

# Site Implementation and Assessment of Lean Construction Techniques

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## Abstract

The goal of this paper is to test the effectiveness of some lean construction tools, in particular, those tools that can be applied in medium size construction firms. Due to the success of the lean production system in manufacturing, the construction industry has adapted lean techniques to eliminate waste and increase profit. A field study was conducted to evaluate the effectiveness of some lean construction techniques including last planner, increased visualization, daily huddle meetings, first run studies, the 5s process, and fail safe for quality. The data collection methods included direct observations, interviews, questionnaires, and documentary analysis. The effectiveness of the lean construction tools was evaluated through the lean implementation measurement standard and performance criteria. It was found that last planner, increased visualization, daily huddle meetings, and first run studies achieved more effective outcomes than expected. However, the results of implementation of 5s process and fail safe for quality did not meet the expectations of the tool champions and the research team. It was found that there is need for behavioral changes and training for effective use of lean tools. Most of the lean construction tools selected for the project are either ready to use, or are recommended with some modifications. A summary of the results is provided, and future research needs are outlined.

**Keywords:** Lean Construction, Last Planner

## Introduction

With the continuous decline in profit margins and increased competition in construction projects, construction contractors are continuing to search for ways of eliminating waste and increasing profit (Mastroianni and Abdelhamid 2003). Although numerous approaches have been developed to improve efficiency and effectiveness of construction processes, lean construction techniques offer the promise to minimize, if not completely eliminate, non value-adding work. Since the early 1990's, the construction research community has been analyzing the possibility of applying the

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principles of lean production to construction. Koskela (1992) introduced the idea of understanding construction as production. The International Group for Lean Construction (IGLC) has made significant contributions to the formulation of theoretical foundation for lean construction by abstracting the core concepts of lean production and applying them to the management of construction processes. Paez et al. (2005) indicated that the nature of the operation, planning, and execution are the key categories that emphasize the differences between manufacturing and construction. Due to these fundamental differences between construction and production processes, the tools of lean production can't be directly used to manage construction processes and a new set of tools is required. The Last Planner system of production control, introduced in 1992, which emphasizes the relationship between scheduling and production control, is the most completely developed lean construction tool (Ballard 2000).

Howell (1999) indicated that lean construction is similar to the current practices in the construction industry; both practices pursue better meeting customer needs while reducing waste of every resource. However, the difference between the current practices and lean construction is that lean construction is based on production management principles, and it has better results in complex, uncertain, and quick projects. One limitation to implementation of lean construction tools in the United States is the lack of investment in research from the construction industry. Banik (1999) stated that the construction industry is hesitant to invest in research and development to improve productivity. Lean construction currently is still in early stage of development. Tools such as Last Planner have been tested in the field and refined over last decade. However, tools such as Visualization, daily huddle meetings, 5S have not been extensively tested and concrete procedures for their implementation are being developed.

This study fills some of the gap in the literature by testing the effectiveness of lean construction tools. The following tools were evaluated: Last Planner, increased visualization, daily huddle meetings, first run studies, 5s process, and fail safe for quality and safety.

The first part of this paper reviews and discusses lean construction techniques and the second part presents a case study of "lean tools implementation and assessment". The effectiveness of the implemented lean tools in the field case study was evaluated, and future research needs were outlined.

## Last Planner System<sup>®</sup>

Ballard (2000) indicates that *Last Planner System<sup>®</sup> (LPS)* is a technique that shapes workflow and addresses project variability in construction. The Last Planner is the person or group accountable for *operational planning*, that is, the structuring of product design to facilitate improved work flow, and *production unit control*, that is, the completion of individual assignments at the operational level. In the last planner system, the sequences of implementation (master schedule, reverse phase schedules (RPS), six-week lookahead, weekly work plan (WWP), percent plan complete (PPC), Constraint analysis and Variances analysis) sets up an efficient schedule planning framework through a pull technique, which shapes work flow, sequence, and rate; matches work flow and capacity; develops methods for executing work; and improves communication between trades. It will achieve *Should Can Will* which is the key term in WWP (Ballard 2000). "Should" indicates the work that is required to be done according to schedule requirements. "Can" indicates the work with can actually be accomplished on account of various constraints on the field. "Will" reflects the work commitment

which will be made after all the constraints are taken into account. Various key contributions to improve the work flow are included: two-way communication, the constraints analysis process in six- week lookahead before assignments are executed, the analysis of reasons for variance after assignments are completed, the efforts of each planner, and the training of the project team. Traditional practices do not consider a difference between what *should*, *can*, and *will* be done, the assumption being that pushing more tasks will result in better results.

The important role of the Last Planner tool is to replace optimistic planning with realistic planning by evaluating the performance of workers based on their ability to reliably achieve their commitments. The goals of Last Planner are to pull activities by reverse phase scheduling through team planning and optimize resources in the long-term. This tool is similar to the *Kanban system* and production leveling tools in Lean manufacturing.

### **Master Schedule**

The master schedule is an overall project schedule, with milestones, that is usually generated for use in the bid package. Reverse Phase Scheduling (RPS) is produced based on this master schedule.

### **Reverse Phase Scheduling (RPS)**

Ballard and Howell (2003) indicated that a pull technique is used to develop a schedule that works backwards from the completion date by team planning; it is also called Reverse Phase Scheduling (RPS). They also state that phase scheduling is the link between work structuring and production control, and the purpose of the phase schedule is to produce a plan for the integration and coordination of various specialists' operations.

The reverse phase schedule is developed by a team consisting of all the last planners. It is closer to reality than the preliminary optimal schedule which is the master schedule. However, without considering actual field factors in the RPS, the RPS is less accurate than the WWP.

### **Six-Week Lookahead (SWLA)**

Ballard (2000) indicated that the tool for work flow control is lookahead schedules. SWLA shows what kinds of work a supposed to be done in the future. In the lookahead window, week 1 is next week, the week after the WWP meeting. The number of weeks of lookahead varies. For the design process, the lookahead window could be 3 to 12 weeks (Ballard 2000). All six-week-lookahead durations and schedules were estimated based on the results of the RPS, and constraints are indicated in order to solve the problems before the actual production takes place. SWLA is distributed to all last planners at WWP meetings. Lean lookahead planning is the process to reduce uncertainty to achieve possible constraint free assignments (Koskela et al. 2000).

### **Weekly Work Plan (WWP)**

Should, Can, and Will are the key terms in WWP (Ballard 2000). Weekly Work Plan (WWP) is produced based on SWLA, the actual schedule, and the field condition before the weekly meeting. Along with this plan, manpower from each trade will be adjusted to the need. The WWP meeting covers the weekly schedule, safety issues, quality issues, material needs, manpower, construction methods, backlog of ready work, and any problems that can occur in the field. It promotes two-way communication and team planning to share information on a project in an efficient and accurate way. It can improve safety, quality, the work flow, material flow, productivity, and the relationship

among team members. Ballard and Howell (2003) indicates that WWP should emphasize the learning process more by investigating the causes of delays on the WWP instead of assigning blames and only focusing on PPC values. Variance analysis is conducted based on the work performance plan from the previous week. The causes of variance should be documented within the WWP schedule.

### **Percent Plan Complete (PPC)**

The measurement metric of Last Planner is the percent plan complete (PPC) values. It is calculated as the number of activities that are completed as planned divided by the total number of planned activities (Ballard 2000). The positive (upward) slope between two PPC values means that production planning was reliable and vice versa. According to Ballard (1999), PPC values are highly variable and usually range from 30% to 70% without lean implementation. To achieve higher values (i.e., 70% and above), additional lean construction tools such as first run studies have to be implemented.

### **Increased Visualization**

The increased visualization lean tool is about communicating key information effectively to the workforce through posting various signs and labels around the construction site. Workers can remember elements such as workflow, performance targets, and specific required actions if they visualize them (Moser and Dos Santos 2003). This includes signs related to safety, schedule, and quality. This tool is similar to the lean manufacturing tool, Visual Controls, which is a continuous improvement activity that relates to the process control

### **Daily Huddle Meetings (Tool-box Meetings)**

Two-way communication is the key of the daily huddle meeting process in order to achieve employee involvement. With awareness of the project and problem solving involvement along with some training that is provided by other tools, employee satisfaction (job meaningfulness, self-esteem, sense of growth) will increase. As part of the improvement cycle, a brief daily start-up meeting was conducted where team members quickly give the status of what they had been working on since the previous day's meeting, especially if an issue might prevent the completion of an assignment (Schwaber 1995). This tool is similar to the lean manufacturing concept of employee involvement, which ensures rapid response to problems through empowerment of workers, and continuous open communication through the tool box meetings.

### **First Run Studies**

First Run Studies are used to redesign critical assignments (Ballard and Howell 1977), part of continuous improvement effort; and include productivity studies and review work methods by redesigning and streamlining the different functions involved. The studies commonly use video files, photos, or graphics to show the process or illustrate the work instruction. The first run of a selected craft operation should be examined in detail, bringing ideas and suggestions to explore alternative ways of doing the work. A PDCA cycle (plan, do, check, act) is suggested to develop the study: Plan refers to select work process to study, assemble people, analyze process steps, brainstorm how to eliminate steps, check for safety, quality and productivity. Do means to try out ideas on the first run. Check is to describe and measure what actually happens. Act refers to reconvene the team, and communicate the improved method and performance as the standard to meet.

This tool is similar to the combination of the lean production tool, graphic work instructions, and the traditional manufacturing technique, time and motion study.

### **The 5s Process (Visual Work Place)**

Lean construction visualizes the project as a flow of activities that must generate value to the customer (Dos Santos et al. 1998). The 5s process (sometimes referred to as the Visual Work Place) is about "a place for everything and everything in its place". It has five levels of housekeeping that can help in eliminating wasteful resources (Kobayashi 1995; Hirano 1996): Seiri (Sort) refers to separate needed tools / parts and remove unneeded materials (trash). Seiton (Straighten or set in order) is to neatly arrange tools and materials for ease of use (stacks/bundles). Seiso (shine) means to clean up. Seiketsu (standardize) is to maintain the first 3Ss. Develop a standard 5S's work process with expectation for the system improvement. Shitsuke (sustain) refers to create the habit of conforming to the rules.

This tool is similar to the 5S housekeeping system from lean manufacturing. The material layout is commonly used for acceleration of 5S implementation on the construction site. Spooore (2003) indicates that 5S is an area-based system of control and improvement. The benefits from implementation of 5S include improved safety, productivity, quality, and set-up-times improvement, creation of space, reduced lead times, cycle times, increased machine uptime, improved morale, teamwork, and continuous improvement (kaizen activities).

### **Fail Safe for Quality and Safety**

Shingo (1986) introduced Poka-yoke devices as new elements that prevent defective parts from flowing through the process. Fail safe for quality relies on the generation of ideas that alert for potential defects. This approach is opposed to the traditional concept of quality control, in which only a sample size is inspected and decisions are taken after defective parts have already been processed. This is similar to Visual inspection (Poka-Yoke devices) from lean manufacturing. Fail safe can be extended to safety but there are potential hazards instead of potential defects, and it is related to the safety risk assessment tool from traditional manufacturing practice. Both elements require action plans that prevent bad outcomes.

### **Research Methodology**

The field study was used as the research strategy in this project. Lean tools from IGLC were tested extensively in this research project. The study tested and evaluated six lean construction tools for possible improvements. They are last planner, increased visualization, daily huddle meetings, first run studies, the 5s process, and fail safe for quality. The data collection methods in this paper include direct observation, interviews and questions, and documentary analysis, and these three methods are applied to each of the tools. Observational data was collected directly from RPS, WWP, and huddle meetings, and the construction process. The Lean Construction tools or techniques and the methods that were used in the first run study and the productivity study were decided upon by the vice president of the general contractor (GC) and the Research Team (RT).

The RT was part of the team in Last Planner, daily huddle meetings, and first run study; but for the rest of the tools, the RT only monitored the process and results. Leaders and participants of Last Planner and Daily Huddle meetings were interviewed on both

weekly basis and at the end of the project. The champion of each tool evaluated the implementation of each tool. Records collected included:

- Last Planner: meeting memos and minutes, various forms of schedules, action tasks with duration, actual completion dates, constraints in six-week lookahead, reasons for not completing assignments as planned, and the results of interviews.
- Increased Visualization: photos, and documentation of the implementation process.
- Daily Huddle Meetings: meeting minutes and the results of interviews.
- First Run Studies: videos, photos, recommendations for productivity improvement from workers and staff, field observation data for crew productivity study, working procedures, and estimated and actual unit costs for the studied items.
- The 5s Process: photos, meeting minutes and the results of interviews.
- Fail safe for quality: SPA, photos, recommendations for quality improvement, the counter measurement of specific items that apply to this project, and the results of interviews.

## Background of the Field Study

The study focused on the first phase of a four-floor university garage project. This garage is a cast-in-place reinforced concrete structure; the structure to be built on top of the garage, a different bid package from the garage project, is a five story building that consists of a steel frame and reinforced masonry walls, designed for retail shops and dormitories. The size of the garage is about 133,500 sq. feet. Participating trades in the lean construction implementation study were limited to the general contractor (GC), the formwork subcontractor (SubA), and the rebar subcontractor (SubB). The GC is a mid size construction contractor with a substantial presence in Ohio, Kentucky and Tennessee. The top management of the GC firm has taken active interest in introducing innovative practices in the organization. They had introduced Last Planner as a planning tool prior to this study. The GC had, on an average seven staff and 26 workers each day on this project; SubA had 14 workers and SubB had 15 workers each day on the project. The Master Schedule of the project was divided into four levels: general conditions, underground utilities, phase I, and phase II. The durations were measured and based on five working days weeks. In the master schedule, the duration of the whole parking garage project was 171 days. The lean implementation focused only on phase I. The Master schedule for phase I had 105 working days, Reverse Phase Schedule (RPS) had 89 days, and phase I was completed in 81 days.

GC has been utilizing Last Planner in most of its projects; however, this is the first time that extensive usage of lean techniques such as Visualization, 5S etc. was made. To ensure successful implementation, a champion (the person who is the leader of the tool) for each one of the tools was chosen. The responsibilities of the champion were to implement the guidelines and provide feedback to the researchers.

Although all the tools have an impact on the overall project, two different teams were involved with each of the tools. The planners' team, led by the project manager, was focused on operational planning and controlling, and included GC's superintendent, the foreman, and the project engineer who was in charge of safety on site, as well as SubA and SubB. All members of the planners' team are called last planners. The workers' team, led by the carpenter foreman, was focused on the daily huddle meetings and included laborers and carpenters as well.

## Constraints and Solutions

Lean Construction is not widely implemented in the US construction industry yet, and lean concepts are relatively unfamiliar. For both GC's staff and subcontractors, this project was the first opportunity to use lean techniques for operational purposes. Changing mind sets and behavior with lean thinking became a challenge initially in this project, and these also had a great impact on the *5s process* implementation. To eliminate this barrier, the GC offered training classes, provided recognition to promote behavioral change, encouraged employee involvement and rewarded real improvement. As a result, the workforce showed a tremendous amount of learning and improving curves on lean thinking and implementation.

Initially monitoring and documenting this project was a tremendous challenge for the RT because the field personnel from GC, sub A and sub B showed little or no interest in the study. At the end of the first week, the researchers were told that they were prohibited from visiting GC staff's trailer and the job site for the duration of the project; the reasons given were that researchers were asking too many questions and were congesting the working area in the trailer. The RT was not introduced to the members of the project initially.

The unfamiliarity with or misunderstanding of lean concepts and implementation were the greatest barriers at the beginning of the project. The project manager reacted strongly, and wondered whether his management ability was being questioned. He frequently expressed to researchers that these additional management tools were not needed. Most of the Last Planners thought that additional management tools, which came from lean manufacturing, were not applicable to the construction industry. They also felt that the tools were unnecessary and had added too much to their work load. This resulted in initial incomplete implementation of all tools, and no constraints were indicated, low accuracy of constraints and variances were provided, no daily huddle meetings took place, and RPS was made for Phase I only.

This was overcome by offering training, providing recognition to promote behavioral change, encouraging employee involvement, and rewarding real improvement. With an enormous metamorphosis, the same members of this project seemed to completely change into a new set of active people. GC and its subcontractors all put in a great amount of effort to pursue good results and new management of this project, and they gradually improved and achieved higher accuracy in their own assignments.

## A Field Study - The Parking Garage Project

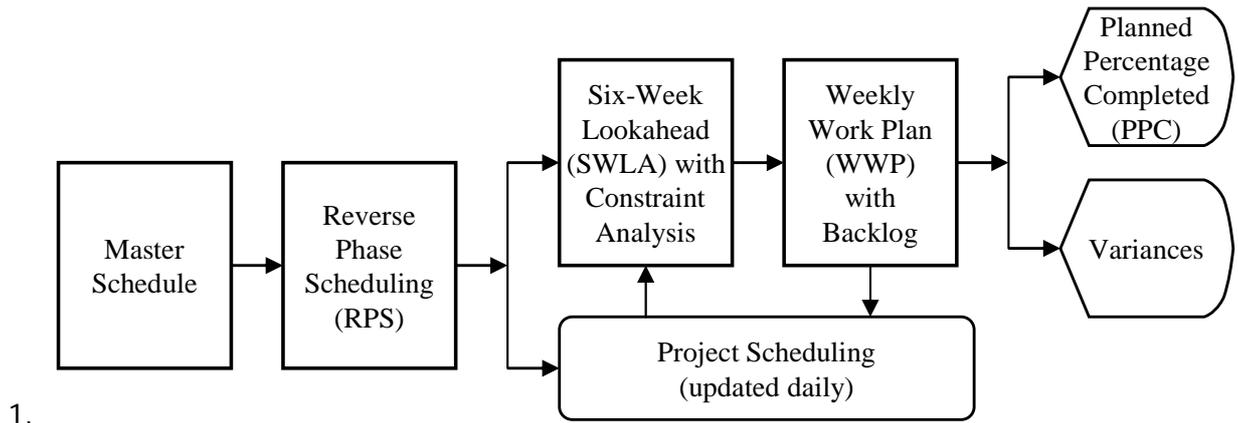
### Last Planner System<sup>®</sup>

In order to eliminate waste and achieve two-way communication, the traditional push-system scheduling technique was replaced by pull-system scheduling techniques and team planning. Figure 1 maps the sequence of the Last Planner process for this project.

Insert Figure 1

The process involved the following steps:

1. A master schedule was developed by the project manager which utilized a push-system approach and cumulative experience from similar projects; it included an overall schedule with all phases. The master schedule and drawings with pouring sequences were distributed to all planners and the rebar supplier before the Reverse Phase Scheduling meeting.



1. Figure 1: The Sequence of Last Planner Process

2. Before the Reverse Phase Scheduling (RPS) meeting, lean concept and Last Planner procedures were explained to all Last Planners. All Last Planners and the rebar supplier participated in team planning, and developed network of detailed activities for Phase I of RPS. One RPS meeting was conducted at the start of the project. Using a long sheet of paper on the wall and post-its, Phase I was split into activities with the feedback of all Last Planners. First, the planners wrote down activities, with their durations, on the post-its, one activity per sheet, and stuck those sheets on a long sheet of paper that was posted on the wall forming a timeline, from a target completion date backward. Next, all planners identified the logic between these activities and adjusted the sequences if needed by moving the sheets, and they discussed and decided which activities would dominate the critical path. Then, float, used as the schedule contingency, was added to the activities that were on the critical path and contained some uncertainty. The milestone of the master schedule was an important guideline for RPS production. Finally, the final schedule adjustment was taking the place. A detailed schedule was prepared and some constraints appeared. The RT observed the whole process and then produced an electronic RPS file from this new set of detailed schedule.
3. Six-week look-ahead (SWLA) is a six-week rolling schedule with constraints indicated. The project schedule updated daily which was adjusted from the actual project schedule. SWLA was produced by the project manager based on the results of the RPS and the project schedule. RT documented constraints with indication by the project manager, and performed the constraints analysis. SWLA was distributed to all last planners at WWP meetings.
4. The participants in the WWP meeting included all Last Planners and the RT. The meetings were held each Thursday. Each trade submitted its own upcoming week's schedule to the project manager on the day before the Weekly Work Plan (WWP) meeting. The WWP schedule, manpower, safety, 5S (clean-up and material lay down area issues especially), construction methods, delivery schedules, and any problems from the job site were discussed as part of the planning process during the meeting. Open and two-way communication was the key to the success of this meeting.
5. At the end of each week or on the following Monday, the researcher interviewed the project manager and documented the actual schedule for each activity that was performed. They then reproduced an electronically updated WWP schedule

and variance control table, and analyzed them. PPC charts and PPC calculations were also prepared by the researcher. The PCC calculation is based on the actual start and finish dates of activities. In addition to the overall Percent Plan Complete (PPC) of the project, individual PPC Charts for each trade were prepared to compare their individual progress. Each planner received both PPC charts during the WWP meeting.

### Increased Visualization

Combinations of visual signs were tested throughout the project, which are described below:

#### Safety commitment

- A safety meeting was held on the job site at the beginning of the project for staff and workers. The importance of safe practices for the company was emphasized and people gave feedback on different safe practices on the job site. A commitment to safety was signed by all attendants. The commitment was placed on the trailer where safety training is conducted for new workers.

#### Safety signs

- Workers provided new ideas and created safety signs in order to increase their involvement in the process. Workers brought forth creative slogans including "Keep an Eye on Safety", "GC Races for Safety". Signs were placed on different spots of Phase I/II, and at the gates of entry and exit.

#### Completion dates

- Milestones for Phase I and II were identified as results of the RPS, and the expected pouring dates were the results of the WWP meetings. The signs included the phase, pouring sequence, and the completion date for each floor. Drawings with pouring sequences were prepared for the workers and placed on their gang boxes. Signs were posted on the pouring pots for each floor of Phase I and II and were also placed on the retaining wall.

#### PPC Charts

- PPC Charts were prepared based on the actual schedules of WWP and the variances analyzed by the Project Manager. In addition to the PPC Charts for the overall project, separate charts by each trade were posted.
- Daily Huddle Meetings (Tool Box Meetings)

At the beginning of the project, a weekly informal setting for all foremen was conducted on the site and people gathered at the start of the day to review the work to be done. Throughout the project, two meetings were formally conducted: last planner for all foremen (GC and subcontractors) and the start of the day, a 5 to 10 minute meeting, for laborers and carpenters (this meeting was started the third week of this project). On a weekly basis, interviews were conducted with the leaders and participants of those meetings to identify potential benefits. The reliability of the questions was measured based on a test-retest (i.e., conducting the survey two times for validation) of 33 respondents. The correlation coefficient  $r^2$  averages were 76%.

## First Run Studies

Two first run studies were conducted. The first study was on bumper walls and the second one was on construction joints. RT followed the PDCA cycle (plan, do, check, and act) proposed as follows:

*Plan:* The activities were selected by GC based on target costs and variability. Drawings and specifications of each element were reviewed, and the foreman set the dates for the study based on scheduled activities. The foreman then reviewed the procedures with the RT before the actual action took place.

*Do the work:* Documenting the process was a stepwise activity because weather conditions and time constraints affected the schedule of activities; hence, at least two repetitions of the same elements were included for continuity. The video file helped to ensure all elements of the operation were included.

*Check:* Two meetings were held to describe and brainstorm the activities. During the meeting short portions of the video were introduced. The foreman, the project manager, and the workers who were involved with the study gave some ideas for improvement. The manager and foremen evaluated the feasibility of their ideas. A key component was the setting of the meeting which allowed workers to speak freely on how the work could be done better.

*Act:* Suggestions and potential improvements were added to the subsequent activities. Not all ideas came from the meetings, but the meetings helped formalize them and put them into action.

*Productivity Studies:* In addition to the video files, productivity estimations for the two activities were performed (Oglesby et al 1989, Mohamed 1996). The field data for the productivity study was recorded and divided into three categories: effective work (E), contributory work (C), and idle time (A). Productivity calculations were conducted by using productivity rating analysis, and labor-utilization factor (LUF), based on the crew balance chart which is the result of one-minute interval field observation data. The productivity rating LUF and field rating can be calculated as follows:

$$\text{Labor - utilization factor (LUF)} = \frac{\text{effective work} + \frac{1}{4}\text{essential work}}{\text{Total observed}} = \frac{(E + \frac{1}{4}C)}{(E + C + A)}$$

$$\text{Field Rating} = \frac{\text{Work}}{\text{Total observed}} = \frac{(E + C)}{(E + C + A)}$$

With recommendation for productivity improvement, a modified LUF was made based on a modified crew balance chart. For the bumper walls, a standard crew and the sequence of activities were established but some downtime was not documented and the estimations were biased

## The 5s Process

The superintendent determined the main housekeeping items, and actions that could be implemented. A material layout was made once at the beginning of the project, and was implemented as part of jobsite standardization. It helped to identify the location of material, equipment, and access, which reduced waste, such as search time for material and lay down spaces, and waiting time. All planners repeatedly emphasized the importance and implementation of 5S in all meetings. Foremen from each trade demanded all their members clean up and locate tools and material at the proper places daily. The 5s Process had a successful result initially due to enforcement of

discipline. GC and subcontractors made joint efforts to improve conditions at the jobsite; a housekeeping crew, made up of one worker and one staff member from each trade picked up trash from the whole job site once a week. This additional cost increased the project budget burden.

### **Fail Safe for Quality and Safety**

The project superintendent selected the activity that had potential quality defect problems to further study for prevention purposes. For instance, uneven aggregate distribution occurred around the circular openings and on the sides of the shear wall during the concrete pour. Initial suspicion was that workers did not vibrate the concrete properly. Different vibrators and quality control were carried out, but the condition did not show any improvement. The superintendent found that the problem was not the workers, but rebar sizes and density. Three alternatives were considered: (1) change to smaller aggregate, (2) use self-consolidated concrete or (3) pre-insert extra-vibrators inside the wall and between the circle areas. The study showed that smaller aggregate could not meet the strength of the shear wall, and self-consolidated concrete was not applicable due to the step shape of the shear wall where beams and slab met. Extra vibrating was determined to be the most efficient alternative. Three or four vibrators were used simultaneously and workers hammered the bottom of the circle area manually.

The RT prepared a risk assessment of quality and safety issues (Arditi & Gunaydin 1997). Risk assessment is obtained from the severity times the probability of each evaluated item. The superintendent and safety staff reviewed the most relevant items.

## **Results and Discussions**

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#### **Constraint Analysis**

The constraint analysis was limited to the material category, and it focused more on verifying that the duration of the activities would meet the schedule and that those resources were available. Even though constraints were indicated after the initial stage of the project, they failed to anticipate potential variances. One finding from the observation of the researchers was that six weeks could be a good lookahead period for material flow.

#### **PPC**

WWP meetings were held regularly and the meeting time was adjusted according to concrete pouring schedules. Phase I was completed eight days ahead of RPS and 16 days ahead of the master schedule. Twenty percent of PPC values were between 60% and 70%, forty-five percent of PPC values were between 70% and 90%, and fifteen percent of PPC values were above 90%. Figure 2 shows the overall Percent Plan Complete (PPC) for the project.

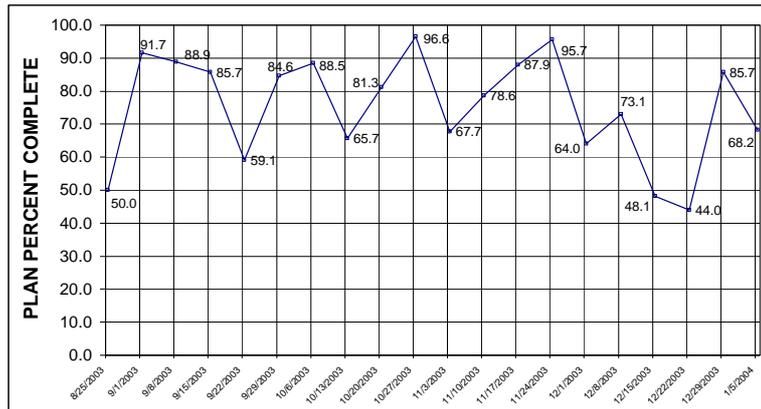


Figure 2: the overall Percent Plan Complete (PPC) of the project

The major reasons that caused downward slopes of PPC values are weather, scheduling\coordination, and prerequisite work. The main reasons for the high PPC values achieved in this project were:

- The project manager approached a new set of pouring sequences to accelerate and shape the workflow rate and optimize the workflow capacity.
- All last planners made a commitment to contribute their best efforts to achieve high reliability.
- All last planners respected each other, established open and two-way communication, and solved most of the problems at the WWP meeting.
- This garage project consisted of repetitive activities which were simpler and had less overlapping work compared with more complex construction projects.

The goal PPC value for GC's Last Planners was between 90% and 100%, which demonstrated that they didn't fully understand the purpose of PPC. Training becomes an important issue here. Towards the end of the project, during a severe winter with a heavy snow fall and wind chill, each trade only had one or two activities on the schedule each week, which meant, if one trade did not finish one activity on time as planned, the individual PPC value for that week would either be 0% or 50%. This happened to GC and SubB for consecutive weeks. These low PPC values had a great impact on their morale. Some Last Planners started to complain that SubA could maintain high PPC values due to their conservative estimations. The RT decided to conduct a calculation and a comparison for the accuracy of scheduling of each trade.

Since GC had a total of 84 tasks, most of them were one- or two-day short duration activities; SubB had a total of 32 tasks with mixed durations; SubA had a total of 16 tasks, most of them were activities of five- to ten-day long duration. Regarding the accuracy of schedule estimation calculations, one day over- or under-estimation was significant to GC. In contrast, it was only of minor significance to SubA. Therefore, in order to evaluate the accuracy of estimations equally, the RT made three different comparisons. In the first two parts of the table, the category is the difference in days between RPS, WWP, and actual duration of activities, versus numbers of tasks from each trade, and proportion to total tasks of each trade. In the third part of the table is the accuracy of estimations between RPS, WWP, and the actual duration of activities, versus the number of tasks from each trade. The results of these three comparisons are summarized as follows: GC had the most accurate and consistent estimations on both RPS and WWP, SubB was placed at second. SubA had the largest margin on his estimations. At the end of the study, questions were raised: (1) how to distinguish

between conservative estimation and improving productivity that had achieved right-on schedule or ahead of schedule, (2) how to prevent conservative estimation in RPS and WWP, (3) will PPC values be used in a normal way to interpolate at the end of the project or during the severe winter weather; these questions will need to be explored in further study.

### Variance Analysis

The performance of the previous week was not reviewed during the WWP meetings. Instead, the project manager provided reasons why the work was not completed (variances) to the RT. Most of the problems were tracked on the spot; therefore, no action plans based on variance analysis were formally conducted. Constraints and variance analysis are summarized in Figure 3.

For variance analysis, weather, scheduling/coordination, and prerequisite work, were the key categories that influenced activities from being completed on time. Most were not accurately indicated. For example, alignments of structural elements were misplaced and one column was missing during the column casting and concrete pouring process. These great defects were caused by human error on site or unclear indication of the drawings that were provided by the architects/engineers, such as not enough information, lack of sections and details to show the connections, too much information shown in a small scale, or not enough dimensions. This caused schedule delays which were not indicated in variances of the project. Because of these defects, workers needed to stop working and wait for the decisions from the engineers. Usually rework was performed. Constraint analysis is limited to material only. The data show that either Last Planners have overcome material problems, or the truthfulness of the indications should be questioned. Without accurate data collection, constraint and variance analysis could not be done further in depth.

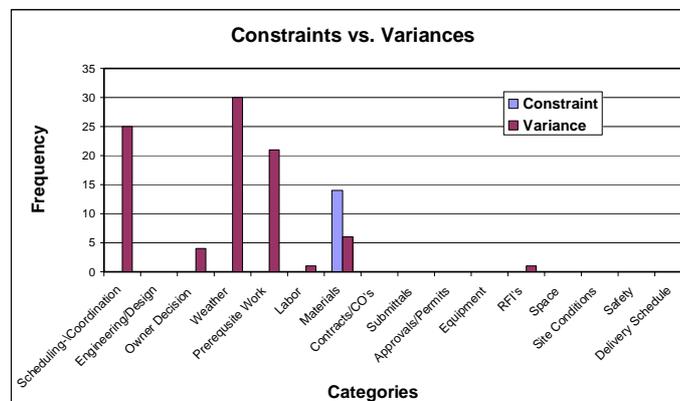


Figure 3: Comparison of constraints and variances

### Increased Visualization

Visual signs were posted at the various locations, but some project milestones were hidden or in dark places. Most of the signs were posted at the beginning of the project except pouring milestones that were ongoing efforts. Workers viewed that safety was an important issue, as the company introduced it in a family perspective. They also were interested in being knowledgeable about the where and when of each pouring sequence. To pursue the best results in this category, financial budget and manpower availability for ongoing efforts are the important keys that need to be evaluated by the project manager.

## Daily Huddle Meetings

Most of the workers and planners stated that their leaders reviewed performance during the meetings. Planners received information on successes and failures more than 73% of the time, and workers received information on performance more than 60% of the time. However, some people failed to remember issues during those meetings. The proportion of planners who remembered the issues ranges from 42% to 100% while the proportion of workers ranges from 17% to 86%. To assess the effectiveness of the meetings, some key categories of issues were selected: quality, scheduling, manpower, clean-up, lack of tools and safety. Both the leaders and the members were asked to suggest the main issues for the meetings each week. The effectiveness is quantified based on the correlation between the response of leaders and members. The results show that the effectiveness was high at the beginning of the project, but dropped during the last three months. The main reason is that new workers joined the jobsite and they received little information about lean construction. The second reason is that the project manager tried to push the issue of cleanup without any reaction from the workers. Most people were focused on safety and scheduling only. At the end of the project, the effectiveness of the foreman meeting was 75% and the start-of-the-day meeting was 29%.

To evaluate the value of the meetings, team members were asked whether they could solve the problems on the jobsite as a result of the meetings. More than 80% of the planners and 67% of the workers found value in the meetings and would like to talk more often to their leaders. This does not mean they contribute to the meetings in the same proportion. According to the last question, between 31% and 47% of the time planners offer some ideas or suggestions. Workers offer feedback between 19.8% and 42.2% of the time.

Throughout the project, the all-foremen meeting was regularly held and key topics were well covered. The main challenge for implementing this tool was the communication between foremen and workers throughout the day. Most of the workers state that they talked to their foremen between two and six times a day and the issue of success/failure on the job site is discussed directly with the crew involved. Therefore, there is little room for new issues during the daily meetings. Hence daily meetings with repetitive issues lead workers to adopt a robotic mode.

Two-way communication is the key to the daily huddle meeting process prior to workers experiencing involvement in the project; it was promoted well in the daily huddle meeting. People are used to not providing feedback or questioning any issues, therefore, commonly traditional one-way communication dominated the meetings. Statistics of the meetings and the instrument (survey) provided valuable management information for the project manager, planners, and foremen. It identified how much information the management level was given and how much information the workers absorbed.

## First Run Studies

The study shows that productivity could be increased from 53% to 62% without additional investment. Placing the material closer to the operation and having a standard crew of two people will have an impact on its productivity. Several site factors that contributed to decreased productivity of construction joints in the study included severe weather, placing material too far from the work location, alignment problems from the prerequisite work that was performed by other trades.

At the beginning of the project, actual bumper wall productivity was far lower than normal. (30% of the expected productivity) The GC decided to select it as a test activity. Shortly after the first run study, productivity increased tremendously; with continuous improvement over time, the productivity increased to almost 3 times the expected value.

Besides the site factors, other physical factors could also contribute to the productivity variation, such as time of day and day of the shift work. The workers were excited to be a part of the video filming process. Furthermore, the company provided an open and friendly atmosphere, not focused on blaming for failure, and encouraged bringing ideas and suggestions. This played an important role in the success of this First Run Study. At the first study meeting, all participants stated that the fear of questioning the status quo was the main obstacle to providing more suggestions at the second First Run Study meeting, even though GC had encouraged the workers to speak openly. The project manager, the superintendent and foremen implemented actions based on the study.

With positive outcomes of the study, the superintendent recommended implementation of this study to activities that are involved with complex construction techniques, multi-trades work overlap, and potential quality problems.

### **The 5s Process**

Construction is a dynamic production; lay down area change dramatically as production is moving forward, hence, the material layout plan should be a continuous effort that includes all trades' involvement. Throughout the project, Sort, Straighten, and Standardize are the winners in this category mainly due to management eagerly making efforts. Conversely, the traditional working behavior became an obstacle for the enforcement of shine (clean up) and sustain. Workers are used to being messy and throwing garbage on the ground, and they think that they were hired to do physical construction work, but not to clean up.

Housekeeping is a behavior that cannot be automatically enforced because workers are not used to it. Therefore, enforcement can't work directly. The foreman should create awareness in the basic principle of housekeeping: leave your work area as you receive it. Additional reasons why cleanup is difficult or not possible could be discussed with people who show little or no concern about housekeeping. Enforcement of the 5s Process is the responsibility of all members of the project. It seems easy to do but it is the most difficult tool to implement successfully. GC realized that behavior change, commitment, and discipline are the keys to the success of housekeeping.

### **Fail Safe for Quality and Safety**

OSHA standards were followed throughout the project and showed that the management level seemed to input more into efforts than the workers. Planners went beyond standard practice and identified particular hazards for their work and some successful actions took place, such as tying off, keeping an eye on leading edge, use of safety glasses and hard hats. Saurin et al. (2002) advocate the introduction of health and safety plans into the project execution as Plan of Conditions and Work Environment. A Preliminary Hazard Analysis (PHA) should be implemented in the planning state. Safety actions are incorporated into the look-ahead planning. Next, planners review the safety requirements for the following assignments that might create additional constraints. Safety practices are integrated into the short-term planning through daily feedback with crew and subcontractors. Performance is tracked through safe work

packages, an indicator of the proportion of safe work. Based on the information collected, the overall percentage safe work improved 27.8%.

Marosszeky et al. (2002) state that quality analysis is affected by the poor detection of defects during the operation and the long cycle times from detection to correction. To address those issues, a lean manufacturing tool is proposed - quality at the source (QAS). In order to implement QAS, checklists were prepared and handed over to the workers so that they can do it right the first time and identify any quality issues as they arise. The % of quality points from the checklists done by the workers was recorded throughout the project. The % QAS improved by 14.0% for the items selected during the project.

People tend to confuse preventing potential defects, which is the purpose of this category, and meeting the quality specification. For this reason, most planners think this tool is unnecessary. However, the superintendent clearly indicated that he welcomed this tool for preventing quality defects. In order to achieve a better outcome more training and a concrete action plan with clear procedures were required.

### Assessment

The tools such as daily huddle meeting, visualization, 5S process etc. are new to the construction industry and as there are no uniform construction industry standards for the implementation of these tools. It would have been erroneous to compare the results of their implementation to the standards in manufacturing industry. The RT designed an implementation measurement standard for the project and assigned the numbers to evaluate the progress. The tool such as Last Planner could be evaluated easily due to its quantitative nature. However, the evaluation of other tools such as daily huddle meetings, visualization, 5s process was based on many subjective criteria. These criteria are listed in the table 2.

Table 2: The criteria of assessments for each tool

Tools	Criteria for Assessment
Last Planner	Pull Approach, quality, knowledge, communication and relation with other tools
Visualization	Visualization, continuous improvement, knowledge, communication and relation with other tools
Daily Huddle Meetings	Time spent under control, review work to be done, issues covered, communication and relation with other tools
First Run Studies	Action Plan, continuous improvement, knowledge, communication and relation with other tools
The 5s Process	Action Plan, continuous improvement, knowledge, communication and relation with other tools
Fail Safe for Quality and Safety	Action Plan, continuous improvement, knowledge, communication and relation with other tools

The progress was assessed on a scale from 0 to 10 to compare the initial, expectation, and achieved status of each tool. The scale for evaluation of implementation of tools is shown below in Table 3. The tool champions were intimately involved in the implementation and they received feedback from the tool implementers at the site.

Table 3: Assessment scale for lean implementation

Item	Description	Value
None	Not implemented	0 - 2
Low	Most of the items are not implemented	2 - 4
Moderate	Partially implemented	4 - 6
High	Most of the items are successfully implemented	6 - 8
Very High	Entirely implementation	8 - 10

An expectation value was set for each tool based on the expectations of each champion. The champions of the tool were representatives from the GC organization who had substantial experience on construction sites.

The final/current status was taken up to the end of Phase II construction, once all the tools had been properly tested. The performance is listed in Table 4.

Table 4: The performance, measure items, and average score of assessments for each tool

Tools	Measure Items	Average Score		
		Initial	Achieved	Expected /Target
Last Planner	Reverse Phase Scheduling, Six Week Look-ahead, Weekly work Plan, PPC Charts and reasons for variances	3.6	7.2	6.25
Visualization	Commitment Charts, Safety signs, Mobile signs, Project milestones and PPC Charts	3.4	7	6.75
Daily Huddle Meetings	All foreman meeting and start of the day meeting	4.6	7.4	4.75
First Run Studies	Plan, Do, Check, Act and Productivity Studies	3.1	6.6	4.25
The Process	5s Sort, Straighten, Standardize, Shine and Sustain (5 S's)	3.6	6.1	10
Fail Safe for quality and Safety	Quality, Safety and SPA	4.4	6.2	7.5

The signs required fro increased visualization didn't get adequate attention from the project management in the initial phase of the project. The PPC charts or project milestones were not posted, commitment charts were not posted on the trailer. A few safety signs were posted at the project site. Due to the continuous efforts taken by the

research team, the level of visualization increased significantly towards the end of the project. Commitment meetings took place and commitment charts were posted on the trailers. The project milestones and PPC charts were posted at various locations at the site. The average score of the state of visualization jumped from 3.4 (low) to 7.0 (high) by the end of the project Figure 4 shows the Spider Web Diagram; which is an overview of the assessment of implementation of the tools in this project. This diagram shows the initial, expectation and achieved status of *the lean construction tools implementation*, which are the results from the assessment of each tool.

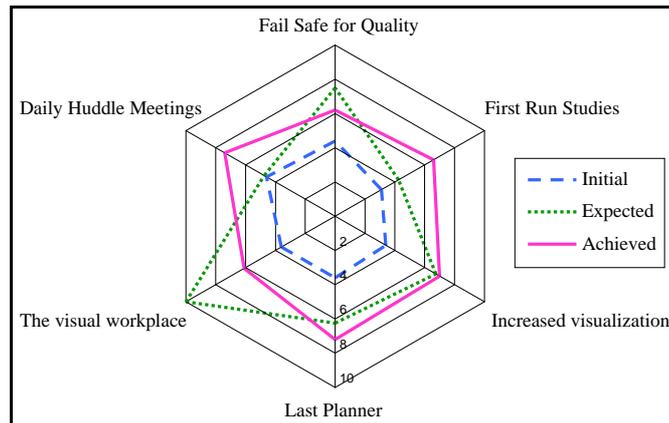


Figure 4: Assessment implementation of tools - Spider Web Diagram

The RT proposed the status of tools for future use based on the assessment implementation of each tool. However, with the experience gathered on the Garage project, it is possible to realize that not all tools show the results and compensate for the effort made by all GC employees. Table 7 summarizes the findings on these tools and the status for future projects.

Table 7: Tools recommended for future use

Enabler	Status	Recommendations
Last Planner	Ready to be implemented	1.Emphasis on Reverse Phase Scheduling 2.Emphasis on variance Analysis
Visualization	To be implemented with some modifications	1. Integrated approach 2. Safety-Quality-Housekeeping
Daily Huddle Meetings	To be implemented with some modifications	Change frequency of the meetings with smaller groups
First Run Studies	To be implemented with some modifications	1 Integrate with scrum meetings (Tool Box Meetings) 2 Document learning process
The 5s Process	To be implemented with some modifications	Housekeeping can be address with Increased Visualization
Fail Safe For Quality and Safety	To be re-examined	1 Use Plan Conditions and Work Environment 2 Use Quality at the Source

## Conclusions and Recommendations

This paper reviewed and tested the effectiveness of lean construction tools that are suitable to apply in construction firms. The authors found that the lean manufacturing tools can be modified for use in construction projects and successfully implemented. The commitment of the top management for implementation of these tools may prove to be the most important factor in successful implementation of these tools. The authors observed a complete attitudinal shift in the project participants in this project. At the beginning of the project, the project manager questioned the applicability of these tools at the site. However, by the end of the project, everyone on the site participated in the implementation of these tools. The training classes offered by the GC, recognition provided to promote behavioral change, encouragement of employee involvement and rewarding real improvement proved to be critical factors in eliminating barriers to change. The workers enjoyed being a part of a structured planning and decision making process.

Training will be a key aspect of implementation and success of the Last Planner at the site. The staff and workers will need to be trained to use this tool effectively. This training may result in an increased burden in early stages of implementation but over the long haul, it will serve to increase the efficiency of construction companies and more than make up for the initial investment in training.

Further research is needed to investigate to find how to distinguish between conservative estimation and improving productivity that had achieved right-on schedule or ahead of schedule using the Last Planner tool. It is also important to develop new methods to prevent conservative estimation in RPS and WWP.

The authors are currently working with the GC to find ways to effectively implement lean construction.

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# CONTRACT OR CO-OPERATION? INSIGHTS FROM BEYOND CONSTRUCTION: COLLABORATION - THE HONDA EXPERIENCE

Richard Bayfield<sup>1</sup> and Paul Roberts<sup>2</sup>

## Abstract

This paper takes as a case study the construction of a new European car plant at Swindon for Honda of the UK (Manufacturing) Ltd (the NEP). In October 2002, the new plant was awarded the British Construction Industry Award for a Building Project. The judges commented:

The 'one team one goal' culture of openness and transparency at Honda's New European Plant, and the company's refusal to accept the status quo, has been rewarded with a building cost of only £701/sqm - a 40% improvement on the cost of the original plant at Swindon completed nine years earlier. Outside the plant is an anonymous shed, which would not be in contention for any architectural beauty award. Inside it is an incredible three dimensional jigsaw of services dedicated to the rapid and economical assembly of high quality cars.

## Introduction

This aim of this report is to answer the question: 'There are many good tools out there but most people don't use them: why?'

Honda is one of a growing number of client organisations which successfully uses so called 'sophisticated' project management tools and techniques. The end result is a number of projects which have beaten tight financial constraints; and have been delivered on time, to the required quality. Indeed Honda's internal benchmarking has shown that construction costs on many projects are comparable with those in the competitive market in the USA.

In September 2001, Honda completed a £130m investment at Swindon. This was for a second 50,000m<sup>2</sup> car plant adjacent to the existing car plant. The construction performance was impressive. As Figure 1 shows, Building costs, including design, came in at just over £35m, equivalent to £701 per m<sup>2</sup>. This key performance indicator of £701 per m<sup>2</sup> can be set into context by comparison with the adjusted cost of £1,173 per m<sup>2</sup> for an almost identical plant built between 1988 and 1992 on the same site at Swindon. Moreover, in 1998, initial cost estimates from many leading UK and Japanese companies were between £800-£1,000 per m<sup>2</sup>. As Honda builds similar buildings around the world it is able to benchmark its construction costs in the same way as it does its car production costs. Currently the UK operation is achieving construction costs comparable with those in the USA. This is particularly important because the USA construction market has long been held up as one of the most efficient in the world.

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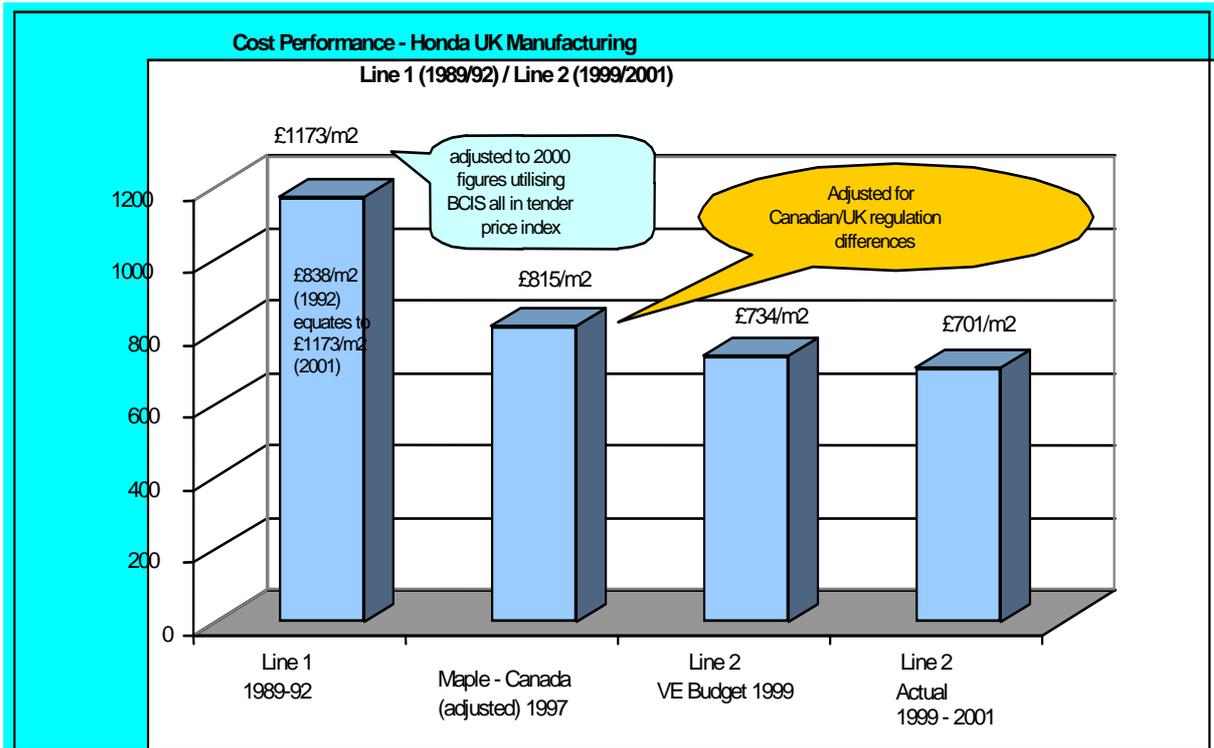


Figure 1. Construction Costs at Swindon compared to other sites.

In summary, Honda has achieved a 40% improvement in its UK construction performance over 11 years (as measured by the building cost for buildings of equivalent functionality). This improvement is well above the 30% improvement suggested by Sir Michael Latham in 1994 in his landmark report on the underperformance of the UK construction industry. The 30% improvement suggested by Sir Michael was widely criticised at the time as being impossible, and indeed there are many who still doubt that such an improvement is possible.

What is more important is that this improvement has not been at the cost of cutting building functionality, nor has it been at the cost of contractor (supplier) margins. Honda recognises that the only way it can survive long term is through its suppliers being profitable. In Honda's case the improvement has largely been achieved by using the best available management tools and techniques, coupled with a company philosophy which actively encourages change and challenges the status quo.

This meant that the recently completed car plant was achieved under a different procurement route and with a different contractual regime from the original plant. Moreover, Honda's own role as client changed between the two comparable projects. In particular, on the NEP it saw itself as central player within a 'one team one goal' philosophy. This significant improvement in out-turn cost between the two projects certainly provides justification for Honda's decision to use the many good management tools now available.

## Honda's understanding of the construction client role

Honda recognises that the client's role is central to the success of the project. Through its automotive business, it recognises that with any business operation it is important to get close to the supply chain. It understands that in all areas of its business there are risks. Its strategy is therefore about risk management not risk avoidance.

## Hypothesis

Honda has clear business objectives, which in turn translate into business strategy. These objectives comprise being a global brand synonymous with quality. However, part of the business strategy necessary to achieve these objectives is to create a culture which encourages 'thinking the unthinkable and challenging the status quo'. The achievement of Honda is that it manages the paradox created by risk. On the one hand it creates a culture in which risk taking is encouraged, on the other it recognises that risk taking should not be reckless, but should be managed.

The importance of culture and risk should not be understated. If the organisational culture does not allow risk taking, which by definition must include change, then however good the alternative new methods are, they will not be adopted. In the commercial world it is often the case that conservative businesses are forced to take risks and to change because of changes in the market; failure to do so would prejudice their survival. In fact, many businesses which fail do so after eventually recognising the need to change but too late in the day to ensure survival. In the non-commercial world there are not the same pressures of the market place to prompt change. In many organisations there is considerable inertia, which acts as an obstacle to change - no matter how attractive the alternatives might be. The thesis of this paper is that long-term success in construction projects is no different to long-term success in business as a whole. The key is a culture which allows, indeed even requires, risk taking and change, but in a structured rather than reckless or foolhardy manner.

## Honda philosophy

'Life is measured by the number of times your soul is deeply stirred': Soichiro Honda.

Honda is a multi-million pound global business. It is also a people driven, philosophy-based company. Honda's philosophy is summed up by: 'Through challenge, fresh ideas, a young attitude [ie young in spirit], teamwork and a friendly working environment, we will achieve all we set out to accomplish'. 'Advancement, challenge, quality and partnership' also describe Honda's philosophy. The Honda philosophy is the key to the construction project's success. The philosophy creates a culture in which it is appropriate to challenge the status quo; indeed the company encourages creative dissatisfaction. This means that every assumption or application within the automotive sector of the business is challenged regularly. It is the drivers (philosophy and culture) of the business which are the key.

## Background information

Honda has invested £1.5b at its Swindon manufacturing plant since coming to the UK in 1985, of which approximately £130m has been invested between 1999 and 2001 on the construction and fit out of the NEP. The project was successfully completed at the beginning of July 2001 to enable trial car production to commence immediately. Full single shift production in the new plant commenced in September 2002. The project has been a considerable financial success having been completed within budget and indeed at a lower cost (£701 per m<sup>2</sup>) than the original value engineered budget of £734 per m<sup>2</sup>. The NEP contrasts with the construction industry's general under performance on major projects.

## The scope of the project

An external view of the building may convey the misleading impression that the project simply involves the construction of a large warehouse type structure (see Figure 2). The reality is that there are huge trenches (large enough to include a car, personnel and machinery) running the length (400m) and breadth (125m) of the building. There are also deep pits, mezzanine floors and a basement for the paint shop area. These accommodate many different processes, machines and robots, many of which are highly sophisticated. The services are highly complex and provide the power and environment for the car production process as well as for the people working inside the building.



*Figure 2. HONDA EUROPEAN CAR PLANT AT SWINDON*

Thus the project comprised a combination of heavy civil engineering involving deep excavations, steel sheet piling, bored concrete piling, heavy reinforced concrete foundations, a steel frame with hanging conveyor plant and extensive infrastructure works. These involved external public highways, new gas, water and electricity supplies and on site wastewater treatment facilities. The work also comprised a complex array of mechanical, electrical and process services and machinery. This covered mechanical and electrical building services and the installation and co-ordination of all the manufacturing equipment, from conveyors to paint booths and robotic machinery.

The challenge of the project was the co-ordination of numerous parallel activities on a fast track programme, whilst achieving the flexibility of finalising many automotive processes and robotic installations at the latest possible time in the project cycle.

## Comparison between the car industry and construction

The car industry has often been cited in the debate over construction performance, the proposition essentially being that the performance of the car industry has been turned around over the last 20 years, why can not construction do the same? Honda has taken that advice literally and adopted and adapted many of its processes and methodologies emanating from the automotive industry and applied them to construction. In particular Honda's innovative approach to automation is reflected in its approach to construction. For example, after careful consideration, a Canadian construction

manager who had never previously worked in the UK was appointed to manage the NEP, a decision unlikely to have been made in many other UK organisations. This appointment was critical and yet it breaks with current orthodoxy. Another example of a novel practice was the training in total quality management (TQM) - at Honda's behest - of key trade contractors prior to the project commencing.

## UK construction performance

UK construction is a huge sector within the economy and accounts for approximately 8% of GDP. However, generally, construction has a poor track record for both small and large projects alike. The larger project failures are often well documented both in the press and in project audit reports commissioned by private clients and the government. For example, the public accounts committee investigating a 72% baseline budget increase on the Trident programme concluded that there was evidence of 'mismanagement on a grand scale'. This kind of performance is not unique: figures in the technical press suggest that the final Jubilee Line out-turn cost will be around £3b as against a £1b budget.

There is evidence of the emergence of a group of more enlightened client organisations that generally achieve a better performance from the construction industry on their projects than the average. From the outset, Honda has been one of these enlightened organisations, though its activities rarely feature in the press. This project was an opportunity to capture and share in the many good practices of one of the world's pre-eminent engineering businesses.

In his report, Sir John Egan said: 'The Task Force is strongly of the view that there is nothing exceptional about what major clients are doing to improve performance in construction. Anybody can do it, given the time, the commitment and the resources'. The construction industry has had available to it for some time several authoritative publications describing how to improve performance and successfully manage construction projects. This includes documents such as the procurement guidance notes produced by the Audit Commission and Treasury as well as those produced by the leading professional organisations (Institution of Civil Engineers, Royal Institution of Chartered Surveyors, Royal Institute of British Architects, Chartered Institute of Building etc.). There are also whole systems such as PRINCE (Projects in Controlled Environments). However despite good material, the reality of UK construction is that few of the recommended professional management techniques and systems are widely adopted. Honda by contrast has been able to implement - and benefit from - many of the widely recommended techniques and systems and also to develop some of its own methods. This begs the question once more - why did Honda use these methods?

## Key findings

We have prepared this paper following internal performance reviews and have also held interviews with key personnel representing all participants within the project (both internal within Honda and external, including designers, contractors, solicitors and insurers).

## Summary

During discussion and interviews with the project participants a number of factors came up repeatedly. These were:

1. Honda placed particular emphasis and effort on identifying its corporate objectives and then developing a strategy to achieve these objectives.
2. Honda considered that the only way to secure work within tight financial restraints and to achieve flexibility of design until late into the construction programme was to use construction management as the method for procuring the works. This was seen as an enlightened approach, which few client organisations would be prepared to take.
3. Honda put considerable emphasis on construction manager selection for the project. It was of paramount importance to select the right team of people with the right attitude who could buy into a 'one team one goal' approach.
4. Honda established very effective communications systems within the project.
5. Honda established a culture of transparency in which problems and issues were not held back but were managed in a pro-active manner as soon as they became visible. There was no attempt to create a blame culture.
6. Honda pre-empts and is pro-active; there is a strong emphasis upon planning at all stages of their projects.
7. The Honda culture encourages the questioning of established procedures ('why?' is a word which is frequently used at meetings, but in a positive pro-active context). Many meetings are arranged to pre-empt future problems.
8. Honda contracts are drafted to be as fair and transparent as possible, generally seeking to place the risk with the party best suited to managing that risk.
9. Effective conflict resolution is seen as a necessary part of the project arrangement. In practical terms this means that all issues are brought out into the open as soon as possible. It also meant that, on this project, regular meetings at director level were held.
10. Honda sought to establish a team approach at all stages of the project. Indeed Honda was aware that the only way the project would be successful would be if everyone bought into the 'one team one goal' philosophy - see Figure 2. Accordingly, everyone was required to sign the following project charter: 'We the undersigned are committed to achieve the successful completion of the project and undertake to work together in a spirit of mutual respect, fairness and using flexible attitudes to achieve our goals to the benefit all parties'. (That is, 'one team one goal' not 'two teams own goal'.)

### **Client involvement**

All project participants agreed that Honda is much more actively involved in its projects than most other clients. For example, Tony Damon of SSOE (USA based designers) stated:

I find that Honda, as an organisation, has been more personally involved in their projects than most clients. This is not to say they are micro-managers, but rather, well-informed, knowledgeable and experienced owners, who know what they want. They take a personal interest in the project and its success. Honda has been excellent at setting forth the vision and goals of the project at the beginning of the project; setting the strategy of how we would achieve the goals; and then personally participating in the tactics to follow through on the strategy. They ensured that these goals were communicated to all members of the project team (designer, construction manager and contractors). Honda worked with the designer

and construction manager to establish the key measures of success and then followed through with monitoring progress toward the goals throughout the project.

Steve Snow of Severfield Reeve (steelwork contractor) stated: 'The construction knowledge of Honda played a large part in the project's success'.



*Figure 2. Team Approach*

### Client differences

What sets Honda apart from the others? Paul Watchman of Freshfields (solicitors) stated:

What sets Honda apart is their culture of testing the existing procedure or orthodoxy. They do not accept the status quo. On occasions they will test to the limit in the way that a car component might be tested. However their approach is not confrontational and they are willing to treat advisors and suppliers as part of a team. Their culture is pro-active and pre-emptive rather than negative, sometimes there is 'creative tension' within meetings reflecting a deep will to succeed. However there is not the fear of making mistakes that is found in some organisations.

Tony Damon of SSOE (designers) stated:

What sets Honda apart is their understanding of what it takes to build a true project team (i.e. have a vision; select the right team; involve the team in the planning (strategy); receive commitment from the team members; communicate the vision and goals to all involved (drive it down); treat the team members professionally and fairly.

Paul Rothera of Rothera Goodwin (chartered architects) stated:

Honda are not preoccupied with headline statements or preconceptions about what they ought to be doing or saying. As a result of [this], Honda are prepared to consider what appear sometimes to be slightly out of the ordinary or off the mark approaches to solutions. In general the above attitudes run right through the clients organisation.

The NEP organisation structure is set out below in Figure 3. The key feature is that Honda effectively acts as both client and project manager but utilises considerable external support in areas where it recognises it lacks expertise and/or resource.

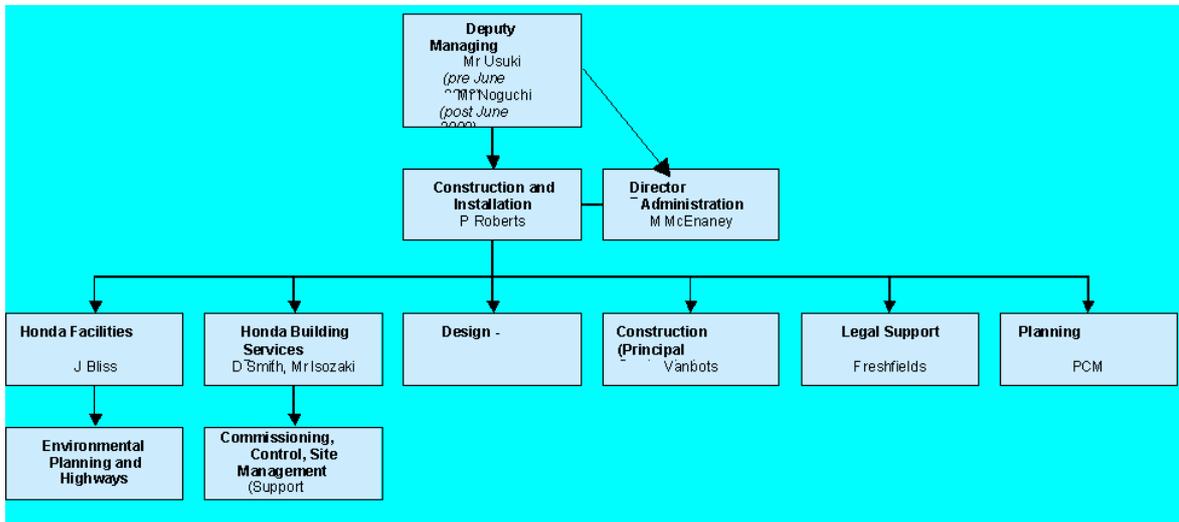


Figure 3. The Organization at NEP

## Construction management

Honda recognised that whilst there is a perception in some quarters of higher risk using construction management as a form of procurement, there is also the potential for gain as the client takes on board risks which main contractors would otherwise need to price. Honda's skill is in effectively managing these potential risks using a pro-active and pre-empting management style in order that their impact (if they materialise) is kept to a minimum.

Honda's strategy was to appoint the construction manager as soon as possible in order that he would be able to work with the design team and make a significant input into the design process from the perspective of value engineering and buildability. The appointment involved an innovative selection process (see Figure 4).

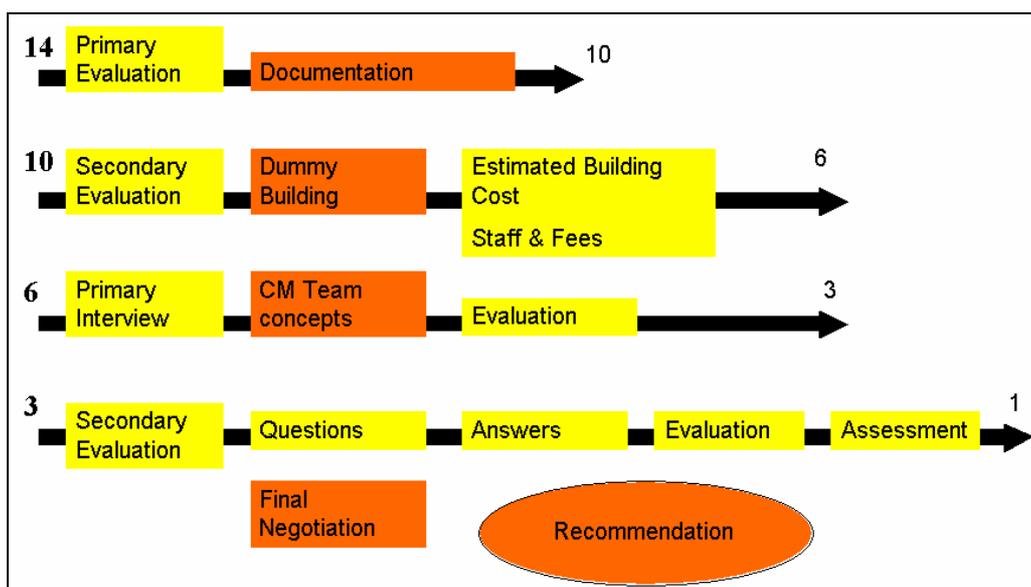


Figure 4. CM Team Evaluation Process - Using QCDMSE

As shown in Figure 4, fourteen leading construction management organisations from the UK and overseas (including Japan) were first invited to offer an expression of interest in the project. The enquiry process was carried out at a distance and Honda's name deliberately kept off this initial enquiry.

As a result of the initial response, ten organisations were invited to tender their construction management services and provide a programme and costing for a dummy building. This was a car plant which had been constructed some years earlier. However by taking this somewhat innovative approach the initial thoughts of the construction managers could be obtained without waiting for the design to be at a stage when initial enquiries normally went out.

A shortlist of six organisations was then invited for a 45 minute interview at which each construction manager was invited to make a presentation. Honda's interview panel comprised representatives of its own in-house business and construction team, the designers (SSOE of USA) and seconded consultants working as part of Honda's team on other projects at the time. The format of the interview comprised 30 minutes for each construction manager to explain their background and experience of similar projects. There was then a 15 minute session of structured questions at which Honda sought to evaluate the ability of the proposed team to achieve the overall project requirements and to measure their attitudes in respect of teamwork, cost control, flexibility and company management structure.

After these interviews a shortlist of three organisations was put forward for a more rigorous final selection appraisal involving a two to three hour interview by the same interview panel. The final interview was preceded by the development of a questionnaire, which was used as the template for each interview. The questionnaire was used to evaluate each organisation under the headings of 'quality, cost, delivery, management, safety and environment' (ie QCDMSE). The weightings under these headings were agreed by the panel prior to the interviews. A further category was introduced of construction manager fees. The final order of weightings was as follows:

- o management: 22%
- o construction manager fees and staff cost: 22%
- o delivery: 15%
- o cost: 15%
- o quality: 11%
- o safety: 7.5%
- o environment: 7.5%.

The highest weighting of 22% was given to management and the fees and staff costs. However this meant that 78% of the selection criteria for the construction manager was not related to his proposed fees. The weighting for approach to construction cost was only 15%, the rationale being that whilst cost issues are very important, without the right management and approach to delivery it would be unrealistic to expect a successful project from a financial perspective. Environmental issues came last simply because the project was under a rigid environmental regime imposed by internal policy considerations and also a project specific environmental impact assessment. The skills being looked for in the prospective manager were essentially to manage construction within these pre-defined environmental restraints rather than develop new environmental standards. A similar view was taken in respect of safety. Honda has its own internal safety regime and this, coupled with the CDM Regulations, meant that

primary assessment was made on the prospective manager’s ability to manage and deliver within these pre-defined safety constraints.

An example taken from a QCMDSE assessment form is separately annexed to this report as appendix 1.

As a result of this final interview process, the Canadian company Vanbots was selected to act as construction manager for the project. Vanbots had no previous UK experience although they had completed a similar project for Honda in Canada. This appointment may appear at first instance somewhat illogical. On the one hand it could be seen as a high risk strategy using a construction manager with no UK experience, on the other Vanbots were the ‘experts’ in what was going to be built. This decision exemplified the Honda culture of ‘challenging the status quo’ but not before they had prepared a thorough assessment of what they wanted and then measured each prospective construction manager against that profile by the QCMDSE system. The key decision was in identifying the need for a construction manager that had appropriate experience, who would complement the others already in the team and who would work comfortably within Honda’s open and transparent project culture.

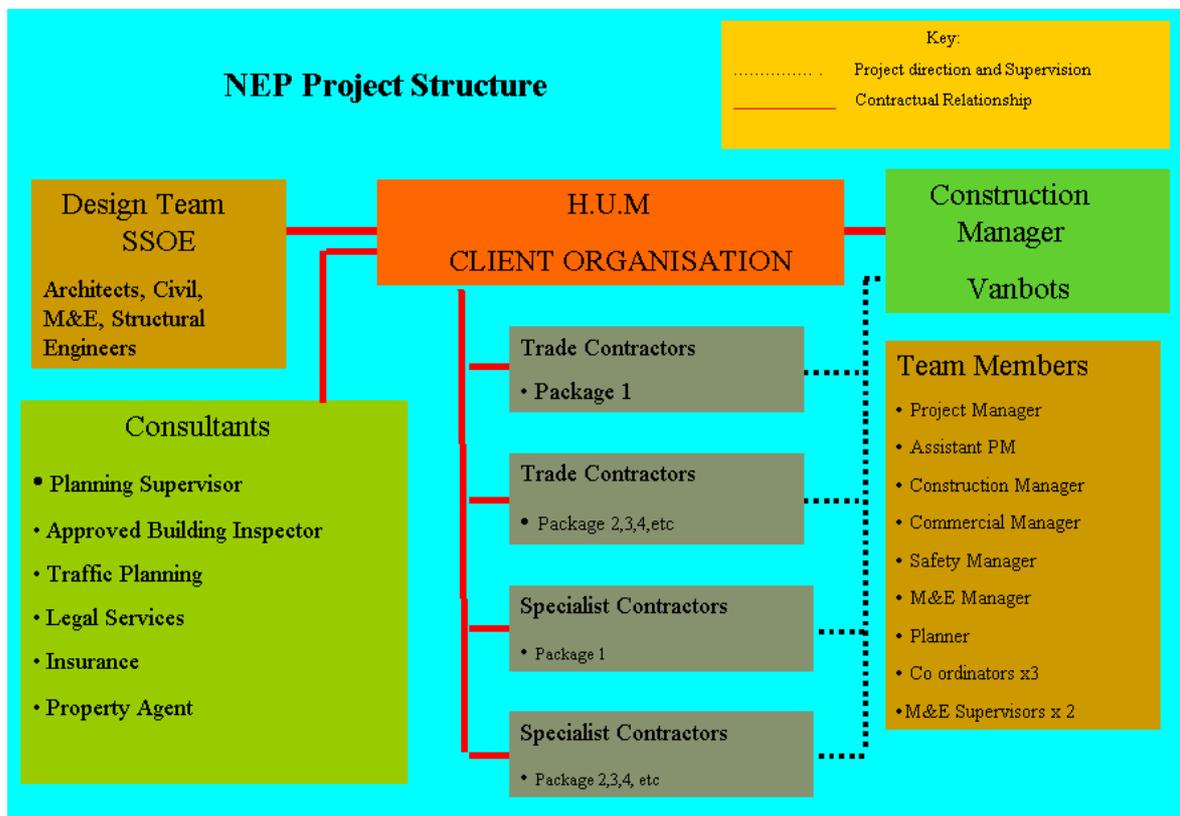


Figure 5. The NEP project structure as proposed by Vanbots

What was also interesting at the interview stage was that Vanbots were able to demonstrate their confidence in a budget of £760 per m2 (based on the dummy building and their knowledge of measures that could be introduced to effect savings without affecting functionality). Vanbots figure of £760 per m2 was close to Honda’s own internal assessment. However all other organisations put forward budgets which were significantly higher (ie in the range of £800-£1,000 per m2). Vanbots proposed a staff structure of 16 site staff which was significantly lower than that proposed by all other organisations and Vanbots professional fee was neither the lowest nor the highest proposed.

## Value Engineering

As a matter of policy, all Honda projects undergo a value engineering (VE) process at which the proposed design is reviewed by all key stakeholders. For this project there were three principle VE sessions. The first was held at SSOE's design office in Ohio, USA in June 1998; the second occurred at Swindon in July 1998 and the third at Vanbot's Toronto office in August 1998. Each of the three principle VE sessions took three to four days and included key representatives of the designers, Honda and Vanbots. The sessions comprised a mix of small special interest cluster groups of four to six and larger review groups (usually at the end of the day) numbering approximately 20. An external facilitator was not used for the workshops, as is often the case for some large projects. The facilitator for the main workshop sessions was SSOE. However the chairmanship for each small 'cluster' group was regularly changed to ensure that appropriate expertise was leading the discussion.

Tony Damon, of designers SSOE, further describes the VE process:

The value engineering sessions included representatives from Honda, Vanbots and SSOE. SSOE acted as facilitator of the session, recording ideas and the evaluation by the group. Minutes of each session were kept via electronic whiteboard. Ideas were encouraged from all participants in a 'brainstorming' type session. Suggestions were then evaluated for technical merit and feasibility (SSOE); construction cost and constructability (Vanbots); and general acceptability, long term impact on the life of the facility and value (Honda). The final decision on implementation was, of course, left up to Honda.

The key outcome from the VE sessions was a radical decision to construct the paint shop within a lowered basement portion of the site. Traditionally paint shops (which are a large part of a car plant) are built on mezzanine floors above ground level. In this instance huge savings on earthmoving were made by adapting the design solution to suit the existing topography. The functionality remained unaltered.

Tony Damon of designers SSOE further describes the background to the paint shop VE decision:

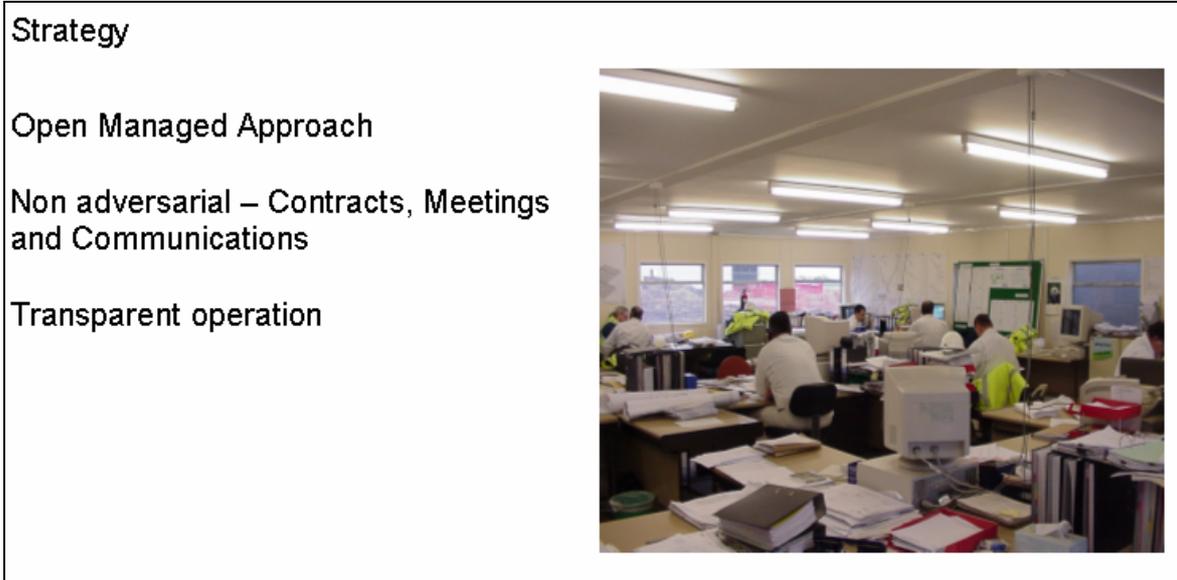
The value engineering idea that, perhaps, had the largest impact on the facility design, construction and cost savings was the decision to lower the paint shop operational floor. Traditionally, Honda constructs a mezzanine level above the level of the main plant floor to carry out this operation. The VE group identified very early on in our sessions that there could be significant cost savings to the project if the mezzanine level were brought down to the level of the main plant. Due to the sloping nature of the site, this saved considerable amounts of imported fill that would have otherwise been required. I believe this concept challenged Honda's paradigm of a paint shop.

Other savings were achieved by changing the structural steel from grade 43 to grade 50 steel and by a rigorous evaluation of hanging loads. On previous car plants there has been some 'overcapacity' designed into the roof structure to allow for future increases in hanging loads arising from additional services, overhead walkways and conveyors. In this instance the project philosophy was to keep increased capacity to a minimum but instead allow the opportunity of isolated strengthening in areas where hanging loads need to be increased at a future date.

As a result of the value engineering workshops, in the summer of 1998 the agreed budget for the project was reduced from over £760 per m<sup>2</sup> to £734 per m<sup>2</sup>. Design progressed in the autumn of 1998, although the project did not commence on site until the summer of 1999. This was in part due to Honda's extended negotiations with the planning authorities relating to environmental impact to external highways.

## Effective communications - co-ordination between trades

Since the early 1990's, Honda has adopted a management philosophy of 'openness' on its construction projects, which it first used with its automotive suppliers. This means all parties working on site share information about their own plans and problems: an approach which on many UK construction projects would be seen to be 'dangerous' or 'high risk'.



*Figure 6. Management philosophy of 'openness'*

Much of Vanbots construction work in Canada is carried out in a similar 'open' way and so there were no 'obstacles' to Vanbots buying in to the Honda culture. In practical terms this meant, for example, weekly meetings chaired by Vanbots with all trade contractors being represented at a senior level. At these meetings the 'look ahead' programme for the whole site would be projected on to a large screen and all difficulties discussed in open forum. There was no hiding place for the contractor who had a late delivery, the designer who was late with design or indeed for Honda who was delaying the finalisation of a detailed design brief.

As a result of the co-ordination meeting, everyone would be aware of all 'risks and threats' to the project programme. However Vanbots as construction manager adopted a pre-emptive and pro-active approach to problem solving at this meeting. This typified their dealings with the trade contractors. In essence the philosophy of the co-ordination meeting would be for all present to look for 'counter-measures' to resolve risks. The prevailing project culture amongst all trade contractors was to jointly agree strategies to resolve problems rather than use them as reasons for delays and claims. Vanbots management style certainly reflected the Honda philosophy.

## Effective communications - co-ordination involving designer

Honda and SSOE have worked closely with the selected steelwork contractor (Severfield Reeve) on a number of projects. Honda and SSOE were therefore confident in Severfield Reeve's design ability. This meant that a direct communication link was set up between SSOE and Severfield Reeve. Naturally Vanbots and Honda were kept informed as to how the detailed steelwork design was evolving. However, the effect of the direct communication between these key specialists meant a smoother and more efficient flow of information and rationalisation of design.

In practical terms there were fewer 'misunderstandings' between fabricator and designer than might otherwise have occurred under a more traditional arrangement in which the trade contractor is kept at 'arms length' from the professional designer. It is hard to measure the true effect of positive communications such as these, however it is considered that a layer of drawings was saved from the overall process by facilitating this direct communication (see Figure 7).

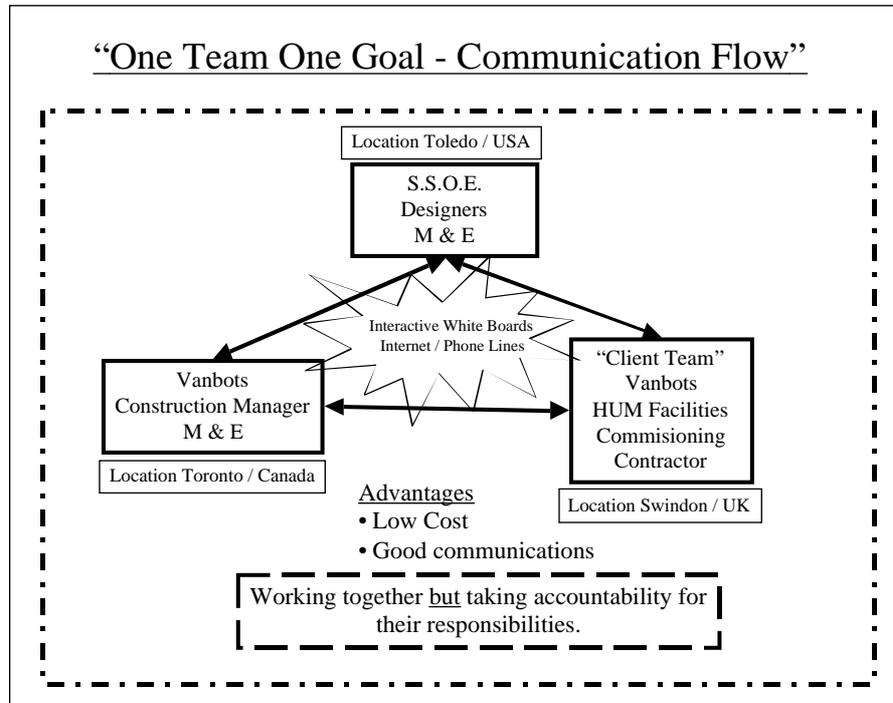


Figure 7. Communication structure in the NEP project

## Planning

‘Why should Honda have to be dependent upon a random aggregation of events when it procures construction?’ - Mike McEnaney (Director of Business Administration, Honda of the UK Manufacturing Ltd).

Honda places great emphasis on planning and on process management systems. This is an unavoidable consequence of the core business which undertakes the following:

- capacity to produce up to 1,000 vehicles per day;
- installs 3,000-4,000 components in every vehicle, the components naturally needing to be assembled in the correct sequence;
- employs just over 4,000 people at Swindon on the two car plants.

Moreover, the automotive business requires process synchronisation and co-ordination at the highest level. In a production line the process demands the right component at the right time, otherwise the production sequence spins out of control. There is not the flexibility which might be found in other industries in this part of the business.

This leads to further process and planning detection systems to ensure a rapid response when the line stops working, and statistical analysis to identify maintenance risks. All of which encourages a culture of pre-empting as well as rigorous testing of existing procedures. The philosophy is to identify potential problems before they arise, whereas

in many industries (including construction) the more normal state of affairs is to 'deal with problems as they arise'.

Applying this thinking to Honda's construction activities results in a greater emphasis on planning (from the employer's perspective) than on most similar UK projects. In particular Honda prepared its own project programme using in house expertise and seconded staff. The programme was refined, developed and updated by the construction manager (Vanbots) working alongside Honda staff. The programme was given high visibility throughout the project by requiring all trade contractors to submit a programme in electronic format (Microsoft Project) at inception of their work and to update it with actual progress on a weekly basis. Honda provided some training assistance when needed, as it recognised that not all of its contractors had all the necessary skills. This meant that at all stages of the project Vanbots and Honda had access to a 'real time' project programme embracing all packages of work which thereby produced a realistic projected completion date based on actual progress to date.

The programme was then reviewed at trade contractor meetings by projecting it on to a large whiteboard (ie a smartboard). The programme was used to identify potential problems, 'what if' scenarios were highlighted and discussed with all contractors present. Thus the effect of a potential delay by one contractor was visible to all. The programme of construction activities embraced some 3,000 activities but weekly reviews were focused on a 'look ahead' for the next two to three weeks, thereby bringing down immediate activities to less than 100 in number.

There were also regular Honda/Vanbots review meetings at which the programme and progress was reviewed and interrogated at a strategic level. This was particularly important because of Honda's developing technology in areas such as robotics. This impacted upon the building itself, as certain building components could not be designed until the robot arrangements were confirmed. Thus certain areas were built as late as possible to incorporate the latest research and development. The programme was used as a tool to manage decision making and identify the 'latest possible decision date before the programme end date was threatened'.

In essence the programme was used as a highly visible tool to 'pre-empt' potential problems and to manage the remaining work (ie the future), rather than to identify where things went wrong after the event. Martin Challons Brown of Marsh Consulting (insurance brokers and risk consultants) stated: 'This project benefited from detailed advance planning including specifications developed with input from all stakeholders so that there were 'no surprises' when letting out packages to contractors.' Mathew Clarke of N G Bailey (mechanical and electrical contractor) stated: 'Overall master plan was good (it relied upon all sub-contractors inputting)'.

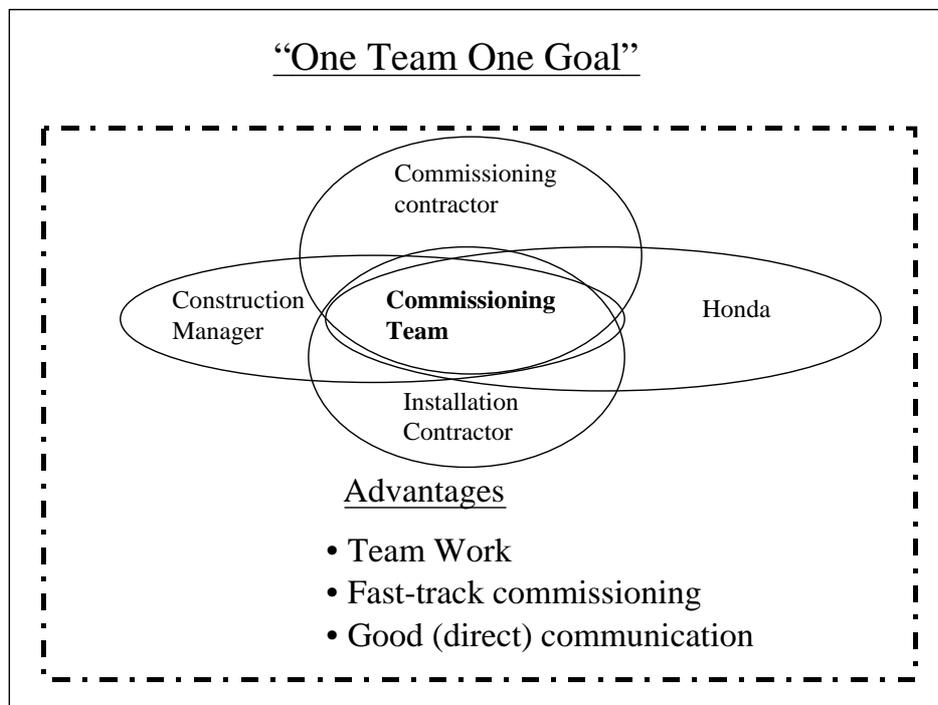
## Pre-empting philosophy

'Identify a problem, define it and solve it, collectively as a team!' - Mike McEnaney  
(Director of Business Administration, Honda of the UK Manufacturing Ltd.)

The pre-empting philosophy was actioned in a number of ways. Some of these, such as weekly trade contractor meetings and detailed updated programmes, have been described already. It was part of the weekly project meetings to consider the key project risks and when appropriate certain countermeasures were put into place. The countermeasures varied from certain contractors working overtime to developing an interim factory operational strategy for parts of the factory whose robot scoping was delayed by internal technology issues.

One particular area of pre-empting was in the field of commissioning. Commissioning is an area fraught with difficulty in heavily processed areas such as car plants. Moreover whilst commission problems are usually to be anticipated, they cannot easily be overcome by a contractual sanction or by making one organisation responsible for everything. Commissioning is an iterative process, which depends upon a number of different components (and therefore packages of work). Indeed on the first car plant built between 1989 and 1991, commissioning involved over 33,000 man hours in engineers' time (see Table 1). There was probably a similar amount of time spent by the contractors who installed the plant and services. Much of this time involved re-work and investigating of the word of one person as against another after project handover by the management contractor.

Given this experience, Honda took a pre-emptive decision on the second car plant and engaged a commissioning team some eight months before practical completion. As illustrated in Figure 8, the brief of the commissioning engineers was to work alongside the installers and understand the system throughout.



*Figure 8 The Commissioning team in relation to project stakeholders*

As shown in Table 1, the target was to reduce commissioning engineers' time to 5,000 man hours - and more importantly to have a working plant at practical completion. Both targets were met, thus achieving zero down time at the start of manufacturing operations. Whilst this approach reflected the risk analysis carried out at the start of the project, it could easily be adopted for more traditional projects with different funding arrangements. All that would be required would be a review of the risk strategy at commissioning stage.

David Law of Initiate Consulting (seconded project management staff) pointed out that there were: '... interactive co-ordination meetings, forward planning integrated with contingency planning for high risk areas, daily team meetings to ensure everyone knows what they are doing'.

Sean McGettigan of SIAC Construction (UK) Ltd stated: 'The project management team adopted a can do attitude from the outset which allowed an open discussions of problems as they arose.'

Paul Rothera of Rothera Goodwin, chartered architects stated: 'Honda are prepared to put in the extra work to ensure they have prepared themselves for most circumstances. This includes investigating options on potential problem areas before they arise.'

*Table 1 Commissioning comparison Line 1 v Line 2*

	Line 1 - E4II Actual Situation (1991)	Line 2 - NEP Actual (2001)
Manpower Actual	33,000 Man Hours	5000 Man Hours
Commissioning Time	3 years	8 months
Commissioning Cost	£300,000	£100,000

## Conflict resolution

'Claims represent inefficiency; all benefit by working efficiently' - Mike McEnaney (Director of Business Administration, Honda of the UK Manufacturing Ltd).

In essence the Honda philosophy is one which, starting with a train of thought, says that problems start small and get bigger if they are not identified and resolved. It is perhaps easier to imagine this perspective from the production line analogy where the same problem can repeat itself hundreds, even thousands, of times a day if left unchecked. Given this philosophy all problems were addressed openly and transparently at trade contractor and other key meetings as soon as they emerged regardless of contractual rights, remedies or blame.

Honda's and Vanbots 'open' philosophy meant that all trade contractors knew where they stood in relation to the progress of other trade contractors and the project overall. Thus the trade contractors were made aware when their slippages were likely to impact upon the progress of others and vice versa. Indeed Honda would be the first to acknowledge that its own technical development in areas such as robotics led to delays to certain areas of the building work.

The open communications enabled many trade contractors to make positive contributions. Whilst those with a background in claims would recommend more limited sharing of knowledge, the effect on the project was clearly positive. There were justified increased costs incurred by a few contractors, primarily as a result of client changes or delayed decisions. This led to negotiated settlements with all contractors such that all final accounts were agreed before the end of 2001 (ie within three months of the project being officially opened). Moreover there were no accounts which needed resolution by an outside third party (such as an adjudicator).

Sean McGettigan of SIAC (cladding contractor) stated: 'Regular meetings were held with the project management team to resolve progress and financial issues. As a result we had no financial disputes and our account was agreed in a progressive manner.'

Matt Clarke of N G Bailey (M & E contractor) stated: 'Good management does not always require aggression and confrontation. Results can still be achieved in other ways.'

Martin Challons Brown of Marsh Consulting (insurance brokers and risk consultants) stated: 'The key was regular update meetings, and the fact that everyone knew and understood each other's role and information / communication requirements.'

## Fair contracts based upon appropriate risk

Honda engaged the solicitors Freshfields to prepare trade contracts that fairly reflected the balance of risk between trade contractors and Honda. The philosophy being that contractors should not have to price for risks that Honda is better off taking or managing. The trade contract was based on a modified JCT Intermediate Form. A standard form was chosen as the basis for the document since it was felt this approach was likely to be seen as less controversial from the perspective of the trade contractors.

The fair and practical approach to risk management (as reflected in the trade contracts) was seen by Carl de Rocher and John Martin of Vanbots as a key ingredient to the overall success of the project:

Honda also has a far more practical approach to risk management; they do not just try to offload all the risks onto someone lower down the supply chain. They endeavour to put the risk with the party that is in the best position to manage that risk, and I believe that this is a key ingredient for the success of the project; by sharing the risk and allocating responsibility where there is control, you move away from the blame / claim culture of British construction, and keep costs manageable.

## Early warning philosophy

A key feature of the contract is the requirement that the trade contractors provide an early warning of any problems as soon as they become apparent. This fits with Honda's 'pre-emptive approach' to identifying and managing problems. Essentially the trade contractor and the construction manager are obliged to give each other notice as soon as they become aware of a matter which may increase cost, delay the project or impair performance.

An extract from the trade contract follows below:

### Early Warning

3.5A.1 The Trade Contractor shall and the Construction Manager may give the other an early warning notice of any matter which in their opinion could increase the Contract Sum, delay completion of the Works, or impair the performance of the Works in use, as soon either becomes aware of it.

3.5A.2 Either the Construction Manager or the Contractor may instruct the other to attend an early warning meeting.

3.5A.3 At an early warning meeting those who attend shall co-operate in making and considering written proposals for how the effect of each matter which has been notified can be avoided or reduced; and deciding upon actions which they will take and who, in accordance with the Contract, will take each action.

3.5A.4 The Construction Manager will record the proposals considered and the decisions taken at the early warning meeting and give a copy to the Contractor together with any instructions he considers appropriate. Nothing agreed at an early warning meeting shall be binding upon the Employer unless the subject of a separate specific written instruction given by the Architect/Project Manager.

3.5A.5 If the Construction Manager notifies the Contractor that he is of the opinion that the Contractor did not give an early warning of an event, which gave rise to an extension of time, a variation, or a claim for direct loss/or expense, which an experienced contractor could have given, the Contractor's claims in respect of

such event shall be assessed taking into account any savings of cost and time which would have occurred if the Contractor had given the early warning.

Thus the contract provides for a separate early warning meeting as soon as one party is aware of a major problem. In practice however, the subject of early warning is first discussed and recorded at the weekly trade contractor meetings. If a potentially serious matter is identified as an early warning at the weekly meeting, then a separate meeting is held to discuss the matter in greater detail. Honda adopted this 'early warning' practice on several previous projects in the early 1990's. This was prior to the publication of the New Engineering Contract which was the first standard form to include an 'early warning' clause.

The successful use of the early warning philosophy and the fact that Vanbots have adopted it on other UK projects is described by Carl de Rocher and John Martin of Vanbots thus:

One aspect of the project that we are using on other projects is the early warning clause. The early warning clause and especially the part that says that a meeting must be held as soon as possible to at least mitigate the problem is key to the team approach philosophy. If there is a problem, then bring it to the table and resolve the issue. The key is to deal with the problems as they rise. It is important to create an atmosphere or culture with subcontractors in which they know they will be treated fairly and with respect.

## Teamwork

In order to reflect the one team one goal vision, a large board outlining the project charter was placed in the reception area of Vanbots project office making it highly visible to all staff, contractors and visitors (see Figure 9). All project participants were invited to sign the board, the text of which was as follows:

We the undersigned are committed to achieve the successful completion of the project and undertake to work together in a spirit of mutual respect, fairness and using flexible attitudes to achieve our goals to the benefit all parties

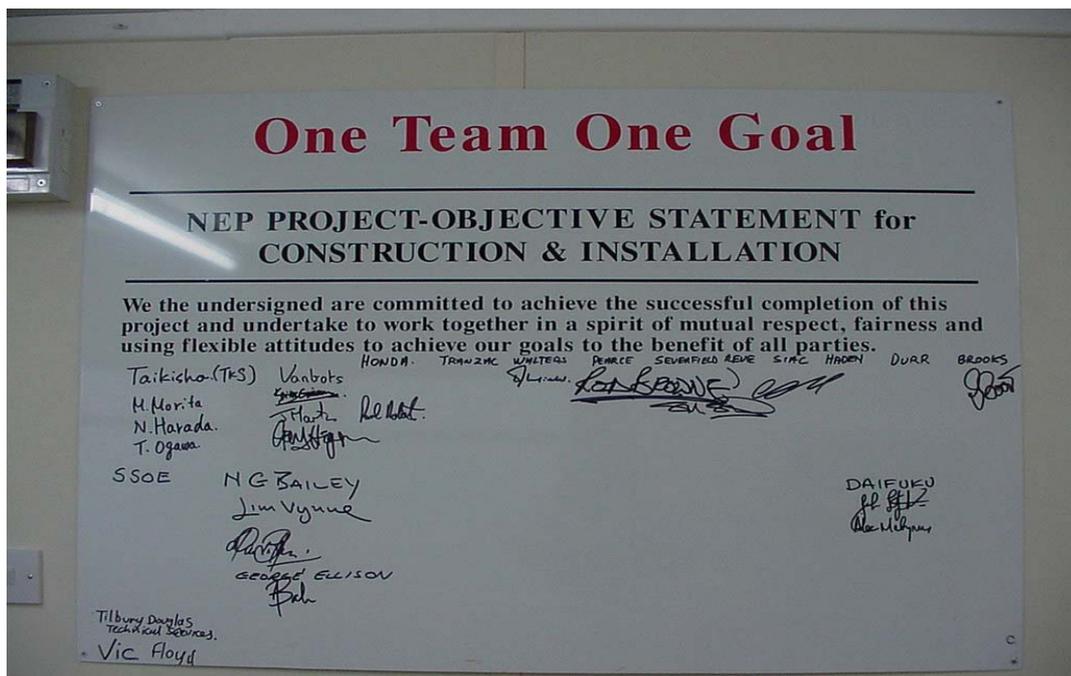


Figure 9. Team approach commitment statement visible to all on project

One key to successful project teamwork was the fact that contractors felt able to share information without feeling threatened. For example, Steve Snow of Severfield Reeve (Steelwork Contractor) said: 'The teamwork approach of Vanbots and Honda - especially when problems arose, they were sorted out by all parties with the only aim being to resolve the issue as quickly as possible and not to use the event to mount a claim or counterclaim.'

The successful project teamwork was seen by Carl de Rocher and John Martin of Vanbots as the most positive aspect of the project:

The most positive aspect of the project was the team approach with Honda. The shared offices and the white uniforms did help to create a 'one team, one goal' attitude on the project. The open book approach by both parties was also a positive aspect of the project that allowed tender packages that met with the construction goals and Honda's goals while keeping within budget constraints. Vanbots' staff dressed in white, the same as Honda, indicating to all the 'one team' approach.

## **Integrated project teams**

A key feature of Vanbots site operation was an open plan office shared with the client and the client's external advisors, including the designers. There were short daily communication meetings first thing in the morning (maximum 20 minutes - with the object of informing everyone of daily site activities and threats to progress). All correspondence, programmes and project data was made available to all members of the project team both in hard copy and by allowing open access to Vanbots computer network.

## **Specialist support staff**

Honda has for a number of years supplemented its own internal team with specialists in the areas of cost control, programming and safety. The arrangements are essentially ad hoc, support being brought in as and when needed. However apart from keeping its own internal staff levels at an appropriate level, Honda sees the main benefits of this approach in terms of cross fertilisation of ideas and flexibility. All seconded staff fully embrace the single status Honda culture including the wearing of white uniforms.

The NEP project involved seconded staff working as part of the client team in the areas of risk management, project planning, safety and cost control. All were given a wide brief to act in the best interests of the project. In practical terms this meant often acting as facilitators and identifying areas where internal or external lines of communication needed to be improved. The brief also included the identification of potential problems whilst they were still at the embryonic stage.

## **Front end cost control**

Honda adopts a financial system on all its projects which it terms 'front end cost control'. A key feature of this system is that estimated costs to complete the project are reviewed on a monthly basis at the same time as actual expenditure to date is reviewed. Thus the risk of a sudden 'jump' in out turn project cost is extremely low. Moreover as risk items such as unforeseen ground conditions are passed then the contingency allowance within the cost plan is either spent or removed and the project budget adjusted as appropriate.

Specifically this means that if a change in design is proposed, then the anticipated cost of the change is agreed before the change is formally agreed. There may be circumstances, such as unforeseen ground conditions, where the change procedure

needs to be managed very quickly. As an organisation Honda has the communication structure to so do.

The effect of this approach to financial management is that Honda has a realistic chance of achieving actual savings against agreed budgets. On many projects if savings are made in one area they are spent elsewhere. In Honda's system savings against a risk item not materialising go back to the company, rather than on enhancements to the previously specified and agreed finishes. This scenario often occurs in the wider construction industry in order that the allocated budget is fully spent. Another advantage of Honda's disciplined approach to financial management is that they are able to negotiate capital allowances with the Inland Revenue in a fast track manner, which gives the company certain cash flow benefits

### **Prompt payment**

It has been Honda's policy for several years to ensure prompt and fair payments to all suppliers. In the early 1990's Honda paid all their suppliers by BACS on a regular date every month and gave advance notice of the precise amount due to be paid. This contrasted with many large organisations that used cheques, which were not always sent timeously.

### **Project insurance**

As part of Honda's project appraisal process, it was decided that Honda would take out an insurance policy for the whole of the works. This decision was made as a consequence of realising that insurance of at least part of the works would be necessary once Honda started to take early possession of certain large areas of the building in order to install process plant and machinery. The prospect of Honda insuring part of the works and the construction manager or the trade contractors insuring other parts was not attractive. It would be complex to administer and would no doubt lead to duplication of cover and therefore wasted insurance costs. The solution was for Honda to take out a block policy for the works and ensure the trade contractors did not include for works insurance in their tenders.

### **Interactive whiteboard (Smartboard)**

Honda has for many years used photocopier whiteboards as part of the automotive business in all its meeting rooms at Swindon and elsewhere. They have been used as part of the automotive business for some time. As shown in Figure 10, these boards provide the focal point for the majority of meetings, whether internal or external, whether with suppliers, designers, contractors or whoever.

The purpose of the whiteboards is to provide a focus for the meeting in what is normally a technical environment, although it may not necessarily be a technical meeting. The boards allow the participants to draw diagrams, plans and sketches in just the same way that a 'flip chart' is used. The boards also allow notes to be made of who attended and key actions agreed at the meeting. All these boards have a photocopier facility so that at the end of the meeting each participant leaves the meeting with an agreed record of future action.

In theory it would be possible for the chairman to make similar notes on an A4 sheet of paper and then photocopy them for all present to take at the end of the meeting. In practice the whiteboard achieves far more because of its greater visibility. This means that all participants in the meeting are effectively stakeholders. Thus a comment on the whiteboard with which some of the participants disagree can be challenged and adjusted. This is much harder to achieve when it is on the chairman's personal

notepad! Moreover because all participants feel that their voice is being heard, the meetings become more productive and more constructive than in other similar environments. The taking of notes and agreeing actions in this highly visible way almost always achieves a consensus. If a consensus cannot be agreed then a record of the alternatives is made.



*Figure 10. Communication meetings to share progress with all team members*

Moreover given Honda's 'pre-emptive' and 'no blame culture,' Honda sees very little benefit in lengthy meeting minutes. In essence therefore the whiteboard note becomes the record of the meeting. The advantage of this methodology is its speed, the fact all present agree the meeting record before it is finally printed and the fact that the management style is oriented towards future actions and deadlines rather than historical review. Essentially the whiteboard methodology reflects Honda's open and transparent philosophy.

Contrast the situation where everyone leaving a meeting takes with them a short written record of what has been agreed at the meeting, followed by the all too common situation in construction projects whereby meeting minutes are circulated at the start of the next meeting, which may be two or three weeks later. Consider also the situation whereby the next meeting starts with a long debate about the accuracy of the previous minutes, and the downward spiral continues. Consider how much time is saved by managers not having to write up lengthy minutes. Honda's view is that lengthy meeting minutes rarely add value to the process and therefore they should only be taken as an exception rather than the rule. Whilst this may be perceived by some as a 'radical' approach to take, it comes from a carefully thought through appraisal of the situation.

On the NEP project the whiteboard approach to managing meetings was taken to the next level by the technical development of 'interactive whiteboards' or 'smartboards'. These are essentially a combination of a 'flip chart' and a computer screen. Individuals can make hand written notes on them but also computer generated images can be projected onto them.

This meant that project meetings had the facilities for drawings, programmes, photographs or plain text being projected onto the screen. The images were then annotated or adjusted in a highly visible way to reflect the agreement of all present. At

the end of the meeting the key action points together with the annotated drawing and programme extracts were printed out and passed to all present. In addition copies of these notes and annotations were emailed to the other relevant members of the project team.

Moreover the computer used with the whiteboard could be linked via the internet to other locations, thereby creating 'virtual meetings'. Thus weekly project meetings were linked to Vanbots and SSOE's offices in Canada and the USA at key stages during the project. The design team in the USA could thus see the same image on their whiteboard as was on the whiteboard in the Swindon project office. Discussion then took place over the speakerphone as to how to resolve problems. This approach significantly improved the speed of decision making and dramatically improved communications. These improved communications greatly increased the effectiveness of the project team as a whole.

## Use of technology

Honda is an organisation which is constantly looking for ways of using new technology, not as end for its own sake, but as a tool to improve its existing processes. The use of the Smartboards on this project is a case in point. The principle of whiteboards being used as the focus point for meetings had been established for several years at Honda, as explained above. The progression from whiteboards to interactive Smartboards exemplifies how Honda uses technological developments. However the Smartboards are very much a tool, which improves the existing process, rather than a fancy piece of technological wizardry brought in to create a misleading impression.

Vanbots as construction manager were very receptive to the use of the Smartboards. Their chief executive, Keith Gillam, describes how the knowledge and skills acquired on this project has been used to win major projects back in Canada:

In June 2001 Vanbots acquired a prestigious project with one of the largest hospitals in Canada. Sunnybrook & Womens College Hospital awarded Vanbots Construction an \$85million construction management program for M-Wing, comprising a three floor addition over existing operating theatres used for trauma. This hospital is the major trauma centre for Southern Ontario. Our task is to install gynaecology and obstetric facilities including operating rooms in addition to orthopaedic facilities, combining three major hospitals into one major facility. In addition we were advised that we would be continuing through a ten year master program should we deliver the services in a successful way.

In securing the project we brought one of our staff from the UK to demonstrate the Smartboard system technology. We successfully convinced Sunnybrook that the systems that we had developed in England with Honda would control the project in terms of programming and project control administration such that a seamless and integrated information flow between design and construction team would be of major benefit to this client. Of all the major construction companies invited to provide proposals, Vanbots was considered to be the only firm that provided this system.

Vanbots Construction recently acquired the expansion to the Royal Ontario Museum in Canada, destined to be the largest natural history museum in North America. This important facility is undergoing a \$200million expansion program. Vanbots was retained in a highly competitive construction management proposal call. The architectural selection had reached a short list of three architects: Byng Thom from Vancouver, Andrea Bruno from Italy and Daniel Libeskind from Berlin. We were able to demonstrate that due to our Smartboard technology, the location of the architect or

any of the design team consultants was immaterial. Communication on design development was instantaneous and bridged any geography no matter which architect was selected. We were retained to comment upon the cost of design, the program of design and construction, and the impact on the existing museum, thus enabling the Royal Ontario Museum to select the appropriate architect considering all the facts. The chairman of the Board of Trustees, in accepting the recommendation of Vanbots from the selection committee, noted that: 'Vanbots is the most technologically advanced construction company of all those major construction companies that submitted proposals which is entirely in keeping with the global outlook of the Museum'.

Ultimately the crystals of Daniel Libeskind was selected and Vanbots now are working with the Smartboard technology and an architect who is located in Berlin.

## Staffing levels

Vanbots proposals to act as construction manager included staffing levels generally lower than its competitors. The two main reasons for this were a management style which was very close to Honda's, coupled with their previous experience of constructing a car plant at Maple in Canada. In the event Vanbots average project team numbered 15 in total and Honda supplemented this with an average of three further internal/seconded staff for the project duration. It is perceived that most UK organisations would be looking for a site team of 24 or more for a project of this size and complexity.

The key areas where significant staff savings were made were in improved communications, no requirement for 'defensive management' techniques and lower cost management requirements. Minute taking and 'defensive' letter writing (ie blame culture) was kept to a minimum through the adoption of whiteboarded meetings for the whole of the project. When problems arose a short record of the facts was noted on the whiteboard and agreed by all, there was therefore no need to get involved in further lengthy correspondence. Most packages were let on a lump sum basis with a schedule of rates and provision for milestone triggered stage payments, thereby considerably reducing the quantity surveying input needed.

## Safety passports

Honda required that everyone entering site had to have a 'safety passport' which was not issued until after each individual had attended an induction course carried out by Vanbots safety team. The induction course focused on site specific hazards and more generic issues of personal protective clothing. The policing of this passport scheme involved a credit card sized photo card, which was checked by site security at the site entry point.

Honda and Vanbots required that all employed wore helmets, high visibility jackets and protective boots. Those who did not comply were made to leave the site. Honda and Vanbots carried out regular safety awareness training and toolbox talks, particular as the site arrangements changed and, with them, the hazards. Certain areas such as the paint shop were restricted to those who had received further training. Whilst safety is never something to be complacent about, the overall safety record of the project was significantly above the construction industry average in terms of the accident rate per 1,000 hours worked.

## Blue Book conditions

At the inception of the project Honda took the view that it wanted to encourage good industrial relations on the project. In risk management terms it was after all in Honda's interests to ensure that there was no industrial unrest. Honda was not employing tradesmen direct and therefore had no scope for direct influence on pay and conditions. However it did make it a contract condition that the employment conditions of the trade contractors' employees reflected national agreements in terms of safety, general benefits and payment. In the event there was no industrial unrest and therefore no need to investigate how rigorously this requirement had been applied in practice.

## Contractor training

Prior to work commencing, Honda held total quality management (TQM) workshops for all prospective contractors and suppliers of professional services. During the course of the project, Honda facilitated training in project planning software (Microsoft Project). The cost involved was a few thousand pounds, however the benefit was considerable in that all parties were working to a common standard in the same way that Excel is generally used as the common standard for spreadsheets.

## Environmental considerations

The existing Honda operation is accredited to the ISO 14001 environmental management standard. Honda were therefore keen to work with Vanbots and SSOE to incorporate good environmental practice within the construction project. The building design incorporated a number of the BREEAM [RB stands for?] design considerations, such as a recycled water system and maximum use of the site topography to minimise visual impact.

Evaluations of the environmental performance of the building services plant and equipment were performed in order to select equipment that operate efficiently and minimise release of greenhouse gases. Some novel approaches were taken to predict the potential nuisance impact of the development on the local residents with the use of computerised noise modelling. More obvious strategies were also adopted, such as construction waste segregation and the use of imported recycled fill materials.

## Lessons from the automotive industry

### Total quality management

The main feature of a TQM culture is customer focus and the recognition that there are many customers involved with any process, whether it is building a car or building a car factory. The customer is not just the end user but also the next person on the production line or the next contractor in the chain (e.g. the brick contractor who has to build a wall on foundations built by the groundwork contractor). The management style which is appropriate to a TQM culture places a premium on setting a clear vision, and operating in a way that encourages openness, trust, teamwork, a pro-active and challenging culture, but also enables performance to be measured and improved. Prior to the NEP project commencing, Honda arranged for a training workshop explaining their TQM philosophy to all construction companies likely to be involved in the project.

## Continuous improvement

Continuous improvement is very much part of a TQM philosophy. The objective is to find ways of improving performance, not only within the organisation but also within suppliers and others (e.g. designers) who have an influence on overall project performance. The key features of a continuous improvement process are that everybody is involved in the improvement process and they should never accept the status quo.

## Gap analysis

It is a feature of Honda's automotive business that as part of the TQM process there is regular measurement of the 'gap' between what was planned and what actually occurred. The measurement can be in quality, money, time or some other variable. The purpose is to measure the difference and then understand why it occurred.

## Effective communication

The effective communication principles, such as using the whiteboard as an aid to facilitate meetings, are probably the most radical and yet most simple methods that can be adopted in other environments.

## Honda culture

A culture which actively encourages questioning and challenges existing practices resulted in a saving on paint shop construction costs of over £1million through the value engineering process.

## Conclusion

The project was completed on time and within the agreed budget. Indeed the saving of £33 per m<sup>2</sup> (ie £734 - £701 per m<sup>2</sup>) equated to a further saving of £1.65m on the agreed construction budget. Construction costs on a like for like inflation adjusted basis were 40% lower than on a similar plant built on the same site some eleven years earlier.

## Central question

The aim of this report was essentially to answer the question: 'there are many good tools out there but most people don't use them - why?' It is clear that Honda's own core values and culture demand that the status quo is forever under threat. Therefore Honda is forever considering new methods and tools; they are fully evaluated and sometimes adopted.

Why is this not the case for other organisations? A clear theme emerged during interviews: neither Honda staff nor their advisors feel under threat of making a mistake. As Mike McEnaney (Director of Business Administration, Honda of the UK Manufacturing Ltd) put it: 'If the culture of never admitting to a concern dominated then it would not be possible to build a car!' At Honda there are high expectations placed on all, but if a problem arises the pervading culture is to discuss the problem and share in its early resolution. This is an important distinction between Honda and many other organisations where a risk averse, 'backside covering' culture pervades.

The challenge for the construction industry, and in particular the major clients who are the major instruments for change, is to recognise that there are huge benefits to be had from adopting the new tools and methods. Moreover it is not just about adopting these

new methods but ensuring that the culture is receptive to new tools and methods in the future. We believe that many client organisations do not fully appreciate all the risks which their projects and organisations face (and if they do not fully understand the problems, how can they possibly develop a strategy to manage them?)

Some client organisations perceive that by attempting to transfer all risk to others, whether contractors or designers they can satisfy shareholders, funders and other stakeholders in the project. In reality it is not possible to transfer all risks and therein lies the crux of the problem. Any project is liable to external risks including political, environmental, economic, social and technical risks (the 'PEST' factors). Risks faced by clients are wider than those normally associated with construction. Moreover, the transfer of all the construction risk to the construction industry means transfer of control of the risk. The result of risk transfer away from the client is that the project is then managed without regard to the overall business needs of the client.

For Honda it is important to be able to influence the project at all times. This is because their business need may have changed and also because the project may need 'rescuing'. If you have the ability to 'get in there', then you have the ability to rescue it.

Paul Rothera of Rothera Goodwin chartered architects stated:

Clients should try to follow Honda's commitment and loyalty to their suppliers and professional advisors and their challenging spirit, rather than hiding behind accountability and justification exercises. By remaining committed to their suppliers a working environment is generated which allows trust and understanding to develop to the benefit of the Client. Public clients need to look beyond the accountability issues. The total or overall value of the final product needs to be reviewed at all times. This total value should extend to reviewing the service provided as well as the usual budget and programme measures. Individuals in public client organisations need to be encouraged to take some risk when setting up project parameters.

Whilst there are probably several different answers to the question: 'there are many good tools out there but most people don't use them - why?' the primary answer must be because of the 'cultural barriers' in many organisations, which act as obstacles to change.

## Recommendations

### Potential 'quick wins'

We list below some tangible methods of project management which have been successfully applied within the car industry and have been used equally successfully within construction. The truth is that all the key findings within this paper have their origins in the car industry, but have been equally successfully applied by Honda within construction. Those methods which can be readily adopted (ie quick wins) are separately identified. These methods of project management can be adopted by any organisation wishing to improve performance and reduce cost. However the key is an organisational culture which allows, indeed even requires, risk taking and change, but in a structured rather than reckless or foolhardy manner.

Whilst it would be good to simply list out the key findings and say the key to success is to adopt them, the truth is that before any change can be implemented within an organisation, there has to be a champion to instigate the necessary cultural change. However, with that rider in mind, we would re-commend the following 'quick wins':

- challenge the status quo;
- learn about risk and then how to manage it;
- recognise the importance of planning;
- recognise the importance of effective communications;
- adopt the smartboard methodology for improving the effectiveness of meetings and reducing management time writing up minutes;
- create integrated project teams and actively promote teamwork;
- accept that conflict (like risk) cannot be avoided and needs to be managed; use methods, such as 'early warnings' to ensure potential problems are brought out into the open at an early stage;
- consider using experienced seconded staff as part of the client team;
- recognise that construction management (despite criticism in certain quarters) can often offer the client extremely good value for money;
- adopt customer focussed total quality management (TQM) methods.

If our 'champion' can only adopt one recommendation then we would suggest the adoption of smartboard methodology for improving the effectiveness of meetings and communication, whilst achieving an overall saving in management time.

## Suggestions for further initiatives and research

In essence this paper simply provides a strong financial argument for clients to adopt the Rethinking Construction recommendations made by Sir John Egan. The key drivers for change were identified by Sir John Egan as:

- committed leadership;
- a focus on the customer;
- integrated processes and teams;
- a quality driven agenda;
- commitment to people.

Given Sir John Egan's recommendations and the 40% cost reduction achieved by Honda (without any functionality change), perhaps the main suggestion is to improve knowledge and education amongst the construction industry's key client decision makers. As to how to improve knowledge and education, there is now far greater potential than ever before as a consequence of the internet. Government sponsored agencies should make use of training opportunities and the internet to disseminate information as widely as possible.

Finally we note that the implementation toolkit for the Egan Report makes certain key recommendations which are very similar to our own:

- move from a risk averse culture;
- challenge the status quo;
- form integrated teams;
- appoint a 'champion' to make it happen.

## Postscript - Rethinking Construction Award (March 2002)

In March 2002, the Western branch of the Chartered Institute of Building awarded Vanbots the 'rethinking construction award' for their work with Honda on the NEP Project.

## Acknowledgments

This is an electronic version of an article published in proceedings of the Society of Construction Law 15<sup>th</sup> June 2004 conference in Oxford: complete citation information for the final version of the paper, as published in the print edition of the Society of Construction Law is available at <http://www.richardbayfield.com/119-bayfield-roberts.pdf> or through the Society of Construction Law (67 Newbury Street, Wantage, Oxon OX12 8DJ, Tel: 01235 770606, Fax: 01235 770580, E-mail: [admin@scl.org.uk](mailto:admin@scl.org.uk), Website: [www.scl.org.uk](http://www.scl.org.uk)).

## Appendix 1 -- Extracts from QCMDSE assessment form

	QCMDSE INTERVIEW CHECK LIST	H	M	L	TOTAL
		5	3	1	
Q1	How will you verify the quality of your employees workmanship whilst on site				
Q3	How do you verify the quality of information in O&M manuals handed over to Honda				
C1	Can you explain how you intend to assist Honda with value engineering				
C2	How do you control cost changes from your subcontractors				
D1	If you were experiencing scheduling problems mid way through an installation project what sort of activities would you employ to try and get back on programme				
D2	What is your minimum guaranteed response time to attend the Swindon site during normal working hours				
D5	How you can you guarantee you resource commitment to Honda				
D6	How do you propose to avoid claims?				
M5	What capabilities do you have for in house design				
M6	How can you demonstrate you competence to perform this type of design work?				
M7	How can you guarantee continuity of Honda site knowledge within your employees				
M8	What level of supervision would you propose to have on site at any one time?				
M15	What in house IT / CAD / Drawing facilities do you have				
M19	How would you co-operate with Honda's contract requirement for early warning.				
M20	How will you coordinate / manage document control, i.e. ensure use of latest design info.				
M21	Do you participate in any training schemes for your employees personal development				
S7	What do you understand by the Honda Safe Working Rules				
S11	How do you intend to manage site safety				
S12	What systems and procedures do you operate for the preparation of method statements				
E2	Does your company operate an environmental policy?				
<b>WEIGHT, times</b>					
	Total				

# APPLICATION OF LEAN MANUFACTURING PRINCIPLES TO CONSTRUCTION

Review By: O. Salem<sup>1</sup> and E. Zimmer<sup>2</sup>

The subject set forth in the reviewed CII report #191, authored by James E. Diekmann, Mark Krewedl, Joshua Balonick, Travis Stewart, and Spencer Wonis, is concerned with the applicability of “lean production” principles, currently being implemented in manufacturing, to the construction industry. The manufacturing industry has seen dramatic improvements in productivity and quality, while reducing cost and lead times. The construction industry has not seen such positive results. Improvement opportunities are in demand. However, both of these industries involve the management of complex operations and strive to deliver a quality product in the shortest feasible time possible. Moreover, in each of these industries it is important to save money and stay competitive. Given these similarities, we wish to decipher if the lean manufacturing principles can be applied to construction and if similar benefits could result. The primary question in this report that the authors seek to answer is, “Does lean practice hold potential for improving construction?”

The authors develop the study by presenting to the readers the theory behind lean thinking. In doing so they state a set of research questions, create a lean assessment instrument, and conduct six case studies. They finally present a set of conclusions and recommendations in support of this assumption that lean practices does indeed hold potential for improving construction. The reader is initially introduced to “lean” and lean theory from the perspective of the manufacturing industry. The Toyota Motor Company, the founder of lean production principles, is integral to this background. These principles or goals include reducing lead times, eliminating non-value adding activities, and reducing variability and are facilitated by methods such as pull scheduling, simplified operations, and buffer reduction. Finally, tools mentioned in the report that have been created to aid these methods include Value Stream Mapping, Just-in-Time, and Continuous Improvement.

With this background knowledge established and identified, the manufacturing and construction industries are compared and contrasted. The comparable aspects of the two are highlighted and focused on in support of the study presented. Also noted are the differences between manufacturing and construction and the difficulties in applying certain lean concepts to construction. Important issues that surface in the report include the greater degree of discretionary behavior and increased uncertainty evident in construction. But with this in mind, the comparable aspects of lean manufacturing and lean construction are grouped into the principles of customer focus, culture/people, workplace organization/standardization, waste elimination, and continuous improvement with built-in quality. A definition of lean construction is stated as “the continuous process of eliminating waste, meeting or exceeding all

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customer requirements, focusing on the entire value stream and pursuing perfection in the execution of a constructed project.”

The goals set for the research team included the development of a comprehensive set of lean principles and validation of these by field observations of lean behavior, value stream mapping, and interviews with early lean adopters. Two tasks were performed in parallel. First, in order to better understand value and waste in the construction operation, a value stream mapping (VSM) was conducted. This type of analysis allows for greater understanding of the value stream of the product, or in other words, identifies types of wasted activities and practices that ultimately do not add value to the project. Along with this, the other task was performed to obtain a better understanding of the lean behaviors that are actually practiced in construction. In accomplishing this, the research team distributed questionnaires and conducted interviews. The report discusses the validation of the questionnaire and the research team proves that it is a reliable tool for measuring conformance to lean principles. This was done with contractors involved in the case study, as well as lean researchers and other companies that have already begun practicing lean construction. From all of this, best practices and recommended actions are drawn.

This approach was implemented in six case studies. Three case studies focused on the process of structural steel erection and the other three focused on the process of large bore pipe installation. The VSM method allowed the team to analyze the field operations and decipher which actions were of value to the project and which were not. The amount of time workers spent on tasks were monitored and logged into corresponding categories of work. The three categories used are value adding (VA), non-value adding (NVA), and non-value adding but required (NVAR). Examples of non-value adding but required work are material positioning and in-process inspections. As the report states, this category includes operations that are required for construction operations, yet have no permanent effect on the finished product. VSM results revealed that out of the combined workable hours for the three structural steel erection case studies, only 11.4 % was VA. The process piping case studies showed 7.5 % to be VA. Further defining this value resulted in added work; or in other words, activities that the client is interested in purchasing.

The study presented is shown to be valid through interviewing, questionnaires, and case studies. Lean practice does hold potential for improving construction. A set of lean principles and best practices is established and recommendations are given to future adopters of lean thinking.

The five major lean principles that the authors conclude are applicable in the construction industry are:

- Customer focus
- Culture/people
- Workplace standardization
- Waste elimination
- Continuous improvement/built-in quality

Subprinciples that stem from these major principles are rated and assessed for applicability. The report suggests that these can be used as a guide for creating a construction organization that moves closer to the ideal of lean production. Moreover,

the report concludes with recommendations for new adopters, but also identifies some of the barriers to developing a lean company of which to be aware.

## Critique

This report strongly addresses the issue of adopting lean practices in construction. The concluded principles and recommendations also show themselves to be meaningful. Overall it was very effective, giving a great summary of where lean construction originates and what the current state of practice is. Up to this point, it was a known fact that construction is different in many ways from traditional manufacturing. But the report gives a great summary of applicable principles, steps toward becoming lean, and likely benefits to a construction organization. The conclusions drawn seem quite valid and consistent with the evidence provided.

The authors deal with the problems presented in a scholarly manner and provide references for many of the known figures in the area of lean production. Included are those from the manufacturing and construction industries. Most of the key players that have contributed to the application of lean manufacturing principles to construction are cited in this report. The authors seem to agree with and accept many of their viewpoints.

The report is very organized, most notably in the sequence of sections. First, it brings the reader up to speed with the history of lean production and explains the theory in a timely fashion that should be understandable by the majority of audiences. An extensive review is included on the relevant management theories. Given that this background knowledge is readily available in the report, it makes for a powerful reference document. It greatly facilitates the learning of lean thinking in construction and allows for quicker review. Going along with this, the glossary of terms was a great addition. The report appears professionally written and readable. Also, layout throughout the document was appropriate and figures or tables are useful for providing the reader with a clear and more meaningful representation of the information.

This report seems to be intended mostly for the moderately experienced practitioner. Having a background in manufacturing and/or construction will be beneficial but certainly not necessary. This report should, more likely than not, keep the interest of leaders in the construction industry who are interested in the benefits shown to arise from lean practices.

In addition, the construction operations chosen in the case studies were very welcoming to a value stream analysis. The method was very effective and the results clearly showed that there was room for improvement in the construction process. When conducting a VSM in a manufacturing setting, a current state value stream map of the current process is first created. This map is analyzed, changes are made for improvement in flow, and a new state map is created by the research team. This approach was a great step forward in the attempt to apply lean manufacturing principles to construction.

Another interesting aspect of this report was how worker movement studies were incorporated, similar to studies conducted by industrial engineers and operation analysts in the manufacturing and service industries. This is because it further supports the idea that productivity in construction operations can be improved and that there are many tools, techniques, and creative methods which show this.

Future research and work is still plentiful. It was evident before reviewing this document and still seems obvious that a major problem in construction involves the area of supply chain management and design information. These are bottlenecks that are inhibiting the flow in the construction process, causing road blocks for further value generation. As the report states, in order to view the entire value stream, the process must be observed from the onset to the end of the project. This is difficult in construction and the reasons are stated in the report. Regardless, it is agreed that more effective supply chains and reliability in design information are focus areas. Also, as said before, metrics for measuring lean construction performance need to be determined and utilized. This is essential for continuous improvement. Just as it is critical in the manufacturing industry, it is critical in construction as well. Finally, the report gives a great overview of lean construction techniques. It mentions specific tools and methodologies that have been developed, like Last Planner™ and JIT, but does not go into extreme detail on each of these as this has been previously done by others. It presents audiences who are previously unfamiliar with such ideas with an inclusive summary about the elements of lean construction and makes suggestions for implementation.

# LEARNING ACROSS BUSINESS SECTORS: KNOWLEDGE SHARING BETWEEN AEROSPACE AND CONSTRUCTION

Review By: C. L. Pasquire<sup>1</sup>

## Introduction

Published in 2004 by The University of Reading, UK; this report details the findings of a 2 year research project funded by the Engineering and Physical Sciences Research Council through the University's Innovative Manufacturing Research Centre. The report is authored by: Stuart Green, Robert Newcomb, Scott Fernie, and Stephanie Weller. It has a foreword by Sir John Gains, Group Chief Executive of Mowlem plc and Chairman of the Management Board of the Innovative Manufacturing and Construction Research Centre at Loughborough University, UK. The work was undertaken in collaboration with BAE Systems, Forticrete, INBIS, Mowlem Aquamen, Mowlem Building, NG Bailey & Co and Scott Brownrigg.

The report examines the extent to which management practice can be shared between aerospace and construction. It claims to expose the commonly held notion of "best practice" as a myth and even detrimental to performance by deflecting attention from the need to adapt continuously changing circumstances. It defines significant differences between aerospace and construction and emphasises that, whilst managerial practices may not be transferable from one sector to another, valuable learning can be derived from cross-sectoral comparisons. The authors further qualify this by explaining the importance of context through the existence of ingrained "industry recipes" that reflect and reinforce the way an industry sector is organised. Fluctuating external pressures ensure that no industrial context is ever static and the dynamics of change must underpin any attempt at knowledge sharing across sectors.

The report is easy to read with helpful margin icons and notes, used to provide extra information. Each chapter contains summary tables inserted at pertinent points intended to act as "handrails" reminding the reader of the main structural characteristics of the two industries under review. Each chapter tackles a specific topic making the report a collection of small stand-alone reviews. This enables the reader to select a chapter and learn from it without the need to read the whole document in order to find something useful. This review looks at each chapter in turn as follows:

## Chapter 2 - Knowledge Sharing : Challenging Assumptions

The roots of knowledge in Lean (production and construction) are founded in systems and therefore is perhaps more comfortable with knowledge management focusing on management information systems. The report, on the other hand, falls in with the alternative school of thought that knowledge is primarily a human endeavour

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concerned with the development of intellectual capacity. This makes this report enormously useful in terms of identifying where Lean Construction can and needs to develop. Making knowledge flow should be a primary goal of Lean Thinking and, of course depends upon identifying the constraints to flow. A discussion about knowledge, its role and its management is extremely pertinent as Lean Construction starts to look at the wider issues impacting on project delivery. Part of this discussion will involve deeper investigation of the distinctions between data, information and knowledge. This chapter makes a good case for the need to understand this and tells us "Competitive advantage lies in the process of creating knowledge. Those who refuse to participate on the basis of what they know already are gambling with a rapidly diminishing asset." It is proposed that part of knowledge is its context and that knowledge is inseparable from its knower, a cautionary note for anyone attempting to learn not only from an alternative industry such as aerospace, but also from an alternative construction organisation/project or the generic proposition of "Best Practice". Failure to recognise the importance of context and knower explains in part why managerial "fads and fashions" can pass without significant impact.

### **Chapter 3 - Structure and Change: Contrasting Contexts**

This chapter provides a fascinating insight into the structural differences between the two sectors demonstrating the fragmentation of the construction industry. Key facts include the dominance of aerospace by one company (accounting for 60% of supplier output) and that aerospace spends around 11% of the sector annual turnover on research and development. Construction, by contrast, has 30 top companies accounting for only 17% of supplier output and spends about 0.3% on R&D. This may not be surprising but hard empirical data does help us understand the context or "industry recipe" for the sector. This chapter focuses us on the issues that must be considered if any change is to be achieved. For Lean Construction it clearly demonstrates the problems faced when attempting to influence project delivery. Aerospace has become highly consolidated in the face of global competition because planes can be built anywhere. This has forced the issues of collaborative working and delivery of value. In construction, the fact that buildings are largely constructed locally prevents global competition and promotes fragmentation and localisation. The attitude and influence of government is also picked out as having shaped the development of each sector.

### **Chapter 4 - Supply Chain Management**

This chapter recognises the use of the lean production systems from automotive as a model for supply chain management within literature aimed at both aerospace and construction, but criticises this literature for its lack of recognition of context. This is possibly justified although the Lean Construction Institute and the International Group for Lean Construction have always advocated that adaptation of lean production and lean thinking is required for successful application in construction and both have devoted much of their work to this. Construction practitioners on the other hand are perhaps seeking useable tools and techniques and do not view their role as encompassing the work required to carry out the necessary adaptation (0.03% R&D investment remember). The view construction practitioners have of themselves is an important point and this chapter unpicks some of this painting a sad picture of a cynical industry that only "talks the talk". The positive aspects of this chapter focus on a discussion of what supply chain management is and should be. For construction

this becomes a long list of barriers to improvement and integration and it is apparent that there is much to do before the industry can claim to properly manage and work with its supply chain.

## Chapter 5 - Requirements management

This chapter opens with the margin note "The construction industry's obsession with cost efficiency misses the point. If you can't get the brief right you might as well pack up and go home. Building the wrong thing cost efficiently does not provide value for money for anyone". This directly illustrates one of the accepted wastes under lean thinking and that aerospace has a specific discipline of "requirements management" to capture and manage client requirement demonstrates how central this idea is. This chapter explores the theory and practice of requirements management and compares it with associated practices within construction. There is much food for thought for Lean Construction here as the chapter contains highly detailed descriptions of requirements management strategy, processes and practice. The reader is left with the feeling that construction designers are not always very imaginative tending to develop the brief based on what they want/can design rather than the other way round!

## Chapter 6 - Human Resource Management

The Lean Construction community has been criticised for the impact of lean thinking on the work force so this chapter arouses intense interest. There are some interesting contracts between aerospace (moving from low skill to high skill) and construction (actively deskilling wherever possible) and one has to wonder how this may influence the growth and development of the industry. Both sectors face increasing difficulty in recruiting and retaining appropriately skilled employees and recognise the need to address this as a matter of urgency. There is also a major difference in the collectivism of staff with aerospace still highly unionised and construction being increasingly characterised by the "hollowed out" firm making wide use of individualised contracting ranging from self-employed operatives and free lance professionals with any directly employed staff negotiating personalised contracts. Lean or not, it seems that both sectors have room for improvement in HRM and the bulk of this chapter comprises theory and discussion about how this may be achieved and what a sector and an organisation should be aiming at.

## Chapter 7 - Innovation

The definition of innovation is acknowledged as problematic with both sectors valuing innovation but not always clear as to the specifics of delivering it. Certainly, the highly technical aerospace industry has a high regard for radical technological innovations whilst construction commonly implements small incremental process innovations. Certainly lean thinking advocates continuous improvement as a core activity in delivering value, promoting the need to be innovative and construction has picked this up through the Egan report as a series of performance targets. These both lack much of the contextual argument this report insists upon and leads us to realise innovation is not the result of serendipity. There is considerable depth in the content of this chapter that advocates of Lean Construction and the construction industry generally should consider carefully. If, as stated in chapter 4, construction only "talks the talk" then real improvements, which by their nature require us to do things

differently and be “innovative”, will pass us by. Two aspects are identified particularly, the industry’s attitude to risk and the interference of the client in the operational activities of the supply side. Both of these aspects are heavily influenced by traditional procurement strategies and by the whole issue of trust and honesty discussed in earlier chapters.

## Chapter 8 - Summary and Conclusions

Each chapter (2 -7) is briefly summarised giving the key points enabling the reader to gain a broad insight into the contribution this report can make and allowing them to home in on a specific chapter to gain more depth. This chapter then proceeds to some major conclusions resulting from the study. Firstly, the point is made that knowledge sharing has much to offer and that it is a much richer exercise than benchmarking because it includes contextual differences, this extends to the notion that best practice recipes are not universally applicable for the same reason. There are also implications for knowledge sharing within organisations as IT systems can distribute information and codified knowledge but are unlikely to contribute to the sharing of managerial knowledge and any company wishing to become a learning organisation will need to address this.

There is a major difficulty with definition with managerial practices having multiple interpretations. Indeed practices of the same name are often radically different when implemented in different sectors. The example of Supply Chain Management is cited to support this. This is partially a result of the dominant industry recipes that give rise to institutionally embedded practices. It is claimed that understanding the sectors historical development is an essential prerequisite to any change agenda. Part of this historical development is the varying models of competitiveness, with construction having taken “the low road” with competitiveness resting as much on contract trading than improving productivity. This has driven the emergence of the hollowed-out firm and seriously threatened the industry’s capacity for innovation and presented significant barriers to innovative practices. Some light is available through emerging new procurement methods. Prime contracting is cited as providing potential for collaborative working and PFI likewise offers the opportunity to stabilise the market. This will not happen though without a commitment to invest in innovation and new skills on the part of the supply side and the provision of continuity of work from the demand side. The authors believe any shift in construction will always be constrained by the structural characteristics of the sector - which may be a realistic if rather pessimistic final word.

## Conclusion

In conclusion of this review, I must confess I enjoyed reading this report. Its particular strengths are the use of margin notes and the tabularised comparisons sprinkled liberally through the text. The language used is clear and logical making the document easy to read and use.

Whilst in some ways it is unsurprising in the extent of its criticism of construction, the clear definition of issues makes it a useful strategic document, pinpointing how the construction sector can start to make better use of knowledge in its management practices.

All in all, this is a must have reference source.