LEAN LOGISTICS: HELPING TO CREATE VALUE BY BRINGING PEOPLE, INFORMATION, PLANT, EQUIPMENT AND MATERIALS TOGETHER AT THE WORKFACE

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ABSTRACT

In the early days of IGLC, logistics was covered in the *Supply chain **and logistics** management* championship. Recently logistics *per se* has disappeared from the list of championships. It was clear from comments at the 2007 mid-year meeting that those present felt it had been correctly subsumed in the current *Supply Chain Management* theme. Work with constructors suggests that the logistics function is just as important as managing the assembly processes at the workface and needs focused attention.

Taking Baudin (2004) as a starting point, *lean construction logistics* is defined as "all the operations needed to deliver a structure or building, except for the making/assembly of the structure or building". An examination of IGLC papers mentioning logistics against this definition suggests that up to now construction logistics is too narrowly cast. A case is made for a separate championship of *Construction Logistics* within IGLC and a distinct discipline of *Construction Logistics* within Construction Management education.

This study draws on a variety of experiences of construction logistics in the UK, makes links to nD design, Last Planner and other lean tools and examines the contribution that Construction Logistics can make to optimizing the end-to-end construction process while minimizing waste and energy use. It concludes that the Last Planner System is first and foremost a *Logistics Planning System*.

KEY WORDS

Lean Construction, Lean Logistics, Construction Logistics, Logistics Planning.

INTRODUCTION

Once upon a time people assembled locally available materials and came together to create shelters and roads, windmills and barns—whatever the family or community needed. In those days there was no shortage of land, there was no hurry and if they ran out of materials it wasn't generally a problem – there were still hens to feed, cows to milk and fields to tend. In many part of the world life is still like that.

But—in areas where construction labour is specialized, in short supply and on piece rates; in big cities where sites are tight and in remote places with a requirement for high technology building—getting materials, people, information, machines, plant and equipment to the workface just-in-time is critically important to project success.

Chambers Dictionary (1972) defines *logistics* as "art of movement and supply of troops" & SOED (1970) as "art of movement and quartering troops (i.e. quarter-master's work)". Baudin defines lean logistics as "*all the operations needed to deliver goods or services, except making the goods or performing the services*" (2004, 10) hence my

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definition of *construction logistics* as "***all the operations needed to deliver a structure or building, except for the making/assembly of the structure or building***"

As one of the reviewers of the abstract for this paper noted (2007):

> *"Logistics is absolutely crucial to the building process as good logistics allow builders to get on with what they are good at – building, and not be too concerned with how the material actually arrives on site."*

I go further—good logistics is concerned with how *people, information, equipment* as well as *materials* arrive at the *workface* able to create value in *safety and comfort* (i.e. the movement, supply and welfare of builders). All of which is good for productivity as Bertelsen & Neilsen (1997) assert:

> *"Studies of logistics show that a substantial increase in productivity can be obtained by delivering building materials … 'just in time' and 'packed for the work process'. The additional cost … can easily be covered by the savings gained on the construction site."*

This paper makes a distinction between supply chain management, project team management, project logistics and the value-creating *building assembly process*:

building assembly (or construction)	the transformational work that creates value for the end user/client/owner by joining together the elements of the building or structure in a particular sequence —this is principally an assembly or a layering process whether it is in the creation of a building or in civils type projects such as roads, railways, dams, channels, etc.
project logistics	creating no value *per se*, it is a process of aligning the operations needed to deliver a structure or building, except for the assembly work above
project team management	A socio/technical alignment process (within commercial realities) to build and maintain the team and the relationships that enable the execution of the project.
supply chain management	A social & commercial alignment process managed by a constructor to create a network (i.e. a *supplier association* or *keiretsu* (Hines & Rich 1998)) of well managed, viable specialists who understand that constructor's *modus operandi* and are available to work on present and future projects. In this definition supply chain management is essentially a development process—development that can occur both within and between projects; supply chain members tell each other about new technologies, working practices, and opportunities and collaborate on tenders and on negotiating future projects.

When these processes work well together the projects are completed with minimum hassle.

As we move towards integrated supply teams there will be an increasing overlap between *supplier association* and *project team* management processes but it will rarely be a 1:1 mapping—the skills required for different projects will almost inevitably vary and the individuals involved in delivering particular skills will change.

While some assert that logistics is part of supply chain management, Jones *et al* offer *lean logistics* as a *new way of thinking about the supply chain*. (1997, 170)

THE LITERATURE

I have looked at all the machine searchable papers delivered at IGLC conferences[2] that include the string "*logistic*". Of these, I have eliminated those that do not include *logistic* in the main text or the abstract. This leaves the following 23 papers:

Table 1: IGLC papers with significant explicit mentions of logistics

1996	1997	1998	1999	2000			2001	2002	2003	2004	2005						2006
Santos *et al*	Fowler	Auada *et al*	Conte Swain & Martin	Childerhouse et al	Holzemer *et al*	Howell & Koskela	London & Kenley	O'Brien et al	Arbulu & Tommelein		Arbulu *et al*	Bjornfot & Stehn	Emmitt *et al*	Hook & Stehn	Jorgensen *et al*	Khanzode *et al*	
1	2	2	1	5			0	2	0	0	10					0	

In these papers logistics predominantly refers to *materials* logistics:

[2] The IGLC items in this bibliography were identified in a Google search for "*logistic* or *logistics* or *logistical*" on 4 Mar 07 within www.iglc.net, www.ce.berkeley.edu/~tommelein/, http://cic.vtt.fi/lean/singapore/, http://www.iglc2004.dk, http://www.iglc2006.cl/, http://www.cpgec.ufrgs.br/norie/iglc10/papers/. This includes papers from 1996(1), 1997(2), 1998(2), 1999(3), 2000(5), 2001(6), 2002(11), 2003(5), 2004(3), 2005(), 2006(8).

Table 2: Predominant meanings of "logistics" in past IGLC papers—some relate to more than one use.

Predominant use	papers	example	#
Logistics and nD CAD	Khanzode et al 2005	Use of nD CAD enables *Evaluation of site logistics plans etc*. (Kanzode et al 2005)	1
Logistics as a separate *silo*	Arbulu et al 2005	*In traditional construction practice, work is done through functional silos such as planning and logistics. Typically, the planning department (or team) creates baseline schedules that drive procurement and logistics operations.* (Arbulu et al 2005)	1
Logistics as material supply/delivery	Bertelsen & Neilsen 1997 Bjornfot & Stehn 2005 Emmitt et al 2005 Fowler & Grey 1997 Holzemer et al 2000 Hook & Stehn 2005 Jorgensen et al 2005 Lessing et al 2005	*Specialty contractors may bring in their own materials handling and hoisting means. This enables them to de-couple their logistics activities at least to some extent from that of others.* (Holzemer *et al* 2000) *… our requirements in respect of site logistics i.e. access, storage, site accommodation, build sequences, etc. and the implications of any of these not being available on site.* (Swain & Martin 1999) BAA T5 logistics Centres (Arbulu et al 2005)	9
Logistics costs (material)	Childerhouse et al 2000 O'Brien 2000	Childerhouse et al (2000) consider *inter alia* the effect of logistics costs on decisions about the extent to which it is reasonable to allow purchasers to customize their new homes	2
Logistics in relation to site production/ operations	Fowler 1997 Santos et al 1996 Swain & Martin 1999 Vrijhoef & Koskela 2005	*The organisation of production and the supply chains is strongly aimed at the convergence of logistics to one site* (Vrijhoef & Koskela 2005);	4
Logistics in relation to supply chain management	Arbulu & Tommelein 2002 Arbulu et al 2005 Childerhouse et al 2000 Emmitt et al 2005 Lessing et al 2005 London & Kenley 2000 O'Brien et al 2002	*SCM focuses on the SC itself and aims to reduce costs, especially those related to logistics, lead time, and inventory.* (Arbulu & Tommelein 2002) *Construction research involving the supply chain concept is … evolving with … influences from the logistics, systems engineering, organisational theory fields*. (London & Kenley 2000) *From a logistics and transportation perspective, SCM is seen as the management of materials, products, and information flow*. (Lessing et al 2005)	6

Predominant use	papers	example	#
Logistics roles & responsibilities	Auada et al 1998 Conte 1998	… *the contract manager began to be responsible by the operational performance of the enterprise under his responsibility, as well as the management of the planning, services schedule and the logistic of the fronts of work.* (Auada et al 1998) *The engineer must assume the responsibility of administering the enterprise as a whole, guaranteeing the necessary logistic support, so that the foreman is able to succeed in his mission*. (Conte 1998)	2
Multi-project resource allocation	O'Brien 2000	*These firms must consider the switching and logistics costs of moving resources between projects*, (O'Brien 2000)	1
unclear	Howell & Koskela 2000	… *the rolling schedule is out of contact with the planning and logistics systems that provide the wherewithal to do work.* (Howell & Koskela 2000)	1

LOGISTICS IN PRACTICE

What follows is based on reading, observations and conversations with practitioners working at various points in the end-to-end construction process.

Bertelsen & Neilsen (1997) state:

> *"If … one looks upon today's logistics in the building process from the builders' point of view it is hard to find any strategy at all. As a matter of fact, the logistics far too often seem to be based on the Oops!-principle i.e., ordering and deliveries take place when the production comes to a halt due to lack of the materials required. This means not only frequent delays and loss of time but also additional costs caused by express deliveries. Another strategy seems to be: 'get it as cheap as you can',*

CONSIDERATION OF LOGISTICS ISSUES IN DESIGN

A number of conversations have related to the inadequate consideration of logistics during design. This has implications for buildability and ultimately for cost. In one instance the design involved a significant roof overhang close to the edge of the site. The design of the roof and overhang structure meant that that had to be installed before the vertical cladding panels so that it was not possible to crane 3-story high panels into place. The panels therefore had to be made in sections and lifted into place from the ground at a significantly higher cost—and with more opportunity for a leaky envelope.

Early constructor involvement

More training for architects is not the answer—we might expect them to be aware of logistics, but there are many more issues demanding their attention as buildings and codes become more complex. Involving constructors in design is one way to get logistics considered at the design stage. This requires that we move away from Design-bid-build procurement to more collaborative forms that enable the logistics plan to emerge with the design.

nD design

n-Dimensional design (BIM) will support this process when time becomes one of the dimensions. nD CAD packages can enable the design & construction team to look at the

organization and management of both the construction sequence and the site well before construction starts. A recent LCI Annual Congress heard how disaster was prevented in this way on the Channel Tunnel Rail Link in Central London—the contactors had a 51-hour window over a weekend to carry out a complex operation to divert a river and a sewer without affecting weekday commuter trains. A virtual rehearsal revealed that, as designed, the pre-cast elements would not fit. A simple re-design put this right and the project was delivered in 36 hours. (Koerckel 2005).

According to Lachmi Khemlani (2005):

> *"The current 2D mode only creates an adversarial relationship between the architect and the contractor, whereas the use of BIM will allow for more collaborative, integrated design-construction teams. BIM is a revolutionary, not an evolutionary technology, which requires a complete rethinking of how we practice architecture."*

Other logistics benefits accrue from moving to nD Design. More accurate counts of materials are possible with object-oriented software, reducing logistics as well as materials costs. At Westbury, a UK house-builder, recently acquired by Persimmon, each estimator used to take-off cavity brickwork in their own way–there was no standard process. After they installed BIM they discovered they had been paying brickies for $10m^2$ more external brickwork than was needed to build one of their more popular house types.

INFORMATION

Information is crucial at the workface—operatives and managers need it to know the conditions of satisfaction for the work to be done. Time and again late or defective information is a reason for delayed delivery of promises. Often operatives and managers complain that too much information has been provided or that it is not in a convenient format. Who takes responsibility for finding out what information is needed, in what form, by whom and when? This is a role for the logistics team in my view.

PEOPLE

At Heathrow T5 getting people to site was a major constraint on material logistics. With up to 7000 people on the project and access restricted to a single bridge with one lane in each direction, early in the process someone realised that logistics was *the* major constraint. On-time completion required two vehicles a minute to cross the bridge every hour the site was open. Constructor operated buses collected and security checked operatives from up to 40 miles away and dropped them off at their workface. Buses also operate from tube stations and off-site car parking (*see* Pearson 2004). With that size of workforce significant welfare and office accommodation is required on site. WCs were provided close to every workface to maintain value creation time (and help operatives on piece rates make good money). All this required managing and T5 has a number of logistics teams.

CONSOLIDATION CENTRES

For some time now construction operations on confined sites have paid great attention to logistics. With nowhere to store materials and space for site accommodation limited, they've had no choice. Many involved in such projects have commented on how much better such projects have gone, yet seem to revert to business as usual when they no

longer need to plan to the same degree because there is more space on site. One of the benefits of the planning is that materials are more likely to arrive just-in-time and can then be moved direct to the workface. This in turn reduces the opportunities for materials to be damaged, stolen or to obstruct operations and require moving once, twice or more before reaching the workface.

The use of consolidation centres in UK construction is growing. The role of a consolidation centre is to receive materials for one or more sites and then to deliver them as required to the sites. Terminal 5 at London's Heathrow has its own and in East London one centre, the London Construction Consolidation Centre (LCCC), serves 4 central London sites. The latter delivers at least daily to the sites it serves in quantities aligned to project requirements. There have been significant benefits to the sites in addition to the just-in-time delivery—materials are inspected on receipt at the centre [damaged materials are returned] and stored in a warehouse until they are required so arrive at the workface in good condition; as much packaging as possible is removed before materials go to site so that there is less to dispose of [and because materials are not subject to external storage they can be delivered to LCCC with less packaging]; because final deliveries only travel a few kilometres from the consolidation centre arrival times are more predictable [3].

The decision to use a consolidation centre may have implications for design as well as be influenced by it—another reason for involving the constructor at an early stage.

Material variation

In the groundwork and civil engineering phases of a project materials tend to be high volume and low variety—cement, aggregates, rebar, shuttering. At fit-out time materials are high-variety low-volume items that need sensitive handling to preserve the finishes the customer will see and feel. The material logistics operation needs to be able to handle both of these extremes and everything in between. All are required just-in-time. On many sites, e.g. housing, some groundwork operations will be going on alongside fit-out work.

OFF-SITE FABRICATION

The T5 consolidation centre provided somewhere warm and dry for operatives to produce rebar cages for just-in-time delivery and installation on site. As well as providing ideal conditions for making the cages, this reduced clutter on site, improved the quality of cages and meant that large volumes of air were only transported a few hundreds of metres.

REVERSE LOGISTICS

Just as important for building operatives and the site is the removal of waste [e.g. packaging, defective, unused, damaged and part-used materials, contaminated and toxic materials]. This is known as reverse-logistics. In the UK later this year all projects of over £200k (~US$400k) will have to prepare a simple site waste management plan showing where and how all waste streams will be appropriately and safely disposed of.

The LCCC is unable to remove packaging and other waste from site because they have chosen not to have a waste licence. They have though developed a significant sideline in refurbishing and returning pallets.

[3] There are wider societal benefits too such as reduced traffic movements in central area sites, significant savings in Carbon emissions (Blumenthal 2006)

There is now considerable attention being paid in Europe to the identification of waste streams as resources for others. This is another role for the logistics team and a potential source of income.

SKILLS SHORTAGES

Who organises logistics if there is no logistics team? Generally it is specialist constructors with the support of the main constructor and often skilled trades people will be expected to put down their tools and load out a floor or even help unload a delivery vehicle. Bertelsen & Neilsen (1997) quote a Swedish study (Hammarlund 1989) showing that around a third of operative time on site is spent "procuring materials"—equivalent to ~10 percent of the total building cost.

In UK we have significant shortages of skilled crafts people. We need them creating value at the workface. Others—a logistics team for example—can do everything else.

There are shortages of construction management skills too—people who understand how a building goes together, how to manage a project. If there is no dedicated logistics team their attention is drawn away from how the building is put together and how that process can be improved to all the logistics issues.

LOGISTICS AND SAFETY

Good logistics will have the minimum of materials on site awaiting assembly[4]. This makes it easier to keep the site clean and tidy and reduces opportunities for slips, trips and falls. An effective logistics team will pay attention to the maintenance of plant and equipment.

Earlier I wrote "good logistics is concerned with how people, information, equipment and materials arrive at the workface able to create value in safety and comfort." For me this includes aspects of ergonomics—ensuring that operatives have healthy access to the workface and comfortable workbenches, tools and equipment to do the job (*see e.g.* Court et al 2005)

LAST PLANNER

So far I have focussed primarily on materials logistics. But what of the remaining seven flows on which the MakeReady checklist in Last Planner[5] is based. Table 3 lists all seven flows with examples in both design and construction

As with *Materials*, moving *People*, *Information* and *Equipment* to the workface creates no value. Value can only be created when they all come together at the workface. Getting them there—and ensuring that they can remain there—is a logistic function.

External conditions are outside the control of the project team—but they can be anticipated. *Space* is primarily about safety and reducing uncertainty.

Prior work will generally be the only value-creating step.

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4 This can have positive implications for cash flow too.

5 For a general description of Last Planner see Mossman (2005)

Table 3: the seven flows[6]

	Flow	Example in Design	On-Site construction
1	**Materials**	Do I have the cheque to go with the building warrant application?	Do I have the bricks, mortar, ties, etc. to build this wall?
2	**People**	Do I have the staff to do the work?	Do I have the operatives to do the work?
3	**Info**	Do I have the information I need to do this task to the required standard? – brief; planning guidance; site investigations; etc.	Are all the drawings, contracts, method statements complete and RFIs answered so that I understand the conditions of satisfaction?
4	**Equipment**	Do I have the CAD systems, number of workstations, meeting rooms; etc to complete the task?	Will I have access to the tools, scaffolding, scissor lifts, hook time, forklift, etc. that I need to complete the task?
5	**External conditions**	Planning authority; building warrant approval; land acquisition	Weather; building inspector; NHBC inspector; utility provider
6	**Space**	will I have control of this aspect of design or are other people going to working on it simultaneously?	Will I have safe access to the work space to do the work?
7	**Prior work**	Is the design for the superstructure complete so foundation design can be started?	Is the wall built so that plastering can begin?

It may not be for the logistics team to chase late delivery of *prior work,* but the logistics team need detailed knowledge of when work is completed, when delays are likely or have occurred so they can ensure that the right materials are ready for each crew *when* they *are* ready to work.

As Bertelsen has noted (2005, my emphasis) *"The complex nature of construction causes often great variability in the flows, not least the flow of work but also other flows such as information, crew, materials and space. One approach is to better manage this variability, where* ***situation based management methods such as last planner have proven efficient."***

It is for these reasons that I suggest LPS is primarily a *Logistics Planning System*.

Measures of the effectiveness of logistics processes

- Percentage of tasks made ready on time
- Time spent waiting by people, by materials
- Itemised cost of delivery
- End-to-end cost
- Delivery delay time
- Area used for storage – planned vs. actual
- Walking distances

[6] based on a list produced at the IGLC mid-year meeting in UK, February 2006. Did the original list come from Lauri Koskela?

LEAN LOGISTICS

Table 4 is adapted from a logistics manual prepared for the German construction company Kőster (Mossman *et al* 2006). This manual sets out the key responsibilities subsumed under logistics using the Baudin definition (2004)—materials of course, but welfare, safety, waste, environment, information and much more besides. The manual recognizes that some elements may be covered under other headings and that any construction logistics plan is likely to develop iteratively alongside the design and the assembly process.

In lean terms, none of these elements create value for the end-user/client/owner but the value creation process cannot be completed without them (see Mossman forthcoming).

Table 4: potential elements in a lean logistics plan

Element	Details
Health and Safety Management	how the site manages the health of the workforce and addresses any particular issues that could affect individual or site safety and health.
Procurement	how project procurement is managed, who has authority and who is responsible
Site Security	how security of site, materials, equipment, operatives, neighbours and future users is managed.
Traffic Management	arrangements for the movements of vehicles on and in the vicinity of the site
Administration Offices	providing for administrative and technical staff who need to be based on or very close to the project site during construction
Site Housekeeping	how equipment and materials on site will be stored safely and securely; how the site will be kept clean and tidy and how that will be paid for.
Environment Management	how sensitive aspects of the environment will be cared for whether they are flora, fauna or parts of our archaeological or architectural heritage
Site Waste Management	how surplus resources and waste will be managed both on and off site.
Insurance	How the project is insured and how the insurer(s) interests will be protected
Information Management	how information will flow to the workface; to suppliers and from the project to neighbours, the community and to other stakeholders
Personnel Management	facilities provided for the workforce and their management.
Materials Management	how materials move from source to workface and how surpluses and waste are moved back from the workface; takes account of the different characteristics of materials and of the constraints that affect their movement.
Site infrastructure	temporary and permanent drainage, water, electrical and compressed air supplies
Plant, tools & equipment management & maintenance	the demand and how it will be satisfied.
Payment Systems	procedures for keeping money flowing.

SITE SECURITY

One of the motivations for setting up the LCCC was to pilot security measures to protect the London 2012 Olympics site. The two large IRA bombs in London were both delivered by construction vehicles and by limiting the vehicles going to site to those

carrying steel, bulk materials and those from the consolidation centre opportunities for a terrorist attack are significantly reduced.

Writing in *Building* on 13 Apr 07 (p. 62) David Gill, MD of Linx International, a security and risk management consultancy, reported (my emphasis) :

> "The National Plant and Equipment Register (TER) reports that plant and equipment theft rose 20% in 2005 to £43m. …. *Construction sites are easy targets for thieves. Most have poor perimeter security, inadequate lighting, a lack of CCTV surveillance and insufficient inventory and asset tracking. Security personnel can be de-motivated and unlikely to be an adequate deterrent to an increasingly sophisticated and professional criminal fraternity who view construction sites as rich pickings …. …. **Site security, site safety and fire prevention need to be considered holistically** rather than as isolated issues. It is essential that all employees, including subcontractors, take seriously the need for security and take personal responsibility for equipment and plant. **Site security needs to be actively managed** and increased security awareness, the implementation of cost-effective security measures and adherence to clear policy and procedure will significantly combat the upsurge in crime on sites."*

I suggest that these are both project logistics team responsibilities.

MATERIALS LOGISTICS STRATEGY

In developing a logistics strategy it is important to strike a balance between

- resourcing to the volume, variety and value of the resources used in each of the three main stages in a project
- managing the project so as to level the peaks in volume, variety and value demands within any financial or other constraints.

To strike this balance successfully requires a deep understanding of both the project and the logistics demands. These and their impact on a materials logistics strategy are illustrated in the table below:

Table 5: Materials logistics strategy, stage of project and characteristics of materials (Mossman et al 2006)

	Civils, groundworks	**M&E, cladding, roofing, etc**	**Fit Out**
Character-istics	High volume, low variety, low value Few suppliers	Medium volume, variety & value more suppliers Some pre-assembly & off-site manufacture	Low volume, high variety, high value Large number of suppliers Many fragile items and items that need protection prior to installation Factory produced
Examples	Aggregates, rebar, cement, bricks, blocks,	Rolled steel sections, cladding panels, cabling, pipes, ducts, containment, insulation	Architectural ironmongery, specialist fittings, light fittings,
Strategy	Dedicated capital equipment Just-in-time production & delivery (e.g. rebar cages)	Concurrent supply routes Focus on high volume, high value and high criticality Just-in-time production & delivery	Factory produced Processes designed for speed of throughput Some load consolidation Centralised distribution in buildings

In reality all three stages happen simultaneously on all but the smallest of projects. This is particularly true of medium to large housing developments and major building projects. In each case it is important to understand the complexities, align all the activities and go for reliability of all the critical processes.

Making any strategy work requires:

- Increased reliability of delivery to site – there are many factors that can impede delivery including Manufacturing problems, Design delays, Long supply chains, Road (and rail) delays, Weather
- Eliminating the need for lay down areas at site – materials stored on site obstruct other operations and can be damaged, creating yet more delay.

DISCUSSION

All of the issues listed in Table 4 need active consideration during the design process, have important roles to play in *Last Planner* implementation and require the active involvement of at least the first- and second-tier members of the *construction* team from early in the design process. Some are, or will soon be, statutory requirements (e.g. Health and Safety Management & Site Waste Management Plans in the UK)

Having a skilled logistics team to manage these issues enables two things to happen:

- Skilled construction operatives can focus on applying their skills
- Construction managers can focus their attention on
  - supporting the skilled operatives to delivery quality work on time,
  - helping improve the construction *assembly* process

There are "green" benefits from sound logistics including:

- reduced requirement for packaging

- reduced waste of materials as less opportunity for them to get damaged[7]
- reduced delivery vehicles to site
- increased use of public transport by operative travelling to and from work

CONCLUSIONS

Building assembly and *logistics* are inter-dependent processes vital to the successful delivery of any construction project. *Supply chain management* covers more than managing the supply chain for a given project. Subsuming logistics within this much broader area means that it is less likely to get the attention it needs.

What thinking there has been about logistics in construction has tended to focus only on materials. Even the dictionary definition is wider than this—including the movement of people (troops) as well as providing their quarters. Accepting the even wider definition after Baudin and resourcing for it, frees building workers and managers to focus their time and effort on the delivering value for the client while others—the logistics team—ensure that everything else is in place to support the value creation process.

LPS is the vital link between the logistics team and building assembly teams. MakeReady and Production Planning support both key processes and PPC is at least as much a measure of *logistics* team effectiveness as it is of *building assembly*. (It is for these and other reasons that I believe that LPS stands for *Logistics Planning System.*)

Logistics deserves a front and centre position in the construction process. Without logistics we could not deliver our projects. With good logistics we can deliver projects (create value) more safely, more comfortably, at less cost and with less waste. I urge

- the lean construction community to consider a separate *lean logistics* championship for future conferences;
- construction educators to give joint top billing to *logistics* in Construction Management programmes and develop construction logistics MSc programmes.

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[7] LCCC highlighted the chronic over-ordering of materials. At practical completion of the first project 5% of the materials ordered were still on the LCCC shelves[7]! That is a lot of money when constructors' margins are less than 2%.

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