AUTODESK UNIVERSITY 2014

ROI of Cloud Based Collaboration and Mobility for Construction

Michael Moran, Manu Venugopal and Ken Stowe

Autodesk Consulting and Business Development

CO5007-R This engaging class is aimed at construction managers, quality managers, and executives from construction service providers who are evaluating the financial impact of Cloud and Mobile Construction Solutions, such as BIM 360 Field software and BIM 360 Glue software. We will explore a detailed and proven analysis tool for collecting project data and then analyzing and quantifying benefits. We will ask attendees to consider a hypothetical $100 million building project as a tangible example, and we will collect inputs from the audience to foster a collaborative discussion. We will then use the results to estimate a return on investment. Real-world metrics from existing projects and case studies will support each step of the process. The methodology can benefit construction professionals who are already using BIM 360 software on their projects and want to understand how the tools affect their key results areas; prospective users of BIM 360 software can also begin to consider which project areas would benefit from these new technologies.

Learning Objectives

At the end of this class, you will be able to:

- Explain how BIM in the cloud improves productivity, schedule & quality
- Use project data to quantify the benefits and cost savings of these tools
- Evaluate ROI and build business cases supported by real metrics
- Track metrics to maximize benefits and improve project performance

About the Speakers

Kenneth H. Stowe, P. E. is a construction technology expert and development strategist at Autodesk, Inc. With 25 years of experience in construction management and project control on projects as large as $1.4 Billion, eleven years in BIM software, experience on four continents, numerous articles, and contributions to four books, Stowe leads a team at Autodesk responsible for construction business development and strategy initiatives worldwide.

With unshakeable conviction in the benefits of BIM and teamwork, Stowe and his team create a unique partnership between Autodesk's product development and industry leaders in the worldwide construction community. For many construction professionals in the U.S., Canada, UK, China, Sweden, Australia, Malaysia, Singapore, France, and other countries, Stowe is a trusted advisor as they invest in tools, process improvements, and metrics to improve and measure total project team performance over the facility lifecycle.

Manu Venugopal is a Building Information Modeling (BIM) enthusiast who focuses on using technology to improve business processes in the architecture, engineering, and construction-facilities management industries. He leads the development and integration of BIM 360 cloud-collaboration platform with ERP (enterprise resource planning) systems, product lifecycle management, document management, project controls, or facilities management systems, and he plays a key role in spreading adoption of Autodesk cloud technologies. Manu plays many roles at Autodesk, including solution architect / customer implementation manager, Certified Scrum Master leading Autodesk teams through agile development processes, and API liaison for Autodesk Developer Network. Manu also designs and architects solutions for customers. Manu received his PhD from Georgia Institute of Technology under the tutelage of Professor Chuck Eastman. His doctoral research introduced a new software engineering methodology aimed at improving the interoperability of BIM systems, and it also introduced semantic web technologies to BIM.

Michael Moran is a consultant at Autodesk, Inc., focusing on Construction Solutions. He helps customers analyze and understand the benefits of using BIM 360 Glue software and BIM 360 Field software so that they will get the most out of using these tools on their projects. His master's thesis in construction management at the Delft University of Technology was a comparative study designed to assess productivity gains from using cloud-based field mobility tools on 15 Skanska AB U.S. building projects. The aim of the study was to help the company identify repeatable success factors. Together with Skanska and Autodesk, Michael conducted a webinar on this case study. He also recently presented a talk about benefits and advancements of cloud-based Building Information Modeling (BIM) at the European 5Di Conference. Other experiences in the building industry include founding and running a concrete specialty forming firm and obtaining a bachelor's degree in architecture.

Contents

Cloud Based Collaboration and Mobility for Construction

Cloud computing is allowing construction project teams to save the latest, up-to date project information in a single, central online repository where it can then be accessed by the team members who need it, wherever they are, provided they have at least some access to the internet[1]. As of Autumn 2014, these cloud-based BIM tools are mainly being used:

- During preconstruction-coordination for multidisciplinary desig[1]n review activities
- During construction and handover to communicate between the office and site by viewing and updating project information on mobile devices

The rapid development of these tools will certainly lead to new use cases and expose more project phases (ie design and building operations) to the performance improvements of cloud based mobility in coming years.

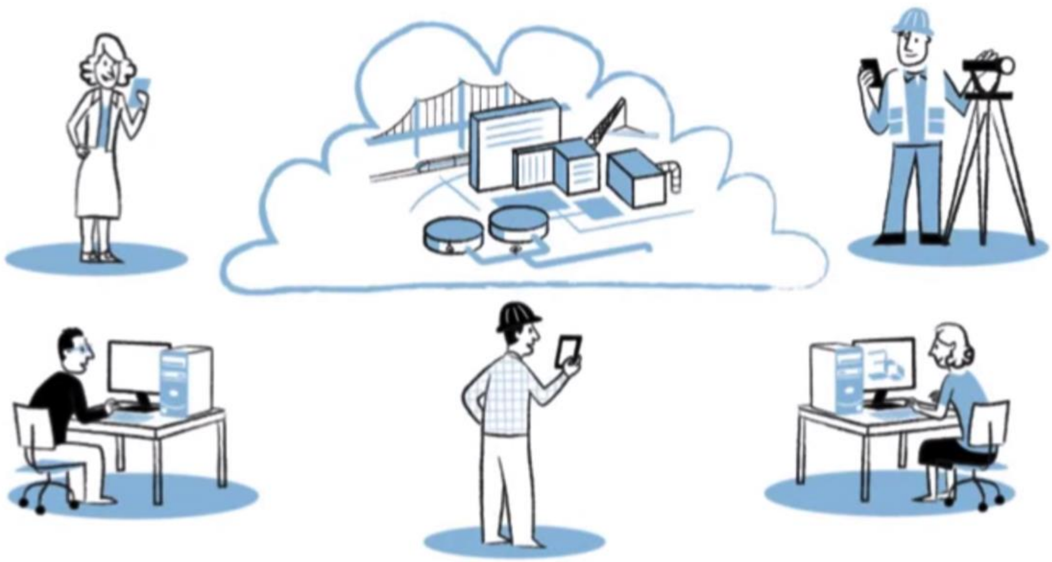

Figure 1: Cloud-based BIM tools gives the project team access to accurate, up-to date information, wherever they are, whenever they need it

[1] Mobile devices can be used offline and then synched to the cloud to download and upload the latest info

How BIM in the cloud improves construction productivity, schedule and quality, and how to quantify these improvements

Productivity improvements

This low productivity is attributable to construction workers spending much of their time in the field performing non-value adding tasks, such as:

- Waiting for preceding trades to finish activities (bottlenecks)
- Searching or waiting for the latest information, drawings, etc.
- Re-transcribing information in the office which was recorded on paper in the field

Compared to other industries, construction labor productivity is low, and has not kept up with steady productivity increases in other sectors.

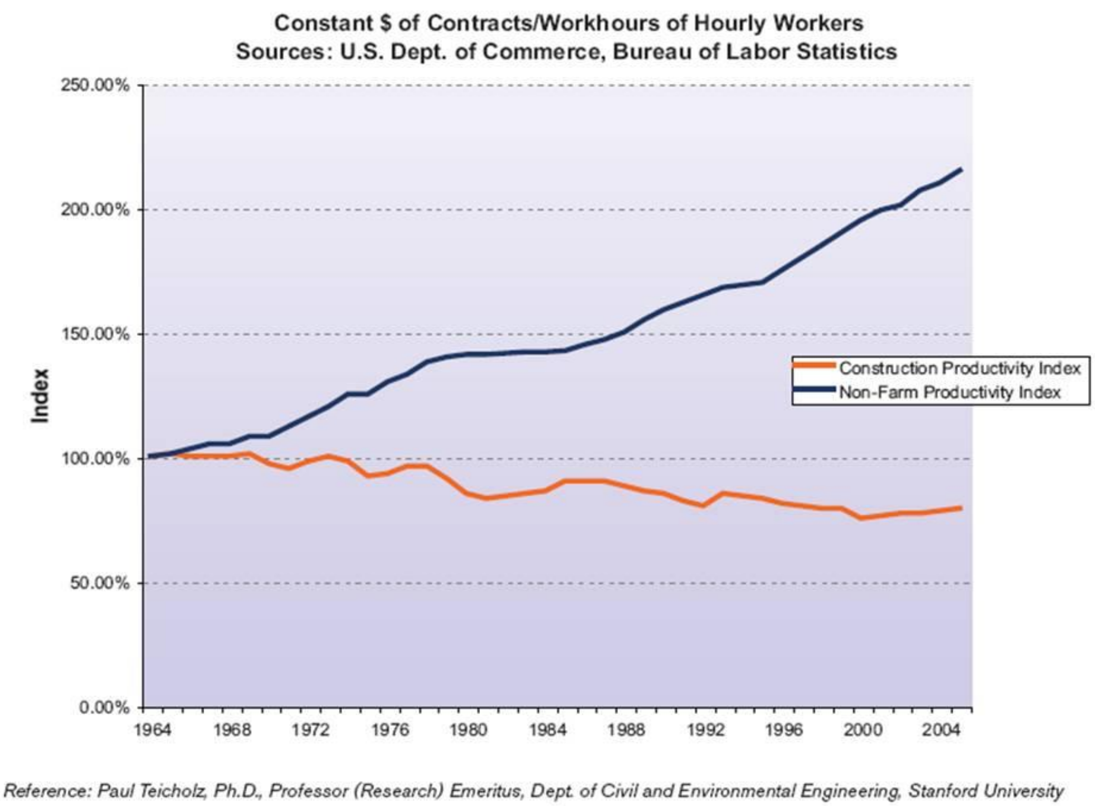

Figure 1 – Construction labor productivity since 1964

By giving all users access to a single source of the latest project information and allowing them to update that information in the field, cloud-based BIM tools reduce much of the time wasted on non-value adding activities.

Type of Activity	Activity Description	Weekly Duration (hours) using Traditional Method	Weekly Duration (hours) using BIM 360 Field	Change (%)
Value Adding	Inspecting quality onsite	10	15	+5
	Walking site with architect/engineer/owner's rep	5	6	+5
	Coordinating with trades for future activities	5	7	+2
	Meeting with construction management team	3	4	+1
	Subtotal Value adding activities	***23***	***32***	***+9***
Non-Value adding	Documenting issues and notifying trades	15	10	-5
	Following up on statuses of existing issues	5	3	-2
	Meeting with subcontractors regarding issues	3	1	-2
	Total Non-Value adding activities	***23***	***14***	***-9***
Total Weekly Hours		**46**	**46**	**-**

Table 1 – Sample survey to capture baseline and new weekly task durations

In table 1 we see an example of changes in typical weekly durations of construction management activities, using a baseline of typical durations using traditional methods as a starting point to measure against. Note that although the total project hours per individual per week (46 hours) doesn't change, the weekly distribution of time has shifted to spending 9 more hours on *value-adding* activities in this case. This can also be expressed as an approximately 20% productivity improvement (9/45*100%).

This productivity improvement may result in financial benefits to construction companies by allowing projects achieve the same results while run with 20% fewer full time equivalents, ie 4 project engineers instead of 5. However, companies may also choose to retain the same staffing quotas on similar sized projects, and instead realize financial benefits by redirecting staff to value-adding activities…achieving better results, including reducing overall project duration, and increasing project quality through having more resource availability for inspections in the field.

Schedule

As explained in the previous section, the reduction of non-value adding tasks leads to optimized end-to-end workflows, and quicker turnaround time for certain key activities. These include:

- Setting out of survey points for formwork, or pipe/duct hangers in the Field
- Reporting and rectification of quality issues
- End of project punch listing/snagging
- End of project commissioning and owner handover

Quicker access to the latest project information such as construction drawings, models or issue statuses can also eliminate 'information bottlenecks' and reduces waiting time. The combined effect of less bottlenecks and optimized workflows can help compress the time needed for certain activities in a project's critical path, with the end result of shaving days off a project's schedule, avoidance of delays and quicker issue turnaround time.

Task	Duration
Prepare	1
Install	3
Finish	3
Inspect	3
Total	**10**

Figure 2 – In this example, the historical total duration of a task is 10 weeks, including a 3 week inspection period at end. This is a baseline to measure against.

Task	Duration
Prepare	1
Install	3
Finish	3
Inspect	1
Total	**8**

Figure 3 – The inspection period has been reduced to 1 week through optimized subcontractor communication and reduced bottlenecks resulting in quicker issue turnaround. Overall, the task has been compressed from 10 weeks to 8 (20% reduction), meaning subsequent dependent tasks can start 2 weeks earlier.

Quality

Increased project quality can be achieved through the combined effects of quicker communication, anywhere access to the latest drawings and models, and more engineering time that can be spent in the field doing value adding activities (i.e. inspections and coordination of trades). This has the effect of shifting the peak of issue resolution earlier in the process (see figure 4), meaning that they can be resolved with less time, effort and cost than if they had gone unresolved. These can include:

- Design coordination issues such as errors, clashes or omissions
- Issues arising from structured quality or safety checklist inspections onsite
- End of project punch/snag/defect lists

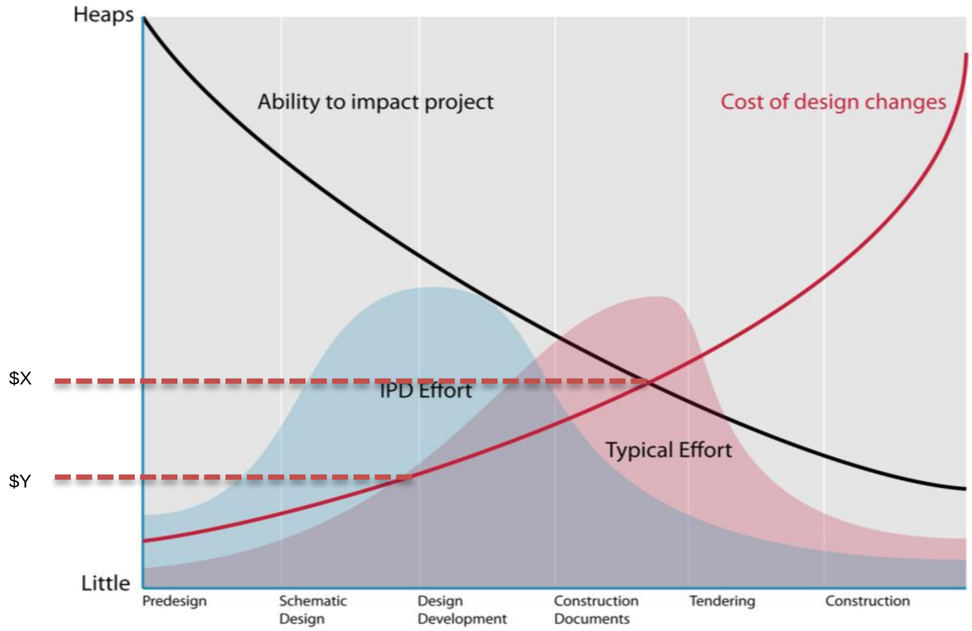

Figure 4 – The MacLeamy Curve, well understood as an illustration of benefits of BIM during design, also applies to construction: more rigorous, proactive inspections earlier in the preconstruction coordination and construction phase of a project can 'nip problems in the bud' and results in less costly rework issues. In this case, the baseline is the average cost of issue resolution using a traditional process is $X, and the reduced total cost is $Y

To illustrate how we can quantitatively measure the cost savings of earlier issue detection and resolution, let's consider an example. A US construction company established a baseline for the cost of resolving a typical non-conformance using a traditional paper-based punch list (AKA snag or defect list) method, by estimating the average costs to resolve a typical non-conformance in four work-packages if found during punch, which as figure 5 shows, consists of many compounding labor, material and rework costs which accumulate over time.

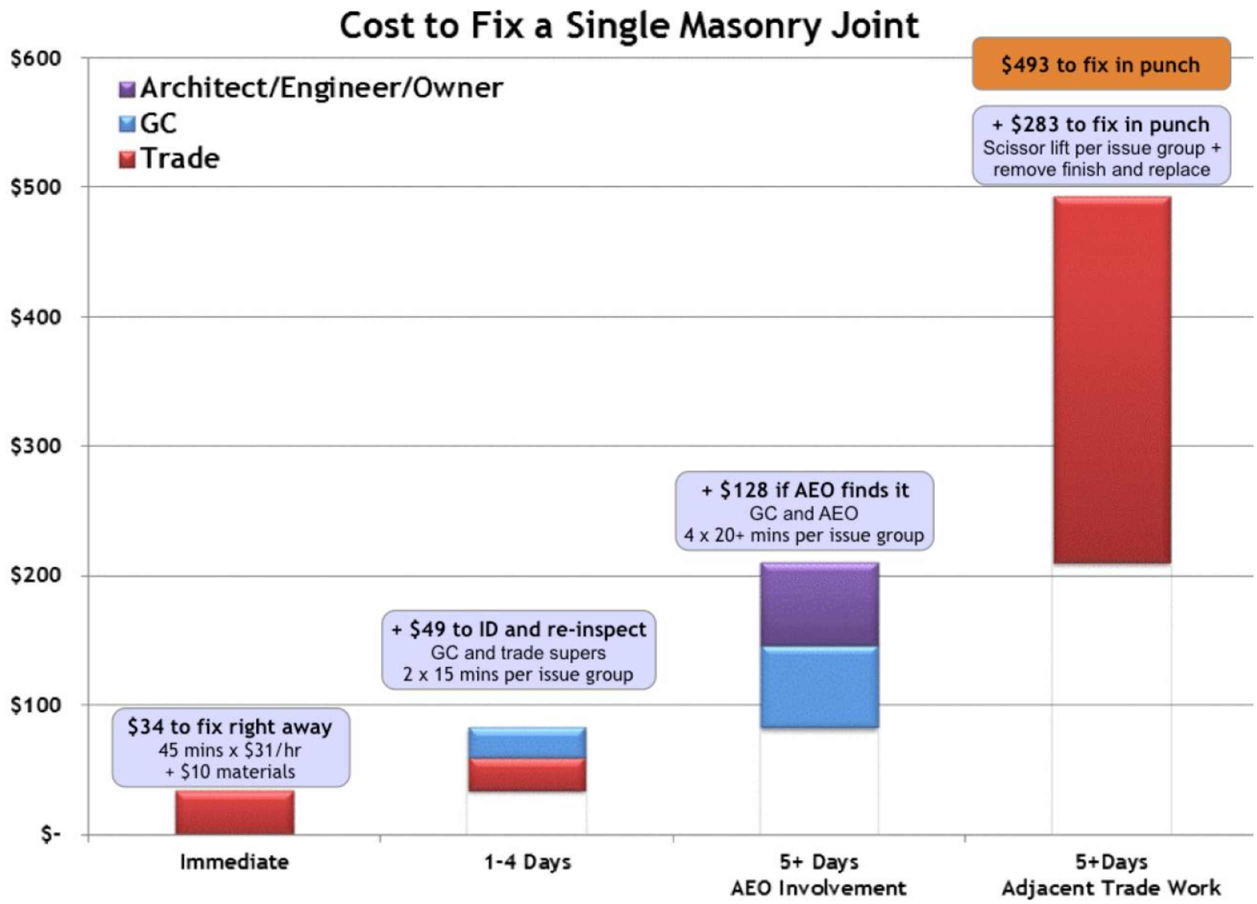

Figure 5: Cost growth of a single non-conformance if left unresolved. Notice that if left unresolved until punch, the finish (installed by a subsequent trade) may need to be removed and replaced to address underlying issue. As in fig. 4, the earlier a problem is addressed, the less it costs to fix.

They then used BIM 360 Field to manage all quality inspections on a large hospital project. 757 non-conformances were resolved before punch, thanks to quicker reporting, communication to trades and subsequent issue close out. This led to an elimination of costly steps (refer back to figure 5) and avoiding the involvement of more parties as time went on. Faster turnaround also resolved non-conformances before subsequent trades could install work which would otherwise need to be removed to fix the problem (highest column on right). The total savings through quicker issue resolution and avoided rework in four work packages alone was estimated to be $120,800 (figure 6).

Work Package	Estimated cost to resolve using traditional methods	Actual cost to resolve using BIM 360 Field
Fire-Rated Assemblies	$44.282	$11.069
Caulking and Sealants	$6.053	$2.006
Masonry-Veneer	$19.638	$2.378
Tile Waterproofing	$70.998	$4.717
Total	**$140.971**	**$20.170**

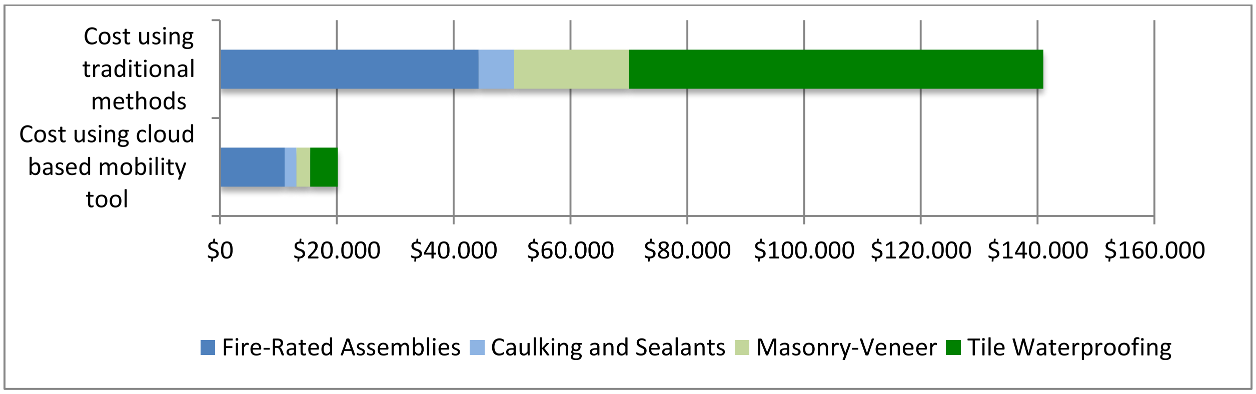

Figure 6: Actual rework costs vs estimated baseline in 4 studied work packages. Again, a hypothetical as-is performance baseline is measured against actual results using the new tool.

The importance of a baseline

In each of the above cases, in order to measure a changes in productivity, schedule or quality after the introduction of a new tool or way of working, we first established a starting point against which to measure. Below is a summary of various KPIs which can be measured to determine as-is performance:

Project performance area	Baseline KPI
Productivity	-Typical weekly time spent on non-value adding activities (hours) -Average floor area coordinated (design review), inspected (construction), commissioned (handover) in a week
Schedule	-Typical current durations of key activities on critical path (days)
Quality	-Typical rework costs on similar size and types of project ($)

The resulting performance improvements can be expressed in time durations, or percentages. The next section explores how these improvements can be translated into cost savings for the project.

Translating Quality, Productivity and Schedule Improvements into Cost Savings and Return on Investment

Estimating the dollar (or euro or pound or shekel) value of performance improvements

Good news – once we've calculated efficiency gains, schedule acceleration and rework reduction attributable to the use of cloud based mobility tools, the hardest part is over!

We now take the average percentage improvements and days saved, and multiply them by various project factors, extrapolating the quantified improvements out over total project duration, workforce and budget to estimate total cost impact on project performance.

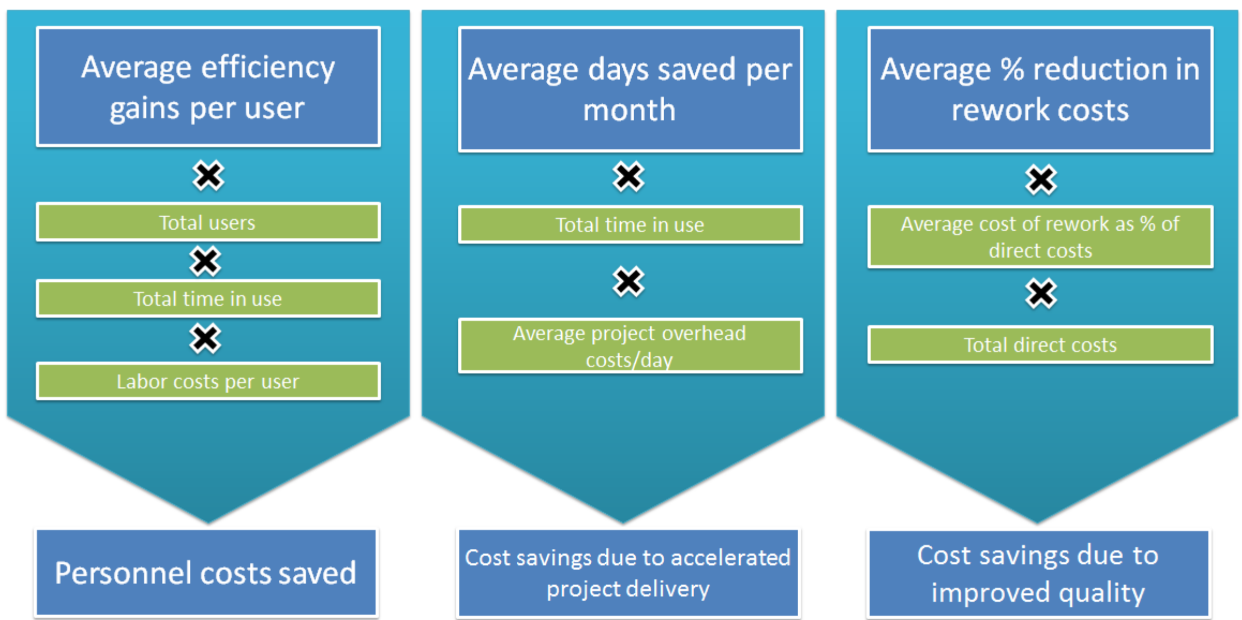

Figure 7: Methodology for translating performance changes into cost savings

The above methodology gives us three distinct types of savings:

- Personnel costs
- Savings due to accelerated project delivery (or avoided delays)
- Cost savings due to improved quality

Calculating ROI

As mentioned earlier, some projects may decide to reduce FTE's, thus achieving the same performance with less staffing requirements, saving labor costs. In that case, the ROI calculation would look like this:

$$ROI=\frac{(Personnel\ Cost\ Savings\ -\ Software\ and\ Hardware\ Costs)}{Software\ and\ Hardware\ Costs}x100\%$$

Others may decide to achieve more with the same sized site team, achieving savings through quality improvements such as reduced rework costs and schedule improvements:

$$ROI=\frac{((Quality\ Savings\ +\ Schedule\ Savings)\ -\ Software\ and\ Hardware\ Costs)}{Software\ and\ Hardware\ Costs}x100\%$$

Thus, these cost savings can be treated separately depending on how a project team decides to translate performance improvements into benefits which affect the project's bottom line.

Discussion of results

This class focuses on three types of quantifiable benefits – *productivity, schedule and quality* - which are not the only benefits which using cloud based BIM tools can deliver. The reason for the focus on these benefits is twofold: these are key project performance areas in which most users of the tools agree that there are benefits, and there is a proven methodology for empirically quantifying savings in these areas.

However, the discussion of benefits and ROI would not be complete without considering that project-level improvements can also have "knock-on benefits" (A.K.A. second order effects) in other areas which improve a construction company's profitability. These include:

- Ability to analyze cross project data generated as a byproduct of use. This is stored in a single repository and can be used to identify trends, supply chain performance, problem areas and opportunities for continuous improvement.
- Increased client satisfaction due to reduced waste, improved project quality, earlier delivery and more complete information handover creating cost savings later in maintenance and operation. This results in increased repeat business, higher rate of successful project bids, and a lower annual cost of project pursuit.
- Insurance against claims after project completion due to clear and complete documentation.
- Improved site safety through more rigorous inspections, and the ability to drive down insurance costs by lowering EMR (Experience Modification Rate).

None of the benefits discussed in this class are exclusively caused by the tools themselves, rather they're achieved by the improved processes which they enable. A car cannot travel to a destination if there is no road, no driver and no fuel. Similarly, cloud based BIM tools need a thorough implementation, infrastructure and resources to be a success and to realize their potential. Teams who maximize the ROI of these tools include project managers and company directors who implement them in a strategic way, and see the introduction of this new technology as an opportunity to transform the way that they work and manage information.

Maximizing ROI by Tracking KPIs

Whether one chooses to focus on quality, schedule, productivity or a combination of multiple factors, once a clear business case has been established, the next logical step is to monitor and track key performance indicators (KPIs) of performance to make sure that those benefits are being achieved, and prove to executives, skeptics and prospective clients that you are improving performance.

For example, if a company decides that the quicker resolution of quality non-conformances is the biggest benefit because of reduced rework costs (see figure 5) and compressed inspection tasks (figure 2), then a KPI could be "*days to close quality issues".* These metrics can be analyzed on a company by company basis across projects to warn of imminent problems, and to build up scores for supply chain quality conformance and responsiveness. This information can even be incorporated into a procurement performance scorecard which can be consulted when considering which subcontractors to employ in the future.

Summary and conclusion

This class has laid out a method for assessing the ROI of cloud based collaboration and mobility tools on construction projects. We began by measuring as-is baselines and performance improvements attributable to the successful implementation of these tools. Then we presented a methodology which translates performance improvements into cost savings which improve a project's profitability and shows how these cost savings can be factored into an ROI calculation. Finally, we discussed how the results can be interpreted, other factors that need can be considered when quantifying benefits, and how the ROI can be maximized.

Ultimately, the purpose of this class is to provoke thought and consider purposeful action. We want to start a discussion about what to measure, how to measure it and how to track those metrics to ensure that we're maximizing the benefits. We may reach some conclusions during the session itself, but these should not be seen as final. Rather it should be seen as one step in a process that will constantly be developed and refined.

Appendices

Appendix A: *EXAMPLE* ROI worksheets populated with *hypothetical* results

This worksheet will be populated in the class, who will be asked to consider a hypothetical $100m hospital project. All input values below are examples.

Project data inputs are filled in the turquoise cells:

$50,00

Project performance Improvements are filled in the green cells:

16,0%

Calculated fields are shown in grey:

$382.500

Project Data

Project Characteristics - Value	Input/Override
Contract value for one total project	$100.000.000
Percent of project value attributed to design	6,0%
Project value attributed to construction	$94.000.000
Project value attributed to general conditions (field offices, security, fencing, trucks, etc.)	6,0%
Percent of general conditions that are variable (time-based) vs. fixed overhead	60,0%
General conditions costs	$5.640.000
Variable general conditions costs	$3.384.000
Percent of construction value attributed to profit or fees	2,0%
Construction Fee	$1.880.000
Project value attributed to direct costs (labor, materials, equipment & subcontractor costs)	$86.480.000
Cost of rework as a percentage of direct costs	5,0%
Project Characteristics - Preconstruction Workforce	
Average no. of pre-construction project managers, BIM managers and subcontractor leads per project	10
Average fully burdened hourly rate	$100,00
Average hours worked per week	30
Average number of pre-construction months	6
Project Characteristics - Construction Workforce	
Average no. of construction project managers, project engineers, field engineers, superintendents, foremen and inspectors	15
Average fully burdened hourly rate	$60,00
Average hours worked per week	50
Average number of construction months	18

Productivity Gains

Pre-Construction Services and Trade Coordination Productivity Gains	Input
Average no. of pre-construction project managers, BIM managers and subcontractor leads per project	10,0
Average fully burdened hourly rate	$50,00
Average hours worked per week	50,0
Average number of pre-construction months	6,0
Average Efficiency Gains Due to Use of Cloud Based BIM Tools for design coordination	**5,0%**
Pre-Construction project hours saved	**600**
Potential reduction in personel costs	**$30.000,00**

Pre-Construction Services and Trade Coordination Productivity Gains	
Average no. of construction project managers, project engineers, field engineers, superintendents, foremen and inspectors	15,0
Average fully burdened hourly rate	$50,00
Average hours worked per week	50,0
Average number of pre-construction months	18,0
Average Efficiency Gains Due to Use of Cloud Based BIM Tools for Construction Management	**16,0%**
Construction project hours saved	**8640**
Potential reduction in personel costs	**$432.000,00**

Total Project Hours Saved	**9240**
Potential reduction in personel costs	**$462.000,00**

Schedule Acceleration

Construction Project Schedule Acceleration	Input
Project value attributed to general conditions (field offices, security, fencing, trucks, etc.)	10,0%
Percent of general conditions that are variable (time-based) vs. fixed overhead	60,0%
Variable general conditions costs	$5.400.000,00
Number Of Construction Months	18
Anticipated Percentage Improvement in Construction Schedule	**8,0%**
Associated avoidance of delay or accelerated project delivery - Months	**1,44**
Associated project savings through schedule acceleration	**$432.000**

Quality Gains

Construction Project Quality Improvements	Input
Project Value attributed to direct costs (labor, materials, equipment)	$76.500.000,00
Cost of rework as a percentage of direct costs	5,00%
Anticipated Percentage Reduction in Rework Costs	**10,0%**
Associated project savings through reduced rework costs	**$382.500**

Total Benefits	
Reduction in personel costs	$554.400
Project savings through schedule acceleration	$270.720
Project savings through reduced rework costs	$432.400
Total Project Savings*	$1.257.520
Project Savings through reduced rework and accelerated schedule	**$703.120**

ROI Calculation	
Liscencing costs	$50.000,00
Cost per mobile device	$500,00
Number of mobile users	15,00
Total cost of mobile devices	$7.500,00
Total Project Costs	**$57.500**
ROI Calculation (Savings - Costs)/Costs	**1123%**

Appendix B: Summary of Customer-Led case studies to establish baselines and quantify savings

Customer	Area of improvement	Detail and reference link
Skanska USA Building	Productivity	Users on 15 projects report average 16% efficiency gains http://bloom.bg/1ziZNem
	Schedule	$1bn Stadium project reduced schedule by 10 days, saving at least $1M http://bit.ly/1tU63XT
	Quality and Productivity	$95 million library project saved $144 in avoided rework and increased user efficiency by 10% http://bit.ly/1rWbS1u
Barton Malow & Maryland General Hospital	Schedule and Productivity (during operations)	$57M Hospital project decreased commissioning and handover duration by 30% and saves 30 min per work order during operations http://bit.ly/13kJFMe , http://bit.ly/1yJDWtz
Turner	Productivity	Established model coordination baseline of 11,241 ft^2 per design review cycle http://bit.ly/1tUcZEx
Gensler	Schedule and Productivity	Architect saved 95 man days during punchlist inspection of 2000 room hospital project http://bit.ly/1sKZwZl