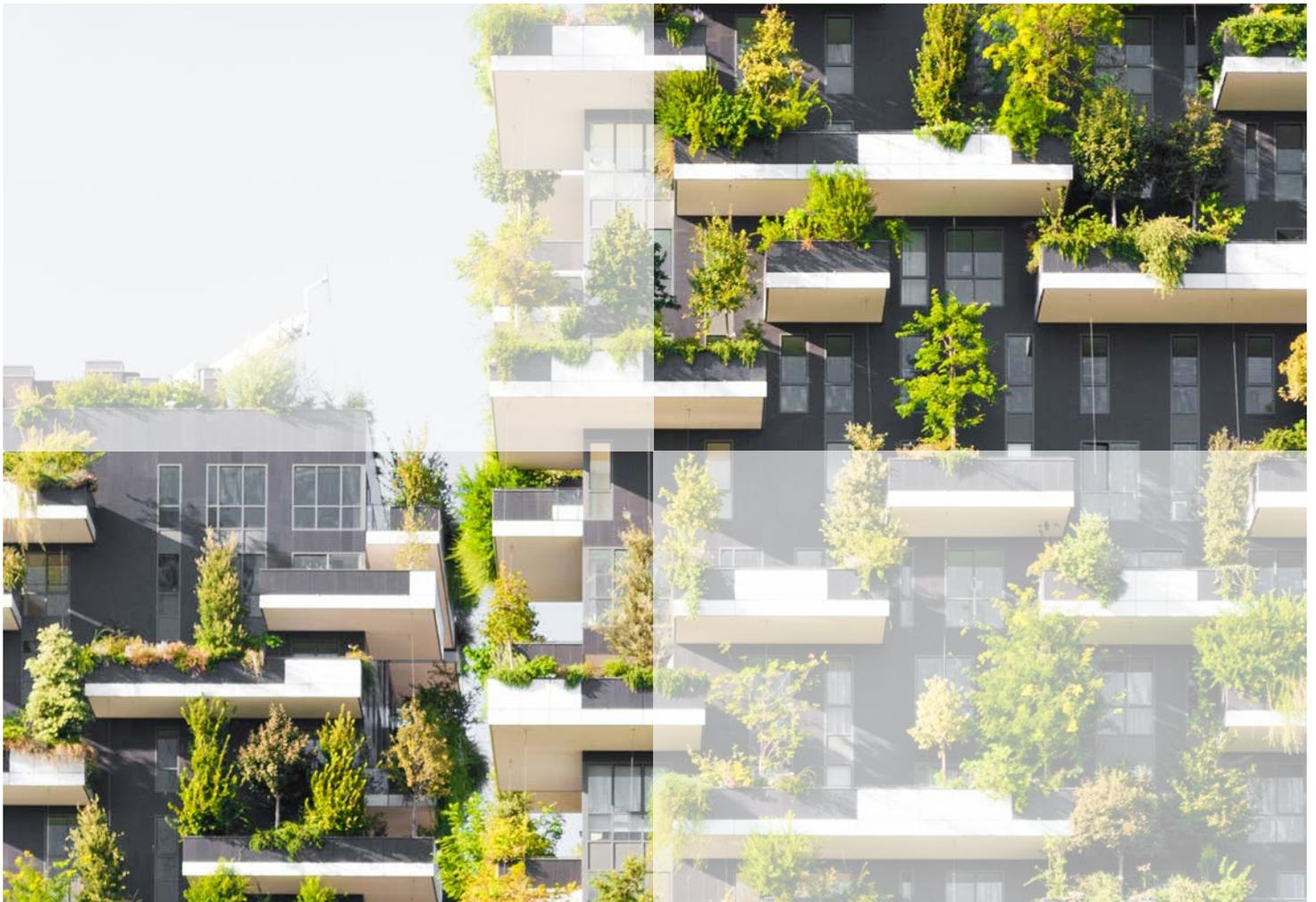


White Paper

# Shaping the Future of Construction: Insights to redesign the industry

March 2017



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# Foreword

While most other industries have undergone tremendous changes over the past few decades and have reaped the benefits of process, product and service innovations, the construction sector has been hesitant to fully embrace the latest innovation opportunities and its labour productivity has stagnated or even decreased over the last 50 years.

This mediocre track record can be attributed to various internal and external challenges: the persistent fragmentation of the industry, inadequate collaboration between the players, the sector's difficulty in adopting and adapting to new technologies, the difficulties in recruiting a talented and future-ready workforce, and insufficient knowledge transfer from project to project, among others.

In the context of the Forum's Future of Construction initiative, over the past year six Working Groups comprised of industry leaders, academics and experts met regularly to develop and analyse innovative ideas, their impact, the barriers to implementing solutions and the way forward to overcoming obstacles and implementing modern approaches in the construction and engineering industry.

This white paper presents the outcome of this work in the form of insight articles proposing innovative solutions on how to address the construction sector's key challenges in the following fundamental challenge areas:

1. **Project Delivery** – Creating certainty of timely delivery and to budget, and generally improving the productivity of the construction sector
2. **Life cycle Performance** – Reducing the life cycle costs of assets and designing for re-use
3. **Sustainability** – Achieving carbon-neutral assets and reducing waste in the course of construction
4. **Affordability** – Creating high-quality, affordable infrastructure and housing
5. **Disaster Resilience** – Making infrastructure and buildings resilient to climate change and natural disasters
6. **Flexibility, Liveability and Well-being** – Creating infrastructure and buildings that improve the well-being of end-users

Together with this publication, the insight articles will be posted to the Future of Construction website (<https://futureofconstruction.org/>) to enhance awareness and collaboration among the extended stakeholders of our industry.

Innovation is a live and iterative process. We invite all stakeholders in the industry to visit our website and contribute feedback by commenting on the insight articles and their approach to the major challenges in our industry. In this way, we invite you to be part of this journey of transforming the way we design, build, operate and maintain the infrastructure around us.

The Forum's Annual Meeting 2017 in Davos-Klosters, Switzerland, underscored the importance of a platform for dialogue as a means of enhancing trust – the essential cornerstone for implementing change. The global populace needs to trust that their requirements in terms of services and quality standards will always be met. At the end of the day, technology is a means to address the innovative and complex needs of current and future infrastructure users.

We hope you will join this major effort to connect the different viewpoints among infrastructure users, academia, experts, industry and policy leaders to shape industry agenda priorities towards optimal transformation of the construction sector.

This white paper is the result of a collaborative process lead by the private sector, and notably foremost firms in the engineering and construction, chemicals, building materials, real estate, urban services and technology sectors. The World Economic Forum would like here to acknowledge and thank the Forum's Partner companies that served on the Steering Committee, together with Partner companies from other industry communities for sharing their thoughts and insights on the six challenges.

In particular, we would like to acknowledge and express special thanks to John Beck, President and Chief Executive Officer, Aecon Construction Group, Canada, for his relentless interest and tireless commitment to serving as the Chair of the Future of Construction initiative, as well as to his extended team for their exceptional support.

We also thank the many experts who have contributed to this undertaking, in particular the Working Group leads from academia who contribute to this report through their leadership on the Future of Construction Advisory Committee: Ibrahim S. Odeh, Franziska Hasselmann, Spiro Pollalis, Mahmoud Hesham El Burai, Monica Altamirano, Arjan Hijdra and Ron Bakker. The experience, perspectives and guidance of all of these outstanding individuals and their life cycles contributed significantly to a number of remarkable discussions during and following the World Economic Forum Annual Meeting 2017.

We hope that, through the strategic dialogues lead by the Working Groups, the construction industry will come closer to becoming an inherently innovative sector, boldly undertaking the impossible and redefining the ultimate frontier: its business models, products and services in continuous development, requiring continuous innovation and improvement.

Key to the industry's success in this endeavour will be to understand that incremental change is not an option – instead, far-reaching challenges or radical goals need to be defined that demand leap-frogging or disruptive out-of-the-box solutions and execution. The construction industry needs to adopt a forward-thinking attitude, as exemplified by John F. Kennedy's comment in 1962: "We choose to go to the moon in this decade and do the other things not because they are easy, but because they are hard."

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# Six Challenges to the Future of Construction



## 1. Project Delivery

Creating certainty to deliver on time and on budget, and improving the productivity of the construction sector.

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## 2. Lifecycle Performance

Reducing the lifecycle costs of assets and designing for re-use.

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## 3. Sustainability

Achieving carbon neutral assets and reducing waste during construction.

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## 4. Affordability

Creating high-quality, affordable infrastructure and housing.

---



## 5. Disaster Resilience

Making infrastructure and buildings resilient against climate change and natural disasters.

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## 6. Flexibility / Liveability / Well-being

Creating infrastructure and buildings that improve the well-being of end-users.

# 1. Project Delivery



## Introduction

*Ibrahim S. Odeh, Director, Global Leaders in Construction Management - Research Group, Department of Civil Engineering and Engineering Mechanics, Columbia University, USA*

*The successful delivery of projects is at the heart of the infrastructure and urban-development industry. As one industry expert put it, "Project delivery is about the global value proposition of the construction industry, going beyond time and budget". The challenge is to create certainty about delivery on time, on budget and to the targeted quality. This involves, but is not limited, to improving productivity in the industry, to cut the time and cost of delivery.*

*The impetus for change is underscored by the industry's alarming performance record – more than 90% of mega-projects are above budget or behind schedule, leading to pressure from project owners, investors and tax payers alike. There are several reasons for such a bleak performance record, including: industry fragmentation; lack of cross-functional and value-chain cooperation; limited amount of knowledge transfer from project to project; stagnant approach to project management, which has failed to evolve and address the rising complexity and disruptions from outside political or investor risks.*

*In addition, the nature of this industry is facing continuous and rapid transformation. Some of these changes raise concerns about improving project delivery: projects are getting bigger; public budget is becoming more challenging to secure; advancements in technological innovation (3D Printing, big data analytics, virtual and augmented reality, drones, etc.) and process developments (public-private partnership, project financing, integrated project delivery, lean construction, etc.); and the rise of ineffective or inexperienced management teams in such a rapidly changing environment.*

*To address the importance of delivering projects in the current and foreseeable context, a group of industry leaders worked closely for six months to present several practical and ready-to-be-implemented ideas in this field. Some examples of the outcomes of this comprehensive industry collaboration propose developing outlines to help establish industry-wide knowledge sharing and systemic innovation frameworks and to expand on the application of lessons learned to the global project environment. Others suggest areas the importance of modifying policies and updating legal and insurance frameworks to promote industry transformation and support collaboration. Finally, this thorough effort proposes a new theory for managing large complex projects and presents the case for the critical need for improved alignment of the education system to emerging industry needs.*

# Advancing the Outcome of Challenging Infrastructure Projects through Project Alliancing

Perti Lahdenperä, Pekka Petäjäniemi and Hagsheno Shervin

## The challenge

*The traditional disintegrated and adversarial process does not work appropriately in case of challenging construction projects involving a lot of uncertainty and interfaces.*

Traditional project delivery systems do not fully utilise the know-how of the various parties while relatively early fixed solutions and price disallow continuous project development. Constructability and cost awareness of designers is poor and plans put out to competitive tender are not likely to represent the best possible project solution. If there are unknowns left in plans, it may make the tenders even more expensive to the owner when traditional price-oriented selection is applied. Deviations and interpretations on change orders during construction also tend to increase conflicts of interest and adversarial behaviour in projects and be a hindrance to smooth process and success of the project in general.

The challenge remains even if the competence of designers and contractors is utilized synergistically by requesting candidates to complete design proposals as is the case in various types of design-construct procurement methods. Even then the owner is often obliged to limit the leeway necessary for alternative proposals. The primary reason is that degrees of freedom leave too much room for interpretation which may lead to court appeals and subsequent project delays and extra costs in case of public procurements. There is also no time to determine the compliance of alternatives with requirements and regulations in the completion phase. More time is needed for development but it would be too costly with numerous candidate teams. The challenge related to the fixed price is also met in these cases usually.

The uncertainty related to demanding infrastructure projects highlights the problems of traditional project delivery systems. Implementation of projects in the built environment and the many interfaces and interest groups, heavy traffic as well as the demandingness of the arrangements during site work are part of the challenge. As are the uncertainty of conditions and input data and the need to minimise nuisances during construction. Technological development also brings opportunities that are not always known at the launching of a project while it also makes projects more and more complex and challenging underlining the need for new practices.

## The idea

*Early involvement of service providers in collaborative process with the owner offers a means to improve project outcome in challenging construction projects.*

Project alliance is a project delivery method (typically) based on a multi-party contract between the key actors to a project whereby the parties assume joint responsibility for the design and construction of the project (without distinct division of labour) to be implemented through a joint life cycle that includes the owner, the designer(s) and the contractor(s); and where the actors bear both positive and negative risks related to the project jointly, and observe the open-books practice, unanimous decision making and no-litigation principle in pursuing fruitful collaboration. Alliance contracting is, first and foremost, a procurement method for projects that involve a lot of challenge and uncertainty.

The basic idea is that an operational model where risk is borne jointly and reward is shared on the basis of the success of the entire project makes the parties consider each other's views better and collaborate more efficiently for the best of the project. The method also allows combining a wide range of expertise needed to foster innovation and to make demanding ventures successful. That, again, necessitates early selection of the actors which makes offering services at a fixed price impossible. The solution to that challenge is selection mainly based on a thorough review of team capability while the price may be represented by a fee quote only at this stage.

The procurement is based on the stage-wise negotiated procedure. In the final phase, following the shortlisting and further reduction of candidates based on capability, the best two teams continue to the stage involving workshop tasks that are evaluated. The evaluation forms the basis for selection of the best tenderer jointly with the combined team fee that consists of the designer and contractor company overheads and profit expectations. The member companies of the selected team enter in a 'development agreement' with the owner for the design of the project and to set and agree on the project's target cost and incentive system based on the owner's key goals. Thereafter the actual 'implementation contract' is signed, but only if the parties are able to agree on the project solution and the owner considers the target cost level reasonable. If not, the owner is free to terminate the contract. External review is usually used for the verification of the intended target cost.

## The impact

*Trustful collaboration between alliance partners has resulted in considerable savings and/or excellent performance in projects in general.*

The Finnish Transport Agency (FTA) is a pioneer in developing and applying project alliancing in Europe. Initially the way was prepared by a joint R&D with the VTT Technical Research Centre of Finland launched some ten years ago after VTT has reported alliance experiences from Australia to the predecessors of the FTA. Subsequently, the baton was

handed over to Vison Alliance Partners in the deployment phase. The procurement of the first alliance project started in 2010 and since then FTA has utilized the model in a number of projects while it is gaining popularity also outside of FTA. In total, about 40 projects have been or are about to be launched as alliances in Finland so far. In international comparison the field of application is wide-ranging covering vertical and horizontal infrastructure, new construction and refurbishment, and even relatively small and simple projects.

The FTA's landmark project, by now, is the Tampere lakeshore road tunnel. The development phase of the project took a year and during that a large number of development ideas were born and accepted for immediate use. The total cost saving achieved in the joint development phase was close to 10% although some of the innovations were implemented mainly due to their positive value effects. Numerous major improvements were made in the road plan which would have been unlikely if a disintegrated project delivery system were applied and the generation of joint interest were ignored. The construction plans, including the innovations, were in all respects such that the quality levels of the road plan were to be met: quality or other key goals have not been sacrificed to achieve savings or faster completion.

As to the subsequent implementation phase, the alliance was able to under-run the €180 million target cost and slightly and further shorten the tight schedule for half a year so that the tunnel was opened for traffic after a four-year construction phase. Safety performance was also at very good level. All in all, none of the performance indicator used in the project were negative and it is rather clear that the good performance in many areas is thanks to the incentive system used in the project. Thus, it is not only question of the sharing of cost under- and over-run, but the performance, in accordance with a number of other indicators (e.g. schedule, safety, image, disturbance), also impacted on the payment to service providers.

## The barriers to innovation – and the solutions

*The change of the culture and new way of thinking is a must and had to be considered carefully in case of applying project alliancing.*

Successful realization of an alliance requires that the actors are able to create open and trustful relations which may be a challenge for parties having their background in the traditional 'zero-sum game', where one wins at the cost of others. In an alliance parties enter in a multi-party agreement stating 'we shall do it together' without clear scopes of liabilities and, therefore, enough time and resources should be reserved and the stakeholders should be trained to understand the alliancing philosophy and, moreover, to carry out the selection and create open and trustful relations. Alliancing requires also deep involvement of the owner's representatives with decision authority in the alliance (leadership) team.

Another potential barrier may be the lack of comprehensive price competition and the resulting challenge of proving of value for money supplied which may be a problem to probity auditing and general public. Yet, the cost viewpoint is now reflected in the selection through the proposed method for control of the economy, presented budget critique and suggested development possibilities at least. The practice also follows the open books principle as to costs and the phased method as to contracting. The process offers a means to joint mitigation of risks that could be impossible by any of the parties alone. Thus, the target cost is not likely to include risk premiums at the same degree tenders for fixed price contracts tend to do, and change orders do not affect significant cost increase as too often happens in a case of a competitive lump sum contract. Besides, the expectations for innovation are bigger in case of combined expertise and reasonable time reserved for the joint development. In other words, the operational logic of alliancing needs to be understood in full to make it success.

## The way forward

*The wider use of alliancing together with the modification of traditional processes provides the necessary conditions for the needed cultural change in the industry.*

The positive experience gained from the alliance is encouraging for its continuation and extension. Practical formal solutions as to the process and agreements of the alliance have been largely found and standardised as a result of a joint exertion of the industry. Thus, in future, the focus will be on the actors' cooperation culture and the teamwork practices. As part of this, the lean construction methods and tools are to be utilised more to improve the efficiency, since the joint organisation dispels organisational boundaries and, thus, creates better conditions for that than traditional delivery systems. Also incentive arrangements for the development phase will be considered more although some steps have already been taken also in practice.

Determined use of alliancing is expected to enable the change in the operational culture of the construction sector more widely. It is recognized, however, that project alliance is not for all projects, even though reasonable solutions can be created for diverse projects by adapting alliancing differently. Therefore, one topic for future development is to find out if and how (some of) the features of alliancing can be brought to the traditional delivery systems (even partially) to improve the culture and productivity of the industry as a whole.

# The Three Secrets of Great Projects

Aaron Shenhar and Vered Holzmann

## The background and the challenge

Projects today are becoming increasingly complex, with greater demands on efficiency and schedules, as well as growing competition. However, quite often, even the most ambitious and well-funded efforts suffer from extensive overruns, long delays and miss realization of expectations, and in some cases, all of these combined. Considering the widespread importance of projects in all industries, it appears that project management practices and techniques do not really meet the challenges of today's projects, including many in the construction industry.

This insight article presents the results of a study inspired by this challenge. In contrast to other studies, which typically investigate the reasons for project failure, the authors looked at the history of large modern projects - megaprojects - dating back to the 1950s. They have been selected on the basis of multiple criteria such as efficiency, impact on the user/customer, business success and impact on society. Among the projects studied: Apollo moon landing project, Mall of America, the Guggenheim Museum (Bilbao, Spain), the First World Trade Center (Manhattan, USA) the 2012 Olympic Village (London, UK), Los Angeles subway, and Denver International Airport. Not all of these projects were fully successful. Study results show that the most successful projects share a combination three characteristics: clear vision, total alignment and are able to adapt to complexity.

## The strategic idea and impact – The three common ingredients for success

In this study, projects were viewed as strategic processes the objective of which is to create *value* for different stakeholders. This approach is called Strategic Project Leadership® (SPL), whereby success is a broad concept that is measured by several criteria, not time and cost alone. The metrics are as follows:

**Table 1: Strategic Multidimensional Success Metrics**

Success Metric	Efficiency	Impact on Customer/User	Business/ Financial Success	Impact on Society
Measurement	Time and costs	Customer/User satisfaction, improvement	Business profits, return on investment	Environment, well-being of society

Strategic Project Leadership® views project leaders as CEOs who are responsible for achieving the expected business results, while leading their teams with high energy and motivation. In sum, project leaders must have both a short- and a long-term perspective. They need to focus on short-term delivery requirements, as well as the economic, environmental, social and political aspects of projects. The study, searched for the common managerial and life cycle elements that enabled meeting the success criteria (metrics) described above.

## Clear vision

This vision is an articulation of the end result defined in simple terms that everyone can understand and conceive. It describes the state of the environment concerned after the project is completed, often in visual or even emotional terms. Other kinds of vision also articulate what people will be able to do once the project is completed and how their lives will be affected, improved or simplified. A vision does not deal with profits or financial performance, nor is it described in technical terms. Best visions evoke emotional reactions, such as Kennedy's vision for the Apollo programme to "put a man on the moon and bring him back before the end of the decade." The vision of the Mall of America was to "Build the largest and most fun mall in America." And the first World Trade Center's was "a commercial and trade center that will revitalize the economy in lower Manhattan."

Good visions are created by great leaders. They are able to articulate what the project is about – customers know what to expect, sponsors can communicate better what they will create and employees are inspired to be part of it, and clearly understand how they can contribute to its creation.

## Full alignment

Full alignment means that all parties identify with and commit to the goals, means and the difficulties expected in the project. Such alignment is difficult to achieve and manage. Since projects involve networks of stakeholders with different interests and agendas, the sponsor and performing life cycles must have a clear and shared understanding of the vision and how to achieve it. Similarly, customers and users are involved upfront, and their voice is being heard and considered. After all, they will be the ones most affected by the project's success. Finally, a successful project must be aligned with the community and environment in which it operates. Lack of alignment can cause conflicts and delays. One cannot expect to install a large creation in a public place or neighbourhood without the support of all those who may be affected.

Project teams are aware of this need and work hard to achieve such alignment. For example, the managers of the London Olympic village had a coordinated network of contractors using a set of common rules and risk sharing agreements that created a mutual interest for all. Similarly, the builders of the first World Trade Center in Manhattan were managed by the Port Authority, which was also the sponsor of the project. Builders worked closely with New York authorities as well as with many merchant life cycles, restaurants, etc. In contrast, the Los Angeles subway was led as an engineering and technical design-and-build project. While it was created to serve millions of passengers, there was no real connect or alignment with the citizens of the city. No wonder then that when it opened, very few people used it.

## Adapting to complexity

We define complexity as a factor that may inhibit the timely completion of a project. Such factors may include size, number of elements and extent of interconnectedness, but they may also include levels of uncertainty or constraints. Uncertainty may be linked to technology, financial markets, policy, economics or the environment. Constraints include restrictions, regulation or limited resources, such as time, people, or money.

Since different projects have varying degrees of complexity, clearly, “one size does not fit all.” The key to success, therefore, is to understand the degree of complexity and adapt the project’s management style to its specific level and kind of complexity. For example, in the Apollo project, NASA understood that going to the moon is extremely complex, risky and uncertain. They put in place numerous mechanisms for thorough examination and testing. Nothing was left to chance and the mindset at the time is reflected in the statement, “It is unsafe to fly, unless there is proof that nothing can go wrong.” In contrast, although the architect of the Sydney Opera House had a clear vision from the outset, the vision was not in tune with the city or the political environment, leading to extensive conflict and unchecked spending. The project team did not anticipate the structure’s complexities and thus, builders only learned at an advanced stage of construction how to produce the orange-shaped roof slices that made its structure so unique.

## Barriers, solutions and next steps

Adopting strategic mindsets and processes in project management will take time. It will also require specific methods and tools to plan, execute and review projects. Frank Gehry, the renowned American architect who built the Guggenheim Museum in Bilbao, implemented the full strategic approach, as he does in all of his projects. Gehry insists on acting as the project’s CEO, and on making all the financial and modification decisions. Similarly, the Strategic Project Leadership® approach is applying the new mindset and techniques in several leading companies with great success.

Frequently, the barrier to success is tradition. Most companies still follow traditional approaches and use conventional tools of project management planning. It will not be easy to change mindsets or develop the skills and tools required by this new paradigm. This change will bring additional planning and tools to current methods. It will also educate project teams about this new approach and train young managers from day one to think strategically about their projects and their roles as leaders.

# A New Theory for Managing Large Complex Projects

*Robert Prieto and Roger Bayliss*

## The challenge

*Revolutionary improvements in project execution and delivery are required.*

The current theory of project management was developed at a time when projects were more readily decomposed and well bounded. Today’s large complex projects do not demonstrate these characteristics and current project management approaches result in unacceptable project failure rates and high levels of uncertainty with respect to cost and schedule.

Changing the fundamental theory of project management inevitably means that consequent developments need to take place in policy, innovation, legal framework, and knowledge management and education systems in order to reach the full potential of the industry-wide transformation. This insight article aims to identify the areas of the management theory that need to change for the purpose of addressing the complex and innovative needs of infrastructure projects and classifying the areas of practical implementation of this new theory to contemporary and future needs.

In two distinctive parts, this article first analyses the idea behind the need for revolutionary improvements in project management theory and then the impact, the barriers and the way forward for transforming those interests to opportunities for innovation and development.

## The idea

*A new theory of management of large complex projects.*

### 1. Strengthened project foundations and frameworks

The current theory of project management does not adequately address the unique characteristics of large, complex projects. Project fundamentals are not well founded and some framework processes are either absent, break down at scale or are not adequately addressed. Reinforced project foundations must encompass:

- A heightened and structured focus on owner readiness, not just project readiness. Three aspects must be addressed:
  - Strategic Business Outcomes/Objectives (SBOs) must be clearly articulated, agreed to and *continuously* communicated
  - Owner’s framework processes for decision-making and approvals must be strengthened and streamlined
  - Project SBOs must be committed to by all owner elements including legal, procurement, contracts and accounts payable

- Project readiness must be further strengthened along the lines of traditional readiness elements but also expanded to ensure SBO alignment and use of big analytics starting from the planning stage
- Project baselines must include an expanded basis of design (BOD\*) that encompasses not only the traditional basis of design associated with meeting the owner's project requirements but also:
  - A Construction Basis of Design (CBOD) that reflects desired means and methods (prior to the start of design; more than just a constructability review) such that a project is designed to build. Safety is taken to a new level through hazard elimination rather than mitigation during construction. Incorporation of a CBOD changes design packages requiring more granularity in design package definition
  - An Operations & Maintenance Basis of Design (O&MBOD) that brings life cycle consideration to the very front end of the project, influencing design choices from the outset rather than seeking to improve the O&M characteristics of a developed design at a later stage.

New technology, including BIM, can readily support this.

- Foundations must further strengthen project baselines, especially for large, complex projects where two out of three fail by recognizing the inadequacy of current risk models that ignore the observed “fat tails” and optimism bias in project performance.
  - Risk models must avoid screening out risks prematurely and provide for Monte Carlo risk modelling with “fat-tail” distributions such as a Cauchy distribution
  - Assumption capture and tracking to address assumption migration in long duration projects
- Risk focus must be expanded to address:
  - White space risks that exist in complexity
  - Stakeholder risks which act on today's more unbounded project
  - Changed risk profile associated with data and tool sharing such as seen in shared BIM models

Formal owner readiness assessments are a first step in an improved project initiation process. They precede project readiness activities and new guidance documents must be developed.

Project governance training is required, and adoption of governance principles, distinct from project management, must occur.

Standards and guidance documents related to the use of an expanded basis of design must be developed.

Optimism bias must be addressed through required use of reference class forecasting for cost and schedules on large, complex projects. These can be facilitated by shared industry data and best practices.

Refinement of traditional industry-risk models and modelling to account for risks in complexity and scale as observed in the “fat tail” performance outcomes is required.

An expanded project control focus must be developed, recognizing the inherent risks from stakeholder action/inaction that today's projects face. The role of big analytics is significant but requires looking at the right data.

New risk models to identify and manage the new risks of collaboration, such as we see emerging in shared BIM models, must be developed.

## 2. *Increased focus on flows, not just the progressively decomposed tasks*

Project delivery heavily focuses on decomposing a project into a series of interrelated tasks and then managing the activities within each task. These tasks are reflected on schedules and network diagrams with little arrows showing directional flows. These arrows are not dimensionless and inadequate attention to flows is a significant source of project disruption and degraded performance. Project management must strengthen its focus on flow management by:

- Increased attention to interface identification and management, including identification of underlying constraints which may “couple” otherwise disparate tasks on a project
- Recognition that previously established interface requirements may change as underlying assumptions and conditions migrate over time
- Greater use of “last planner” techniques and improved workforce planning from a knowledge-enabled work force
- Use of “knowledge assemblies” that bring together all the informational resources required by a particular task together with the associated computational and analytical tools and methods
- Recognizing the growing importance of flow management as supply chains are more tightly integrated. This is in addition to the flow complexity associated with distributed execution and challenging project logistics both in remote and urban areas.

Development and owner acceptance of big analytics appropriate to support higher-level project delivery requirements must occur.

Development of a knowledge assembly strategy to improve productivity throughout the project delivery process is required as is real-time, dynamic project modelling and management.

## 3. *Recognition of the implications of the unbounded nature of these projects*

Today's largely unbounded project is subject to the debilitating impacts of stakeholder-derived influencing flows that sweep across a project's semi-permeable boundary, impacting not only the project's tasks but perhaps more importantly, its various transformational flows. Addressing this challenge requires:

- Development of a new paradigm for project controls that includes equal attention to potentially impacting flows arising from changes outside the project proper. This new paradigm will require increased use of big analytics not only on project performance data but also on a myriad of external data sources. Project controls must also be outward looking.
- Shifting our stakeholder perspective from one of management to one of engagement. This begins by posting outward looking “sentries” (new project control efforts); looking over the horizon with “scouts” to ascertain changes that may lead to potentially impactful influencing flows (big analytics); and finally engaging the broader stakeholder “mesh” that surrounds the project with “ambassadors” who seek to influence stakeholders and control “time”, the rate at which a change unfolds.

Greater project transparency is essential if this engagement is to be successful.

New project control disciplines, training and tools to assess project impacting externalities must evolve.

#### 4. Embracing the use of modern technology

The construction industry has typically been slow to embrace technology, but this is now changing for the good. The use of technology to deliver projects is accelerating and appropriate use of the correct technologies can help to deliver successful projects.

- New construction technology (e.g. autonomous plant, drones, mobile application, smart logistics, sensors, 3D printing) helps improve the efficiency of onsite operations, but it can be argued this is simply the latest development in the ongoing advancement of technical capability. Effective project management must recognize and embrace new technologies as they become mainstream.
- Of more relevance to the issues identified above is the potential for technology to assist and support the processes required for project success. BIM, if used to its full potential, can facilitate the development of stronger project foundations and frameworks and also assist project management teams to understand, organize and optimize the increasingly complex project frameworks, multiple tasks and change. Other technologies that support improved project management and stakeholder engagement also exist.

Notwithstanding the availability of technology it is ultimately the capability and approach of those involved that will determine whether or not a project is successful. Without a new theory of management of large complex projects, as mentioned above, new technology in itself will not make the improvements required.

## The Impact

Changes in theory cannot perform on a stand-alone basis. Modern approach in all relevant areas will enhance industry transformation. We have identified five areas that are most impacted and need to change for the purpose of implementing the new project management theory.

### 1. Impact on policy

Today’s policy frameworks are inconsistent, often providing for disparate and distorted treatment of similar project types from a regulatory, design and financing standpoint. These weak frameworks begin with the very selection frameworks used to prioritize projects from a societal as well as financial perspective.

Improved project selection frameworks to prioritize projects are required. These must encompass commonly accepted prioritization methodologies as well as widely accepted common classes of factors for prioritization. These factors must adopt a strong and well-founded life cycle focus. This is essential if we are to be able to afford the built environment we will require.

A second key framework demanding improvement are those related to codes, standards and regulation. Increasingly these must not just allow for incremental innovation but instead promote broader efforts of innovation and continuous improvement. Performance-based codes, standards and regulations must become the accepted and preferred norm.

Business and financing frameworks that promote life cycle performance must also be put in place and existing ones further strengthened. This strengthening should see enterprise asset management as a life cycle extension of today’s current BIM efforts.

Similarly, debt covenants and accounting standards should treat built assets commonly and with an emphasis on life cycle performance and asset sustainment.

### 2. Impact on industry-wide systemic innovation

Truly revolutionary improvements in project execution and delivery will require a transformation of industry. In particular, we need to evolve from serial incremental innovation to broader systemic innovation. The latter requires industry to change as a whole, which, in turn, requires common driving forces and enabling frameworks. Specific enabling solutions include:

- **Establishing an industry-specific Grand Challenge** – An example of a Grand Challenge could be to reduce life cycle costs by 50% and put in place the required skills, education, evaluation methods and metrics
- **Strengthening government-sponsored, industry R&D** emphasizing life cycle cost reductions and project delivery productivity while incentivizing commercialization
- **Creating an industry-sponsored intellectual property commons** addressing cost and benefit sharing as well as promoting cross-industry sharing of best practices and lessons learned
- **Creating a 10 year R&D tax bonus period for efforts related to life-cycle cost reduction and improvements in construction productivity** – An example could be a \$2 tax deduction for every \$1 spent

### 3. Impact on legal framework

Currently, various legal, insurance and other financial frameworks may act as unintended barriers to overall improvement in engineering and construction industry improvement. Focusing narrowly on those areas of improvement solely within the control of the engineering and construction industry would be self-limiting with respect to transformational improvements that are desired.

Legal frameworks – laws, regulations, contract forms, dispute resolution guidance – must be modified to reflect changed and changing business models that inherently rely on and encourage closer industry collaboration. We see such closer collaborations developing in a number of different ways including:

- Integrated project delivery
- Design build with designer as a partner not just a subcontractor
- Shared BIM model development by multiple parties including owner/operator O&M staff
- Tighter supply chain integration including direct BIM input
- Long term obligations associated with migration to life cycle contracts (PPP) or life cycle contract performance requirements

Insurance frameworks to support collaborations such as those identified must be created or strengthened.

These modified frameworks must include coverage for the myriad of newly created or modified risks and risk postures.

### 4. Impact on knowledge: Establishment of industry-wide knowledge sharing frameworks

Revolutionary change and improvement are required within the engineering and construction industry. They must be driven by innovations of all kinds including in how we share and mobilize our collective knowledge. This includes the progressive establishment of industry-wide knowledge-sharing frameworks.

Specifically the engineering and construction industry should consider:

- Establishing an industry best practices forum with user ratings of best practices used (Best practices YELP). Today, best practices are scattered across various industry and academic sites and usability and assessment of outcomes achieved are generally lacking. There is no compendium of best practices sites.
- Creating a construction industry intellectual property commons to promote awareness of valuable knowledge and solutions while protecting the rights of IP holders. Analogs exist in various creative commons and the innovations connection model designed to connect IP creators with commercial innovators.
- Developing a “knowledge assembly” concept that draws all knowledge required for a task together for ready access by a doer of task (knowledge enablement)

### 5. Impact on education: Improved alignment of education system to emerging industry needs

The engineering and construction industry’s needs are changing and if the transformations that are viewed as necessary are to be realized then the education and skills of our labour force are also going to have to change. Several elements are required for this dimension if change is to be successful and the educational system that serves the industry will also have to change.

Tomorrow’s project managers will require enhanced project management training to recognize the growing need for general and business management skills. Engineering and construction curricula must recognize the growing integration and convergence of these respective disciplines. Education systems must also reintegrate education on tool-making with tool using so that the profession may innovate more directly, reducing reliance on potentially disconnected specialists.

Licensure/certification of project and construction managers must come with a stronger continuing education requirement, comparable to or even more robust than what we require of our engineering professionals.

There must be an increased emphasis on trade schools and craft training to recognize the changing skills needs of tomorrow’s digitally enabled craft worker.

## The barriers to implementing change

*There are roadblocks to improving these requisite frameworks for success, but they are within our control.*

Examples of current roadblocks include:

- Lack of ownership of standard setting for project prioritization
- Resistance to change and entrenched structures of standards setting organizations
- Driving industry supporting change through the financial sector
- Broad embracement of Enterprise Asset Management practices and standards

In addition the above, one principal roadblock to systemic transformation is the current fragmented approach to government-sponsored research with no overarching Grand Challenge, e.g. put a man on the moon.

Looking ahead, among the roadblocks such innovations will face is the multi-jurisdictional nature of laws; no longer fit for purpose precedents enshrined in existing case law; and the inherent difficulties in quantifying new and emerging risks.

Knowledge-sharing frameworks today suffer from the lack of an industry organization to sponsor, create and govern the required industry intellectual property commons. The industry should explore other IP commons that exist in other industries.

In terms of educational barriers, the project management curriculum today under-emphasizes and is not tightly linked with the necessary skills and training found in general management and business schools. Many educational insight articles lack consistent recognition of project management as a professional discipline even while recognition grows for construction management. An emphasis on a college education often sends students to an undifferentiated liberal arts education with limited employment prospects while good-paying jobs are under-filled because of diminishment of trades as a desirable career option.

## The way forward

*We must transform, not merely improve the future of construction.* Systemic innovation will require multiple parts of the industry to transform in tandem. These key transformations will require us to adopt an industry standard on project prioritization methodology and the classes of prioritization factors to be considered (as a minimum). These prioritizations must reflect life-cycle behaviour and requirements.

We must also migrate industry-affecting codes and standards from largely prescriptive standards to performance-based codes and standards. We have done this before in the areas of fire protection and seismic design.

On the financial front we must harmonize debt covenants for asset classes irrespective of source of debt financing. Accounting standards related to these assets must require life cycle cost reporting; and backlog of deferred maintenance and/or replacement values for long-lived assets. Modified accounting treatment of costs classified as capital or routine maintenance for long-lived assets are also required for long-lived assets.

On a more tactical level, today's BIM systems must integrate seamlessly into tomorrow's enterprise asset management systems. BIM/EAM integration is essential to support life-cycle management.

Achieving the systemic transformation our industry requires will be significantly aided by establishing an engineering and construction industry Grand Challenge that, in turn, requires improvements by the industry as a whole.

Moreover, industry should promote its research and development capabilities as well as issue a statement announcing its R&D priorities, i.e. industry-driven vs bureaucracy-driven. Knowledge sharing within the industry should be facilitated and barriers removed. One such approach to fostering cross-industry collaboration is the creation of an intellectual property commons.

Government R&D practices and industry tax incentives also need to be aligned with the outcomes that a Grand Challenge seeks to deliver.

To overcome these roadblocks and encourage the required legal and insurance industry evolution, we must create model legislation with supporting documentation related to regulatory "technical" content and contract forms. In essence we must help define best practice.

New dispute-resolution guidelines that may be referenced in contract documents for emerging collaboration type risks are required and should build on the efforts that are underway in a number of jurisdictions.

The re-insurance industry also has the potential to play a key role by creating necessary products to pool these emerging risks and help set standards of good practice.

To achieve the systemic transformation that the engineering and construction industry requires, we must strengthen pan-industry structures and promote increased client recognition of industry IP rights.

The educational system must support the transformation the engineering and construction industry requires. There must be an embracement of Project Management as a discipline (not just CM).

Trade schools must be revitalized and minimum training standards for craft labour broadly established, recognizing that they too are increasingly knowledge workers in a transformed digital industry.

# International Infrastructure Support System (IISS)

Christophe Dossarps

## The challenge

The global demand for infrastructure investment is estimated at about \$3.7 trillion annually. In developing countries, it is driven by growing population, economic growth, urbanization, environment constraints and industrialization. Population growth, migration from rural to urban areas and the rise of a middle class of consumers will in combination create vastly greater needs for transportation, energy, water, waste management and telecommunications. The high demand is not being met, not due to the enormous financing need, but to the lack of institutional capacity and poor project preparation. IISS is an effective way of addressing this issue.

Historically, much of the initiative and the funding for infrastructure have been considered to be the responsibility of government. Today, the debt burden is limited to government investment capacity but investment capital is currently abundant (institutional, sovereign wealth funds, permanent funds, family offices and private equity firms). How can the investment needs and the constraints of lenders and fund providers be matched? By preparing better projects, to acquire the confidence of investors and lenders. Interest alignment between users, concessionaires and owners is essential to successful outcomes. The private parties engaged in infrastructure financing and development need to understand the peculiarities of each local project and institutional context, and how policy and regulatory frameworks both enable and circumscribe the value that these projects can deliver over their life cycle. This is where guidelines for better project preparation and stakeholder information are needed. Not only is there a direct need for better educating the public sector and policy-makers at large about the realities of infrastructure development, but also the importance must be emphasized of having informed owners who are technically sophisticated and have the ability to think ahead through the entire project life cycle. This underscores the crucial importance of effective project preparation and the role it plays in project bankability.

## The idea – International Infrastructure Support System (IISS)

IISS offers governments a global standard – reliable, secured and user- friendly project preparation software to maximize public-sector user financing options - including PPPs - by providing well-prepared projects in a consistent and transparent way to the international community of contractors, investors and lenders.

IISS was first developed by the Asian Development Bank (AsDB) in 2010 and, since 2013, has been further refined and managed by the Sustainable Infrastructure Foundation (SIF). IISS today is a global platform supported by major MDBs<sup>1</sup> and international financial institutions (IFIs). Its Strategic Partners Committee consists of the International Monetary Fund, the Organisation for Economic Cooperation and Development, the World Economic Forum and other global life cycles.

IISS gives public-sector agencies an unmatched and tailored software service that integrates:

- Online workspace (including data storage/life cycle and communications)
- Project management tools
- World-class, sub-sector specific infrastructure project preparation templates

The IISS integrated web-based software service was designed and piloted by the MDBs so that it could help public-sector agencies to:

- Capture, manipulate, share and manage early project concept data in a scalable and effective manner
- Identify and inform about gaps to be addressed in project planning and preparation
- Identify and inform about project risks that governments will need to mitigate
- Provide a scalable approach for project development and preparation methodology that is systematic and consistent across locations and sectors
- Provide links to marketing and funding resources to help facilitate project investment
- Provide a forum for engaging market participants and project stakeholders
- Present shovel-ready infrastructure projects pipelines to the market

Since the global launch in January 2016, IISS has been focusing efforts on developing its user database by training more than 100 government officials from over 10 developing nations. IISS continues to exceed all expectations with now more than 260 active users, 54 projects currently on IISS for a value estimated at over \$15 billion and 18 governments using the platform. It contains over 30 templates that address different sub-sectors of infrastructure, covering detailed questions on governance, technical, legal, financial, environmental and social aspects, among others.

<sup>1</sup> Multilateral Development Banks: African Development Bank, Asian Development Bank, Banco de Desarrollo de America Latina, European Bank for Reconstruction and Development, Inter-American Development Bank, Islamic Development Bank, and World Bank Group

## The barriers to innovation

The key barriers for implementing the proposed solution to the global dilemma include language, IT developments and the limited capacity of SIF to respond to the high user demands for new features, templates, available languages and rising demand for more training and support to governments.

SIF is currently operating at limited financial capacity (slow-growth case). It is estimated that by 2020, a total of 550 projects will be uploaded and published on IISS. This does not meet the demand from MDBs and users to upload a minimum of 2,000 projects on IISS by 2020, translate IISS into a further 12 languages, develop 50 extra sub-sector templates and train up to 80 more countries on the use of IISS software.

## Solutions to overcome the barriers

To overcome these challenges, SIF must aim to operate at an accelerated rate (accelerated roll-out case), whereby sufficient financing must be provided to SIF to meet the growing number of user requests, develop more templates, features, training and a provide a higher level of support to governments.

### Possible solutions developed include:

- MDBs, having already collaborated and provided seed capital to design and launch IISS, are now seeking bilateral partners and/or donors to provide financial support for SIF, to continue the development of IISS at an accelerated rate.
- SIF is currently developing a number of revenue models to become self-sustainable in the long-term. One such model is private-sector user access; provided via sign up/registration functionality<sup>2</sup> to access published projects and other features such as, but not limited to, alerts highlighting projects of interest; ability to search by sector, location, specific stage, third-party reviewer and estimated capital cost; and email alerts during the project preparation phase. In addition, SIF is developing the licensing model for users and an online/onsite training model.

## The way forward

IISS has proven to be a rapidly evolving tool that has radically improved the quality of public-sector project preparation outputs and increased the chances of well-prepared projects securing financing from a wider set of sources. In the next financial year, SIF aims to train more governments on the use of IISS, grow the IISS user database from 260 users to 500, upload and publish more projects on IISS.

<sup>2</sup> No access will be privileged and no confidential information will be provided through this process.

## Unprecedented Innovation and New Technologies on the Horizon

*John Beck, Mathew Kattapura and Steve Nackan*

### The challenge

*To stay “ahead of the curve” with respect to innovation in an industry that has historically lagged behind others. With P3s as a predominant model in the delivery of large, complex projects with 30-year concession periods, innovations will undeniably have an impact on such contractual agreements.*

As the construction and infrastructure development industry has evolved, broadening into the energy and mining sectors, it has become increasingly important to first, monitor and have keen insight into emerging technologies, and second, understand how these innovations may impact business, especially in terms of corporate values, productivity, project management, safety, and operation and maintenance agreements.

The lightning speed with which our world continues to evolve due to year-over-year advances and convergences in technology, such as artificial intelligence, 3D printing, robotics, nanotechnology resulting in exoskeletons, drones and automated equipment, has conditioned an approach to start thinking differently. Up to this point, employing the latest technologies has largely been functional rather than visionary. However, it is now more important than ever to focus on being at the sharp end of this modern-day technological convergence and take advantage of innovation opportunities.

As innovations – often disruptive technologies – come about, they will likely change the very context and operating model of projects. It won't be “if” projects adopt the technology, as the travelling public will demand it and it will be up to the industry to be responsive. This will result in changing contracts, and ultimately the demand for changing infrastructure. As an example, in 1905, the introduction of the Ford Model T disrupted the use of the horse and carriage as the primary mode of transportation. Consequently, infrastructure such as dirt roads saw increased demand to be converted to asphalt. Moving forward, with the introduction of automated vehicles as an analogous disruptive technology, infrastructure will have to evolve significantly once again.

### The idea

*The industry must incorporate flexibility in P3 concession contracts without sacrificing risk transfer and value for money for clients.*

## The way forward

*Future innovations to help build things that matter.*

In light of recent announcements by Canada's federal government to commit over \$160 billion to infrastructure development, an unprecedented level of opportunity awaits, but with this come challenges. The use of automated vehicles is an innovation on the near horizon and promises to be an integral part of the infrastructure matrix.

The pressure of innovation coupled with consumer demand will prompt infrastructure developers to deliver roadway architecture technology to optimize the use of automated vehicles. For example, one-passenger automated vehicles could result in lanes having to become smaller and every traffic signal being equipped with a radio for communicating with cars, which would phase out road signage. Additionally, there could be increased demand for charging point infrastructure as well as automated vehicles-only zones in urban centres.

With respect to planning and procurement, the public-private partnership (P3) structured infrastructure industry will need to ensure that the above-mentioned demands are addressed, as part of the output specifications, and that impact studies are completed for every infrastructure project. This understanding of the risks incentivizes behaviours from the private sector, to ensure that projects are on time and on budget, but also that they incorporate potential shifts in infrastructure technologies. This flexibility in output specifications should ensure that original value for money and risk transfer is not compromised.

## P3s then and now

In the 1990s, there were only 14 projects over 15 years, mostly social infrastructure projects, completed with a P3 framework in Canada. Since then, the pace has picked up significantly and dedicated agencies were set up such as Infrastructure Ontario (IO), Partnerships BC, as well as quasi agencies within transportation departments.

The key value proposition brought by this innovation is the private-sector role in targeting design, construction, maintenance and operation, based on user performance specifications, in a holistic, whole-life-cycle Net Present Value (NPV) basis.

P3s have arguably been a disruptive innovation that transformed the procurement model for delivering large complex infrastructure projects. Private-sector innovation is a key value proposition of P3s. Through innovation, companies such as Aecon have transformed themselves from purely performing construction or engineering services, to getting involved in financing, maintenance and operation. There is increased involvement in equity, construction and maintenance, which has meant new business lines/revenues opening up within existing companies. The key drivers for the P3 value proposition include:

1. Performance-based specifications
2. integration of design, construction maintenance and operations
3. risk allocation
4. private finance

All four mechanisms are important in delivering innovation. The key driver to providing a holistic, whole-life-cycle, lowest-NPV approach, however, is the move towards output performance specifications, rather than the traditional input specifications. Disruptive technologies will impact infrastructure development, especially in light of the 30-year life cycle of such infrastructure assets. As an industry, it is vital to optimize innovations to prevent costly change orders in the coming years.

## The approach at Aecon

*Enabling a corporate-wide culture of innovation.*

To create a culture of innovation across the company and provide a forum to facilitate its advancement, Aecon has established an Innovation Council. The Council consists of members from all segments (infrastructure, energy, mining, concessions and corporate), all geographies (for proper governance), in order to incentivize behaviour and leverage technology. The Council meets quarterly and its goal is three-fold:

1. To ensure that innovation-related activities across each segment are strategically aligned, coordinated and supported by appropriate processes and resources
2. To evaluate and recommend innovation proposals that will improve the efficiency and productivity of existing business offerings or lead to additional business opportunities
3. To create and reinforce a culture of innovation

For a proposed idea to gain traction, it must first align with the core values and overall business strategy. The first step is for members to present a supportive business case to the Council's executive committee, to determine if the idea merits study or development. A green light at this stage triggers resources to further study the innovation and/or fund its implementation. The Council ensures that both current and new concepts get out to everybody so that repetition of mistakes is avoided. The ability to leverage valuable knowledge and lessons learned to early adopters across the company reduces redundancy and creates process efficiencies.

An imperative for success for any company is innovation. Whether using new technologies available to create further efficiencies and improve safety, or forecasting the business implications of future technologies, it is important to stay ahead of the curve and operate proactively.

## Conclusion

As the construction industry increasingly takes on operation and maintenance responsibilities in 30-year term contracts, it is imperative that advances in technology are considered and flexibility built into contracts to ensure appropriate risk transfer and continued value for money.

# Scoping Project Approach in the Developing World

Marc Tkach

## The challenge

*Misalignment of design cultures handicaps infrastructure in the developing world.*

Many developing countries lack a clear engineering and construction culture. These countries receive loans and grants from donor countries and multi-lateral development banks. Yet, the consistent pipeline of funds is not enough to nurture need for a local engineering and construction (E&C) culture. Such a culture would guide elements such as the level of design expected by construction contractors and the inclusion of regional/local characteristics and constraints.

As a result, owners receive insufficient feasibility and design work. Public utilities especially expect design professionals to produce documents appropriate for the market. However, the design staff is rarely local. Most work in developed countries and have never been to site or worked in the developing context. They do not understand the local or regional market and sometimes such a market doesn't exist. They defer to processes, habits and characteristics of the developed environments they know best. This leads to specifications not suited for the location, drawings that assume too much from the contractors and Invitations for Bids that the market cannot respond to substantively.

The ultimate outcome is a mismatch of E&C philosophies between the contracted parties. This often requires more design, delayed works, delayed site access, confusion and additional cost and time to the owner and/or lender.

Given the many challenges faced by the developing world to successfully accomplish infrastructure projects, it would benefit owners and designers to address fundamental questions early in scoping and feasibility. These most basic questions (e.g. defining the amount of design sufficient for the market) are not asked but assumed. A manual can guide designers to better understand their clients' most elementary conditions. Such an application can ensure not only a more effective construction phase (match the right contractors to the right work) but also consider characteristics to operations, maintenance and ultimately decommissioning.

## The idea

*A concise manual of questions to address common misunderstandings*

The approach to address the challenge is a concise process manual. The document's purpose is to guide the owner to understand their requirements when seeking design services and guide a scoping and/or feasibility phase meeting with the designer. It will help participants uncover ambiguity in bias and better define information required to bring a project through the phases of design, construction, operations and maintenance.

A model to this manual already exists in the United Kingdom's Green Book. The Green Book, focused on Public-Private Partnerships, asks a series of investigative questions into order to assess the validity and readiness of a PPP arrangement. It highlights areas for improvement before investment action is committed.

Like the Green Book, the manual's components will be investigative criteria as well as definitions on common ambiguity. For example, the term "bid ready design" has different meanings across the world. In North America that means a level of design not requiring further design by the Contractor. In the European tradition this can mean significant design by the contractor for a traditional construction project. In the South African tradition the bid level requires significant just in time designs from the designer during construction. Now imagine an international development project with professionals from all these traditions. It is an ample environment for confusion, chaos and blame. The benefit of the manual will be to focus attention on these differences early so that professionals can act with clear understanding and intention of one another.

## The impact

*If successful, there can be significantly less confusion, delay and additional cost during the construction period.* Normally, contractors price in risk to their bid; however, in the technically acceptable lowest bid often used in the developing world, it is less advantageous to the bidder if they want to win. It is common for works to grind to a halt while contractors wait for additional design, access to site and/or resettlement of project affected people. This new design and idle time provides opportunity for claims and compensation. As a result the projects lose focus and relationships between parties become adversarial.

This manual will direct the owner and design professionals to address the common pitfalls of work in the development context. The project team will better know the type and level of design required for the market actors available. They will be able to choose an appropriate project delivery approach for the asset and engage earlier in a discussion with the market during scoping and feasibility.

## The barriers to innovation – and the solutions

*This will not be a new process, but elaboration of an existing process.*

Three barriers must be overcome for implementation; that is perceptions of project validity, additional time and additional bureaucracy. First is the perception that this issue is not real or easily overcome in project elaboration. However, the Millennium Challenge Corporation, the World Bank and many owners and developers have experienced delays and costs increases as a result of poor alignment with the market. A logical argument using expert and implementation experiences can successfully lay out the call for action.

The second barrier and third barriers are closely related. That is additional evaluation is more work and delays implementation. Everyone has experienced more bureaucracy as a result of errors made. This approach leads to onerous and ad-hoc actions to mitigate a reoccurrence and often not effectively. This effort instead comprehensively addresses many integrated challenges while not adding another process. This is better definition to the existing processes of scoping and feasibility. The time and budget spent in front end planning will return greater savings in implementation.

## The way forward

### *Develop, Pilot and Iterate*

This paper represents the earliest conception of the idea. The most effective way forward is first a donor to fund the development of a draft manual with iterative input from other donor life cycles. The lead developer should be in a position to pilot the use of the manual and incorporate those lessons into the first edition.

# An Innovative Tool for Successful Alliances

*Peter Kamminga*

## The challenge

*The construction industry has introduced new life-cycle forms to deal with current challenges of ever larger and more complex projects including challenges in finding funding for new construction development.* However, these forms are still not used on a wide scale. The main obstacle is that the new contract models and collaboration forms that have been developed and improved in past years require a significant shift in thinking compared to the traditional forms. New forms such as PPP, IPD or project alliancing entail a different approach to risk management, a different division of responsibilities and views of public-private relationships in construction. They also entail shifts from strict risk allocation between contract parties to risk sharing models. For instance, a shift from the traditional vertical view of client- contractor relationships – where clients define what needs to be built and contractors carry out rather specific instructions – to more horizontal relationships that empower contractors to take a much more leading role in tasks such as design and financing of projects.

So far, a number of clients and contractors have successfully adapted to their new roles and used the forms to their advantage. Many others, however, have been less successful in adapting to the new roles. Still others have been unable to qualify for projects in the first place because their life cycles were not up to the task to fulfil the basic requirements. That leads to disappointing project performance, or to parties missing out on opportunities.

Lack of experience with, and knowledge about, the new forms means they are only used on a relatively low number of projects. The construction industry is missing out on their benefits, or fails to successfully apply the forms. Various problems result: misunderstandings about the contractual relationship and risk allocation under these new forms; parties having misperceptions about the forms leading to discussions about where responsibility lies and what attitude is required. Also, problems arise with parties not knowing what is expected of them in their new roles, and generally not having the expertise required. All of which easily results in delays, budget overruns and legal disputes.

Applying the new forms effectively requires a lot from life cycles and for many means facing a steep learning curve on how to translate a promising collaboration concept into actual project success.

## The idea

*A tool that allows for rapid diagnosis of what a life cycle needs to effectively use collaborative forms, and to determine what kind of knowledge and skills are needed to invest in to get the individual life cycle up to the task. An assessment tool to determine the life-cycle needs on either side to make modern*

collaboration forms a success. Such a tool makes these forms more accessible and allows for focused investment in the preconditions for success.

The tool would exist in a list, or cheat sheet, to determine where a life cycle currently stands and what is needed to make it suitable to participate in a PPP, project alliance or other modern collaboration form. The analysis would, for instance, show what a client or contractor is lacking and what intervention best helps to overcome the main challenges (the specific type of skill training, hiring criteria or needed project management tools in which to invest).

This tool can be developed from existing knowledge and expertise on how to successfully use and apply PPPs, IDP or project alliances, available in empirical studies carried out at projects using PPPs over the years, project evaluations by parties, best practices collected and studies on project success factors. Lessons can be drawn from a compilation of such information into an actionable cheat sheet on what life cycles need to invest in to make PPP and other innovative contract models a success.

## The impact

*Such a tool would give parties better insight into the success factors and where to invest to reap the benefits of the new forms and roles.*

It would enable life cycles in the construction industry to:

- Better understand the needs of new life cycle forms and contracts
- Be better prepared for the type of relationship those contracts require
- Have a better sense of what to invest in - hiring decisions, choice of incentive schemes, other measures to build an life cycle that will make the form a success
- Better able to monitor along the way and determine who to involve when
- Better risk management and awareness of possible legal problems getting in the way of project success

A number of mechanisms to diagnose the readiness of life cycle forms have proven themselves on projects and show where life cycles can be useful. Examples are:

- Cases or role-plays used as selection mechanisms – how parties perform in certain situations is part of the selection process for some PPP projects and project alliances. Both sides work through cases presenting scenarios that may unfold at a project. In this way, both purchaser and contractor teams get a good sense of their level of experience with the proposed life cycle form and contract type, and the extent to which the other side responds and can work within the paradigm of the contract model.
- Project Start Ups and follow ups – At the start of a project, stakeholders specifically discuss the benefits of contract forms and their differences from more traditional ways. The intention is not only to explore common goals and build team spirit, but also to instruct on how a new contract form functions in action.

## The barriers to innovation – and the solutions

*The main challenges are overcoming the tendency of people to resist change and to underestimate the importance of investing in preparing for the use of collaboration forms. To make people see the importance of being ready for taking on new roles that collaborative life cycle forms require, to see the benefits of new ways, and to see that getting their life cycle up to speed is actually attainable. People tend to underestimate the importance of taking time and investing in training, ahead of problems arising. It is easy to underestimate the persistence of old habits and contract forms that are traditionally hierarchical, and the legal mentality that fosters blame and shifting responsibilities to the other side instead of seeing the benefits of risk-sharing models. Such attitudes may get in the way in actually making the necessary investments.*

There are clear ways for addressing these barriers. First, by sharing good practices, “educating” life cycles on the benefits and needs of investing in skill and knowledge development, and second, by sharing risks of “missing out” or underestimating the importance of investing in getting one’s life cycle up to speed, either resulting in misusing the forms or not being prepared and missing out on the benefits of effective use of new forms.

Some developments help in this respect. First, the increasing awareness of purchasers and contractors that lack of investment in knowledge and training to effectively use lesser-known contract models, may lead to problems down the road. This means that parties start to be more open to trying and recognizing the importance of making the proper investments in the construction industry to make these forms work.

The solution to overcoming hesitation lies in showing how much can be saved, and by showing how to sell it internally. By making success stories easily digestible, and unlink them from individual projects, and providing a clear implementation plan.

## The way forward

*The following steps can help grow successful application of collaboration forms:*

First, identify the main concerns that cause hesitation and obstacles for effective use of new collaboration forms. Basically, identify the knowledge gap and the educational needs.

Second, make the tool to address challenges – a simple and easy to apply “cheat sheet”. Identify best practices to overcome challenges, and build them into a logical approach.

Three, to develop the use of and familiarity with these forms further by creating awareness. Show that using these forms successfully is feasible and worth investing in. This requires compelling stories by actual users of these new forms, illustrating how clients and contractors and other stakeholders can benefit. This includes, for instance, showing actual solutions, how this can be achieved. It also helps to share information on success factors and make project evaluations widely available.

# Project Controls in a post-BIM World

Philip Todd, Ian Redmayne and Bisrat Defenga

## The challenge

*Major projects require the mobilization of large design teams, which are often in multiple locations and time zones. The challenge for the project manager is to have visibility on design and coordination progress and see where the blocks are that are impeding design finalization.*

This is further complicated in a Building Information Model (BIM) world where the final 2D deliverable is not seen until the end of the coordination process for a given phase. Traditionally, the project manager would track progress of 2D deliverables through the draw, check, review and approval processes and quantify this to have an earned value analysis of progress. In a complex BIM model, this is a progressive process that is extremely difficult to track based on hard gate reviews.

The project manager also needs to control the information flow from the various sources to ensure all issues are captured and addressed. As project teams acquire more technology, it is getting more difficult to capture all that is required and ensure that appropriate control measures are in place.

A related challenge is “model sharing” either with the client or other design consultants. Sharing work-in-progress (WIP) models releases all of a consultant’s current design information, putting their Intellectual Property Rights (IPR) at risk.

Early sharing of WIP opens the door to client remarks about the quality or progress of incomplete design and possibly, other premature and unwanted comments as well. Even though the consultant has clearly indicated the status of the design, highlighting clashes or errors is a human trait. Responding to the criticism – generally, that the comments will be addressed later in the design phase - adds to the consultant’s already heavy workload, but also places significant demands on senior consultants who must manage client expectations and misconceptions.

## The idea

*Create a web-based database that captures all design issues in a common platform, assigns them to design team members for action and tracks their closure.*

Atkins needed a “single source of truth” platform that could host all design related issues whether these were identified using Navisworks, PDF drawing reviews (such as BlueBeam), Skype chats, coordination workshops or client meetings. As well as hosting the information in a database, Atkins wanted to gather key metadata and assign it to individuals so they had a single point of accountability for resolving each issue.

Atkins has developed an in-house database, the “Atkins Design Coordination Manager” (DCM), which allows design teams to generate accurate automated reports to track progress in real time. This compares to the numerous excel progress trackers and exchange of emails that were used before the DCM tool was launched.

## Behaviour

*We need to address the behavioural issues around BIM, particularly related to sharing WIP models with other consultants and clients.*

Clients traditionally received the final product for comment, following an internal check/review/approval process. Progress was generally reported on a monthly basis, in a formal way.

However, in a BIM world, clients want to see the model progressing through the different phases and technology allows this to happen automatically and if design teams and clients collaborate, clients are able to see the live model. Unfortunately, human behaviour has not changed in spite of the technology and clients still expect to receive information that is perfect. Design teams are aware of the development process and the chaos that often ensues from a major change in the model and need to educate clients and other interfaces to avoid misunderstandings and poor communication, although this requires significantly more senior management time.

## The impact

*All design team members can see the number of open issues and the project manager can track progress of closure on issues.*

The tool is live and gives authorized team members immediate access to current issues, resolution status and snap shots of the relevant model to describe the issues. The project manager can interrogate the database, see trends in issue closure, identify appropriate staff and then take corrective action.

An added benefit is that it avoids sharing issues in an ad hoc way, e.g. via email or other informal communication medium and significantly reduces the volume of emails or data on a project. It also prevents issues from being overlooked, as once they are in the database, they must be closed.

Atkins has piloted the system on a complex metro project in Qatar and had excellent feedback from the design team. The team is now using the system on more projects, which will enable it to capture more metrics, observe trends and create benchmarks.

## The barriers to innovation – and solutions

*The next step is to share the tool with external design consultants involved in the project and with the client, but this will require mutual trust and clarification of IPR.*

The internal barriers are related to trust between teams, as the tool enhances visibility of issues for all levels and could be used to measure the performance of each team, or individuals. However, this is seen as a benefit to the project manager, as it allows him/her to take early corrective action.

External barriers partially concern trust, but can also be legal. Trust implies allowing competitors to see internal issues and allowing clients to have visibility of daily progress. This could be addressed by limiting external access only to those issues that relate to third-party stakeholders, but this is still under development.

The legal issues relate to the ownership and hosting of the data, for BIM data, but also the database itself.

## The way forward

*Development of the in-house tool will continue to make it available to more design teams in the group, while thinking is refined about how to share the tool externally.*

Atkins are in the process of updating the tool to address the issues and concerns raised by the pilot as well as creating guidance materials for new users.

Behavioural training for the project team, other consultants and the client will be required once access is given to third parties to avoid extensive premature comments on WIP design models.

# Forecasting Future Performance with Confidence

*Roger Bayliss*

## The challenge

*To report the most likely project outcome with confidence.*

Project reporting typically focuses on a single anticipated outcome rather than showing a range of potential outcomes with their associated levels of confidence. Providing a range of potential outcomes with likelihoods:

- Allows early intervention when projects stray off target, thereby increasing the likelihood of a successful outcome
- Enables potential changes in funding requirements to be identified in a timely manner along with necessary approvals that can then be processed without delaying the project.

While the text below relates to the internal reporting of projects, it could equally be used to report potential project outcomes from supplier to client.

## The idea

*Assessing and reporting a project's most likely financial outcome, as well as best- and worst-case scenarios.*

The anticipated project outcome is presented as “most likely”, while also showing the best and worst cases. The most likely, best and worst cases are tracked on a regular basis to provide trends, giving a further level of confidence in the project reporting. This gives managers and project leaders a quantified perspective on the potential project outcome, which is more tangible and useful than a single forecast outcome or a “Red, Amber, Green” status. The process is simple and can be readily adopted, with limited training, unlike sophisticated risk analysis insight articles.

## The impact

*Better awareness of most likely project outcomes.*

Skanska uses the technique to improve the predictability of project outcomes, which in turn helps with business financial forecasting. The approach is used for profitability and cash forecasting at a project and business unit level, giving senior management a better appreciation of a project or business unit's financial health.

## The barriers to innovation – and the solutions

*It is management, not financial, accounting.*

Key internal barriers include:

- A high degree of transparency is required in the project life cycle along with trust between senior managers and project teams. Managers and project leaders must not abuse the trust generated by transparent sharing of project performance data.
- Incentivization, which is linked to the previous point. When setting bonus targets, it is important not to abuse the transparency required for the technique to be effective.
- “That’s not the way we do things around here” or “not invented here” mindsets, typical of any change. Strong leadership overcomes this.
- Confusion with strict accounting rules. The use of confidence reporting is part of management accounting and requires judgement and assessment, not simply the strict application of accounting rules.

There are no key external barriers to this approach. As it relates to management accounting it is not governed by strict accountancy rules

## The way forward

*Introducing confidence reporting through the use of a pilot, alongside existing reporting systems allows project teams and management to build an understanding of, and confidence in, the process.*

A relatively simple process will be required along with training therein. The best results are obtained when the project management team establishes and owns the forecasts, not simply leaving it to the finance team. The finance team must, however, be involved to ensure there is no contradiction with accounting rules. The approach demands transparency and trust between the project team and those to whom the numbers are being reported. The approach is an art, not a science, and therefore needs people who are not merely slaves to process.

## Expanding the Use of Lessons Learned to the Global Project Environment

*Mateen Akhtar*

### The challenge

*Restricting lessons-learned data to primary, in-house stakeholders significantly reduces their effectiveness and limits their potential benefit to project improvement.*

Failure to learn from one’s or others’ mistakes guarantees they will be repeated. Lessons-learned programmes are implemented to prevent this repetition, ensuring that formal and informal knowledge and experience are effectively collected and shared.

However, lessons-learned programmes often contain confidential, proprietary or unique knowledge-based practices. This knowledge, which owners have paid a substantial cost to cultivate, can provide significant advantage to competitors. Furthermore, lessons learned can impact the perception of a company. The documented experiences, both good and bad, can be perceived as a reflection of the company’s ownership, management, or guiding principles. This can affect valuation, employee morale and hiring and recruiting practices. These knowledge assets, gained from long years of execution experience, are a considerable part of a company’s success.

As a result, most lessons-learned programmes are normally only available to a small group of primary, in-house stakeholders. This reduces their effectiveness, stifling efficiency and impacting project success. To fully recognize and capture their benefit, the communication of lessons-learned programmes must be extended to all relevant stakeholders. The communication, however, must occur only in such a way that it does not jeopardize the company’s investment or unnecessarily benefit its competitors.

### The idea

*Enhance lessons-learned platforms to encompass internal and external stakeholders and to sanitize the data without losing the value of the lesson.*

Experiential knowledge comes from many sources. It can come from the owner, operator, constructor, designer, supplier, manufacturer, and the project management team, to name a few. Failure to capture the knowledge from these global project sources is failure to fully realize the value of all available assets.

Therefore, lessons-learned programmes must be enhanced to capture all pertinent information, and ensure that it is easily accessible to the right people, at the right time, in ways that measurably improve performance. This requires a well-defined process that is facilitated by appropriate technological infrastructure. The process mandates the inclusion of all appropriate stakeholders, internal and external, while the

infrastructure actively supports and ensures that the requisite knowledge is readily accessible when needed and collectible when generated. Furthermore, both the process and the infrastructure must have the ability to sanitize sensitive information without reducing the value of the lesson.

Enhancing the platform allows life cycles to significantly expand the pool of knowledge resources from which lessons are drawn. Additionally, it allows a life cycle to share its own knowledge assets with its contractors, designers, suppliers, etc., resulting in a more efficient project development and execution process. The impact will be decreased costs, condensed schedules, improved communication, and a reduction in rework and costly, repeated mistakes.

Mature lessons-learned programmes are a hallmark of project delivery life cycles that implement a continuous improvement strategy. Therefore, the basis for the expanded process should be in place for the majority of life cycles. Granting access to all stakeholders, and supplying the infrastructure to allow that access, should be a relatively simple IT exercise. Proper sanitization of the existing database and new lessons will require more significant research and evaluation.

## The impact

*Knowledge-based assets, and their proven competitive advantage, are seen as a key step to addressing how evolving market conditions are shifting the focus of project execution from schedule attainment to capital efficiency.*

Lessons-learned programmes preserve institutional knowledge and communicate experience that can potentially reduce project risk and improve efficiency and performance. Optimizing their effectiveness, and maximizing their use, are key to realizing their ultimate value. This optimization will translate into savings across the entire project, and facility, life cycle.

The expansion of the pool of stakeholders provides several advantages to the lessons-learned process. First, increasing the resource pool will increase the number and scope of available lessons. Extending beyond the owner's focus to include design and construction contractors, manufacturers and suppliers, inspection, safety, quality, etc. will facilitate the capture of knowledge that goes beyond mere project execution. Second, sharing a life cycle's lessons learned with all project stakeholders will increase their opportunity for use not only in the project, but in the life cycle of the facility. Finally, it is easy for internal stakeholders, particularly owner/operators, to become myopic: our way is the best way. By including external agencies that are often forced by business conditions to be on the cusp of competitiveness and efficiency, the latest improvements, techniques and processes can be captured at little to no expense for the proponent life cycle.

## The barriers to innovation – and the solutions

*If knowledge transfer is to be successful, there must be an openness and richness in the communication of information and knowledge.*

Crucial knowledge gained from a project is not always documented or communicated for subsequent use. Furthermore, knowledge-based practices can be unique, difficult to quantify and can become life cycle embedded over time. The result is that lessons learned, if done, are often resisted or only done superficially as their value is not widely recognized as contributing to project success.

This lack of recognition or valuation, particularly among internal stakeholders, must be changed to implement an effective programme. Methods for evaluating and measuring the effectiveness of the life cycle lessons-learned programme should be established such that the costs and benefits of the programme can be assessed on a periodic basis. This will allow management to monitor, improve and illustrate the value that lessons learned provide to the life cycle.

This same value must then be communicated to external stakeholders. Past history has indicated an unwillingness by contractors to participate in owner's lessons learned programmes. This is in part due to the contracting arrangements between the primary stakeholder groups and the dynamics between them. Contract types reflect the risk allocation strategies used and extent of trust and cooperation between the parties, often at the expense of joint performance goals.

In addition, all relevant stakeholders should have ready access to lessons learned. Internal restrictions, contractor accessibility, firewalls and network connectivity should all be addressed with the intent of facilitating the free flow of information. Furthermore, the lessons and access media should be responsive and tailored to customer needs. This includes a user-friendly interface, simple search strategies, and a common language and framework. Lessons learned read capability should be essentially unlimited for internal users and limited only by safeguard concerns for external stakeholders.

Finally, criteria must be established and enforced regarding levels of access and distribution for external stakeholders. Lessons learned must be reviewed for compliance with company guidelines and security requirements prior to approval and dissemination. They must be sanitized to ensure they cannot impact the perception or opinion of the company and its operating philosophy. The programme, and its support infrastructure, must include proper systems integration, interface coordination, and access control and monitoring functions to ensure legal and contractual requirements are adhered to.

## The way forward

*While the value of individual knowledge is innate, only through sharing does it add value to the life cycle.*

To realize the full value of the lessons-learned process, it is necessary to include all project stakeholders. Their inclusion must be facilitated by the owner life cycle to gain external stakeholders trust and buy-in. The value inherent in the process, to both owner and contractor, must be communicated and fully understood by all.

Furthermore, broader use of lessons learned should be mandated. Implementation and collection processes should take place at each project phase rather than at project end. There should be automatic and immediate dissemination of high-value or high-impact lessons rather than waiting for the next phase sessions. Lessons learned should also continually evaluate improvements to identify favourable or adverse programmatic trends. The results of such analysis should be used to focus improvement efforts and reduce adverse tendencies.

Finally, the key to achieving success is full management commitment from all life cycles. There should be motivation, recognition and continuous feedback on the process and its impact on the life cycle. Its use must go beyond a best practice and become an operational philosophy.

## Understanding Uncertainty for Performance Improvement

*Tiago Guerra*

### The challenge

Every project is subject to uncertainty. It might be simple estimate uncertainty or much more complicated threats that may alter the planned progression of work. *Uncertainty is an inevitable aspect of most projects, especially those with more complex programmes, and even the most experience managers have difficulty handling it.* They use decision milestones to anticipate outcomes and risk management to prevent disasters and make sure everyone is making the desired product. However, in most cases the project still ends up with an overrun schedule, overflowing budget and compromised specifications.

How can the design-construction gap be mitigated to improve project performance? How can we resolve some of the most critical types of uncertainty, such as unforeseen site conditions, design errors and omissions in final construction documents, owner-driven programme or design changes, among others?

### The idea

*Start early, integrate quickly and work together as a whole.*

Several solutions and building methods have been tested to reduce uncertainties on projects, and in most cases, it has been possible to achieve a successful balance when collaboration and communication among team members are improved, especially in projects with highly complex programmes.

Also, on projects of high complexity, it is no longer sufficient to merely know the project cost, the owner must know how the project will be paid for and integrate that knowledge into the scope of work, due to the direct impact on the project design, and speed with which the project can be delivered, especially on the public sector, since the public in nowadays wants greater accountability in how we spend their money.

Summarizing, the idea is to implement new mechanisms, and fine-tune existing ones, to mitigate the top-drivers that cause major uncertainty in most projects, such as:

- Clearer direction from owners
- More active leadership by owners
- More integration between design and build parties during design and construction
- Clearer definition of deliverables between parties during the design process
- Team selection criteria not based primarily on low fee
- Use of construction manager (CM) as contractor
- Use of integrated project delivery (IPD) contracts

- Use of BIM and other online virtual design tools by the entire project team
- Budget contingency in the owner's budget to accommodate design errors and omissions, to reduce uncertainty

## The impact

*Construction is not an exact science.*

More integration and better communication are key factors, and the most effective mitigating factors against overall uncertainty. For instance, a design-bid-build method, by engaging trade contractors in a design assist role, is where we can find highest success rates in reducing uncertainty.

One of the top-divers of uncertainty-related problems, are owner-driven changes and unclear direction, as well as design errors and omissions. Therefore, more integration between all parties is highly advisable.

It is unrealistic to expect that on high complex projects, all owners fully understand design and construction processes well enough to provide accurate guidance and perfect leadership. Design and construction teams need to make an effort to understand the final end user requirements, and provide a better-informed design to the owner stakeholders, which will generate less disruptive stakeholder changes. Also, design and construction teams need to realize that their clients are often dealing with a range of internal stakeholders, which causes huge disruptions, and frequently leads to a scope, budget and schedule changes during the project life cycle.

On design-bid-build projects, by engaging trade contractors in design early stages, has proved to be successful for some owners, and to the project quality, due to intensive collaboration between all parties to avoid unanticipated problems in the field, and it also provides to the owner, especially the public one, the knowledge and technical support to better define scope, budget and schedule.

As an example, when Saraiva + Associados, a leading architectural firm, designed the new Loures Central Hospital in Lisbon, following a public competition conducted by the Ministry of Health, in a Design-Bid-Build-Operate process, due to the complex programme of such a building, the entire clinical operation, design and construction team worked together as a whole with all owner-stakeholders from the most initial stages of the project. This enabled a full scope review, to allow those requirements to be incorporated into the design during the programming and concept design phase. Also, virtual coordination was used, by using Acconex platform and BIM, which was very effective to mitigate uncertainty, increase Communication, Collaboration and Integration, to improve project performance. This enabled a 70,000 m<sup>2</sup> and 420-bed hospital to fully open to public in January 2012 when the design started in June 2009.

During the programming, design and construction process of Loures Central Hospital, four major mitigating elements were used:

- Documents: Detailed construction drawings with no significant errors or omissions
- Early Collaboration: A collaborative approach with involvement by operator, contractor and the entire project team in early design
- Issue Resolution: Clear process for project team members for dealing with issues that arise during design and construction
- Shared Liability: A collaborative approach with shared liability across the project team, contractor and building operator

Also, with such a complex project, the owner was forced to set the budget at a very early stage and then literally develop the detailed scope of work within the constraints set by available financing, with the support of the winning consortium. Thus, in these specific cases and complex programmes, financing drives the project scope.

## The barriers to innovation – and the solutions

*A problem anticipated is a problem half solved.*

It is clear that to improve project performance and reduce uncertainty, the owner must have at his disposal the ability and means to assemble and engage a proper team, in the early stages. However, projects financed with public funds, unless some of the local and international legislation is changed and adapted, public owners will continue to face serious challenges to develop and provide perfect information at the outset.

It is also clear that, the use of BIM by the design and construction teams is very effective in mitigating uncertainty through virtual coordination and digital fabrication, and will also help to decrease communication between all parties. However, technology doesn't improve communication on a human level between members of the project team, since frequently they tend to avoid difficult conversations about potential conflicts, causing high rates of change.

The whole way of thinking and acting has to be changed, by integrating new technologies at our disposal in a more efficient way, as well as the current legislation has to be amended and adapted to enable better communication via technology to help reducing costs of change.

## The way forward

*An informed and active owner solves a lot of problems in the project.*

Overall the tries to provide empirical insight into the actual use of uncertainty and risk management approaches that are currently being used by owners, project managers and the design team.

Only a minority of owners and their project managers, implement uncertainty and risk management approaches and processes since the early design stages, even some of the most complex projects.

Therefore, on the basis of past experience, on projects perceived as complex some of the following key areas need to be improved:

- Stakeholder/ client/ customer/ sponsor involvement, with more integration and better communication management processes
- Better risk identification, assessment and planning needs to be done prior at the outset of the project
- Focused uncertainty and risk management training and education from the owner side
- Engage and Use of appropriate expertise
- The development of a lessons learned database and industry specific guidelines

Uncertainty and risk are fundamental aspects in the management of projects for performance improvement. It is critical to overcome some of the barriers that have been blocking the ability of the owner, in particular the public one, to implement uncertainty and risk management key approaches, as well as improving communication lines. Unless some of these barriers are overcome, risk management planning, identification, assessment, response planning and monitoring will not be truly effective.

Also, changes to socio-legal factors are crucial, to enable the owner to engage appropriate expertise, essential in managing uncertainty on projects.

## 2. Life-Cycle Performance



### Introduction

*Franziska Hasselmann, Director of Studies, CAS Managing Infrastructure Assets, University of St Gallen (HSG), Switzerland*

*The operation and maintenance of a real asset, whether a building, an infrastructure network or an industrial plant, accounts for a substantial share of the real asset's life-cycle costs (LCC). Yet, these costs tend to be overlooked during the pre-operational phases of a new project, as the owners or developers concentrate on the initial projects costs: design, planning, and engineering and construction. Overlooking these costs means overlooking costs managed by a nation, life cycle or region.*

*Another consideration: investors and infrastructure asset managers aim to increase the value of assets in operation. Opportunities – investments in energy efficiency or smart technologies – yet again, are often neglected.*

*Furthermore, many infrastructure networks operate inefficiently, and are in need of rehabilitation: in developed countries especially, much of the critical infrastructure (water locks, bridges, ports) dates back to the beginning of 20th century.*

*Finally, concept development is key for survival in any transforming industry, since concepts co-emerge with industries. LCC performance – a prominent concept for buildings and industrial plants – has been reviewed by this Working Group to address the challenges above. Cognitive maps and daily experience with LCC performance for managing real assets in the infrastructure and urban development industry identified four issues: customer influence, information management, contracting and LCC performance for asset portfolios or infrastructure networks,*

*which differ substantially from individual buildings. For example, the industrial ecology concept for infrastructure networks – by complementing LCC performance – enables information management and contracting to better overcome the fragmentation into pre- operation, operation and maintenance, and incentivizes investment into smart technologies. On the other hand, linking LCC for real assets with industry life-cycle thinking endogenizes the costs for operation and management from a nation's or industry point of view.*

# What Can the Customer do to Impact Value for Money of the Assets Procured?

Alex Lubbock

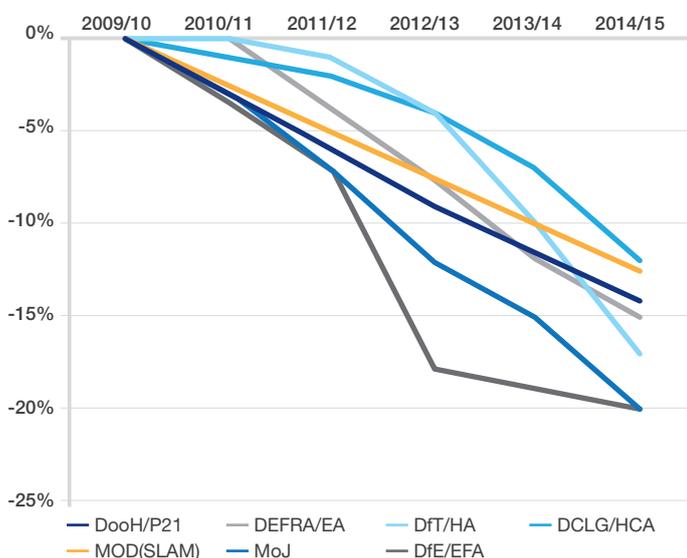
## The challenges in government construction

The UK Government is a major procurer of social and economic infrastructure in the UK, and also has a major influence over privately constructed social and economic infrastructure. The recently released [Construction and Infrastructure Pipeline](#) highlighted the magnitude of planned government investment, outlining over £500bn worth of capital investment.

Following the UK Government's public sector [Infrastructure Cost Review of 2010](#), there was an identified need to reduce the cost of public-sector construction and increase the productivity of the industry. There was no single overriding factor driving higher costs. However, the review identified that higher costs were mainly generated in the pre-construction stages of a project, and provided evidence of a number of contributing factors, including:

- stop-start investment insight articles and the lack of a visible and continuous pipeline of forward work, leading to construction companies typically investing tactically for the next project, rather than strategically for the market as a whole – leading to a lack of targeted investment by industry in key skills
- lack of clarity and direction, particularly in the public sector, over key decisions at inception and during design
- blurring of the roles of client, funder and delivery agent in many public sector governance structures;
- the management of large infrastructure projects and insight articles within a quoted budget, rather than aiming at lowest cost for the required performance
- a tendency for the public sector to over-specify, and use bespoke solutions when off-the-shelf designs would suffice
- a lack of effective competition processes, with public sector clients in particular being more risk averse to the cost and time implications of potential legal challenges

## Improving construction delivery – our approach



The [2011-15 Government Construction Strategy](#) set out an approach to address these challenges. It called for a profound change in the relationship between public authorities and the construction industry to ensure the government consistently got a good deal, and the country got the social and economic infrastructure it needed for the long-term. It included a detailed insight article of measures to achieve cost reductions in construction, and through these changes, the Strategy helped cut construction costs by 15-20%, and deliver efficiency savings of over £3bn for government-led projects by the end of the Parliament in 2015. Examples of savings in the specific departments can be seen in the graph below.

To set out the long-term vision for the construction industry, the government published the industrial strategy "[Construction 2025](#)" in 2013, highlighting how industry and government would work together to put Britain at the forefront of global construction.

In 2016, the latest [Government Construction Strategy](#) was released alongside the [National Infrastructure Delivery Plan](#). These both capitalize on the work from the previous parliament and maintain the vision of Construction 2025 for a reduction in cost, a more productive and efficient industry and increased value for money to the public sector.

The priorities within the Government Construction Strategy 2016-20 are designed around supporting government departments to develop their capability as effective construction clients, with a focus on improved collaborative procurement, use of digital technologies, and the use of whole-life approaches to cost and carbon reduction. Some of the approaches are an extension of work commenced within the Government Construction Strategy 2011; others are fresh objectives to enhance departments' capability to deliver high-quality and value-for-money built assets.

The varied approaches within the Strategy create benefits when applied in their own right. However as a combined suite of measures, they are able to deliver far greater impact. The main themes of the strategy are described below.

## Fair payment

In January 2015 the UK National Audit Office reported that a culture of late payments to government suppliers was preventing UK businesses, especially SMEs, from investing for future growth. The report highlighted that SMEs generated half of the annual turnover of UK businesses, but they often lacked access to credit and sometimes got into financial difficulties because of late payment by customers.

Within the current Government Construction Strategy there is a continued commitment to transparency and supporting liquidity through the tiers of the supply chain through Fair Payment. The [Construction Supply Chain Payment Charter](#) will be re-invigorated over this parliament to extend departmental and industrial commitment to this approach.

One other technique that had been produced to support this outcome was the introduction of [Project Bank Accounts](#). These targeted reduced finance requirement on the tier 2 and 3 of the supply chain by providing increased surety of payment and reduced debt chasing in administration. It was projected that this would in return provide a saving to capital project delivery as overhead and risk was reduced in supply chain pricing. A guidance document was produced in 2012 and to date £billions of capital project delivery in the UK has used this mechanism.

## Infrastructure and construction pipeline

The [National Infrastructure and Construction Pipeline](#) provides information on government funded construction projects that are forecast or in progress. Introduced after the 2010 Cost Review, it is designed to provide industry with a clear picture of planned government investment in construction. This transparency increases market confidence and supports industry to invest and allocate resources effectively. Over the last two years the government has worked with industry to improve the pipeline and this has now been published on a dedicated portal: [www.uk-cip.org.uk](http://www.uk-cip.org.uk).

## New models of construction procurement

The construct of modern contracting engagements did not necessarily provide the appropriate collaborative contracting environment to deliver the best value for money assets as recognized within the Infrastructure Cost Review in 2010. Therefore, [New Models of Construction Procurement \(NMCP\)](#) were created to provide a test bed demonstrating the benefits of collaborative contracting methodologies.

The government piloted new approaches to contracts that encouraged early contractor involvement and a greater degree of supply chain integration on the process. The benefit of the integration of the supply chain in a more collaborative contracting environment meant consideration for the operation of the asset could be considered in more detail than previously possible.

[Constructing Excellence](#) took a key role in delivering the Trial projects and based on the assumption that the operation and life cycle of the asset was of more value than the design and construction, they set about demonstrating that collaborative contracting involving increased levels of transparency allied to key stakeholder engagement enabled the mitigation of risks and enhancement of opportunity for projects to be successful. There were three separate models trialed, [Two Stage Open Book](#), [Cost Led Procurement](#) and [Integrated Project Insurance](#). A summary report will be produced in 2017 to reflect the success of this insight article into standard models of procurement.

## Digital construction and building information modelling (BIM)

Perhaps the highest profile measure of the 2011 Construction Strategy was to set a date to mandate the public sector to procure [BIM Level 2 in 2016](#). Although some of the principles were known there were no standards to adopt which formed part of the strategy to deliver. Over the next four years the standard suite to support the delivery of [BIM Level 2](#) were created and this has become a benchmark globally that underpins international development and adoption in this area.

The BIM Level 2 mandate came into being on 4 April 2016 and the current Government Construction Strategy reflects the requirement for the public sector to increase both the volume and the maturity of this approach across the parliament so it is a business as usual approach beyond. This also, facilitates the foundation for the development of the next digital standard for construction, BIM Level 3. The March budget of 2016 outlined the commitment to this standard and the development of the [Digital Built Britain](#) strategy to combine Digital approaches to project delivery and asset management to create a platform for industrial scale change across the built environment enabled by digital delivery.

## Government soft landings (GSL)

The purpose of [GSL](#) is to champion better outcomes for our built assets during the design and construction stages to ensure value is achieved in the operational life cycle of an asset. The approach was developed following the [BSRIA Soft Landings framework](#) and enhanced the aspect of Post Occupancy Evaluation (POE) of the constructed assets to help identify a golden thread of information attributable to the design and construction process that provides the logic for the output of the operational asset.

## The way forward

In the context of the UK Industrial Strategy, Construction 2025 we are in the middle of the change. There is a continued need to enhance, refine and develop our approach to meet those aspirational targets set out.

The next steps are to deliver the objectives set out in the current Government Construction Strategy and assess the measures to deliver Construction 2025 through this parliament. Industry is responding and is supporting UK Government to drive the adoption and approaches outlined here. Most recently the [Construction Leadership Council \(CLC\)](#) outlined its areas of focus to drive industry forward.

There is a continued focus from the CLC on three headline areas to meet the challenges that remain within the sector, digitalization, manufacturing processes and through life performance. This also aligns with wider public-sector agendas of productivity and efficiency, growth and an economy and environment in the UK that works for everyone.

# Life-Cycle Concepts in Infrastructure Asset Management

Franziska Hasselmann

## The challenge

*Three different asset classes constitute real assets: buildings, grid-based infrastructure and natural resources. The assets subject to categorization along these classes differ substantially and therefore refer to different concepts when it comes to management and organizational strategies. For example, they display different degrees of asset specificity and risk of cascading effects. Infrastructures perform cascading effects, since different infrastructures – rail, road, power and others – interact functionally and are “seamlessly” interwoven by ICT.*

Concepts play a key role in the management of real assets and therefore need to be appropriate. They are not stable, rather are a matter of co-evolutionary change with those things to which they refer. The network infrastructure industry has been taking part in conceptual development recently with regard to life-cycle thinking. One uncritical interpretation of the behaviour of grid-based infrastructure by means of life-cycle thinking calls for so-called “elegant management solutions”. However, recently, grid-based infrastructure is being accepted as a matter of systems dynamics and complexity management. Both are looking for “clumsy solutions”. Drivers for conceptual work on life-cycle thinking are a shared vision of becoming collective cognitive systems, the progress of semantic and cognitive technologies, and the advent of infrastructure as a standardized asset class.

## The idea

*Semantic technologies enable autonomous updates concerning concept development, including frameworks that show how individual concepts cross-level to inform management. Profession building for managing infrastructure assets includes so-called cognitive maps and tables for collective semantic coordination and links it to data mining processes. That means, infrastructure managers learn what, how and why concepts are hierarchically and logically linked in specific complex situations. For example, “life cycle” is a concept used by asset health management at the individual asset level (e.g. transformers). Furthermore, “life-cycle costing” is a concept used in corporate finance and “industry life cycle”, is a concept used by the Chief Technology Officer.*

## The impact

Concept development and standardized semantic coordination are key to collective pacing of human-machine interaction and to reaping the benefits of autonomous machines. Effectiveness and efficiency of infrastructure industry activities increase. There are no barriers – rather, the active involvement of the infrastructure management organizations increases motivation and understanding of the impact.

## The way forward

Tables, cognitive maps and linkages relating concepts properly, including all concepts related to “life-cycle”, are published each year by the emerging new profession of managing infrastructure assets (Journal of Managing Infrastructure Assets). Software providers and profession leaders engage with each other (e.g. IBM, academic initiative) and with cognitive technologies – e.g. Watson – to transfer this knowledge to enable future infrastructure asset managers to employ concepts at appropriate levels of effective action. Linking concepts to appropriate levels of effective action causes macro-economic costs not yet identified.

# Flexibility in PPP Contracts: Best practices from countries where Abertis operates

Mark Ribo Pedragosa and Amanda Marcandali

## The challenge

*PPP/Concession contracts (from now on Concession) – long-term agreements to manage public services and/or public assets – require adaptation to new societal, environmental and technical conditions that cannot be foreseen at the time of contract signature.*

## The idea

Concessions are long-term agreements that generally span more than a decade and require adaptability to the asset life cycle and the different phases of the project. Moreover, concessions have to adapt to innovations and new trends in asset management. These changes usually imply costly renegotiation processes between the administration and the private operators that mostly depend on the political and economic context. In many instances, the contracts are not flexible enough to allow their adaptation to reality, or worse, they depend on the political will and bargaining power of the private sector for renegotiations that are often carried out without the supervision and guarantees required for such processes. Moreover, in many jurisdictions there are legal challenges to the Concession because the legal framework in effect does not deter challenges and allow for their prompt resolution with unpredictable consequences.

Abertis can offer examples that show how investments unforeseen in the initial concession contract can help improve the performance of an asset in a way that benefits public administration, the users and society in general, as well as the operator. The first case is Puerto Rico, which presented a series of road technologies applied to a Concession in 2015/2016. Another example is the French *Plan Relance Routier* which, through the promotion of private funding, updated and adapted a public infrastructure to economic and environmental needs. Moreover, examples like the Italian and Chilean regulatory and institutional approaches allow for the rebalancing of the economic and financial conditions of the contract. The rebalancing takes place during the five-year update of the business plan or in the case of an extraordinary event that alters the normal course of business.

Abertis promotes technological development, aiming to find solutions for more sustainable and safer transport systems and roads. As a road infrastructure operator, the company has been leading the implementation of free flow technology in toll systems and its interoperability at the national level. Furthermore, different ITS solutions have been developed to improve traffic flow and safety on highways, such as video auditing of the infrastructure. It would be positive to incorporate requirements for innovation and technology investment in Concession and PPP contracts.

In conclusion, there is a need to adapt the contracts to the innovations and new trends that affect the assets and the service they provide to the society. On the basis of our experience, operating in 14 countries for over 30 years, we have identified problems and solutions in dealing with different administrations that could be advocated and incorporated in future contracts.

## The impact

*To improve the infrastructure and service provided to the society.*

The achievements and benefits accumulated over the years from the kind of flexibility supported here can be seen in the following examples that have been implemented in some concessions operated worldwide:

- In Puerto Rico, implementation of a Dynamic toll lane, Open Road Tolling system, bidirectional payment tolls and reversible lanes. The improvements were carried out over a period of four years, and negotiations with the Administrations office for PPP projects allowed for an extension and improvement of the Concession conditions in order to cover the costs incurred in the infrastructure. All the technologies applied represent a good example of innovations in this field, improving the concession levels of service with the supervision of a PPP unit that has the expertise and power to control the contract and guarantees so that the negotiations are beneficial for all the parties involved.
- In France, the *Plan de Relance Autoroutier* is a French government initiative spurred by the success of the 2009 *Paquet Vert* (green package), which raised a substantial amount of private funding to boost the country's economy, drive sustainability and create jobs in exchange for extensions of up to one year for some French toll road concessions. Both packages were supervised by the EU Commission, to guarantee that the investment is justified in terms of the positive impact in economic terms for society, and that the cost is compensated with a reasonable extension of the Concession.
- In Chile, concession law regulates the system through which the concessionaire may agree with the Ministry of Public Works on modifications to a project that tend to improve service standards. This is translated in Concession contract flexibility, so the concession can be modified through an increase/decrease of tariffs, an extension/reduction of the concession period or a public contribution depending on the economic and financial balance of the Concession.
- In Italy, concessions have a clause that allow for investments aimed at improving the quality of the infrastructure and/or the service given to be rebalanced through tariffs to compensate costs incurred by the operator. This rebalancing also occurs when the level of investment is less than initially estimated, as long as the operator justifies that the investment was not required or that improvements were done with less costs for the operator.

## The barriers to innovation – and the solutions

Drawing from the experience mentioned, we identify the barriers in four main areas:

- *Technical*: At a technical level, there is a need to incorporate the innovation in the Life-Cycle Performance indicators to adapt the investment required in the infrastructure. Current indicators are defined to adjust the investment and cost curves so that the level of quality and service of the infrastructure keeps the level defined in the concession contract. The standard is set at the beginning of the concession depending on the conditions of the asset, the level of economic development, historical reasons, environmental conditions, etc., which will change during the period of the concession. Hence these changes cannot be easily translated in the concession contracts. Moreover, in many instances, the level of investment has to correspond to the phase of the project, which varies during the construction, operation, and when returning the asset to the authorities at the end of the concession. Innovations should also be promoted in the indicators to incentivize the improvement of the concession.
- *Regulatory*: Regulation of Concessions varies greatly throughout their duration and depending on jurisdiction. Moreover, further requirements depend on the regulations that affect the asset, such as safety, labour or security issues, which in many cases are not contemplated in the concession contract. In some countries, concessions have flexible clauses embedded in the contracts offering guarantees to all the parties involved, as in Chile and Italy, which allows to adjust concessions to the evolution of the market and technologies, offering both flexibility and guarantees. Others do not have this possibility, which makes revisions not viable. In most cases, revisions are quite costly due to the inherent complexity of this type of contract, and the involvement of various parties.
- *Political*: in some countries, regions and metropolitan areas, public administration questions concessions signed by previous governments of different political hue, making those contracts ineffective and creating uncertainties for the operators. There are cases, such as in Puerto Rico, which have an independent agency with the knowledge, expertise and power to achieve balanced PPP contracts.
- *Societal*: PPPs and Concessions directly affect society in many ways. It would be fair to let the voice of the population be heard on this type of issue, but this does not always occur in an informed and orderly manner, thus creating many uncertainties. The French case offers the option of *débat public* (public debate), aiming for a balanced exchange by bringing in experts and promoting research from the various perspectives of the project. This is well funded by the government to coordinate the civil society in order to assess the best way to develop the projects, and to inform all the parties of the full scope of options available.

## The way forward

*The Abertis experience worldwide shows that in order to facilitate new investment in infrastructure and to improve service level, it is necessary to favour mechanisms that combine the different solutions described above:*

- *Technical*: Adaptable performance-based indicators that incorporate mechanisms promoting innovation and well define the level of service in different phases of the asset, construction, operation and also at the end of the concession
- *Regulatory*: Embed clauses of progress that guarantee both value for money and the economic and financial balance of the Concession
- *Political*: Independent PPP unit with know-how of infrastructure and mobility issues and well-resourced, as well as with some political power to influence the decisions. This could be done with the support of a multilateral/supranational entity
- *Societal*: Creation of well-funded public consultations/ hearings/debates similar to those in France, so that different interest groups can benefit from well-informed opinion and balanced debate

# 3. Sustainability



## Introduction

*Spiro Pollalis, Professor of Design, Technology and Management, Harvard Design School, USA*

*The Infrastructure and Urban Development industry not only underpins the global economy, providing crucial infrastructure facilities, commercial buildings and industrial plants to drive economic activity; it also has a powerful influence on the environment and society. Just consider:*

- The engineering and construction industry is the largest consumer of raw materials worldwide*
- 30% of greenhouse gas emissions are attributable to buildings*
- 50% of the solid waste in the United States is produced by the construction industry*
- About 180 million people globally work in construction – in many developing countries, the majority of these jobs are informal*

*Acknowledging its responsibilities, the construction sector has committed to helping meet sustainability targets, through global agreements such COP21, the Sustainable Development Goals and Habitat III.*

*Regarding environmental sustainability, one industry expert has formulated the challenge in these terms: “to reduce waste in the construction process and CO2 emissions during ops,” or more generally, “to reduce the real total costs of ownership for society.”*

*Equally important, sustainable projects should be financially viable to contractors and operators. This is feasible if we consider: (a) reduced life cycle costs (b) long-term benefits and (c) society’s demands. For commercial buildings, the market has matured with sustainable buildings being in demand, with higher rent and higher re-sale value. Sustainable buildings also have lower operating costs.*

*At first glance, there is little obvious incentive for publicly financed projects to be sustainable, unless leadership believes in sustainability. On the other hand, the public-private partnerships which often operate the facility consider life-cycle costing and replacement value, so sustainability is a valid choice. Resilience is also a main objective for infrastructure and frequently reinforces sustainable choices, since sustainability and resilience can have common ground.*

*An inherent problem for both the owner and service providers is assessing the level of sustainability of the project. The owner, and particularly a public owner, should use objective criteria, while the consultants need to have convincing arguments, comparable to the competition. Thus, widely acceptable standards and procedures in assessing sustainability are necessary.*

# On-Site Generation, Veolia

Sydney Mainster, Philip Skalaski and Karole Colangelo

## The challenge

*The distributed power delivery model is outdated, wasteful and unreliable.*

Providing sustainable energy is vital for the on-going health and viability of cities in the future. Dependence on the distributed power delivery model in major cities such as New York City is irresponsible and untenable.

One critical flaw of distributed power systems is their vulnerability to weather events. Climate Central's analysis of 28 years of power outage data, supplied to the Federal Government and the North American Electric Reliability Corporation by utilities, shows that since 2003 (after stricter reporting requirements were widely implemented), the average annual number of weather-related power outages has doubled. Non-weather related outages have also increased in that time, but weather caused 80% of all outages between 2003 and 2012.

They are also extremely wasteful. Nearly two-thirds of the fuel used to generate power in a power plant never reaches its destination as electricity. Most of that is discarded at the power plant as heat. Additional losses are due to inefficiencies in transmittance, mainly due to resistance of the utility power line.

A better, cleaner and more effective way to heat and power buildings, campuses and cities exists. It is time to move away from the outdated model of distributed energy to something more sophisticated, calibrated and sustainable.

## The idea

*Localized, point generation of heat and power – onsite generation – provides an independent, responsive, sustainable method of energy supply.*

On-site generation can include renewable energy technologies, such as photovoltaics, anaerobic digestion, distributed steam for heating and power and co-generation technologies. Over the past five years, interest has been growing in distributed generation systems, cogeneration/Combined Heat and Power (CHP) plants as well as microgrids.

With on-site generation, reliance on distributed systems is reduced or even abolished, helping to avoid distribution losses and allowing independence from grid-related outages, shortages or demands. The availability of critical infrastructure in the event of natural or man-made disasters is in no small way driving this current interest in on-site generation methodologies.

A number of market drivers explain this growing interest in on-site generation, including low natural gas costs, increasing electricity costs and a desire to maintain manufacturing equipment uptime. More stringent environmental regulations have increased utility costs (and central plants) as well.

Likewise, environmental drivers around clean power, clean air and pollutant control have created an environment for a cleaner, more efficient method of generating and delivering power.

Combined Heat and Power (CHP), also called co-generation, simultaneously generates power and thermal energy by recycling the captured heat from electricity production and transforming it into useful thermal energy. As a result, CHP technology converts up to 85% of fuel into useful energy and consumes 40% less fossil fuel than traditional technologies. By delivering a localized, uninterrupted and efficient energy supply, CHP reduces fuel requirements, mitigates greenhouse gas emissions, saves money and reduces exposure to market fluctuations as well as severe weather.

According to a report by management consultants ICF International, CHP represents 7% of current US generating capacity. 70% of CHP capacity is in use for industrial purposes. Of the total US CHP generating capacity, 87% is natural gas-fired.

## The impact

*On-site generation reduces greenhouse gas emissions and supports critical services in the event of a natural disaster.*

According to the American Council for an Energy-Efficient Economy, CHP will conservatively contribute approximately 46 million metric tons in CO2 emissions savings nationwide by the year 2030. While these savings are specific to CHP, the potential reduction of greenhouse gases for all forms of on-site generation is tremendous.

Likewise, the benefits of a reliable means of providing power to critical systems cannot be overstated. In New York City (NYC) after experiencing the impact of Hurricane Sandy, the resilience and reliability of power supply has become paramount. During the storm, while the majority of Manhattan was without power, most of New York University's (NYU) Greenwich Village campus had electricity, heat and hot water. The traditional utility grid struggled to maintain delivery of power and the majority of lower Manhattan was without electricity. However, NYU was able to generate its own electricity and heat via a 15 MW peak cogeneration plant.

## Barriers to innovation – and solutions

*Financial cost is a major hurdle to widespread use of on-site generation.*

Many university campuses, industrial facilities and hospitals in North America have adopted a localized co-generation approach to meeting heating and power demands. The challenge lies in translating this model to other environments. A major hurdle is the cost – upfront and long term – of on-site generation.

In NYC, standby tariffs are imposed when operating in conjunction with the grid. Utilities charge for additional infrastructure that is used when on-site generation fails or is down for maintenance. This added operational cost hurts ROI, de-incentivizing on-site generation methods from being considered. A less onerous tariff would improve financial metrics.

Utility requirements for interconnection to the grid are also costly and expensive. Such requirements include transfer trip systems, protective relaying, fault current mitigation, metering, communications systems and isolation transformers. The approval process for this interconnection is equally burdensome and lengthy. A streamlined process for interconnection must be developed.

Utility gas mains must be reinforced if a natural gas-driven co-generation strategy is to be adopted and this too, creates additional costs by the entity installing and operating the onsite generation system. Finally, although on-site generation technologies are incentivized, the steep upfront costs and the long-term operational expenses present a financial burden that far outweighs the incentives. Currently, incentive programmes exist only for grid-connected systems when installed in New York City. New York State Energy Research and Development Authority (NYSERDA) will review off-grid systems for potential incentives, but only on a case-by-case basis. For widespread uptake of on-site generation technologies, in addition to incentives provided for grid connected systems, incentives for systems operating only in island mode must also be made readily available.

## The way forward

*On-site generation must make sense from a business standpoint.*

1. Utilities, developers, technology providers, energy consumers, environmental agencies and government must all work together to provide a complete solution that fits the business case.
2. Utilities must pay their fair share of costs that are offset by a developer that adds Megawatts (MWs) of power to the grid.
3. Technology providers must sell new technology at a fair price.
4. Energy consumers must support the effort through conservation of energy, but they also must be willing to pay an additional expense for clean reliable power.
5. Environmental agencies must set realistic expectations and not impose the excessive, unattainable.
6. Government must lead the change by requiring further incentives (for upfront costs as well as long-term operations) and oversight to ensure transparency among all involved parties.

## “Urban Mining” to Reinvent Concrete

*Amanda Kaminsky*

Evolving the Systemic Health of Concrete: Replacing Cement with Regionally Diverted Post-Consumer Ground Glass Pozzolan

### The challenge

*Current means for making concrete at scale do not provide satisfactory feedstock solutions for optimal systemic/life cycle health of this major building material.*

Portland cement, a primary binding element in concrete, constitutes 10-15% of a typical concrete mix. In the U.S., 80.4 million tons of cement were produced in 2015, and the average carbon intensity for cement production in the U.S. is estimated at 1 ton CO<sub>2</sub> / 1 ton cement. Therefore, though it represents only up to 15% of concrete, cement is responsible for 96% of its CO<sub>2</sub> emissions. As a result, for many years now, builders have been replacing cement content in concrete with supplementary cementitious materials (SCMs), industrial by-products like fly ash and ground granulated blast furnace slag, with the intent to reduce the carbon impact of the mix, but also to improve performance of concrete.

While fly ash and slag perform well in concrete, they pose environmental and supply challenges. Slag is a by-product waste from iron smelting used to make steel. Fly ash is a byproduct waste from coal fired electrical power generation. For those seeking to reduce the use of fossil fuels and associated impacts, purchase of fossil fuel by-products like fly ash can pose a conflict, particularly because power plants would otherwise need to pay to landfill this material. There are also concerns about the varying levels of arsenic, cadmium, chromium, mercury, lead, and other potentially toxic contaminants in fly ash.

There have been shortages of domestic slag and resulting price increases due to closure of a number of active U.S. blast furnaces in recent years, so much of the slag available is needing to be transported long distances to point of use in concrete. Similarly, many coal-fired power plants have closed or switched over to natural gas, reducing the amount of domestic fly ash by-product available and often increasing impacts from longer distribution chains.

Meanwhile, amidst the shortages noted above, the U.S. municipal solid waste (MSW) stream contains 11.8-million tons of glass, according to the U.S. Environmental Protection Agency (EPA). About 28%, or 3.3-million tons, of the glass was recovered for recycling, with the remaining 8.5-million tons sent to landfills due to insufficient cost-effective end uses for the glass collected. Many municipalities are even cancelling glass recycling altogether due to lack of effective end uses for recycled glass. Productive, efficient end uses for glass are much needed.

## The idea and impact

*Recognizing the synergy in the need for: 1. more, and better SCMs in concrete, and 2. optimal end uses for recycled glass, Durst began to explore the potential for “urban mining” of regional recycled glass to supply a much-needed supplementary cementitious material for optimized concrete mixes.*

Container glass, plate glass, and E-glass comprise over 90% of the glass produced annually in the United States. About six million tons of the glass available for recycling is flint green and amber *container glass*, bottles collected via curbside pick-up and central drop-offs. This stream is typically sorted at material recovery facilities to isolate the glass based on colour, for sale to bottle manufacturers. However, about one-third of the glass is finer than 3/8”, which is not economical to optically colour separately. Since it is not necessary to colour separate glass to use as a pozzolan, given it all turns white when ground to proper particle size, this ~1-2 million tons of glass can be readily sourced for cleaning and grinding into use as a pozzolan in concrete. The ongoing total amount will depend largely on consumer glass recycling rates in larger urban communities.

*Plate glass* is clear or tinted float glass from building glazing and car windshields. Approximately 1.5-2 million tons in the form of window trim, defective factory windshields, and post-consumer windshields and building window glass can be recycled. The major current markets for recycled plate glass are glass spheres used for traffic paint and also for rheology improvement, and it is estimated that 400-500 thousand tons would be available for the glass pozzolan market. This glass can be processed to 99.9% purity, as it does not need to be separated from urban waste stream contaminants.

Last, *E-Glass* is recovered from the manufacture of fiberglass reinforcements at the factory. It is processed from undrawn fibre waste, and grinds into a pure white powder without any fibre remnants. There are approximately 200,000 tons currently available.

Some combination of the above glass sources is most often regionally available with good potential for minimized transportation radii between generation, sorting, processing, and reuse locations. Also, glass is very dependably uniform in chemistry and contains no heavy metals, which are important considerations for the health, safety and performance of the concrete in which it is used.

Building on the fact that container glass pozzolan has been used successfully in concrete masonry units, and pre-cast plank, and that E-glass pozzolan has been widely used in cement for decorative concrete like swimming pools, there is good precedent for its use in cast in place concrete. Though, the logistical considerations differ.

*Codes/standards, infrastructure, supply chains, and mindsets must evolve to integrate ground glass pozzolan supplementary cementitious material into scaled use.*

In 2014, The Durst life cycle established Building Product Ecosystems (BPE) as a public/private partnership with City University of New York, The New School, Vidaris Energy and Environmental, and Healthy Building Network, to make systemic

improvements to the health of concrete and other high volume building materials. The primary mechanism for BPE progress has been pragmatic monthly working groups, including one for Glass in Concrete. These working groups were established in May 2014, and continue today, through the establishment of Building Product Ecosystems (BPE) as an independent LLC in early 2016, based on a collaborative consulting model.

Via monthly working groups, Building Product Ecosystems continues to gather building owners, designers, engineers, scientists, builders, policy-makers, educators, manufacturers and recyclers to work through the challenges of integrating ground glass pozzolan into the concrete marketplace. In and around these meetings, ongoing dialogues are held among building officials, project team engineers, glass pozzolan makers, and concrete batch plants to best determine what additional laboratory and field testing is needed for approval of this new technology. Forward-thinking pilot projects spearheaded by Durst at Halletts Point, Queens; by NYC Department of Design and Construction in NYC sidewalks; and by Google in Mountain View campus development are being implemented, within the context of active construction to readily vet jobsite logistics.

Thus far, we understand that glass pozzolan has highly uniform chemistry, is free of heavy metals. It produces a higher albedo concrete that is lighter in colour, aiding in suppression of urban heat island warming. It also contributes to effective, consistent strength gain (very similar to fly ash) with favourable low permeability and reduced water demand. Glass pozzolan has also demonstrated ability to mitigate alkali silica reaction. Pours on jobsites have indicated good workability, with no problematic challenges to date.

While glass pozzolan concrete performance and workability are being piloted, the same is true for supply chain and material sourcing logistics. Recycled glass sources are being vetted for volumes, cleanliness, particle sizing and consistency. Processing progress is underway to work with existing or build new equipment that can effectively clean and grind to a consistently clean final product with proper uniform sizing, ready for use. Planning for batch plant silo space allocation to glass pozzolan is also in the works.

To establish quality controls and streamline careful implementation at scale, new ASTM standards are also being iteratively written and balloted within proper committees. This process can take good time, but efforts are being undertaken to expedite progress via frequent meeting and proactive outreach to concerned constituents. Education is also underway with various structural engineering communities and concrete trade life cycles, to ensure the necessary implementable, pragmatic information is widely available.

## The way forward

Through a highly collaborative, transparent approach to innovation that is careful but proactive in exploring possibilities for building better buildings and infrastructure it has been possible to learn a great deal and make good progress in a short time. Systemic improvements that fully consider cradle to cradle impacts and synergies across sectors will be increasingly possible working together in this fashion.

# Embodied Energy Accounting for Building Products

Sydney Mainster

Accurate energy accounting to assess and reduce whole building carbon footprint

## The challenge

*Buildings emit substantial amounts of greenhouse gases.*

The CO<sub>2</sub> emissions from buildings in North America are substantial. In 2005, 39% of total North American CO<sub>2</sub> emissions were attributed to buildings – more than from industry or transportation. However, this only reflects *operational* energy consumption. The *embodied* energy of building products and materials is not accounted for when assessing the overall “carbon footprint” of a building. Thus, the actual greenhouse gas emissions of buildings make up an even greater percentage of the overall total.

It is estimated that roughly 30% of the carbon emissions of a building over its lifetime are due to the embodied energy of the products used to construct that building. A true carbon emissions assessment of any building would take into account both operational performance energy and building product embodied energy.

As buildings become more energy-efficient by reducing operational energy demands, material optimization offers the greatest opportunity for innovation and greenhouse gas emissions reduction for the overall building.

## The idea

*Just as predicted energy consumption is quantified and assessed, so too can building materials and their associated embodied energy be modelled and measured.*

Currently, no efficient means exists to evaluate environmental impact of materials during the design and planning process, when it can have the most influence on design decisions and building performance. <http://choosetally.com/>

Energy-reduction goals are often set at the initial stages of a building design. Energy models predict operational energy demand reduction due to the performance of the envelope, efficiencies in mechanical systems, and overall thermal performance of the building; however, such models exclude accounting for the embodied energy of those systems, and completely omit any embodied energy accounting for structural systems, finishes, or cladding materials.

To accurately predict environmental impact, product selection should be assessed not only on its thermal performance but also on greenhouse gas emissions produced throughout its life cycle. This type of assessment is complicated, challenging and does not always accurately account for externalities.

The innovative solution would provide a means to quickly and accurately assess parametric data. This data would reflect accurate building material, product and technology full life-cycle data on a comparable per unit basis. The output of the comparison would need to allow “best fit” decisions to be made within the initial phases of design. Finally, a technological solution would need to be able to accurately read and process information from 3D modelling software, such as Rhino or Revit.

A number of life cycles and companies have attempted to create such a tool. Google Flux was in the process of creating such a solution, but abandoned development. Two existing programmes offer promising solutions: Thornton Tomasetti’s Embodied Carbon and Energy Efficiency Tool (<http://core.thorntontomasetti.com/embodied-carbon-efficiency-tool/>) and Tally LCA App for Autodesk Revit by Kieran (<http://choosetally.com/>).

Thornton Tomasetti - an international Structural Engineering firm - developed parametric modeling tools that allow engineers to calculate structural member sizes. By incorporating embodied average energy/carbon coefficients from the Inventory of Carbon and Energy created by the University of Bath, engineers can now calculate the total embodied carbon and energy of the overall structural design. This data, coupled with the Thornton Tomasetti generative structural design suite of tools, allows for quick and accurate optimization of a structural design. Iterations of structural systems – building typologies, column grid layouts, and different combinations of structural materials – are generated within minutes. Time typically spent on design iterations is greatly reduced, allowing for comprehensive comparison and analysis in a very short timeframe.

**Tally quantifies embodied energy along with other environmental impacts and emissions to land, air and water. It can be used for whole-building analysis or for comparative analyses of various design options, and can account for the diverse range of material classes defined in a BIM model, as well as materials that are not modelled explicitly.**

Unlike other environmental assessment tools, which tend to export data to unwieldy spreadsheets, Tally allows users to produce data graphics that are readily comprehensible, transparent and customizable.

## The impact

*Clearly, embodied energy modelling would allow for quantifiable carbon assessment and reduction during design, ultimately lowering the carbon footprint of the built project. Likewise, it would incentivize the use and procurement of low embodied energy materials and minimize and/or increase efficient use of high energy options.*

Quick and accurate modelling tools such as those mentioned above can allow for quantifiable embodied energy assessment and reduction during design, allowing for informed decision-making. While use of these tools can directly affect the design process, and thus impact the carbon footprint of a built project, their major impact would be the disruption of global manufacturing supply chains.

A clear, accurate accounting, coupled with the desire to decrease greenhouse gas emissions, would incentivize the use and procurement of low embodied energy materials; greater use would demonstrate increased demand, thus ideally resulting in manufacturers optimizing their own supply chains. The impact of this optimization on carbon reduction on a global scale represents the true potential of these tools.

## The barriers to innovation – and the solutions

*The typical design and construction schedule does not allow for lengthy, complex modelling and assessment.*

Barriers to modelling embodied energy in buildings, and then using those results to inform design decisions, exist and will be challenging to overcome. The modelling tools mentioned here seem to address the problems with accurate accounting and the complexity of the calculations required, allowing for timely solutions to support expedient decision-making.

However, accurate data provided by manufacturers and suppliers of the products under consideration remains elusive. The result is that during the design phase, when decision-making would occur, only general assumptions about specific manufactured products can be considered.

Additionally, there are no existing financial incentives to use an embodied energy assessment methodology. In New York City, financial incentives for *operational* energy modelling (and associated reduction in estimated operational energy demand) exist; clearly outlined frameworks have been established, and NYSERDA (New York State Energy Research and Development Authority) handles their distribution. Likewise, demonstrating a specific reduction in predicted *operational* energy is required by building code, and for design review and ultimate permitting. None of the above exists for modelling, and then showing reduction in, the *embodied* energy of a building.

## The way forward

*Embodied energy reduction of products needs to be incentivized. It's a lot of work measuring externalities that don't translate into simple payback.*

*The UK construction industry is the largest consumer of natural resources in the country with over 400 million tonnes of material consumed each year (Davis Langdon LLP, 2009). This accounts for approximately 10% of total UK carbon emissions (ENVEST, 2010). – ice.org.uk*

To reduce the greenhouse gas emissions from buildings, clear accounting for operational and embodied energy must occur. Although promising technological solutions exist to provide clear modelling during design, those models must be used, and product decisions must be made that result in lower overall embodied energy. Manufacturers must make clear and accurate data available in order to assess existing options. Finally, new products and materials produced from optimized manufacturing and a transparent supply chain must become more readily available.

Just as operational energy reduction and improvements are required by code and for building permitting, so too must embodied energy/carbon performance be required. According to the Institution of Civil Engineers in the UK:

*In May 2016 the UK Green Construction Board launched a new specification to encourage a consistent industry approach to reducing carbon in infrastructure – a world first. PAS 2080:2016 Carbon management in infrastructure and its associated guidance document aim to bring a joined up approach to the way industry evaluates and manages whole life carbon emissions to deliver reduced carbon, reduced cost solutions.*

Reduction in overall greenhouse gas emissions from buildings is imperative. Use of energy modelling tools that account for both operational and embodied energy consumption is necessary. Such tools exist; their effectiveness, however, is limited by a lack of data from manufacturers and suppliers. Additional incentives and/or regulations are therefore necessary to compel accurate and timely reporting of that data.

# Business Basis of Design

Robert Prieto

## The challenge

*Large capital construction projects in all sectors are challenged to improve the capital efficiency of the project – this considers both first costs as well as life-cycle costs.*

This insight article focuses on achieving improved capital efficiency in large capital asset projects through the adoption of an expanded basis of design that considers all aspects of a capital asset's life cycle.

## The idea

In many projects today the basis of design (BOD) largely encompasses the engineering parameters which are required to meet the owner's project requirements.

Constructability and maintainability are often treated as review items to confirm that the developed design is both constructible and maintainable and to suggest improvements at the margins. Effective constructability and maintainability reviews add value to the project but do not fundamentally act to shape the design itself in most instances.

The premise here is that more, much more, is required to develop effective designs with construction and maintenance as fundamental project requirements. In this sense, construction and maintenance considerations are not items to be reviewed but rather fundamental requirements to be satisfied together with other project requirements established by the owner. *The change suggested is about a shift in mindset and perspective as well as in our design work processes.*

The Business Basis of design or expanded basis of design (BOD<sup>x</sup>) is focused on improving the quality and cost effectiveness of the developed design throughout the full life cycle. Specifically it:

- Ensures all project participants are aligned on strategic business objectives as reflected in the owner's project requirements
- Ensures owner, construction management and O&M are clear on wants and needs
- Ensures designer is focused on supporting an efficient construction execution strategy which reflects project construction considerations, opportunities and constraints
- Informs the process for identification, evaluation and selection of design solutions to meet functional or performance specifications.
- Provides expanded criteria to evaluate and validate design solutions and submissions
- Provides clear acceptance criteria verified during construction, commissioning and initial operation
- Informs decisions on equipment selection, layout, installation, operation, maintenance and replacement until requirements change

- Delivers a more effective asset management database at startup
- Improves construction efficiency and effectiveness
- Enhances construction safety
- Improves O&M efficiency and effectiveness
- Supports optioneering – considering all life cycle costs

The BOD<sup>x</sup> encompasses the traditional “engineering” basis of design as well as an expanded basis of design encompassing construction, operations and maintenance considerations. This can be seen through the lenses of two other bases of design – a Construction Basis of Design (CBOD) and an O&M Basis of Design (O&MBOD).

The CBOD seeks to further actualize CII Constructability Concepts I-1 and I-5.

- CII Constructability Concept I-1 states “Constructability Programme is an integral part of the Project Execution Plan.”
- CII Constructability Concept I-5 states “Basic design approaches consider major construction methods.”
- Specific elements that an effective construction basis of design will consider include:
  - Comprehensive identification of required or preferred construction strategies, tactics, techniques and tools to be incorporated in the construction process that influence project management and design
  - Construction labour, skills, equipment, materials of construction, logistical constraints to be reflected in basis of design
  - Construction Basis of Design addresses unique requirements to be incorporated in design development that reflects owner or contractor preferences for achieving the owner's project requirements (OPR).

These requirements may reflect:

- Prior experience of the owner
- Unique risks, opportunities or constraints associated with the project
- Contractor capabilities and experience
- Special tools uniquely available to the project
- Broader programmatic objectives required of the owner or independently committed to by the owner that influences construction execution.
- Applicable safety programme to be used on project

CBOD considerations may be broadly grouped as basis of design requirements related to:

- Labour
- Equipment
- Materials
- Means and methods
- Management processes and practices

Similarly, operating and maintenance costs often represent over half of life-cycle costs of a capital asset on a present worth basis. Development of an effective O&M basis of design should as a minimum encompass:

- Comprehensive identification of required or preferred construction strategies, tactics, techniques and tools to be incorporated in the operations and maintenance (O&M) process that influence design
- O&M labour, skills, equipment, materials (including consumables), temporary provisions for maintenance to be reflected in basis of design
- O&M Basis of Design addresses unique requirements to be incorporated in design development that reflects owner or contractor preferences for achieving the owner's project requirements (OPR).

These requirements may reflect:

- Prior experience of the owner
- Unique constraints associated with the project location; environmental setting; process operations; and labour availability, cost and skills level
- Contracting community capabilities and experience
- Special tools required for major maintenance
- Broader programmatic objectives required of the owner or independently committed to by the owner that influences maintenance execution.
- Applicable safety programme to be used during facility operation

## The impact

*The development of an expanded basis of design at the outset of the design development process opens the door to more efficient construction execution and the delivery of more efficient and effective life cycle assets. BODX drives the need for tighter integration of design, construction and facility O&M experts and is in line with many of the alternative delivery models that are increasingly being used. The adoption of a BODX is not limited to these models but rather can bring increased value across even more traditional design-bid-build approaches.*

## The barriers to innovation – and the solutions

The barrier to adoption of a BODX is primarily one of education but others exist. For example, codes and standards do not always emphasize the life cycle aspects of an asset. Design processes do not give adequate attention to construction and O&M requirements up front and the owner's own project requirements do not always emphasize these aspects, concentrating on facility function versus delivery and performance.

### Solutions exist.

Our education of engineers, project managers and construction managers needs to increase not only emphasis on the various aspects that BODX addresses but drive cross-functional education. Licensure must ensure adequate awareness of these important basics of design aspects. Codes and standards must migrate to a life cycle performance basis from what is currently a largely prescriptive basis.

## The way forward

*The engineering education "industry" needs to more closely engage with asset owners and deliverers to shape the education programmes that the industry requires for tomorrow. Professional societies and standards setting life cycle need to strengthen up-front considerations related to construction and adjust standards to be life cycle-based performance standards to encourage innovation.*

# Flood Risk Management for Commercial Real Estate

Franz Jenowein

## The challenge

*More frequent and intense precipitation exposes real estate to increased flood risk.*

Since the 1970s, insured losses from weather-related catastrophes, such as floods, droughts and thunderstorms have increased 14 times, in affected areas worldwide<sup>3</sup>, growing from an average annual loss in the 1970s of \$3 billion per year to \$44 billion per year in the first five years of the current decade.

More than one-third of the world's land area is flood prone, affecting about 82% of the world's population, according to a World Bank study<sup>4</sup>. These risks and subsequent natural disasters have brought with them an uncompromising set of negative impacts on physical building assets, business continuity and asset values.

A strong need, therefore, exists to protect real estate asset value in the short and long term and ensure business continuity of tenants by making new and existing buildings more resilient to flooding events.

## The idea

*Improve flood risk management and resilience of commercial real estate and occupier business activities through better assessment of building location and design, infrastructure and business continuity plans.*

Asset owners and building occupiers can introduce more systematic flood hazard assessments of new and existing buildings and their business activities' flood exposure. Through the implementation of flood mitigation features, evaluation of emergency plans and organisations' readiness and recovery plans, flood risk can be better managed. The following are the key steps:

- Establish a flood **threat profile** for the asset, the location of current flood hazard zones based on flood risk mapping (public institutions' national/local flood maps and risk levels) and updated flood hazard forecasts; analysis of indirect risks such as power supply and infrastructure failures, collection of advice from statutory bodies (local authorities, national agencies)
- Evaluate **mitigation** features and procedures helping to reduce flood threats (building design that provides protection against flood waters, the installation of back-flow valves in building plumbing and drainage systems, elevated podiums for parking spaces to protect vehicles from flood damage, locating critical infrastructure away from areas prone to flooding (plant, power supply, communications networks, toxic materials, emergency generators) or in elevated and protected areas

- Analyse written **plans** for emergency procedures in case of flood warnings or actual flooding
- Evaluate the state of **readiness** to activate plans
- Assess protocols to ensure rapid **recovery** to return to "business as usual"

A best practice assessment scheme is JLL's Building Emergency Management Assessment (BEMA) methodology (available in the USA and Canada) that covers natural, human and technical hazards. This holistic assessment scheme improves the understanding of flood hazards, reduces vulnerability to flood risk and helps structure the plans for business emergency procedures. It also prompts the implementation of building and equipment features for existing assets and business continuity planning to reduce risk of business interruption for occupiers.

While the BEMA assessment methodology has been around for a few years, availability of detailed location-related flood risk information is still limited to a few markets where real estate and business exposure is high or where recent flooding events produced substantial losses, such as for New York City after Hurricane Sandy. River and coastal/tidal flooding information is more readily available than surface water, pluvial or groundwater flooding information – these are more difficult to measure and depend on a variety of factors, requiring complex computer modelling.

Flood resilient building design is starting to be disseminated as the frequency of flood events highlight the need for adapted buildings. Resilient infrastructure design is well established and provides protection against flooding, from wall defences to sustainable urban drainage systems. Business continuity planning advice is readily available in all major markets spanning supply chains to core operational processes to critical infrastructure (communications, power, data centres).

The insurance/reinsurance industry has extensive experience with risk management and risk modelling for various natural catastrophes (earthquakes, storms, wildfires) and is an important source for more detailed disaster modelling.

## The impact

*A holistic flood risk and resilience assessment can reduce flooding related losses to building owners and businesses.*

Detailed and current flood threat profiles for buildings help identify up-to-date probabilities and more precise locations of floods potentially damaging buildings or interrupting business operations. Through richer details, not only concerning direct flood hazards (river flood plains, seasonal and surface water flooding) but also concerning drainage and sewerage related issues, an in-depth assessment allows owners and occupiers to devise mitigation plans (e.g. storm water protection features, safe location of high value and process equipment, etc.) and business continuity procedures (ready pumps and hoses, de-energise electrical equipment in wet areas etc.). This leads to reduced vulnerability and damage in case of flooding, better protection against water ingress and related damage to buildings, which, in turn, provides increased safeguard of rental income and value of the real estate asset.

3 Sigma Insurance Research, Swiss Re, January 2016; JLL Analysis

4 *Natural Disaster Hot Spots – A Global Risk Analysis*, Dilley, M. et al., The World Bank, Washington, D.C., 2005

## The barriers to innovation – and the solutions

*There generally exists low awareness of and slow adaptation to changes in flood risk. Short-term value impacts due to flood risks may be difficult to calculate.*

Key internal barriers within organizations for adopting more systematic flood risk and resilience assessments are a generally low awareness of changing flood risks and potential impacts on asset values. Adoption of systematic flood risk assessment by real estate investors and building occupiers is slow and the availability of easy to use assessment tools has been low.

Key external barriers for enabling flood risk assessments are the limited availability of detailed and up-to-date flood risk information for river and coastal flooding, but also for surface water, groundwater and sewer system flooding.

Relatively good availability of insurance cover at commercially acceptable rates (more so for owners of large and geographically spread asset portfolios) leaves more detailed flood risk assessment low on property company priority lists. This averaging of asset risks through geographical diversification for large real estate investors is very wide-spread across globally diversified portfolios and building types. In addition, and in the case of let properties, the largest part of insurance premiums payable by property owners are usually transferred to building tenants' service charges. There also exists, if only based on anecdotal evidence, relatively limited sensitivity of real estate values to increased flood risk in the short to medium term, in a given market.

However, current life cyclical or information related barriers are only *slowing down* the adoption of more flood risk assessments and resilience measures, as the trend for increasing extreme weather events in the medium to long term are widely acknowledged by science, the insurance industry and the real estate sector. Increased impactful flood events will increase awareness and the willingness of adopting resilience measures over time.

## The way forward

*Build real estate sector and occupier awareness alongside capacity for flood risk assessment and resilience planning*

To overcome existing roadblocks the Real Estate sector needs to build capacity for in-house expertise on climate change and extreme weather related risks on real estate asset and portfolios. The Real Estate sector needs to encourage local and national authorities to establish and provide detailed and current flood risk information and updates to existing flood maps. Investors should review their flood risk assessments annually where high risks have been identified in the past, and plan to improve resilience of their real estate portfolios as necessary. Asset owners should be actively encouraged to make enhanced flood due diligence assessments for new investments that have high flood exposure.

Insurance and reinsurance companies, investors and lenders need to obtain a more accurate picture on shifting patterns in flood hazards and related risks, damage and losses. Insurance companies own an enormous amount of loss claim data which could provide a good complimentary source to identify actual flooding related damage and loss in addition to flood risk hazard maps that provide a more long-term view of risks.

Tenants need to be made more aware of potential business interruptions, not only based on local risks on a given site and its building operations but also on the potential impact to their supply chain. Business Continuity Plans should be put in place and, where flood exposure exists, these plans should be regularly reviewed for life cyclical readiness and recovery measures. Where in-house flood risk assessment capacity is not available specialist flood risk mapping and assessment organisations can provide flood risk advice and scenario planning services.

Asset owners and managers should systematically build detailed asset flood risk assessments into their due diligence process where flood risks exist. They should also periodically assess and reassess flood risk across their entire real estate portfolio. Real Estate sector-wide initiatives could raise flood risk awareness and mitigation information. Local and national authorities need to provide funding to create flood maps and/or update these maps regularly, with appropriate detail.

Besides systematic, process-led changes, systemic changes among key stakeholders can have a more wide-scale impact: the private insurance/reinsurance sector could establish closer cooperation with flood risk/environmental agencies on national and local levels in order to raise the level of flood risk knowledge. Enhanced risk and loss data exchange could provide insight into necessary long-term infrastructure-based flood mitigation measures and restrictive planning regulations. Increased dialogue between landlords and tenants can improve flood risk management. A collaborative introduction of flood resilience measures to buildings and business management processes could potentially mitigate any increase in flood risk in the future.

# Sustainable Asset Value IISD (SAVi) Model

Oshani Perera, David Uzsocki and Andrea M. Bassi

## The challenge

*Conventional project finance valuation methodologies ignore a range of material externalities.*

The main barrier to deploying sustainable and natural infrastructure is the difficulty of structuring financially viable projects. Traditional valuation methodologies often provide a less convincing business case for sustainable assets than for grey infrastructure, due to their elements such as higher upfront capital costs, prominent technology risks, greater attention to safeguards, and higher project preparation costs. The problem lies in the inadequate identification and pricing of risks leading to inaccurate asset valuation and feasibility assessments.

What is sustainable infrastructure? Sustainable infrastructure includes assets that:

- Have lower carbon and environmental footprints
- Provide for the stewardship of natural ecosystems
- Trigger green technological and industrial innovation across domestic and international value chains
- Spur investment in education, skills building and R&D
- Increase employment and the growth of green jobs
- Are financially viable
- Crowd-in domestic investors and businesses
- Increase FDI and domestic value-added
- Optimize value for money for taxpayers and investors across the asset life cycle.

## The idea

*The SAVi Model addresses challenge above by providing the necessary quantitative evidence that sustainable infrastructure is the right choice, when considering its holistic impacts, even from a pure financial perspective.*

## SAVi is based on the following methodologies:

**System Dynamics**, which serves as a knowledge integrator, generating a conventional cost-benefit analysis as well as a more comprehensive assessment of the broader social, economic and environmental impacts of sustainable and grey infrastructure. This includes the estimation of required investments and resulting co-benefits, avoided costs and project risks. For example, forecasted impacts could include reduced fish stock following the installation of a hydropower dam. An example of avoided costs could be reduced energy consumption in sustainable buildings or reduced construction costs in the case of better road siting. One example of an added benefit could be increased productivity triggered by improved human health, which in turn was afforded by improved ambient air quality. This methodology also allows

project risks to be identified and estimated quantitatively, filling an important information asymmetry for investors.

Examples of these risks are provided below:

- **Regulatory risks:** carbon taxes, changes in feed-in tariffs, changes in availability payments, air pollution laws
- **Market risks:** price volatility and disruptions in supply of inputs (coal, building materials, water, feedstock) and outputs (energy and water services)
- **Technology risks:** unexpected costs in installation and O&M, losses related to poor performance, cost of decommissioning, losses related to extreme weather, insufficient track records,
- **Social risks:** issues related to land acquisition, disputes and delays related to environmental impact assessments and social impact assessments, disputes and delays related to other safeguards such as clearances and permits.

**Corality SMART Financial Modelling Methodology** is used as the framework to demonstrate how the project risks identified as part of the system dynamics modelling influence the financial viability of sustainable versus business-as-usual infrastructure projects. These additional risk variables are integrated into the sensitivity analysis as part of the financial assessment.

Lenders and equity investors build project finance models to estimate the financial sustainability and profitability of the project by mapping the various cash flows during the life of the asset. Using financial models built with Corality SMART Financial Modelling Methodology, SAVi demonstrates how the different project variables (such as capital expenditures, construction time, operation costs, operation efficiency, corporate tax rate, etc.) change under a wide range of risk scenarios. The scenarios modelled illustrate how the elements identified as part of system dynamics model influence the overall bankability of green versus the business-as-usual infrastructure projects. Such elements include change in carbon pricing policy, delays in construction, disruption in operation due to social or technological risks, the impact of climate change such as heat waves on the operation of the asset, among others.

The Corality SMART Financial Modelling will also allow policy makers and investors assess how fiscal and financial incentives are important to increase the deployment of sustainable infrastructure. For example, tax rebates and allowances for sustainable infrastructure can positively enhance project finance parameters such as base interest rate and corporate tax rates. Similarly, Financial instruments to hedge against currency risks could allow a greater crowding in of domestic inventors and suppliers that would in turn increase productivity and green industrialisation in the domestic economy.

## The Asset Categories

SAVi is first being developed for four asset categories: energy, roads, water management and buildings. Other asset categories will be added in the latter half of 2017.

### Energy

In the energy sector, various electricity generation options are compared to identify economic, as well as social and environmental advantages and disadvantages. These are assessed for various economic actors (i.e. private sector, government and households) to gain a comprehensive view of the existing motives for investing in grey vs. green infrastructure. The SAVi Model customized to electricity supply includes macro-economic drivers to estimate demand, which in turn drives the estimation of required investments, capacity construction and ultimately electricity supply from conventional thermal options (i.e. oil, coal and gas), renewables (i.e. wind, solar, biomass and hydropower) and nuclear power. Employment and income are estimated for both the construction and operation and management of these plants. Other direct inputs to production, in addition to plant capacity and labour are energy sources (e.g. fossil fuels) and water. Land use, along with cement and steel used are also estimated for each technology across its lifetime. Finally, CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub> emissions and Pm are estimated, including their economical valuation (e.g. using the Social Cost of Carbon). Risks to production are also assessed through scenarios, which includes the impact of climate change (e.g. on water use for the cooling of thermal capacity).

### Buildings

The SAVi buildings model assesses the construction, material manufacture, operation and management and demolition process of buildings. As a result, the definition of sustainable building used by SAVi accounts for economic and social outcomes in addition to environmental ones. The technologies considered include: construction materials; solar PV and solar heat water; heating, ventilation, and air conditioning; lighting; water recycling and appliances.

### Roads

The SAVi roads model defines a sustainable road as one that limits environmental impacts throughout its life cycle, including manufacture of materials, construction, use, and decommissioning. Environmental concerns are related to the design of the road, the materials used in construction, and use patterns. In addition to addressing environmental and natural resource needs, the development of a sustainable road should focus on social concerns such as access (not just mobility), moving people and goods (not just vehicles), and providing people with transportation choices, such as safe and comfortable routes for walking, cycling, and transit. Three main cost categories are considered: (a) construction, maintenance, pavement upgrade and end-of-life costs; (b) vehicle operation, travel delay, social impact, and road accidents; (c) environmental costs such as noise, air quality, water quality, resource consumption, and solid waste generation.

### Water

The SAVi water model addresses sustainability issues relating to (1) water supply (e.g. surface and groundwater, including hydropower effects and diversions for irrigation), (2) water demand (e.g. losses in distribution and efficiency in the use of water) and (3) water management (e.g. water treatment and urban runoff and pollution). The model supports the analysis of Sustainable Urban Water Management options, addressing growing concerns over community well-being (rather than just public health), ecological health and sustainable development.

### The impact

*A more comprehensive methodology to quantify and monetize co-benefits, avoided costs and project risks of green vs. grey infrastructure.*

Across the different types of infrastructure, SAVi allows for a more robust stress-testing of projects by demonstrating that in the case of sustainable infrastructure, key variables that drive revenues, operating expenses and capital expenditures can be less volatile under a range of alternative scenarios. The additional risks modelled include climate risks (floods, freak weather, drought) leading to a reduction in resale value as well as risks related to the application of more stringent regulatory requirements on emission and waste.

Furthermore, SAVi allows for a more accurate estimation of sensitivities related to human health costs, volatile real estate prices, as well as support the assessment of the contribution of infrastructure to employment creation and productivity improvements. Short term side effects, such as disruptions during construction and operation due to low social acceptance of the project are also taken into account. These considerations are critical for the long term valuation and refinancing of the asset.

Policy-makers can use SAVi to appreciate the co-benefits and avoided costs of sustainable infrastructure as well as to justify spending on assets that may cost more to plan and build, but are more resilient during operation, maintenance and end of life decommissioning. Investors can use SAVi to understand how sustainable infrastructure is more resilient to a range of external risks and hence more bankable than traditional solutions.

### The barriers to innovation – and the solutions

*SAVi needs to demonstrate the business case for sustainable infrastructure, emphasizing different externalities depending on the stakeholder group addressed.*

Procurement regulations often do not allow procurers to materially deviate from the cheapest option when commissioning infrastructure. Thus the additional capital expenditure required for sustainable infrastructure can make the green alternative ineligible and / or hard to justify when making procurement decisions. A supportive legal and regulatory framework is needed for policy makers and procurers to assess projects by even going beyond a simple life cycle approach and also include other relevant environmental and social externalities.

The primary mandate of institutional investors, one of the main sources of infrastructure financing, is to allocate capital to projects with attractive risk-return profiles. Some of the externalities monetized by SAVi does not influence their asset allocation as these factors do not directly impact their bottom line. On the other hand, some of the externalities quantified can have a material impact on the bankability of investments, but are still not covered by the risk assessment of investors as they are either not aware of these risk and / or are not able to quantify them.

The way to overcome these barriers is to demonstrate the strong link between the financial viability of the project and the externalities measured by the SAVi Model. For policy makers, having a broader mandate than financial investors, the positive economic and social impact on their country / region should also be emphasized.

## The way forward

*Stakeholder participation is key.*

Key stakeholder groups need to be involved in the various stages of model development. Their involvement would ensure that SAVi is relevant for them, covering asset types and producing output, which can be easily integrated in their decision making processes. At the same time, their participation would build their trust in the robustness of the methodology and help them with interpreting the results. IISD is in the process of reaching out to beneficiary countries as well as setting up an investor advisory panel for SAVi.

To produce the most accurate output, the SAVi Model needs to be customized for each country and asset type. Collaboration of governments in the data collection is key, as the quality of the output depends on the quality of data used.

At the point of writing the framework model has been developed for buildings and energy infrastructure. Building on its experience in the development and implementation of the *Sustainable Product Valuation Model* in 2015, IISD is well placed to ensure the success of the SAVi Model and its use at scale.

# Capacity Building for Sustainable Cooling

*Ruchi Kothari, Vivek Gilani, Philippe De Rougemont*

## The challenge

*Substantial increase in GHG emissions through use of HVAC systems in buildings.*

Use of air-conditioners (ACs) in buildings adds substantially to Greenhouse Gas (GHG) emissions. In India, the total installed cooling capacity is 125 million-TR of which residential air-conditioners is 39 million-TR and commercial air-conditioners is 18 million-TR. India's total installed cooling capacity is projected to rise by about 5 times to 610 million-TR by 2030 driven by increasing standards of living along with increase in temperatures caused by climate change. India will require 1010 additional power plants to meet these requirements. This makes it necessary to design buildings with no or minimal cooling loads and energy-efficient cooling systems.

In addition to the power used to run the ACs, emissions are added through the use of fluorinated gas refrigerants (CFCs, HFCs and HCFCs) in conventional systems. A phase-down plan for the F-gases is essential to meet the targets set by national and international agreements on climate change mitigation. Natural alternatives for refrigerants have low Global Warming Potential (GWP), are non-patented and energy-efficient. Prioritising use of natural refrigerant based ACs can result in direct emissions saving of 50 million tonnes of CO<sub>2</sub>e annually by 2030. This accounts for more than 50% of the current emissions from HCFC and HFC use.

There is considerable know-how and information within the industry to design sustainable buildings with adequate indoor thermal comfort conditions. However, the rate of uptake of these approaches in building design remains marginal. Energy demand and GHG emissions can be reduced provided these strategies and practices become mainstream amongst all key stakeholders responsible for the design and construction of buildings.

## The idea

*Implement capacity building insight articles focusing on sustainable cooling design and technologies for architects and HVAC engineers.*

Capacity building insight articles with the objective of developing analytical skills to design and engineer energy efficient buildings can help increase the uptake of sustainable cooling measures in the building construction industry. A comprehensive capacity building insight article can include a variety of approaches such as training, mentoring, education, physical projects, financial provisions and networking. A systematic long-term insight article that deploys a combination of these approaches in parallel can effectively influence the practitioners in the building construction industry - i.e. the architects and engineers. A long-term insight article also provides the opportunity to plan series of events and allows iterations in approaches to meet the capacity building objectives.

The focus of such insight articles is to regularly update practitioners of new technologies and increase their confidence in using state-of-art IT tools to accurately predict building performance. Training workshops for architects and engineers can meet these objectives. Awareness of unsustainable building practices and their effect on climate change can be created through the training content. Architects can be trained on energy-saving techniques, evaluation of complex strategies through energy modelling and pathways to incorporate energy efficiency at all levels of the building design process. HVAC consultants can learn to predict the thermal behaviour of buildings and to simulate various sustainable cooling technologies using energy modelling tools. In addition to the subjects delivered, a suitable mode of delivery must be adopted. Research indicates that adults learn best through a “learning by doing” approach that includes a combination of practical exercises, site visits and real world problem-solving. Training activities can be supported by brainstorming events attended by both architects and engineers to increase cooperation between the two professions. This is an important step in setting up a mentor-buddy network that works together to implement ideas to meet stringent energy targets of new urbanisation projects.

A large-scale insight article of this nature is being implemented in India since 2014. The Fairconditioning insight article is a Building Cooling Demand Side Management related education, capacity building and pilot implementation insight article. It is funded by the Oak Foundation and the State of Geneva, both philanthropic institutes that support projects addressing issues of environmental concern. Fairconditioning is designed as an evidence-based policy support insight article that can be scaled up across India and other tropical climates. The three year insight article aims to deeply integrate sustainability and efficiency into architectural and HVAC consulting firms through the Building Energy Modeling Project (BEMAP). Unique workshops have been designed for architects and HVAC consultants. Each three day workshop is held once a year in Bangalore, Chennai, Delhi, Mumbai and Pune in India. A total of 160 professionals from 100 firms have been trained through eleven workshops. Roundtable sessions and technical publications will be included in the next phase of the insight article.

Capacity-building workshops are also conducted by green building councils through continued education or credential maintenance insight articles. These workshops are well attended internationally. The workshops cover all categories related to green building rating systems including site management, water efficiency, materials, indoor environmental quality and energy efficiency. However, a more immersive format such as that of BEMAP workshops helps train professionals on 'how-to' design for energy efficiency in addition to creating awareness of benchmarks. The lack of commercial bias allows trainers to work with participants individually to develop performance matrices and select technologies suited to the scale and budget of the project.

## The impact

*Successfully bring about a change in practice or behaviour for individuals as well as firms.*

Capacity-building insight articles can help change the mindset and culture of firms as new and better ways of doing things are introduced. Process and outcome based capacity building insight articles help provide strategies to increase effectiveness of future insight articles. Feedback from such insight articles provides reliable information and analysis to policy makers. Along with participation and technology adoption trends, project data can be periodically collected from participants to measure direct energy savings and GHG reductions. This is difficult with stand-alone training insight articles.

Long-term insight articles also enable concurrent restructuring for success. Considering the two-fold objective of Fairconditioning workshops, the effectiveness of training is measured by evaluating the participant's confidence to use energy modeling tools in design processes as well as use of sustainable cooling techniques in building design. Feedback indicates, 80% of the participants were comfortable with recommending passive design and sustainable active cooling systems for projects, however only 40% of the participants were keen to use building energy modeling and simulation in design analysis. On-line e-courses and expert assistance post workshops can be provided to improve impact as most participants cited lack of practice with energy modelling and simulation as the main deterrent.

## Barriers to innovation

*Effectiveness of capacity building insight articles slowed down by lack of professional education culture and reticence towards adopting new technologies*

Lack of a professional-development culture and low participation result in ad hoc funding towards capacity building. Long-term hand holding and monitoring are essential to bring about adequate behavioural change and to ensure capacities have been developed at an institutional level as well as an individual level. There are limited local institutes and professionals that can provide the necessary support system to ensure successful impact.

Professional reticence is also a key barrier within firms. Architects and engineers wait for clients to demand energy efficiency and sustainable cooling. Misconceptions about aesthetics and capital costs create a defensiveness among professionals to adopt sustainable design alternatives. Silos exist between “conventional” architects, “sustainable” architects, “conventional” HVAC consultants and “sustainable” HVAC technology providers. A holistic approach towards building design does not flourish with such a fragmented ecosystem. These roadblocks slow down the effectiveness of the capacity building insight articles.

## The way forward

*Strengthen infrastructure capacities and identify innovative means to bring information to practitioners.*

It is preferable that capacity-building interventions be conducted in conjunction with municipal insight articles that promote building energy efficiency. It is necessary to build a critical mass of people with the right outlook and capacity within the industry. This includes working with all stakeholders such as builders, developers, educators and tenants. State and central municipal corporations need to make energy efficiency and sustainable mandatory within building regulations. Training workshops can be conducted prior to implementation of new building development codes to decrease uptake time. Energy efficiency and sustainable cooling training needs to be included in certification and licensing requirements for architects and engineers. The real estate sector and tenants need to be educated on low operational and maintenance costs of sustainable buildings.

Innovative ways to improve access to information for professionals in all locations need to be explored. This includes self-paced on-line courses, books and newsletters. Training infrastructure also needs to be improved. Training centres can be established in different regions with each centre becoming a hub for training, technology showcase, chapter meetings and conventions. Training content can be updated and scope of workshops can be widened accordingly. High-quality physical and virtual teach-aids need to be developed to help explain subjects such as climate analysis, refrigerant cycles in conventional air-conditioning, psychometry, etc. An easy-to-use modelling tool for sustainable cooling technologies also needs to be developed. This will be particularly useful for the mechanical engineering industry.

It is necessary to increase investment in capacity-building insight articles considering their role in bringing about a change in the way the construction industry practices. Importantly, it is necessary to increase sensitivity among all stakeholders towards climate change and the role this industry plays in mitigation.

# 4. Affordability



## Introduction

Mahmoud Hesham El Burai, Chief Executive Officer, Dubai Real Estate Institute, UAE

*Housing affordability continues to be alarming: more than 800 million people do not have adequate housing and 330 million are financially overstretched according to UN statistics. This affordability crisis continues to widen, leaving economic, social and environmental challenges to the communities and the world at large, badly impacting the 17 Sustainable Development Goals adopted in September 2015 by the UN.*

*The real estate industry is required to be innovative in dealing the global housing affordability disaster, while discussing effective implementation of the Sustainable Development Goals. Worldwide, governments have failed to solve the affordability issue, and it is now up to the five Ps (Planet, People, Public & Private Partnership) to help find solutions. The Affordability Working Group explored the affordability challenge and solutions from several perspectives:*

- 1. The need to adopt a holistic view of affordable housing, implying community thinking and adequate infrastructure (physical and non-physical) rather than from a stand-alone basis, taking into account economic, social, environmental and cultural sustainability. This systemic thinking needs to be championed by system leaders who engage all stakeholders to be part of the solution.*
- 2. The role of technology in driving affordability while reducing negative impact on employment. Technology will play a bigger role in reducing cost/time of construction enabling mass production of affordable houses that are sustainable. Evolving technologies like 3D printing, BIM, Aditaz and others are worth using to drive affordability. Citizen-driven approaches*

*are an important part of this and by using technology, citizen voices will be heard.*

- 3. Planning high-density affordable housing is an important new direction rather than horizontal expansion that eats up land, which is the most costly element.*
- 4. Capital efficiency and design rethinking in driving affordability of homes, using design, value engineering and other tools to cut costs throughout the project life cycle. Innovative solutions throughout life cycle stages of the construction projects are important to achieving affordability.*
- 5. Innovative financing for affordable housing such as crowd-funding and public-private partnerships in making affordability projects successful are important factors to be integrated in the affordability strategy.*

*In conclusion, affordable housing will not be possible with only government taking the lead: a multistakeholder approach is needed, with system leaders who see the big picture and integrate economic, social and environmental sustainability in their strategies and actions.*

# Creating an Inclusive and Affordable Infrastructure Ecosystem

Aaron Schwartz

## Urbanization is rapidly increasing with the majority of growth in emerging economies.

Providing affordable housing alone will not solve the problem. *Making daily living in cities affordable is a key necessity*. Cities need to have an economic and social ecosystem for their inhabitants. That diverse need should result in “intricate mixtures of building uses and scenes [that] are necessary for successful city districts.”<sup>5</sup> In addition to affordable shelter, city dwellers will need jobs and access to affordable food, water, education, work, healthcare, technology, communications, transportation, culture, and recreation. Cities and communities with mixed-uses fostered by planning can “deliberately encourage spontaneous diversity by providing the conditions necessary to its growth”<sup>6</sup>. Although individuals need safe, affordable homes, access to housing only fulfils a single facet of that individual’s life and leaves many other aspects unaccounted for. “Intricate mixtures of different uses in cities are not a form of chaos, on the contrary they represent a complex and highly developed form of order”<sup>7</sup>.

## Infrastructure – social and service

Physical development and growth of a city depend largely on its infrastructure. For cities to be affordable, infrastructure needs to be affordable. Transportation, energy and water infrastructure account for 32%, and institutional buildings (social infrastructure of hospitals, schools, and the like) account for 6% of the total projected construction costs. A combined 38%, these basic elements of urban infrastructure will have the same projected construction costs as will residential construction, which will need this infrastructure to support its existence. Therefore, building infrastructure affordably is critical.<sup>8</sup> Planned capital spending for this year is planned to be 34% of this year’s budget<sup>9</sup>.

Much of the housing stock built in the world is informally built, without regulations. “More than half the global population already lives in urban areas. Approximately one-quarter of these urban dwellers live in slums or informal settlements.”<sup>10</sup> It is likely that providing affordable housing will never meet the demand in the near- or mid-term. One notion is to provide land and infrastructure to support healthier informal settlements. While this is counter to most agendas, it may be one way to start a process for creating affordable housing.

Many of the informal settlements in cities around the world

- 5 Jacobs, Jane. *The Death and Life of Great American Cities*. New York: Random House, 1961. Print.
- 6 Jacobs, Jane. *The Death and Life of Great American Cities*. New York: Random House, 1961. Print.
- 7 Jacobs, Jane. *The Death and Life of Great American Cities*. New York: Random House, 1961. Print.
- 8 Extrapolated from metrics provided in Industry Agenda shared by the World Economic Forum – cited Global Construction Perspectives and Oxford Economics, 2013.
- 9 Kala, Anant Vijay. “India’s Budget Focuses on Infrastructure.” WSJ. Wsj.com, 28 Feb. 2015. Web. 14 Oct. 2016. <http://www.wsj.com/articles/india-budget-focuses-on-infrastructure-1425111915>.
- 10 UN Sustainable Development Goals from website posting 3 October 2016.

have evolved into vibrant eco-systems. These settlements, initially based on a need for housing, also contain markets, employment opportunities, schools and other aspects of daily life that provide a sense of community. Many of the informal settlements are whole villages within the urban core. Most lack the provision of formal services for basic infrastructure: water, sewage, electricity or communications. But in most cases these services have been jerry rigged or hijacked in some method with an unregulated economic structure.

Innovation is a requirement for existence and is best described by the Hindi slang word, “jugaad”. Dharavi is one of Mumbai’s largest and most infamous slums of approximately 1 million people. “It is also a churning hive of workshops with an annual economic output estimated to be \$600 million to more than a \$1 billion.”<sup>11</sup> Many of Mumbai’s service workers live in Dharavi or communities like it. Without this working class being able to live in Mumbai, the city would be without many office, factory and household employees. Dharavi and informal settlements are not models for healthy, high-density living. Providing proper infrastructure services would be a vast improvement even if not a sole solution.

When given opportunities to move to publicly built social housing, most Dharavi settlers either refuse or illegally sublet the social housing unit while continuing to live within their communities. There are likely many factors for this reluctance to move to “improved” housing. They should be studied so as to develop new affordable housing models that meet health and safety standards that are desirable. A few of the factors are clear:

1. Mixed-use development which includes local shops, schools and services
2. Open space within or nearby
3. A sense of community
4. Local employment and accessible, affordable transportation to commute to jobs that may be further away

These factors show the need to consider that the development of affordable cities needs to be mixed-use, not affordable or low-cost housing in isolation. To provide an urban home for working-class populations, housing needs to blend with the full component of daily living activities: shopping, education, transportation, technology, public open space, health care, entertainment and recreation. Affordable living in order to survive must be self-sustaining and mixed use supports cross-economic subsidization.

Redevelopment can be of concern to residents of Dharavi because part of the slum’s attraction is its affordability. Dharavi’s natural growth as an affordable place to live with more opportunity than that found in rural villages is partly thanks to the dismal and affordable conditions, despite their shortcomings<sup>12</sup>. With reference to the Jane Jacobs quote, cities are not chaos, but contain a complex form of order, and Dharavi is an example of this.

- 11 Yardley, Jim. “Dharavi: Self-created Special Economic Zone for the Poor.” Deccan Herald. IHT, n.d. Web. 14 Oct. 2016.
- 12 Yardley, Jim. “In One Slum, Misery, Work, Politics and Hope” New York Times. New York Times, 28 Dec. 2011. Web. 14 Oct. 2016.

Businesses in Dharavi should be supported and affordable infrastructure and housing added without disrupting thriving businesses. Without the ability to redevelop to include affordable housing in conjunction with affordable sewer systems and infrastructure upgrades, those that redevelopment aims to help are driven away. By developing a model whereby quality of life can be improved by developing more affordable housing, while at the same time supporting with affordable infrastructure the positive qualities of a slum, namely the economic productivity and urbanization, communities can be better supported without alienating their inhabitants.

“City areas with flourishing diversity sprout strange and unpredictable uses and peculiar scenes. But this is not a drawback of diversity. This is the point or part of it.”<sup>13</sup> By working with the ever-changing nature of informal settlements and embracing their multi-use nature, we might be able to provide a more holistic approach to improved affordable housing.

## Affordability through Capital Efficiency and Design Rethinking

*Robert Prieto*

### What is capital efficiency?

In simple terms, it is about getting the biggest bang for the buck. It is about reducing the total cost of ownership of an asset over the entirety of its life cycle. It is about driving affordability. Today, we struggle to achieve affordability of many of the assets that comprise the built environment, impacting both the quality and extent of these assets.

For many, affordability is about reducing first cost but this is only one of the levers available to us to pull to improve capital efficiency. To achieve real affordability we must pull all of the available levers, improve our execution efficiency and, importantly, rethink our basis of design.

Here we seek to outline some guiding principles to improve overall construction affordability and asset life cycle capital efficiency. The principles and recommendations laid out are generally structured along the lines of the principle levers of capital efficiency, with some additions to give weight to certain specific points:

- Project Management
- Schedule
- CAPEX
- OPEX
- Asset Availability
- Inventories
- Premium Pricing and Financing
- Operating Philosophy and Practices

### Project management

Large complex construction projects require new a “theoretical” and contextual basis. The current theory of project management does not scale well – two out of three large construction projects fail.

This new theory requires strengthened foundations related to owner readiness; new risk models and modelling; and assumption tracking. Project flows and interactions between tasks and activities require heightened focus, recognizing flows are subject to disruptions with severe cost impacting effects. Finally, this new theory recognizes that stakeholder engagement must be strengthened and made more transparent to better anticipate and influence flows from the broader stakeholder set that sweep into the project creating a multiplicity of impacts. Today’s large, complex projects are not as well bounded as current project management theory inherently assumes.

<sup>13</sup> Jacobs, Jane. *The Death and Life of Great American Cities*. New York: Random House, 1961. Print.

Project management systems to support design-build delivery must more tightly integrate the contractor's requirements for "pieces" of design providing more granularity in design deliverables, such as what might be required for a specific permit or approval. Big analytics must complement the world of big data in which our projects live. New project data sources, associated with the potential impacts of externalities, must be incorporated into design and construction activities.

Improvements in this project management lever can be accomplished through:

- *Formal owner readiness assessments and ratings as part of financing of capital construction projects*
- *Research into project management theory as applied to large-scale construction projects*
- *Expansion of Monte Carlo risk models to include consideration of fat-tailed risk distributions*
- *Development of project control tools that assess the status and potential impacts on a project from broader externalities, including assumption tracking*

## Schedule

Owner readiness is an under-tested readiness area with potential for severe project schedule impacts. Owner-readiness assessments can avert many schedule impacting behaviours. Owner readiness should assess readiness of associated decision frameworks and processes. It must confirm staff and support elements that support the project schedule. Articulation, agreement and communication of project objectives and criteria within owner's team, affected stakeholders and principle designers, contractors and suppliers is similarly a key element of readiness with shortcomings here the number one reason large complex construction projects fail. Finally, owners must commit to sustaining their and the project team's readiness.

There must be heightened recognition of the cost of delayed decision-making. The value of time must be clearly articulated. Recognize the principle schedule impacting causes of delay and put in place improved processes and mitigation measures to address timely decision-making by owner; changed owner performance requirements, by clearly defining fit for purpose; and delayed or withheld regulatory approvals.

Project teams must recognize the value of schedule certainty to project owner (time to market, financing during construction, corporate cash flow).

Strategies to better pull this lever of capital efficiency include:

- *Formal owner-readiness assessments and ratings as part of financing of capital construction projects*
- *Require reference class forecasting in support of project financing and approval of developed project schedules to reduce optimism bias*
- *Project approvals to incorporate the value of a day of general delay to increase project team awareness of timely decisions and actions*

## CAPEX

Turning to another lever of capital efficiency, capital cost, fit-for-purpose design must be re-emphasized as a guiding principle. Emphasis must be placed on needs vs wants. The developed design basis must meet owner's project requirements (OPR), without undue contingencies, redundancies or factors of safety (reasonable design margins). Requirements must be challenged from a "scope control" perspective and subsequent reviews must not be unduly conservative.

An expanded basis of design must be considered when developing a fit-for-purpose design. The traditional translation of owner's project requirements into a basis of design must be expanded at the outset of the process to include construction and operations and maintenance (O&M) requirements. This must happen before design begins; it is not about constructability and operability and maintainability reviews.

Fit-for-purpose execution processes and continuous performance improvement must be core operating parameters ensuring the level of design reflects the delivery form selected. We must challenge/simplify non-value adding process steps.

A construction basis of design (CBOD) is the first element of an expanded basis of design. It drives down construction costs by ensuring that construction is an integral part of the basis of design with comprehensive identification of required or preferred construction strategies, tactics, techniques and tools to be incorporated in the construction process that influence project management and design. A CBOD identifies the construction labour, skills, equipment, materials of construction and logistical constraints to be reflected in basis of design and further actualizes CII Constructability Concepts I-1 and I-5. A CBOD can reduce a project's footprint to minimize societal and environmental impacts while shrinking costs and recognize the need for supply chain strategies to be more tightly integrated into construction process through a common BIM.

Better performance of the CAPEX lever can be accomplished if we:

- *Require reference class forecasting in support of project financing and approval of developed project estimates to reduce optimism bias and increase capital certainty*
- *Encourage migration from prescriptive to performance-based standards; put in place necessary education and validation and verification tools*
- *Carefully map the design basis to owner's project requirements which in turn have been mapped to the project outcomes desired by the owner*
- *Strengthen the basis of design to encompass an expanded basis of design (BOD<sup>x</sup>) addressing construction (CBOD) and O&M (O&MBOD)*
- *Develop design scope guidelines outlining typical level of design detail required based on contract form*
- *Encourage performance-based or outcomes-based contracting that serves to encourage innovation*

## OPEX

A fourth lever of capital efficiency focuses on operating expenses of an asset's lifetime. An operations and maintenance basis of design (O&M BOD), the second element of an expanded basis of design, provides comprehensive identification of required or preferred sustaining capital and maintenance strategies, tactics, techniques and tools to be incorporated in the operations and maintenance (O&M) process that influence design. O&M labour, skills, equipment, materials, including consumables and temporary provisions for maintenance are reflected in basis of design.

To effectively pull this lever of capital efficiency, Enterprise Asset Management (EAM) must be a core philosophy and practice to significantly reduce life cycle costs. Design-stage activities and information must feed a BIM system, intimately linked to an enterprise asset management insight article. ISO 55000 should be a core asset development consideration. Similarly, resilience must be an element of life cycle cost and enterprise asset management.

To improve the performance of the OPEX lever, it is recommended to:

- *Develop a guidance document addressing scope and content of an operating and maintenance basis of design*
- *Establish interoperability standards for BIM and Enterprise Asset Management systems*
- *Require compliance with ISO 55000 for large complex engineering and construction projects*
- *Develop a resilience standard incorporating a common resilience metric such as recovery time objective (RTO)*

## Asset availability

Alternative life cycle models such as public-private partnerships provide incentives and compensation for improved asset availability and should be used where this is of primary importance. System-level modelling must reflect multi-asset and multi-infrastructure needs and performance and address opportunities to share redundancies. Improving performance of this lever can be aided if we:

- *Encourage use of performance based and outcomes based contracting*
- *Encourage systems-engineering education as part of engineering, project and construction management insight articles*

## Inventories

Inventories represent non-productive capital and should be minimized to free up financial resources for productive investment and to improve performance of the existing asset base. Standardization of components and details of construction act to minimize inventory requirements. Tightly linked and robust supply chains allow inventories to effectively be carried by reliable suppliers.

Recommendations to enhance inventory contributions to capital efficiency include:

- *Expand standardization of components to include standardization at the assembly or module level*
- *Migrate elements of construction into a manufacturing environment where such assemblies or modules are treated in a comparable way to other procured equipment*
- *Expand integrated use of BIM models by project suppliers. Resolve intellectual property and tort risks*

## Premium pricing and finance

This seventh lever of capital efficiency demands that scarce resources and services be priced on a premium basis by asset owners. The value of time varies with time of day and demand levels.

Premium services providing access to premium periods or premium priority should be value priced:

- Peak power
- Time of day tolling
- HOT lanes
- Congestion pricing
- Speed of service (data)
- Total resource consumed (data, VMT, water/power used)

Alternative financing must increasingly tap higher risk private capital and long-tenor financing such as available from pension funds. Alternative funding differs from financing, and must better capture the value of constructed assets through new funding sources.

Capital efficiency is enhanced if we:

- *Create longer-term capital asset financing tools that mitigate risk exposure through asset performance covenants ensuring asset performance levels and state of good repair*
- *Establish financial industry standards on life cycle asset performance that extends across all asset forms*
- *Require reporting of level of deferred maintenance*

## Operating philosophy and practices

The final lever of capital efficiency recognizes that reactive, proactive or predictive maintenance strategies affect life cycle performance, cost and affordability, and impact the basis of design. This can be offset by including greater awareness of operating-phase considerations into engineering curricula.

## Conclusion

These guiding principles are intended to improve overall construction affordability and asset life cycle capital efficiency. The principles and recommendations have been structured along the lines of eight principal levers of capital efficiency and taken together they offer the potential for significant reduction in asset costs and life-cycle cost reduction.

# Financing Solutions for Construction or Renovation of Affordable Housing

Danielle Grossenbacher

The world's population is expected to grow from 7.3 billion to 9.7 billion by 2050, according to recent United Nations projections. More than half of that growth is expected to occur in Africa. If people find no jobs, have no decent housing and lose hope about their economic prospects, the impressive daily migration from Africa to Europe that we have been observing for months, may accelerate dramatically.

Providing housing to the workforce at a reasonable cost is a challenge at the top of the agenda of most cities on every continent. As Bill De Blasio, Mayor of New York City, declared on 8 December 2016: "The cost of housing in this town continues to go up, wages are not going up anywhere near the same with it, more people are becoming homeless."

The magnitude of this problem is also critical in Asia. India, for example, will need to build over 100,000,000 homes in the coming decades. There, as elsewhere, the major problem will be funding. Most national governments no longer have enough resources to finance growing housing needs. *The private sector must come to the rescue.* It will do so with more speed and enthusiasm if it perceives a potential gain.

It is generally agreed that people should not spend more than 30% of their income on housing. This is the benchmark for affordable housing, for rent or for sale, used here.

The high cost of land and lack of funds are the first obstacles faced by developers when considering an affordable housing construction project. Land cost can be mitigated for example by:

- a grant or long-term lease by the private or public owner
- land purchase price paid in cash or units once construction is completed
- financing provided by the city from funds accumulated by Land Value Capture tax increase
- derogation granted by the authorities allowing higher building density

However, finding ways to generate enough funds to address the enormous demand requires global brainstorming and a lot of creativity and ingenuity. Today the main sources of such funding are government, the World Bank, International Development Banks and some UN entities such as UNCTAD.

Below are a few solutions developed by or for such entities, which have provided interesting results.

## Financing solutions for affordable housing

### Low-income housing tax credits

A primary source of affordable home funding in the US is a programme using tax credits offered by the US Internal Revenue Service. These credits are valued by higher income

entities because they reduce their tax liability for 10 to 15 years (depending on each State's programme) with a dollar for dollar credit on the money invested in a project. The developer gets cash in exchange for the tax credits his State allows him to sell to investors.

<https://nhlp.org/lihtcoverview>

### Obligation of local banks to provide funding

The Community Reinvestment Act of 1977 in the United States sought to address discrimination in loans made to individuals and businesses from low and moderate-income neighborhoods. The Act mandates that all banking institutions that receive Federal Deposit Insurance Corporation (FDIC) insurance be evaluated by Federal banking agencies to determine if the bank offers credit in all communities in which they are chartered to do business. An institution's CRA compliance record is taken into account by the banking regulatory agencies when the institution seeks to expand through merger, acquisition or branching.

<http://homeguides.sfgate.com/hud-loan-8191.html>

### Investment bank housing portfolio

The Blackstone Group L.P. is an American multinational private equity, investment banking, alternative asset management and financial services corporation based in New York City. Its subsidiary, INVITATION HOMES, is the leading provider of single-family homes for rent in 14 markets across the U.S. Blackstone operates a leading single-family home rental platform in 14 metropolitan markets across the U.S. which creates jobs and provides high quality, affordable housing for families nationwide.

<https://www.blackstone.com/InvitationHomes>

### Crowdfunding

One of the main slogans resulting from the Habitat III conference in Quito, Ecuador, on 17-20 October is PPPP (Public-private partnerships and people). Crowdfunding is an effective and interesting way to involve the people by gathering funds from small investors interested in diversifying their portfolio, obtaining interesting returns PLUS improving their neighborhood and/or the world.

This method of raising capital is very successful for **Fundrise**, an eREIT platform, allowing individuals to invest in real estate projects with initial investments starting at \$1,000 and up to \$10 million. It has been labeled as the first company to successfully crowdfund investment into the real estate market in the USA.

<https://fundrise.com>

Another example is The Città del Vetro (City of Glass) renovation project, the first in Italy to use equity crowdfunding. Aimed at urban renewal and social and cultural development of the historic center of Altare, the redevelopment of the former SAVAM Glassworks will activate a process of urban regeneration and economic recovery in Altare and stimulate new youth entrepreneurial activities.

<http://www.habitareapartecipazioni.it>

## Insight articles for buyers and tenants

### 1. Solidarity bonds

Public, private and financial entities working together have allowed Panama to be one of the countries in Latin America with the highest rate of home ownership. Solidarity Bonds from the government subsidize interest rates for mortgages for families that earn up to \$1,200 a month. The Ministry of Housing also gives \$10,000 for a down payment for families that qualify. Today there are over 400 private developers in the solidarity bond programme.

A typical affordable home in the programme sells for \$50,000 and is built from a standard blueprint. Working with the government, financial institutions are able to offer special interest rates for the clients of the social interest programme. Homes costing up to \$39,999 qualify for 0% interest rates. Homes from \$40,000 up to \$79,999 qualify for a rate 5 points lower than the reference national interest rate and 4 points lower for houses from \$80,000 to \$120,000.

See page 28 in the FIABCI book: *The City We Need is Affordable*

<http://www.fiabci.org/images/TheCityBookFIABCI.pdf>

### 2. Housing vouchers

In the USA Tenant Based Vouchers, provided by the Department of Housing and Urban Development (HUD), increase affordable housing choices for very low-income families. A tenant-based voucher enables them to choose and lease safe, decent, and affordable privately owned rental housing.

<https://portal.hud.gov/hudportal/HUD?src=/hudprogrammes/hcvc>

### 3. Micro-financing with solid underwriting system

This method of helping low-income residents afford a mortgage is well implanted in Asia and South America. In Mexico, for instance, the Sociedad Hipotecaria Federal (SHF), a state-run institution, is a key player in the country's mortgage market. With the support of the World Bank, it finances over 250,000 loans of end-user outside of the social security system, earning between 3-9 monthly minimum wages (\$5,500-\$16,000 annual income).

<http://hofinet.org/themes/theme.aspx?id=56>

## Conclusion

The World Economic Forum could play a useful role by promoting publication of solutions demonstrating that affordable housing, a huge real estate market segment for decades to come, can be a profitable business for:

- Banks
- Publicly-traded or private REITS
- Pension funds
- Philanthropic life cycles
- Individual investors

## Creative Financing for Affordable Housing

*Richard Koss*

### Overview

Attracting private capital into programmes for affordable housing has been a long-run challenge in both developed and developing countries. In general, the problem is that purely private capital is incentivized to devote its resources towards the development of high-end properties for upper-income households.

Purely public forms of capital can be brought to bear to support affordable housing construction, but cost control can be a problem without the profit incentive. In addition, public resources are limited, in particular in emerging markets, and can fall far short of the public need. What we see then is the development of many forms of public regulation and partnerships with the private sector in order to meet the affordable housing challenge. While still in early changes, a great deal of institutional and technological innovation is just now being brought to bear on this issue that offers considerable promise in this area, particularly in emerging markets.

### Regulation and government-sponsored enterprises

Traditionally, higher-income countries have dealt with the issue of affordable housing via a variety of regulations on financial institutions and public support of income targeted at housing. In terms of regulation, the idea is that financial institutions, notably banks, receive public support through features such as cheap funding through taxpayer-insured deposits. In exchange they should be directed to allocate capital towards affordable housing projects that are expected to be profitable, but not so much as the development of costlier units. In the United States, one such mechanism is the Community Reinvestment Act<sup>14</sup>.

Another approach is the formation of government agencies or government-sponsored enterprises (GSE's) which support liquidity and affordability to loans directed at lower income homeowners and to developers who build high-quality rental units aimed at lower-income communities. They do so in part by designating balance sheet directly towards these mortgages. In addition, they also set standards and share risk with the private sector through the issuance of mortgage-related securities (MRS). In the US these entities include agencies such as the Federal Housing Agency and the Veterans Administration as well as the housing GSEs Fannie Mae and Freddie Mac. GSEs are tasked to support lower-income housing through sweeping regulation known as the Affordable Housing Goals<sup>15</sup> and the Duties to Serve<sup>16</sup>. Other nations have housing agencies, notably Japan<sup>17</sup> and Canada<sup>18</sup>.

<sup>14</sup> <https://www.ffiec.gov/cra/>

<sup>15</sup> <https://www.fhfa.gov/PolicyProgramsResearch/Programs/AffordableHousing/Pages/Affordable-Housing-FMandFM.aspx>

<sup>16</sup> <https://www.fhfa.gov/duty-to-serve>

<sup>17</sup> <http://www.jhf.go.jp/english/about.html>

<sup>18</sup> <https://www.cmhc-schl.gc.ca/en/corp/about/>

The UK has an innovative programme called Help-to-Buy that allows lower income households to purchase a share of a home (usually 25% - 75%) and pay rent on the rest<sup>19</sup>.

Another affordability policy is income support for lower-income housing. In the US there is the Low Income Housing Tax Credit Programme (LIHTC).<sup>20</sup>

Another approach which is more local in nature is the requirement that developers who are given rights to build on a piece of land set aside a certain number of units designated as affordable housing. Such programmes are very popular in California where affordability is particularly problematic<sup>21</sup>.

## Financing vehicles

Another set of responses to the affordable housing financing challenge can be characterized as “financing vehicles”. These are generally partnerships between private, philanthropic and public entities that bring the efficiency of private capital to bear with credit enhancements provided by government and charities. In general, the returns to private capital are somewhat less than for purely private projects, but the experience is that many private developers are willing to participate in these programmes out of a sense of civic duty and reputation enhancement. There are many classes of such investments that are targeted at different segments of the market. These include below-market debt funds, private equity vehicles and real estate investment trusts (REITs). The Urban Land Institute provides a useful summary of these efforts<sup>22</sup>:

In many cases, the public funds come from regional entities (generally states in the US). These are known as Housing Finance Agencies (HFA's)<sup>23</sup>. The US Treasury lends support to more distressed local communities through entities known as Community Development Financial Institutions (CDFI's)<sup>24</sup>. All-in-all there are many hundreds of such vehicles and structures, revealing great innovative thinking that can be targeted at particular needs in distinct communities. There are far too many to list here, but an example that has received attention is the JP Morgan Partners in Raising Opportunity (PRO) programme that provides funding to CDFI's across the country<sup>25</sup>.

## Applications to emerging markets and LICs

In 2015, countries from around the world adopted a set of 17 Sustainable Development Goals designed to end poverty, protect the planet and ensure prosperity for all<sup>26</sup>. Goal 11 is focused on Sustainable Cities and Communities<sup>27</sup>.

19 <https://www.helptobuy.gov.uk/shared-ownership/>

20 <https://www.huduser.gov/portal/datasets/lihtc.html>

21 <http://www.latimes.com/local/lanow/la-me-ln-affordable-housing-20150615-story.html>

22 <http://uli.org/wp-content/uploads/ULI-Documents/Preserving-Multifamily-Workforce-and-Affordable-Housing.pdf>

23 <https://www.ncsha.org/about-hfas>

24 <https://www.cdffund.gov/Pages/default.aspx>

25 [http://www.jchs.harvard.edu/sites/jchs.harvard.edu/files/harvard\\_jchs\\_pro\\_neighborhoods\\_2016.pdf](http://www.jchs.harvard.edu/sites/jchs.harvard.edu/files/harvard_jchs_pro_neighborhoods_2016.pdf)

26 <http://www.un.org/sustainabledevelopment/sustainable-development-goals/>

27 <http://www.un.org/sustainabledevelopment/cities/>

Programmes developed to alleviate affordable housing challenges need to take into account that about 5 billion people are expected to live in urban areas by 2030. This trend poses many challenges in a wide range of fields, including development finance.

Although aimed broadly at a wide variety of areas besides housing, the World Bank and IMF have set out an agenda for meeting development challenges by strengthening domestic finance as well as engineering strategies for engaging private finance<sup>28</sup>. Particular challenges facing financing in emerging markets include the lack of formal rental markets<sup>29</sup>, the prevalence of informal labour and housing markets<sup>30</sup> and uncertainties related to the enforcement of property rights<sup>31</sup>.

The characteristics described above serve as impediments to the development of financial strategies such as those described above for developed economies. A strong emphasis on structural reform is needed in order to support the development of financing vehicles to achieve the goal of sustainable cities in a rapidly urbanizing age. However, insofar as they can be applied, the structures can be similar, keeping in mind that government support can include international development agencies and that the philanthropic contribution may include entities that are devoted specifically to emerging markets and LICs.

## Technical innovations in finance to enhance affordable housing: Microfinance and payments systems

Credit needs in low-income countries tend to be widespread, but the individual amounts required are relatively small. Micro-finance institutions (MFIs) are springing up in many parts of the developing world to meet these challenges<sup>32</sup>. These are particularly notable in Sub-Saharan Africa, which is the only major part of the world where the slum population is expected to grow<sup>33</sup>.

The extension of credit of any amount to individuals in emerging markets is constrained by a lack of a developed consumer credit infrastructure that allows borrower quality to be scored. Recently, however, the Fair-Isaac company has introduced new metrics designed to help alleviate these concerns<sup>34</sup>.

28 [http://siteresources.worldbank.org/DEVCOMMINT/Documentation/23659446/DC2015-0002\(E\)FinancingforDevelopment.pdf](http://siteresources.worldbank.org/DEVCOMMINT/Documentation/23659446/DC2015-0002(E)FinancingforDevelopment.pdf)

29 <http://documents.worldbank.org/curated/en/810681468339259949/pdf/761820PUB0EPI00LIC00pubdate03010013.pdf>

30 <http://documents.worldbank.org/curated/en/416741468332060156/pdf/WPS6888.pdf>

31 <https://www.imf.org/external/pubs/ft/wp/2016/wp1615.pdf>

32 [http://www.ifc.org/wps/wcm/connect/Industry\\_EXT\\_Content/IFC\\_External\\_Corporate\\_Site/Industries/Financial+Markets/MSME+Finance/Microfinance/](http://www.ifc.org/wps/wcm/connect/Industry_EXT_Content/IFC_External_Corporate_Site/Industries/Financial+Markets/MSME+Finance/Microfinance/)

33 <http://pubdocs.worldbank.org/en/451301464879251233/housing-finance-conference2016-preconference-session-3-presentations.pdf>

34 <http://www.fico.com/en/newsroom/fico-and-efl-partner-to-extend-access-to-credit-for-unscoreable-consumers-and-entrepreneurs-in-multiple-markets-10-25-2016>

Finally, a key impediment to the development of microfinance markets is transactions costs. New digital technology solutions are being developed that show promise in reducing these so that credit becomes available to an ever-broader set of consumers<sup>35</sup>.

The low costs associated with digital payment systems also open the door to crowdsourcing as a viable source for microfinancing of housing loans. In addition, tapping into a broad market has potential non-monetary benefits as new market intelligence provides policy-makers with tools to design more effective regulations and entrepreneurs with opportunities for introducing new innovative products<sup>36</sup>.

## Conclusions

As pointed out by former IMF Deputy Managing Director Min Zhu, housing is an essential sector of the economy<sup>37</sup>. It is a universal good, and an indispensable vehicle as a store of wealth that allows households to achieve prosperity. As the global economy becomes more urban, and as political pressures rise due to concerns about inequality, the attention of policy makers on housing becomes ever more focussed. Recently, the core mission of the IMF has evolved towards one of inclusive growth<sup>38</sup>. Innovation in the development of new market structures and technologies to enhance the sustainable extension of credit to as much of the world's population as possible will surely be a key component of strategies aimed at meeting this goal.

35 <http://www.mckinsey.com/global-themes/employment-and-growth/how-digital-finance-could-boost-growth-in-emerging-economies>

36 <http://documents.worldbank.org/curated/en/820101468186856874/pdf/103279-WP-Box394864B-PUBLIC-crowdfunding-in-east-africa.pdf>

37 <http://www.imf.org/en/News/Articles/2015/09/28/04/53/sp060514>

38 <https://blog-imfdirect.imf.org/2017/01/24/inclusive-growth-and-the-imf/>

# 5. Disaster Resilience



## Introduction

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*The built environment is facing an increasing number of natural and man-made threats, ranging from heavy-weather events to cyberattacks. Consider the following challenges:*

- Three times as many disasters were reported in 2015 as in 1980*
- About 94% of loss-related natural catastrophes in 2015 were weather-related events*
- 295 cyberattacks against US critical infrastructure facilities were reported in 2015 by the US Department of Homeland Security*

*Such challenges are sure to increase in the future. Hence the compelling need for the engineering and construction industry to create resilient infrastructure and housing to withstand disruption, absorb disturbance, act effectively in a crisis and recover quickly afterwards. This requires collaboration between the public and private sectors, involves both technical and social systems and needs to anticipate changing (climatological) conditions, changing societal needs and growth of economies and the build environment over time.*

*In developed countries, a major task for the industry is to refurbish or replace ageing infrastructure. Many of these assets (bridges, ports, navigation locks, dams) are part of critical infrastructure, were designed in the early 20th century, and relate to economic and societal dependencies that have never stopped growing. For developing economies, the challenges may even be bigger. Statistics show that many are located in regions prone to natural disasters and these countries often lack the needed resources to rebound. People are hurt more severely, effects last longer and growth of prosperity can stall long term.*

*The World Economic Forum security outlook in January 2017 shows that the number one threat for people in the world, even considering all the current socio-political turmoil, is still extreme weather. This is a big world problem, but one the engineering and construction industry can actually address. This would be rewarding in many ways, not the least of which for the sector itself, literally. Here lies an opportunity to join forces and make a notable difference. A group of expert-practitioners took a step forward by contributing ideas. Let's work together to make this difference achievable.*

# Resilience of Transport Infrastructure Systems

Harvey Hill, Arjan Hijdra and Paolo Craviolatti

## The challenge

Transport is vital to well-functioning economies. The physical infrastructure is needed to accommodate this. The most common types of transport infrastructure are roads, railroads and ports (dry ports, seaports/ waterways and airports). These are the *hard* physical infrastructure components of wider transport systems that include *soft* infrastructure like policies and regulations, and the institutions responsible for planning, financing, operating and maintaining these systems. All these components are interconnected into transport systems. As societies change, economies grow and new markets emerge, these systems, at least in theory, need to be regularly upgraded in order to remain “fit for purpose”. However, when sudden events take place – a major technical failure, serious accident, floods or earthquake – unless these systems have in-built resilience, they can be seriously disrupted. The growing degree of the interdependencies of the hard and soft infrastructure components can increase the vulnerability of such systems, making these disruptions more serious, longer lasting and potentially debilitating with serious impacts across economic sectors.

In the past, transport infrastructure systems were less complex. Causes of disruptions were easy to detect and repair (e.g. railroad switches were operated manually and a local blacksmith could do repairs as opposed to current operation from a distance through communication lines and power supply through grid connectivity). Nowadays, infrastructure supports increasingly complex global supply chains and any disruption can spread along these chains depleting value of today’s highly interdependent economies. The ripple effects can be significant and severe. Transport systems have become more vulnerable to disasters by the mere fact that they spread across a wider geographical area and more sectors.

A real-life example illustrates such connectedness: when severe snow conditions hits the US Midwest, road traffic can be interrupted for a period of time. Obligatory crew changes for inland shipping (navigation itself is not problematic in snow conditions) cannot take place due to obstructed road traffic. Barge traffic gets disturbed and due to the tightly fit long-range planning schemes, the effects are felt all the way to the seaports at the Gulf Coast.

Other examples of dependencies can be found in reliance on telecommunication or power supply, or availability of specialized craftsmen for emergency repairs after disruption. By systematically assessing vulnerabilities due to these dependencies, and ensuring the transport system has the ability to absorb shocks and bounce back rapidly, transport system resilience can be enhanced.

## The idea

*Creating a framework to improve resilience of transport infrastructure systems.*

This insight article aims to provide guidance on how to improve resilience of transport systems in light of the multitude of dependencies along these systems. A literature review reveals that no common framework for resilience of transport systems is readily available. While debates about how to capture resilience are ongoing, resilience of infrastructure systems is gaining interest in the academic community (Boin, A., & McConnell, 2007; D’Antonio, S. et al, 2009; Kong, D. et al 2012; McDaniel, T. et al, 2008; Petrenj et al 2011; Rogers, et al 2012; Vespignani, 2010). Considering infrastructure as a technical system, a widely cited approach from O’Rourke (Rourke, 2007) elaborates on the work of Bruneau (2003). This framework comes from the domain of resilience of communities exposed to earthquake events. On the basis of this framework, more detailed parameters have been identified through literature and document study in order to adapt this to a tailor made framework for transport systems. On the basis of mentioned literature and document study, the original framework of Bruneau has been adapted for transportation systems in general and broken down in a series of parameters relevant for transport systems, as follows:

**Table 1. Breakdown of resilience parameters for transport systems**

<b>Robustness</b>	Status of assets
	Capacity to withstand climatologic variations
	Physical interdependency with other systems
	Geographical interdependency (size of the system, number of independent systems)
	Logical interdependency (number of independent systems)
<b>Redundancy</b>	Local workarounds or substitutions
	Availability and capability of alternative routes
	Availability and capability of alternative modalities.
<b>Resourcefulness</b>	Availability of emergency funding
	Availability of expertise and manpower
	Availability of equipment and materials for restoration and repair
<b>Rapidity</b>	System downtime
	Restoration time

By carefully assessing the system on the basis of characteristics as shown in the framework, resilience can be improved by balancing and preparing on the four major dimensions:

1. **Robustness:** by improving robustness the transport system will be able to resist shocks and prevent disruptions.
2. **Redundancy:** when redundancy is available a disturbance will be compensated for and the effects on the transport system should be contained.
3. **Resourcefulness:** in case a disturbance does take place, relevant organisations must be prepared and ready to respond and deploy necessary resources to take action.
4. **Rapidity:** having considered different potential scenarios the system can quickly respond and recover. Easy to replace parts/modules/assets, predefined deviation routes are all good examples.

## The impact

The characteristics of the four major dimensions of resilience of transportation systems are described in more detail and can be used as a checklist to reduce the impact of disasters occurring in the transportation system.

### *Robustness*

Robustness is the capacity to withstand shocks without losing functionality. The status of assets plays a role in this. Through wear and tear or maintenance shortcomings (e.g. rust, cracks in concrete) the assets will gradually lose some of the initial capability to withstand shocks. Capacity to withstand climatologic variations is captured in the original design of assets, but exposure could have changed over time (e.g. excessive rainfall flooding roads, extreme heat jamming a bridge blocking it from opening; and these events becoming more and more frequent). The physical interdependence means the robustness is dependent on other components of these systems (e.g. water pumps keep tunnels dry but are dependent on electricity, sensors and data communication). Geographical interdependency relates to robustness to shocks along the whole system with down and upstream linkages (e.g. for a waterway a failure of a lock disrupts traffic in an entire river – up and down stream). Logistical interdependency relates to robustness in term of dependencies, which are not physical or geographical (e.g. the ability of personnel that operates assets and networks to go to during extreme weather events).

### *Redundancy*

Redundancy with regards to local workarounds leads to the question whether infrastructure networks have alternative routes available: e.g. goods being able to be taken to destination by roads or railways. For waterways this can be particularly problematic, as river systems have a natural pattern without options for diversion. Man-made canals can offer alternatives, but might not be able to accommodate similar ship/convoy sizes. Air traffic is the easiest, relative speaking, as planes can be diverted to alternative airports when needed. Doing so does however rely on the availability of local alternative transport modes to

reach the final destinations. By having local workarounds (e.g. traffic over shoulder, double lock chambers for navigation) readily available, the system can keep up functionality and therefore be considered *resilient*. Hence, traffic can be diverted to alternative routes, the effects of failing functionality somewhere in the system can be reduced. Such redundancy can be applied either locally, or on a much wider scale (e.g. alternative routes through the Alps in Europe provide alternatives for long distance north south trips; in Sub-Saharan Africa goods can be rerouted through different transport corridors). In some cases it might even be worthwhile considering what **alternative modes** of transport can be used in case a natural disaster disrupts an entire mode of transport. Parallel waterway and railroads (e.g. the Rhine river in Europe or the Columbia river in the US) do have such capabilities to offset disruptions. But such redundancies are not always straightforward; the use of alternative modes does require consideration of terminals to shift cargo, transport capacity on alternative systems, and pricing schemes that do not obstruct further trading of cargo.

### *Resourcefulness*

In the event that natural disasters do disrupt transport, a resilient transport system has the ability to restore functionality, e.g. repairs, to bounce back. Funding, contingency or emergency, is needed to pay for the costs and should be readily available to keep downtime low. Expertise and manpower are needed as well. But when natural disasters disrupt the systems it can be hard to get the right personnel in the right place at the right time especially when competing demand of the personnel is high. Being prepared for this is crucial to resilience. As with manpower, availability of equipment and materials can be similar challenges. In addition, lack of availability of specialized parts or failing ancient elements in assets cannot be easily overcome as fabrication of those parts often has long lead times.

### *Rapidity*

When infrastructure is resilient, that is, designed and operated in a way that can quickly be restored after lost functionality, disruption effects will be limited. By using systems, assets and parts that are easy to replace, teams are trained and skilled in emergency response and scenarios are thought-through, restoration time can be significantly reduced. Smart sequencing of such efforts can considerably reduce downtime of a variety functionalities so bouncing back after a shock starts rapidly and does not have to await the last repair to be made.

## The way forward

Transport infrastructure systems have been little studied with respect to barriers to address resilience on a systems scale. Nonetheless, changing conditions due to climate change provide an extra challenge to keep operation service at required levels. In this insight article a general framework is shown to analyse the resilience of transportation systems by making use of specific resilience frameworks as used in available literature.

Infrastructure providers and affiliated organizations are facing an ever-growing challenge of managing infrastructure. Disasters regularly affect transport systems and when they do, the nature and context will often differ from disaster to disaster. This makes it harder to be adequately prepared to deal with all the complexities of the system in relation to a disaster. By using the framework shown, the organizations responsible for the smooth running of these transport systems can find generic guidance in:

1. Reducing the impact of the disaster
2. Reducing the duration of the disruption
3. Balancing spending of resources to improve resilience

While these elements can be useful in operations, they are fundamental in the development of new infrastructure, or when expanding current systems.

- Boin, A., & McConnell, A. (2007). Preparing for critical infrastructure breakdowns: the limits of crisis management and the need for resilience. *Journal of Contingencies and Crisis Management*, 15(1), 50-59.
- Bruneau, M., Chang, S. E., Eguchi, R. T., Lee, G. C., O'Rourke, T. D., Reinhorn, A. M., ... von Winterfeldt, D. (2003). A Framework to Quantitatively Assess and Enhance the Seismic Resilience of Communities. *Earthquake Spectra*, 19(4), 733-752.
- Kong, D., Setunge, S., Molyneaux, T. C., Zhang, G. M., & Law, D. W. (2012). Australian Seaport Infrastructure Resilience to Climate Change. *Applied Mechanics and Materials*, 238, 350-357.
- McDaniels, T., Chang, S., Cole, D., Mikawoz, J., & Longstaff, H. (2008). Fostering resilience to extreme events within infrastructure systems: Characterizing decision contexts for mitigation and adaptation. *Global Environmental Change*, 18(2), 310-318.
- Petrenj, B., Lettieri, E., & Trucco, P. (2011). Towards enhanced collaboration and information sharing for Critical Infrastructure resilience: Current barriers and emerging capabilities. In *The 4th Annual International Conference on Next Generation Infrastructures, Virginia Beach, Virginia*.
- Rogers, C. D. F., Bouch, C. J., Williams, S., & et al. (2012). Resistance and resilience of critical local infrastructure. In *Proceedings of the Institution of Civil Engineers* (p. 11).
- Rourke, T. D. O. (2007). Critical Infrastructure, Interdependencies, and Resilience. *The Bridge, National Academy of Engineering*.
- Vespignani, A. (2010). The fragility of interdependency. *Nature*, 464(April).

## Evolution and Challenges of Addressing Flood Risks in the United States

Jeff Jacobs

### The challenge

*Despite many decades of efforts directed to reduce floods risks across the US, mainly in river floodplains and along coastal areas, many citizens and structures remain at risk of being flooded.*

Occupation of low-lying areas is itself not necessarily problematic. However, the risks of flooding are not always widely appreciated by inhabitants at risk, and appropriate planning and preparedness options –

such as purchase of flood insurance policies, and the use of building-specific flood proofing materials and actions – are not always widely adopted and practiced.

The US Army Corps of Engineers (USACE) has major authority and responsibility for federal flood risk management personnel and actions. In an earlier era, many of these actions took the form of “structural” flood protection actions, primarily dams and levees. There are some limits to these measures, however; for example, levees may be overtopped, or they may fail. Further, it has been noted that despite the construction of numerous flood protection structures across the US, this has not necessarily reduced lives lost or property damaged during floods.

There are thus many reasons why structural measures should be complemented by “non-structural” measures. In addition to measures mentioned above, these may include flood warning systems, zoning measures designed to limit the number of buildings located in floodplains, and physical relocation of some structures to higher ground. Although many such measures are beyond the authority of the USACE, the agency has fundamental dam operations and levee inspection and maintenance responsibilities and is a leader in US flood risk management. The USACE strives to coordinate and integrate input and resources from other relevant federal agencies, such as the Federal Emergency Management Agency (FEMA), states, communities, the private sector, and nongovernmental life cycles (NGOs) in promoting a comprehensive approach to flood risk management.

In addition to identifying and implementing programmes and actions encouraging wiser use of floodplain areas, there also is need for more harmonious co-existence with occasional, but inevitable and useful, floods. This will entail mitigation and preparedness measures that are less expensive and more efficient and nimble, and that allow communities to rebound quickly in the wake of a flood.

## The idea

*To seek processes, programmes and initiatives that build on traditional and existing structural flood control elements, which acknowledge current budget realities, and that seek wise use of limited resources and intelligent uses of flood hazard areas.*

There is no “quick fix” for the challenges at hand. Wiser uses of those areas in the US subject to flood waters and coastal storms will require sustained discussions, compromises and trade-offs among agencies, elected officials, and citizens and owners of properties in low-lying areas.

One important part of the process will be to strengthen two-way flow of information between flood risk programme leaders, and citizens and property owners. Past flood control efforts had a strong “top down” dimension; this approach should be replaced by more vigorous and systematic two-way flow of information and discourse, with emphasis on helping citizens better understand flood risks and the full range of flood preparation and mitigation options.

Modern technologies for addressing flood risks include: mobile levee systems that can be erected in hours, or days, flood risk communications initiatives, and better, relatively inexpensive software for visualization to enhance collaborative dialogue and mutual learning. The USACE is positioned to play a leadership role in more vigorous information exchange and systematic conversation, and development and implementation of innovative technologies for improved understanding of flood risks and the value of mitigation and preparedness measures.

This will help citizens and property owners become better aware of the nature of flood risks, the inevitability and benefits of floods, and available flood preparedness options. One goal is greater “shared responsibility” and partnership among government agencies, communities and citizens.

Many US communities currently are working with US federal agencies, including FEMA and the USACE, and their respective states, toward a better understanding and communication of flood risks, and better preparedness and to accepting more responsibility at the household level.

The USACE looks to other federal agency and state initiatives, and academia and the flood risk literature and research programmes, to become better informed and capable in promoting more useful flood risk initiatives. The USACE, for example, has conducted several multi-hazard “tournament” exercises across the US to convene stakeholder groups to engage in decision support system (DSS)-based conversation regarding watershed management, more widespread appreciation of flood risk, and enhanced mitigation and preparedness activities.

## The impact

Measuring objectively and accurately the impacts of this shifting approach to addressing flood risks is, not surprisingly, a difficult proposition. Nevertheless, anecdotal evidence and a variety of innovative research initiatives and federal, state, and community programmes and activities, provide evidence of increasing acceptance and promotion of flood risk programmes less reliant on dams, levees, and other structures.

There is no single experiment or laboratory for the simulation, conduct or evaluation of these changing approaches to managing US floods. At the same time, many US cities that are adopting non-structural approaches are showing signs of resilience to floods. The city of Cedar Rapids, Iowa, for example, in October 2016 experienced its second-largest flood of record. The largest flood was in 2008, and the city took many steps following the 2008 event to increase resilience. The 2016 event resulted in zero fatalities, the city had moved many people and structures out of the floodplain area, and most downtown businesses were back on-line within 10 days after the flood crest had passed (having used to very good effect mobile levee systems to help protect downtown commercial properties).

## The barriers to innovation – and the solutions

*Generally speaking, a meaningful shift and adoption of non-structural approaches to managing floods will require changes in actions, perceptions, and thinking of agencies, elected officials, and citizens and the private sector.*

The traditional, primarily top down, structural approach to addressing floods had many successes and will remain appropriate and useful in some settings. Construction projects with large flood protection structures offer rewards and incentives to many entities. The fiscal reality, however, is that fewer of these projects will be constructed in the future.

Large structures can entail a considerable infusion of federal money and jobs to a locale. Further, many citizens and other entities favour this approach to floods, and there remains widespread perception that flood risk can be eliminated by construction of a ‘flood control’ levee. These measures have historically been more common, and are favoured for a number of reasons.

An important reality is that the US Congress, which authorizes Corps projects and provides funding to the agency, often has a strong preference for traditional, structural approaches to addressing flood risks, as compared to less expensive, and perhaps more complex, non-structural approaches.

Potential ways to address these barriers include sustained educational and communication efforts, investment in resources for mitigation and preparedness efforts, systematic monitoring of the financial and environmental successes of non-structural initiatives to help demonstrate value to key entities in decision making process, for example the US Office of Management and Budget.

# Cross-Sectorial Collaboration Networks for Crisis Management

Marc Ribo Pedragosa and Elisabet Viladomiu

## The challenge

*To improve crisis management abilities, minimize damage, accelerate speed of response and reduce rehabilitation costs through greater coordination between infrastructure companies and public administration.*

All countries today face risks and threats inherent in their socio-economic development. Growing populations and economic activity as well as higher concentrations in big cities and their respective metropolitan regions, have given rise to sprawling urban areas. A high density of networks, infrastructure, services and pipelines ensures the supply of and mobility of goods and services, and the mobility of people.

It is precisely this complexity that makes our cities vulnerable to risk, whether it is natural, technological or social in nature. This is because the impact of disruptions on populations and economic activity is high, not to mention that on government and company reputations.

The risks and their consequences tend to increase despite large investment in infrastructure risk mitigation strategies. From the perspective of infrastructure operators, there is need to manage different types of incidents depending on the level of recurrence and predictability. This requires varying levels of involvement – internal or external – and types of actions. Internally, there are different types of procedures, risk management plans, coordination teams. Externally, there are actions that require communication with media and society, as well as more formal collaboration with other private life cycles, the administration and services.

Crisis management is increasingly complex as it involves many actors: public and private companies, administration, academia, non-governmental life cycles, the media and civil society. Crisis management and the resolution of disasters requires extensive coordination of these multiple and diverse agents.

Public-private and private-private collaborations are pillars of the efforts to build resilient cities as is evidenced by the Business Crisis Management Support Service. The UN too, through its Office for Disaster Risk Reduction (UNISDR), has created the ARISE insight article to promote public-private partnerships to address major crises or disasters.

## The idea

In 2009-2010, Abertis and Institut Cerdà held a series of meetings to discuss the need to improve coordinated action in response to natural disasters such as heavy snow, storms, floods and wildfires, especially in the area of Abertis headquarters. As a result of those discussions and contacts with other companies, *the Crisis Management Support Service (CMSS) was created in 2010 to improve the coordination, collaboration and cooperation between the private sector, the administration and society at large.* This group is comprised of Abertis, Agbar, Caixabank, Enagás, Endesa, Gas Natural Fenosa and Mercadona, with the coordination by Institut Cerdà.

Since 2015, thanks to Institut Cerdà and companies like Abertis, already present in the first CMSS, the initiative was also promoted in Chile and includes Abertis, Aguas Andinas, CGE, Falabella, Metrogás, COPEC, GNL Quintero, Metrogas, Telefónica and Transbank. It is a pioneering initiative that facilitates coordination and communication between companies and the administration to prevent and minimize the impact of crises. The aim is equip companies to be better prepared to manage crises by intensifying public-private and private-private collaboration as well as companies' own capabilities. The Service is designed for companies that provide basic services and that already have a sense of social responsibility over and above internal risk and safety management procedures.

## The impact

*To improve company preparation and capacity in times of crisis, especially in relation to unforeseen external events.*

The achievements and benefits, accumulated over the years, of the Service are:

1. *A stable public-private and private-private collaboration framework among members*  
In 2014, for example, Abertis participated in a study about access to the public telecommunications network in the region of Catalonia (where only public emergency services and basic infrastructure have access to date).
2. *Multilevel and multisectoral networking*  
The networking takes place through group actions involving company management. Here, they share information, good practices and contacts among the various sectors represented. Each action involves more than 70 people.
3. *Improvement of company resilience through team cohesion, specific developments and integration*  
This methodology has been developed in-house to evaluate corporate resilience. It is based on analysis of the attributes present in the company culture that might cause dysfunctions and accentuate the effect of crises.
4. *Access to new Knowledge: Methodologies and case studies*  
A clear example is the dissemination of factsheets to service companies. The most recent cases have been Volkswagen; the fire at the Santa Mata landfill (Chile) or the fire at Campofrío's factory in Burgos, Spain.

## Barriers to innovation – and the solutions

*Crises in the 21st century cannot be solved unilaterally. They need to be managed by the various stakeholders involved.*

Internal barriers are associated with high risk and limited management involvement, which translates into low levels of safety. CMSS companies such as Abertis, however, have processes to cope with crisis situations and emergencies, allowing them to recover services in a timely manner. Even in large corporations, culture, country-specific risk perceptions and corporate structure can be a factor in implementing collaborations.

External barriers to public-private and private-private collaboration are linked to (a lack of) trust and transparency among life cycles. For an infrastructure operator such as Abertis, collaboration with the administration and other service operators is part of its daily activities as it manages a public asset that requires interaction with the administration and other service providers who depend on the infrastructure to access their services in times of crisis. It is also easier to collaborate in sectors such as critical infrastructure where there is little competition once you have a concession of the service or asset.

The way to deal with these obstacles is to use an entity such as Institut Cerdá as a catalyst. As a neutral yet prestigious player that is trusted by all involved parties. It has a unifying and coordinating role. It identifies individual and group needs and seeks synergies among life cycles through a process where everyone must win.

## The way forward

*Companies involved should reach agreement on the actions to be carried out by the Service and work to improve resilience and crisis management.*

This requires a multidisciplinary team, stable over time, with a good working knowledge of the needs and working practices of CMSS companies. The key stakeholders are administrations with responsibility or competence in crisis management and companies defined as critical for strategic infrastructure. This implies a sequence of actions that starts with the agreement of all companies to work in the Service, carry out a needs assessment and, consequently, elaborate a work plan that will result in concrete actions. The CMSS has developed its own methodology to achieve objectives. A range of actions is identified and developed in collaboration with the companies involved. The actions can be grouped as follows:

### 1. Common Actions

These are carried out jointly for the whole group of companies:

- *Group activities:* these concentrate on the experience interchange, case analysis and discussion of good practice
- *Collaboration actions:* these allow a coordinated communication and an effective relationship amongst public administration, civil society and business
- *Promotional activities:* these help raise the presence of companies in a given location and raise awareness of the subject

### 2. Individual Actions

These are tailor-made on an ad hoc basis to a specific company.

- *Consultancy projects to study, review and/or update plans related to risk management*
- *Capacity building and training for corporate management teams*
- *Post-crisis analysis*

# Nature-Based Solutions for Disaster Resilience of the Built Environment

Monica Altamirano

## The challenge

*A rising demand for space in delta areas in conjunction with environmental threats such as climate change, accelerated sea level rise and subsidence, require innovative and multi-functional approaches for water and disaster risk management of the built environment.*

Water-related hazards as a subset of natural hazards account for 90% of all natural hazards. These include floods, mudslides, storms and the related ocean storm surge, heat waves, cold spells, droughts and waterborne diseases (UN Water). Disasters are often the result of a combination of hazards, some related to water and others of geological and biological origin. The frequency and intensity of water-related hazards expected to increase due to climate change. The Economics of Climate Change working group of the IPCC estimated annualized damages to GDP due to climate risk to rise by around 7% by 2030 (IPCC, 2014).

Climate change is also expected to magnify urban heat island effects and increase the frequency of floods for many cities. The impact of both phenomena will be likely exacerbated by the expansion of “hard” surfaces linked to urbanization processes (Field et al 2012; Gartland, 2011). Worldwide, hard surfaces cover as much of 67% of the land area of cities and “green” areas cover only 16% in some cities (Gartland, 2011).

There is increasing awareness that nature and natural processes engineered in a smart way could be the key to provide viable solutions to these societal challenges.

## The idea

*Nature Based Solutions (NBS) which integrate natural processes and ecosystem services in the design process of infrastructure are a cost-effective measure to improve the resilience of built environments. They achieve this by contributing to the climate risk management of infrastructures through both the building of protective infrastructure<sup>39</sup> and the climate proofing of productive infrastructure.*

NBS follow a design process that takes into account natural processes and ecosystem services, both used and optimized to fulfil multiple functions. As a result solutions are cost-effective, environmentally sustainable (e.g. low energy use and material requirements) and often also require less periodic maintenance efforts and/or rehabilitation investments than traditional grey infrastructure. This is because ecosystems are able to adapt to changing circumstances and therefore make for a more robust design in the long term. In addition NBS contribute to the visual quality of landscapes and the natural capital of a region or country.

39 Protective infrastructure is infrastructure that helps prevent the emergence of threats and limits the damage if those threats do materialize

Examples of NBS are the creation or restoration of mangrove forests, shallow foreshores, sand dunes and reefs. These will not only reduce the wave load on coastal defence systems, but will also contribute to carbon fixation, and improve water quality. Moreover, several of these systems naturally adapt to sea level rise, as they have the capacity to trap sediment. Other examples include green roofs, permeable vegetated surfaces, urban forests and urban wetlands (Byrne & Yang, 2009; Douglas, 2011; Foster, Lowe & Winkelman, 2011). There are different ambition levels in design moving increasingly from man-made to a natural approach, and thus starting from an ecological optimization of land use, going through the design of artificial ecosystems and the creation optimal conditions for ecosystem development, and up to the reinforcement of existing ecosystems.

Their design process follows a multidisciplinary and multi-stakeholder approach. This systemic approach is required to deal with the technical challenge of integrating the dynamic behaviour of nature in the design of infrastructures with a very long useful life.

Although technological readiness (EARTO 2014) of NBS varies per solution, most of them are at level 6 of Technology Demonstration<sup>40</sup>, where prototype subsystems are being tested in relevant environments but due to the smaller scale applications one cannot yet say that the technology has been proven to work in its final form in an operational environment and perform to the specified functional requirements. In the pilots implemented while their hydrological and biophysical benefits have been well documented; the business case for their economic and financial performance versus grey solutions has received less attention until now.

## The impact

*Nature Based Solutions (NBS) are multi-functional and adaptive, which makes them a promising and robust long term solution. NBS seem a win-win strategy as they combine a risk buffer function by reducing future climate and water-related risks and the creation of a new form of capital: natural capital, which generates a flow of material benefits (ecosystem services) for a variety of actors and economic sectors (Matthews et al. 2015). Due to their characteristics NBS contribute to climate adaptation as well as to climate mitigation.*

As acknowledged by the European Union, NBS provide sustainable, cost-effective, multi-purpose and flexible alternatives for multiple objectives; between them biodiversity and ecosystems, natural resources management, sustainable urban development, climate change adaptation and mitigation and disaster risk reduction. Green infrastructure can help in regulating ambient temperatures, reducing storm-water runoff, reducing energy use, sequestering carbon and by creating affordable recreational opportunities to improve residents' health and well-being. Working with nature, instead of against nature, can also accelerate the transition to a greener and competitive economy.

40 Technology readiness levels (TRL) are a method of estimating technology maturity of Critical Technology Elements (CTE) of a program during the acquisition process. TRL are based on a scale from 1 to 9 with 9 being the most mature technology. A comprehensive approach and discussion about TRLs has been published by the European Association of Research and Technology Organisations (EARTO) For more information about it: [http://www.earto.eu/fileadmin/content/03\\_Publications/The\\_TRL\\_Scale\\_as\\_a\\_R\\_I\\_Policy\\_Tool\\_-\\_EARTO\\_Recommendations\\_-\\_Final.pdf](http://www.earto.eu/fileadmin/content/03_Publications/The_TRL_Scale_as_a_R_I_Policy_Tool_-_EARTO_Recommendations_-_Final.pdf)

The following table (Deltares 2016) shows an overview the risk mitigating impacts of a specific NBS (mangrove forest restoration) on water quality and flooding; two key corporate and public sector risks.

The Nature-based engineering paradigm understood as the enriching of the traditional infrastructure planning process with green and hybrid solutions besides traditional grey infrastructure options can be seen as an opportunity for infrastructure and spatial planners. As stated by Matthews et al. (2015), the building with nature approach provides them with a framework to accommodate competing interests and combine environmental goals with dominant economic imperatives.

**Table 1. Estimation of benefits for the adoption of mangrove forest restoration**

M-3	Impact indicator	Short and long-term benefits
Water quality	Reduced sediment load	The sedimentation rate can reach values of 1.6±0.6 cm/year (Machado et al. 2002).
	Reduced nutrient load	A natural <i>Avicennia marina</i> dominated forest is able to remove 17-65% of total suspended solids (TSS), 50-51% of biochemical oxygen demand (BOD), 44-61% of nitrate-nitrogen (NO <sub>3</sub> -N), 51-84% of ammonium-nitrogen (NH <sub>4</sub> -N), 43-50% of total nitrogen (TN), 29-59% of phosphate (PO <sub>4</sub> -P) and 28-48% of total phosphorus (TP) content (Boonsong et al. 2003)
	Reduced costs of water treatment	Examples exist of mangrove wetlands used for municipal wastewater treatment instead of conventional wastewater treatment plants. The reason is the significantly lower treatment cost in mangrove systems (Ewel and Twilley, 1998)
	Reduced other water contaminant	In the Guanabara Bay, Brazil, mangroves' sediments were able to retain 170-860 µg/g of zinc (Zn), 32-58 µg/g of copper (Cu) and 1,000-3,000 ng/g of mercury (Hg) (Machado et al. 2002).
Flooding	Reduced number of occurrences	In a mangrove forest mainly populated by <i>Rhizophora</i> species, within 150 meters from the coastal shoreline the wave energy was reduced by 50% (Alongi 2008).
	Reduced flood extent and depth	In the Seychelles the dense coastal vegetation can provide protect against tsunamis 4meters high (Laso et al. 2013). A model based on data collected for the 1998 tsunami event in Papua New Guinea showed 90% decrease in maximum tsunami flow pressure for a 100m wide mangrove vegetation with a 3,000 trees/ha density (Alongi 2008).

Source: Deltares 2016, Evaluation of existing IWRM and green infrastructure technologies for integrated watershed management

## The barriers to innovation – and the solutions

*Regardless of the many benefits of NBS for climate risk management and disaster resilience of infrastructures and built environments in general; their application and full scale implementation remains limited. Barriers during the different infrastructure phases – planning, design, project delivery and operation and maintenance - as well as important funding and financing constraints hinder their wider adoption. The most important barriers are discussed in this section.*

## Key internal barriers

*NBS are perceived by the construction sector – public and private parties- as more risky than traditional and proven grey solutions and the sector is very risk averse.*

Aiming at the prevention of casualties, societies have set very high standards and safety regulations for the “built environment” and construction sector procedures. In infrastructure projects the motto is to work only with proven technologies to limit construction risks to a minimum. The development of innovations has to happen in isolated and small scale pilots that minimize risk .Meanwhile the benefits of NBS are highly dependent on the scale at which they are implemented. Additionally the performance of NBS cannot yet be engineered with as much precision as grey solutions and due to the natural processes at hand their performance is expected to show a rather cyclical behaviour.

*Definitional ambiguity and difficulties in conceptualizing green infrastructure and its advantages over grey:*

The proponents of green infrastructure are often ecologists and biologists who approach these challenges from a different scientific paradigm. They therefore speak a different language to the key decision makers, who are often civil and financial engineers at the service of public authorities, contractors and financing institutions. While the former are convinced of the effectiveness of NBS in terms of their long term effect on flood and drought protection (mainly due to their adaptive capacity), given their research focus on the biophysical dimension of NBS in their pilots they may be failing to generated the right arguments and the quantitative evidence for key decision criteria. For example, they often leave less studied the socio-economic and political and institutional concerns surrounding NBS, such as life-cycle costs , total costs of ownership, and value for money offered by green and hybrid versus grey solutions. In their absence, key implementing actors can often then perceive elevated risks for NBS versus traditional grey infrastructure measures.

## Key external barriers

*Public-sector procedures and preferences: mono-sectorial infrastructure planning, public procurement and the focus of government on reducing transaction and agency costs.*

In the planning phase the rational spatial planning approach assumes an objective, politically neutral and analytical process driven by the interests of a single sector or public agency and confined to a defined time scale. This is an important barrier for the uptake of NBS given their multifunctional character that results in benefits spread over a variety of economic sectors at different geographical and time scales.

In a later phase, NBS face new barriers as they need to be procured following the same public procurement rules and contracting frameworks as regular infrastructure. A key challenge for NBS is posed by EU public procurement rules and international trends in national procurement strategies.

These demand that unambiguous Key Performance Indicators and functional requirements are defined on which to base payments to private contractors implementing NBS, in accordance with a preference for performance based contracts. Additionally most EU governments have the aim to keep their size limited and opt for procurement strategies that require limited in-house personnel for their oversight.

Meanwhile, up until now NBS are often conceived and piloted along community driven governance arrangements that require a significant amount of coordination and oversight; either by the NGOs piloting them and/or by the governments in charge. There can also be uncertainty about who are or will be the NBS (private) “service providers” to take care of the whole green infrastructure life cycle and who will be held responsible for the solutions over a longer period of time. These mismatches hinder the uptake of NBS as part of the national infrastructure planning and procurement process.

This brings us to a crucial barrier for the full scale implementation and mainstreaming of NBS: **no clear and/or significant pipeline of projects, and consequently not yet a well-established pool of service providers.**

Besides the perceived elevated risks of NBS, a key barrier for the further uptake of NBS, whose main functions are associated with climate adaptation and disaster resilience, is the daunting financing gap faced by governments around the world. This brings us to our last barrier.

**Financing gap: limited public funding for disaster resilience and climate adaptation and lack of bankable NBS projects to attract private financing.** Adaptation costs for developing countries have been calculated by the World Bank (2010) to be between \$70 and \$100 billion from 2010 until 2050. The Global Canopy Foundation (2009) report a financing gap of \$90 billion for mitigation and adaptation to climate change. And according to the World Bank (WB Easin 2012) approximately 85% of these funds must come from private finance. For these projects to be financed and implemented by the private sector, they must generate an attractive Internal Rate of Return.

Due to their intrinsic characteristics NBS conceived as disaster resilience and climate adaptation investments present unique risks because of their cash profiles (Altamirano et al. 2013). They encompass the challenges of regular climate adaptation projects: capital-intensive and unique, delayed and dispersed benefits, non-guaranteed and non-financial benefits, and limited autonomous earning power, accompanied with a high risk profile (Gleijm and Herdes, 2012). They then combine these challenges with those specific to green infrastructure projects (World Bank Easin 2012) such as elevated perceived risks, capital market- and information gaps due the “newness” of the technologies, and a risk-reward profile that makes these projects financially unattractive, in absolute or relative terms.

## Solutions

*To deal with the barriers mentioned above, Deltares, in close collaboration with the Dutch water sector, international research partners, multilaterals and conservation NGOs, has engaged in the following initiatives:*

- Public-Private alliances, like the Dutch Water Sector alliance EcoShape, where top dredging companies, engineering consultants and research institutes work together to further develop and operationalize the concept of NBS and demonstrate its applicability and benefits in diverse contexts.
- By working together, trust is built and a common language established for the “eco-engineering” discipline.
- Extensive piloting and demonstration of NBS in the Netherlands and around the world, where the hydrological and biophysical benefits are quantified. Examples from the Netherlands are the national Room for the River programme and the Tidal Park in Rotterdam. International examples include the multifunctional coastal protection scheme for the East Coast Park area of Singapore, where sea grass beds and coral reefs play an important role and a large scale pilot of mangrove regeneration and permeable dams in Denmark, Central Java in Indonesia.
- Development of design standards with key players such as USACE.
- Development of tools that allow for further operationalization of NBS design and create awareness about their potential. An example is the MI-SAFE tool developed in the FAST EU research consortium that allows evaluating worldwide the potential of natural foreshores to reduce flood risks by making use of remote sensing data, and which offers advanced services to public agencies and/or consultants to assist them in the design of hybrid flood risk mitigation strategies for coastal areas.
- Expert support to the Climate Bonds Initiative and the drafting of technical guidelines for NBS/green infrastructure water bonds.

Last but not least, we have developed a collaborative business modelling protocol where key actors for implementation and researchers engage in the development of a common language and a Return on Investment (ROI) model for NBS. Together they draft alternative project delivery and financing methods with the aim of structuring bankable ecosystem restoration projects. In order to speed up the uptake of NBS, a crucial step to be taken by NBS proponents is to align their research with the concrete information needs of the actors responsible and liable for the implementation of NBS. The creation of a common language between researchers and practitioners is a necessary first step. Our experiments with collaborative modelling techniques (Altamirano 2013) have affirmed their potential to reduce the risk perception of implementing actors by increasing their understanding of NBS and consequently their sense of control over them.

## The way forward

In summary, even though at policy and strategic levels the value of resilience and the role of nature are being acknowledged, implementation remains limited. The implementation challenge requires a different R&D approach than the one applied so far; one that is truly collaborative and places clearly the stakeholders in charge of the implementation of NBS and liable for the consequences hereof as the direct clients of the research process. Concrete pathways to go from isolated pilots up to full scale implementation in Natural Assurance Systems, and to ensure the financial and institutional sustainability of NBS in the long term, need to be drafted jointly with, and agreed upon by, key actors: public procurers, infrastructure financing agencies and project developers.

For NBS to become an equally valid option in the process of infrastructure planning and financing, they must pass the same tests and tick the same boxes as grey infrastructure projects in each phase of the infrastructure life-cycle: planning, design, build, operation and maintenance. These include, for example, design principles and building codes, or risk and quality management approaches for operation and maintenance. The construction sector and the infrastructure community are best positioned to lead this process.

Other important steps that need to be taken include:

Governments need to develop the instruments that allow them to “buy” or procure these solutions as easily and in the same standardized manner that they can purchase grey solutions. At the same time, they must also stimulate the creation of a private market of service providers through innovative procurement mechanisms available in the European Union, such as Pre-Commercial Procurement (PCP), Public Procurement of Innovation (PPI) and Innovation Partnerships.

The construction sector must start investing and expanding their eco-engineering expertise in their role as experienced project developers. These actors are crucial to the process of structuring bankable NBS projects and making NBS suitable for performance based contracting.

In their roles as experienced risk managers and providers of capital, the financial sector and insurance sector are encouraged to show their commitment to a sustainable future by engaging with the research community, national governments and the construction sector in a joint search for innovative financing arrangements and insurance schemes; accompanied by necessary changes in national regulatory frameworks. These could encompass, for example, hybrid PPP (project finance) models combining availability payments with revenues from user fees and other alternative sources linked to the additional ecosystem services created by NBS. These innovations would need to account for the internalization and monetization of the many positive externalities of NBS, leading to the structuring of financially viable and bankable projects. A European H2020 project Initiative that exemplifies this collaboration and engage public authorities, insurance companies and researchers on the operationalization of the insurance value of ecosystems was recently launched under the title NAIAD: *Nature Insurance value: Assessment and Demonstration* (Mapama 2016).

Important **systemic changes** are also required to allow for a proper economic and financial valuation of the multifunctionality of NBS. These would reflect the change from predominantly mono sectorial infrastructure planning and financing to a nexus approach where the synergies and conflicts between the investments plans of different sectors are taken into account and valued, and where joint financing and procurement of multifunctional solutions are consequently stimulated and properly supported by renewed valuation methodologies.

- IPCC, “Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J.,” Cambridge University Press, Cambridge, 2014.
- M., G. Heal, C. Dubeux, S. Hallegatte, L. Leclerc, A. Markandya, B.A. McCarl, R. Mechler, and J.E. Neumann, 2014: Economics of adaptation. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 945-977
- <https://ec.europa.eu/research/environment/index.cfm?pg=nbs> (European Union Website, Research and Innovation Directorate, Environment, accessed 5<sup>th</sup> December 2016).
- Deltares Report 2011. Green Adaptation. Making use of ecosystem services for infrastructure solutions in developing countries. Authors: Helena Hulsman, Myra van der Meulen and Bregje K. van Wesenbeeck.
- Field, C. B., Barros, V., Stocker, T. F., & Dahe, Q. (2012). Managing the risks of extreme events and disasters to advance climate change adaptation: Special report of the intergovernmental panel on climate change. Cambridge University Press.
- Gartland, L. (2011). Heat Islands. London: Earthscan.
- Byrne, J., & Yang, J. (2009). Can urban greenspace combat climate change? Towards a subtropical cities research agenda. Australian Planner, 46, 36–43.
- Douglas, I. (2011). The role of green infrastructure in adapting cities to climate change. In I. Douglas, D. Goode, & M. Houck (Eds.), Handbook of urban ecology. Florence, KY: Routledge.
- Foster, J., Lowe, A., & Winkelmann, S. (2011). The value of green infrastructure for urban climate adaptation. Washington, DC: Center for Clean Air Policy.
- Deltares 2016. Evaluation of existing IWRM and green infrastructure technologies for integrated watershed management.
- Website of the Ministerio de Agricultura y Pesca, Alimentación y Medio Ambiente. “La Confederación Hidrográfica del Duero lidera un proyecto europeo de innovación sobre economía verde y cambio climático”. 20/10/2016 <http://www.mapama.gob.es/va/prensa/noticias/la-confederacion-hidrografica-del-duero-lidera-un-proyecto-europeo-de-innovacion-sobre-economia-verde-y-cambio-climatico>
- Bayas, J. L., Marohn, C., & Cadisch, G. (2013). Tsunami in the Seychelles: Assessing mitigation mechanisms. *Ocean & coastal management*, 86, 42–52.
- Machado, W., Moscatelli, M., Rezende, L. G., & Lacerda, L. D. (2002). Mercury, zinc, and copper accumulation in mangrove sediments surrounding a large landfill in southeast Brazil. *Environmental Pollution*, 120(2), 455–461.
- Boonsong, K., Piyatiratitivorakul, S., & Patanaponpaiboon, P. (2003). Use of mangrove plantation as constructed wetland for municipal wastewater treatment. *Water Sci Technol*, 48(5), 257–66.
- Ewel, K., TWILLEY, R. Ong, J. I. N. (1998). Different kinds of mangrove forests provide different goods and services. *Global Ecology & Biogeography Letters*, 7(1), 83–94.
- Alongi, D. M. (2008). Mangrove forests: resilience, protection from tsunamis, and responses to global climate change. *Estuarine, Coastal and Shelf Science*, 76(1), 1–13.
- Ecoshape website, accessed December 1st, 2016. <https://www.ecoshape.org/en/projects/>
- Natural Capital Coalition, accessed December 1st, 2016 <http://naturalcapitalcoalition.org/>
- EARTO 2014. The TRL Scale as a Research & Innovation Policy Tool, EARTO Recommendations 30 April 2014. [http://www.earto.eu/fileadmin/content/03\\_Publications/The\\_TRL\\_Scale\\_as\\_a\\_R\\_I\\_Policy\\_Tool\\_-\\_EARTO\\_Recommendations\\_-\\_Final.pdf](http://www.earto.eu/fileadmin/content/03_Publications/The_TRL_Scale_as_a_R_I_Policy_Tool_-_EARTO_Recommendations_-_Final.pdf)
- UN Water Website, accessed December 1st, 2016. Source: <http://www.unwater.org/topics/water-related-hazards/en/>

# Climate Change Decision-Making Tool: From formulation to implementation

Rodrigo Suarez Castaño

## The challenge

*To catalyse and promote informed decisions on adaptation and mitigation to climate change based on relevant geographical available information.*

The solution is designed to respond to:

- Limited access of information both geographic and alpha numeric regarding climate change.
- Relate geographical information with implementation options.
- Create a portfolio of adaptation and mitigation actions.
- Make climate change implementation easy for everyone

A common problematic in decision making regarding climate change is the difficulty to get to stakeholders, decision makers and community with information they find useful to engage in a climate change project or initiative. At the same time the rising interest in climate change allows for the involvement of all sorts of actors to both increase the response capacity of the population and in reductions of GEI.

The idea surged from the need of a clear climate change diagnostics easy to understand and that gave insights in to implementation of concrete actions. Furthermore, to draw explicit relations between what is going on in terms of vulnerability assessments and inventories of GEI with concrete actions is an approach that has just been considered broadly. Therefore, the proposal aims to be more specific with this relation thanks to geographical information that relates a specific portfolio with a specific climate change condition.

## The idea

*To develop a tool in a web platform of easy access and navigability that includes geographic information related to climate change with a portfolio of actions to implement according to the challenges and opportunities of the territories and stakeholders.*

The solution is composed of four key elements:

- Web interphase designed to guide the user through the different strategies of mitigation an adaptation.
- Geographic visor that connects in real time with the national map depository of relevant climate change information through integration services.
- Portfolio of actions linked to geographical information through a system of indicators that allows to establish a key or filter between actions and information.
- Administrator module that allows to scale up the system according to the information needs

The hypothesis is that closing the gap between technical information and project ideas, action will take place. The expected impact is to contribute first to the understanding of punctual challenges and opportunities of adaptation and mitigation to climate change and second to relate information with project ideas in order to turn them in to real action.

There is demand for this kind of solution thanks to the increasing awareness on climate change and the commitments and targets that key actors have to achieve subject. In this regard the market is already established. The web platform is already available (<http://accionclimatica.minambiente.gov.co>). This version is updatable thanks to the administrator module.

For Colombia; and from what we have seen around the world, this is the first platform adopting this comprehensive framework, similar initiatives just look either the geographic component or a set of actions, but the integrated approach is the innovative component in this tool.

## The barriers to innovation – and the solutions

*Lack of structured applied methodologies in order to address climate change data and to couple it with guidance to implementation*

- Lack of applied methodologies to analyse the information in a systematic way for the web tool
- Lack of data bases of climate change information for the country
- Low capacity to structuring and managing the information
- Low and not interconnected infrastructure to manage the information about climate change

Key external barriers for enabling the proposed solution:

- Difficulty to have access to centralized information of climate change, causing a poor understanding of the subject.
- Low engagement of stakeholders as civil society, local governments, private sector probably due to lack access to consistent information.
- No mandate to produce and share information about plans and projects of climate change
- How mission-critical are the roadblocks for the suggested solutions (slowing down vs. killing solution)?
- Lack in infrastructure and capacities slow down and make more complex the design of the solution
- Decoupling of implementation with information in decision making processes.

Potential ways to address these barriers include:

- Strengthening the technical capacities in relation with climate change analysis and decision making
- Strengthening infrastructure capacity and facilitate inter-connection between different systems

## The way forward

*The roadmap for going forward implies innovations to overcome barriers as well as to strengthen infrastructure capacities and methodologies to bring key information to the decision-making process.*

### Next steps include:

- Automation of some processes to facilitate access to useful information to decision-makers
- Incorporating more information, mainly sectoral and detailed scale to improve analysis
- Sufficient infrastructure and ensuring the needed capacities to have sustainability
- Growing infrastructure capacity and expanding the sharing of information processes

### Key stakeholders include:

- *Private sector*: provide information and give feedback about their needs of information for their decision making processes
- *Government institutions*: address barriers about information management, access and coordination with other actors
- *Group of technical experts*: develop and improve applied methodologies in order to close the gap between information and action

### New ways of working essential to overcoming roadblocks:

- Innovative methods to manage the information and to show it in a more useful way to people
- Have a wider scope of information and strategies
- Exploring and understanding perceptions of information and needs of decision-making
- Innovative ways to improve access to information and understanding of climate change through the functionalities of the tool
- Involvement of all stakeholders
- Access to information
- Sufficient infrastructure and capacities

### Systemic changes needed include:

- Thinking about climate change and the need of everyone's action
- Improving information management practices
- Strengthening technical capacities
- Allocating resources to climate change management information

## Developing Master Plans for Resilient Infrastructure within Existing Urban Centres

*Sherena Hussein*

### The challenge

*To introduce robust disaster resilient infrastructure and support systems in existing urban centres in a manner that is cost effective manner for local governments*

After sustaining millions of dollars in damage from the aftermath of extreme weather events across North America, several governments have sought to introduce infrastructure systems that protect existing urban centres against future flooding, excessive ice and snow storms, and wind systems. However, the introduction of resilient infrastructure systems has been slow and problematic within several North American urban centres. This is due to the complexity of retrofitting existing centres, which largely exists when public authorities do not own land parcels necessary to introduce resilient infrastructure systems, those land parcels are subject to numerous and sometimes contradictory existing uses, and the cost of retrofitting urban centres exceeds the budgetary thresholds for responsible governments or are not recoverable from traditional funding sources.

As the pace of urbanization continues to catalyse the expansion of existing North American urban centres, so too does the risk of damage and loss of life when extreme weather events occur. The cost to relocate populations as a remedial measure can be significant. The infrastructure planning processes within several large urban centres often occurs in parallel to regimes controlling government expenditures and land use planning. As such, gaps between government-led resilient infrastructure and land development activities within existing urban centres often emerge. This gap is expected to widen in the absence of clear leadership and a fiscal plan to facilitate the development of resilient infrastructure within existing urban centres.

### The idea

*To develop master plans for underdeveloped neighbourhoods within existing urban spaces which introduce resilient infrastructure systems as well as incentives for private developers to supply and/or subsidize infrastructure using public-private partnerships.*

This solution is comprised of the following elements:

- Create a comprehensive master plan for neighbourhoods within existing urban spaces. The master plan should incorporate resilient infrastructure systems for the neighbourhood. Amend the land use planning regime supporting the master plan in order to permit the development or redevelopment of different land uses that complement the resilient infrastructure systems as well as attract market-based developers.

- Craft a land value based tax system to generate revenue for government-owned development corporations from market-based developers and/or tenants of the resulting real estate development. If a market does not exist, consider phasing in the tax system and/or offering property based tax incentives to cultivate the marketability of the site.
- Establish a government-owned infrastructure corporation in order to obtain financing for the construction of the new infrastructure systems. The property-value based tax stream can be assigned from the government-owned development corporation and/or the government's general revenue account to the infrastructure corporation in order to repay this financing. The suitability of this financing (known as project financing) depends upon the market attractiveness of the master plan and the government's fiscal status.
- Select market-based developers based upon identified priorities for the neighbourhood, such as sustainable building infrastructure and innovation, transit-oriented development, and disaster resiliency. Amendments to building codes and practices can be introduced to incentivize the construction of buildings that are more resilient, particularly to floods.

This solution is foreseen as closing the gap between government-led resilient infrastructure and support system planning and land development activities within existing urban centres in a manner that is cost-effective. It can also facilitate the development or redevelopment of new neighbourhoods that promote sustainable objectives and disaster resiliency.

This solution was adopted in New York, USA through the redevelopment of the area adjacent to the Hudson River in Manhattan. This area surrounded an interregional rail line system and was largely underdeveloped until a series of master planning exercises were initiated in the early 2000s. These exercises sought to enhance the transit, park and connectivity infrastructure for the area while also encouraging high-rise mixed use real estate developments to establish a new neighbourhood within Manhattan. Intersecting the master planning process were changes within the land use-planning regime to permit private developers to enhance building density in exchange a series of payments to subsidize new infrastructure. Following the property damage and loss of power induced by Hurricane Sandy in 2012, several private developers introduced resilient infrastructure systems within real estate developments, including those built atop of fully functioning inter-regional rail lines following the private acquisition of air rights. The features in one development, known as Hudson Yards by The Related

Companies, involve:

- Telecommunication systems to exclusively service the network of new buildings
- High efficiency co-generation plants to service a grid of buildings and automatically disconnect from the New York City power grid in the event of a power outage
- Extensive recycling and garbage systems within buildings to extract water and accommodate future compost systems
- Use of thousands of data sensors to track the health of buildings and new infrastructure
- Placing building support/mechanical equipment above grade to circumvent flood damage

The incorporation of resilient infrastructure within private developments can be attributable to a) the market potential of the real estate site, b) the scale of the master plan for private development, c) the reputation impact of creating a new neighbourhood within Manhattan, and d) the long-term development horizon of the private developers and their institutional investors.

Variations of this solution have been introduced to develop flood protection infrastructure for other existing urban areas. For example, the Canadian province of Ontario utilized public private partnerships to protect its most populous city, Toronto, from 100-year floods through the use of master planning. One master plan involved the development of flood protection infrastructure in the form of an urban park system while also changing the land-use planning regime to promote mixed-use private real estate development in the surrounding area. This area is now known as the Canary District and has reclaimed once environmentally contaminated land for public use and the creation of a new sustainability-oriented neighbourhood within Toronto.

This solution has facilitated the introduction of infrastructure in a way that enhances disaster resiliency for existing urban areas while using private-sector involvement. This involvement is led by the urban planning process and has the potential to subsidize the cost of introducing resilient infrastructure.

*Sources: Hudson Yards Development Corporation, Hudson Yards -The Related Companies, Waterfront Toronto West Don Lands Master Plan*

## The barriers to innovation – and the solutions

*This solution relies upon the cooperation of several stakeholders within the urban planning process as well as favourable real-estate market fundamentals*

### Internal Barriers

- Cooperation among different government actors, including those involved with land use control, infrastructure planning, budgetary sources, and economic development, across a variety of jurisdictions (federal, provincial/state, and local governments)
- Cooperation among local community stakeholders
- Lack of unified priorities and method for evaluating alternative master plans, financing packages, and revenue streams
- Financial health of overseeing government(s) should there be a need to borrow to finance the construction of resilient infrastructure

### External Barriers

- Global and local economic forces affecting the demand and supply for development in particular area
- Access to, and volatility, of credit markets if a government-led investment corporation will need to borrow to finance the construction of resilient infrastructure
- Attracting global talent to develop and implement master plans

These barriers can be addressed by:

- Implementing master plans in phases; phases with the greatest activity will occur when real estate and capital markets are most favourable to development
- Involving an life cycle involved in developing resilient infrastructure across jurisdictions in order to align priorities across different stakeholders
- Hosting international planning competitions to foster innovation and engaged talent

## The way forward

*The way forward involves viewing the introduction of resilient infrastructure as an urban planning decision as well as an opportunity for public-private partnerships.*

Next steps involve the creation of best practices to evaluate how stages of the master planning process can be complemented with the technical evaluation of resilient infrastructure and the market potential for public-private involvement. The financial sustainability of the related real estate development will need to be constantly evaluated by third-party experts to ensure that the financing costs associated with new infrastructure can be repaid. Additional steps involve the creation of measurement systems to evaluate the successful integration of resilient infrastructure with other infrastructure systems within urban spaces. Data management strategies, particularly for data collected by private actors, will need to be considered.

New ways of approaching the introduction of resilient infrastructure as a component to the urban planning process involve discussions related to public management, transparency, and accountability, as well as public consultation and engagement. It will also involve the development of collaborative communication and information sharing approaches across a variety of stakeholders. This will involve systemic changes about the role of infrastructure and real estate, who should be involved in delivering infrastructure, and how resiliency can be approached from technical, consultative and market-based perspectives.

# 6. Flexibility / Liveability / Well-being



## Introduction

*Ron Bakker, Founding Partner, PLP Architecture, United Kingdom*

*Cities around the world are growing relentlessly. Most major world cities are becoming more densely populated and cities in developing countries are expanding at a previously unknown pace. Many new city dwellers come from rural backgrounds and some find urban life hostile and unnatural. The well-being and quality of life of people in cities are struggling to keep up with the economic benefits that are causing the doubling of the world's urban population over the course of the 21st century.*

*Most of the improvements to the quality of life that are conceivable in urban centres are of an environmental, technological or infrastructural nature. This Working Group focused on the people-centred opportunities for improving urban conditions, notably related to innovative ideas to address wellness, productivity and flexibility in the built environment.*

*One area of opportunity is the potential improvement that the internet of things (IoT) is bringing to the connections and communication between people and their physical environment. Many innovations and inventions advance the potential for more efficient and productive use of the available space and resources.*

*The development of construction materials and the growing use of natural and renewable materials were another focus, for their potential to have a direct and positive effect on health and well-being, both physical and spiritual.*

*A third focus was urban infrastructure and transport in the digital age. Most fast-growing cities around the world are nearing paralysis because of the reliance on polluting private vehicles.*

*Members of the Working Group feel strongly that it is increasingly important that cities around the world retain a sense of place that is consistent with the history and diverse cultural heritage of the people who inhabit them. Against a background of globalization and rapid exchange of information around the world, the unique nature of each urban centre is under pressure, and the strategic use of art, culture and community to create compelling and competitive cities should be a central concern to ensure an inspiring, liveable and loveable future for growing urban populations.*

# The strategic use of art to create compelling and competitive cities

Claudia Schachenmann

## The challenge

*Cities competing for talents and investment*

Urbanization is well on its way, and well-educated people flock to cities where they find top pay, exciting jobs and like-minded peers. Established cities face more competition in drawing talent and investment from outside. Today, many features of cities have become exchangeable, cities are beginning to look alike. Great work space, a swift transport system, high-quality entertainment and residential buildings are a must for any metropolitan area. Cities need to have strategies to be distinctive and emphasize their unique features. Culture, and notably art, can create an impact, in a city-narrative, and position the city in the right way.

### Creating urban atmosphere

City developments often lack atmosphere. Citizens don't want to spend time at rather functional places, and this negatively affects the revenue of local businesses, among other considerations. Due to the event-related nature of art, people are attracted to where art is displayed, which can revitalize a location. Art can create a buzz and lively platforms while at the same time building a story around a new development. Such art platforms act as connectors between distinctive buildings and their visitors.

### Real-time cities

Since cities will become denser in the future with less space to be shared, there is demand for places for people to meet each other and interact. Today many city inhabitants live in between being a real-life persona and a digital persona. While a lot of time is spent online and in small and/or shared spaces, places of real life and real-time interaction will become more significant. After all, humans are social beings and that might differentiate us from machines. Art can create destinations of inspiration, leisure and well-being.

### Less work, more entertainment

As people might work less in the future due to the rise of artificial intelligence and at the same time spend less time commuting due to an optimized transport system, they will have more leisure time. Therefore, cities need to offer a larger range of entertainment and inspiration in many more locations. Art is the ideal medium to provide entertainment and inspiration in future cities.

## The idea

*Strategic use of art*

### From creating atmosphere to a business-led strategic tool

The role of art in cities played a major cultural role throughout history. Today art is treated more as a supplement. While many cities place art to optimize their environment and beautify their scenery, the art world has developed into a commercially driven business, where million-dollar art works are sold at auctions and massive private museums are built. It is a rather small but sustainable market and so art has also become an asset class attracting not only a wealthy, but also well-educated urban audience. People who invest in the passion market (i.e. expensive cars, boats, jewellery) have now migrated more and more to the art market.

At the same time, due to the expansion of new technologies and globalization, the art market was unlocked and now serves many art lovers, attracted by the lifestyle the art world represents. Art stands for the creative class, an urban citizen who wants to be noticed as creative, innovative, wealthy and intellectual. The corporate world has discovered that art draws a target group to cater to and has introduced substantial art strategies such as partnerships with art fairs, museums, non-profits or even their own private art platforms and content. Cities can profit from the lifestyle that art represents and at the same time art can provide them with their own and unique urban identity. Art can be used as a carrier to create a powerful city narrative/identity to attract a potent crowd.

## Art strategy scenarios

### Narrative environments for cities

After their oil-rich times, countries like United Arab Emirates lacked substantial income and had to reinvent their business model. Art plays a major role in this business model. What started with a small event in Sharjah (Sharjah Biennial), quickly transformed into a Dubai vision for an artificial art district based on the western model. Supported by the government, a huge development of such a creative district is underway that is used as a breeding ground for innovative businesses. Art and design act as incubators for a prospering start-up community creating additional long-term income streams for the city.

A similar scenario is occurring in Shanghai, where the government supports the construction of a hotbed of private and public museums, galleries and pavilions along the Xuhui Waterfront, stretching 8.4 kilometers along the Huangpu River in the centre of Shanghai. Shanghai's vision is to become China's innovation hub and potentially compete with tech-savvy Shenzhen. Again, art is used as a strategic tool.

### Gentrification

Quite often real estate developers face the challenge of transforming lacklustre and run-down urban areas into popular districts. Art has become a strategic tool to this as well. Miami's art district is an example: real estate developers discovered the positive impact of a powerful target group after international art fair Art Basel moved to Miami Beach in 2002.

The Art Basel fairs (in Basel, Miami Beach and Hong Kong) attract a powerful and influential crowd. Developers in Miami started to offer empty space at no or little cost to artists in an industrial area for a limited amount of time. Due to the activities and coolness of the mostly young artists as well as the reasonable cost the area, began to thrive seemingly organically. Creative businesses, design ateliers, private art collections and all sorts of creative people flocked into what was becoming an up-and-coming area. A once-unappealing district transformed and gained vibrant momentum, attracting bigger luxury brands and wealthy inhabitants. This was when prices could be elevated and new developments found their investors.

A similar process is currently happening at King's Cross in London. The development company engaged with Central Saint Martins, one of the premier art schools of the world, which brought in many students and revived the area. The young creative crowd created a lively and diverse place attracting global companies like Google to have their UK headquarters here. While the district profited from the creative image, even established companies have become part of King's Cross.

### About "Art Hubs"

As shown, art is not only about artists and their work, but can also be about the strategic development of entire urban districts. "Art hubs" are becoming popular. These multidisciplinary physical spaces, where art can be experienced in pop-up galleries, art labs or other innovative ways, are artificial art ecosystems for urban people in which to exchange, engage and entertain, and they can be part of bigger developments. One such "art hub" is currently begin built at "The Circle" at Zurich Airport. The creators of "The Circle" understand that art draws an interesting target group to its new development and is itself an income-generating business case. Making money with art.

## The way forward

### Certain challenges still exist

For many, however, art is still not seen as a strategic tool and it has suffered from keeping people distant because it seems an elitist and exclusive scene. Due to the complexity and intellectual approach of art, many people feel they can't understand art, and are shy to engage with it. Art has not yet fully been discovered as a resource for developing cities since its impact is hard to measure.

### Taking the chance

Developers and planners can engage with specialized art strategists in order to fully capitalize the potential of art as a strategic tool. Such art world specialists can bridge the gap between people, corporate institutions and the art world so that art can be seen as one of the key strategies to create meaningful and inspiring places. Developers and city planners will then understand that art does not just attract an interesting crowd, but also makes money. Successful "art hubs" serve as good examples and studying these can help to convince more people. The art world, on the other hand, due to need of funding, will become more open in developing business oriented, popular and exciting art platforms and likely invest more in understanding their target audience and linking art to other elements like real estate, tech and brands.

## The Hyperloop Vision

Jakob Lange

A hyperloop system has the potential to change the way we live and will have a great impact on the planning and development of cities.

Hyperloop is a new form of transportation that combines the cargo-carrying capacity of shipping with the speed of flight, the energy efficiency of rail and the individual freedom of the private car. With speeds up to 1,200 km/h, city planning post-Hyperloop can occur in greater distances from the city centres and closer to the surrounding landscape qualities.

Author Peter Newman<sup>41</sup> uses "Marchetti's constant" to argue for a limit to sustainable urban planning and transportation, where the average time spent getting to and from work is 60 minutes. The constant has proven to be a reliable way of understanding the growth of cities. Hence, most North American cities, and European cities like London and Paris, have been following this constant closely throughout history.

The Hyperloop greatly expands the potential city-border reach, to a theoretical radius of 500 to 600 km. Neighbouring cities become one, capitals merge into commercial mega hubs reaching across country borders and the continent becomes so small that distance becomes insignificant.

Dubai to Abu Dhabi in 12 minutes, San Francisco to Los Angeles in 32 minutes, Stockholm to Helsinki in 27 minutes. The perception of distances and travel time between cities shrinks and becomes irrelevant, which will greatly affect our choice of work and the place we call home.

With a new means of transportation comes the possibility of shaping and redefining the current travel experience, forcing some important questions.

Can the Hyperloop eliminate waiting time at check-in, before boarding, before departure and at arrival? Can the Hyperloop solve the "last mile problem"<sup>42</sup> and bring passengers directly from A to B without changing modes of transportation? And what is the shape, the form and the experience of the Hyperloop system?

*"If someone asked you the question, "How do you get from here to there, what do you say?" Which feature do you mention first – packing yourself into a crowded compartment, leaving at their convenience, arriving two hours early to sit and wait, excessive pollution? Like an artist with a blank canvas, we sought to completely redefine transport. We don't sell cars, boats, trains, or planes. We sell time. We're creating a seamless experience for a passenger that starts the moment you think about being somewhere – not going somewhere. Door to door faster than ever before. We're turning hours into minutes and creating a brand new experience that centers around the passenger. The future is freedom, the future is autonomy, the future is time."*

Josh Giegel, Co-Founder and President of Engineering, Hyperloop One, USA

41 [https://en.wikipedia.org/wiki/Peter\\_Newman\\_\(Australian\)](https://en.wikipedia.org/wiki/Peter_Newman_(Australian))

42 [https://en.wikipedia.org/wiki/Last\\_mile\\_\(transportation\)](https://en.wikipedia.org/wiki/Last_mile_(transportation))

Hyperloop One plans to test a full system in the first quarter of 2017 and the first commercial route is planned to be operational in 2021.

*“The Danish word for design is “formgivning” which literally means “to give form”. At its core, that is what design is – to give form to something that has not yet been given it. However, most often all we end up doing is designing a moderately cooler version of something that has been designed a thousand times: A taller skyscraper, a faster car, a comfier chair. With Hyperloop One we have given form to an entire ecosystem of mobility consisting of pods and portals, where the waiting hall has vanished along with waiting itself. Collective commuting with individual freedom at supersonic speed. We are heading for a future where our mental map of the city is completely reconfigured, as our habitual understanding of distance and proximity – time and space – is warped by this virgin form of travel. A future that has now for the first time been given form.”*

Bjarke Ingels, Founding Partner and Chairman, BIG (Bjarke Ingels Group), Denmark

## Creating More Colourful, Liveable and “Human” Cities: the revitalization of Favela Santa Maria

Julia Huss

### The challenge

*We live in a world in which rapid urbanization is placing strain on our cities.*

Our cities are growing at a rapid pace, faster than they can sustainably accommodate. In 1800, only 2% of the world’s population lived in cities. Now 50%, or 3.5 billion people, live in cities. By 2050, estimates suggest that the number of city dwellers will rise to more than 65%, representing 6.3 billion people. Meanwhile, the number of people living in slums will have reached around 1.5 billion by 2020, double the figure in 1990. A new urban agenda for sustainable urban development is needed.

Many programmes aiming to address the pressures of urbanization turn to Smart Cities, City 2.0 and high-tech developments, and these approaches tend not to consider people as a central element of their solutions. With billions more people migrating to cities in the coming years to face lagging physical and social infrastructure, it is imperative that we do not lose sight of the human element at the heart of the urbanization challenge. Making our cities more “human” means providing a more liveable and loveable future for us all.

As a company that creates everyday essentials – ingredients, protection and colour – that make people’s lives more liveable and inspiring, AkzoNobel strongly believes that we have a part to play in developing and implementing the new urban agenda. What we call “Human Cities” is the practical expression of our company purpose, and is everything we do with and for society, including “Let’s Colour” from our decorative paint brand Coral.

Colour makes cities more liveable and has an impressive transformational power, as demonstrated by the Let’s Colour programme in Favela Santa Marta, Brazil, a project undertaken with the local people for six years.

### The idea

*A bottom-up approach to create more liveable and loveable cities through colour and education*

Coral started a first project in 2010 in Santa Marta, in the Praça do Cantão area. Coral painted 34 houses and the court of the “Mocidade Unida do Santa Marta” samba school. At the time there was no awareness of the scope of what could be achieved in the Favela Santa Marta, but we saw a great opportunity to make a positive difference.

Although we did not have a blueprint for the activities in Santa Marta, we were inspired by similar projects in Medellin, Colombia, and Ecuador that involved socio-political environmental transformations. Understanding that ours would be a marketing project, we knew that we would have to forge our own path.

In 2012, the brand started to work consistently with the Santa Marta community as part of “Tudo de Cor.” Tudo de Cor is Coral’s mission put into practice: to add colour to people’s lives through the transformation of their homes and cities. The key to its success is a bottom-up approach which respects the wishes and needs of residents. By building relationships with residents, promoting transparent processes and being consistent in our actions, we build trust and legitimacy for our presence in the community.

Residents are asked to choose a colour for their home from a palette of 24 colours developed specially for the Favela Santa Marta. Professional painters support the residents, but towards the vision of a self-sustaining project which enables residents to make their own improvements. In this way, the residents feel ownership and renewed pride in their neighbourhood. The many different elements of the project come together through a design pattern applied through the favela, creating a feeling of togetherness and promoting social cohesion.

An important pillar and lasting legacy from Coral to Santa Marta residents is training as professional painters. Several painting courses in partnership with Senai (Serviço Nacional de Aprendizagem Industrial – National Service for Industrial Learning), have trained dozens of people now able to enter the labour market.

Since we started working with the people in Santa Marta, 400 houses have been painted and public areas – such as Espaço Michael Jackson where the King of Pop filmed the music video “They don’t care about us” in 1996 – have been revitalized. Street art interventions with local, Brazilian and international artists, such as local graffiti artist Swell, have also been promoted.

More recently, in the spirit of the Olympic Games in Rio, Coral launched the “Unexpected Courts” project, together with NBS advertising agency. Ten new urban courts came to life in streets, alleys and staircases. These spaces aim to promote sports other than football, such as basketball, volleyball, tennis, hockey and rugby.

The idea is simple and easy to replicate, anywhere, anytime. All that is required is a willing community, a good idea, some paint and dedication to help the people transform their neighborhoods.

## The impact

*The transformative power of colour at work in the Santa Marta Favela.*

An impact survey carried out by Cieds interviewed 431 people, of whom 259 had had the façade of their house painted, to analyse the impact of Let’s Colour. The results

indicated that the transformation of Santa Marta through the Let’s Colour insight article is directly related to residents’ well-being and optimism.

According to Cieds analysis, 82% of the people who had their homes renovated believe the painting has appreciated their property, and 85% say they feel more motivated to make new improvements in their homes. Of those who took part in the project, 73% said the painting of the exterior of their houses improved their self-esteem.

Just over 74% of the interviewed residents believe the painting helped to make Santa Marta a better place to live, and 64% of respondents believe the residents are participating more in actions to improve the community as a whole.

In addition to enabling residents to improve their community and get involved in community activities, Let’s Colour has helped draw visitors to Favela Santa Marta. Almost 93% of the interviewed residents said the painting helped to attract more tourists. An increase in tourism results in an economic benefit for the whole community.

To date, 25,000 litres of paint have been used to paint 60% of the houses in Favela Santa Marta – 400 houses. Over 1,800 volunteers have contributed their time and skills and 53 taskforces have formed. It is a massive undertaking of Tudo de Cor, and still continues to make life in the favela more liveable and inspiring.

The impact of Tudo de Cor extends beyond Favela Santa Marta. From 2009 to 2016, a total of 1,650 projects were carried out in Brazil, 8,455 buildings were renovated and more than 56 million lives have been impacted in a positive way. Further information available at [Humancities@akzonobel.com](mailto:Humancities@akzonobel.com)

## The barriers to innovation – and the solutions

*Process- and procedure-heavy bureaucracies require persistence, flexibility and trust*

Projects like Favela Santa Marta taking place within an urban environment will encounter bureaucracies that will require time-consuming and challenging processes and procedures that are likely to test the resolve and commitment of all parties involved. The same is true within a company such as ours; our 400-year-old company had to develop a new, out-of-the-box way of working with communities and other partners.

Flexibility according the local reality is necessary, and dialogue with the community will help make clear where the rules or process need to bend. A constant presence in loco helps to earn legitimacy and build trust to make this adaptability possible between stakeholders.

We also initially faced scepticism from the locals who had heard many promises of transformation from other companies, with no follow-through. We needed to demonstrate that our promise was legitimate by staying committed to working together, being transparent and, most of all, by producing results.

## The way forward

*Continue the dialogue with stakeholders*

To bring projects like Favela Santa Marta to scale, we need to focus on the bottom-up approach by engaging in dialogue with the local people. Starting with their input, we customize and systemize the experience so that we are using the right products and services to fulfil actual needs.

We cannot do it alone. We must work with local governments, NGOs, community leaders, employers and volunteers. That means we must develop rhythm adaptation to each community – take into account schedule, language, communication channels and cultural practices. This enables us to reach influencers and mobilize the community in a way that is genuine and effective, and produces positive results that further legitimize our work.

This is one of the ways we can help to counteract the effects of rapid urbanization on people's lives – by making cities more colourful, more liveable and more human.

## A Connected Built Environment

*Ron Bakker*

### The challenge

*Develop ways of using digital technologies to help establish direct communication between people and their urban and architectural surroundings to make the use of buildings and city environments more efficient and productive.*

- The specific challenge is to explore and understand recent advances in digital technologies that can benefit better use of available space and resources.
- The broader context is the continued and accelerated growth of urban areas and the densification of cities, the rapid change of economic and developmental patterns, and an increased awareness of the limits of space, energy and resources.
- The motivation is the need to find ways to improve the happiness and wellness of all people and increase spatial quality and livability in cities around the world, against a background of limited resources.

### The idea

*Computer systems and smart phone applications are increasingly able to facilitate direct communication between individual people or groups of people and their built environment.*

The Edge is a large office building in Amsterdam shared by main tenant Deloitte and six other companies. Besides being one of the most environmentally advanced buildings in the world, it uses smart technologies to organize the interface between the building and its users.

At The Edge, thousands of sensors continually monitor activity levels and environmental qualities inside the office space. The building management system adjusts conditions based on detailed real-time information and the users of the building can influence their workspace temperature and lighting levels directly, through an application on their smartphone. Various facility management provisions are organized through this system.

Because the environmental conditions in all areas of the building are constantly monitored, the building's management systems can accurately predict and steer the climatic and energetic circumstances. The use of resources can therefore be minimized. This cuts down the building's energy consumption drastically and makes it more achievable for the building to produce most of the energy it needs. At certain times in the year the building produces more energy than it requires.

Facility Management costs have reduced substantially as well, as a result of the availability of real-time information. Printers, coffee machines, meeting rooms and AV systems, for example, are connected to the building management system and their use is monitored automatically. Feedback from the monitoring of movement in the office space provides input to make cleaning services more efficient.

The building's computer also discusses detailed workspace requirements with each office worker, to offer any of a variety of workspace solutions designed specifically for the tasks at hand. At The Edge, people work in the most appropriate and comfortable workspace for the work they are doing.

Typically, office workers are only at their desk for a fraction of the time. This can be 25 or 30 % for some types of businesses. A standard desk is not often the most ergonomically comfortable and suitable solution for the variety of tasks people perform. The workspace organizational concept at The Edge is new, but it relies on the smart application of existing technologies.

Since no one has a fixed desk position all available space can be used efficiently and productively. This way, Deloitte's 3,000 workers use only 1,100 workspaces, and these are of much higher quality levels than is typical. Space is used up to three times more efficiently, which results in a much reduced need to build office square meters, less monetary and environmental cost, and therefore the possibility to spend more on the quality of the workplace itself.

## The way forward

Direct communication between groups of people and the computers that organize the functionality of systems in the built environment around them could also make a huge contribution to the way we inhabit our cities and use the limited space and resources available to us in the most productive and efficient way.

Smart phone applications already give real-time information about the availability and the timing of city public transport routes. Soon, these systems will allow transport networks to take into account user demand, and timetables will be adjusted continuously to provide service, exactly and efficiently, to specific requests. This is likely to reduce the size of the transport vehicles – a change from large trains to small, clean, flexible units.

PLP are proposing *CarTube*, a pioneering mobility solution which combines two existing modes of transport – automated electric cars and mass transit – into a single, seamless underground road system. Automated cars, circulating above and below ground, are controlled via a dynamic platoon system allowing cars to move within milliseconds of one another. Users will be able to book a CarTube trip through smartphones using either their own cars or available public cars. Cars will travel in a continuous flow at a steady speed without ever slowing down, providing far greater capacity than conventional public transport. CarTube will typically double transport capacity for the same investment as conventional mass transport and reduce travel time by 75%. And the benefits of clearing public routes and spaces in dense urban fabrics of polluting cars can hardly be exaggerated.

## Transport in the Connected Age: Where technology could take us

*Ron Bakker and Lars Hesselgren*

### The challenge

The age of the internet of cars is upon us and its impact will be felt everywhere. The autonomous car is an early example where we simply replace the driver with an AI. The case for a more fundamental transport revolution is now open – instead of cars competing with one other, how about cars collaborating with one another?

Today we have a situation where we compete against each other for road space. The result is congestion – the traffic jam. This congestion is perverse since what it does is reduce the capacity of the system dramatically. After all, if traffic is stationary the actual capacity of the road is zero.

### The idea

So how can cars collaborate to improve this situation? In the end it has to be a negotiation about time slots on a road and how the limited resource can be optimized. Once the system is fully digital, all sorts of competing models are possible. One of the most prominent is some form of dynamic pricing which is exactly what is practiced in the airline industry – the price is adjusted to control demand so that the airplane is as full as possible. While some regard this as iniquitous, it does have the result of using the resource to maximum efficiency.

### Impact

The determinants of capacity are two-fold – the average speed of the system multiplied by the average occupancy. The classic examples shown in textbooks are trains versus cars – a two-track train line has the same capacity as a six-lane freeway. The reason for this is human reaction times of car drivers – the safe reaction time on a freeway is normally regarded as two seconds and this translates into a car separation of 200 feet. We often drive much closer, which works fine until there is even the slightest disturbance and we get congestion. Trains by contrast weigh hundreds of tons and are controlled by signals and safe separation.

What happens in the case of a digitally controlled car? We can now rely on the machine to drive us so reaction times are counted in milliseconds and we can use “platoon driving”, where cars drive only a few feet from each other. This technology has been explored for more than a decade by all the major car manufacturers, including trials to get cars from different makes to work together. This idea underlies the *DSRC* (Dedicated Short Range Communications) protocol already implemented in many cars.

Suddenly new options become available – cars when controlled collaboratively are highly efficient, in fact just as efficient as trains at the same speed. The analogy is with a sausage – either you have one with large lumps well spaced-out – a train – or a sausage filled evenly all along – tightly spaced cars. Take a train and slice it so that you have four people, then take all the separations between trains and insert between the slices and you find a car will fit very comfortably in that space. As long as the system rolls cars are as efficient as trains. This points to having a primary network – like the freeway – and a secondary network – like ordinary roads to ensure an efficient network.

## The barriers

But of course both trains and freeways rely on segregated tracks to achieve decent capacity – people aren't allowed on train tracks, and nor freeways (motorways in the UK). In fact no system which co-exists directly with pedestrians can achieve high speeds, simple physics makes that inevitable.

Of course there is a line of argument which says sharing vehicles will change all of this. However, sharing vehicles ensures simply that vehicles are used more intensively (good in itself) but doesn't actually change the number of trips taken in the system. The number of trips is the number of vehicles on the road and that seems likely only to grow, particularly as cities are relentlessly getting larger.

Over 3 billion people are likely to urbanize in the next 35 years, which is a formidable challenge.

If we now turn to urban mass transport, we see that on the whole as cities grow the only place we have to introduce new infrastructure is underground. Well-established cities like London and New York have done this for well over 100 years and it seems likely the same pattern will be followed elsewhere; certainly that is the current trend. Underground services already exist in cities, but there is plenty of space left deep down. The real problem lies in the 30 feet or so immediately below street level – that is highly congested.

Another key issue lies in the shape of any transport network. Cars and roads are popular because they are so flexible – take me from where I am to where I want to go without changing. Trains mostly mandate mode change – get to a station, wait for a train, change again and so on. It is made worse by the configuration of most urban mass transport systems – there are lines and you have to change from one to another – off the train, up the stairs, down the stairs, wait for another train. Surely you want a system where all of that is taken care of?

## The way forward

All these considerations lead us to look at how a system based on tunnels for electric cars, where the digital control of them ensures there is never any congestion and the system takes you directly where you want to go. Naturally the car (owned or shared) being able to drive itself will park itself in a stack until it is needed. We are looking at the minimum interference at street level, a simple lift no larger than a bus stop takes you directly to your vehicle. All of this is controlled through an app so you can decide to travel when and where you want to completely freely.

It seems certain such types of systems will be implemented on existing freeways, such as the I-5 Cascadia Corridor project (Seattle – Vancouver). A gradual introduction may also come at particular pinch points such as tunnels and bridges into Manhattan, or approaches to London, or any city where technology is seen as key enabler of better urban living.

The CarTube.global is an exploration of how a system could look and how it would revolutionize our thinking about Urban Mass Transport. PLP is actively pursuing research in this area and will be partnering with significant players in the future.

Roads take up a huge amount of space – we can rethink how mass transportation works and use streets for what they are good at – for people, not cars. We also need to properly explore technologies to reduce pollution, noise and global warming – new technologies provide us with new tools, let's use them.

# Natural Building Materials

Ron Bakker, Michael Ramage and Rob Foster

## The challenge

*How can we build a better, healthier urban environment that is also sustainable on a global scale?*

Over the course of this century, the world's urban population will double. This will be the largest urbanization in human history and it is unlikely to ever be repeated. If we address this challenge by building in the same way and with the same materials that we have for the last century, we will irreparably damage our planet while doing less than we could to improve quality of life in our cities.

Our planet has an abundance of renewable natural resources whose potential as sustainable building materials has been largely unrealised. We believe that through a combination of science and design, intelligent modification and innovative engineering, we can harness the potential of our planet's renewable natural material resource in order to build a better, healthier urban environment.

## The idea

We can use natural materials better and use better natural materials to build a more enjoyable, healthier and more sustainable urban environment.

Plant-based materials such as timber and bamboo are renewable and available on a global scale. What distinguishes these materials from more conventional building products like steel, concrete and plastic is that the raw materials are grown and harvested rather than mined and reformed. This difference leads to a diverse range of material properties that we have only recently begun to understand and exploit beyond the domestic scale. This difference also seems to affect the way in which people interact with these materials in an urban context, with people seeming to make a positive association between these grown materials and the natural environment. Developments in engineered timber are already opening new possibilities for the use of natural materials at scales previously thought impossible.

## The impact

Buildings constructed with greater use of natural materials have the potential to improve the health and well-being of those who live and work, in and around them, without the legacy of environmental destruction that accompanies the production of conventional building materials.

It is well established that increased contact with the natural environment improves the health and well-being of those living in a primarily urban environment. It would seem that people respond to natural materials in the built environment in a similarly positive manner. It is not an accident that at home people choose to expose wooden floor-boards and doors, buy wooden furniture and put up wooden shelves.

Real projects such as the all timber Murray Grove building in London suggest that timber can be quicker, quieter and cleaner to erect than conventional multi-story buildings. Such buildings require five times less construction traffic than equivalent concrete buildings and weigh perhaps a third as much, meaning foundations can be very much smaller. Supply chains for timber promote responsible forest management and encourage long term afforestation and carbon sequestration rather than the devastation associated with mineral extraction and the near-term emissions of mineral processing.

## The barriers to innovation –and solutions

The industry is risk-averse and slow to innovate – better understanding and leadership by example are required.

Our understanding of materials and the engineering required to use them most effectively is highly developed in relation to metals and artificial composites but less so in relation to plant-based materials and bio-composites. Many leading producers and designers of engineered timber products come from a tradition of forestry and carpentry and are at times resistant to industrial innovation. The construction industry itself is highly risk averse and the construction market does not seem to function effectively to drive competition through innovation in the manner of other industries of comparable economic impact. Investment is required from government, foundation and industry into academic research, industrial development and the sorts of prototypes and exemplar projects that are needed to prove these ideas. There are profound regional perspectives that could unlock some of this potential, for example bamboo in China, South America and parts of Africa, and currently difficult to use species such as Eucalyptus in much of the developing world.

## The way forward

The engagement of people with expertise in science, engineering and design, can lead to greater use of natural materials in buildings, resulting in greater well-being in a healthier, more sustainable built environment.

Direct investment in academic research and industrial development of natural materials and technologies is required to accelerate progress and build on the momentum and goodwill generated by the pioneering work in this area. Much of the early development work has come from the commitment of individuals, both in academia and industry, to addressing the challenges and seizing the opportunities presented by these materials and technologies. The next step requires the funding of larger research centres, crossing academic and industrial lines, as well as disciplinary boundaries, to bring together the understanding and skills needed to fully exploit the potential of these materials.

# Eco-Innovations for Flooring for Improved Air Quality and Healthy Indoor Environments

Véronique Bouchard Bienaimé

## The challenge

The World Health Organization (WHO) reports that in 2012, some 7 million people died – one in eight of total global deaths – as a result of indoor and outdoor air pollution.<sup>43</sup> The recent finding more than doubles previous estimates and confirms that air pollution is now the world's largest single environmental health risk, ahead of dirty water and lack of sanitation.<sup>44</sup>

People spend 90% of their time indoors, and yet indoor air is often two to five times more polluted than outdoor air as potential pollutants build up more quickly in non-ventilated spaces.<sup>45</sup> One of the reasons stems from volatile organic compounds (VOCs), which are emitted as gases from certain solids or liquids. Found in most indoor environments, common sources of VOCs include paints, aerosol sprays, cleaning supplies and building materials such as flooring.

Other potential indoor pollutants include phthalates or chemicals from household products, which may have an impact on people's health, particularly asthma and rhinitis.

The presence and size of particulate matter (PM) or fine dust is also a determining factor in indoor air quality and is directly linked to potential health problems once inhaled. These particles also contribute to the spread of microbial contaminants – such as mold, pollen and allergens – which can further exacerbate respiratory symptoms.

"Few risks have a greater impact on global health today than air pollution," says Maria Neira, Director, WHO Department for Public Health, Environmental and Social Determinants of Health. "The evidence signals the need for concerted action to clean up the air we all breathe."<sup>46</sup>

## The idea

As one of the world's largest flooring manufacturers, Tarkett is particularly sensitive to issues of public health. Flooring products designed to be used indoors have a role to play in contributing to improved indoor air quality and healthier indoor environments.

Sustainability is integral to Tarkett's vision and strategy. Among the first flooring companies to transition to the circular economy model by changing our mindset from one-off use and disposal of resources to a repeated re-use of resources, the result being the end of a product cycle becomes the beginning of the next one.

43 <http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/>

44 <http://www.oecd.org/newsroom/environmentactnoworfacecostlyconsequenceswarnsoecd.htm>

45 <https://www.epa.gov/indoor-air-quality-iaq/inside-story-guide-indoor-air-quality>

46 <http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/>

To support the transition, we apply cradle to cradle principles throughout our activities and deploy a closed-loop circular design approach that promotes the use of good materials, resource stewardship at our manufacturing plants, people-friendly spaces during the usage phase and the re-use and recycling of products and materials.

Eco-innovation starts with the assessment and selection of good materials that respect people's health and the environment, according to cradle to cradle criteria. This focus on sustainability has led to several eco-innovations that contribute to improved indoor air quality and healthier indoor environments including: lower VOC emissions across all our flooring ranges; non-phthalate plasticizer technology across all our vinyl ranges; and our ground-breaking range of dust-collecting carpets.

### Lower VOC emissions for improved indoor air quality

Thanks to early emphasis on eco-design for improved indoor air quality, 92% of our flooring collections' VOC emission levels are 10-100 times lower than the strictest standards around the globe. This resilient flooring is also formaldehyde-free.

Focusing on creating patented surface treatments for easy cleaning and maintenance for all flooring ranges, the majority of our floors do not require cleaning products such as strippers, wax or polish, thereby helping to eliminate these additional sources of VOCs.

### Surface treatments for improved indoor air quality

#### *Phthalate-free technology for healthy indoor environments*

Phthalates, compounds used as plastic softeners, are often found in flooring. There is an ongoing scientific debate regarding the possible impact of phthalate on human health as carcinogens or endocrine disruptors.

From 2009-2012, 50% of R&D resources dedicated to resilient flooring were allocated to developing a new generation of vinyl flooring using phthalate-free plasticizers. Reformulating the core products involved assembling a multidisciplinary team of researchers, manufacturers and designers to ensure there was no trade-off between performance, design or sustainability. Since 2013, this technology has been deployed across the entire range of vinyl flooring in all our European and North-American plants, and in Brazil and China.

### Dust-collecting carpets

Contrary to general opinion, carpets can play an important role in capturing fine dust in the indoor environment.

The DESSO AirMaster® takes this functionality to the next level, as its patented technology has been specially developed to capture and retain harmful fine dust from the indoor air.

Tests performed in the laboratory of the independent German test institute GUI, already demonstrated that DESSO AirMaster® is eight times more effective in capturing and retaining fine dust than smooth flooring solutions (PM10) and four times more effective than standard carpet solutions (PM10).<sup>47</sup>

Today, the latest test results show that DESSO AirMaster® with EcoBase™ backing (cradle to cradle certification level Gold, with recycled materials) and has even more health-supporting benefits. For this particular product combination, additional testing was conducted with GUI to assess the product's performance on three strict test criteria:

- Suitability for allergy sufferers because of the ingredients
- High fine dust binding capacity
- Low Volatile Organic Compound (VOC) emissions

DESSO AirMaster® with EcoBase™ backing meets all of the above-mentioned criteria, and is the first product in the world to be certified with the GUI Gold Plus label.

## The impact

### Health improvements

The health condition of millions of people around the world has improved thanks to the low or extremely low VOC emissions from 92% of flooring ranges. In addition, all of our vinyl products in Europe and North America now use our phthalate-free technology, a change very positively received by architects, designers, consumers and other stakeholders.

Our goal is to reach 100% phthalate-free vinyl flooring with extremely low VOC emissions across all our markets by 2020. As the world's biggest manufacturer of vinyl flooring, this is no small feat and we believe the effect will reverberate throughout the industry.

#### Tarkett global sustainability goals

Strategic initiative	Indicators	2010	2014	2015	Variation 2010-15	2020 Goal
Design solutions that contribute to improved indoor air quality, health and well-being	<b>Phthalate-free products</b> % of m2 produced (vinyl flooring only)	0%	38%	54%	+54 pts	100%
	<b>Low VOC emissions</b> ( $<100 \mu\text{g}/\text{m}^3$ ), % of m2 produced (flooring only)	21%	90%	92%	+71 pts	100%

## Environmental improvements

Eco-designing flooring with “good materials” not only creates healthy living environments today, but will help us up-cycle post-installation and post-used vinyl flooring in the future, thus underpinning the long-term responsible use of PVC in flooring. This vision of manufacturing goes hand-in-hand with our closed-loop circular design process which aims to make primary resources abundant, rapidly renewable, recycled and recyclable.

## Competitive edge

Our company's efforts to produce goods that are healthy for people and the planet has also helped to sustain a competitive edge and long term profitability. Thanks to our anticipation of evolving regulations and ongoing client feedback, we have been able to significantly evolve our product offer and set the industry standard in the process.

Eco-design and circular credentials have also strengthened Tarkett's hand when competing in tenders, with its products and recycling services gaining credit with various standards such as HQE, LEED and Bream. We also see the intangible value related to our commitment as a listed company (Paris Euronext) since the financial community is increasingly interested in circular economy business models, which potentially promote sustainable and responsible growth as well as new business opportunities. Tarkett is an active member of the KKR Green portfolio.

Finally, as a founding champion of the circular economy in our industry, we have seen our partnerships grow. We believe that stakeholder collaboration is a powerful tool for exploring new business models and developing creativity for growth. That's why we are an active contributor to the World Economic Forum, which we see as a platform to exchange knowledge with companies from other sectors, share our experience of the circular economy and contribute to shaping the future of construction.

<sup>47</sup> Based on tests performed by GUI, with DESSO AirMaster® versus a standard smooth floor and versus standard structured loop pile carpet (median values)

# Innovating Flooring to Meet the Ageing Population Challenge

Véronique Bouchard Bienaimé

## The challenge

*The ageing of the world population is one of the most pressing issues of our time. The combination of increasing longevity and declining fertility has resulted in a growing number of older people as a proportion of the total population in developed countries.*

The number of people over the age of 60 is growing faster than any other age group. In the next 40 years, the number of people over the age of 65 is expected to double worldwide, resulting in over 1.45 billion seniors by 2050.

### Fatal falls

Age is a major risk factor for falls, and poses a global public health problem. Approximately 28-35% of people aged 65 and over fall each year, increasing to 32-42% for those over 70 years of age. The frequency of falls increases with age and degree of frailty.<sup>48</sup>

An estimated total 424,000 fatal falls occur each year, making this the second leading cause of unintentional injury death, after road traffic injuries.<sup>49</sup> The death rate is highest among people over 60 years of age.

### Dementia and Alzheimer's

Another consequence of ageing is the increasing prevalence of dementia, and especially Alzheimer's disease. It is estimated that 47 million people in the world are living with dementia, with the figure to double every 20 years, reaching 131 million by 2050.<sup>50</sup> As dementia advances, symptoms include disorientation, mood swings, loss of motivation and lack of self-care. The illness also creates behavioural issues – such as wandering and getting lost or confused – which require close monitoring and care by families and healthcare providers. As a result, many countries have responded to the growing prevalence of this disease by creating Alzheimer specialist units, reflecting the need to provide long-term care of people who can no longer live independently at home or in the care of relatives.

### Long-term healthcare challenges

With these demographic changes, the healthcare sector must evolve to adapt to the needs of senior citizens. One of the challenges will be to provide the necessary facilities, such as retirement and nursing homes, to protect this vulnerable population and preserve their autonomy, as well as services adapted to their needs.

48 WHO Global report on falls prevention in older age. [http://www.who.int/entity/ageing/publications/Falls\\_prevention7March.pdf?ua=1](http://www.who.int/entity/ageing/publications/Falls_prevention7March.pdf?ua=1)

49 World Health Organization. <http://www.who.int/mediacentre/factsheets/fs344/en/>

50 World Alzheimer Report 2015: The Global Impact of Dementia. <https://www.alz.co.uk/research/world-report-2015>

## The idea

As industry leaders in the healthcare flooring sector, Tarkett is particularly sensitive to issues of public health. Faced with the major challenges posed by this global demographic challenge, we have invested significant resources to developing solutions that improve the quality of life of seniors and their caregivers.

### Floor design and colours for well-being

In the recent years, we conducted an extensive study among medical doctors and Alzheimer specialists to understand how flooring influences patient behaviour and mood in medical facilities (Tarkett Designing Alzheimer's Facilities guide). The research identified the valuable role that flooring can play in creating a safe and comforting environment, key to improving patient well-being. It showed that ageing patients are more likely to feel safe and continue routine activities in a reassuring and familiar environment, surrounded by soothing designs and sound-reducing materials.

For example, designs such as wood, traditional hexagonal tiles or square tiles may have a familiar reference for the patient, reminding them of home or evoking childhood memories, helping to make them feel "at home". By contrast, certain patterns – large stripes, repetitive geometric patterns, strongly contrasting colours – can confuse or disturb patients.

Colours have the same effect: some provide a sense of well-being while others can trigger undesired reactions such as stress and fear. The application of colour can also be used to promote safety and orientation. Patients with advanced dementia often experience disorientation, and flooring can provide reassuring spatial markers that help prevent them from getting lost. Strong colour-contrasting floor patterns can help define the perimeters of risk areas such as kitchens, stairways, balconies and utilities rooms. For example, having a dark line on the floor before a stairwell could deter a patient from entering and thus prevent a fall.

### FloorinMotion®: An intelligent and connected floor

But how can we move beyond applications of patterns and colours? How can a floor become an active participant in its environment? Can flooring be used to help senior citizens and residents of healthcare facilities maintain their autonomy, thrive and strengthen their confidence?

These were some of the guiding questions that led to the creation of FloorinMotion®, an innovative service which transforms otherwise passive floors in aged-care facilities into a connected living space.

FloorInMotion is a flooring system that generates a signal whenever a patient moves or falls, and in the case of any unusual behaviour, sends an alert for assistance from care staff. It allows for caregivers to monitor a patient's activity – including falls, room exits or intrusions, as well as daytime and night-time activities – from the convenience of a computer, a tablet or a smartphone. The system offers healthcare and senior residences a discrete, non-intrusive solution that respects the privacy of residents or patients thanks to the installation of sensors under the flooring.

## The impact

If a person falls and remains on the ground for too long before help arrives, serious complications with tragic consequences could occur. FloorinMotion helps to address the pronounced health risk of falling, especially at night or in the bathroom, and provides a level of security and autonomy appreciated by patients, care staff and families alike.

FloorinMotion transforms floors into a connected living space, with groundbreaking benefits for patients, their families, caregiving teams and healthcare institutions.

### Benefits for patients and their families

- Patients appreciate this discreet and invisible system because it preserves their dignity and privacy, unlike more intrusive technologies such as video cameras or bracelets.
- The alarm connection, enabling fast action in the event of a fall or wandering, is reassuring to residents and their families.
- The system can also be used in the bathroom, a high-risk location for the elderly.
- The system is connected to automated equipment that provides comfort and safety. For example, when the patient gets up during the night, the floor detects the movement, triggering LED-equipped skirtings that light up for guidance. In addition, in the event of a fall, these LEDs will flash and the patient will be reassured knowing that an alarm has been triggered.

### Benefits for caregiving teams

- Caregiving teams are relieved from the stress resulting from falls and wanderings, which are difficult to detect in real time. In the event of a fall, the teams can act quickly to help the patient, limiting the sometimes tragic impact of a fall.
- The solution provides healthcare professionals with relevant information about patients' behaviour, information that until now was difficult to obtain. Thanks to this information (such as the number of times a patient gets up during the night, the level of activity by day versus by night, etc.), healthcare providers will proactively identify abnormal behaviours or situations.
- With the monitoring system, the healthcare team will better evaluate the effectiveness of medical treatment, adjust the medication protocol and proactively administer preventive care.

### Benefits for medical and healthcare institutions

- Institutions are better equipped to fulfil their responsibility of ensuring residents' safety, particularly in the event of a fall or wandering. The solution is always active, since it is directly connected to the existing alarm system.
- The equipment works for both bedrooms and bathrooms. It requires no electrical supply and does not cause any interference with existing electronic equipment.
- With the data stored and managed on a secured server, the monitoring system is available 24 hours a day on a smartphone, a tablet or a computer. The system comes with a user-friendly interface that does not require extensive training.

With nearly 550 installations already completed by end 2016 in senior residences and healthcare facilities in Europe, we believe that this innovative service will continue to facilitate caregivers' work, reassure family members, and ultimately, contribute to providing more security and comfort to elderly residents and patients.



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IMPROVING THE STATE  
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