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# Connect & Construct Building Value through ICT

How SMEs can build on ICT to better participate in the Construction Industry supply chain

*Enterprise and Industry*

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Luxembourg: Publications Office of the European Union, 2014

ISBN: 978-92-79-43173-9
doi:10.2769/50446

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Printed in Belgium.

PRINTED ON ELEMENTAL CHLORINE-FREE BLEACHED PAPER (ECF)



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**Acknowledgements**
This publication is produced by the consortium of the Connect & Construct initiative and its members would like to express their thanks to all stakeholders involved in the project, especially participants in the pilots and governance group, the members of the Connect & Construct Advisory Group, the members of the Connect & Construct Expert Group and the European Commission DG Enterprise and Industry for their valuable support, feedback and contribution throughout this action.

Connect & Construct consortium partners: Capgemini (lead), Athens University Economics and Business, Arcadis, Bycon Associates, Alliantis, Stú-k and Public Cinema.

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www.connectandconstruct.eu

# FOREWORD

## BUILDING ON ICT TO CONNECT SMEs IN THE CONSTRUCTION INDUSTRY SUPPLY CHAIN

Europe's small and medium-sized enterprises (SMEs) and the challenges they face are at the centre of the European Commission's attention. As President Juncker said in his opening statement at the European Parliament last July, SMEs are the backbone of the EU economy, being the main source of growth and creating 85% of new jobs in Europe. They will provide the innovative products and services of the future to address an important number of societal challenges.

Information technology is one of the strongest drivers of competitiveness, innovation and change in our modern economy and holds significant potential for smaller enterprises. Indeed, European SMEs grow two to three times faster when they embrace the Digital Economy[1]. Information technology cuts across all sectors of the economy; in fact, more than 75% of the value added created by the Internet economy is in traditional industries. Its greatest force lies in the modernisation of traditional activities, leading to higher productivity levels. In parallel, industrial value chains are becoming more and more sophisticated and globalised. The competitiveness of SMEs increasingly depends on their capacity to better connect to larger enterprises and become part of global value chains.

President Juncker stressed the importance of the Digital Market and has set the objective of creating a Connected Digital Single Market in the course of the new Commission's mandate. This will generate up to EUR 250 billion of additional growth in Europe, creating hundreds of thousands of new jobs, notably for younger job-seekers, and a vibrant knowledge-based society.

The new Directorate-General for the Internal Market, Industry, Entrepreneurship and SMEs will play a key role in its creation, particularly by ensuring that companies can take advantage of IT tools to develop their business across the EU and that consumers can have access to goods and services wherever they are in Europe.

The European Commission has been working to improve the efficiency of the EU business environment through the smart use of ICT. The implementation of the "Small Business Act" for Europe is on track and this initiative will be updated in 2015.

In 2008, the Commission launched an EU initiative to promote the smart use of ICT and the integration of SMEs in global industrial value chains. The objective is to lead the modernisation of industrial value chains through the smart use of information technology and offer SMEs better access to global markets. This initiative is a key step towards the integration of SMEs in the Digital Single Market.

The Connect & Construct demonstration action is the last part of this initiative. Conceived to promote a common framework for seamless and interoperable information exchange and a wider uptake of ICT, this initiative will enable European companies operating in the construction industry, (and, in particular, SMEs) to use ICT more effectively.

I am extremely pleased about and welcome the initiative of signing a Memorandum of Understanding among representatives of governmental organisations, non-profit organisations / educational institutions, private software companies and construction industry companies to further promote and extend the benefits of this action. This type of public-private partnership projects should lead the transition from a demonstration phase to mass market deployment and uptake of ICT.

**Daniel Calleja**
Director General of DG Internal Market,
Industry, Entrepreneurship and SMEs

1 *Source "Internet Matters, Essays in Digital Transformation, McKinsey & Company, 2012"*

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# FROM BRICKS TO CLICKS!

To succeed in the digital century, construction companies need to embrace more ICT and use it more innovatively. Construction today should be more than bricks and paper: more advanced ICT tools provide many ways in which the construction supply chain can work more effectively and efficiently. This is important, as the construction industry plays a fundamental role in the European economy and for employment: in 2013, the European construction industry generated 8.8% of total EU-28 GDP and provided 6.4% of total EU-28 employment.

The construction industry supply chain covers a wide range of value-adding activities from the initial expression of the client's request, all the way through design, contracting, construction, operation and maintenance, and through to refurbishment/ replacement and de-commissioning/demolition and site rehabilitation.

The standard business model involves no integration at all or a main contractor acting as a system integrator with sub-contractors. The use of sub-contracting is in fact a key feature of the industry.

The chart on the next page illustrates all this in more detail. It also shows how the situation is expected to evolve between now and the end of the decade. SMEs will remain the backbone of the industry, regulation will increase and competition will remain fierce. However, relationships will become more collaborative and projects more integrated.

"The construction industry is moving slowly. By using ICT more effectively, the construction industry will achieve what it needs the most: to be more efficient, more cost-effective and at the same time to deliver safer and more successful projects."

**Nikiforos Galanis, Embiria Consulting**

# CHARACTERISTICS OF THE CONSTRUCTION INDUSTRY

| MARKET CHARACTERISTICS | CURRENT BUSINESS LANDSCAPE | FUTURE OUTLOOK (2020) |
|---|---|---|
| PRESENCE OF SMES | • Strong presence of SMEs<br>• SMEs act as subcontractors selected on the basis of cost/price<br>• SMEs operate typically at local or regional level | • Strong presence of SMEs<br>• Emerging types of specialised SMEs (e.g. sustainable construction, energy efficiency, smart materials, waste management) competing mainly on the basis of specialised services/offering<br>• Broader geographical presence and larger size of certain specialised SMEs |
| DEGREE OF REGULATION | • High levels of regulation for energy and environment, labour requirements, standardisation, and service/product quality standards | • Higher levels of regulation of terms of competition, energy, environment, workforce welfare, and quality of services<br>• Harmonised regulation of cross-border competition<br>• Customised rules reflecting local conditions in different markets |
| COMPETITION | • Fierce<br>• Price-based<br>• Only leading designers and consultants, and large construction companies compete at international level | • Fierce<br>• Value-based (with price considerations)<br>• Delivery of environmentally sustainable construction solutions offering value over their lifecycle (total cost of ownership)<br>• Balance between economic efficiency and environmental sustainability<br>• Increased internationalisation of business environment and competition for specialised SMEs and suppliers of (smart) construction materials |
| TYPES OF RELATIONSHIPS | • Short-term relationships<br>• “Opportunistic” relationships<br>• Lack of trust and commitment | • Longer-term relationships<br>• Less “opportunistic” relationships<br>• Increase in trust and commitment |
| BUSINESS MODELS | • “System integrator” (main contractor) coordinating multiple “satellite” actors (subcontractors)<br>• Mainly traditional (non-integrated) contracts | • Increase in PPPs and voluntary, collaborative relationships<br>• Increasing use of integrated contracts |
| USE OF SUBCONTRACTING | • Extensive<br>• Price-based | • More extensive<br>• More specialised<br>• Less price-based |



In moving towards more effective use of ICT, the construction industry is currently facing some serious challenges in the process of data and information exchange. These challenges generally fall into one of four categories:

➜ **Semantics**: In this context, this means that construction companies do not use the same modelling standards, do not define terms the same way, and store and present the same information differently. This is a barrier to exchanging information digitally; humans have to get involved in order to interpret the information. Information from different sources that needs combining may have to be dealt with manually.

➜ **Data formats**: There is no common format for exchanging data. In most cases, the data format incorporates the semantic definitions. In that case, the data format is not universally applicable. There are generic formats available, but commercial software packages often do not adhere to them strictly. This leads to a loss of information.

➜ **Data exchange**: Other issues that can hamper exchange of data include the fact that file sizes are often large, too large to be sent readily by e-mail. Sending them by e-mail may also not be secure enough. If the information is delivered on paper or as a PDF, a dimension may be lost. A one-dimensional drawing on paper is not the same as information-rich 2D or 3D models.

➜ **Processes**: Often it is not clear who should be delivering what information, when, and to what level of detail. In addition, problems often arise from lack of version control, not paying enough attention to change management, failing to track commonly used files, and duplicating the storage of files and information. All of these are potential sources of errors. The results are delay, additional costs and “friction” along the construction supply chain.

The construction industry mainly exchanges information by e-mail, but this often cannot cope with the large files needed for 3D models and visualisations, for example. But using one-dimensional documents and PDFs is just not the same. In addition, companies often use different definitions and different formats, so someone has to spend time interpreting the information.

## ICT USAGE HAS CLEAR BENEFITS, BUT UPTAKE REMAINS LOW

**The construction industry supply chain could clearly benefit from using ICT more as this would save time and money, and lead to productivity gains, increased competitiveness and capacity to innovate. The solutions exist, but this industry still has one of the lowest levels of ICT uptake of any. Moreover, market analysis for the Connect & Construct project not only confirmed that uptake is low, but that the smaller the company, the less likely it is to be using ICT.**

**The main barriers to ICT adoption include the initial cost. It is not seen as affordable. In addition, the solutions available are not always user-friendly or not suitable for customisation. They are not necessarily interoperable with other solutions. And finally, those who work in the construction industry supply chain are often not really aware of what ICT can offer and lack the necessary expertise.**

# CONNECT & CONSTRUCT (C&C): THE FRAMEWORK

There are ICT solutions available to address the problems the construction industry currently has in exchanging data without losing information or needing to interpret it. However, SMEs often do not have the resources to buy and use them.

Connect & Construct has therefore developed, demonstrated and validated a ready-to-use, free-of-charge framework for digital collaboration. It provides all the functionalities the industry could need in a one-stop web interface, which relies on open-source software and open standards.

**Figure 1** shows where the Connect & Construct Framework sits at the interface between the tools and standards currently available and the construction industry.

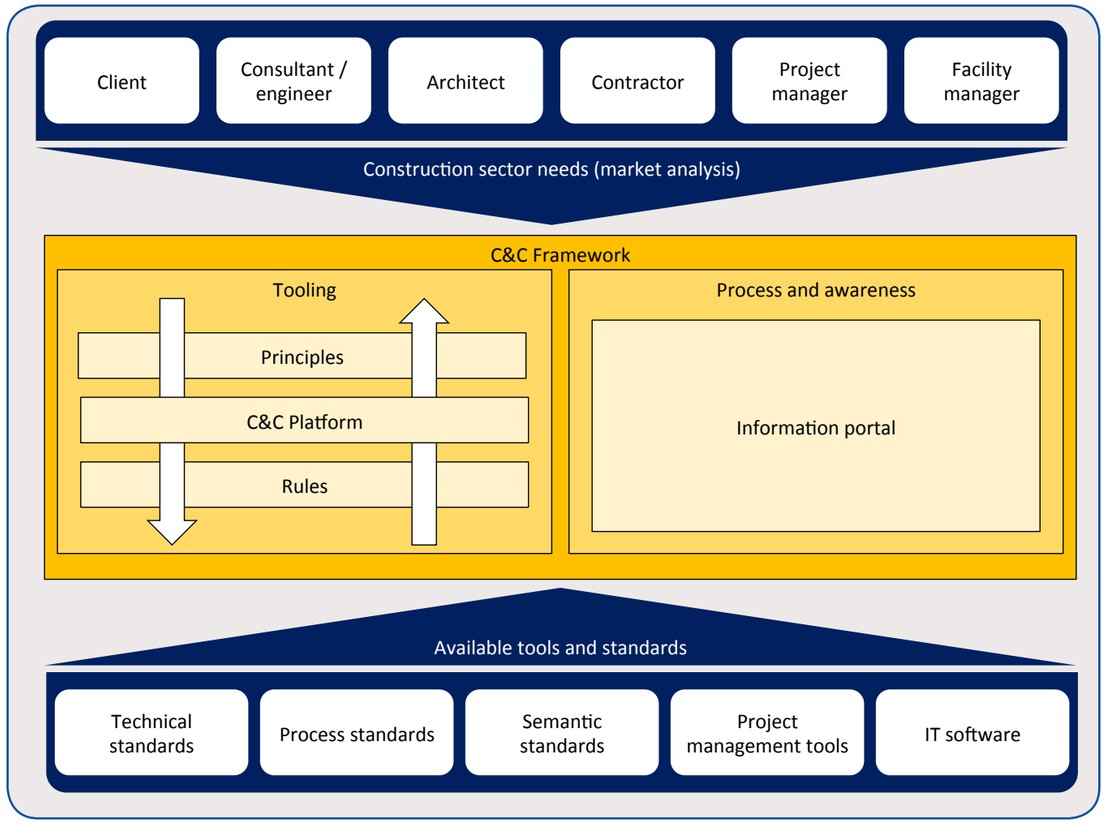
The framework breaks down the barriers to ICT usage. It does this in three ways:

(1) It applies a set of **principles and rules** to use when exchanging information digitally.

(2) It uses a **reference implementation** to demonstrate that it is possible to develop easily accessible tooling using ICT solutions that are already on the market. This reference implementation is called the **C&C Platform**. The platform has demonstrated that it is possible to provide the functionalities needed to exchange construction information digitally using any operating/ICT system and without the need for large investments or advanced knowledge of software development.

(3) It includes an **information portal** to increase the awareness of construction companies, and in particular SMEs, of the benefits of digital information exchange. It shows them how to adapt their business processes so they can collaborate online, and how to use ICT, and related standards and protocols, to their advantage.

*Figure 1*






# C&C: PRINCIPLES AND RULES

The work done under the Connect & Construct project all relates to a defined set of principles and rules. These principles and rules describe the basis for digital exchange of information in a project environment.

The C&C principles define structural conditions for effective digital information exchange, regardless of the ICT systems used.

The C&C rules elaborate on these principles at a more practical level. They describe in detail what the different parties need to define and agree on before starting to exchange information digitally.

This is not a completely new set of principles and rules. Existing open standards and protocols are the foundations, but they have been further developed, i.e. these existing principles and rules are now more readily accessible for construction companies wanting to apply them in daily practice. Information that is already available has been made much easier to apply.

Thus, the Principles and Rules describe how internationally recognised standards and protocols should be used if a construction industry supply chain player wants to exchange information digitally in a project environment. The Connect & Construct Platform then translates the principles and rules into operational tools.

These Principles and Rules make it possible to:

- define roles, milestones and draw up a project schedule at the start of a project;
- apply existing (open) standards and protocols.

## C&C PRINCIPLES

- Determine employer's / client's information exchange requirements and key decision points
- Make clear agreements among all the players involved in the process on what information is to be exchanged digitally when, and how
- (Preferably) Set out these agreements in contracts
- Etc...

## C&C RULES

- Determine the file name structure
- Determine a file folder structure (to be included in the online storage platform)
- Determine an identification structure (what identifiers will you use for specific information, e.g. ways to define an object and its characteristics)
- Determine a versioning/change to structure
- Etc...

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# C&C: PLATFORM

The Principles and Rules lie at the heart of the Connect & Construct Framework and have been used to build the C&C Platform. The platform was developed to prove that these principles and rules for digital information exchange actually do add value and are easy for existing enterprises to apply. The C&C Platform is what is known as a reference implementation of the C&C Principles and Rules. The architecture of the C&C Platform contains the following elements:

- **Document Management System (DMS)**: a central storage system with an unlimited file size;
- **Model server**: a server for central storage of IFC models (the open standard for 3D construction models);
- **Web interface**: an Internet connection is all that is needed for users to be able to upload, download and view information stored in the DMS and the model server, or to access pre-defined project management templates.
- **Service interface**: an interface enabling users to upload, download and view information stored in the DMS and the model server using their own companies' software.

"Do not use complicated software solutions, but make the relevant information accessible to everybody at any time during the process. The C&C Framework makes sure everybody knows what to do and when."

Aart van der Vlist, BIM Full Circle

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# C&C: INFORMATION PORTAL

SMEs often find it difficult to use ICT not because there is no information available, but because they cannot find their way through the mass of information to the right information: what should I use when and how? Providing the answer is crucial in helping construction supply chain companies become 'more digital'.

To fill this gap, this project developed an information portal consisting of a self-assessment tool and an information section. This portal helps organisations to find the right information when taking their first and next steps in ICT adoption. It provides useful information for becoming 'more digital' and guidance through the maze of ICT standards, communication protocols, initiatives, and other.

SMEs can use the self-assessment tool for a 'digital maturity check' and to obtain tailored advice on how to make better use of ICT.

The information section presents an overview of ICT information relevant to the construction industry.

"Construction companies are currently struggling with the adoption of BIM in their way of working. They need pointers in how they can handle this in their organisation. In that respect, this information portal is very useful."

Albert Trip, Meander Hospital

# HOW THE C&C FRAMEWORK WORKS IN PRACTICE

Exchange information faster, waste less time on coordination, reduce errors and failure costs – what is not to like? It all sounds fantastic on paper but does it really work?

This is a more than valid question for every construction industry company to ask. To provide a clear view on this, the Connect & Construct Framework was successfully piloted in more than 25 pilots in 2013 and 2014. The pilots covered a multitude of real-world projects in every phase of the construction lifecycle and involved a number of European countries.

Figure 2 provides an overview of the countries covered during the pilots.

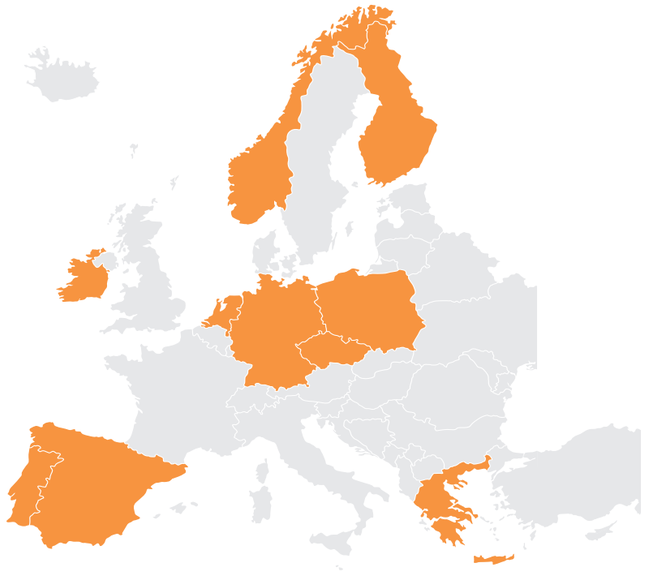


*Figure 2*

"Projects will be better, quality will be better, costs will be lower and transparency will increase."

Albert Trip, Meander Hospital

"The platform streamlines the process and gives you the quality and consistency of information that you are managing."

Paul Boireau, BIM Solutions Centre

"The C&C Platform provides a single point of reference for many groups working together. It is very useful in particular for SMEs working at pan-European level."

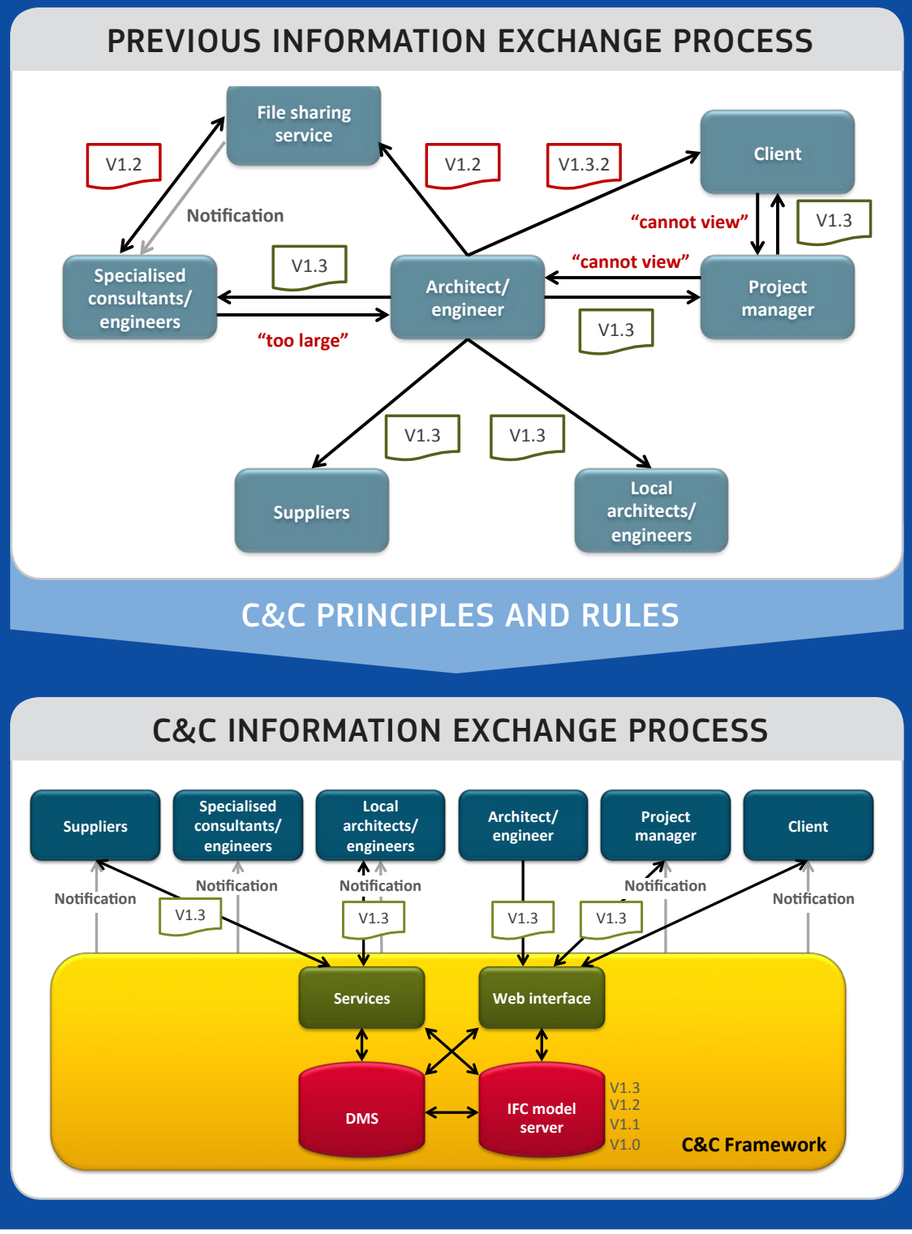
Nikiforos Galanis, Embiria Consulting



In the past, many construction supply chain players working on the same project exchanged relevant information between each other but not among all players. This resulted in fragmented information exchange. There was no alignment on the standards to use or on the way to exchange information. This caused problems with files being too large to exchange by e-mail, use of standards and formats that some players could not view, and companies working on the wrong versions of documents.

Now, using the C&C Framework, the same players use a single platform to exchange information that is uniform. This single platform, which is easily accessible via the internet, provides up-to-date and complete information to everyone involved at all times and in the agreed format.

*Figure 3*



# WHAT ARE THE BENEFITS?

## RESULTS OF EUROPEAN PILOTS

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The pilots run during this project were all thoroughly evaluated with the participants – with very good results. More than 75% of the pilot participants were strongly positive about the usefulness and the user-friendliness of the platform. In addition, 72% would recommend the platform to their business partners. More importantly, the platform was considered to have had a major positive impact on both reliability and efficiency of data and information exchange.

Reducing the error rate and saving time were seen as the greatest benefits from exchanging data and information via the platform.

Errors account for 30% of total costs: accurate information exchange can make a significant difference. The C&C Platform reduces the number of mistakes because all the relevant information from different sources and in different formats is complete and up-to-date, and it is stored in a single place that provides a complete overview of the latest status.

The time needed for project management can also be significantly reduced by working in accordance with the Connect & Construct Framework.

Pilot participants are enthusiastic about this platform because it provides easy access to the world of open standards and protocols, while the project management templates provide easy- and ready-to-use tools at the start of a project.

More than half the pilot participants cut their error rate by more than 15%; more than half also said they saved more than 15% of the time they usually need thanks to this framework.

"We are reducing the number of mistakes, we are reducing the time needed for administrative procedures and we are even enhancing the projects. Using the C&C Framework means we can share more information with less effort."

**Alfons Civit Martinez, Territori + Arquitectura**



# KEY ACHIEVEMENTS

## C&C Platform

**75%** of the users were satisfied with the functionalities and security performance of the platform.

Over **80%** found the platform very easy to use; **75%** needed fewer than 5 hours to become familiarised with the platform.

Overall, **50%** achieved time savings of more than 15% and reduced the number of errors in their projects by more than 15%.

The more experienced users became, the easier obtaining major benefits became: **63%** of novices, **80%** of intermediate users, and **100%** of the advanced users reduced the time they spent on projects and the number of errors in their projects.

**70%** want to continue to use the platform after the project; **55%** would recommend the platform to their business partners.

More than **70%** believe that the platform will contribute to a more competitive and efficient construction industry.

## Information portal

**65%** gained a better understanding of digital information exchange through using the information portal.

More than **85%** found the information portal easy to understand and simple to use.

More than **50%** said using the self-assessment tool had led to an increase in their digital maturity.

More than **80%** would recommend the information portal and self-assessment tool to their business partners.

A Dutch architect benefited from the C&C Framework during the building of a home for the elderly in the Netherlands. The complete project was engineered and executed using the principles and rules of the Connect & Construct Framework. Because the Connect & Construct Framework was used during the design phase, the firm was able to place the major air channels in the crawl space. This meant that there was room for the suspended ceilings on the floors to be higher.

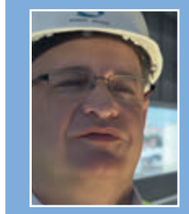
The project involved many players, but via the Connect & Construct platform they all had access to all the relevant documents at all times during the process. This was a key success factor, which saved significant amounts of time which would otherwise have been wasted waiting for information from other players. There is no need for complicated software solutions; what is critical is to share relevant an up-to-date knowledge.

"The Connect & Construct Framework offers many possibilities for the future, notably in making working together more efficient, increasing professional pleasure and improving customer satisfaction.
We encountered these advantages during our pilot with the Connect & Construct Framework. Use the economic crisis to implement this new way of working and it will increase your future profits!"

Aart van der Vlist, BIM Full Circle

A Spanish building supervisor involved in the rebuilding and expansion of a three-storey school of over 2000 $m^2$ faced the challenge of information transfer between the different (Spanish) players during a project complicated by the fact that the school remained open as normal during the work. In what order should the instruction be givens? How should documents be distributed across all the companies involved? How could visualisation of BIM-models be achieved and made accessible to anyone who needed them?

The Connect & Construct Framework was used for the architectural aspects of the work on the building and to make choices before the work on the construction site started. Everyone had access to the same integrated information. The IFC 'library' on the platform provided visualisation of the BIM models used. A lesson learned was that training in understanding and using the opportunities of the Connect & Construct Framework fully is a key success factor.



"The possibilities of Connect & Construct are amazing. It is a great tool for information distribution and it makes precisely coordinated continuation of construction projects possible."

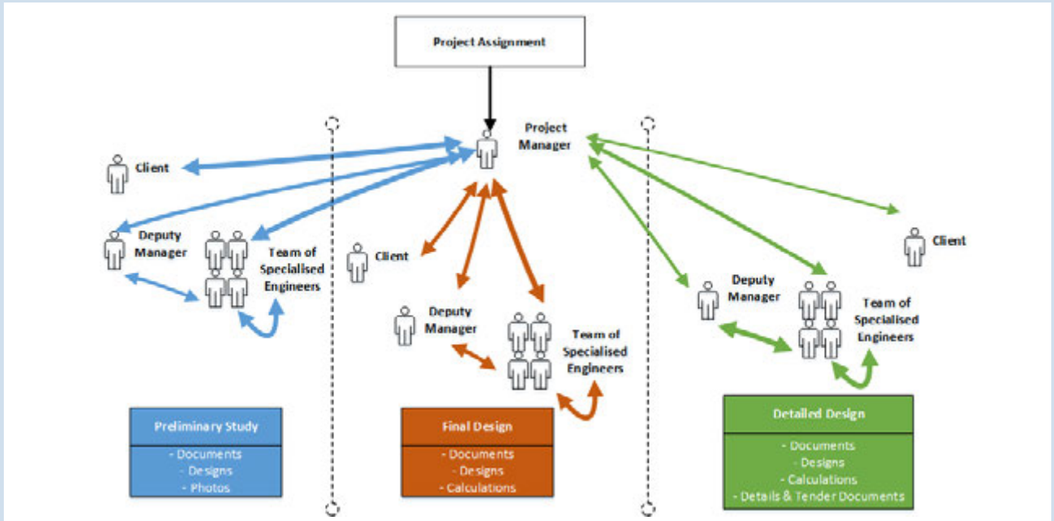
Manuel Bouzas, easyBIM

"Using the C&C Framework reduces the uncertainty that comes from communication failures."

Nikiforos Galanis, Embiria Consulting

Using the platform enabled them to replace their existing communication and data flows with a digital exchange process. By doing this, they could assess the degree to which a more sophisticated, ICT-enabled data exchange process would reduce communication and response time while at the same time increasing the accuracy, reliability and above all, efficiency of their project.

Construction projects involve exchanging a great deal of information and data. In this particular project, it is possible to identify three phases: i) preliminary study, ii) final design, and iii) detailed design. Different types of information and data must be exchanged with many different parties at each stage. In addition, there are often many feedback loops to adapt the design to the wishes of the client. These adjustments require a high level of interaction between many parties as each may impact substantially on another's work. The figure gives an overview of the workflows during such a construction project.




## The role of the platform

In this project, the platform did not replace existing workflows, but made them more efficient. Communication that was previously one-to-one or one-to-many (for instance via e-mail or conference calls), was replaced by many-to-many. All the information was available in one place and this enabled easy communication across all parties accessing the same information at the same time.

## The benefits of the platform

The main benefits of using the platform were savings in time from more efficient workflows, reduced interaction between one or more parties, and fewer errors. It took some time to set up (1-2 hours) and required some additional effort to get to know the system (3-5 hours), but use of the platform cut the total number of days needed for the project by 20 (a 10% reduction). This was equivalent to saving EUR 5 000-6 000 on this project or some 11% of the total project cost.

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# PAVING THE WAY TO THE FUTURE: STAY CONNECTED!

The C&C philosophy will live on beyond the end of the two-year project. A Connect & Construct governance group takes over from the Connect & Construct action from 2015. It will be made up of representatives of government organisations, non-profit organisations/ educational institutes, private software companies and construction industry companies.

A Memorandum of Understanding (MoU) underpins the work of the governance group. By being part of this group, these organisations endorse the significance of the continuation of the Connect & Construct Framework and its philosophy.

The members of the group are committed to contributing actively to the governance by periodically updating the C&C principles and rules and by signalling to the market the importance of uniform requirements for the digital exchange of information in the construction sector.

They have also undertaken to unite a number of their peer organisations in Europe behind the framework in the years ahead and actively to disseminate the philosophy of the Connect & Construct Framework.

These organisations recognise the value of the Connect & Construct Framework for the digital exchange of information and as a sound basis for the development of new ICT solutions.

Stay connected via the website ***(www.connectandconstruct.eu)*** to familiarise yourself with the latest Connect & Construct developments now and in the future!

## THE ULTIMATE GOALS OF THE C&C GOVERNANCE GROUP ARE TO:

- raise awareness of the C&C demonstration action results;
- stimulate the uptake of the C&C Framework in all 28 countries of the European Union;
- promote new projects and innovative solutions on the basis of the C&C Framework;
- maintain and update the C&C Framework on the basis of market developments;
- create a common vision on the future role of ICT in the construction industry.

NB-04-14-905-EN-C

ISBN 978-92-79-43173-9

doi:10.2769/50446

Publications Office