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DIGITAL-MODEL DATA-DISTRIBUTION IN CIVIL ENGINEERING CONTRACTS

ABSTRACT:

Purpose

The use of digital-models to communicate civil-engineering design continues to generate debate; this pilot-work reviews technology uptake towards data repurposing and assesses digital (versus traditional) design-preparation timelines and fees for infrastructure.

Design/methodology/approach

Extending (building-information-modelling) literature, distribution-impact is investigated across: quality-management, technical-applications and contractual-liability. Project case-study scenarios were developed and validated with resultant modelling-application timeline/fees examined, in conjunction with qualitative semi-structured interviews with eleven prominent stakeholder companies.

Findings

Results generated to explore digital-model data-distribution/usage identify: an eight-percent time/efficiency improvement at the design-phase, and a noteworthy cost-saving of 0.7% overall. Fragmented opinion regarding modelling utilisation exists across supply-chains, with concerns over liability, quality-management and, the lack of Australian-Standard contract-clause(s) dealing directly with digital-model document hierarchy/clarification/reuse.

Research limitations/implications; practical implications; social implications

Representing a small-scale/snapshot industrial-study, findings suggest that (model-distribution) must emphasise checking-procedures within quality-systems and, seek precedence clarification for dimensioned documentation. Similarly, training in specific file-formatting (digital-model-addenda) techniques, CAD-file/hard-copy continuity, and digital-visualization software, can better regulate model dissemination/reuse. Time/cost savings through digital-model data-distribution in civil-engineering contracts are available to enhance provision of society's infrastructure.

Originality/value

This work extends knowledge of 3D-model distribution for roads/earthworks/drainage, and presents empirical evidence that (alongside appropriate consideration of general-conditions-of-contract and specific training to address revision-document continuity), industry may achieve tangible benefits from digital-model data as a means to communicate civil-engineering design.

Keywords

Digital-modelling, Data-distribution, Civil-engineering, Managing/maintaining-information

INTRODUCTION

Available methods of communicating engineering design documentation have grown from the use of hard-copy blueprints, evolving beyond computer-aided-designs, towards integrated digital-models. Despite increasingly commonplace digital-data-modelling software, hard-copy (signed-off) drawings are still favoured by many in industry as a principal means to disseminate engineering design and upkeep (Steel 2012). Whilst the contractual obligations and responsibilities related to traditional, hard-copy engineering-drawing dissemination are very well understood by practitioners, the same cannot be said of digital-model data-distribution. The civil-engineering industry remains somewhat unsure of the risks and/or benefits of using digital-model data to communicate design solutions, and uncertain of the potential to repurpose a civil-engineering model for use in asset-management activities. Many involved in the design and creation of infrastructure projects remain reticent about the extent to which modelling might improve both their design procedures, and post-construction asset-management (Steel 2012). Whilst subjective support exists for digital-model data-distribution in civil-engineering contracts, industry continues to seek information about the extent to which benefits do, in point of fact, balance the risks of uptake.

CIVIL-ENGINEERING DATA-MODELLING ISSUES

Building information modelling/BIM-Infrastructure civil-engineering data-modelling produces (not software per-se but) digital-models that communicate construction/engineering design information (Li et-al 2009; Li et-al 2012). However, it is suggested here that respective user-disciplines differ in their understanding of the potential for model-repurposing over a built asset's life-cycle (Hughes, 2000; Cai, 2006;). BIM-software, used for architectural/structural and mechanical and electrical activities somewhat lends itself to assist a building's future retrospective refitting (retrofitting) during its operational and maintenance life-span (Azhar, 2011; Becerik 2012); civil-engineering modelling software on the other hand, which is applied primarily to earthworks, drainage infrastructure and transportation-engineering is very much tied to site-establishment and a particular site environ. A need exists to build upon existing theory (Tran, 2011; Cheung 2012) and tie the subject matter into, not only design-stage application but also, asset-management.

Arguably a key difference between BIM and earthworks/drainage-activities data-modelling is the level of opportunity for model reuse or repurposing, with civil-engineering infrastructure activities largely (re)survey-intensive. Substructure/sub-element establishment falling within the remit of asset-management requires civil-engineering digital-data-models might be argued as having only limited potential to assist facilities managers in retrofitting upgrades, when compared to design-model aspects that encompass architectural/structural superstructure and, mechanical and electrical fittings and fixtures.

Analysis of the key issues relating to 'civil' (transportation, drainage and earthworks) data-modelling, can however be addressed by review of work pertaining to 'BIM'; this is justified, not only by acceptance of an industry 'truism' that the generic label of BIM covers *all* construction but also, by the fact that both building jobs and civil-engineering projects require distribution of respective information to a range of inter-disciplinary parties.

The following discussion outlines the main issues surrounding data-model data-distribution, namely: quality-management and drafting; liability and contracts; and, intellectual property and remuneration; all framed progressively as a reflection upon key variables. Analysis of these core variables allows the development of research objectives outlined in the ‘methodology section’ towards a main aim of assessing key benefits (extending work by Sas, 2008; Arayici, 2011) in digital-data-model distribution in *civil-engineering contracts*.

Quality (/quantity) management, drafting timelines and contracts

A civil-engineering digital-model [and related BIM execution-plans and quality-assurance-procedures put in-place instead of traditional/manual methods (Hartmann, 2012)] has potential to reduce hard-copy set-out point information, reduce road cross-section illustrations, and allow for smaller-scale simplification of longitudinal-sections’ drawings (Li,2009; Li, 2012). Thus *quantity* of information provided in drawing-form can be reduced, but only if it is known from the outset that: native format digital versions of design drawings and models used to produce them are to be provided universally to the principal and contractors/subcontractors; and, that the parties receiving the files are capable of using information in that format (in other words, are able to use software capable of reading all supplied data). If these two modelling antecedents are not met (or only partially met by deciding upon digital file dissemination at the post-contract stage), designers logically adopt a ‘default’ position, by ensuring that *all* (traditionally required) information is placed on their drawings (and accordingly ‘invoiced by timesheet’), irrespective of potential duplication or irrelevance. Discussion of ‘eastings’ and ‘northings’ below, is a case-in-point.

A mine-expansion project of access roads, camp infrastructure and ancillary plant facilities will require a multitude of drawings. Just one of these drawings, a site-plan for an unsealed heavy-vehicle access-road, can be expected to require identification and siting of up to thirty (30) equating-elevation-level easting and northing set-out points (Donaldson, 2013). Since digital-model data-distribution reduces duplication and multiple-party verification, elimination of several dozen (unnecessary) set-out points for easting/northing/levels (across many design drawings to locate key features) can occur if modelling is adopted early. Indeed after the certificate of practical completion such points lose relevance.

Set-out points on design drawings are time consuming both for designers to produce, and for recipients to process/re-digitise. In a worst-case (remote/unintegrated) scenario, surveyors receiving hard-copy of several hundred eastings, northings and levels might seek to recreate their own digital copy. The checking process (invariably carried out by a senior drafts-person opening a CAD file and/or modelling software file, checking each supplied coordinate with a corresponding digitised/re-digitised equivalent) is laborious. Whilst industry’s current extensive use of ‘disclaimers’ (detailed below) seek to dilute contractual obligations and responsibilities, surveyors’ still seek to check document-consistency such that, supplied design-data matches construction/as-built versions. Even with data provided ostensibly ‘*for information only*’, vigilance and checking for errors and mismatches between contracted hard-copy documents and digital-information is essential.

Best-practice for civil-engineering set-out points is available; beyond laser-scanning products such as *Trimble* for producing a digital-model of existing infrastructure, need remains to provide integrated geometric design information to a construction team that extends traditional hard-copy set-out points, through a digital-model of strings rather than points. In other words, the surveyor ideally seeks to receive a reliable native-format digital-model that forms part of the contract-documents, without having to navigate ‘disclaimer-stamps’. Thus,

there's a need for full explicit (contractual) recognition of a model distribution system that utilises location input from Global Positioning Systems by incorporating Machine-Grade-Control (MGC) guidance software. Major civil-engineering design programs such as Autodesk Civil 3D, Bentley InRoads and 12d Model are all capable of exporting data in a format recognised by MGCs. Smart-plant utilises on-board computers to control machine hydraulics and location accuracy, allowing construction of earthworks directly from the digital-model, eliminating (traditionally placed) surveyor's set-out stakes, saving time and (time-sheet) fees, towards improved set-out activity productivity rates of between 10-40% (Gomez, 2007; ACIL Tasman, 2008; Bennink 2009). Future refurbishment of same-specification structural concrete road bases or asphalt-pavement wearing-courses might well gain from original design-model data, but would need to balance model usage with the constant requirement for maintenance contractors to reposition upon existing substructure.

Although availability of advanced equipment is increasingly common, the extent to which BIM balances the technology application with contractual-obligation/responsibility, is seldom clear-cut. Well-developed (revision) management procedures are important for BIM (Arensman, 2012) at the construction phase; however, theory can be somewhat at-odds with practice. To use a very basic example, a truism exists in industry that traditional hard-copy drawings are typically checked by senior staff prior to being issued as tender/contract-documents. Data gathering interviews here identified that 'digital-model data requires these same checks but largely, senior-staff are less comfortable checking three dimensional models than hard-copy'. A platitude might be that industry needs to address quality control (and liability), as design data moves down the supply-chain and, extends into an assets usable life-span.

At various project stages, requisite checks form part of quality systems that require to be made explicit within (standard) forms of contract. General conditions of contract (set-out in Australian Standards AS-4000 clause 8) that seek to define responsibility for 'correct information', as well as (AS-4000 clause 29) conditions related to the need to establish and adhere to a conforming quality system, currently make *no* explicit provision for digital-models. The lack of standard contract clauses defining risk allocation for model content is an issue (Foster 2008) as is, perceived liability (discussed below) of stakeholders.

Liability

Unlike hard-copy drawings, design-models can be somewhat easily edited after distribution (Azhar, 2011; Kotwal, 2011); liability for model updates is an issue. For the party providing the model, there is concern that once the data leaves their control it may be modified deliberately, accidentally or as a result of software incompatibility (Florkowski, 2007). Regardless of the cause, modification is seen as a serious risk (McAdam 2010a; McAdam 2010b). Resultantly, many designers are resorting to the use of 'disclaimers' to accompany the digital-models that are distributed in editable format(s). The purpose of such a disclaimer is to indemnify the information supplier/source from claims that may arise as a result of the digital-model being edited erroneously and, to distance designers from liability (Donaldson, 2013).

Disclaimers typically state that the digital data is provided 'for information proposes only', and that where a discrepancy is perceived to exist between the model and the signed hard-copy drawing, that drawings take precedence; somewhat flying in the face of the underlying philosophy of digital-modelling (Larson, 2008; Foster, 2008; Arensman, 2012). Disclaimer/caveats are an increasingly common feature in distribution notes. Contract

administrators (and legal departments) are all too aware that the inclusion of ‘for information only’ as an attachment to transmitted digital-models by their design colleagues, is unlikely to diminish responsibility and obligation. In the absence of explicit contractual provisions, disclaimers currently provide some designers with a placebo of reassurance; others however, are much less comfortable. In some cases, the main consultants’ default position is simply *not to share* any modifiable models. An Australian government report from 2010 (BEDMG, 2010) makes the point that the design team may have a policy of not sharing BIM information with contractors as a risk management strategy, particularly in relation to data accuracy.

Concerns over digital-model liability are also expressed by recipients. Nominated and domestic suppliers/subcontractors are similarly uncertain of the extent to which digital-models alone, are (contractually) binding; digital-models are still routinely checked against hard-copy for discrepancies and anecdotal evidence suggests that, if found, parties further down the supply-chain will simply correct minor errors in the model, and in some cases find it easier to recreate/remodel their own area of concern from scratch. Arensman (2012) found that whilst industry wants to rely solely upon digital-models, stakeholders remain wary of doing so.

Liability concerns and disclaimer statements are further compounded by uncertainties regarding model intellectual-property, where a designer’s digital-model is ultimately determined by the propensity for reuse (and the relative cost of time and labour in its creation as well as the potential for lost revenue if used by others). IP rights are a concern for BIM, since an organisation’s own in-house innovative designs, disseminated for one job, may be open to (re)interpretation by others seeking to use similar innovations to secure both new and refurbishment projects independently. The value of a softcopy model extends beyond a particular project, since multidisciplinary models contain significant libraries of standard specification entities; digital-models have high usability if ‘repurposed’. Overall, the rights different parties are granted regarding the completed building model remains an ongoing issue, particularly since the collaborative nature (and specialist input that occurs) during the creation of integrated models, makes it hard to determine who owns the final package (Foster 2008; Larson 2008). Clarification of ‘patents’ within a design-model and a more explicit identification and ‘registration’ of individual innovation, may ensure that specific ‘patented design’ gains legal protection. Ironically to obtain a patent, concepts must be placed within the public sphere and thus, whilst a design (component) is legally protected, that same ‘winning’ innovative approach is also made (even more) publicly available to competitors (Donaldson, 2013).

Project ‘procurement’ may provide a way forward, where a client purchases (or gives a donation towards) a submitted completed design-model; thus, winners are given the chance to bring the design to fruition and losers simply release the rights to the submitted model for suitable/appropriate remuneration. Indeed, as part of a bus-station redevelopment in Perth WA (within the Australian National Infrastructure Construction Schedule), a multi-stage tendering process sought initial expressions-of-interest for the design-&-construct project, which resulted in a subsequent invitation to supply, for suitable remuneration/donation (and implicit transfer of IP from the design/builder organisation to the client), a digital-model of the design proposal. This process allowed subsequent tenderer review and ultimately, the award of the contract (estimated at between Aus\$100m-250m) to the winning consortium, and suitable compensation for the ‘losing’ supplied models (NICS, 2014). This type of procurement and remuneration for digital-models (and implicitly, respective IP) as part of the tendering process, invites further discussion of fee structures directly below.

In a civil-engineering context a tangible, explicit value-addition as a result of digital-modelling is currently undetermined. Anecdotal evidence suggests that where a principal requests digital-model data dissemination, civil-engineering design consultants have no structured approach for subsequent fee charges (Donaldson, 2013). From a principal's perspective, if a finished model is of value after their project's practical completion (as a facilities management tool) appropriate remuneration carries merit not least given the argument that extra fees are incurred in the creation of a model and the related extra work required to check future updates and maintenance proposals. If however, the model is perceived simply as a (high-tech, efficient) means to bring the project to fruition, extra fees may be less justifiable, especially since three dimensional models are already being created by designers as a means to produce drawings, and will continue to be generated regardless of whether or not modelling explicitly make-ups the official contract-documents.

Indeed currently, quality-management system documentation, that checklists all materials specifications and installation compliances, must be made available to the client at project hand-over for no additional fee (confirming that all sub-element installations and specified materials comply fully with Australian Standards/ Building Codes of Australia). This contractually required 'quality-system compliance check-list' is arguably of more importance to asset-managers, as they seek fit-for-purpose refurbishments, than original digital design-models.

Quality management systems and their place within contractual arrangements as well as, the responsibilities and obligations of stakeholders to ensure compliance with design standards and, liability concerns (all as discussed above) are the key elements in digital-modelling of civil-engineering infrastructure. The method below describes the approach taken to examine these factors in more detail.

METHOD TO ASSESS DIGITAL-DATA-MODEL DISTRIBUTION BENEFIT

The overarching aim of this work is to assess key benefits [extending work by Sas (2008) and Arayici (2011)] in digital-data-model distribution in *civil-engineering contracts* and to this end the approach taken, to build upon the key issues described above, sought to generate data to address the following objectives:

- Determine key issues faced currently by industry in digital-model distribution.
- Assess drafting/drawing preparation timelines and quantify fees, to determine explicit tangible modelling benefit and potential efficiency improvements.
- Verify modelling preparation estimates and key issues, by qualitative semi-structured interview with prominent civil engineers/stakeholders towards validation of results.

Background review identified liability, intellectual property rights, contracts, quality management, software compatibility and fees as the key issues facing digital-model data-distribution. These key issues, along with industry's utilisation of models and, attitudes to potential time/cost savings from modelling, formed the basis for the primary data collection, via a qualitative (/pilot-study) approach.

An initial document analysis of civil-engineering projects and resultant calculation of timeframes and fees related to modelling was examined further by semi-structured interviews with both designers and constructors. Specific questions were also produced for interview with corporate legal counsel working for a consultant. Conclusions and recommendations (from both primary and secondary research data) were subsequently presented to industry

members in the form of a draft report for verification; their feedback (from three of the original design interviewees, one of the constructors and the corporate legal counsel participant) went towards validation of results.

To measure and achieve the research objectives, the method of data collection selected embraced a qualitative research method, and to ensure reliable responses in this regard, a semi-structured interview questionnaire was developed, which addressed directly the issues specific to digital-model data-distribution in civil-engineering contracts, for a sample-space of companies involved in civil-engineering design work. The semi-structured interview was designed to include questions that gave opportunity to express subjective comment that the panel thought represented industry as a whole. Answers were collated towards objective analysis to reflect professional-opinion, serving as qualitative-data in this regard. This research, considered somewhat of a pilot-study, targeted 11 key stakeholder companies. Accurate/reliable answers were generated by interviewing experienced engineers from the Western Australian (WA) civil-engineering industry from pivotal firms including: DeGrey-Civil; Worley-Parsons; Pilbara-EPCM; Kellogg-Brown-&-Root; Brierty; Advantage-Civil; Lycopodium-Infrastructure; Lycopodium-LTD; Lycopodium-Minerals; The-Civil-Group; and, Xtrata.

This project interviewed a total of eleven experts who work in the WA civil-engineering industry. Seven of these interviews were conducted in person. Three were conducted by phone and one was conducted by email. Of the eleven experts, six worked for engineering consultancies carrying out design work. Three work for contactors carrying out construction work. One worked for a mining company and one was a legal counsel for a consultant.

The interviewees were asked semi-structure interview questions, incorporating reflections upon two 'Lycopodium' case-study/scenarios of infrastructure projects of medium-size and small-size); case-study project questions were designed with three objectives in mind: firstly to measure current industry practice regarding the utilisation of digital data-distribution; secondly, to measure the effect that the identified key issues have on the distribution of data; and thirdly, to measure and verify the extent to which digital data-distribution offers real world efficiency improvements in civil-engineering projects. The questionnaires contained a mixture of common questions, as well as questions specific to respective civil-engineering obligation (design/construction/client). This distinction was required as certain questions were only relevant to specific parties.

Generally, case-study timelines for the two Lycopodium case-study/scenarios of infrastructure projects of medium-size and small-size and their respective typical/representative fee-structures/timelines sought to outline information-generation, in drawing form, through expert-judgement, validated by external engineer's review and subsequently re-validated by presenting to the 11 interview panel to confirm the reasonableness of the data-set; consensus confirmed the practicality of the drafting timeline and fee assessment.

FINDINGS & DISCUSSION: DRAFTING TIMELINES AND FEES ASSESSMENT

Drafting preparation and fees assessment

A calculation of efficiency improvements gained by utilising digital-model data-distribution was undertaken for this study by seeking reflection upon two typical case-study project scenarios (as mentioned developed by the authors from practical/actual jobs) and the

production of respective design-model/drawing deliverables for: a small civil works project of Aus\$~6.7 million project value, and; a medium civil works project of Aus\$~20m.

Production calculations for the two case-study projects were made for two scenarios. On the one hand, preparation timelines/fees were calculated for a situation where the contract makes *no* explicit stipulation for the distribution of data by digital-model; and on the other hand, timelines/fees were calculated for a situation where digital design-model data-distribution is an explicit contractual requirement.

Calculations (and subsequent validations) were based on the assumption that the amount of hours estimated to complete a digital-model, in lieu of traditional media, includes model error-checks prior to issuing. It is also assumed that even if a digital-model is *not* stipulated explicitly in the contract, current practice in industry means that a (high) degree of digital-modelling will still be carried out (in isolation, booked in timesheets and feature in progress reports) whether supplied ‘for-information-only’, or not at all. Similarly, preparation/calculations are also framed with an assumption (as mentioned by one respondent) ‘that industry currently spends more time on modelling and less time preparing (isolated) hardcopy (automated) drawings’; anecdotally (and subsequently verified by interviews), ‘many more hours are spent modelling than are booked with timesheets recorded against hard-copy drawing’.

Drafting preparation: deliverables calculation for a medium-sized civil project

A ‘medium’ civil-engineering infrastructure job was selected for analysis (based upon the author’s own in-house projects), consisting of: 18km of road(s); 10 road intersections; 18Ha of bulk earthworks pads; 4km trenching for buried services; and a project value of ~Aus\$20 million. Documentation preparation timelines were calculated. The resultant preparation timeline breakdown was assessed as follows:

Scenario-1: medium project, *no* contractual requirement for digital-model data-distribution.

The in-house design-model generation from scratch was calculated as 1,300 hours (*commonly produced even with no ‘contractual’ requirement to prepare/fine-tune/disseminate a digital-model*). Similarly, timelines were also determined for preparation of: drawing-index and roads site-plan @10hours & 30hours; road plan long sections 1-through-to-30 of separate/specific representations @40hrs/drawing; road cross sections 1-through-to-50 @20hrs/drawing; intersection plans 1-through-to-5 @40hours/drawing; roads and drainage details 1-through-to-10 @40hrs/drawing; earthworks layout-plan @ 20hours; earthworks-pad detail-plans 1-through-to-10 @40hrs/drawing; earthworks-pad sections 1-through-to-5 @30hours/ drawing; top-soil stripping-plan @40 hours; underground-services key-plan @40 hours; and, underground-services plan 1-through-to-10 @40hours/drawing.

Thus where there is *no* requirement for, nor access to, an overarching digital-model, the total timeline for the production of drawing deliverables related to a large civil-engineering job = **5,190 hours**.

Scenario-2: medium project, contractual requirement for digital-model data-distribution.

This in-house design-model generation recorded 1,560 preparation-hours (*where there is a specific and explicit ‘contractual’ requirement to prepare/check/fine-tune/disseminate digital-models*). Notably: drawing-index and roads site-plan preparation-time @10hours & 30hrs

respectively; road-plan long-sections 1-through-to-15 @40 hours/drawing (*road-plan long-sections 15-to-30 not necessary*); road-cross sections 1-through-to-25 @20hours/drawing (*road-cross sections 26-to-50 not necessary*); intersection-plans 1-through-to-5 @20hours/drawing (*where model preparation and access affectively halves respective preparation times*); roads-&-drainage details 1-through-to-10 illustrations @40hrs/drawing; earthworks-layout plan @20hours; earthworks-pad detail-plans 1-through-to-5 @40hours/drawing (*plans 6-through-to-10 not necessary*); earthworks-pad sections 1-through-to-5 @30 hours/drawing; top-soil-stripping plan @20hours/drawing (*where model access affectively halves preparation times*); underground-services key-plan @40hours; underground-services plan 1-through-to-10 @20hours/drawing (*where model access again halves preparation times*).

Thus where there *is* requirement for, and access to, an overarching digital-model, the total timeline for the production of drawing deliverables related to a medium civil-engineering job = **3,830 hours**.

A medium civil-engineering job can be argued to experience a difference in preparation time of (3830hrs/5190hrs) 74%, when comparing the different requirements for explicit modelling; thus a reduction in the overall timeline, through efficiency increases gained by modelling, is **26%**.

Drafting preparation: deliverables calculation for a small-sized civil project

A ‘small’ (author’s typical/representative) civil-engineering infrastructure project/job was selected for analysis consisting of: 6km of road(s), 4 intersections, 6Ha bulk earthworks pads, 2km buried services trenching; totalling ~Aus\$6.7million project value. (Re)calculations of preparation times were (again) carried out resulting in a total timeline for the production of design deliverables related to a ‘small’ civil-engineering job of **1,370 hours** where there *is* explicit contractual need for an interdisciplinary overarching model (*in lieu of 1,810 hours preparation time for deliverables where there is no contractual obligation to distribute digital-model data*). Overall, a **24%** efficiency gain occurs as a result of explicit data-modelling for small civil-engineering jobs.

Fees assessment

These calculations identify that overall a 25% reduction in drafting and modelling time is possible through utilisation of digital-model data to communicate design. This was subsequently verified as reasonable by the interview panel. Similarly the panel of expert designers provide a consensus that ‘drafting and modelling hours contribute towards one-third of the design fees for a project’.

Following-on from interview reflections on the fees structures, a consensus did indeed find that ‘improvements in drafting and modelling efficiencies as argued here, result in a ~8% cost saving (25%*one-third) at the design phase of a project’. Thus design fees contribute to 8.5% of the total project value of a civil-engineering project, resulting in a cost-saving of 0.7% (8% of 8.5) overall, across the contract sum.

In other words, consensus opinion amongst the expert panel consulted, finds that ‘modelling can result in a saving of towards Aus\$~140k in a medium civil-engineering project and, a saving of towards Aus\$~47k in a small civil-engineering project’.

FINDINGS/CONCLUSIONS: INDUSTRY SNAPSHOT OF TIME/FEE/UTILISATION

The methodology and figures for efficiency gains were presented to the design industry interviewees for comment. Five of six *design-respondents* confirmed ‘time/cost savings as correct/reasonable’; one design-respondent stated that ‘cost savings were less likely due to software training overheads’.

Constructors were asked to estimate their own potential savings gained by modelling. Two of three respondents stated that there would be ‘significant savings if they were to receive contracted models’, while the remaining respondent stated ‘the savings would be 4 days on a month long project and several weeks on a 6 month long project’.

Efficiency improvements at the design phase were envisaged by 5 design respondents ‘to facilitate value-management and improved design/specification selection towards cost saving over the lifecycle of a project (*no figures were forwarded as justification*)’.

Constructors unanimously (3 from 3) responded that ‘digital-model data would produce efficiency improvements’; their quantified response indicated ‘a potential saving of 13% from the elimination of duplication, improved accuracy of site set-up and more confidence in material take-offs when producing/forwarding tender bids’.

Model utilisation

Two of six design-respondents use digital-model data as contract-documentation. Three of the remaining designers maintained a default position ‘not providing digital data, however when requested, they would provide it for information only purposes’. The final designer’s default-stance was to ‘always provide digital data for-info-only’. All three construction respondents sought digital data regularly (albeit received and stamped ‘for-info-only’); no constructors have received digital data as a ‘contract’ document. All design-respondents in this study agree that ‘intellectual property is *not* a concern for civil models’.

Respondents see value in utilising digital-model data but a lack of consensus on use as contract-documentation (and subsequently in repurposing data for asset-management) identifies that further work is required and that, as digital-model distribution increases (albeit for info) the need for standardised (design-stage as well as life-cycle asset-management) practice is necessary.

Quality Management

Four design-respondents state concerns over quality management of model data in terms of revision control, software compatibility and checking procedures. It was argued by respondents that ‘since models are not (or seldom used as explicit) contract-documents, stakeholders are unable to utilise document-controllers’, thus requiring ‘*personal* management of revision control, with the potential that outdated designs are constructed from the for-info-only digital-models’. Two respondents have experienced issues with document-controllers not understanding digital file-formats and discarding important data.

Neither constructors nor principal-interviewees report concerns with revision management of digital data. Half the design-respondents use *informal* checking procedures for digital data prior to issue but argue that ‘familiarity with software can greatly influence comfort levels when checking’. Minor software compatibility issues had been experienced by two design-respondents and one constructor but these were stated as being ‘easily resolved through

communication with other stakeholders' (with BIM perceived as having most software-incompatibility issues).

Inadequate training for document-controllers is argued to contribute to problems with digital-model data supply on the design side. Lack of checking procedures remains an issue for the majority of respondents. Given liability and update-mismatch concerns, the design industry's checking procedures are argued to require improvement at both the design-stage, as well as at any future asset-management stage.

Liability and contracts

Whilst 2 design-respondents had no liability concerns when supplying digital data, the remaining four stated liability as the *primary* concern and particularly, the potential for erroneous edit. Disclaimers that emphasis hardcopy were used by half of the design-respondents when supplying digital data. The legal-counsel-respondent when questioned on disclaimers stated that a relevant contract-clause would have most influence in determining the outcome of a dispute. Constructors stated that disclaimers were regularly received with digital data and noted that in their experience hardcopies always precedence over digital data.

Constructor/ principal-respondents shared the concern that mismatches between supplied digital data and drawings required checks of model against drawing, to avoid being liable for building from erroneous digital data.

Contracts

As mentioned, two of six design-respondents have supplied digital data as contract-documentation, with one of these respondents having to classify civil-engineering 'digital-models' as 'reports' to comply with the contract. As discussed, disclaimers are used in lieu of contract clauses to set documentation precedence. Generally the lack of contract clauses relating to digital-model data in both Australian Standard forms of contract (AS4000 1997; AS2124 1992) and Australian bespoke contracts, contributes to uncertainties in providing digital-models as contract-documentation. Respondents suggest an update of the Australian Standard forms of contract to encourage (both BIM and) civil digital-model data uptake.

General

Towards verification, a draft/iteration copy of this paper and the extended report (Donaldson 2013) was provided to all industry respondents; five of whom replied. All 'agreed with the conclusions and recommendations', and indeed one suggested that 'until the Australian Standard forms of contract AS4100 and AS214 provide clear allocation of risk between parties, they will not issue digital data as contracted documentation''

RECOMMENDATIONS

Quality management

To address quality-management/revision-control for digital-models, this work recommends that digital-models be adopted as explicit contract-documentation (with file-format clarification) to enable use of official document-control-channels during issue. Further, training requires to be given to document-control staff in file-formats for digital-models and file-extensions advice. This recommendation to go alongside implementation of viewing (visual-aid) software for digital-models, with online document-management-systems

(Aconex/4P-Project) adopted to manage digital-data as an impartial-copy (to address dispute and hasten distribution to external-parties). It is also recommended that stakeholders standardise digital-modelling procedures namely, standardising string/point/model/surface naming-conventions towards improved checking; and that, designers formalise checking procedures and ensure that multiple design superseded-options are not left-in, such that designers/drafts-people avoid modifying parts of CAD-drawings ‘as shortcuts’ in modelling techniques.

Liability and contract-clauses

For project clarity related to liability and contract-documentation, this work recommends digital-model-data be treated as contract-documentation, provided that industry seeks contract clauses more explicitly tailored to Australian Standard forms of contract clauses-8.1 of AS4000-1997 and clause-8.2 of AS2124-1992 to better define documentation precedence and, clause-29 be reviewed towards quality-systems for digital-models.

Fees

Design-respondents questioned in this study stated that increased fees for supplying *civil-engineering works* digital-model data was not currently justified (four respondents declined to comment upon BIM fees, which were deemed outside their ken). Respondents agreed that there is little-to-no extra work required in order to provide infrastructure models; checking procedures notwithstanding. Respondents state that civil models lack value in being repurposed for new/upgrade projects arguing that topographical, geological and climatic conditions dictate input and that, unless verified by survey, original/existing civil-engineering design-models are unlikely to serve as reliable data for future projects.

CONCLUSION

This work extends knowledge of distribution of 3D models for roads/earthworks/drainage in practice, and finds that specific early-design time/cost savings can be generated such that the impact of digital-model data-distribution in civil-engineering-contracts better satisfy society’s demand for practicable infrastructure; albeit that, opportunities for data-set repurposing needs further examination. The (pilot) study presented finds that digital-model data-distribution provides savings in time (25% reduction in drafting/modelling time is possible, translating to a saving of several weeks for a ~6-month-long project). Similarly this small-scale study demonstrates that amongst the sample of WA experts consulted, utilisation of digital-model data-distribution achieves cost savings (0.7% saving relative to the contract-sum, translating to Aus\$140k savings in a medium civil-engineering project and, Aus\$47k savings in small civil-engineering projects). To benefit from efficiency improvements, the results presented here recommend generally that digital-model-data be distributed explicitly as a contract-document and, that specific general-conditions-of-contract clauses may better reflect this requirement towards improved (future) repurposing.

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