WHAT SHOULD YOU REALLY MEASURE IF YOU WANT TO COMPARE PREFABRICATION WITH TRADITIONAL CONSTRUCTION?

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ABSTRACT

This paper presents the final part of the IMMPREST[4] toolkit, describing in detail the measurement of risks and benefits of using prefabrication within a construction project. Based on extensive research in the UK and against a background of rising interest in prefabrication as a construction solution, this paper reinforces the need to make informed decisions which have auditable processes if the complexities of comparison are to be fully understood. The model field trials raise many questions about existing cost focussed approaches revealing barriers to innovation of any sort including the integration of Lean Thinking into construction. This paper builds on the work presented in three previous IGLC conferences.

KEY WORDS

Prefabrication, Preassembly, Measurement, Benefits, Risk, IMMPREST, Cost, Procurement, Innovation.

INTRODUCTION

There has been much debate within the AEC community about the definition and use of prefabrication within the design and construction of the built environment and the research team at Loughborough University have been and continue to be, at the forefront of this debate. One of the leading research outputs from this team has been the IMMPREST toolkit and much of the work associated with this has already been reported back to the IGLC in earlier papers (Pasquire & Connolly 2002; Pasquire & Connolly 2003; Pasquire, Gibb & Blismas 2004). From these it can be seen the uptake of prefabrication in construction is limited despite the well documented benefits that can be derived from such approaches (Neale *et al.*, 1993; Bottom *et al.*, 1994; CIRIA, 1999, 2000; BSRIA, 1999; Housing Forum, 2002; Gibb & Isack, 2003). A major reason posited for the reluctance among clients and contractors to adopt prefabrication is that they have difficulty ascertaining the benefits that such an approach would add to a project (Pasquire & Gibb, 2002). The use of prefabrication, by many of those involved in the construction process, is poorly understood (CIRIA, 2000). Some view the approach as too expensive to justify its use, whilst others view prefabrication as the panacea to the ills of the construction industry's manifold problems (Groak, 1992; Gibb, 2001). Neither of these views are necessarily correct.

A pilot study by Pasquire and Gibb (2002) demonstrated that decisions to use prefabrication are still largely based on anecdotal evidence rather than rigorous data, as no formal measurement procedures or strategies are available. This means decisions regarding the use of prefabrication are consequently unclear and unrecorded. The benefits of prefabrication are largely dependent on

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4 Interactive Model for Measuring Preassembly and Standardisation benefit in construction

project-specific conditions and the combination of building methods being used on a project. Direct comparison of components is not usually possible due to interdependencies between elements, trades and resources. These complexities make the derivation and use of holistic and inclusive evaluation methods difficult and the unlimited combinations of components, site conditions and degrees of prefabrication inhibit the development of a comprehensive evaluation system; however sufficient common factors exist for a degree of valid comparative analysis. This is a major step forward as current traditional models focus on direct cost and are largely ignorant of value, therefore these models cannot 'record' the benefits prefabrication can promote. This paper completes the reporting of the IMMPREST research project by describing how these issues can be considered, recorded and used for future learning within an interactive CD ROM based toolkit of the same name. The paper continues by identifying deeper areas for consideration and relates the issues to the broader theme of innovation generally and Lean Construction specifically.

TOOLKIT DESIGN

When designing any tool there are two principal considerations, firstly ensuring the user can understand the tool preferably with minimal training or change to their existing method of working; and secondly the function the tool is attempting to perform. Frequently these two considerations are in conflict and there is a challenge in developing tools for complex functions that are simple to use. The research undertaken for IMMPREST showed that insufficient attention was given to the initial high level discussion over whether or not to prefabricate a building or parts of a building and yet it was well understood that failure to considered the prefabrication option from the outset of a project severely limited the opportunities for realising the benefits prefabrication can offer. Whilst there are certain barriers to traditional construction that may result in a late decision to prefabricate; such as an unforeseen labour shortage or a new technological solution rendering the planned option obsolete, generally speaking, these are exceptional occurrences rather than regular opportunities. There was therefore a need to provide a front end tool that would stimulate the appropriate discussion of the suitability of prefabrication for the project early in the process thus avoiding potentially wasteful late evaluations. The remaining tool function was the facilitation of the detailed evaluation of the options to be compared. Taking these issues into consideration the final toolkit design contains three sections as illustrated in Figure 1.

In order to reinforce the user friendliness of the toolkit, tutorials and worked examples are provided, along with a comprehensive help facility

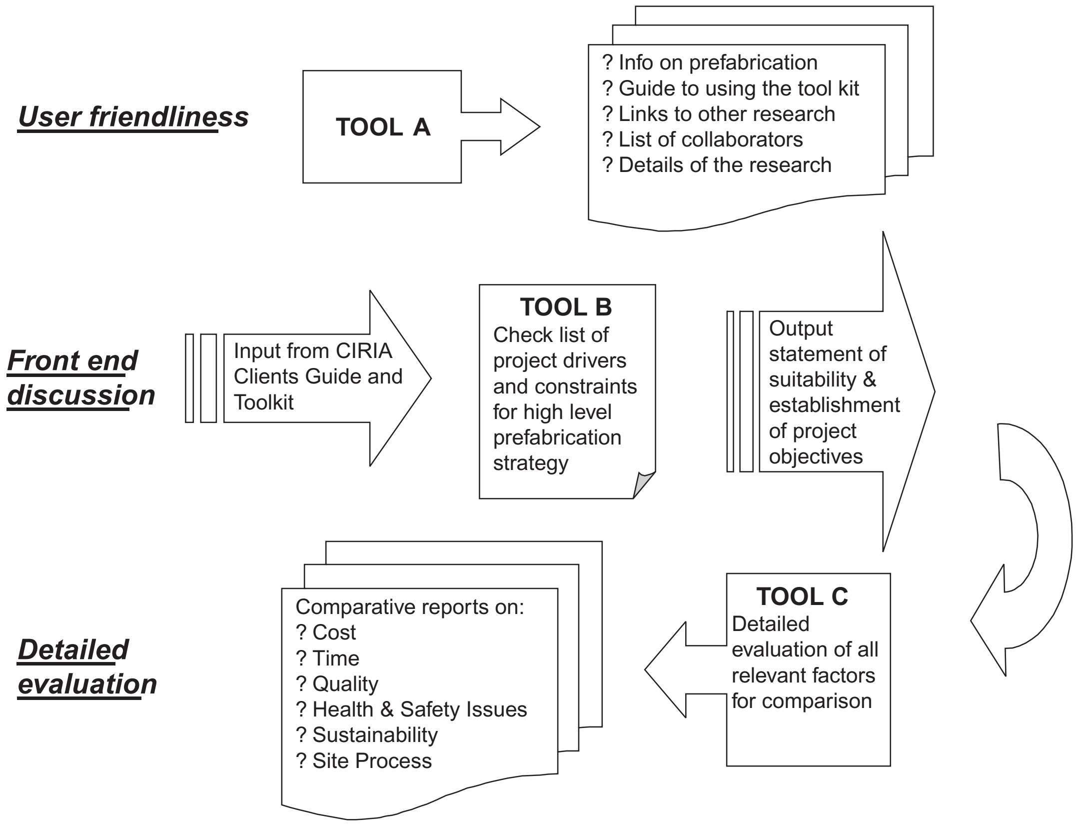

Figure 1: IMMPREST Toolkit design

accessible from any point within the system. To facilitate the use of the tool, every screen can be printed and saved, this enables "what if" comparisons allowing the impact of a variety of choices to be seen and recorded before a decision is made.

The data used to design the toolkit was collected from UK construction companies, consultants and clients over a 3 year period. Data collection methods included case studies, interactive workshops, interviews and developmental trials and data was collected from within over 30 different organisations. Over 100 copies of the toolkit have been distributed within the UK with limited distribution to USA and Europe. A follow on study returned to the research participants and carried out field trials, the findings of this study are reported at the end of this paper.

DESIGNING TOOLKIT B

The extensive industry input to the toolkit (from some 200 construction personnel) demonstrated two principal problems that the research team felt the tool could help overcome:

Firstly, a surprising reluctance on the part of project teams to clearly identify project drivers. Despite modern Value Management theory, there still seemed to be an expectation that a building not only could but had to, fulfil all and every aspect of a Client's "wish list" with equal weighting. No evidence was collected that demonstrated projects had a value vision or mission based on rigorous evaluation of client need with one exception (for BAA). Deeper than this, project team members were all approaching a project with an individual view of what would make that project successful rather than a project view, in other words, they were superimposing their own definition of value onto the project. Clearly, this flies in the face of the first component of Lean Thinking—that value must be specified by the customer. For construction this is provided by what the building does - its contribution to the Client's organisation, rather than what it is.

Secondly, the construction strategy intuitively started with traditional construction methods with innovations such as prefabrication only being considered when costs needed to be trimmed, hence the demand for proof that prefabrication is cheaper. Research by CIRIA (1999 & 2000) shows this approach to be missing the best opportunities to realise benefit from prefabrication. As argued by Pasquire and Connolly (2003) the construction strategy should start with the assumption that prefabrication will be used unless it is otherwise shown to be inappropriate for the project.

Toolkit B was designed to address both these issues, firstly by limiting the selection of project drivers forcing the team to consider the levels of importance to the Client, and secondly by leading a strategic discussion over what is or isn't appropriate for prefabrication whilst evaluating the project drivers and constraints as described by Pasquire et al (2004). Once this high level strategy has been visualised IMMPREST Tool C can then be used to carry out more detailed evaluations, to facilitate this, the project constraints identified in Tool B are carried over to Tool C. These constraints are the issues that may prevent the benefit from prefabrication being realised—the risk items, the things to watch out for.

DESIGN OF TOOLKIT C

The problems of comparative evaluation of traditional and prefabricated construction have been discussed in several papers (Pasquire et al 2004, Blismas et al 2005). In summary these include the assessment of non-cost issues and how to differentiate between factors that are not measurable in any traditional sense, in addition to the identification of the factors that are relevant to the comparison. These factors were identified from the case studies and industry participants. The methods of assessment came from basic qualitative research methodology theory such as Yin (1994) and as the data is qualitative the toolkit allows the user to factor the evaluation according to their confidence in its reliability. The final part of the design was the way in which the evaluation findings could be presented to maximise ease of interpretation. Generally the industrial collaborators preferred bar charts as the means of visual presentation with positive values showing an increase in benefit. This works well for all factors except cost, where a positive value usually means an increase in cost. It was decided therefore not to represent actual cost on the bar chart but the cost benefit and a positive value means a saving rather than a cost. The system therefore transposes the positive and negative values from the worksheet for this one chart. The conclusion from this is a summary screen showing bar charts for the six basic factors each measuring benefit (higher) or disbenefit (lower) in relation to a benchmark of 1.00 where 1.00 is the value given to the traditional option. There is a chart for each of the following six factors: 1. Cost; 2. Time; 3. Quality; 4. Health and Safety; 5. Sustainability and 6. Site Issues. The first 3 are the traditional project drivers for Clients, H&S issues are of paramount importance for all concerned, sustainability may be important to all or any of the project participants and site process is of primary concern to the constructors and project managers. Each factor has interdependencies on the others and it is

Summary Benefit Assessment			< Back to Summary		Print Page			
Traditional	Option Described							
S&P Option	Described							
Description of		**what measured**						
CATEG ORY	**ITEMS**	**DETAILS & MEASUREMENT**	**USER NOTES**	**Trad**	**S&P**	**Confid ence**	**Benefit**	Score
First level descrip tor	second level descript	details of what to be included in evaluation		£0	£0	not applicabl e	0.0%	
	second level descript	details of what to be included in evaluation		£0	£0	not applicabl e	0.0%	
	second level descript	details of what to be included in evaluation		£0	£0	not applicabl e	0.0%	

Figure 2: Standard IMMPREST Worksheet Format

important to avoid any double counting of effect. The bar charts are comparing the benefit of a two specified options “traditional” and “S&P” (standardised & preassembly). It is possible to compare the benefit of a partially prefabricated option against a more extensively prefabricated option or any other state as the actual construction being compared is always user specified for each evaluation. Only two options may be compared at any one time.

From the summary screen each of the six factors can be assessed through an individual worksheet. These worksheets are based on Excel and have a standard format as shown in Figure 2.

The research identified the pertinent items to be measured for each category and they are detailed on the relevant worksheet as a list of questions and notes. Evaluation of cost and time factors require the greatest amount of hard data with the cost factor having the greatest number of items. Some hard data items are required for the other factors but they also demand high levels of soft or non-quantitative data (Pasquire et al 2004). A user may find it impossible to answer all the questions as much of the data required is not commonly collected or, in some cases, even recognised as pertinent. Incomplete sheets do not prevent the tool from working and a conclusion may still be reached. It is possible, and in some sections required, to enter an answer that is intuitive rather than based on hard data. In order to make this intuitive data meaningful, the toolkit request the user to enter a confidence factor. If the data is hard then confidence is high, if it is based on experience and observation then confidence may be medium, if the answer is a guestimate then confidence is low. The confidence factors are used to indicate the reliability of the output of the toolkit encouraging a degree of heuristic use and reminding the user of the “rubbish in, rubbish out” philosophy of IT. Clearly, many of the factors that appear initially as medium or low confidence indicate issues that might drive revised data collection strategies for future projects enabling a more confident approach to that aspect of the evaluation.

FACTORS TO BE CONSIDERED FOR DETAILED EVALUATION

The detailed items and considerations for each of the six factors are contained in Tables 1 to 8 along with the method for assessing the items. These methods vary from quantified measurements of cost and time to more subjective assessments of degree of difference in performance.

The worksheets form a framework within which to structure project information which, when collected, then becomes the database for future evaluation exercises. Not all elements will be relevant to all users. The tables principally cover all those aspects that are relevant to the Client and building owners/users (if different). It was felt that the se aspects should be visible to the whole supply chain even if they were only able to execute a small part of the project with little influence on design and/or construction. This will contribute to Customer Focus and may encourage more collaboration across supply chain members.

FOLLOW ON STUDY

Eighteen months after its initial launch, a follow on study investigated the uptake and performance of the toolkit. This study had a three pronged approach comprising firstly a simple questionnaire distributed to the research participants and secondly interviews with five users. The final part involved a detailed case study enabling the

Table 1: Factors to consider when measuring construction & manufacturing costs

Construction and Manufacturing Costs (measure in £)		
Category	**Items**	**Details and Measurement**
Materials Costs	Basic materials	Basic material costs including finishes and fittings as necessary. Standardisation and use of 'off-the-shelf' products can vastly reduce this component
	Extra-over structural materials etc.	Extra-over materials for module frames and structural support. Over design of components for temporary purpose. Structural support for S&P components within facility frame
	Specific/special packaging	Packaging of modules or fittings therein, after assembly is completed
	Waste	Cost of material waste and disposable materials used in the construction or installation of the components/elements
Labour (including supervision)	Manufacture (Off-site)	Labour costs, including supervisors and other supervisory and site management personnel. Remember to measure savings from standardisation and learning from repetition, if applicable
	Construction/Installation (On-site)	Labour costs, including supervisors and other supervisory and site management personnel. Remember to measure savings from standardisation and learning from repetition, if applicable
	Commission & test	Labour and professional costs, including supervisory personnel
Plant	Small plant and equipment	Cost of moveable plant and equipment. Where shared, then proportion of cost based on % usage time
	Large plant	Cost of large plant and equipment. Where shared, then proportion of cost based on % usage time
Access	Access and enabling works	Cost of scaffold, access etc.
	Transport costs	Transporting costs, specific to the element, to deliver materials or completed S&P modules to site [may be included in module price of supplier]
Complex construction costs	Rectification & rework (Quality)	Total cost estimate to rectify any damage or unacceptable workmanship, based on predictions of various approaches
	Work stoppage/interference/ productivity losses	Cost factor estimate of the productivity losses possible between different methods, including weather stoppages, damage, theft and interferences etc.
	Prototyping and testing costs	Cost of materials and labour in prototyping, building mock-ups, testing components etc.
	Production changeover costs	Costs associated with changing production runs for bespoke products as opposed to selecting standard lines

research team to work closely with a project team to test the tool under real conditions. The case study took the form of a reflection on a past project in which prefabrication had been used. It attempted to identify what factors had contributed to the project success.

The main finding from the survey was that few people had taken up use of the toolkit, due mainly because they had taken part in the research for personal interests and had not disseminated the work into their organisations. The second finding was in common with the interviews and case study was the desire for the tool to be web based rather than on a CD-ROM to facilitate use and sharing of information. One company, a QS practice had placed the toolkit on their intranet thus turning it into a company wide application. All users claimed tool B to be a useful teambuilding and project evaluation tool and it had been successfully used on projects. Tool C proved to be less well accepted for a number of reasons including:

- The generic approach meant a substantial amount of measurement needed to take place before the costing worksheet could be completed
- There was some confusion over how to define the traditional option
- Different users had different requirements from the output and felt the generic approach prevented them from getting an answer appropriate to their specific view or role

Table 2: Factors to Consider When Measuring Project Costs

Project Costs (measure in £)

Category	Items	Details and Measurement
Site Prelims	Health & welfare facilities	Proportion of costs of Health & welfare facilities for the element
	Site office facilities	Proportion of costs of site office facilities for the element
	General site overheads	Proportion of any further site-set-up cost items (e.g. hardcore provision round site for access)
On-site Logistical Costs	Storage (Site Constraint)	Storage costs off-site, or proportional costs for on-site storage
	Vertical movement (Site Constraint)	Proportion of costs of any cranage, or other lifting plant
	Horizontal movement (Site Constraint)	Proportion of costs of any horizontal movement plant, or other equipment
Overheads (may be included in Professional below)	Head office overheads	A proportional cost item based on the cost of the element/package against project cost or turnover as appropriate
	Manufacturing facilities	A proportional cost item based on the cost of the element/package against project cost or turnover as appropriate
	Other	A proportional cost item based on the cost of the element/package against project cost or turnover as appropriate
Professional (design, plan, manage)	Design costs	Design, professional and associated costs for the element/ package (may be proportional)
	Planning costs	Planning, professional and associated costs for the element/ package (may be proportional)
	Contract & Tender costs	Contract, tendering and associated costs for the element/ package (may be proportional)
	Management costs	Project/Contract Management and associated costs for the element/ Package (may be proportional)
Other & complex project costs	Health, Safety and Security Costs (Health & Safety)	Potential cost implications of Health & Safety measures on the project, apportioned to the element (e.g. air-bags for roof workers)
	Environmental-related Costs (Sustainability)	Potential cost implications of Environmental measures on the project, apportioned to the element (e.g. landfill tax)
	Respect for People (Sustainability)	Potential cost implications of Personnel-related measures on the project, apportioned to the element
	Incidental costs and claims	Any other costs of the project, apportioned to the element (e.g. loss of revenue claims from neighbouring businesses)

- A number of people felt the tool did not allow project specific detail to be considered adequately
- There was considerable opinion that the only part that provided meaningful information was the costing worksheet
- There was some doubt that the cost implications were still fully accounted for. Intuitively companies felt they were saving money by using prefabrication but were unable to actually identify where or what those savings were.

As the follow on study evolved it became clear that there are several major issues confronting the research team mainly revolving around the need to demonstrate benefit as cost saving. The first of these is that the attitude towards benefit/cost depends largely on the perspective of the organisation and its position within the supply chain. This attitude is strongly influenced by the procurement strategy in place and the interest in cost is a means of maximising profit not increasing benefit. Without increasing profit, there is little incentive for companies to promote changes. It was felt, although not proven, that the improved cost certainty offered by prefabrication reduced the opportunities to increase profit frequently embedded in traditional procurement and construction methods. These methods permit change and uncertainty and require as a result risk contingencies to be built into the contract sum and provide vehicles for increasing the Client's expense.

Table 3: Factors to Consider When Measuring Project Life Cycle Costs (source Flanagan and Norman 1991)

Project Life Cycle Costs (measure in £)

Category	Items	Details and Measurement
Capital Costs	Land, taxation and related costs	Land acquisition, taxes and related costs
	Demolition & site clearance (if applicable)	Demolition and site clearance costs
Opportunity Costs	Costs associated with loss of opportunity	Costs associated with choosing one option for investing capital over another. Typically loss of revenue would fall into this category, e.g. longer project durations mean possible losses in revenue
Finance Costs	Finance costs	Finance costs for land purchase, construction, during intended occupation etc.
	Loan charges	Public sector costs
Operation Costs	Fuel	Fuel costs apportioned to element as appropriate from gas, oil, coal, electricity, other
	Cleaning	Costs of cleaning and maintaining cleanliness within the facility
	Rates	General rates
	Insurances	Various insurance costs
	Security and health	Security, pest and dust contra-costs
	Staff	Building operations staff costs
	Management and administration of building	Facilities management costs and fees
	Land charges	Land-related charges and rentals
Maintenance Costs	Element-specific	Complex maintenance issues and costs related to bespoke modules
Salvage & Residual	Resale value	Resale values (or costs)
	Related costs	Related costs
	Capital gains tax	Capital gains tax

Table 4: Factors to Consider When Measuring Time

Time (measure in hours, days or weeks)

Category	Items	Details and Measurement
Off-site and pre-construction activities	Design, planning, procurement duration [before manufacture]	Duration of all pre-construction phases of the project relevant to the element
	Off-site manufacture	Duration of off-site module manufacture, including lead-times
On-site activities	Site establishment	Duration for site establishment and set-up for entire project (as influenced by the specific element)
	Installation/construction	Duration of on-site installation/construction of the building, whether modular or traditional
	Commission/test	Duration of commissioning and testing stage for the modules, and the entire facility
	Rectification (snagging)	Duration between practical and final completion

All measured in time units of weeks days or hours; any costs associated with these items must be included in the cost evaluation worksheet

Table 5: Factors to consider when Measuring Quality

Construction/manufacturing quality (compare as significantly better, moderately better, similar, moderately worse, significantly worse or not relevant)

Category	Items	Details and Measurement
Level of quality	Grade of finish	Level of opulence or grade of the product
	Tolerance levels, Accuracy to design	Tolerance or variances of the product, closeness to design specifications
	Assurance/Consistency	Degree of certainty of product quality during manufacture or construction
Defects and damage	Number of defects [non-conformance notices]	Failures to achieve the specifications, or damage to the product before final completion
	Susceptibility to damage	How easily can the product be damaged, particularly after manufacture
	Severity/degree of damage rectification	Level of damage during installation or before hand-over, that can be repaired locally (as opposed to requiring a new pod, or substantial replacement)
Customer Requirements	Aesthetics	Visual appeal of the completed product, and/or the process
	Complaints	Client and user complaints of the product
Information Management and flow	Design information flow and management	Quality of information, its flow and management through the design process of the product (e.g. measure the number of revisions)
	Manufacture/Construction/installation information flow and management	Quality of information, its flow and management through the manufacture/ construction/ installation process of the product

Life Cycle Quality: (compare as significantly better, moderately better, similar, moderately worse, significantly worse or not relevant)

Category	Items	Details and Measurement
Performance and Functionality	Predictability/reliability of the component	Predictability of the performance and life of the product
	Fit for purpose	Subjective measure of the 'fitness for purpose' of the product
	Flexibility for future use [future-proof]	Adaptability of the product for changes to accommodate future trends in technology, or changes to facility's use or configuration

Contracting costing systems frequently work with a number of different costs depending what the data is being used for. For example the cost of a piece of sub-contract work will have a target cost and an outturn cost, additional costs are added to this to cover contract matters and a final set of costs will exist as a target for comparison with the outturn cost. The outturn cost may cover exactly the same resources, managed and/or negotiated down or up, or may include entirely different resources. In addition to this, there may be the (lump sum) price charged for the work which may be as the tender or not, depending on the circumstances. It is not unheard of for a company to make its main profit through the activity of purchasing of materials. The question of reliability of cost data is a major issue on complex projects which evolve during the construction process. This evolutionary process itself militates against meaningful cost reconciliation enabling cost to be allocated to activities and events where the final construction output may be so different from the starting point (the tender) as to render comparison impossible. This results in some costs remaining unallocated and even unrecoverable across the supply chain. There are also costs incurred which are never actually counted such as non-productive time for staff and directly employed labour and a whole host of wasted resources lumped under overheads. These are important considerations for any improvement or change initiative which so often has to provide cost evidence before a company will implement it.

All people contacted claimed the toolkit made them think much more deeply about the various issues and frequently referred to it as a check list of items to discuss and define throughout project planning and execution activities, even if they did not enter data. In this respect, the toolkit was well received and considered a valuable decision support tool.

Table 6: Factors to Consider when Measuring Health and Safety Benefit

Construction and Manufacturing (measure as significantly higher, moderately higher, similar, moderately lower, significantly lower or not relevant)		
Category	**Items**	**Detail and Measurement**
Health and safety ratios	Persons on-site	Number of personnel on-site involved with construction or installation of the modules
	Ratio of on-site versus off-site operations	Measure of the number of operations performed on-site against those done off-site. A crude measure of activity level on-site, as opposed to the safer, comfortable off-site environments
Safety	Persons working in difficult or dangerous conditions	Measure of persons working at height and requiring harnessing by statute, or working in ground or trench deeper than 1m etc.
	Housekeeping	Degree to which activity and process contribute to site waste and untidiness. Cleaner and neater activities (as with S&P) generally provide a safer working environment.
Health	Chronic health risks arising from processes	Exposure to any hazardous substances within the ground or on the site
	Noxious material exposure risk	Exposure to any noxious materials such as asbestos, solvents etc.

Life cycle health and safety (measure as significantly higher, moderately higher, similar, moderately lower, significantly lower or not relevant)		
Repair, maintenance and replacement	H&S Ratios	Ratios of personnel and operations involved with repair/ maintenance/ replacement of the modules
	Safety	Measure of persons working in dangerous situations and the level of site cleanliness during repairs/maintenance
	Health	Measure of chronic health risks and noxious materials exposure during repairs/maintenance
Demolish and decommission	H&S Ratios	Ratios of personnel and operations involved with demolition/ decomm. of the modules
	Safety	Measure of persons working in dangerous situations and the level of site cleanliness during demolishing or decommissioning
	Health	Measure of chronic health risks and noxious materials exposure during demolishing or decommissioning

CONCLUSION

It can be seen from the tables that many of the items listed are not currently recorded in any meaningful way. One of the principle findings from the trials of the toolkit is that it changes the way construction practitioners think about the information they collect on future projects. Conversely, the differences between the data required and the data actually recorded means some substantial changes in existing information management processes. Without this change, meaningful comparison will continue to be inhibited by a lack of data and design decisions will still be made on intuition with direct cost issues an influencing factor. The IMMPREST toolkit can help to overcome these problems by directing the design team through the decision making process and by influencing the type and quality of data collected from projects. There is a real need to unpick the complex costing issues surrounding the construction process although the success of this activity will depend largely on the procurement strategies in place. Modern methods involving framework and open book approaches will facilitate this but identifying the cost issues embedded in less collaborative approaches will prove challenging.

The research team at Loughborough are continuing work into this and many other issues surrounding prefabrication and preassembly not least through their current involvement with the Build Off-Site Initiative in the UK and as part of their Rapid Construction research theme under the Innovative Manufacturing and Construction Research Centre funded by the EPSRC.

Table 7: Factors to Consider When Measuring Sustainability (based on M_4I)

Sustainability Issues (measure as significantly higher, moderately higher, similar, moderately lower, significantly lower, not relevant)		
Category	**Items**	**Details and Measurement**
Sustainability	Ecological impact	Impact of the project to the areas habitat and wildlife
	Energy consumption	Level of consumption during the construction phases of the project, and during operation (indicator of the energy-saving measures incorporated into the design)
	Water consumption	Level of consumption during the construction phases of the project, and during operation (indicator of the water-saving measures incorporated into the design)
	Waste	Degree of waste management in design, and during construction. E.g. waste minimisation, segregation, recycling, re-use etc.
	Materials	Choice of materials based on criteria such as design, quantity, production, transport, product life, environmental impact etc.
	Transport	Impact of transport through fuel consumption and pollution; Number of deliveries to site, size of vehicles, type etc.
	Physical pollution	Air, water and land pollution, both during construction and throughout the whole life
	Community pollution	Noise and light pollution on the community both during construction and throughout the life of the project
Social	Local residents and community groups (Site Constraints)	General impact upon the local community

IMMPREST also contains a Respect for People section under sustainability

Table 8: Factors to Considering when Measuring Site Benefit

Site Issues (measure as high, moderate, low or not applicable)		
Category	Items	Details and measurement
Site space & storage	Site space available on site for movement, storage etc.	An assessment of the space available on site for general movement, storage, assembly etc.
Multi-trade interfaces	Number of trades that interact within a restricted area	A relative measure of the number of different trades that would work within the same spaces on a site; Presumably better planned in a factory environment Level of coordination required between the trades and elements constructing the structure; dependant on complexity of structure and the number of trades; Increases the possibilities of conflict and wastage
Skilled labour	Availability of skilled on-site labour	Skilled labour required on-site, reflecting the labour requirements of the manufacture or installation process; Some sites may have great difficulty in obtaining skilled labour; Skills differences between different processes should be highlighted
Access to site (incl. Delivery)	Accessibility for vehicles and personnel to and onto site (physical and security)	Vehicular accessibility to the site, through traffic, roads etc. Accessibility for products and personnel on sites with heavy security restrictions.
Live working conditions	Restrictions to on-site work by facility remaining functional during construction works	Extent to which sites continue to operate as on-going facilities during construction and their restriction on construction (e.g. commercial premises, prisons, airports, schools etc.)
Movement of units on-site	Availability of suitable moving equipment	Restrictions imposed by the available site equipment, such as reach, maximum loads etc.; especially relevant to modular construction
Restrictions	Restrictions on site work by external parties (Sustainability)	Restrictions on site or factory works by other parties such as neighbouring residents, local authorities etc.
Other	Other relevant site-related constraints	

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