ADOPTING A PROGRAM MANAGEMENT APPROACH TO MAXIMIZE THE BENEFIT OF ‘VERTICAL CITIES’
Tall buildings are bigger, better, faster and more prevalent than ever. Driven by rapid growth in Asia and the Middle East, the race among the world’s cities to build the tallest, ultimate record-busting skyscraper on the planet is fast and furious. But these skyscrapers leave a legacy city beneath, whether that is in the form of an open landscape for development around the Jeddah Tower in Saudi Arabia, or a city prime for redevelopment in the shadow of the Petronas Towers in Kuala Lumpur, a programmatic approach to design and development can ensure this legacy is overwhelmingly positive.

Well-executed skyscrapers can be a real economic-development driver. The Petronas Twin Towers in Kuala Lumpur, built in 1998, was the world’s tallest until it was eclipsed by Taipei 101 just six years later. Whilst it may no longer be the tallest building in the world, the towers successfully changed the perception of Kuala Lumpur worldwide (Bremner, 2007). These world class vertical buildings raise the bar for other buildings in the city, be it malls, office blocks or hotels.

There is no doubt that “Supertall” and “Megatall” represent a new vision of vertical urbanization, but as the race for grandeur surges, so does the risk and disruption caused by our increasingly unstable and rapidly changing planet. The unthinkable is no longer unthinkable, some of these threats remain unforeseeable and outside of our control. The most effective way to ensure successful and safe delivery in this unpredictable climate is by taking a commercially led programmatic approach.

By looking at the development as a whole program of works, identifying the deliverables required to achieve desired business outcomes, managing the interfaces with the surrounding infrastructure and establishing robust planning and scheduling, the bigger pictures becomes clearer, as does the route to benefits realization. Supertall buildings and surrounding developments are unique projects facing unique risks; risk management is at the core of this programmatic approach. Focusing on trends, forecasting and actively managing and mitigating the risk from the outset will have tangible, measurable and beneficial impacts on the outcomes for the development and the wider city environment.

These outcomes however, are not solely economic. As our population continues to grow and our resources become scarce, another challenge we face in this volatile climate is building cities sustainably to meet the growing demand. By 2050, the world population will have grown to nine billion, from about seven billion today (Risen, 2013). Building vertical cities can save energy, support our growing population and preserve our horizontal spaces for food production, nature and recreation.

But it is not always the case that these vertical cities are simply responding to urbanization. Buildings like the Burj Khalifa and the Shanghai Tower are often called vertical cities, but they are not the direct result of the demands imposed by highly urbanized space. They are born from a city’s burning ambition to make their mark. An iconic tall building enhances the global image of the city. It is likely to put the city on the world map, thereby signaling and promoting its significant economic progress and advancement (Ali, 2012). These big, innovative, and distinctively designed skyscrapers are potential game-changers. If they get it right, these new developments can attract phenomenal levels of tourism, by combining high-end mall space, offices, hotels and even ski slopes and aquariums.

However, as these cities get bigger and more complex, layer of enterprise and delivery risks are added. The future of the building is coming at us with increasing speed and intensity, the difference between the thrill of victory and the agony of defeat is very small. Supertall and megatall developments are no exception. Minimal deviations from plan are compounded and can have major implications on the overall performance of the program.
Location

The location of a vertical city can be a challenge and a key opportunity. When looking at the global landscape of vertical cities, over the past 50-60 years we have seen an eastward shift in the geographical makeup of the world’s tallest buildings (see figure 1), corresponding to the economic emergence of these nations. It is evident from the high rise trends in the Middle and Far East that these countries use architecture to demonstrate the development and achievement of their nations. These dynamic structures also identify opportunities in the development, or indeed the redevelopment, of the cities surrounding these vertical metropolises.

The Shift East

How location of the world’s tallest buildings is changing

Of the world’s current 100 tallest buildings over half have been constructed in the past four years (59). 90% of these have been built in either China, wider South East Asia (for example, South Korea) or the Middle East.

In 1930 99% of the tallest 100 buildings were located in North America with 51% in New York City alone*. Today (2014) this has decreased to just 16%.

Specifically China is the country with the most tall buildings in the top 100 (30) across over 15 cities. Meanwhile, 20% of the world’s tallest 50 buildings are currently in Dubai.

Today South East Asia (48%) and the Middle East (30%) regions now account for more than three quarters of the tallest 100 buildings in the world.
In countries like China, tall buildings are an effective way of housing large numbers of people, as the population migrates from the countryside to the cities. In the Middle East, tall buildings are more of a statement of intent. The Burj Khalifa represents Dubai’s push to become a world city, and the costs of its construction need to be set against that bigger picture (Langton, 2013). On its own the building represents valuable real estate, but the 829 meter tall structure, which includes apartments and a luxury hotel, is not simply an expensive marketing tool for the Emirates. The “wow” factor of being in the shadow of the tallest building on Earth has pushed up land values all around the Burj, creating an economic ripple effect that benefits the whole city. Emaar Properties, the developer behind the Burj, have made it the centerpiece of a new business and residential district, charging a premium for properties with clear views of the skyscraper. Even if the Burj Khalifa had failed to turn a profit, its presence has raised the surrounding property value enough to more than offset the difference.

Table 1: Average sale and rental rates across selected developments of Dubai
Faheem, M (2015) CBRE

<table>
<thead>
<tr>
<th>DEVELOPMENT</th>
<th>OFFICE - SALES RATES (AED / FT²)</th>
<th>RESIDENTIAL - SALES RATES (AED / FT²)</th>
<th>RETAIL - RENTAL RATES (AED / FT²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LOW</td>
<td>HIGH</td>
<td>LOW</td>
</tr>
<tr>
<td>Premium Area (Burj Khalifa)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downtown Dubai</td>
<td>1,750</td>
<td>2,350</td>
<td>1,800</td>
</tr>
<tr>
<td>Other Dubai Areas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dubai Marina</td>
<td>1,575</td>
<td>1,900</td>
<td>1,300</td>
</tr>
<tr>
<td>Dubai International Financial Centre</td>
<td>1,700</td>
<td>2,000</td>
<td>1,650</td>
</tr>
<tr>
<td>Jumeirah Lakes Towers</td>
<td>1,175</td>
<td>1,450</td>
<td>1,150</td>
</tr>
</tbody>
</table>

Conversely, one notable oversight on the Burj development is the public transportation link. In the hot Arabian sunshine, a 1.5km walk from the nearest metro station to the iconic landmark and adjoining Dubai Mall is a result of poor planning and insufficient interface management. The distance may seem negligible, but in the height of the summer when temperature can reach above 50°Celsius, the walk is unbearable. The benefit of developing a city in an emerging market that has a relatively flexible landscape with an evolving public transport strategy is to link the two together, promoting the use of the new metro and creating ease of access. Taking a programmatic approach to the whole development would have built this functionality in at an early stage.
The Triple Bottom Line

A tall building is not only iconic in design but economically, socially, environmentally impactful. But can a tall building ever be sustainable? We are no longer in the age of the high-rise urban ghettos of the latter half of the 20th century, tall buildings can offer unparalleled innovation and exhilaration, with a flurry of technological advances that enable skyscrapers to be just as green if not greener than their low-rise counterparts (Ijeh, 2015). There is a balance required between creating a truly iconic development that attracts investment, tourism and promotes a city brand, ultimately warranting higher rental income, and building sustainably, environmentally as well as economically.

The industry is becoming increasingly aware of the costs and benefits of building “green.” Knowledge in this area is advancing rapidly, and the higher visibility, status, and design quality of tower buildings means that they are often the forefront of research and implementation of sustainable strategies. The adoption of LEED-type methods are helping to develop the efficiency of individual buildings as “products”, though there are many aspects of sustainability that are not included in these methods. When addressing sustainability, it is important to not only look at the energy efficiency of buildings, but also their relationship to infrastructure and their long-term financial viability.

Many key factors need to be taken into consideration as early as possible to ensure a safe and efficient structure is delivered not only within time and to budget, but that also allows benefits to be realized and business outcomes to be achieved. The delivery of major buildings is becoming ever more complex, driven by legislative change (sustainability), technological change (BIM) or the continuous fragmentation of the design/procure/construct process. This complexity is compounded for vertical cities where the systematic analysis, mapping and management of the interdependence between individual activity and tasks is magnified.

The role of the Program Manager is to create the right ‘controls’ to inspire the team to deliver the required quality and innovation that tall buildings demand, but within a controlled and risk assured delivery strategy. Figure 1 summarizes five principles of program quality assurance used on The Jeddah Tower.
**Health and Safety Assurance**

Building tall represents many risks and as a result health and safety should always be foremost in any construction project. Building a vertical city has to consider the risks as does any other construction project, but there should also be a focus on key areas, such as working at height, complex lifting operations, access and egress arrangements, perimeter working and fire and emergency preparedness. Mitigation measures for these key hazards must constantly be reviewed, updated and tailored to ensure that the risks of working on a high-rise development are being adequately managed. Figure 1 describes the approach to Health, Safety and Environment (HSE) that was adopted on the Jeddah Tower.

As an example the following eight key fatality risks have been identified on the Jeddah Tower in relation to the construction methodology:

- Lifting operations
- Work at height
- Shaft and riser works
- Building perimeter works
- Edge protection
- Fire
- Electric shock and
- Falling materials.

For each of these fatality risk areas prescriptive risk control standards are then developed which are incorporated into the safe systems of work. The application of the standards can be audited to assure compliance.

Of specific importance in the Middle East is the need for Behavioural Leadership. The Behavioural Management of Safety (or BMOS) integrates behavioural strategies and processes into health and safety management systems. Working at all levels of a project or program, BMOS analysis promotes safer behaviour and environmental conditions to deliver continuous improvement in health, safety and business performance. A BMOS program creates a systematic approach that defines a set of behaviours to reduce the risk of work-related injuries. This is achieved this by collecting data on the frequency of safety critical behaviours, providing feedback and reinforcement to encourage positive behaviour. The data is also used to identify root causes, facilitate problem solving, and develop recommendations for continuous improvement with particular emphasis on improving communication and awareness at all levels.

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**Figure 3: The Jeddah Tower approach to HSE**

<table>
<thead>
<tr>
<th>Jeddah Economic Council (the Client)</th>
<th>Arcadis &amp; Mace (JV)</th>
<th>Dar Al-Handasah Consultants</th>
<th>Saudi Binladin Group (Contractors)</th>
<th>Contractors</th>
</tr>
</thead>
</table>

**STRATEGIC**

- Implement a strategic/proactive approach to HSE Management
- Provide leadership at all levels
- Ensure Accountability/Ownership
- HSE performance monitoring
- Provide education at all levels
- Set best practice expectations

**TACTICAL**

**OPERATIONAL**
Focus on Design Innovation

The viability of any development is dependent on costs vs revenue. These factors get ever more complex when building tall. Typically, as the height of a building increases so does the cost of construction. Many of the challenges faced in the development, design and construction of tall buildings focus on finding innovative responses to mitigate risks associated with the key cost drivers, these must be identified early.

Buildings like Jeddah Tower could remain the exception rather than the rule as cost is the major obstacle preventing developers going much beyond the one-mile mark. It isn’t the engineering, it’s the economics (Baker, 2008) that is holding back the development of more tall buildings. The reason that many skyscraper schemes never come to fruition is usually the business plan. Every time you increase the height, the volume increases by several times more. The Burj Khalifa is a good example of how to mitigate having too much space to sell by keeping the building as slim as possible. This can be measured and monitored throughout the design process by using a programmatic approach and analyzing the building’s useable space to keep the design in line with the desired outcomes.

Building Information Modeling (BIM) and other virtual construction services are a critical part of executing skyscrapers. Using these techniques means more efficiencies and accuracy in pre-construction planning and strategies, and equally important, during construction. In addition to innovative methods for coordination of structural and mechanical engineering, information can be extracted from the model to facilitate estimating, procurement, clash detection and field management. The 3-D model can be used to identify and avoid safety hazards. The use of this technology can enhance our overall productivity, provide instant clarification and offer important cost savings in high-rise construction.

Prefabrication is not a new concept, but architects and engineers are tuning their hats to the concept of prefabricated skyscrapers to promote innovation and ‘Lean Construction’. Due to the repetitive nature of supertall construction, even small improvements can have big effects if integrated early enough. Simplifications of design, details and construction methods can save a lot of time and money if managed effectively and efficiently at the front-end. However, innovations need to be balanced with reliability, fully exploring these innovative solutions from the start is fundamental to actively assessing, managing and mitigating the risks.

On the Jeddah Tower, innovative piling techniques were implemented by using a 110m Kelly Bar, manufactured for drilling rigs, this removed the need for extension pieces to be inserted during drilling operations. This cut cycle times for depths down to 100m, a reduction of 50%, and saved approximately 70 working days.

State of the art computerized drilling rigs were used (see Figure 4), which bettered tolerance targets by 50%. On site fabrication of all reinforcement cages ensured quality of fabrication and consistency of supply in order to maintain schedule. Environmental factors were also considers and by recovering the drilling fluids, which were then stored in site tanks and recycled using dedicated temporary storage pond.

Figure 4: The Jeddah Tower computerized drilling rigs. ©Jeddah Economic Company / Sales & Marketing Dept.
A key consideration in the design of a vertical transportation system in tall buildings is to reach the optimum balance between the quality and quantity of lift service provided, the capital cost of the lifts themselves and the loss of revenue-earning, tenantable space taken up by the provision of lift cores and plant rooms. This becomes even more critical as buildings become taller than 50–60 storeys.

The type of vertical transportation system is often linked to the specific use of the building and may facilitate the requirement for sky lobbies. Double decker lifts, a relatively new technology, have been used in many high rise developments to provide efficient solution to minimize tower core area requirements and meet passenger requirements.

The challenge of moving people up and down such tall buildings is one of the reasons why the prospect of a mile-high building becoming a reality appeared almost impossible until the unveiling of Jeddah Tower design. The longest distance it is currently possible to travel in an elevator is 504m, up to 638m in the Burj Khalifa, however Jeddah Tower will contain 57 elevators and 10 escalators and the highest elevator will rise 660m, with the world’s fastest double deck Elevators which ascend at 10.5 m/s from the lobby to the observatory level. This is made possible by using carbon fiber rope technology (Kone Ultrarope) as illustrated in figure 5.

It is challenging for elevators to go faster because of the rapid change in air pressure over such a distance. Early appraisal of options and development of a strategy that meets specific requirements of building design is critical to avoid costly late design changes or delays caused by inefficient ways of working.

Figure 5 illustrates of Kone elevator system on the Jeddah Tower. ©KONE
Performance Management

The adoption of quality controls processes and approaches need to identify and forecast the root issues that may have a negative effect on schedule, cost, quality and overall performance. These could be human, personality or system issues which are slowing things down or preventing quick implementation. If necessary issues may need to be micro-managed and micro-monitored until they are back on track.

Constant and clear communication of intent throughout the team is essential to create a culture that is focused on the expectations and outcomes. Early identification of the key trends to be monitored and forecasting KPI’s will enable the analysis of progress and predict scenarios. On the Jeddah Tower a specific performance management regime has been adopted to identify trends and forecast outcomes (Table 2). This is of specific concern for tall buildings where the compound effect of delay to an individual task can have exponential consequences.

<table>
<thead>
<tr>
<th>REGIME</th>
<th>KPI</th>
<th>OUTCOME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor Submittals with specific focus on:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Design Drawings</td>
<td>Duration to complete review</td>
<td>Engineer performance</td>
</tr>
<tr>
<td>- Shop Drawings</td>
<td>Approval status</td>
<td>Contractor quality</td>
</tr>
<tr>
<td>- Materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Request for Information</td>
<td>Duration to answer RFI</td>
<td>Engineer performance</td>
</tr>
<tr>
<td>Non-Compliance Reports (NCRs)</td>
<td>Number of NCRs issued</td>
<td>Contractor performance</td>
</tr>
<tr>
<td></td>
<td>Number of NCRs Closed</td>
<td>Construction quality</td>
</tr>
<tr>
<td>Site Productivity</td>
<td>Floor Cycle duration</td>
<td>Contractor performance</td>
</tr>
<tr>
<td>Site inspection</td>
<td>Readiness for inspection</td>
<td>Contractor performance</td>
</tr>
<tr>
<td></td>
<td>Approval status</td>
<td>Construction quality</td>
</tr>
<tr>
<td>Health &amp; Safety</td>
<td>Accident Frequency Rate</td>
<td>Readiness for inspection</td>
</tr>
</tbody>
</table>

Table 2: Jeddah Tower Program Management controls framework ©Jeddah Economic Company / Sales & Marketing Dept.

In addition to traditional schedule and cost reporting, performance data on the Jeddah Tower is captured on a weekly basis and outcomes are presented in weekly and monthly dashboards (Figure 6). Performance issues are further analyzed and appropriate actions identified to reverse negative trends. This micro-management identifies root causes at a more fundamental level and provides key insight into performance.

Figure 6: Jeddah Tower 3D Logistics Concept ©Jeddah Economic Company / Sales & Marketing Dept.
Construction Logistics and Operational Readiness

Logistics planning is critical for construction speed. There is a bottleneck at the base of every building built where manpower and materials enter and leave the building. This issue is magnified in the construction of tall buildings where peak flows of resource need access to the vertical site. Adequate hoists must be installed, and their use must be meticulously managed. Experience in operational readiness has proven that it is essential to integrate the “opening and operation strategy” into the design and construction schedule. Early stakeholder engagement with the end users and appropriate authorities is required to meet and manage expectations and avoid delays.

For the Jeddah Tower specific areas of focus have been:

**Systems Analysis**
Not all systems are equal when it comes to onsite installation and coordination with other trades. Analysis on tall buildings brings a clear focus on hoisting, stocking and area requirements, all of which have an economic effect to the installed system. Emphasis must be placed on buildability, the management of onsite work area requirements and the simplification of systems. Efficient and effective planning of servicing, repair and replacement must be considered along with appropriate ‘Stack effect’ planning.

**Site Logistics/Crane and Hoisting Scheme**
Logistics planning is key to streamlining material movement to workface and eliminating redundant or inefficient labour and plant. On the Jeddah Tower resources will peak around 7,000. It is critical to engage with the design team very early in the process to identify areas for material deliveries and ensure worker welfare is meticulous planned. See Figure 6: Jeddah Tower 3D Logistics Concept.

There is a significant cost associated with cranes and lifting strategies. Jeddah Tower uses “Jump Lifts” which were invented for the Sears Tower in Chicago. By utilizing this system, hoisting is contained within the core eliminating the need to close up curtain-wall sections out of sequence. This technique is not only lower in cost, but it also means that the interior hoist is not affected by external weather conditions.
Procurement Methodology and Timing
Tall buildings are unique, requiring inventive solutions that are at the cutting edge of the industry. Using manufacturers to help deliver these solutions can offer an innovative buildability advantage. This innovation, if properly procured, can be brought in during the design strategy without impacting competitive tendering. This procurement process must be clearly mapped out in advance with a specific emphasis on requirements for design input, proprietary products, phased procurement and site logistics.

Schedule and Trade Sequencing
On tall buildings, there are a number of trades that have to work sequentially and vertically. The most efficient approach is to plan the critical trades from floor to floor, tailoring trades at the same pace, creating optimum vertical sequencing. This coordinated approach allows results in improved production rates and better quality control.

Design aspects can often inhibit the optimal pace, identifying this early means that adjustments can be made to improve constructability. For example, the core of the building is the main pacesetting trade, simplifying the core will save time and money by setting a faster leading pace.

Construction Quality Control and Assurance
Quality control and assurance is key to setting expectations, working within tolerances and creating repeatable sequences. Construction quality can be assured by designing these into the details and building in regular schedule checks. It is critical to carry out performance testing as early as possible, ensure that shop drawings are coordinated and that the right mock-ups are being produced.

Manufacture/Offsite Pre-Assembly
Manufacturing offsite and using techniques for pre-assembly can save money and time, and promote quality control. It is critical to assess the site logistic and hoisting plans as this will determine extent of off-site assembly.

The Jeddah Tower curtain walling design is a high performance system similar in specification to the Burj Khalifa. The complex system, which comprises of over 33,000 curtain wall panels, is being manufactured and assembled offsite to simplify and streamline onsite installation.

Material and Tradesmen Availability
Early awareness of market constraints and capacities means these restrictions can be accommodated by adapting design solutions. Designing to promote competition is key and it is critical to secure commitments from trade contractors and material suppliers early.

Tolerance and Movement
Tall buildings are designed for their completed configuration. However, during construction a building may have higher degrees of loading that the finished product. It is more cost effective to design with the construction sequencing known, rather than build in excess capacity at additional expense that may never be utilized. Coordinating cumulative trade tolerances and deflection criteria, accommodating for lateral and thermal movement and planning for differential movement can help to identify the construction sequence and allow the building to be designed accordingly.

Maximizing benefits through Program Management
Program Management provides substantial measures of stability, clarity and certainty. The application of sound Program Management principles when building an iconic tall building provides the discipline, organization, structure and processes to manage and mitigate risk whilst also creating the environment to drive design and construction innovation. The result is the creation of exceptional buildings and outcomes, the larger and more complex the challenges, the bigger the benefits.

Commissioning and Occupancy
The testing and commissioning strategy must be considered early so the opening and operation strategy can be integrated into the schedule. The construction schedule must be driven by pre-commissioning and start early with progressive sign offs. The coordination and integration of life safety and shaft pressurization, flushing of chilled water system and system integration testing, validation and handover can limit or eliminate the cost of temporary and/or retrofit work. The impact of this is heightened on tall buildings due to the intricate and innovative nature of the design.

Tenant Special Requirements
These can have a big impact on MEP and structural design requirements. Identifying these as early as possible and accommodating for them within the design will eliminate risks to schedule, cost, and quality, removing the need for retrospective structural coordination and other costly changes.

Interior Development Phasing / Tenant Special Requirements
The testing and commissioning strategy must be considered early so the opening and operation strategy can be integrated into the schedule. The construction schedule must be driven by pre-commissioning and start early with progressive sign offs. The coordination and integration of life safety and shaft pressurization, flushing of chilled water system and system integration testing, validation and handover can limit or eliminate the cost of temporary and/or retrofit work. The impact of this is heightened on tall buildings due to the intricate and innovative nature of the design.
Tall buildings have challenged technology itself and allowed us to build towers more efficiently and sustainably; and to create internal environments that are comfortable, productive, and energy-efficient. The prevalent green movement has propelled the design of high performing tall buildings to employ intelligent technologies and smart materials. Optimizing a design for efficiencies can shorten the construction schedule, easing the financing costs and reducing the risk of price rises during the construction phase. Greater savings can be made through phasing of works to allow works to be carried out concurrently and allow staggered opening, including the possibility of earlier income streams. Maximizing buildability requires the early, intensive interrogation, planning and scheduling of the development, with detailed consideration of alternative methodologies.

It is critically important to first understand the business goals and objectives, rather than hastily launching the delivery of technical services. Program Management can deliver these iconic skyscraper and their surrounding cities safely, efficiently and at speed by providing a quality control and assurance framework. Very small deviations from plan can have a big bottom line impact. It is not enough to manage to time, cost and scope of work without understanding the critical interdependencies and risks unique to delivering vertical cities. Investing in a Program Management approach from the beginning will undeniably ensure that not only are the outputs achieved, but benefits are realized and outcomes achieved.

References

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