile in Information

Technologies (IT), are being implemented and affecting the way of working and creating teams, not as opposed roles, but flatter and capable of deciding at an early stage on issues that concern them. And especially the client is involved as the centre of the project.

Although Agile's iterative frameworks cannot be equated with waterfall projects in construction, it is possible to adopt the imperative that the client participates more in the whole process. It is quite clear the relationship of all this to the Lean philosophy, with its application in Lean Construction and Collaborative Methods in Construction as Integrated Project Delivery.

In a first approximation, it is more important to introduce this culture of behaviour in all the parties involved in the construction process than developing the corresponding techniques which will be explained below.

The main work of organizations in the future will be to determine on what to base our trust and collaboration [20]. Therefore, let us contribute all together to a change of mindset in the way in which construction takes place in Spain and then we will implement the methodology for the improvement of the whole process.

8. REFERENCES

- [1] D. Cortés, CFA - Unidad de Real Estate, F. Loes - Unidad de España (2016). La situación inmobiliaria en España. La productividad del sector de la construcción en España. BBVA Research, Abril 2016.
Available at: https://www.bbva.com/wp-content/uploads/2016/04/Situacion_Inmobiliaria_abr16.pdf
- [2] M. Della Rocca, T. Duvall y M. Palter (2017). Dear Washington. We need to rebuild. How to get it right. Time Magazine, Special Report Infrastructure, USA, April 10th. 2017 Pag.40.
Available at: <https://backissues.time.com/storefront/2017/dear-washington-we-need-to-rebuild-/prodTD20170410.html>
- [3] K. Liker Jeffrey (2004). The Toyota Way, 14 Management Principles form the world's greatest manufacturer. McGraw-Hill, United States of America (ISBN 0-07-139231-9).
- [4] L. Koskela (2000). An exploration towards a production theory and its application to construction Technical Research Centre of Finland, Espoo, 408 VTT Publications.
Available at: <https://aaltodoc.aalto.fi/handle/123456789/2150>
- [5] L. F. Alarcón Cárdenas y E. Pellicer Armiñana (2009). Un nuevo enfoque en la gestión: La construcción sin pérdidas. Revista De Obras Públicas (3496), páginas 45-52.
Available at: http://ropdigital.ciccp.es/detalle_articulo.php?registro=18732&anio=2009&numero_revista=3496
- [6] C. Ayats Perez, (2015). Lean: Diseño y construcción. Un cambio necesario. Editorial Círculo Rojo, Almería, Andalucía, España (ISBN: 978-84-9115-796-0).
- [7] J. F. Pons Achell(2014). Introducción a lean construction (1 ed.). Madrid, España: Fundación Laboral de la Construcción.
Available at: www.fundacionlaboral.org
- [8] AIA California Council (2014). Integrated project delivery an updated working definition. The American Institute of Architects (AIA), California Council.
Available at: http://www.aiacc.org/wp-content/uploads/2014/07/AIACC_IPD.pdf
- [9] AIA California Council. (2007). Integrated project delivery: A guide. The American Institute of Architects (AIA), California Council.
Available at: https://info.aia.org/SiteObjects/files/IPD_Guide_2007.pdf
- [10] O. Wilson, (2014). The Owner's guide to starting integrated building projects Amazon Distribution, Leipzig, Germany (ISBN-13: 978-1499627329).
- [11] Lichtig, A. William (2006). The Integrated agreement for lean project delivery. Construction Lawyer, Volume 26, Number 3, Summer 2006, página 25, American Bar Association.
Available at: <http://heinonline.org/HOL/LandingPage?handle=hein.journals/conlaw26&div=31&id=&page>
- [12] O. Matthews & and Howell, G. (2005). Integrated project delivery an example of relational contracting. Lean Construction Journal Vol.2, April 1st.2005.
Available at: http://www.leanconstruction.org/media/docs/lcj/LCJ_05_003.pdf
- [13] R. Agarwal, S. Chandrasekaran, and M. Sridhar (2016). The Digital Future of Construction. McKinsey & Company, Voices, October 2016.
Available at: <http://www.globalinfrastructureinitiative.com/sites/default/files/pdf/The-digital-future-of-construction-Oct-2016.pdf>
- [14] B. Succar, W. Sher, and A. Williams (2013). An integrated approach to BIM competency assessment, acquisition and application. Automation in Construction, Vol.35, Pags. 174-189.
Available at: <http://www.sciencedirect.com/science/article/pii/S0926580513000836>
- [15] E. Pellicer Armiñana, A. Sanz, B. Esmaili, & K. Molenaar (2014). Comportamiento colaborativo en el sector de la edificación español: Análisis preliminar de los datos. 18th. International Congress on Project Management and Engineering, Alcañiz, Spain, Pags. 0789-0798.
Available at: <http://www.aepro.com/index.php/en/repository/funcstart-down/4188/>
- [16] The Project Management Institute (PMI). (2013), PMBOK Guide, 5th. edition, ANSI/PM 99-001-2013. The Project Management Institute, Pennsylvania, United States of America (ISBN: 978-1-935589-67-9).
- [17] Soler-Severino, M. (2013). Manual para la dirección integrada de proyectos (project & construction management). Colección MeDIP. Editorial Mairea. Madrid, España (ISBN: 978-84-941569-3-9).
- [18] X. Brioso, (2015). Integrating ISO 21500 guidance on project management, lean construction and PMBOK. Procedia Engineering, 123 (2015) 76 – 84.
Available at: <http://www.sciencedirect.com/science/article/pii/S18777-05815031616>.
- [19] AIA Minnesota, School of Architecture. (2012). IPD case studies. The American Institute of Architects (AIA).
Available at: http://rp.design.umn.edu/resources/documents/IPD-Case-Study-Matrix-2012_corrected02.pdf
- [20] The Economist. How to build more efficiently. The construction industry's productivity problem. And how governments can catalyze change. The Economist, UK, August 17th., 2017.
Available at: <https://www.economist.com/news/leaders/21726693-and-how-governments-can-catalyze-change-construction-industrys-productivity-problem>

WHAT DO YOU THINK?

To discuss this paper, please submit up to 500 words to the editor at bm.edificacion@upm.es. Your contribution will be forwarded to the author(s) for a reply and, if considered appropriate by the editorial panel, will be published as a discussion in a future issue of the journal.