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Low Carbon Airport projects development using the Design Gap Risk Threshold approach

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The paper discusses why to adopt a new method called Design Gap Risk Threshold to tackle communication process in the project team. The state of practice in airport projects in Italy has been compared with the Chicago O'Hare green renovation project. The results show that design team are lacking of proper communication management to allow the integrated design needed to achieve sustainability goals. Results have been applied in degree thesis and airport design competitions. The most relevant result of the research was about organisation: the project success depends upon the design process that goes towards communication processes full integration.

Keywords: design gap risk threshold, low carbon airports design, life cycle design, design communication management, collaborative design

1 The Life Cycle Thinking in airport design and the Design Gap to be faced

The issue addressed in the research is about methodologies and tools for Life Cycle Thinking (LCT) in airport design. It's demonstrated that structured design communication processes play an important role in enabling Low Carbon Building (LCB) targets. The research tackles, through the current ISO 9001 organisational requirements needed for ISO 14040 and EMAS standards, the design team capability to demonstrate sustainability in their project design. According to the more diffused guidelines for organisation in AEC services structured communication processes in project design are identified in three groups: *planning, management and control*.[1] The LCT method point to higher airport performances to face environmental problems influenced by Sky Industry. It requires the project design requirements integration and basically asks for an improvement of the Level of Service (LOS).[2] The industrial problem arisen from the Life Cycle Design (LCD) is not taken into account in former models. Quality of information in terms of creation, manipulation and transmission about materials, components and systems and about robust details is required. The UK Government's online portal for planning and regulation resources is one first answer to such demand by the project stakeholders. The organisational model of the project team has to be also modified in accordance to have more structured communication processes within the group. Collaborative design technologies can take place at this stage enabling the integration capabilities. The problem to face can be referred to the broader industrial problem of the Design Gap in Construction as it has been identified in the literature.[3] The Design Gap is a concept that expresses the lack of performances achievement by the project. It's for example a project process output which doesn't meet the client/customer and/or the user requirements

1 UNI (2005). UNI ISO 10006:2005 Quality management systems - Guidelines for quality management in projects. Milano
2 Trasportation Research Board (TRB) (2011). ACRP Report 55, Passenger Level of Service and Spatial Planning for Airport Terminals
3 Egan J. (1998) Rethinking Construction: The report of Construction Task Force, Department of Trade & Industry, London

4 ibid
5 Daley R.M. (2010). Chicago Climate Action Plan, Our City, Our Future, Progress Report, Chicago

whatever in the life cycle. This concept represents in the Quality Management literature the so call non-quality of the product in terms of customer and/or user expectation (satisfaction). Problems rising from Design Gap seem critical both for quality of the product itself (by the resulting fabric) as well as for the expectations of sustainable behaviour of the building in its life service. In UK it has been estimated that between 1994 and 1999 the quantitative, qualitative and economic impact of design errors amount affect around 87% of projects.[4] Troubles are arising from all design steps: the Planning stage, the Design brief, the Schematic Design, the Design Study, the Review of contract, the Constructability/Site Work and Construction Design documents. The research, starting from this point, explores the causes of the Design Gap and it seeks to address the question of what and how the project groups are able to embed and take advantage of the available collaborative design technology. We've analysed in detail how communications are handled by the design teams in Construction Documents stage; we've tried to identify ways and means to improve efficiency and achieve the requested LCB performances targets set.

2 New scenario perspectives for the Construction Industry

The Construction Industry stakeholders are today facing new challenges: global climate and non renewable resources warning are reflected on the local operating levels, technological innovation is very quick, in the international markets new trends occur. This scenario will deal with acceleration in building changes. These are shown by two aspects: the organisational processes that will have to be reoriented with timeliness; the demand of innovative products which are green is on most people's radar. Recent action plans are adopted in US to push innovation: i.e. the Chicago Climate Action Plan started in 2008 set up 5 strategies to create awareness and also stimulate the market:[5]

- energy efficient buildings
- clean and renewable energy sources
- improved transportation options
- reduced waste and industrial pollution
- adaptation

These are the results in the first two years: 456 initiatives developed through 16 City departments and sister agencies to reduce emissions and adapt to change; 13.341 housing unit energy retrofit to be more efficient; 393 commercial and industrial buildings; 30.542 appliances; 20 million more Chicago Transit Authority rides annually; 35 million gallons of water saved by day; 1.8 million more green roofs installed; 120 green alley; 636 new car share vehicles available; 208 hybrid buses at CTA fleet; 508.000 gallons of alternative fuel used; 83% of construction and demolition debris recycled. The policy goal to further slow the effect on climate change of the City and region for the year 2020 is to achieve 25% below 1990 levels saving 15.1 million metric tons of CO_2. In particular the Chicago Department of Aviation's (CDA) green initiative and policies for O'Hare and Midway International Airports are guided by the CDA Sustainable Airport Manual (SAM). The SAM integrates sustainable planning and practices from design through construction, operation, maintenance and all airport functions and those of its tenants. Sustainability efforts of CDA date back to 2003, when Chicago began to modernise the city airport (OMP - O'Hare Modernisation Program). Major actions done until 2009 include: over 220.000 sq.ft. of green roofs to help Urban Heat Island Effect mitigation, energy saving, reduction of storm water run off, adopt a balanced OMP planning to avoid hauling away of several million of cubic yards of soil using these for landfill on the airfield, requiring the use of Ultra Low Sulphur Diesel Fuel in all construction equipment and retrofits for all existents ones for cleaner emissions, buy about 90% of construction materials within 500 miles or less (calculated regional benefits about 138 millions); recycling or reuse of 95% of all OMP construction – demolition materials including metals, wood, concrete, asphalt and gravel. As results the North Traffic Control Tower (NACT) at O'Hare International Airport has earned Four Green Airplanes[6] as well as Leadership in Energy and Environmental Design (LEED®).[7] In particular the innovative purpose by Green Airplanes score system is focused on not only *what* you built but *how* you built it. This was an up dated process view of the project that created a new Green Airplane Certificate award system. It took in one hand new technologies and best practices used by airports around the world and in another hand it's updated to correspond with the US-GBC LEED® 2009 for New Construction and Major Renovations Rating System. This way sounds also good for the economy, because it generates investments not only money saving. According to these aims we notice that the conventional Airport building process is sequential and it reflects the input of designers, constructors and key suppliers involved in cascade process. It's too slow to be re-oriented with timeliness. Furthermore contractual documents provide a definition of the chain much better on the contract side. This system is often a barrier to the effective use of green skills and suppliers know-how utilisation. Just like other standards the SAM is now required as part of all City Airport Contracts. SAM is introduced in the Request for Proposals Process; included in project kick-off meetings for design and construction; every design team is required to have a LEED® Accredited Professional on staff; designers submit SAM checklist at key design milestones for review (30%, 60%, 90%, 100%); contractors required to comply with sustainable construction specifications. Thus new organisational faster processes are needed: the literature shows innovative models like the networked ones. Such type of organisation asks for collaborative platforms based on faster, cheaper, multi-client and multi-directional and interoperable communication processes, which may provide customised information on demand. The resulting integrated design applied in the SDM (Sustainable Design Manual) by CDA in Chicago shows that constructors and suppliers may work joint in the projects to improve the results. In the research we noticed that the project organisation is increasingly central in all industries, because it allows the information as an engine for sustainable accomplishments in realisation. The production already appears now re-oriented to LCB, we must consequently pose the problem if the way the planning is managed can correspond to such vision or if rather it is necessary to adapt methods and instruments with other elements to accomplish sustainability.

6 The Sustainable Airport Manual Green Airplane Rating System consists of all the points available for each credit, by project category, for each check-list. The total points achieved vary on each tenant and scores can be used to determine the SAM Green Airplane Rating. It was presented at the American Association of Airport Executives (AAAE) 2009 Airports Going Green Conference [airportsgoinggreen.org]

7 LEED® buildings certification standards set up around the world by Green Buildings Council

3 Key enabling and emerging tools for Life Cycle Design and management

Looking at this scenario design technologies make available tools working in organisational systems set. These tools have a direct impact on the quality of process and product results in terms of performances. These can enable the capacity to reengineering the knowledge, not only the production chains. According to Carrara et al working environments for architectural design will allow the improvement of design quality of complex buildings mainly enhancing collaborative processes.[8] The Building Industry absorbs about half of world energy consumption. For that reason multidisciplinary nature of the design and construction process increasingly grows. As a consequence using classical design methods it's harder to achieve expected results in term of efficient solutions. Collaboration within project team it's still difficult if the design methods aren't changed. Kalay focuses the need to bring together what specialisation has dispersed, in the form of comprehensive data structures, fast communication and better data management methods.[9] The results, he says, however have been disappointing: these are unable to keep pace with the growing complexity of buildings, and along with it, the growing specialisation. The new challenge is to create a shared understanding within project participants (like in a jazz session) to achieve a joint decision making in technical solutions. Trento and Jeong discuss in their doctoral research how distributed collaborative model for linking semantics in multidisciplinary design will help the project information. Criticising the failed centralised data database model that quickly becomes too large, they purpose a distributed model.[10] New tools allowing the possibility to perform the parametric design it's necessary to reorganise the design process and project management, in function of the specific project goals, as it's shown by the application of SAM in airport terminal contractual requirements for design (Figure 1).

4 Field research and case study selection criteria

The investigation phase of the research was aimed to data collection about communication processes accordingly with ISO 10006:2005 Guideline for Quality Management Systems application to project. The case studies inquiry was focused on organisational issues (Plan, Do, Check, Act activities) through semi-structured questionnaires application. The aim was to investigate the communication processes problems that lay among different members of the design team.[11] Each participant of the design team has to develop specific tasks to be integrated in the design activities, despite belonging to different companies and being geographically dispersed. The final result in the airport design is that the project performances meet customer's/owner expectations. This may be achieved only by design integration as it's explicitly indicated in the recent Public Works Regulations in Italy.[12]

Different interfaces, corresponding to different professional profiles, interact during the project. The research has investigated them as significant indicators for the Design Gap Risk. The field research was on airport design as representative of the following aspects: the high standardisation and international definition of expected levels of sustainability performance;[13] the project planning with a strategic green view; the presence of different professionals figures with dissimilar background and expertise, and needed consultants of different disciplines in the team; the presence of a high level of complexity of the project. Another significant aspect, as mentioned earlier, is the fact that the green airport design is one of the few governed by international regulations also shared by all interested parties world-wide. Since the criteria that influence the LC design form today a common start-up point also for all projects in airport planning, we can assume that the re-

8 Carrara G. et al (2009). Collaborative Working Environments for Architectural Design, Palombi Editori, Roma

9 Kalay Y.E. (2004). Architecture's New Media : Principles, Theories and Methods of Computer-Aided Design, The MIT Press, Cambridge Massachusetts

10 Trento A. & **Jeong Y.,** (2009). A distributed collaborative model for linking semantics in multi-disciplinary design. In: Carrara G., Fioravanti A., Kalay E.Y. Collaborative Working Environments for Architectural Design, Palombi Editori, Roma

11 UNI (2005). op cit, p 7.6

12 d.P.R. 5 Ottobre 2010, n. 207 Regolamento di esecuzione ed attuazione del decreto, legislativo 12 aprile 2006, n. 163, recante «Codice dei contratti pubblici relativi a lavori, servizi e forniture in attuazione delle direttive 2004/17/CE e 2004/18/CE». (G.U. n. 288 del 10 dicembre 2010)

13 ICAO/IATA advisory directives and UE Sky Industry regulation sults of the research can take value beyond the borders of one country and of a continent too. The selection of representative case studies was a direct result of a brief investigation on all Italian airports to identify the design projects considered significant for the research. It has been gathered information about the type of design project carried out in each class of airports (hub, regional, local, excluding fly surfaces), the type of bid or contract, the professional skills involved in the design phase and their tasks (see the following paragraphs on the analysis). It has been also collected data regarding the number of movements, the passengers and goods flows in the last three years. Given defined sampling criteria, the projects were selected involving the following Italian airports: Torino-Caselle (TRN); Brindisi-Casale (LIBR); Catania-Fontanarossa (CTR); Napoli-Capodichino (NAP). For comparison we've analyzed the green renovation project of the international airport of Chicago O'Hare (ORD) Ill., US.

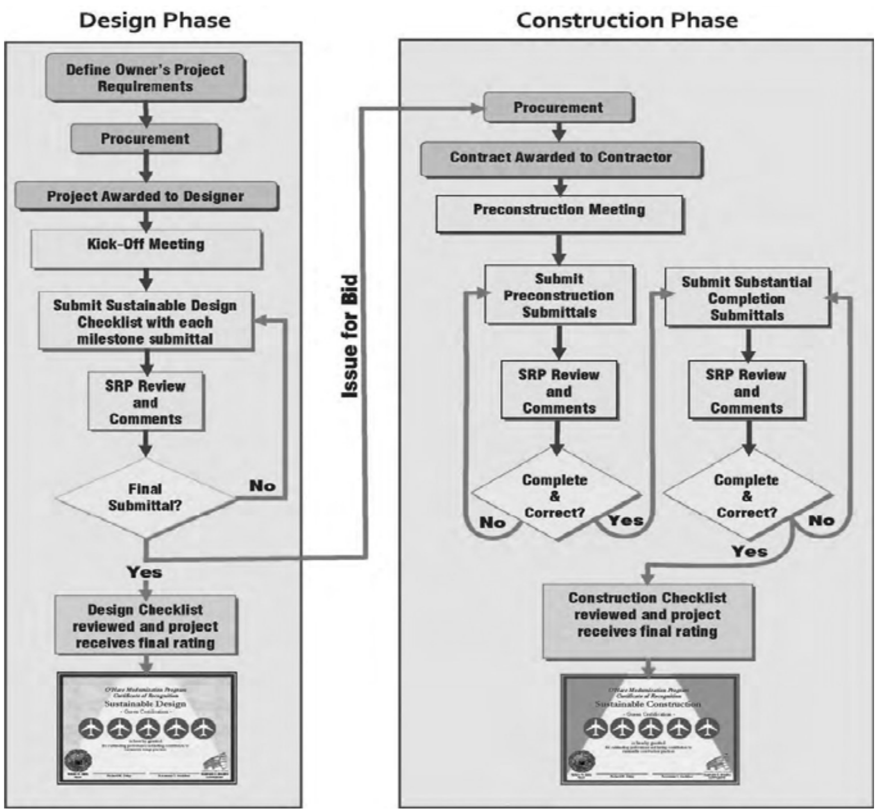

Figure 1 Project flow accordingly with the CTA's SAM (revised 2009)

5 Features of passenger terminal design analysis

Given the above mentioned warning scenario the investments needed to adapt the terminal and to maintain the structure at acceptable standard levels regards more and more the goal. It's going to happen in a relatively quick time range if it's compared to almost all other types of buildings, as the O'Hare International Airport renovation project demonstrates. The passenger terminal is the cornerstone of the airport system and it defines its architectural image; combined with

14 Edwards B. (2005). The Modern Terminal: New Approaches to Airport Architecture, Spon Press, New York

the quantity and quality of offered services, it's the most crucial aspect in the architectural design of this type of facility. The project quality is evaluated in terms of compliance to meet the implicit and explicit customer, airline companies, owner company and, obviously, passengers requirements as well as to their implicit expectations. Indeed one of the most important to all participants today are sustainability issues. Lack of LOS (if confronted to standard classes are functionally inadequate or poorly equipped) are instead very negative for the efficiency of the terminal and thus decrease the competitiveness and earns of the infrastructure. The number of passengers using the plane for business or vacations is constantly growing and airport owner companies have to plan investments with a long-term strategy based on estimated passenger traffic flows. However, given the rapid technological trends (for example development of aircraft design) these investments needed to adapt the terminal and to maintain the structure to acceptable standard levels regards more and more the goal to decrease its environment impact. Often these interventions, which include the maintenance, the renovation and the new construction of some new part of the passenger terminal, take place with time intervals significantly lower than the average duration of the natural life of the part object of the work. That means that the input for the start of a new design cycle is not given by the obsolescence of an item, given the simply lack of performance, or by the life cycle end. The design process start moves from commercial, operational and management needs or basically on the rise of new requirements as well. These are often imposed by legislation or new trends like the green leadership challenge shows. The BAA (British Airports Authority) has estimated that the average Life Service of airport facilities shall be: 100 years, for runways, taxiways and aircraft parking; 50 years, for transport networks, interconnection of roads and the terminal building (as a whole and evaluated for its functionality); 20 years, for equipment and systems of transport of passengers; from 5 to 20 years for plants; from 5 to 10 years, for offices; from 3 to 5 years for shops, bars and restaurants. For the terminal design the requirements include the creation and development of flexible architectural concepts, the design of compatible and more sustainable technological solutions. Airport owner companies need to build or renovate the terminal with time subsequent upgrading without affecting the terminal operation and good functionality (Figure 2).

In order to answer to this complex set of needs it is necessary to conceive a new method for terminal design. That has to be based not only on flexibility but also on the adaptability and "ability to replace".[14] It is also to be referred to environmental friend processes and products (LCT). To address all these needs is essential to think the whole airport terminal as a set of fixed and stable elements (for example structure, plants, etc.) and of parts which are subject to change in a smaller time frame, such as internal partitions, equipment and furnishings. The subsystem that we have focused in the research regards in particular the terminal envelope requirements. That's the more interesting part from the LCB issues applied to the PAX terminal. The questionnaire was divided in 3 parts containing the analysis subsets as is described in the following paragraphs.

15 Landrum & Brown (2009). Airport Passenger Terminal Planning and Design, TRB (Transportation Research Board), National Academy of Sciences, Washington DC [www.TRB.org]
16 1995-2006, Helmut Jahn, Murphy/Jahn Architects

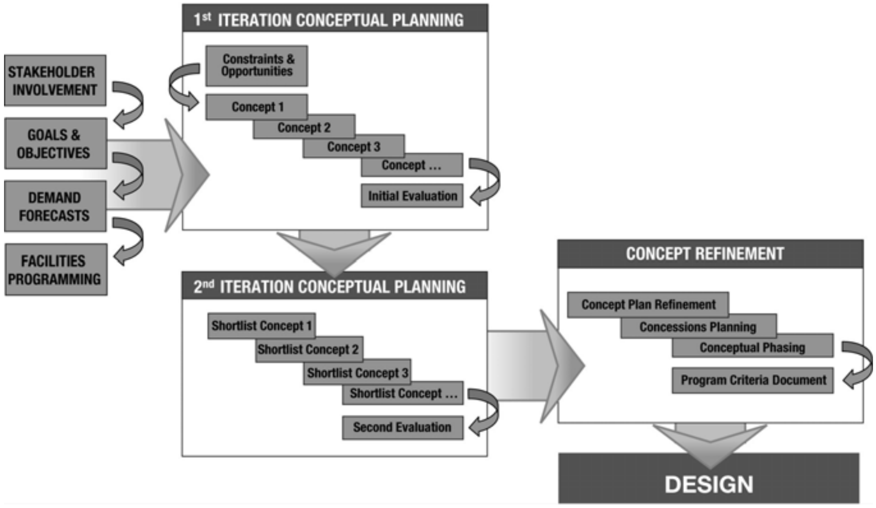

Figure 2 Typical terminal design start steps[15]

6 New specification items at the construction stage in the airport terminal design

The envelope system of the passenger terminal is, in some respects, the watershed between a system made of fixed and stable elements and a system composed by temporary elements. The envelope, despite an average life cycle similar to the structure life cycle, it is clearly distinguishable by it, because of the criteria that guide the design, which are primarily aimed to ensuring an active participation in saving end/or producing energy and diminishing environment impact. The evolution of the architectural technology has transformed the envelope systems from a protective barrier to a dynamic system able to satisfy a fully integrated set of performances. Confronting the more advanced airport projects, like the Bangkok Airport,[16] we can observe the architectural technology is now revolutionised toward a more sustainable envelope as mentioned above. The site management during works also became important to improve environment of such very large, thus very critical, structures like we've observed in Chicago. Technical solutions have been adapted also to the need to decrease the distances materials come from: choose natural or recyclable materials sound not sufficient at all. It appears very new after globalisation drunk to easily adapt and cut supply chain miles in relation to changed needs. We must remember that if the service life cycle of structures can be considered between 30 and 50 years, the envelope has relatively shorter life for various reasons (architectural image, changes in the functional layout and in the distribution systems, technological obsolescence, integration with other systems, and so on). For these reasons in the terminal envelope and in the structure design are adopted separate design concepts. We can also observe an increasing use of dry assembly technologies, which demonstrates the design adaptation of a faster modification. Thus it's also necessary to plan the decommissioning process of components and materials at the end life. According to these design concepts the research investigated the construction documents stage, limiting the analysis to the envelope design. Being the construction documents stage is the most detailed phase of the project design, these include service life, maintenance, and decommissioning stage view. In general all the building components and elements are designed starting from the identification of a set of requirements classes (modularity, integration, control of energy, noise and fire, mounting/dismounting and maintenance of the system's part). Because at this design stage critical issues like as interoperability of the information on project performance verification adopted by the design team should be effectively supported by parametric Computer Aided Design the inquiry also tackled this point.

7 Focus on the design team and the design management system

The innovative nature of the research is determined by the analysis of the design process information feeding. The method used to get the information about this issue was the field research. It was conducted through the use of a semi-structured questionnaire based on ISO 9001:2009 requisites. The questionnaire formed by both open-ended and closed questions was given to project managers to collect at the same time quantitative and qualitative data on the specification design step. The questions refer to the following aspects: 1) the conditions and the peculiarities of the project, in relation to the context; 2) the arrangements for co-ordination and collaboration among the involved professionals in relation to different project phases; 3) the different points of view of every team member and the information requirements of each one; 4) the arrangements for planning, management and control of both communications and information; 5) the representation of objects through the CAD data model for interoperability; 6) the ability to quickly share information within all the participants the planning process; 7) the level of reliability for effective interoperability of the used applications. Referring to the project management the field research has shown the processes and the main stages of the detailed design process for each case study project. We recognised issues related to: a) the organisation of the design group; b) the project management interface; c) the communication processes (sender, receiver, document content, formats, technologies and media); d) the quality of communication management (planning, management, control and auditing); e) the control of the product's performance (requirements specifications). For the acquisition of the necessary information it has been identified the different process owners and their activities. More information was obtained through the detailed examination of the exchanged documents and of the communication flows (planning, checking, feed-back), both content and tools were evaluated according to the needs expressed by the users themselves. As mentioned above the questionnaire was divided into 3 parts to facilitate the reading and the filling out. The main sections are:

- design and communication planning
- design development and communication management
- design verification and communication control

Within each section there are questions and answers gathered in homogeneous groups (architects, engineering, equipment designer, green rater, etc.) according to the treated theme.

8 Data analysis accordingly to Design Gap Risk Analysis method

The data collected through the questionnaire were analysed by a double step. In the first step the information obtained were analysed in a qualitative way, then it

17 Emmitt S. & **Gorse C. A.** (2003). Construction Communication. Blackwell Publishing, Oxford
18 Dainty A. et al (2006). Communication in Construction: Theory and Practice, Taylor and Francis, Oxon

was conducted a quantitative analysis of the same data set. The qualitative analysis of the information was done through SWOT (Strengths, Weakness, Opportunities, Threats) analysis of the collected responses. In detail four SWOT matrixes were built for every case study. The four matrixes, each one illustrating strengths, weaknesses, opportunities and threats in design phases have been built. These were based on the same PDCA criteria that guided the construction of the questionnaire. Accordingly with the ISO 9001 the four scopes of the analysis are the following: 1) Design and communication planning; 2) Design development and communication management; 3) Design verification and communication control; 4) Purchasing processes. In the second step the same data sets have been analysed using a quantitative method. The number of answers compared with the total number of questions in each section has been measured. This information was significant because project managers, who completed the questionnaire, were asked to answer only the questions related to the tasks performed during the details step. Therefore, for any other task not performed or for any issues that was not considered in the project, the instruction was to do not answer. LCB specific issues have been not put in evidence in this stage, because these were considered already integrated in the previous project planning. The answers were then evaluated with a score range of 1 to 6 (corresponding to an evaluation scale from *very poor*, to *poor*, to *partly poor*, to *partly good*, to *good* and to *very good*). The score was attributed to every answer of each case study considering both the level of the corresponding answers emerged from questionnaires and the effectiveness of the response according to requirements outlined in UNI EN ISO 9001 and in UNI EN ISO 10006, and also confronted to best practices in communications identified in construction sector literature.[17 18] The project design is limited to the respect of the minimum threshold accordingly with the terms of law. No explicit requirement on sustainability issues was considered in the selected case studies. The green expert or green rater qualification, beyond the professional registration, is required for almost one professional in the design team. In the ISO 9001 scheme they are seen as a know-how supplier consulting for LCB goals, thus they are interpreted in the organisational scheme as full members of an empowered design team. It means that the design teams even if ISO 9001 certified are missing these experts but they must anyway to collaborate with them. These are professionals who, probably, work in a significantly different manner and tend to assume the project integration role. Only in one case study an integrated and collaborative setting has been activated. The project team has exploited the corporate network and it has used a web-based system for information sharing. Such organisational scheme allows easiest support to green know-how integration. In other cases the communication and the exchange of design information still occur substantially with traditional procedure, contents and means.

9 Emerged evidences in the qualitative analysis

Four SWOT matrixes were built to sum up the emerged evidences from the detailed case study analysis. Matrixes were created on the basis of criteria relating to the four main scopes, mentioned above. The first scope (Design and Communication Planning) results show that the project teams have difficulties in applying the integrated management system in the design practice. Many activities, such as verification, validation and monitoring project, are not carefully identified and planned. The design team do not properly review the contract requirements and doesn't include in this phase any improvement of performances goal, the some is done by other members who are concerned to strictly accord the contents to the assigned tasks and price. The design requirements reflect the concerns of the owner company, that requires to be assured of any foremost asks for fixed times and costs. Environmental aspects are not taken into proper consideration: the design project is limited to the respect of the minimum quality threshold. In current practice the project responsible, negotiates with the owner company during the briefing, while the other team members are involved in the further steps of the design project. The late involvement of the other stakeholders has often led to design changes to avoid affecting airport during operation. Even the communication plan (if done) is inadequate in several critical LCB aspects. It provides generic indications regarding design communication processes. Team members, therefore, habitually communicate through informal channels and there is no tracking, check and recording or conservation of the majority of these interactions. The answers related to the second scope (Design development and Communication management) show the difficulties of using the integrated management system in the practice and the ineffective application in to the design quality goals. The planning process figure a model of a traditional cascade design approach in which the architectural designer shall bear all the architectural and technology solutions. The planning just in a further step takes advantage of the contributions of specialists (structural, equipment, energy, etc.). In the airport projects the interaction among team members is not yet transformed into a real networked and collaborative organisation since the beginning. Consequently, the communication management system, although planned, do not responds properly to the participants' information need. Therefore participants generally adopt different standards creating interoperability difficulties during work development. The planning of the design review and verification of the outputs of each subprocess are defined steps by the majority of the case study. The field application of the planned measures, however, seems to be not so effective, especially regarding two key issues. First we observe how the procedures for validation (documentary) are quite poor. There is also a gap in the way of keeping under control the design changes between the programming phase and the following development steps. The problem particularly is referenced to documents and the means of transmission to be used. Even the results of customers and users satisfaction surveys once the done building is in use (Post Occupancy Evaluation, on site tests, etc.), are rarely recorded and stored in an useful manner. The weaknesses already emerged in the procedures of audit results recording is evident. While taking care for the acquisition of the environmental information, we observe in practice that these are widely disregarded by the suppliers itself. The definition of instructions for the information management by the project team is never the result of a shared planning among participants, but on the contrary it is the expression of the information needs of the main organisation only.

10 Emerged evidences in the quantitative analysis

Based on scores assigned from 1 to 6, the questionnaire answers were also elaborated in a quantitative analysis; output graphs compare the results obtained in the cases study to the four scopes mentioned above (Figures 3 to 7). The score 0 has been assigned for no answers. After the method application it has been assessed that the desirable entry level by the design teams has to correspond to an average score of 4.5 (considered as the *Design Gap Risk Threshold* DGRT).

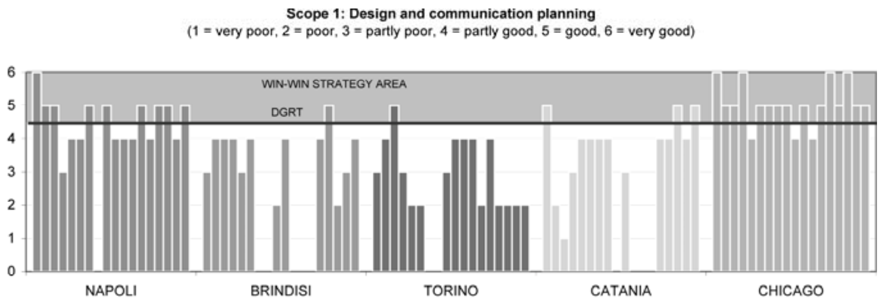

Figure 3 Achieved scores/ answers grouped by case study according to the design and communication planning (scope 1)

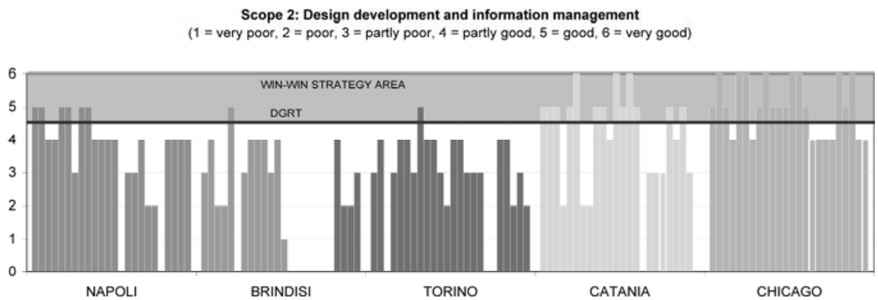

Figure 4 Achieved scores/ answers grouped by case study according to design development and information management (scope 2)

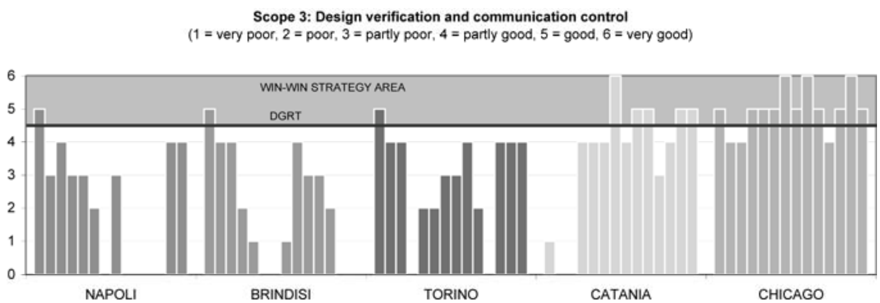

Figure 5 Achieved scores/ answers grouped by case study according to design verification and communication control (scope 3)

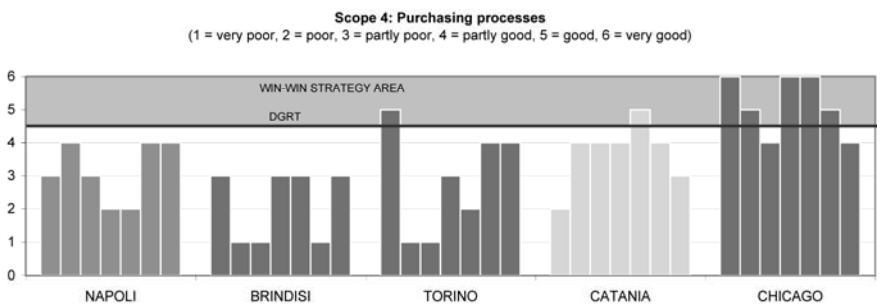

Figure 6 Achieved scores/ answers grouped by case study according to purchasing processes (scope 4)

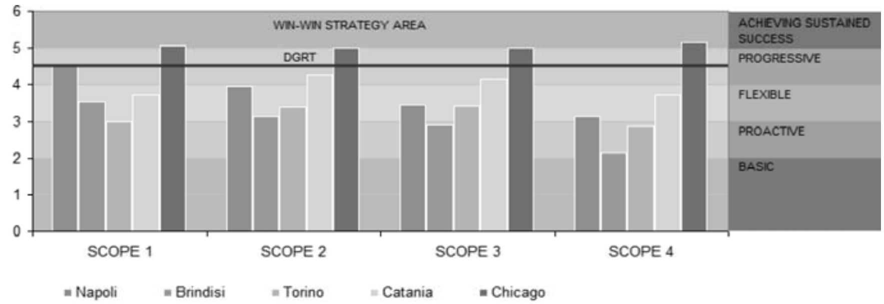

Figure 7 Achieved average scores/answers grouped by scope according to the case study

The charts illustrate the results of DGRT evaluation as attributed score to each answer grouped by colour. The differences are noticeable in both the comparison between the different case studies and in relation to the different scopes. The last graphic shows the average values by case studies grouped according to the scope of reference. This chart shows clearly how the goals reached in the specific scopes of proceedings design phases are really unsatisfactory. The fact that the scope whose average value is the lowest is the last one, clearly denotes that the procedures and measures applied in the interface setting with other members of the design team are still one of the key nodes to be resolved in order to achieve the goals of the so call *Win-Win Strategy* (WWS) applied to project design activities. The research results in Italy cases study have been lastly confronted with the benchmark case of O'Hare Airport green renovation in Chicago, Illinois.

11 Critical analyses in relation to Low Carbon Design targets

The research results indicate some forms of innovation is needed in team organisation management and design methodology for LCB goals. To better address the dynamics, both technological and of the globalised market, now in place, new approaches with faster operational speed should be experimented. As the research has demonstrated the planning leads the whole project realisation, in particular communication processes are critical to achieve the expected quality of the product. In the last 10 years Europe seems very backward in terms of design methods and tools and plagued by a formal and epidermal project quality management. As shown LCB technical specifications management is inadequate and communication processes are poor. Therefore technical solutions and details cannot ensure the expected quality levels of the final product. Especially if verified as LCB product these are inadequate. Furthermore, the design practice does not encourage innovations in any direction: either procedure or contents. The result of the study on the basis of the collected data clearly demonstrates that the problems to be solved rise mainly form the process lacks during the project design. Moreover, the environmental problems, which could be treated in an integrated way, instead of becoming an incentive to improvement, it seems to stop it. For example methods promoted in Europe and generally referred to the concept of Life Cycle Thinking (ISO 14040) and of Life Cycle Design or, at international level, those like as LEED® have not spread so much in terminal airport constructions from designers, manufacturers and clients. It's a fact that expert and more competitive clients ask for higher quality levels in design projects (i.e. see the SAM objective for O'Hare Airport renovation).

12 Research results and beneficiaries

The project groups are rapidly evolving. We observe the gradual disappearance of traditional design team as a part of a unique organisation with all the necessary competence inside where instead the progressive diffusion of new aggregates, such as networked teams, represents an indirect confirm of this phenomena. Unlike traditional teams, these virtual teams work exceeding spatial, temporal and organisational boundaries and the relationship within the group are much more similar to those typical of the *industrial supply chain*. These links are much more effective and are strengthened through the help offered by information and communication networks. The birth of the virtual team, thanks to Relational Technologies,[19] puts new demands to be satisfied in design communication management. The development of sophisticated software, intended only as hypertechnologic islands of automation, has not produced in the practice the expected benefits in terms of increased efficiency of communication processes. The reasons are clearly demonstrated in the research as due to the lack of the *communication culture* in the design team. The application has been too much oriented towards greater specificity based on the idea that this could represent the increasing complexity of the design process. The design process, instead, puts new demands like LCB requirements embodiment in the project by the networked relationship among the experts, design team members and stakeholders. Former approaches have proved to be decisive especially in the quality of information that have been produced in the highly specialised local islands of automation, marked by extremely specialist languages,[20] but they do not provide equally effective for those information sent to other members of the team (Figures 8 and 9).

19 Wolfram S. (2002). A New Kind of Science. Wolfram Media, Champaign, Ill

20 Pollalis S.N. (1997). Computing in the building process, B.O.S.S. Magazine, 4

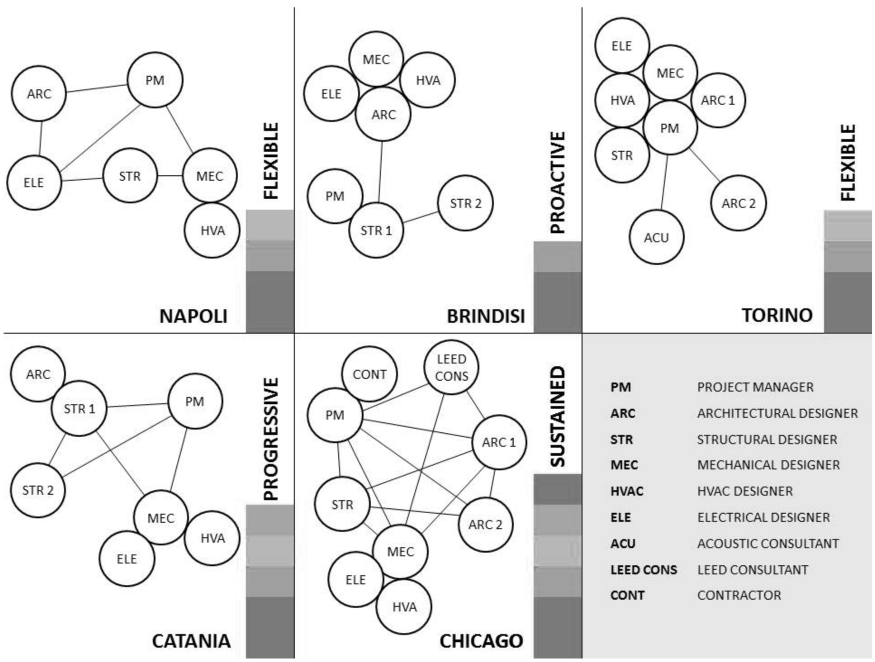

Figure 8 Cases Study confronted with the Collaborative Design networked organisation model

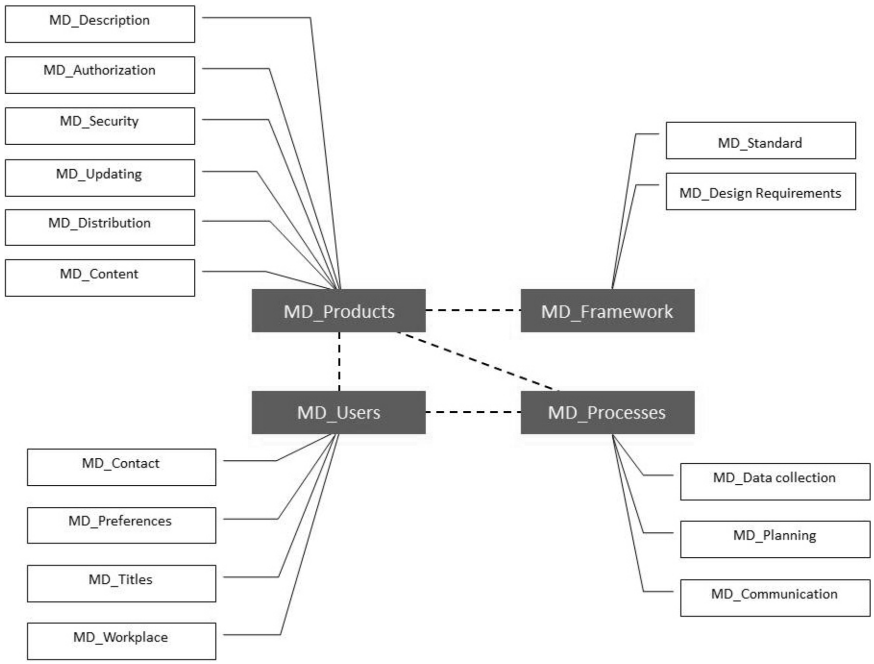

Figure 9 User Profile analysis tool contents

The lack or only partial account of the user of that information within the involved parties has not yet allowed new technologies to fully express their potential in strengthening communication processes. The communication issues, rather than facilitate those processes, have often caused other problems such as overproduction of uncontrollable and redundant information, poor interoperability among diverse software and tools of different disciplines involved in LCB, with the result that the project goals get lost. There are still a lot of resistance and barriers to be overcome in order to ensure an efficient and effective communication in airport projects. Such resistances occurred in research are the *invisible barriers* in the communication processes and lead to dysfunction and errors in the development activities. Among these in the research were also detected technical barriers. Even real cultural barriers due to the different project approaches and to multi-cultural aspects are pointed out. Other barriers are procedural and these are due to a lack of integration in the organisation systems, or rather to the separation by the planning and realisation phases of the airport projects. The scenario of the Sky Industry is temporary-based because the collaboration among the members of the project team often is to make together once only without continuity of relationships. Therefore each project faces unique characteristics in the context that, unlike what is happening in the other sectors, have never met in stable organisations although formed by third parties. The design team members because of their technical culture highly differentiated already mentioned express themselves in specialist ways and by languages not fully communicating. Therefore they tend to act independently in their own category, producing a poor product data integration that is the opposite of what is needed for the LCB goals. The research seeks to demonstrate the ability to obtain an effective improvement in these processes by bringing back the user as the centre of the communication process [FIGURE 9].

The goal id to reduce the Design Gap risks in relation to LCB project targets. The research defines a sound method through an effective planning and management of communication processes in project design. This allows an effective design management. The research, by combining the LCD process approach and the integrated management systems of the project has defined the criteria for the rapid establishment of information requirements of each participant involved in the design process (User Profile Method). It’s set up in order to rapidly build an efficient and customised model of team communication which is tuned according to the specific design. The direct beneficiaries of the results of this research are the whole project group. But as the project is the driving force, even industrial manufacturers and construction companies can push innovative organisational approaches for the project by using these results. This may help the development of LCB products with closer co-operation strategy of mutual benefit (WWS). The research brings in an innovative method to define communication processes for the green airport design by taking into account the potential of relational technologies (R-Tech) already available on the market.

13 Research future development

The further development regards the application of the research method and tools for the Low Carbon airport design it may concern:

- organisation and management of the *project design process as a communication network*
- adoption of customised multiple communication interfaces based on the *User Profile tool*
- adoption of the process approach like PDCA (Plan Do Check Act) type in a *networked team*
- adaptation of *lean construction logic to the project team* management
- definition of the *Communication Plan of the project design* and relative operational and relational procedures defined by the necessary content information for the user (based on the User Profile)
- introduction of the *advanced method in the process* of planning, management and verification of technical information (like as already verified Robust Details)
- embedding *system of requirements/performances* that incorporates specific knowledge in the design process (for example tools for LCT, LCD, LCA, LCC, LEED and other LCB qualification methods)
- adoption of *integrated project teams with producers* referring to what we know in the basis (airports, housing, schools, hospitals, infrastructures, etc..)
- management of the need for *personalization of the final product* (specific project)
- *product oriented association in the supply chain* (local and/or global)
- design of pre-assembled components and disposal at the end of the useful life of the product (disposal, recycling).

Recent experiments at the Institute for Sustainable Construction at Edinburg Napier University have shown that these types of combined approach lead to improve the quality of product in housing projects. According to these studies we would ultimately aim to airport design process that rather responds to the user needs profile and to ensure the achievement of green project goals. In particular, the Low carbon *product development* approach in airport design like that the research made available implies a new vision by the Sky Industry that is based on an alternative set of priorities, largely related to the project design, such as:

- incorporate the expectations of the end user, both airport owner and passengers as well (as in the case of the LCB or universal design explicit requirements)
- develop airport solutions that exceeds the expectations of the end user (as in the case of the LEED integrated approach is required for commercial spaces)
- translate expectations into a coherent and measurable set of requirements/performances (see Performance Based Design method)
- define how this framework influences the outcome i.e. by the envelope system and components (see Robust Details);
- develop airport projects that are able to provide an adequate service in specific circumstances of intervention (like to build during airport operations)
- give clearly defined sustainability objectives to the integrated group of design-supply-construction (like in pilot projects and innovation experimentation);
- continually check the satisfaction of users with objectivity accumulating knowledge from the former projects design received feedback to be used in subsequent planning (see Plan, Do, Check, Act approach);
- develop innovation in airport Low Carbon design with suppliers to improve the product without losing reliability (promoting Joint Research University-Enterprises).

Conclusions

The Low Carbon Design process, instead, puts new demands like as the communication relationship network within the airport projects stakeholders. The lack or only partial account of the user of that information within the involved parties has not yet allowed new technologies to fully express their potential in strengthening communication processes in airport design. There are still a lot of resistance and barriers to be overcome in order to ensure an efficient and effective communication in airport design. Among these were detected both technical barriers and cultural ones as well. Other barriers are procedural and basically referred to the lack of design process integration. The scenario of the Sky Industry is temporary-based: the project group often work together once only without continuity of relationships. Each airport project, therefore, faces unique characteristics in the context, in the set of project design requirements and in the type of relationships within the stakeholders involved. During design development the project team members express themselves by specialist languages not fully communicating each other and therefore they tend to act independently producing a poor product data integration. The research has demonstrated the ability to obtain an effective improvement in the design integration by bringing back the user as the centre of the communication process. The goal is to overcome the Design Gap Risk Threshold. It has been demonstrated that’s not only a problem of more or less fast exchange of information, but rather of informative integration of different project design aspects that are defined during development phases. The research has defined a method and tools for effective integrated planning and management of the project design focusing on information integration for product development. The research has achieved the goals of identification and tagging the information needs of different stakeholders/users involved in the airport design process. This foreshadows a performance-based approach in the project design communication management. The research by applying this approach in the project communication has defined the criteria for the rapid establishment of information requirements of each participant involved in the design process (by User Profile method). Referring to the four above outlined scopes of investigation, it was well defined strengths to be developed, weaknesses that must be eliminated, the opportunities to exploit and the threats to avoid in the airport design. The results are applied in airport projects for design competition and degree thesis projects focused on Low Carbon airport design.

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