RESEARCH REPORT

External Research Program

Technology Dissemination: Triggering Innovation Adoption in Canada's Home Construction Industry

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TECHNOLOGY DISSEMINATION : TRIGGERING INNOVATION ADOPTION IN CANADA'S HOME CONSTRUCTION INDUSTRY

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ABSTRACT

Canada's residential construction industry has an extremely low level of innovation adoption with many new products taking 20 to 25 years to penetrate the market. Consequently, industry is only using about 50% of available innovations at any point in time. Extensive research of this issue is fairly consistent in its findings that the unique structural nature of the industry and limited resources create an environment which is not conducive to innovating.

This work proposes a new approach to improving industry's rate of innovation, but foregoes the past practices of merely 'encouraging' innovation in favour of a more pro-active , even aggressive, approach which attempts to almost force, or at least certainly trigger, innovation adoption.

The objective is to 'load' one general contractor and its sub-trades with innovative technologies. It is then assumed that the sub-trades who are now beginning to enjoy the benefits of these innovations will employ them on other works to gain a competitive economic advantage. This in turn will encourage, or even force, other sub-contractors to adopt similar technologies in order become more cost-effective and competitive.

'Loading' in this context means providing the support and technical information necessary to implement 100-200+/- product or process innovations. Loading is important from three perspectives: First to capitalize on as many advances as possible, "If you're going to do something, do it right!."; second to offer a sufficiently broad range as to find innovations which are compatible with the contractor's corporate cultural and procedures and lastly, and perhaps most importantly, to demonstrate the benefits of and create a *pro-innovation* corporate and job-site environment.

This report looks at a demonstration project which tests this theory. The report includes the findings from an extensive literature review, the construction of two testbed homes, and an evaluation of the process and findings. While the work was unable to conclusively prove the value of the proposed approach, collected information and site observations suggest its underlying validity and hint at its potential. The work concludes with a suggestion of how further work might be pursued, or even the concept commercialized.

PURPOSE:

Among Canada's industrial sectors, construction and particularly small-scale residential construction are considered to have some of the lowest levels of research and development or innovation adoption. While many new products and services are being brought to the general retail market in a matter of a couple of years, research suggests that it takes upwards of 20 to 25 years for innovations, such as roof trusses, to fully penetrate the residential construction markets. The net result of this extended introduction period is that at any point in time the industry is only using, and benefiting from, something akin to 50% of available innovations. This results in increased environmental impacts, poor construction quality but higher priced housing.

Without investigation, one might assume that the slow rate of innovation take-up was, or is, in some fashion related to a shortage of available innovative materials, products or construction techniques and processes. However, even a modest review shows that there is an abundance of available innovations and that the problem is not one of insufficient innovation but rather one of insufficient *adoption* of available innovation.

There has been extensive research conducted regarding the various aspects and potential causes for these delays in introducing and adopting construction innovations and the available literature is fairly consistent in its findings noting that the unique structural nature of the industry and its low levels of income, and particularly profit, combine to create an environment which on the whole is not conducive to innovating. While exact figures have not been secured for profit levels, one report suggests that construction profits have been flat or even declining for the last decade. With the recent exception of Alberta, most of Canada has endured a relatively flat or depressed housing market over the last few years. As a result of this poor fiscal environment, most firms are "lean & mean" lacking the resources to properly explore, evaluate or test innovative materials and construction techniques.

The very nature or organization of the construction industry has also been cited as impeding innovation. With low-cost bidding, prescriptive specifications, project-specific construction and a high level of sub-contracting, there is little incentive for individuals or firms to be progressive and invest the effort and resources to innovate and try to redirect the juggernaut known as 'building' down new paths. The problem is compounded by man's natural resistance to risk, " How do I know it won't fail in 20 years and come back to haunt me ?" Some of this concern is legitimate when one considers that given the nature of the home construction process, it may take 10-20 years, or more, for some materials or construction systems to fail. Add to this man's natural inertia; "This is the way we've always done it!", and one can appreciate some of the delay for innovation adoption. While legitimate concerns, when considered in moderation, the result of these attitudes in our construction industry is an uneconomical delay in advancing the technology of building.

Against this background, the following work proposes a new approach to

Against this background, the following work proposes a new approach to improving the rate of innovation adoption at the job site and in the managerial organization of the small-scale residential construction industry. For this work, 'small-scale' refers to the type of wood framed buildings generally associated with single family residential, or smaller non-residential construction. Further, the work departs from past efforts which may, in the main, be described as passive or merely 'encouraging' to focus on a more pro-active , even aggressive, approach which attempts to almost force, or at least certainly trigger, innovation adoption. The work attempts to engage prime general contractors in a cooperative endeavour to introduce a broad spectrum of cost-saving technologies to the full range of sub-contractors involved in a home's construction.

It is hoped that a positive experience and clear demonstration of the innovations' benefits will induce the general contractor to *insist* on their use within his projects thus *forcing* their adoption on a company specific basis. It is then assumed that the sub-contractors who now enjoy the benefits of utilizing these innovations will employ them on other works to gain a competitive economic advantage. This will then enable them to secure more work which in turn will encourage, or force, other sub-contractors to become more cost-effective to compete. As will be seen in the report, this work was only partially successful.

Although this may initially appear to generate less income for the contractors and thus create a negative environment in which they will oppose innovations, the report discusses how those innovations can lower the trades' costs which in turn can result in lower housing cost for the consumer while at the same time resulting in higher profit for all members of the construction team.

In a sense, one would be correct in arguing that the above process currently takes place in the Canadian construction environment; however, the proposed approach attempts to **significantly accelerate that process** plus it offers a more formalized mechanism for individuals or agencies to pro-actively stimulate information dissemination and innovation adoption.

The following report looks at a demonstration project which involved an extensive literature review, the construction of two homes, one being a benchmark unit, and an evaluation of the process and findings. The work concludes with a proposal for a national pilot project to further develop the theory underlying the concept of forced or triggered innovation adoption.

ACKNOWLEDGEMENTS:

I wish to acknowledge the pivotal and supportive role played in this project by the following individuals and firms While these contributors provided information and insights which were crucial to an understanding of the issues under review and the subsequent completion of the work, any errors in analysis or interpretation are solely the responsibility of the author.

Dilworth Quality Homes - KELOWNA

As a firm, Dilworth Quality Homes showed insight and leadership in the exploration of innovative construction practices. As a partner in this research effort they provided the support and encouragement so vital to the work's development, execution and ultimate success In particular notice must be made of the following individual's contribution

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Mr G Aisling, General Manager, Land Development and Housing,
Emil Anderson Construction
Mr S. Hansen, Building Manager
Mr D DeShane, Project Superintendent

Resource Centres

Special thanks is extended to the librarians and research staff at the many libraries and organizations whose resources repeatedly prove to be a treasure trove of priceless construction information Though so often anonymous, the assistance and skills of these individuals are central to any research efforts in this area of endeavour The following centres provided the information and reports upon which this work is based

Canadian Housing Information Centre - CMHC - OTTAWA
National Research Council Library - OTTAWA
U S. Department of Housing & Urban Development Library - WASHINGTON
National Association of Home Builders Library - WASHINGTON

NAHB - Research Centre UPPER MARLBORO, MD

Special notice must be made of the many published reports and general information emanating from this organization and the role that information played in this author's understanding of the information dissemination process in particular and residential construction management and practices in general

Professor C. Davidson - University of Montreal - MONTREAL

Professor Davidson's work on Technology Watch was of considerable assistance and encouragement and provided a key insight as to how one might organize an innovation dissemination process

EXECUTIVE SUMMARY:

This work looks at the issue of the slow rate of innovation adoption in the small-scale residential construction field. The report proposes an approach to speed such adoption and discusses a demonstration effort to test that theory. A theory which holds that if one is able to convince a general contractor and their sub-trades to adopt certain cost-cutting innovations that in time other sub-trades will in a sense be *forced* to also adopt those innovations in order to remain competitive. This is referred to as 'dissemination by infection'. The work includes a discussion of a literature review, the identification and selection of innovation technologies for inclusion in the demonstration, the proposed and actual work plan and the findings and conclusions. The work concludes with a preliminary proposal for a national pilot project to develop the underlying theory further.

For the purposes of this report 'small-scale' generally means the single-family, wood-framed residence; however, the area of study can logically be expanded to include any of the smaller, wood-based areas of construction such as small commercial, industrial or even institutional work wherein the construction process and the managerial or organization environment parallel that found in home building.

The work is divided into nine chapters and an Appendix containing the following elements.

CHAPTER 1- INTRODUCTION

The opening chapter discusses the basic theory of a new approach to improve information dissemination **and** innovation adoption. The text highlights the particular point of focus for the work which is the actual adoption process and defines the various parameters for the subsequent discussions involving the types and categories of innovations. It also looks at the difference between innovation creation and innovation adoption and explains the importance of the later. Finally, the chapter considers the question of potential cost-savings and how any benefits may be apportioned either to the contractors or the home buyer.

CHAPTER 2 - INFORMATION SEARCH

The chapter describes the literature review and information gathering process and provides a distillation of the findings. Those findings are divided into four main sections. The first outlines the many quoted impediments to either innovation creation or innovation adoption, while the second looks at innovation accelerators. These are followed by a presentation of general observations taken from the literature and interviews which could not be easily categorized as pro or con comments such as the observation that:

> " Contractors will innovate to remain competitive,
> but won't innovate to gain a competitive advantage."

The chapter concludes with a discussion of two points which were seen as having particular relevance in terms of the proposed research thesis for improving innovation adoption. The first of these are 'change agents' and 'gatekeepers' , those individuals who can have a significant impact on the rate and nature of innovation adoption within their sphere of influence. The second issue is that of 'Technology Watch' which is a process for distilling pertinent information from the flood of available data and making it more precise and focus for interested recipients. Absent from this chapter, but to be found in Chapter 4, is information on innovative technologies which were utilized in the demonstration project.

CHAPTER 3 - PROPOSED WORK PLAN

This element is a more extensive explanation of the proposed work plan outlined in Chapter 1 and provides details of the project's implementation . Subjects covered include the selection of the contractor, the technologies chosen for demonstration, issues of pricing and contributions by the trades. The chapter also includes a comprehensive point-by-point discussion of how the proposed innovation adoption approach addresses the many issues raised in the Chapter 2 discussion of the many impediments to innovation. The work concludes with a discussion on how the proposed approach differs from more traditional activities such as training and demonstration projects.

CHAPTER 4 - INNOVATIVE TECHNOLOGIES

This chapter concludes the presentation of the material garnered from the literature review and information gathering procedures wherein it details the various technologies which are documented for consideration by the general contractor and sub-trades. A preliminary and brief non-vetted list of some 228 items can be found in the Appendix. This chapter provides greater detail on 34 technologies, products and strategies for which the contractor sought additional information before making a final selection of strategies for inclusion in a demonstration home. In additional to individual items, there is an aggregation of primarily framing strategies under the broad heading of Optimum Value Engineering [OVE] techniques and a somewhat more comprehensive exploration of Cycle Time Reduction as a distinct cost saving strategy. The section on Cycle Time Reduction is illustrated with a comparison of a typical and a reduced construction schedule plus a paper from the National Association of Home Builders [NAHB] on what one saves by reducing their construction schedule by one day. Finally wherever possible, the potential benefits in either time or financial savings are provided for the various innovative strategies.

CHAPTER 5 - PROJECT IMPLEMENTATION

The implementation process is described in detail noting both the actual tasks undertaken, the problems which arose as a result of the schedule and lists those technological innovations which were pursued to the construction stage.

CHAPTER 6 - FINDINGS

This chapter highlights the site observations and reports on the work of the general and sub-contractors during its execution. There is also a discussion of the various individual technologies in the testbed home.

CHAPTER 7 - CONCEPT TRANSFERABILITY

While conceived as a concept geared to a market specific, small scale residential construction industry, the process being explored was also evaluated for its potential transferability to other contractors, markets, and construction segments. This chapter explores those issues and while it is suggested that the concept's transferability to more conventional institutional, commercial or larger public structures may be limited, there appears to be no reason why the concept will not readily transfer to other contractors, markets and even the smaller scale non-residential construction.

CHAPTER 8 - CONCLUSIONS

This summary chapter discusses the project in terms of its initial goals and achieved successes. While noting that the work was a qualified success it does discuss how the findings were interpreted and why further work is considered desirable.

CHAPTER 9 - FUTURE OPPORTUNITY

The work concludes with a discussion of how the ideas and findings arising from the work might be expanded into a business or non-profit endeavour to capitalize on or address the need for improved innovation adoption. Under a section titled "Future Opportunity", the report discusses a possible role for any lead individual, company or agency, and broaches the concept of 'Technology Champions' who as independent consultants, but innovation promoters, will be the vehicle through which a lead agency delivers its programme. The duties of these 'Technology Champions' are discussed in some detail. The work also includes information on funding options including the potential for a cost-recovery or profit based system. The chapter concludes with a brief section on one implementation scenario for a pilot project.

APPENDIX

The Appendix contains three elements. First, the original un-vetted list of innovative technologies considered for possible inclusion in the demonstration home. This list is comprised of two distinct elements: pages A1-A6 contain construction and management oriented technologies which form part of this study. The later half of the listing pages A7 - A12 encompasses some 95 various marketing items which while not part of this study were culled from the literature for review as to whether they might apply under the more technical category which is the centre piece of the work, and are included for the edification of the reader.

Secondly, the Appendix contains the full set of reduced construction plans for the home which was built as both the baseline and testbed units.

Finally one will find examples of innovation evaluation sheets which were developed by the National Association of Home Builders in the U.S.. However, as these sheets were received too late to be used in this project, they are offered primarily as a guide to any individuals seeking to continue with this work.

RÉSUMÉ

La recherche dont il est question ici traite des enjeux découlant du faible niveau d'adoption des innovations dans le domaine de la construction d'habitations de faible envergure. En plus de proposer une méthode visant à accélérer l'adoption des innovations, le rapport fait état d'un projet de démonstration ayant pour objectif de valider la méthode proposée. La méthode est fondée sur l'hypothèse suivante : il suffit de convaincre un entrepreneur général et ses sous-traitants d'adopter certaines mesures d'économie innovantes et, tôt ou tard, les autres sous-traitants se verront obligés d'adopter ces mêmes innovations s'ils veulent demeurer concurrentiels. Cette technique s'appelle « l'influence par l'exemple ». L'étude est composée des éléments suivants : une analyse documentaire, une liste de technologies innovantes à intégrer au projet de démonstration, le plan de travail réel et proposé, ainsi que les constatations et les conclusions. On termine en proposant la mise sur pied d'un projet pilote à l'échelle nationale visant à étoffer davantage les hypothèses de travail.

Pour les besoins du rapport, l'expression « de faible envergure » signifie normalement une maison individuelle à ossature de bois; toutefois, le domaine d'étude peut très bien être élargi pour y inclure les petits ouvrages à ossature de bois de type commercial, industriel voire institutionnel, pour autant que le procédé de construction, la gestion des travaux et le milieu organisationnel soient semblables à ceux de la construction résidentielle.

L'ouvrage comporte neuf chapitres et une annexe :

CHAPITRE 1 - INTRODUCTION

Dans le chapitre 1, on aborde les fondements de la méthode améliorée de diffusion et d'adoption des innovations. Le texte est axé sur le processus d'adoption et définit les différents paramètres portant sur les discussions ultérieures relativement aux types et aux catégories d'innovations. On y explique également la différence entre la création et l'adoption des innovations, l'accent étant surtout mis sur cette dernière. Enfin, le chapitre traite de la question des économies d'argent possibles et du partage des gains éventuels entre l'entrepreneur et l'acheteur de la maison.

CHAPITRE 2 - RECHERCHE DOCUMENTAIRE

Ce chapitre décrit l'analyse documentaire et la cueillette d'information qui ont été effectuées, et comporte un résumé des constatations, lesquelles ont été réparties en quatre grandes sections. La première souligne les nombreuses entraves à la fois à la création et à l'adoption d'innovations, tandis que la deuxième aborde les éléments susceptibles d'accélérer l'adoption des innovations. Suivent un ensemble d'observations générales tirées de l'analyse documentaire et des entrevues qui ne pouvaient aisément faire l'objet d'une classification pour ou contre, comme la suivante :

« Les entrepreneurs vont innover pour demeurer concurrentiels, mais
ils se refuseront à innover pour gagner un quelconque avantage concurrentiel. »

Le chapitre se termine par une discussion portant sur deux questions particulièrement pertinentes quant à l'hypothèse de travail visant à améliorer l'adoption d'innovations. La première de ces questions concerne les *agents et les gardiens du changement*, ces personnes qui influent sur le rythme et la nature de

l'adoption d'innovations dans les limites de leur sphère d'influence. La deuxième question est liée à la « veille technologique », processus par lequel sont filtrées les informations pertinentes à partir de la masse de données disponibles, afin de les rendre plus précises et utiles pour les personnes intéressées. On a abordé dans le chapitre 4, plutôt que dans le présent chapitre, tout l'aspect des technologies innovantes qui ont été utilisées dans le projet de démonstration.

CHAPITRE 3 - PLAN DE TRAVAIL PROPOSÉ

On y explique plus longuement que dans le chapitre 1 le plan de travail proposé et on décrit plus en détails la mise en œuvre de la recherche. Les sujets abordés comprennent la sélection de l'entrepreneur, les technologies dont on veut faire la démonstration, les enjeux relatifs aux coûts et la contribution des sous-traitants. Le chapitre comprend également une analyse exhaustive de chacune des méthodes proposées par rapport aux nombreuses entraves à l'innovation signalées dans le chapitre 2. On termine en expliquant comment les méthodes proposées diffèrent des activités traditionnelles comme la formation et les projets de démonstration.

CHAPITRE 4 - TECHNOLOGIES INNOVANTES

Ce chapitre achève la présentation du matériel tiré de l'analyse documentaire et de l'activité de collecte d'information en ce sens qu'il décrit en détail les technologies qu'on a décidé de présenter à l'entrepreneur général et à ses sous-traitants. Une courte liste préliminaire comprenant 228 éléments non évalués est consignée dans l'annexe. Le chapitre présente de plus amples détails portant sur 34 technologies, produits et stratégies au sujet desquels l'entrepreneur a demandé de plus amples renseignements avant d'arrêter son choix sur les innovations à intégrer à la maison de démonstration. En plus des éléments individuels, on trouve une synthèse des principales stratégies liées à la charpente sous le titre général de techniques de calcul à valeur optimale et une étude assez détaillée de la réduction de la durée totale du cycle comme technique d'abaissement des coûts. La section qui traite de la réduction de la durée totale du cycle est abondamment illustrée à l'aide de comparaisons entre un calendrier typique de construction et celui d'un calendrier réduit, en plus d'un article rédigé par la National Association of Home Builders [NAHB] qui traite des économies réalisables si on écourte le calendrier de construction d'une journée.

Enfin, dans la mesure du possible, les économies potentielles de temps ou d'argent ont été fournies pour chacune des stratégies d'innovation.

CHAPITRE 5 - MISE EN ŒUVRE

Le processus de mise en œuvre est décrit en détail, y compris les tâches réelles entreprises, les problèmes rencontrés en raison du calendrier ainsi qu'une liste des innovations techniques qui ont été amenées jusqu'à l'étape de la construction.

CHAPITRE 6 - CONSTATATIONS

C'est au sein de ce chapitre que l'on a consigné les observations notées sur place et les rapports relatifs à l'exécution des travaux par l'entrepreneur et ses sous-traitants. On aborde également les différentes technologies utilisées dans la maison de démonstration.

CHAPITRE 7 - APPLICABILITÉ DU CONCEPT À D'AUTRES MARCHÉS ET À D'AUTRES INDUSTRIES

Bien que le concept vise un segment particulier du marché, celui de la construction de petits bâtiments résidentiels, le concept à l'étude a été évalué en fonction de son applicabilité potentielle à d'autres entrepreneurs, à d'autres marchés et à d'autres segments de l'industrie de la construction. Le chapitre 7 traite de ces enjeux, et même si on croit que le concept trouve une application limitée à des ouvrages traditionnels de nature institutionnelle, commerciale ou à des édifices publics, on ne voit pas pourquoi le concept ne pourrait pas être adopté par d'autres entrepreneurs ou marchés, voire pour des ouvrages non résidentiels de faible envergure.

CHAPITRE 8 - CONCLUSIONS

Dans ce chapitre, on résume la recherche en fonction de ses objectifs initiaux et de leur atteinte. Tout en notant que la recherche a répondu aux attentes, on discute de l'interprétation des constatations et de l'utilité d'effectuer des travaux additionnels.

CHAPITRE 9 - OCCASIONS FUTURES

On termine l'ouvrage par une analyse portant sur la possibilité de reprendre les idées et les constatations tirées de la recherche pour les intégrer à une entreprise ou à un organisme sans but lucratif afin d'en tirer avantage ou encore pour améliorer l'adoption des innovations. Dans la section intitulée Occasions futures, on aborde la possibilité qu'un particulier, une société ou un organisme puisse jouer un rôle, et on évoque le concept de parrains de la technologie qui, à titre de consultants indépendants, mais promoteurs de l'innovation, sont en mesure de véhiculer l'exécution d'un programme proposé par un organisme principal. Les responsabilités de ces parrains de la technologie sont expliquées avec force détail. Le plan de travail contient également des renseignements sur les options des financement, y compris la possibilité de récupérer les coûts ou celle de mettre sur pied un système rentable.

Le chapitre se termine par une courte section décrivant un des scénarios de mise en œuvre du projet pilote.

ANNEXE

L'annexe est composée de trois éléments, dont le premier est une liste non vérifiée des technologies innovantes qu'on a jugé susceptibles de faire partie de la maison de démonstration. Cette liste comprend deux éléments distincts : les pages A1 à A6 renferment les technologies axées sur la construction et la gestion qui ont été abordées dans l'étude; les pages A7 à A12 présentent quelque 95 éléments liés à la mise en marché qui, même s'ils ne faisaient pas partie de l'étude, ont été tirés de l'analyse documentaire.

On voulait ainsi déterminer si ces éléments pouvaient s'apparenter à la catégorie plutôt technique qui compose le thème principal de l'étude, et les inclure pour le plus grand bénéfice du lecteur.

Deuxièmement, l'annexe renferme un ensemble complet en format réduit des plans d'exécution de la maison-témoin et de la maison à l'étude.

En dernier lieu, l'annexe contient des exemples des feuillets d'évaluation des innovations, mis au point par la National Association of Home Builders des États-Unis. Toutefois, comme ces feuillets n'ont pas été reçus à temps pour être intégrés à l'étude, ils sont présentés à titre de guide pour les personnes qui voudraient poursuivre le travail entrepris dans ce domaine.

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CHAPTER 1: INTRODUCTION

BACKGROUND:

The motto of the innovation movement in Canada's residential construction industry could well be:

"You can lead a horse to water but
you can't make him drink."

While developers, general contractors, and sub-trades are continually bombarded by innovative products and repeatedly exposed to the leading edge technologies and management breakthroughs in other industries, there appears to be an ingrained resistance to incorporating them into the residential building field.

It is estimated that even with today's aggressive marketing and modern information dissemination techniques, it still requires 15-25 years for a new technology to fully penetrate its chosen market. If we adopt a typical 20 year span for the full range of available technologies this means that on average the Canadian residential construction industry is only making use of some 52% of available quality improving or cost-cutting innovations. Further, half of that advantage is only gained during the last five to six years of each innovation's introductory period.

The causes for such slow technical advancement have been addressed in numerous studies, some of which are referenced throughout this report; particularly, in Chapter 2 which addresses the literature review and background research process. However, this project suggests that this rate of technology adoption is unacceptable and that a new means of introducing, facilitating, encouraging or promoting greater innovation within the residential construction environment is required and suggests an alternative approach.

As early as 1989, the Research Centre for the, National Association Home Builders [NAHB] in the US noted in their report,[16] "Diffusion of Innovation in the Housing Industry" that there were plenty of available innovations, but that the problem was one of slow adoption or utilization. This view was echoed in the 1999 report on the NRC/IRC "Construction Industry Roundtable on Innovation" wherein it was noted [Pg.13] that while only 4% of firms engaged in formal research and development, 40% of firms reported that they were engaged in implementing newly adopted innovations. Obviously, innovation adoption is more important than innovation creation as it affects more firms. Further, it has been suggested that within the residential construction industry a firm must typically build at least 1,000 units a year to be able to support an R&D effort. Whereas it is doubtful if more than a couple of Canadian firms enjoy that level of production, it is increasingly obvious that ours must be an industry of adopters rather than focussing on creators.

During the course of this work there was one observation made which was not documented in any of the discussions or literature and that is the problem of the self-fulfilling prophesy. When one reviews any materials related to innovation within North American construction in general and Canadian residential construction in particular it represents an almost unbroken catalogue of the numerous, *and justified*, reasons why this industry doesn't, won't and can't innovate. It is almost as if the literature is providing an underlying justification for the preordained failure in any future attempts.

One example of this doom and gloom scenario is the supposed lack of investment in R&D. The difficulty may arise from comparisons between the very dispersed construction industry and more easily defined industries such as pharmaceuticals. The question which arises is "How do you compare say 6 major integrated pharmaceutical firms who spend $500 million and produce *and document* 20 new drugs each year with an industry of 20,000 diverse players who may only invest $5 Million dollars but who make 1,200 modest undocumented changes, improvements and advances within their own limited spheres of influence?"

One goal of this work is to break this cycle of limited expectation, faltered attempts and anticipated failure.

Against this background, a need was seen to improve the rate and nature of innovation adoption within the single family residential construction industry. This report outlines such a strategy, the underlying conditions which affect the proposal, its implementation in a demonstration project plus its net results and concludes with a proposal for a future initiative to make the proposed concept nationally available.

PROPOSAL:

General Thesis:

The underlying concept is to create a system whereby a general residential contractor and his sub-contractors are 'loaded' with innovative technologies which they learn and apply to one or two preliminary homes. It is then assumed that those technologies, or innovations, which upon evaluation are shown to improve the general contractors' overall financial, marketing or scheduling activities will be adopted by them as part of their general ongoing construction process. The key to improved information dissemination and innovation adoption rests in the belief that the sub-contractors who are in a sense now 'forced' to utilize these cost-cutting or improved innovations within one construction environment will elect to introduce them to other general contractors as a means of improving their own competitiveness and thus winning more jobs. Finally it is assumed/hoped that the sub-contractor's competitors will in turn be 'forced' to adopt these same technologies, or subsequent improvements in order to remain competitive.

In a sense this is dissemination through 'infection' whereby the 'disease' is innovation, the hosts are the various sub-contractors, the transmittal medium is the competitive bidding environment and the driving force is self-preservation. In essence, one could argue that this is essentially the current process for dissemination. However, the proposed approach differs in that it 'forces' or accelerates the process of information dissemination and innovation adoption through two strategies. First, the proposed process attempts to create a positive innovation atmosphere throughout the general contractor's organization which will, in and of itself, facilitate more and quicker adoption of innovations. Secondly, by utilizing a pro-active and systematized approach to introducing innovations and product information those very introductions will be assisted or promoted by the agency or individual who is bringing the information to the construction process.

As is discussed later, opportunities may exist for various individuals, companies or agencies to undertake or lead these introduction efforts for a fee thus further increasing those entities interest in achieving successful innovation introductions.

Potential Widespread Advantage:

Given that each home requires the services of between 15 and 20 sub-contractors, it is felt that the focussed and driven innovation transmittal technique being proposed could have a very prompt and widespread impact rather than the conventional concept whereby one manufacturer or industry sub-component introduces one technology to one trade at one time. However, a risk exists that a shotgun approach may be counter productive for as is discussed later, it can place one trade at odds with others without any compensating benefits. Consequently, this concern must be both recognized and addressed.

Facilitate -vs-Force:

There must be some discussion concerning the nature of the tone or intent of the proposed dissemination effort. While words such as: facilitate, encourage, support or endorse are often used when proposing such efforts, it is felt that in this context the more appropriate word might be 'triggered' adoption for in these instances, once the general contractor has elected to continue utilizing a particular innovative technology they will, in a sense, 'force' their sub-trades to adopt that

technology in the same way that they 'force' them to use specific materials or specific construction details.

It also bears noting that the concept of 'forced' or more aggressive adoption programmes are coming into vogue within the construction industry as it has been for years within major manufacturing spheres such as the auto or aircraft industry whereby major manufacturers work backwards up the supply chain to assist, encourage, or even 'force' upstream suppliers to adopt progressive delivery, manufacturing and quality control strategies which contribute to the overall quality of the finished plane or car. An example of this can be found in Britain, where the national airport authority and some of the larger building agencies are beginning to move upstream to suppliers, contractors and sub-contractors to encourage, insist or 'force' them to adopt innovations which contribute to a better overall construction picture. This proposal builds on those concepts but proposes 'forced innovation adoption' in a most benign sense focussing instead on education and the ever present self preservation of a competitive market as a means of 'triggering innovation adoption' and it is that intent and wording which is used henceforth.

One might logically suggest that if the concept of 'forced innovation adoption' being presented is valid then the use of *greater force* might achieve *greater results*. At this time there would appear to be only two viable options to achieve such an increase in force, legislation by way of building codes or coercion from the general contractor. Both options were rejected as many of the innovations such as better business practices or certain new tools can not be legislated. More importantly, it was initially decided that any process must work within the broad general existing environment of contemporary construction practices and relationships and it was felt that *greater force* was inconsistent with that operating criteria

Study Focus:

Traditionally, much of the work on innovation has focussed on the diversity of players and structural impediments to its dissemination to the extent that the original intent of this project was to improve the dissemination process ; however, it soon became evident that it was important to recognize the difference between innovation dissemination and innovation adoption and the study focus was redirected to recognize that distinction. Consequently, this work elects to focus instead on one very small and specific point in the overall innovation continuum and that is the point wherein the sub-contractor or, in some instances involving managerial issue, the contractor **elects to adopt** a particular innovative technology. The objective is to help ease and multiply those pro-innovation decisions.

In some senses this work might be considered presumptuous in that it tends to ignore the many of the traditional models proposed for addressing the various issues which have been identified as impediments to innovation . This is not to deny the existence of those impediments, but rather it is felt that the proposed approach of 'infectious dissemination' speaks to them in a more direct result-focussed rather than process-focussed approach.

Code Impediments:

It should be noted that the role of building codes as impediments or barriers tends to be different than the more industry oriented impediments such as small scale operations or lack of R&D funding in that the latter can be overcome, *if desired*. Codes however are in the short term generally beyond the influence of the innovators or even the industry. This reality is recognized within this study and all of the innovative technologies proposed are Code acceptable.

Innovation Selection Criteria:

This work has elected to focus its attention on those innovations which offer the general contractor an overall economic advantage. This was done in response to two general conditions or observations:

i There are enough cost-effective innovations available from which to choose such that one need not pursue those innovations

which offer other advantages but which carry an incumbent need to 'sell' or justify an accompanying cost 'up charge'.

ii Lifestyle innovations such as energy efficiency, green building, or healthy homes while being cost-effective on a long term or societal basis often represent added buyer costs and as such require additional 'selling' beyond the effort required by the chosen range of innovations.

The common attribute generally found in those innovations which have been ignored is that they tend to be those strategies or products which the first round of sub-trades can not automatically adopt in order to gain a market advantage over their rivals. Thus, they are innovations which do not have a sort of self-perpetuating infectious quality which is the underlying dynamic or driving force behind the broad project thesis.

Innovation -vs- R&D

The following work will not be dealing with what is normally thought of as R&D, research and development, which is essentially the generation of new products and processes. Rather, the focus is on innovations which in the context of this report means products or processes which are existing and available to the market place, but which have not been adopted or used to any meaningful degree by the individual company under consideration.

The term 'innovative' will vary based on the level of adoption of any particular technology between differing companies. A perfect example of this is the concept of "Optimum Value Engineering" or OVE as it applies to residential construction. While the concept and detailed practice guidelines have been available for decades, and used successfully by some firms, the OVE concept has enjoyed such limited penetration as a building system that it can still be classified as innovative to some firms or even geographic markets. An innovative technology does not have to be a new technology.

Categories of Innovations:

This report follows the convention utilized by the Organization of Economic Co-operation and Development [OCED] which classifies innovations into three distinct categories:

Product innovations which means new or substantially improved goods or services [ie. A better siding.]

Process innovations which are new or substantially improved methods of production. [ie. Better way to paint the siding.]

Organizational innovations which are changes in the business methods by which goods and or services are produced.
[ie. Better planning to require fewer painters.]

The study speaks to all three issues but focusses on the first with some examples of the second and mainly only references to the third; although, cycle time reduction which is mentioned in the report constitutes a prime example of 'organizational innovation' and is a key goal of the project. Further, the innovations considered in this project are all applicable to the home or the home's construction itself and do not include such equally valuable innovations as better methods to produce more consistent products in an off-site manufacturing environment.

Transparent Innovations:

In the main, nearly all of the proposed innovations are essentially 'transparent' in terms of the average consumer. Most buyers neither know, or care, if their drywall is from manufacturer 'A' or "B'. Nor in most instances will it matter if even major building elements or the environmental envelope are 'innovative' as long as they are assured that they meet code. This reality is even more pronounced when dealing with process and managerial techniques wherein the materials and assembly details remain the same, but the underlying organization have been innovated. Consequently, most discussions will not address either the consumer's input or a consumer impact.

The transparency factor also plays a role in eliminating the need to 'sell' innovations which might result in a final price increase to the home buyer. In general one can state that while the *general* home buyer is willing to purchase upgrades such as improved finishes, luxury appliances and fixtures or life-style add-ons such as pools and hot tubs, they have been reluctant to pay higher prices for product or process innovations which do not contribute directly to their enjoyment. This consumer attitude played a part in the decision to focus on 'cost-saving' innovations such as framing techniques and managerial process strategies rather than life style options such as improved energy efficiency or better indoor air quality.

Marketing innovations:

Despite the general transparency of the proffered innovations as noted above, when necessary the innovations are presented within the context of any requisite marketing allowance which must be made to facilitate their acceptance by the public.

Whose Cost Benefit ?

For convenience, cost benefits within this report are generally expressed as accruing to the general contractor. This was done to acknowledge that innovations by some sub-contractors may save him money or time, which is money, but that some of those savings may be off-set by necessitated increases in other costs to other sub-contractors. The results are important, not the interim steps.

In an ideal world, any innovations would result in more money for everybody or put another way, higher profits for the general contractor, higher prices for the sub-contractor and lower costs for the consumer. This need not be an idealized picture. If one can save $100 by adopting new technologies, each of the three main players: contractor, sub-contractor and buyer can enjoy a $33.33 benefit as there is 'more money for everybody'.

Finally, this work does not assume that any financial benefit will necessarily be shared with the consumer. While such sharing via lower home prices is a logical goal based on the assumption that lower costs will mean more sales and thus continuing higher profits from a growing market, the degree of sharing will vary by market conditions. In a slow market the general contractor may elect to utilize his increased profit margin to lower prices and retain or gain market share. In a hot market, those same increased profits may be kept as just that or as a means to increase the quality or perceived value of the home as a means to differentiate one's offerings from the competition and again retain or increase market share.

Summary:

Because of its current form, practices and resources, Canada's residential construction industry has demonstrated considerable difficulty or reticence to adopt and benefit from the veritable plethora of innovative processes or products available to it. This project speaks to this broad problem and offers a solution which is discussed and evaluated in this report. In essence, the work proposes to provide one general contractor with the skills and information necessary for them to induce their sub-trades to innovate. It is then hoped that once the sub-trades begin to see the benefits of those innovations that they will continue to utilize them to gain a market advantage over their competitors who in turn will be forced to innovate to stay competitive.

For convenience the work focusses on innovations which exhibit strong cost-benefits and which don't require additional 'selling' to consumers. In a sense, the innovations are transparent from the consumers' perspectives. Further the work deals exclusively with existing innovations and is not engaged in conventional R&D efforts.

Finally, while it is recognized that a broad innovation programme could be beneficial to consumers, sub-trades and contractors alike. *This* project assumes that all economic benefits will accrue to the builder and their trades.

CHAPTER 2: INFORMATION SEARCH

INTRODUCTION:

An extensive literature review and interview process was undertaken to gather information on the various aspects of the proposal. The centre piece of the literature review process included visits to the libraries at CMHC and NRC in Ottawa, the libraries of the National Association of Home Builders and the Department of Housing and Urban Development [HUD] in Washington D.C., plus various libraries at the University of British Columbia. The work was augmented with on-line searches of related institutions and topics such as NAHB's 'Toolbase' and "PATH" website. **[www.pathnet.org]**

PATH which stands for "**P**artnership for **A**dvancing **T**echnology in **H**ousing" is a joint public-private American initiative with a very broad and aggressive goal of significantly improving U.S. housing over the next decade. With annual funding in excess of $10 Million , this constitutes a very significant endeavour and corresponding source of leading edge information.

Telephone and personal interviews were also conducted with personnel associated with the above institutions or in related fields. Finally telephone interviews were conducted with the project managers or information officers associated with a variety of construction or energy oriented information and promotion efforts such as B.C.'s "EnerSave" programme to ascertain their current practices as they relate to information dissemination and programme promotion.

The results of this work which included the review of some 2,500 pages of information from various periodicals and books plus numerous reports was vetted and can be found within this report. The information falls into two distinct categories: descriptive information on innovative technologies which were considered for inclusion in the test home and more generic information dealing with the broader issue of innovation diffusion and adoption. The noteworthy elements of the former are listed and discussed primarily in Chapter 4 titled "Innovative Technologies". Information on the issue of dissemination appears throughout the report as references or observations but with the primary analysis and discussion in this chapter.

INNOVATION RESEARCH FINDINGS:

The information on innovation in construction is often confusing, disappointing and misleading.

Confusing for it generally fails to dis-aggregate the separate innovation tasks of *creation, diffusion* and application or *adoption*. Whereas each of these constitutes very unique functions with very unique associated problems and impediments, their mixing in the literature tends to create a false impression of the problem. For example, while a small firm may not be able to *fund innovation* creation, there may be nothing to stop that firm from *adopting innovations*. Similarly, while an industry may fail to financially endorse innovation, it may be well suited to diffuse or spread the word about innovations.

Disappointing because with two exceptions, the literature did not significantly acknowledge the issue of *innovation adoption*. The general sense created is that if something is invented, and the industry is made aware of same then it has achieved a successful introduction. Given the aforementioned example of Optimum Value Engineering we know this to be incorrect. Almost everybody knows about 600 mm c/c in-line stud and joist framing, but almost nobody uses it.

The works tend to try and find one solution to the total innovation process of creation, diffusion and adoption model rather addressing their differences. With the increasingly vast amount of technology being offered, the system appears to be taking on the appearance of an increasingly large funnel, while the cone keeps getting bigger, the spout remains the same size.

The amount of innovation take-up is restricted by the general failure of the innovation adoption bottleneck.

Misleading because in general, the works create the impression that the industry is short on innovation or worse maybe, it is that innovation is difficult or even impossible for most small firms to achieve. As will be seen neither position is correct and yet one suspects that this pessimistic view rather than any real experience may be driving, or more exactly hindering, many firms' efforts to innovate.

For convenience, the findings from the various reports and studies have been aggregated into three major categories: impediments to innovation, innovation accelerators and observations. The latter being a collection of thoughts, conclusions and miscellaneous comments. Individual references are only noted where deemed important. Further, in reviewing the following lists, the reader is asked to remember that (a) we are dealing primarily with innovation adoption and (b) there is an abundance of existing viable and cost-effective innovations from which the industry can readily pick at this time.

Impediments to Innovation:

The literature generally lists the following main impediments to innovating:

Firms Size:
Smaller firms lack the requisite resources, both financial and human to invest in an innovation programme. In this vein, one can add the many larger firms who also lack the necessary fiscal resources due to the generally poor performance of the construction industry. While detailed figures were not provided in the literature, estimates varied from comments about limited or no real profits since 1989 to before taxes profits of only 6%.

Experience:
Few firms have the in-house knowledge base necessary to evaluate new technologies and processes.

Limited Skills:
Many firms lack the inherent skills to take advantage of new technologies such as might be the case with a small traditional builder confronted with a innovative computer based management and estimating programme.

Fragmentation:
The high level of sub-contracting and lack of inter-trade communication makes multi-trade innovations very difficult to co-ordinate.

Liability:
Firms are very concerned about their liability as it pertains to new technologies.

Building Longevity:
New technologies are unproven over the long lifespan of the buildings in which the innovations are required to function.

Project Specific Industry:
Because so much work is of a one-of, project specific nature, firms do not have the opportunity to develop linkages and establish techniques for capturing benefit and trading-off innovation induced costs or bonuses. Further, with a project-based industry contractors tend towards short-term goals.

Feedback Gaps:
Feedback on other's past experience is slower than in other industries thus creating a paucity of positive experiential input. This lack of information about peer review hampers the broad believability or acceptance of innovations as having been 'proven' in the field by colleagues, even if competitors, whom contractors trust.

Schedule Rigidity:
It is often difficult to include time within a schedule to learn how to utilize and implement innovations.

Negative Perceptions:
Many firms have been led to believe that innovation per se is not an overall beneficial strategy or that if they do attempt to innovate, the chances are that they will fail ie. the self-fulfilling prophecy.

No Perceived Advantage:
The literature and normal field experience do not present an aggressive picture of innovation benefits or payoffs thus creating a "Why bother ?" attitude. This attitude is also linked to a supposed inability for small firms to capture the benefits of innovating; however, as noted later, this particular concern is highly questioned by both other literature and the author.

Institutional Distrust:
Contractors tend not to believe the information or advise offered them by academic or governmental information sources which they see as non-field tested, preferring instead the advice of peers.

Word of Mouth:
A couple of reports built on the above finding and went so far as to discuss how contractors receive or prefer to receive their information and noted that in general, contractors responded best to information which they received via word-of-mouth in general discussion with, or presentations by, other contractors. While this may be a result of available time, they like their information distilled, not written, it also appears to reflect their penchant for validated information from peers.

Restrictive Codes:
In some instances, codes can hamper truly innovative materials and techniques.

Diversity of Clients/ Owners:
Many innovations constitute up-front costs with downstream benefits which do not generally benefit the developer-builder who sells the homes yet can't recoup a payback on the increased cost of any innovation.

Lowest Cost Tendering:
With a lowest-bid approach to awarding contracts, there is no incentive for bidders to do, or even suggest, anything more than the traditional minimum.

Marketing the Traditional:
Many residential marketers sell "The home like mother had.", they market the 'status quo'. Most buyers seem to feel that the old way of doing things is best which thus hampers innovation.

One wonders why the rich want the latest electronic toys, cars and mechanical gadgets, but traditional, old-fashioned homes. The final chapter in this report discusses a potential formal programme to increase the rate of innovation adoption. One proposed element of that programme is the study of various aspects of the innovation adoption process. The answer to the above question may be a valid topic for investigation. If one better understood the dichotomy between consumer preferences for 'new goods' -vs- 'traditional homes' , builders may be able to better market their innovative inclusions and hence be encouraged to increase the innovative content.

Trialability :
Many innovations can only be tested in-situ thus exposing contractor to extreme liability for an unknown commodity.

Cost-Effect Awareness:
Innovation promoters often fail to provide *reliable* and *convincing* information that their product is indeed cost-effective. This extends to their failure to provide any form of peer review.

Lender Acceptance:
Some larger innovative materials and techniques initially can not secure mortgage lender or warranty provider acceptance even though the innovation may be code approved.

All or Nothing:
For many smaller builders, the home they are working on may be their sole source of income; consequently, they are in effect 'betting the farm' if they apply the innovation to their one-of structure . Failure could essentially put them out of business.

Geographic Spread:
Because each geographic entity has its own building inspectors this means that each inspector and jurisdiction in turn must be re-educated to the benefits of an innovation. Furthermore, there is nothing to suggest that there is much cross-

fertilization between jurisdictions and inspectors. Most industry participants have been subjected to varying degrees of "I don't care what they do in ___[Fill in the Blank]____, here we do it my way."

Cyclical Industry:
The cyclical ups and downs of the industry keep firms mean and lean, thus denying them the resources to innovate. Further, contractors see themselves as unable to innovate because they are either too poor in a downturn market or too busy in an upturn one.

Innovation Accelerators:

The literature does not list many accelerators or pro-innovation attributes in the residential construction industry. The few which were noted are discussed below.

Entrepreneurial:
The industry in general and small builders in particular are entrepreneurial by nature and as such are often willing to personally take the risks associated with introducing a new technology.

Profit Linked:
Because the profit line is so visible and so closely tied to actions on even a house by house basis, any positive innovative actions are immediately rewarded. Conversely, negative actions are also immediately noted on the bottom line. In some instances a visible profit line constitutes a pro-innovation attribute as it allows innovation to be introduced, tried and evaluated in a one-off experimental environment and to some degree limits the requisite investment or degree of risk.

Competitive Nature:
Though somewhat an extension of the two previous points, when adopted, innovation is quickly rewarded due to the competitive nature of the industry.

Unstructured Industry:
In many regards, home building is a builder, buyer or project specific industry which unlike electronics for example, does not rely on rigid commonality of materials or standards. Consequently, innovations can be introduced by one contractor or on one project without requiring the *consent* of other industry players.

Repetitive Units:
Because many homes are similar and in particular multi-family units are essentially identical, any accepted innovations can be rapidly spread and produce benefits for the innovative organization. In essence, larger firms **can** capture the benefits of innovation and thus introduce and 'advertise' them to other players.

Cross-Project Performance:
In the residential construction industry many smallish contractors who won't initially see any innovations in a single home, are exposed to them on larger multi-family or even non-residential projects where innovation is accepted, and can thus import those innovations to the single family home construction environment.

Buyer Indifference:
Many innovations are unseen by the consumer and thus they can be introduced with limited risk of affecting the marketability of the home; as one report expressed it, " Buyers are more interested in what's on their wall than what's inside the walls."

Industry Diversity:
Because the industry is comprised of such diverse and independent elements, innovation can be introduced by one firm without affecting others.

Observations:

In addition to formal pro & anti innovation findings, the various reports noted a number of general observations which could not be clearly categorized in either column, and which are documented here.

Contractor Willingness to Innovate:

Perhaps one of the most unusual observations which was drawn from a couple of reports was that contractors were seen as:

Not willing to innovate to gain a competitive advantage but willing to innovate to stay competitive or to counter another contractor's more aggressive innovative actions.

This observation may reflect two converging attitude; first the contractors' willingness and ability to quickly implement those techniques, innovative or otherwise, which they see as desirable and their general desire to have new information conveyed or confirmed by peer-review or other contractors. The adoption of an innovation, even by a competitor, still constitutes peer endorsement.

It should also be noted that it is essentially impossible to restrict the flow of information on job-site innovation. Nor is it deemed necessary as many contractors consider a one to two year lead on their competitors as a worthy goal to pursue.

Innovation Triggering:

There was extremely limited information on the actual finite and precise process of 'triggering' the adoption of innovation. Although the role of 'champions' or ' gatekeepers' whose actions promote innovation adoption ,were seen as important to the broader implementation process.

There is a general sense in the literature that innovation adoption is a somewhat massive and complex problem which will require extensive governmental or industry reorganization to address. However, two reports did briefly address the actual process of innovation adoption if not how to trigger more of it. The process involved in a normal adoption process for any new technology includes the following distinct steps:

Need Identification- determining that current practices are not as efficient as desired. This step is sometimes omitted when an individual first sees a solution and then realizes it could improve their operation in which case 'Awareness' becomes the first step.

Awareness- simply getting to know about the existence of a technology and its potential application.

Interest- increasing awareness and collection of pertinent information.

Consideration- An initial determination as to whether the technology offers an 'advantage' over prevailing alternatives.

Trial/Testing - an initial risk taking exercise of the new technology.

Evaluation - consideration of an innovation's performance and ability to satisfy the intial stated need.

Adoption- actual decision making event wherein the technology is mentally or formally accepted for future use as a regular part of the construction process.

This project is focussed on the last of these events and hopes to increase its occurrence by manipulating the first six in some fashion.

Quantity of Innovations:

A number of reports expressed the view that there was no shortage of innovations available to the construction industry. A 1997 report [1] for IRC on " Nature of Innovation in the Canadian Construction Industry" noted:

" Lack of technology isn't the problem, barriers to take-up of innovation are..... All the barriers to technology transfer should be explicitly considered in each research project.....The goals of strategic planning should be to :.. address barriers and constraints to innovation."

The report continues:

"The ultimate goal of public sector R&D organisations working in the construction field

should not be to simply investigate and refine technology. The goal should be to cause effective technology transfer, thus creating private sector benefits of increasing the public good.....Lack of technology simply isn't the main problem."

This failure to address the issue of application or adoption continues to this day. In the U.S., the PATH programme expends $10 million/year on technology exploration, demonstration, evaluation and communication but essentially nothing on improving actual adoption.

Incremental and Process Innovation:

Though viewing innovation from slightly differing perspectives, a number of reports noted that innovation did not have to be big, splashy or product solutions. Rather, they recognized the importance of many smaller incremental advances and particularly noted the importance of process innovations as the term applies to the project management of the trades and construction itself.

These are important observations for the former allows change or innovation in a less confrontational manner often representing mere extensions of accepted products or building techniques and the second is transparent to the consumer and has essentially no impact on the buying decision.

It was also noted that management process innovations were expected to have the greatest impact on construction. This position is endorsed by the recent advances in 're-engineering' of the manufacturing and service industries which seek not the 4%-8% improvements often associated with such older theories as Total Quality Management [TQM] but rather seek 80% or even 100% increase in profitability and corresponding cuts in such areas as complaints, warranty work or administrative burdens.

Proper Selection:

Much effort seems to be directed to identifying, and picking for promotion, the 'right' innovations or emerging technologies. This was particularly evident in the NAHB work and continues to this day with their listing of major technologies in the PATH , ToolBase Technology Inventory which seems to deal with larger issues and not with the 'quirks' or 'tricks of the trade' which actually contribute quite significantly to overall construction efficiency and hence lower costs.

This approach may stem from the need to slot technologies into traditionally accepted categories such as energy efficiency, quality, safety or environmental factors. Or, it may also derive from the institutional need to only select technologies which can be demonstrated to be 'effective' . As the reader will note, the process proposed within this report adopts a more shot gun approach wherein innovations are only generally evaluated before being introduced to the industry which in turn makes the final evaluation of their appropriateness on any given project.

Cost-Benefit Missing:

While more an attribute of the technical information which is discussed in Chapter 3, it bears noting that there was a surprising number of technologies presented which were not accompanied by a viable, but more importantly believable cost-benefit analysis. One is hard pressed to imagine how any contractor can be expected to change habits, or invest in new technologies without answers to the most basic of questions; "What will it cost/save me?".

Worse, when technologies do prove to be more expensive, most promoters do not include either viable alternative benefits and none include information or insights on how to *sell* that technology and upcharge to the home buyer.

Focussed Comments & Observations:

There were two additional, particularly focussed observations which are pertinent to this study. The first deals with the varying nature of the participants in the innovation dissemination process who are classified according to their penchant for adopting innovations and includes such individual classifications as 'early adopters' etcetera. The second area of particular interest deals with the

issue of 'technology watch' as it applies to the construction industry. Both are discussed below.

Adopter Ratings:

Almost all discussions on innovation touch on the *pro* or *anti* attitude of key individuals towards risk taking and adoption. In general, the various classifications include the following categories which are taken from a 1989 NAHB [16] report:

Innovators: first adopters and most entrepreneurial comprising some 2.5% of all potential adopters.

Early Adopters: next group to accept innovation are often leaders in their society and comprising 13.5% of the potential adopter pool.

Early Majority: encompassing 34% of the potential adopters tend to still adopt before the bulk of the market. They are influenced by peer group and economic pressure.

Late Majority: also 34% of market only adopt after most competitors have accepted change.

Laggards: are the remaining segment, 20%, who adopt last or not at all and who are traditionalists.

To this group should be added the additional terms of **'Change Agent'** or **'Gate Keeper'.** These terms tend to refer to individuals who are normally classified as 'early adopters' as described above, but who also have significant standing within their own peer group and whose opinions on their experience with a new technology are often sought or noted as indicators of an innovation's suitability for its proffered role.

These various terms tend to find use in most works wherein the authors suggest that in order to accelerate an innovation's market introduction that the promoters should focus on early adopters as they constitute the easiest 'sells'. The proposal outlined in this report differs somewhat from this conventional view.

The underlying position of this work is that seeking out early adopters, in what might be called the status quo approach, is essentially a passive process whereby one , at best, tries to 'tweak' the system in order to speed technological adoption.

This report seeks to introduce a more pro-active and aggressive approach. An analogy might be drawn with the earliest food gathering and farming practices. Attempting to locate and disseminate innovation to early adopters is somewhat akin to the work of earliest hunter-gatherers who searched the forest 'hoping' to find food. Conversely, the innovation adoption process proposed in this work can be more likened to farming wherein resources are formalized and managed on a focussed basis to generate, force or trigger innovation adoption just as seeds are planted to force or trigger crops.

Despite the foregoing, it will be seen that the various classifications can still be valid within the context of this work, but will be used in order to identify and hopefully engage the most appropriate type of adopter contractors to whom this reports findings and proposed adoption process are marketed, and not just to find firms or individuals to who information is disseminated.

Technology Watch

The second area of particular interest is that of 'technology watch' a process which tends to involve an agency be it government, an institution, academia or some form of trade association which seeks out information in its particular area of interest for subsequent distribution to a select audience of like-minded organizations. While the work often involves an evaluation process prior to distribution of the information, the process is still essentially one of *innovation dissemination*. The reader will recall that the stated focus of this work is *adoption* not dissemination; however, in reality something, either information, a product or a process, must be disseminated in order to be adopted. Consequently, 'technology watch' does have a supporting role within the proposed adoption process and the following information contributes to those activities.

The first report, a Nov.6,1993 article in "Building Research and Information" by Bardin et al, explores the dissemination of technical and scientific research findings to french architects and engineers in the construction industry. Two particular issues which the authors note are the very poor level of innovation dissemination by its creators and the preference of the professionals to secure information which had been vetted and endorsed by a peer. In their conclusions they note the value of utilizing some form of information brokers, but in particular, they call for the creation of selected 'gate-keeper' practitioners who should join with researchers.

The second report, a 2000 presentation by Prof. C. H. Davidson of the University of Montreal deals with the difficulties of information dissemination and the potential role of a formalized 'technology watch' function. Prof. Davidson explains the purpose and operation of such watches and describes how smaller entities, such as most construction firms, lack the resources to implement such a function independently . The work does however continue to suggest a shared technology watch operation and describes how it might function. The illustration on the following page is taken from that report.

In that illustration, the reader will note that in scenario "D", a watch entity provides a collection, processing and evaluation service before disseminating the vetted information to the client group of smaller construction entities. As will be discussed in Chapter 9, the 'watch' function might be undertaken either by an individual, a consortium of individuals or a broader more comprehensive grouping of individuals and agencies. Also, the small firms could represent either a group of equal and independent contractors, or a series of sub-contractors working under one contractor.

Prof. Davidson's paper provides valuable insights on how this critical function might be introduced into the heretofore unserved small scale residential construction industry.

SUMMARY:

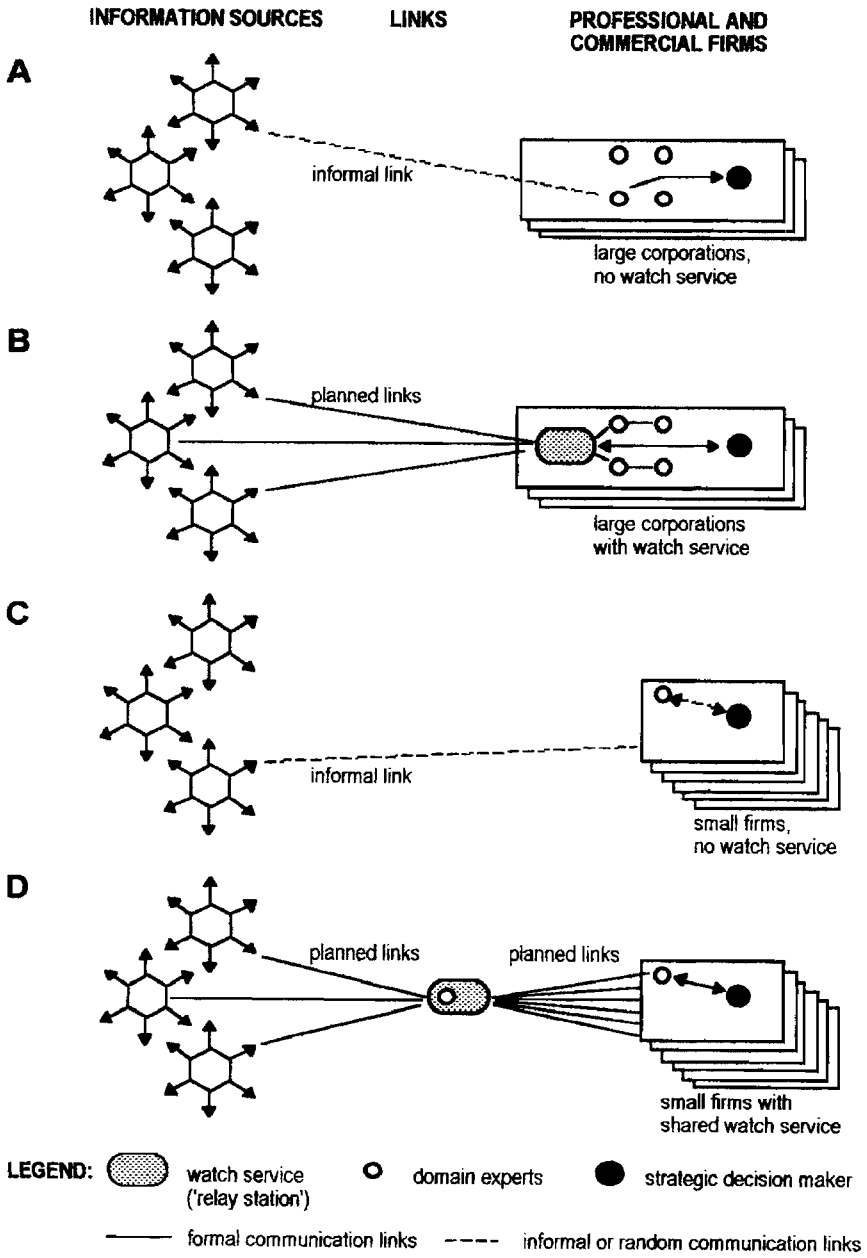
In summary the literature suggests that while there are various impediments to all aspects of the innovation introduction process, there is nothing inherent concerning innovation in the residential construction field to suggest that there are structural impediments to introducing a successful innovation initiative which can not be overcome.

While the available material focusses on primary or significant materials, products and construction process innovations, various articles and comments clearly extol the value of both small incremental innovations and innovations in the area of project management and construction business practices. The former is noted for its potential ease of introduction wherein the incremental innovation is often seen as just a modest adjustment to an already existing technology which the industry uses. The latter innovations in construction management and related business practices are noted for their potential to have very significant impacts on construction just as they have in the manufacturing and service industries.

In the main, the information drawn from the available literature, academic reports and personal interview does not deal very extensively, if at all, with the issue of actual innovation adoption. Most of the works appear to view the problem as one requiring significant fundamental change to the whole construction industry rather than one which can be addressed as a point specific issue such as is being proposed in this study.

Finally within the context of the broad thesis outlined in Chapter #1, there is nothing in the literature to suggest that the proposed underlying concept of "dissemination though infection" is not a viable approach, and as will be shown, many of the impediments to innovation listed above are addressed directly in the more fully developed proposal discussed in the next chapter.

Figure 1
Communication Links in the Technology Transfer Process [Prof. C. Davidson , U. of Montreal]



CHAPTER 3: PROPOSED WORK PLAN

INTRODUCTION:

This chapter discusses the actual implementation strategy which was ultimately employed in the demonstration project. It builds on the proposal outlined in Chapter #1 but is modified and expanded as required to reflect the findings which arose from the literature review and interview activities.

PROPOSED WORK PLAN:

Activities:

The proposed work plan has seven primary steps:

Benchmark current practices to provide a basis against which the impact of any innovation can be measured. [This task was subsequently dropped as discussed in Chapter 5.]

Select management team, preferred sub-contractors and identify intended job site.

Gather information on existing construction problems to be addressed or potential innovations to be considered.

Evaluate optional innovations and select test home plan and construction details.

Apply innovations with a primary focus on accuracy and secondly on speed. This step includes a critical "outlook" function wherein tradesmen are invited to contribute to the overall innovation identification process.[See next section.]

Evaluate the attempted innovations. [It is expected that 1/3 of innovations will be a success, 1/3 will be generate a neutral response and 1/3 will be dropped.]

Modify as required and implement the innovations on a regular basis.

Adoption Promoters:

Successful implementation of the above plan can be aided in a number of ways:

Contractor Selection:

One of the most critical decisions is the selection of an appropriate general contractor. While in any widespread programme or free-market application of the concept there may be less of an opportunity to choose which contractor with which to work, for this project the contractor Dilworth Quality Homes was selected based on the following attributes:

- Is a significant builder within the local market who can benefit from investing the effort in developing a more innovative construction approach thus providing sufficient resources to manage and invest in the proposed work.
- Is cognizant of the value of innovations and interested in improving their competitive advantage through their use. This provides the 'driving force' behind the project.
- Has a stable work force of sub-trades with whom they work on a repetitive basis. This allows for a cooperative work environment and high level of communication and trust.
- The sub-trades work for other general contractors in the residential field. This will facilitate the spread of information and experience with innovations to other construction environments.

Innovation Selection:

The selection criteria for the innovations remains the same as outlined in Chapter#1:

- The innovation must be essentially cost neutral or cost saving.
- The preferred technologies are those which are basically transparent to the consumer and thus have no, or limited, negative buyer impact.
- All innovations must be code acceptable.

Project Parameters

Successful implementation of such a proposed work plan is significantly aided by adopting the following strategies.

Innovation Consultant or "Innovation Champion":

The work of this project was dependent upon the involvement of an "*Innovation Consultant*" who acted much like a coach, promoter and sometimes referee and who undertook the basic investigation and evaluation of alternate innovations, provided information on the selected innovations to the general contractor and assisted in the subsequent introduction of those innovations to the sub-consultants.

However, in this project the 'innovation consultant' was also the prime researcher and author of this report; consequently, the term 'innovation consultant' is generally used throughout the report so as to emphasize the role and tasks rather than the researcher.

Further, in Chapter 9 wherein the report explores the possibility of a future commercial approach to the promotion of various innovation and the creation of innovation oriented companies, the role of the individual who works with the general contractor to introduce innovations to their firm is referred to as the **"Innovation Champion"** in order to suggest a title more reflective of their ultimate role and to distinguish him or her from the researcher or innovation consultant leading this project.

Teamwork:

It is imperative to make it clear at the outset that innovation is a team endeavour and clearly indicate the overall goals of cost and building time reductions, but phrase it in an encompassing way such as: 'The goal is '***for everybody to make above average income or profit.***" The initial aim is to increase incomes at current home retail prices. Any benefit to the consumer can be applied once the learning curve for the selected technologies has been mastered.

As an extension of the team work concept, the general contractor and the innovation promoters must be prepared to work closely with the sub-trades and craftsmen providing the encouragement, information and even training as required to ensure that they feel that they are both part of the larger, and somewhat protective team, but that they are sufficiently independent so as to have personal ownership of any innovations being pursued in their sphere of work. This ownership is deemed important as it contributes both to the quality of the eventual work and the participants sense of responsibility and contribution.

Pricing:

Do not focus on pricing or particularly on grinding the sub-contractor in the initial application of any technology. Where appropriate and justified by the potential market, attempt to engage the supplier in contributing financially to the work in order to reduce some of the financial risk to the sub-trade.

Base Comparison:

For larger general contractors it should be possible to identify a home which is similar to the home model which has been selected as the test-bed unit. By conducting walk throughs of the conventional model during the construction process, it will be possible to identify existing trouble spots which can be prime candidates for innovation interventions. As noted below, input by the trades people at this point can be very helpful and reinforces the impression and reality by participants that the general contractor is attempting to respond to their concerns and thus they have both ownership and responsibility for the ultimate success of the innovation process.

Trades Contribution:

One of the most important information gathering processes normally occurs during the actual job site implementation process and that is gathering input from the trades people and workers themselves.

Various studies have shown that often in excess of 60% of innovations and process changes eventually adopted on an open and progressive job site are a result of suggestions from the workers themselves versus the management or owners. This parallels findings in the manufacturing fields such as the automotive industry, particularly in Japan, where upwards of 80% of production line improvements come from the line staff themselves.

When considered, this finding has a logical basis for it is these frontline troops who have the most immediate knowledge of the processes in which they are involved and who have 'studied' the problem intimately. There is an added advantage in pursuing these worker oriented proposals for such an action endorses the work and the innovation process is aided by the pride of ownership emanating from the employees. This can also work at the sub-trade management level where the contractor/owner also feels a sense of pride and ownership when their suggestions are pursued.

Good questioning techniques, can elicit enormous amounts of directly applicable information if the trades people sense a commitment to their problems. If necessary, these techniques must be studied prior to the project.

OVERCOMING IMPEDIMENTS:

The proposed approach addresses most of the numerous concerns or impediments to innovation noted in the preceding chapter. In some instances the 'infection' approach directly overcomes these impediments while in other cases it makes them irrelevant and skirts the issue. For convenience, the following discussion mirrors that earlier listing.

Firms Size: *Smaller firms lack.....*

By working in association with the general contractor and under the guidance of an innovation consultant, even the smallest sub-trade can draw on the requisite resources to pursue an innovation strategy. Further, the financial burden is shared and apportioned as appropriate.

The 1997 IRC discussion paper "Nature of Innovation in the Canadian Construction Industry" makes the point [Pg.12] that

> " Financial risk is perhaps the single biggest hindrance to innovation."

However, it is critical to understand that not all innovation is expensive. The new 'CentrePoint' tapes which make it essentially impossible to not find the correct centre line of a measurement cost less than $20 to purchase and yet will result in error free placement of toilets in alcoves, medicine cabinets and other mounted elements on walls, or will correctly locate the drilled hole for the spout in an expensive acrylic shower stall wall. By cost-effectively aggregating these modest technologies through their normal outlook activity, innovation consultants can dispel concerns about the expense of innovating.

Many managerial skills and attitude changes are essentially cost-free and yet they tend to get lumped into the same "costly, can't be initiated" basket with such advances as pumper trucks, Insulated Concrete Forms [ICF] or even such disruptive technologies as steel framing which will require some significant changes to the building practices of three or four major sub-trades.

Experience: *Few firms have the in-house...*

In the proposed process the innovation consultant either possesses or works with the various suppliers to find the information necessary for small firms to properly evaluate the proposed technologies. It is important to note that the primary roles of the consultant are those of educator and driving force. However, upon their departure, the general contractor and affected sub-contractors will have a background for undertaking their own future initiatives thus the process creates the potential for subsequent non-consultant directed work.

Limited Skills: *Many firms lack skills.....*

The innovation consultant can either train or secure the services of suppliers to demonstrate, install or train employees in innovative techniques.

Fragmentation: *The level of sub-contracting...*

Because the entire process being discussed is predicated on team work under the guidance and direction of the general contractor, initial inter-trade conflicts can be resolved within the envelope of the learning process.

Liability: *Firms concerned about liability...*

While firms can not be relieved of their liability, increased product knowledge, anecdotal information and peer comments supplied by the innovation consultant will allay many liability concerns. Further, in some demonstrations the consultant can either secure additional warranties or the ultimate consumer can be made aware of any innovation which was utilized on their homes and sign a waiver on contractor liability.

Building Longevity: *Due to the long lifespan...*

Even with the proposed programme the building lifespan will remain extensive and hopefully even extended due to good building practices. The best that one can do to address this concern is to demonstrate how quality is increased and maintenance requirements decreased hopefully giving the contractors the same sense of security as touched on in the previous point.

Project Specific Industry: *Work is a one-of..*

The consultant functions as a link between a range of innovation experiences and the contractors who are new to the innovation field. Thus the consultant and the process have a form of artificial memory which carries over from project to project and negates the prevalent one-of project experience.

Feedback Gaps: *Feedback on other's past....*

Similar to the one-off or project specific issue raised above, the consultant is able to provide a form of artificial feedback on other contractors' experience or if necessary facilitate the feedback loop by helping to establish contact between current innovation users and the future innovators who form the project team.

Schedule Rigidity: *Difficult to include time...*

Because the innovations are being introduced under a comprehensive exploration programme, both the general contractor and the numerous sub-trades can plan for the requisite 'float time' needed to integrate a new technology and learning curve into the construction schedule. This is not a case of one sub-trade trying to wedge their learning curve into a previously established conventional building plan.

Negative Perceptions: *Not a beneficial strategy...*

Because the innovations are presented in a most positive light and as part of a general contractor endorsed activity, the participants are more apt to begin with a positive attitude and thus stand a better chance of success. The process has another highly important benefit wherein any success is expected to create an overriding pro-innovation environment which it is hoped will sustain itself following the conclusion of the formal consultant driven initiative and as such will facilitate the future exploration and introduction of innovations.

No Perceived Advantage: *"Why bother ?"*

By the time most participants are introduced to any consultant led innovation process, the general contractor has been convinced of the potential benefits and identified both the potential innovative technologies and accompanying benefits which they wish to pursue with the sub-trades and suppliers.

Institutional Distrust: *Contractors don't believe...*

Although as outsiders they will still be viewed with some suspicion, the innovation consultants can cite specific contractor examples, or as noted above provide peer comments in support of an innovation. They can also provide 'word-of-mouth' information which industry participants tend to prefer. The consultant acts as a distiller of knowledge and information providing the quick condensed information which is so useful at the beginning of any innovation endeavour and which helps to at least pique individuals' interest.

Finally, because, in a sense, they have used many of the proffered innovations in previous consultations and projects, innovation consultants may be able to join the peer group network generally preserved for contractors.

Restrictive Codes: *Codes can hamper...*

While this process can not affect formal code acceptance of new technologies, the participating consultant can work with code authorities to establish an innovation's position within the code and then work with local regulatory authorities to explain the often obscure underlying technology and demonstrate its conformance to codes.

Diversity of Clients/ Owners: *Front costs downstream benefits.....*

Drawing on broader experience and point of view, the consultant can often provide a more comprehensive overview of how an innovation can benefit the general contractor, or how downstream benefits can be marketed to home buyers.

Lowest Cost Tendering: *Lowest-bid approach...*

Consultants can sometimes utilize their knowledge or familiarity with an innovation and demonstrate to the end user or buyer that a low first cost does not necessarily imply a lower end cost.

Marketing the Traditional: *"Like mother had."*

At best, the consultant may be able to provide information on how other contractors have addressed this issue and marketed innovation in an environment where "It's not as good as it used to be..." is the consumer's prevailing attitude.

Trialability : *Innovations only be tested in-situ....*

Though a demonstration project, the work is being undertaken in a real construction setting and generally under organizational conditions typical of normal construction process and trade interactions; consequently, the type of approach being used and evaluated as a means for introducing innovative materials and processes is considered as "**in-situ.**

Cost-Effect Awareness: *Promoters often fail...*

The proposed work plan explicitly acknowledges and provides opportunity to catch all costing information, plus any off-setting costs and compare them to a benchmark situation.[This task was subsequently dropped as noted in Chapter 5.]

Lender Acceptance: *Can not secure mortgage..*

As with regulatory officials, an innovation consultant can work with lenders to demonstrate the reliability of an innovation and thus ease their concerns about long term viability of any new technology and its affect on future building worth.

All or Nothing: *Sole source of income.....*

While no consultant can completely eliminate risk from a project, small contractors or sub-contractors will have a heightened sense of security when they are supported by a consultant who is versed in all aspects of a proposed technology but who has no vested interest other than the success of the builder.

Geographic Spread: *Each inspector.....*

As with the peer review and one-off project issues, the consultant can act as a bridge and information source linking inspectors who are new to a particular technology with their colleagues in other jurisdictions. In this fashion, the inspectors will have quick ready access to what they will view as an unbiased opinion which should ease the introduction of any new technology.

Cyclical Industry: *Cyclical ups and downs ...*

Because the proposed work involves an innovation consultant as the project manager and driving force, even 'lean & mean' firms have the necessary staff to explore innovation. Further, by bringing both support and broad based costing information to a project, the consultant can demonstrate how the benefits of innovation have application in both rich and tight times and how the benefits can be used to either cut margins during lean periods or increase profits in hot markets.

ALTERNATIVE STRATEGIES

The proposed strategy and work plan differ from the three more traditional means of disseminating information: training, demonstration and research networks or construction centres in a variety of manners. The most basic variance is the proposed programmes reliance on the competitive market place as the driving force behind any supplemental information dissemination and innovation adoption. This element is missing from the three alternatives noted. However, the dissemination by infection also differs from the individual alternatives in the following manners.

Training:

Unlike training which focuses on individual technologies and which often ignores the issues of costing and marketing, the proposed approach is an integrated system which looks at the needs of upstream suppliers and downstream customers and provides a hands-on accommodation of related trade needs. It also attempts to work within a real environment and responds to interpersonal and inter-trade relationships.

Demonstration Projects:

Demonstration projects traditionally are more marketing tools than experimental test beds such as is being proposed. While it would not be unreasonable **in this project** to reject one third of the technologies being studied, demonstrations tend to only highlight those systems which are deemed 100 % acceptable before they are included in the demonstration. Further, because the proposed system is limited in its application to one general contractor at a time, it is able to look at a very broad range of possible innovations without running the risk of diluting its intent. It also varies from demonstrations in that it can handle and evaluate managerial and process innovations more effectively. It is hard to show in a demonstration home how having differing front-end and back-end project managers on one job is more effective than the conventional one project manager per home approach.

The innovation adoption process is more profit oriented and has an unwavering underpinning of business cost-effectiveness. Demonstrations on the other hand often deal in non-quantifiable issues such as healthy housing or energy conservation. In a sense, the innovation process is somewhat more market responsive as the units to which the innovations are being applied must still be sold on the open market as conventional units and thus the innovations are being tested in a more conventional home retailing environment.

There is also an unstated element of coercion in the proposed innovation process wherein the general contractor has expressed their interest in new technologies and 'invited' their sub-trades to join them in its exploration.

Unlike the demonstration process, which is often undertaken by bodies other than those who are being courted to adopt a new technology, the proposed dissemination and trigger approach provides the target audience with experience and skills upon which they can draw to pursue their own subsequent initiatives. Further, demonstration projects tend to be passive invitations to consider a design philosophy of technical innovation and don't posses the 'trigger' attributes which lie at the core of this work.

It can also be suggested that the proposed approach is essentially more cost-effective than a demonstration endeavour. While demonstration homes can only be built in limited locations, the innovation promotion approach can be initiated in a wide range of locals and, any initial costs not covered by increases in efficiency are borne by the general contractor and trades and not by the various institutional bodies such as CMHC, IRC or NRCan who often sponsor demonstration homes.

Finally, because of the personal nature of the hands-on experience fostered through the innovation triggering process, there is a better chance of innovation adoption because of the 'ownership' which the participants have taken in the innovations with which they have worked; an experience not to be found in a demonstration home tour.

Technical Centres and Research Networks:

While the value and need for these types of information sources was covered extensively at the end of Chapter 2, under the discussion of 'technology watch', they still have limited impact in the ultimate and very fine tuned goal of innovation adoption. Even the 1999 NRC/IRC Roundtable on innovation noted: "Research organizations (IRC) rank low in their visibility as sources of information" and thus must rank even lower as vehicles for innovation adoption.

Unless the information system is prepared to address all of the impediments to innovation listed above and which it is suggested the proposed approach does, then it is difficult to foresee how the centres or networks can significantly affect the ultimate take up or adoption rate of innovations. It is envisioned that these organizations will continue to play a critical role in accumulating, and in some instances evaluating information and technologies before disseminating or marketing that information to the construction industry. However, they can't and they won't significantly alter adoption rates.

Further, these information sources should consider the form and nature of their dissemination efforts. As noted in various reports, the source of information is of primary importance. This was possibly best addressed in CMHC"s 1989 study " Technology Transfer and Innovation in the Canadian Residential Construction Industry" wherein the author noted [Pg.14]:

> "The quality of the information and its format is important, but the credibility of the source is the most critical element at this stage..... The recipient and his peers must have an opportunity to discuss, exchange views, develop opinions and receive peer feedback. ... Case studies have confirmed that all effective communications were a combination of vertical communication [advertising, sales presentations, brochures etc.] and opportunities for discussion at professional association meetings and training sessions."

It is suggested that when research networks implement the necessary types of changes to force the type of innovation adoption being considered that they will be promoting a dissemination and adoption strategy much like that being proposed.

Push-Pull Variance

The reader should be aware that this work departs to some extent from the prevailing wisdom concerning how innovations should be introduced into the market place. Much of the literature suggests that the most successful introductions are those which respond to what is called 'MARKET PULL' wherein an identified problem provides the driving force to innovation generally both in terms of its development and market introduction. The other type of innovations and introductions are those which are driven by the innovation itself which has been developed rather independently of any overt need and is then introduced in a somewhat pro-active manner. This second type of introduction is called "MARKET PUSH" and refers to the process of trying to PUSH the product or process into the market place.

The observation favouring the 'MARKET PULL' strategy is generally valid in the case of individual innovations. However, the concept being proposed in this work envisions the simultaneous introduction of numerous innovations plus the active, long-term participation of an innovation consultant who will be guiding the general and sub-trades through the innovations' evaluation and introductory phases. Furthermore, because the innovation consultant has to a fair degree pre-evaluated the innovations before bringing them to the contractor, these innovations are in a sense being offered as the consultant's response to what he perceives as market needs.

The combination of these two concepts wherein the consultant helps to PULL innovation by identifying problems based on a broader understanding of the innovation potential available while at the same time providing a PUSH in an effort to achieve a successful conclusion will help to make the proposed 'forced' introductions more successful than stand-alone market PULL initiatives.

SUMMARY

The proposed work plan encompasses seven distinct activities: benchmarking the current state of construction, selecting the project team, gathering information, evaluating various options, applying select innovations, evaluating those innovations and modifying the work plan or the innovations and their application as appropriate.

In order for a project such as this to be successful; particularly if one is pursuing down-stream information dissemination one has to engage an appropriate type of general contractor. Some of the evaluation criteria include: the contractor's operation must be significant to justify the cost and ensure an adequate impact; the contractors must themselves value the idea of innovation (If they can't walk-the-talk, they will never convince their sub-trades to participate); they require a stable workforce whose continuing contribution will justify any investment in training; and the sub-trades must also work for other general contractors. This last point is somewhat flexible and only becomes truly important if one's primary interest is the widespread dissemination of information through the 'infection' process previously discussed rather than the promotion of the general contractor's business via innovation.

The innovations can be more readily introduced if they are cost-effective and essentially transparent to the consumer. In this manner there are no upcharges which have to be justified and the consumer will have little interest and thus less resistance to things which they perceive as not germanely affecting their home. Further, the most successful innovation introductions involve products and processes which are readily code compliant.

The introduction process itself will be most successful if the general and sub-contractors are engaged as a team and utilize the services of an innovation champion or consultant who helps to introduce innovations and resolve conflicts. The teamwork can also significantly benefit when the trades are invited to contribute to the process and they are both listened to and encouraged to participate. Finally, care must be taken to not use any innovation initiative to gouge the sub-trades over any potential savings otherwise they will merely view the entire exercise as a money grab by the general contractor and at best passively resist change or at worst sabotage the effort.

The pro-active and teamwork approach being explored in this project helps to overcome many of the stated current impediments to innovation. By working as a team with the assistance of an innovation consultant, the project reaches a critical mass of skills, experience, resources and drive which have tended to be the stumbling blocks to other more independent, single company efforts.

The proposed approach also seems to address the shortcomings which are evident in some of the more traditional means of introducing innovations. The teamwork approach overcomes the isolated single trade focus which is the hallmark of most training efforts. Because the sub-trades are working in a real construction and costing environment, any successful innovations are more accepted than generally happens in high-profile , but subsidized demonstrations. Finally, the hands-on, in-field exposure of the proposed system lends any findings greater credibility than might attach to an innovation being promoted by a technical centre or building institute.

In brief, the consultant led, team-based, real-site environment of the proposed innovation adoption and information dissemination approach being proffered here appear to either overcome or circumvent many of the impediments of conventional approaches and may offer a new means to introduce innovation to Canada's residential construction industry.

CHAPTER 4: INNOVATIVE TECHNOLOGIES

INTRODUCTION:

In addition to the findings discussed in Chapter 2 on the subject of innovation adoption, considerable information was gathered on innovative techniques, materials and strategies for evaluation and possible use in the proposed demonstration project. After a preliminary review of the materials, some 228 'innovations' were selected for further exploration. A full list of brief descriptions on each strategy can be found in the Appendix.

Initial Selection List

While the project was intended to be primarily technical or construction oriented in nature, the above selections include 96 items or strategies which could be classified as administrative in general and which have been included at the end of those listings under "Marketing and Sales". These were included to illustrate the fuller range of cost-saving possibilities truly available and to provide opportunities for further consideration or exploration of these strategies either by parties involved in the project or the reader.

Where possible, the initial listing for each strategy includes a rough estimate of its perceived benefit and where appropriate identifies the trades, beyond those directly involved in the innovation, who would be impacted by adoption.

Second List

The following section outlines the individual technologies which were selected by the general contractor from the preliminary list of 228 ideas for further review. Further information was gathered to confirm the initial findings and prepare a more comprehensive information package for subsequent analysis. The following is a listing of the selected items. However, it must be noted that in the formal presentation to the general contractor, these strategies were supported by extensive documentation and accompanying trade literature where appropriate, material which has been omitted here for brevity.

These items are generally listed according to the order in which they are introduced into a newly constructed home. However, the various framing strategies, which might normally be referred to under the broad heading of "Optimum Value Engineering" have been grouped to reflect their interdependency and for the reader's general convenience. Further, at the end of the listing the reader will find a somewhat fuller discussion of "Cycle Time Reduction" which in a sense constitutes one of the underlying objectives, that of construction time reduction for the implicit cost savings normally associated with such action.

Further, it must be noted that none of the cost savings quoted under the sections on 'Impact' include an amount for increased opportunity costs. For example, if a particular strategy take four less man hours than the work it replaces, the evaluation only credits the cost of the man hours saved and does not recognize that those hours could be applied to securing and undertaking additional work which in turn will result in further benefits.

CULLED LIST OF POTENTIAL COST-CUTTING STRATEGIES

FOUNDATION SYSTEMS

1 POST & BEAM FOUNDATION SYSTEM

Description:

This system utilizes pressure treated posts and perimeter beams to replace the traditional 8' deep concrete basement. Particularly, suited to home plans which incorporate crawl spaces or slab-on-grade construction replacing same with an open gravel floored crawl space.

Trade Off / Potential Problems

The post and beam system interfaces well with traditional trades and materials, but is not compatible with homes on sloped sites wherein walk-out basements are typical. Although it can be used in concert with more traditional foundations on a flat site. The concept may also suffer from a degree of market resistance compared to concrete foundations if lost storage space or public perceptions of overall quality and safety are not addressed.

Impact

The system saves approximately $37/lin.ft. of foundation. Total savings will vary according to the home size and design. On a flat site a typical home of the scale utilized in this study and illustrated in Chapter 5 these savings could represent some $8,200 which could be used either to lower costs or to provide more finished living space, a more usable and attractive unfinished attic or a larger garage. This strategy can also save significantly on the overall construction schedule; particularly in areas where heavy rain or severe winter conditions can make basements problematic.

2 ANCHORMATE BOLT HOLDERS

Description

These plastic, reusable positioning tabs are attached to the concrete forms and locate the traditional anchor bolts which tie the sill plate to the foundation thus holding them in the proper position and depth during placement of the concrete.

Trade Off / Potential Problems

No identifiable problems as strategy is used independently and has limited impact on other trades.

Impact

Because these represent an added 'tool' or 'task', they constitute a cost increase which can only be considered in terms of quality and subsequent ease of placement of mud plates.

3A "Q-LINER" PIER UPLIFT REDUCTION SYSTEM

Description:

This combination of hard circular plastic collar and heavy duty poly liner is used as a pouring tube for cast-in-place piers up to 20'+/- deep and upon setup of the concrete, the collar acts as a slip plane on the upper 5'-8' of the piers to reduce uplift from frost heave or expansive soils acting on the pier.

Trade off / Potential Problems

No identifiable problems with introduction of the system as it is used independently and has limited impact on other trades.

Impact

Retailing at $52+/-. for 8" and $45+/- for 5" collars the "Q-Liner" acts as an added cost item whose benefit only becomes evident with reduced call backs and thus their use will be very dependent upon the construction location. However, it is noted that "Q-Liners" have not had a single call-back since their introduction in the mid-80's.

3B PIER SLIP COLLAR - CMHC JOB-SITE INNOVATION # 91-012

Description:

A Canadian adaption to the "Q-Liner" which involves wrapping a bottom bearing wood pier with 4-5 layers of 6 mil poly to provide a slippage layer against frost heave and expansive soil uplift.

Trade Off / Potential Problems

Essentially cost neutral and no impact on other trades or practices.

Impact

Saving achieved through reduced call-backs and limiting of potential structural damage.

4 SELF-CONSOLIDATING CONCRETE

Description

This product is a concrete mixture which has been researched by a number of bodies and was recently utilized in forming the basements for the administration unit at the Canadian Centre for Housing Technology at IRC. The main advantage of this product is that its free-flowing properties allow it to be placed in a large foundation often from just one point and requires a minimum of vibration or rodding and yet provides a superior finished surface.

Trade Off / Potential Problems

While there appear to be no inter-trade conflicts, the concrete slurry is so fluid that any low sections of the forms, such as might be found in a stepped foundation wall on a sloped site for a walk-out basement arrangement, must be capped to prevent overflowing of the concrete above the form due to hydrostatic pressure from higher concrete sections.

Impact

At this point, the primary researchers have just begun to collect cost-comparison data as it might apply to typical residential basements And consequently, detailed cost savings can not be estimated. However, anecdotal information suggests that savings in placement labour and associated work will justify a 10% premium in concrete costs. At this time the researchers are working to lower the unit cost of the concrete and expect to be competitive very shortly

5 STEMWALL FOUNDATIONS

Description:

The essence of this strategy is the elimination of the typical 8"x 16" footing in favour of an 8" foundation wall which bears directly on the soil of the excavation and in many instances can be placed in a trenched excavation if absence of a basement eliminates the need to dampproof.

Trade Off / Potential Problems

No negative inter-trade impacts anticipated; however, while not disallowed by the building code, it is not a traditional foundation approach and will require extra effort to work with local inspectors. This approach has particular application in study area where many homes bear on or very close to bedrock.

Impact

Stem walls can save from $300-$500 / home.

6 BIGFOOT - PIER FOOTING FORM

Description:

This stepped, conical-shaped footing form is open at the top to accept the attachment of an 8"or 10" dia. Sonotube. When in place, with the sonotube attached, the excavation can be backfilled ready for concrete .

Trade Off / Potential Problems

No negative inter-trade impacts anticipated.

Impact

Bigfoot reduces the various cost of pile or pier pads by 90% labour (1/3hr) and $3-$5 material. More importantly, the holes can be backfilled as soon as the bigfoot is placed thus improving site circulation & safety, but more importantly, their use eases scheduling of the backfilling operation and subsequent pouring of the piers. At $19/form these appear to be a justifiable investment.

7 The FOOTING TUBE

Description:

This product is an extension of the BIGFOOT concept described above but incorporates a pier column for a total height above bearing of 62" making it suitable for decks / shallow foundations. Because the tube is sloped, it resists uplift forces and saves on column placement, poly wrapping and clean-up.

Trade Off / Potential Problems

No negative inter-trade impacts anticipated

Impact

At a price $2200/50 Footing Tubes, ($44/Tube) delivered in Kelowna, B.C., these compare favourably to the $30 - $33 which includes labour required of the BIGFOOT pad alone and provides a superior product.

8 FAST FOOT & FAST BAG FOUNDATION SYSTEMS

Description:

A Canadian designed foundation system which uses a combination of metal frame and fabric, left-in-place forms, to replace the traditional formed board and stake Footing forms and column pads.

Trade Off / Potential Problems

No identifiable problems with introduction of the system as it is used independently and has limited impact on other trades

Impact

Fast Foot appears to save approximately $1/foot on typical residential footings Fast Pad saves 30%+ or some $22.20 per pad. On the proposed testbed home this amounts to some $240 saved on the footings and a further $89 saved on four pier pads. For a total saving on the home of some $329.00+/-

9 MUDSILL STRAP ANCHORS

Description:

This construction approaches calls for replacing the concrete imbedded anchor bolts with imbedded strap ties. Where the former must be properly placed, kept clean, mated to the mudsill and bolted, the later are merely bent out of the way while the top of the foundation is smoothed and then bent back and nailed into the framing.

Trade Off / Potential Problems

The strap tie approach will require modest change in work for the cribbers but should result in an essentially neutral or even positive cost position. Further, the strap ties are cheaper per piece than the bolts, small pieces such as the nuts and washers won't get lost, threads can't be damaged, and they are always in the right location.

Impact

Although the tie supplier, who also supplies tie-down bolts, has not generated comparative cost analysis between their various product, use of strap ties should have a positive cash and time impact on construction and as such their use and evaluation appears justified.

FRAMING PHASE

10 CARPENTER'S STEEL STUD

Description:

This product is a form of hybrid steel stud in that it is intended to be used in concert with wood framing and in fact is designed in such a manner that it requires wood plates for its assembly. Shaped basically like a conventional steel stud, with the conventional punch-outs, the 'Carpenter's Stud' has flanges at both ends which are bent and then nailed to conventional top and bottom plates. These studs are available in both a non-load bearing 2x4 interior stud and load bearing 2x4 and 2x6 studs intended primarily for exterior walls.

The popularity of the stud varies somewhat inversely with the cost of lumber. When lumber prices soar, the relatively stable pricing of steel, and steel studs, becomes more attractive. When lumber prices fall, builders forget about the price fluctuations to which they are periodically subjected and revert back to timber framing. As of this writing, US lumber prices are hovering around $2.30-$2.40 per stud. Furthermore, builders are often having to cull anywhere upwards of 20% of their orders. Consequently, steel studding looks increasing attractive, a picture which will change with the next downturn in construction and subsequent easing of wood cost. If this product is to prove itself, it must do so on benefits other than just costing.

Trade Off / Potential Problems

The stud requires a modest learning curve by the framers but beyond that there is limited, if any, required adjustments by other trades and there have been no identifiable problems to date. In general reference to steel studs, some residential electricians have complained about the added cost and labour of providing higher quality wiring or utilizing grommets at all openings to protect their conventional wiring. However, the stud's manufacturer contends that these concerns abate with time as electricians become more familiar with the product and enjoy certain benefits from the pre-punched openings.

Impact

While hard up-front cost benefits will vary according to the price of lumber and the willingness of electricians to become familiar with the studs, the manufacturer reports that his information from the field suggest that on average, contractors utilizing the "Carpenter's Steel Stud" have reduced their warranty call backs by some $300- $500 per home due to few or no nail pops, squeaks and similar wood stud related issues; savings which can only be determined once such reduced warranty benefits have had an opportunity to manifest themselves.

11 OVE " Optimum Valuer Engineering" STRATEGIES

The following section contains a listing of a variety of framing and construction details which might normally be included under the broad trade description of OVE "Optimum Value Engineering" techniques. For convenience, these are presented in point form; however, they are in the main self-explanatory and only limited detailed information is provided. It must be understood however, that in the field, the introduction of any OVE strategy requires detailed investigation, precise drawings, trade discussion and training, interim evaluations, refinements and a learning curve.

In general the various studies on this construction approach suggest that the full scale application of OVE techniques to a typical home can save somewhere in the order of 10% on labour and materials, exclusive of cabinets, equipment, services and overhead.

Table 1:
Estimated Cost Savings from Individual Optimum Value Engineering Strategies

Reference	Description	Cost Impact +/-
11-1	Use 3" basement slab on well compacted base versus typical 4" slab [-25% Conc]	-$200
11-2	Eliminate wire mesh in slab as it adds little to slab quality Include expansion lines	-$80
11-3	Set plumbing and service lines flush with basement slab to simplify slab finishing	
11-4	Six inch basement walls are permitted to 6 foot height	-25% conc.
11-5	Eliminate sill plates and bear directly on smoothly finished and level concrete wall	-$53
11-6	Use 24" joist framing versus 19.2" framing	-20% cost
11-7	Eliminate all bridging	-$85
11-8	Use blocking versus double joists under non-load bearing walls	-$65
11-9	Utilize any of numerous alternate OVE based headers and beams such as ply box beams etc.	-$75 to -$90
11-10	Consider 117/8 wood I's @ 24" c/c versus 91/2 wood I's @ 16" c/c although cost comparable, the required 3/4" sheathing produces a better floor and the added depth makes servicing easier and web openings easier.	Cost neutral Quality Improved
11-11	Utilize 2x3 interior walls. Less expensive and provides 16 sq ft more space in typical home.	-$235
11-12	Co-ordinate wall openings to align along one edge of standard stud spacing	-$85
11-13	Use single studding around non-load bearing openings , block with scraps for added rigidity.	-$45
11-14	Consider combination play and 2x beams over garage openings	-$75
11-15	Use open soffit design for gable ends with rake board and no soffit	-$265
11-16	Utilize 8' closet openings with no returns at sides	-$70
	TOTAL: Direct potential savings for listed items noted Findings from various OVE studies suggest a potential total saving of **Average potential savings based on the two optional figures =**	-$1,365 -$3,000 **-$2,180**

DETAILED "OVE" ANALYSIS

The potential of apply an OVE strategy was demonstrated in an analysis which saw the demonstration home which is illustrated in Chapter 5 subjected to a stud-by-stud evaluation of all framing materials. Whereas the floor joists and roof trusses were already at 24" centres, these were excluded from the review. However, based on the use of OVE techniques such as two-stud corners, blocking rather than

studs at intersecting walls, more precise use of 2x4 versus 2x6 studs at some locations and in posts, more efficient framing around windows and doors and some increased blocking to allow for the removal of some studs in short walls, it was possible to make the following framing changes:

2x6 stud count reduced by 124 pieces
2x4 stud count reduced by 143 pieces
63 2x6 studs replaced with 2x4 studs.

Based on current Kelowna contractor lumber prices, and with taxes included, these changes amounted to a lumber saving alone of between $875.00 and $900.00. Given that these savings can be achieved with no noticeable impact on the consumer and requiring nothing more than changes to the construction details and further when one considers the limited profit margins being imposed on much of the residential construction industry, one must suggest that these techniques merit consideration.

12 JOB SITE FRAMING TABLES

Description:

When volume and weather conditions permit, elevated framing tables can be introduced into the job-site during the framing stage. These tables are easier to work at as the staff aren't bent over, guides can be set at 8' to ensure straight and square walls and some pre-marking of the table itself will speed layouts.

Trade Off / Potential Problems

While the quality of the resulting wall panels should be superior, to conventional platform results, this approach requires the presence of a fork-lift to move many of the panels and lift same to upper floors.

Impact

Costs impacts could not be calculated for this fabrication approach. However, such a system would encourage and facilitate greater standardization of parts and organization of the work with pre-planning, pre-cutting and sub-assemblies being natural outgrowths of the system.

SERVICES

13 WOODEN PLENUMS

Description:

By carefully configuring the wooden framing system with strategically located bulkheads, cut-outs and soffits plus proper air sealing strategies, it is possible to route tempered air through a home with minimal metal ducting essentially using the floor plates as plenums.

Trade Off / Potential Problems

There will be an increase in the required framing with special attention needed to certain bridging and cut out conditions. Further, care must be taken to ensure that this approach meets the 'ducting' requirements of the 'authority having jurisdiction'.

Following trade-offs for increased framing the proposed approach could save approximately $0.75/sq.ft. On a typical 2,000 sq.ft home for a total of some $1,500.

14 PLENUM ENCLOSURES & BULKHEADS CMHC JOB-SITE INNOVATION # 91-010

Description:

Replace conventional 2x2 and 2x4 framing around dropped ducts, beams and piping with a combination of drywall panels secured one to the other with light weight utility angle iron.

Trade Off / Potential Problems

This approach reduces the required bulkhead framing and sets off final determination of enclosure sizes until the drywall stage, simplifying the scheduling and releasing the framer earlier.

Impact

Though this approach entails some modest increase in work for the drywaller, the requisite skills are within his normal trade practices and as such should require a minimum of cost increase. Further, the finished quality of the work is solely dependent upon his input and simplifies jurisdictional disputes. Detailed cost trade-offs could not be determined.This approach has the added benefit of reducing the overall depth of the bulkhead by some 1½ inches as the drywall can now be tight to the lowest element and this increase in headroom may justify the use of this technique in its own right, or as an adjunct to the OVE strategy of eliminating the sill plate.

15 SPEED WIRING

Description:

The essence of this organizational technique involves using significantly larger electrical crews to wire a residence than previously considered efficient. In practice this might involve replacing 2.5 men working over 3+/- days with five electricians working just one day. Based on the experience of contractors in the US who utilize this system one can suggest this can be a very time and cost effective strategy

Trade Off / Potential Problems

The major required change in practices is that the residence should be free of all trades save for the electricians during the wiring period.

Impact

Zaring Homes, a major US builder suggests that they can save 37% (40 man hours -vs- 64)/ home on labour; utilizing five men for 1 day versus 2 men for four days. An estimated comparable figure suggests potential savings of 16 man hours per home in Kelowna or the equivalent of wiring 3-4 extra homes every two weeks with the same labour resources. In addition to the electrician's savings, the general contractor can cut two days out of their production schedule. [See note regarding Cycle Time Reduction cost savings]

16 EXTRA KITCHEN PANEL

Description:

When the length of required electrical runs warrant it, consideration should be given to installing a secondary sub-panel in or near the kitchen to minimize the number of runs to that electrical intensive area. At that time consideration can also be given to serving the second floor from that panel or installing an entirely separate panel for just that area.

Trade Off / Potential Problems

There are no inherent tradeoffs in connection with this concept as the work and materials are all limited to the original electrical trade.

Impact

Any cost savings must be calculated on a home specific basis to ascertain if the cost of the panel and primary feed to it are justified by the savings in secondary wiring and labour.

ENVIRONMENTAL BARRIERS

17 VAPOUR-FORM inc. JOIST SPACE SEALER

Description:

These pre-formed heavy-duty poly vapour barriers fits between the joists at the outside wall and creates an effective air vapour barrier at what is traditionally a most difficult space to properly seal.

Trade Off / Potential Problems

There are no trade conflicts as the work is performed by the same trade and at the same point in the construction process.

Impact

The beneficial impacts appear to be three in number: The installed cost is approximately $45 less/house than the conventional header sealing approach. There are four additional hours for installers to work on other projects for a benefit to the sub-contractor of some $100/house. Lastly, the homeowner's heating bill is reduced by about $38/yr and although not significant as a percentage of most heating bills, it still constitutes an additional benefit.

18 2x4 STUD & EXTERIOR INSULATION -vs- 2x6 CONVENTIONAL STUD FRAMING

Description:

This framing strategy suggests that utilizing an insulation wrapped 2x4 exterior stud wall is both cheaper and superior to the conventional batt insulated 2x6 exterior wall.

Trade Off / Potential Problems

The primary impact falls on the insulators who will now have to provide and install two inches of exterior insulation. Further, some additional detailing may be required around the windows and doors to accommodate the insulation to window fit and sealing.

Impact

For the type of homes and framing under consideration in this study, the proposed innovation would have the following impact: Detailed studies from the insulation industry suggest that the combined framing and insulation costs can be reduced by some 10%. The overall wall insulation value is increased by 19%. The home should be more marketable as the 'blanket wrapped' approach is a desirable feature and sales tool.

However, these costs could not be confirmed in the Kelowna market but this strategy is included due to the potential cost savings and very real improvement in marketability.

FINISHING

19 NO-COAT PRE-FINISHED DRYWALL CORNER AND TRIM BEADS

Description:

These are pre-formed, paper-faced, plastic corner beads which can be installed with just a light feathering into the adjacent wall surfaces. With trim and supporting installation tools available for almost all wall configurations, this new installation technique could speed drywall finishing and do so at a cost saving and higher quality.

Trade Off / Potential Problems

There are no trade conflicts as the work is performed by the same trade and at the same point in the construction process.

Impact

The beneficial impacts appear to be three in number: The installed cost is approximately $.35 less/foot than the conventional corner beading . This is comprised of 70% less materials and 67.5% less labour thus easing the construction schedule while freeing labour for work on other jobs.
Mud drying time is also reduced, further aiding scheduling.

20 PRE-FINISHED ATTIC HATCH

Description:

This drywall accessory simplifies the placement and finishing of the attic access hatch thus allowing greater freedom in their placement.

Trade Off / Potential Problems

There are no trade conflicts with the work being done by the same trade at the same point in the construction process.

Impact

No costing comparison has been performed by the manufacturer. The general contractor, in concert with the drywaller should test the product and determine if the product cost of $170 is justified by the speed, ease and quality of the finished access.

21 DRYWALL RESCHEDULING - CYCLE TIME REDUCTION

Description:

Total construction cycle time can be reduced somewhat if the drywall trade completed both the kitchen and bathrooms first in order to allow the cabinetry and plumbing trade quicker access to these labour intensive areas.

Trade Off / Potential Problems

There could be a cost penalty impact on both the drywall and cabinetry trades. The former who is being asked to complete some work out of sequence and from the later who must invest greater effort to keep their finished work protected from other on-going activities.

Impact

Precise cost benefits can not be calculated at this time. However, the reader should consider the discussion of "Cycle Time Reduction' following these listings to help determine if the benefits arising from the reduced overall construction schedule merit the added expense and effort implicit in this proposed reorganization of the drywall tasks.

22 CANADIAN GYPSUM

Description:

Canadian Gypsum wallboard is promoting its new drywall panel compositions as being superior to the older gypsum and paper mixes.

Trade Off / Potential Problems

Whereas the proposed product is indistinguishable from the current one, no problems are anticipated.

Impact

The manufacturer is claiming three benefits which contribute to a 10% saving in installation time. Panels score and snap more evenly thus requiring less trimming and subsequent patching. The panels handle easier, due to increased rigidity and are also more durablePanels remain flatter in storage thus reducing subsequent work in finishing.

23 DRYWALL CLIPS

Description:

Drywall Clips have proven to be one of the most difficult technologies to introduce on the general construction site as the benefits all accrue to the framer, electrician and insulator while the added costs and uncertainty of change are borne by the drywaller. Consequently, this technology can either be dropped as an unnecessary bother, and the savings foregone, or the general contractor can use this technology shift as a demonstration of their willingness to test new ideas and support or even promote innovation on the job-site and use these clips as one measure of the project's effectiveness.

Trade Off / Potential Problems

This technology will entail a significant trade-off. Savings from the reduction in lumber and labour required for framing must be weighed against the added work which may be required with the drywall clips. Due to the very limited and inconsistent information on potential added costs or cost savings attributable to this technology it is suggested that while the idea appears intriguing, the only way to test its suitability is to utilize it on a residence, calculate the costs and cost trade-offs, evaluate and refine the system and retry to confirm any interim findings.

Impact

Some literature suggests potential savings ranging from $200-$1000 per home utilizing drywall clips while one study indicated that there could be a saving of as much as 10% in lumber use. Although that claim seems somewhat exaggerated, it does indicate some sense of the potential benefits which might accrue if drywall clips are provided a fair evaluation and subsequent use.

24 LOW TEMPERATURE PAINT

Description:

In order to extend the construction season or reduce the cost of temporary heating of the house, the painting contractor should consider 'low-temperature' paints such as the new Sherwin Williams "LowTemp 35".

Trade Off / Potential Problems

There are no trade conflicts as the product is merely a material substitution by the painter.

Impact

No costing comparison has been performed by the manufacturer. However, while the anticipated benefits include savings from less temporary heating, it is the possible reduction in the construction cycle time which should prove to be the most important benefit.

INSPECTIONS & WARRANTY

This section looks at both what is generally considered the 'final' inspection and warranty issues. This is done under the presumption that if the home is properly finished that many of the finalizing and modest repair items might be eliminated. The section also looks at the issue of consumer education via a homeowner's manual and related literature assuming that such efforts will reduce warranty calls.

25 FINAL INSPECTION

Description:

Some builders have found that one way to increase consumer confidence is to invite buyers along on a series of site 'visit/inspections' thus conveying the impression that they are committed to the buyer's well-being and that they have nothing to hide. One builder conducts five walk throughs; one orientation visit, inspections at framing and drywall, one three weeks before closing and a final inspection just before closing. Other builders have found that clients look for, and find, fewer 'errors' or problems with their home if the final inspection is actually referred to as an orientation visit.

Trade Off / Potential Problems

No trade offs are required as inspections are a normal management duty.

Impact

Utilizing this approach, one builder achieved a 95% satisfaction level with their clients and referral accounts rose 25%.

26 HOME WARMING GIFT

Description:

Each new home buyer should be welcomed with a house warming gift which, in addition to any 'gifts' the developer wishes to include should contain the following elements:

- small containers of touch-up paint in every colour used in the home.
- a couple of small disposable paint brushes
- wood putty sticks in the colours necessary to match all finished woodwork.
- small tub of spackle and putty knife or tube of tile silicone grout
- trade literature on all systems and maintenance of all finishes
- list of maintenance items listed by season.
- sandpaper, tape measure and even change of address cards.

Trade Off / Potential Problems

There are no trade conflicts or potential problems as this work item is undertaken by the general contractor's sales staff. The cost of these kits can be reduced by working in association with some of the major trade suppliers. Sherwin Williams has such a programme; however, in return for the promotional benefits many major paint supplier would probably be willing to donate, clean paint cans

to use as welcoming baskets. This construction strategy works well when undertaken in concert with the issuance of a home owner's manual as discussed below in item # 29.

Impact

While it is impossible to identify a direct cost-benefit analysis, one contractor who has utilized this system has found that the use of a $75 welcoming kit has consistently reduced his warranty calls by 50%.

27 HOMEOWNER MANUAL

Description:

Within the BC residential market the New Home Protection Office has made homeowner manuals an element of their mandatory warranty process. However, while mandated, they can still be used to advantage by builders to (a) actually reduce warranty calls and work, by clearly defining what is and isn't a warrantied item, (b) suggesting homeowner driven fixes and solutions and (c) acting as a promotional sales tool through their professional presentation and completeness. It bears noting that CMHC has developed such a product which is publicly available. [CMHC Prod. # 61841 '*Homeowner's Manual*', 1999, 150 Pages ($39.95 in 2001)]

Trade Off / Potential Problems

There are no trade conflicts as this tool is generated by the general contractor and while part of their project administration and it should have input from the marketing staff.

Impact

No cost-benefit figures have been generated for this management item, but anecdotal information supports the evolution of this mandated item into a marketing tool.

The following articles on warranty presume that the general contractor has included a budget line item in his project costs for warranty work and that either the return of this money to the homeowner or its dispersion as a warranty service cost is irrelevant to their profit or loss picture.

28 SERVICE VOUCHER & WARRANTY PAYOUTS

Description:

One technique for reducing and practically eliminating warranty calls in the first year period is to provide free "Service Vouchers" to the home buyers which they in turn 'cash-in' for warranty calls, or if they are not used in the first year, they can be returned for a cash payment equal to their face value. In one example a contractor even provided a bonus voucher, worth $75, at the end of the first four months when the consumer returns a completed marketing and follow-up survey.

Trade Off / Potential Problems

There are no trade conflicts as this tool is an internal management procedure of the general contractor and neither reduces the scope nor range of their warranty work obligations.

Impact

If the general contractor has budgeted 2%+/- for warranty work on a $100,000 home their payment of $300+/- to redeem warranty vouchers in the first year can be viewed as a very significant cost benefit. One general contractor employing this system reported that he had essentially no warranty calls once he initiated this programme and certainly no calls on minor items as the home buyers were very anxious to recoup their $300 warranty pay out.

29 WARRANTY SERVICE NOTICES

Description:

Warranty calls can often be reduced, eliminated or forestalled to a time convenient for the contractor by having periodic pre-arranged warranty inspections such as at 3, 6 and 12 month intervals following the sale of the home. This approach assures the consumer that their interests are being met, that the contractor will stand behind his product and that their concerns; regardless of how minor, will be attended to.

Trade Off / Potential Problems

There are no trade conflicts as this is an internal process for the general contractor who can simplify their operations when these periodic inspections are anticipated and can be worked into slack periods.

Impact

One builder noted that this approach raised his warranty costs from 1% to 1.25% of overall costs but credits the approach with increasing referral sales 10 fold. One contractor, building 100 homes/yr noted that except for any emergencies, warranty calls had almost stopped and reported no calls in the previous three weeks before the survey interview.

30 COMPUTERIZED WARRANTY CONTROL

Description:

This management control strategy proposes the use of hand-held devices, such as the PALM PILOT with customized software to list, integrate, priorize, track and transmit to sub-trades data about required warranty work. These hand-held field devices can be integrated with an office computer system with which data is uploaded or downloaded as appropriate. Using a variety of customized programmes, contractors can largely automate much of the notification, tacking and subsequent work approval process on a construction site. While discussed here as a 'warranty' oriented tool, the software was originally intended to manage new construction and can function admirably in that role.

Trade Off / Potential Problems

There are no external trade conflicts as this management strategy is internalized to the management processes of the general contractor. However, it will require considerable rethinking and a learning curve within the general contractor's office and organization as this function is computerized and automated. For an office contemplating a more computerized operation, starting with warranty automation may prove a viable introductory process.

Impact

Research could not find detail cost-benefit information related to the use of this technology however, the following benefits and anecdotal information support this technology:

- automates periodic notification of unfinished work items
- semi-automatic notification to sub-trades of required work
- integrates readily with main-frame office computer
- requires 'one time' entry of data with automatic transfer to pertinent data bases and personnel
- reduces file access time from up to 10 minutes to seconds
- reduces personal chatter from notification phone calls
- facilitates quicker release of hold-backs as work is tracked and completions speeded
- tracks and identifies recurring problems and problem sub-contractors
- tracks rate of service on notifications for work.

31 PERIODIC NOTICES & CONSUMER INFORMATION

Description:

One strategy to forestall warranty calls is to provide in-home information sheets, possibly as wall posters, fridge magnets, in the homeowner manual or as periodic mail out notices to past home buyers notifying them of required maintenance work which will keep the buyers' systems in tip-top form and significantly reduce or even eliminate many justified or unreasonable warranty calls. An example of this is an autumn notice to blow-out the irrigation system before freeze-up.

Trade Off / Potential Problems

There are no trade conflicts as this is an internal contractor task handled by office staff during spare or slow periods. This system can be very cost effective at $.55+/- for 300 pieces.

Impact

When combined with the ' Warranty Service Notices' noted above, this management tool can reduce warranty calls by nearly half and essentially eliminate problem calls. Considering that warranty calls can easily run $100-$300 per instance, any call reduction justifies the investment in time and resources. This continuing service from the builder has repeatedly been shown to contribute to increased consumer satisfaction.

32 INTEGRATED DRAFTING / ESTIMATING

Description:

This approach calls for house plans to be computer drawn utilizing a drafting program which automatically produces a materials list which can then be exported to a estimating data base.

Trade Off / Potential Problems

There are no trade conflicts as this operational change is an internal builder function and should simplify the materials cataloguing and order process.

Impact

It has been calculated that the use of an integrated drafting and estimating program and the detailed itemized materials order which follows therefrom, will save 5%-15% on materials cost per job For a house with some $50,000 to $75,000 worth of hard material costs this can run from a low of $2500 to a high of $11,250 or an average $6,500/unit. Admittedly a seemingly high figure, but if the process can save just $1,000/unit the $4,000-$6,000 investment in new software would appear to be an advantageous decision.

TOOLS

The following listing describes some modest tools and equipment discovered during this work which while not having a major impact on the construction process could simplify some tasks, improve the accuracy of others or merely make the work a little less onerous.

These tools should be provided by general and sub-contractors to their trades if not for the potential monetary savings then for the vote of confidence such a supply instills in the workmen and to demonstrate that superior, cost-effective and innovative workmanship is a company goal to which everybody is invited to contribute.

33 The CLEAT

Description:

The CLEAT is a small proprietary tool used in the drywall industry to assist in hanging ceiling boards. The tool can also be used as a rocker to raise the wall board off of the floor for nailing. The tool has its greatest benefit when used on cathedral ceilings and could replace various lift and temporary bracing systems.

Trade Off / Potential Problems

There are no trade conflicts as the tool is intended for the drywall trade and impacts no others.

Impact

No costing comparison has been performed by the manufacturer. The general contractor, in concert with the drywaller should test the product and determine if the product cost of $30/US is justified by the speed ease and quality of the finished access.

34 CENTRE-POINT TAPES

Description:

These tapes have both full-scale and half-scale markings thus it is possible to take a measurement, say of a recess for a toilet, on the top edge of the tape and by laying out that same measurement with the half-scale bottom readings find the exact centre of that recess This tape both saves time and results in far fewer mistakes, such as trying to find the mid-point in a $13^{5}/_{8}$" opening

Trade Off / Potential Problems

There are no trade conflicts as the tool is used by individual tradesmen and has no impact on others.

Impact

No costing comparison has been prepared by the manufacturer but obviously the time saving and potential cost savings resulting from even one minor error justifies the $25+/- cost of the tape.

35 ULTRA-SQUARE

Description:

One simply wonders why such a handy little tool was not invented sooner or why they aren't found on all job sites. The Ultra-Square is best described as a 4.5" deep "T" shaped, plastic tool which can be used in conjunction with a standard tape to locate the edges, centres or individual placement of single, double or triple stud configurations simultaneously on top and bottom plates. Further, the Ultra-Square can be used to locate and mark a full range of rafter cuts up to 45 degrees in one setting versus the 13 required with a traditional rafter square. The tool pays for itself in one hour through time savings in marking various studs, plate and rafter dimensions.

Trade Off / Potential Problems

There are no trade conflicts as the tool is used by individual tradesmen and has no impact on others..

Impact

No costing comparison has been prepared by the manufacturer but even the briefest reading of the trade literature confirms that at $15, the tool is a must for every carpenter's tool belt.

36 The JOISTER

Description:

This tool helps in locating and placing joist hangers square and at the proper height while holding them in place in order that the framer has both hands free for his nailing.

Trade Off / Potential Problems

There are no trade conflicts as the tool is used by individual tradesmen.

Impact

It has been estimated that with the Joister, joist hangers for all sizes of dimensioned lumber joists can be placed at the rate nearly 10 times faster than conventional installation or some 150 per hour or 250 per hour using a nail gun.

Description:

A plastic replacement for the conventional cedar shim used in a variety of construction situations. Noted for not swelling, breaking cleanly and being dimensionally consistent and stable, the EZ-SHIM at $0.93/shim F.O.B. Santa Barbara CA-vs- $.16 for conventional cedar, appeared to be a viable product substitution, but one-time, non-bulk shipping costs have eroded that advantage.

Trade Off / Potential Problems

There is a concern that these higher quality shims would be subjected to theft on the job site.

Impact

With shipping included, the shims were approximately 3-4 cents more expensive than standard shims and only merit consideration if the general contractor wishes to explore all possible technologies as part of a broader programme of introducing innovative materials and techniques.

COMPARATIVE COST ANALYSIS:

While it is recognized that a builder may elect to only utilize a few of the strategies noted above, or that the resulting fiscal benefits will vary both between general contractors and between various markets, it is possible to consider the potential impact of the suite of cost-saving strategies being considered. The adjacent listing offers such an overview and is calculated on the proposed home.

Given the summary and the caveats noted at the bottom of the adjacent Table, it would not be unrealistic to attempt to achieve the $20,000 cost reductions being suggested , but recognizing that even a 50% success rate on just the documented strategies will effect a 10% cost reduction or an initial $10,000 +/- saving in the total cost of the typical 2,000 sq.ft home built in Canada today.

Table 2:
Potential Cost Saving Summary

Ref.	Description	Benefit +/-
1	Wooden post and beam foundation replacing 8' concrete basement	-$5,500
2	Anchormate bolt holders	
3A &B	Q-Liner column uplift reduction & Pier Slip Collar	
4	Self-consolidating concrete [Can absorb 10% material upcharge for labour saving]	
5	Stemwall foundations to eliminate footings	-$400
6	Bigfoot pier pads	
7	Footing Tube	
8	FastFoot foundation and FastPad pier foundation	-$330
9	Mudsill strap anchors	
10	Carpenter's steel stud	
11	OVE strategies [Savings broadly estimated by various sources at $1 365 to $5,000]	-$2,180 est
12	Job site framing tables	
13	Wooden plenums	-$1,500
14	Plumbing enclosures and bulkheads	
15	Speed wiring [Savings comprised of -37% labour and -50% to 75% in time]	-$560
16	Supplemental kitchen panel	
17	Vapour-Form joist header sealing system	-$44
18	2x4 exterior wall w/ exterior rigid insulation - vs- 2x6 batt insulated wall	-$1,025
19	No-Coat drywall corners	-$1,015
20	Pre-finished attic access hatch	
21	Drywall reorganized work plan for 'Cycle Time Reduction'	
22	Canadian Gypsum's new board -10% on labour	-$300 est
23	Drywall clips [Highly variable and contentious costing]	-$580
24	Low temperature paint [Savings variable by season]	
25	Final Inspections	
26	House Warming gift with integral touch-up kit	-50% warranty calls
27	Homeowner manual	
28	Service vouchers and warranty payout	
29	Warranty service notices - increased referral sales	
30	Computerized warranty tracking	
31	Periodic notice cards of seasonal maintenance requirements such as furnace check	-$500 to -$700
32	Integrated drafting/estimating programme Quoted savings widely variant, $2,500 to $11,500, dependent upon current estimating and purchasing practices	$2,500
33	CLEAT drywall tool	
34	Centre-Point tapes	
35	Ultra-Square framing tool	
36	The JOISTER	
37	EZ-Shims	
	Cycle-Time Reduction included here for the convenience of calculating the total savings	$3,750
	TOTAL OF ESTIMATED SAVINGS FROM ITEMS VALUED ABOVE	**$20,300**

In reviewing the above figures three key issues must be remembered:

- Some items are not costed and any benefits will only manifest themselves in longer term pay back as warranty work is reduced and referral sales increase
- In practice savings must also be calculated to include additional opportunity benefits
- It is unlikely that all strategies will be adopted on any one project consequently, the TOTAL potential savings represents a best situation and the ACTUAL savings on any one home will be lower though still significant

CYCLE TIME REDUCTION

The following discussion is predicated on the assumption that a builder who achieves the cycle time reductions being discussed is able to use the inherent advantage of such time reductions to secure additional contracts to fill the time thus made available. Further, it is assumed that these additional projects will be executed with generally the same staffing resources and thus constitute a cost and profit advantage. Naturally, a contractor may elect to utilize any potential cycle time savings to either improve quality or to provide a less pressured work environment; however, regardless of the ultimate path chosen, any cycle time reduction can be valued and that process is discussed below.

Description:

'Cycle Time Reduction' as a managerial strategy does not speak to any individual task, but rather addresses the general importance of reducing the overall construction cycle time for a project such as a house. Cycle time reduction can be achieved in a variety of means; however, it bears noting that a survey of builders suggests that 53% of any improvements can be secured from just four contractor managed initiatives:

a) better, more formal scheduling process
b) partnering with sub-trades
c) improving plans and specifications
d) faster approval of contracts and change orders

Obviously because of their scale, some of the changes described above will necessitate significant adjustment; particularly, within the prime contractor's organization. It is interesting to note that most time reduction strategies do not involve changes to specific work methods, but rather changes to the organization and management of those tasks.

Though admittedly optimistic, the potential cycle time reduction found in the following comparative schedules, Figure 2, suggests that construction time for a contractor might be reduced by up to 5 weeks. Though generous, even if one achieves half of that saving or some 12.5 days it could be worth over $3000 per unit.

Impact

A builders' survey suggests that most typical firms can cut between 23 to 28 days from a typical construction cycle and that any builder should be able to reduce his project time by at least 15 days.

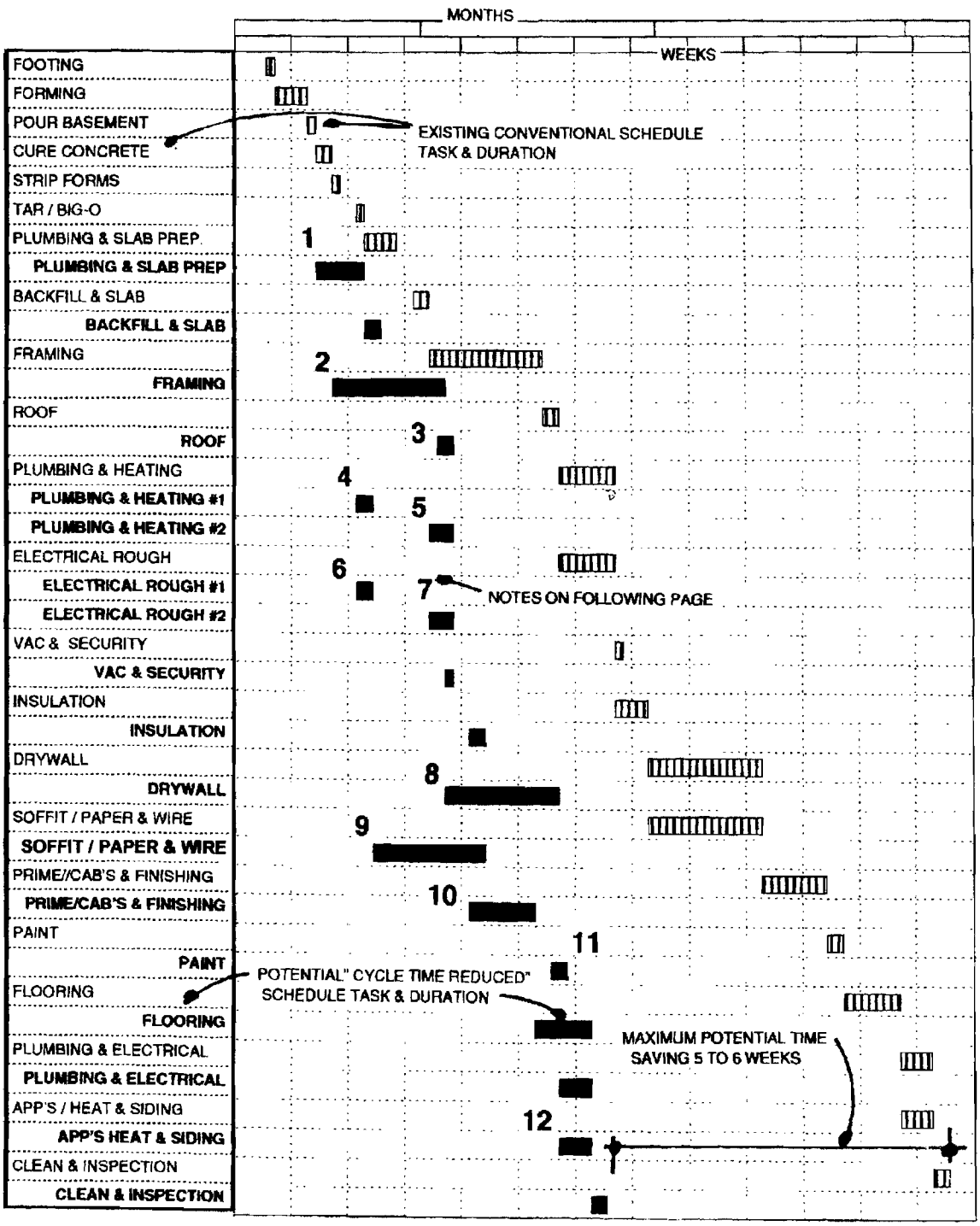
A 15 day reduction for many builders equates to a 20% saving in time and allows for an additional 20% of starts per year. For a builder constructing 65 homes a year this equates to some 13 additional homes, to cover payments for staff, overhead and profits, and yet achieves this with essentially the same work force.

It is estimated that each workday removed from a construction schedule can be worth $250+/- day. Thus, 15 days could be worth $3750 in clear profit, to which must be added the aforementioned increase in overall profits from the additional starts which the cycle time reduction now allows.

The reader can follow the logic behind these claims, and even attempt an estimated day valuation for their own operation, by reviewing the three worksheets found at the end of this Chapter and which are available from the National Association of Home Builders Research Centre, 800.638.8556 ext.714

For similar information from their web site, go to **www.nahbrc.org** and type 'cycle time reduction' into their search engine. This will produce a list of available publications and the viewer should look for and click on "What is a Day Worth?".

Figure 2:
Comparative Conventional and 'Cycle Time Reduction' Construction Schedules



Notes to "Figure 2" Time Saving Strategies

The more significant time saving strategies illustrated above in Figure 2 are explained below and referenced to the numbers included in the Gantt chart.

1 Sub-slab plumbing and gravel preparation etcetera can commence as soon as the concrete is poured for the walls. If desired, it is even possible for this work to commence before the walls are poured.

2 Framing can start once concrete has set up and may even commence concurrent with form removal if the detail at wall top and sill plate are conducive.

3 Roof can commence as soon as exterior walls are stable. Some non-load bearing interior walls can be left to last.

4 Plumbing and heating should begin as soon as the first floor is in from which to hang services.

5 Remainder of servicing picked up as soon as framing complete.

6 Electrical should begin as soon as the first floor is in from which to hang services.

7 Remainder of electrical servicing picked up as soon as framing complete.

8 Drywalling can begin as soon as home is weathertight and begin with one side of interior walls, with the remainder done following inspection.

9 Work on exterior should begin as soon as first floor is finished framing. Wiring etc. around openings can be completed at end of work.

10 With kitchen and bathrooms drywalled first, cabinets should be installed as remainder of home boarded.

11 An early start on painting can be facilitated by using vacuum attached drywall sanders, closing off some areas and scheduling drywall to free major areas for painters.

12 Finishing is advanced by painting the kitchen and bathrooms first.

SUMMARY:

During the course of gathering and evaluating information on a wide variety of innovative products and practices a number of points became very clear:

i) There is absolutely no shortage of tested innovations which small-scale residential contractors could exploit to their advantage.

ii) There is a sufficiently broad range of innovations to meet the needs of all sizes and types of construction companies.

iii) Most innovations do not require any unique skills to implement.

iv) The innovations which will tend to have the most significant payback involve undertaking fundamental changes in thinking and operations. However, even these innovations tend to be inexpensive and easy to adopt if management wish to innovate and will in essence '**walk-the-talk**'. The advantage of these types of innovations for most firms is that they tend to involve internal operations and thus are inexpensive to introduce and relatively free from interference by sub-trades , customers or the prevailing economy or market conditions. [Note: This type of innovation did not form part of this study, but examples were gathered during the literature review process and were evaluated. They can be found in the Appendix section titled "Technology Substitution List" Items # 133 and beyond which begin on Pg. #A7.]

In brief, there are lots of innovations and there exist few, if any real structural impediments to residential construction companies adopting many of them and enjoy significant financial rewards for their pro-active efforts.

Figure 3A:
NAHB "Cycle Time Reduction" Strategy and Discussion

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MARCH 1998

QUALITY

CYCLE TIME REDUCTION - WHAT IS A DAY WORTH?

Edward Caldeira, NAHB Research Center

Builders can make real progress in reducing build cycle time by "building it the right way the first time." Cycle time reduction is a natural by-product of fewer mistakes to correct, less adjustments to make, and a streamlined construction process.

To get employees and trade contractors to understand the importance of cycle time, put it into dollars and cents. Every builder can calculate what a day is worth by looking at some key factors:

Cost of Money. Whether it is interest on a construction loan or lost investment opportunities, it takes money to build. And money costs money. For example, the cost of money for a typical home = ($25,000 land cost) + ($110,000 hard costs/2) x (10% annual interest rate)/365 = $22 per home per day.

Contractor Costs. Streamlined production processes allow contractors to complete jobs in less time and to produce more homes with the same crews. While material costs may not change significantly, there are substantial savings in contractor labor costs. Builders can share in the benefits. In a typical example, labor savings from being able to reduce a day from the schedule = ($30,000 contractor labor per home/100-day build time) x 50% share of benefits = $150 per home.

Management Costs. As problems are prevented, staffs become more efficient. Streamlined production processes reduce build time without additional management attention. In a typical example, management savings for eliminating a day from the schedule = ($225,000 annual production management, superintendent, and administrative salary and benefits + $60,000 overhead)/(20 homes per year x 365) = $44 per home.

Sales Opportunities. When the standard build schedule satisfies buyers who need homes quickly, new sales opportunities exist. For example, if a 100-day schedule were reduced to 90 days, the average value of removing a day from the production schedule = (5% additional homes sales x $15,000 margin per home)/(100 day current build time - 90 day target schedule) = $75 per home.

The total savings in the example above is $291 per home per day. Other builders calculate a day to be worth between $50 and $500 using their own data and including or excluding various factors.

What is a day worth to your company? Have a company team use the form below to perform your own calculations. Everyone will agree that removing a day from build time is very worthwhile.

Figure 3B:
NAHB "Cycle Time Reduction" Strategy and Discussion

WHAT IS A DAY WORTH?

CALCULATION FORM

1. Cost of Money (per home)

A. Land Cost ..... $ _____
B. Hard Cost ..... $ _____
C. Average Hard Cost (B + 2)[1] ..... = $ _____
D. Average Investment (A + C) ..... = $ _____
E. Annual Interest Rate ..... _____ %
F. Cost of Money Per Year (D x E) ..... = $ _____
G. Cost of Money Per Home Per Day (F ÷ 365) ..... = $ _____

2. Contractor Labor Costs (per home)

A. Hard Costs ..... $ _____
B. Contractor Labor Percent of Hard Costs[2] ..... _____ %
C. Total Contractor Labor Cost (A x B) ..... = $ _____
D. Current Build Cycle Time[3] ..... _____ days
E. Contractor Labor Cost Per Day (C ÷ D) ..... = $ _____
F. Builder's Share of Benefits ..... _____ %
G. Total Value to Builder Per Home Per Day (E x F) ..... = $ _____

3. Management Costs (per home)

A. Executive Management Salaries[4] ..... $ _____
B. Construction Administration Salaries[4] ..... $ _____
C. Field Superintendent Salaries ..... $ _____
D. Field Assistant Salaries ..... $ _____
E. Total Construction Management Salaries (A + B + C + D) .. $ _____
F. Employee Benefits Percent of Salaries[5] ..... _____ %
G. Employee Benefit Costs (E x F) ..... = $ _____
H. Total Construction Management Costs Per Year (E + G) .... = $ _____
I. Number of Homes Per Year ..... _____
J. Management Cost Per Home (H ÷ I) ..... = $ _____
K. Current Build Cycle Time ..... _____ days
L. Management Cost Per Home Per Day (J ÷ K) ..... = $ _____

(continued on next page)

[1]Divide by 2 for average value.
[2]Estimate 43% of hard costs (1996 Means Residential Cost Data).
[3]Build cycle time is typically from foundation excavation to closing.
[4]Salaries can be adjusted for a percent of time spent on construction management activities
[5]Benefits are typically 35% of salaries.

Figure 3C:
NAHB "Cycle Time Reduction" Strategy and Discussion

WHAT IS A DAY WORTH?

Calculation Form (Continued)

4. Sales Opportunities

A. Current Build Cycle Time ..... days
B. Target Build Cycle Time ..... days
C. Build Cycle Time Reduction (A - B) ..... days
D. Number of Homes per Year .....
E. Percent Increase in Home Sales (due to reduced cycle time) ..... %
F. Profit Per Home Sold ..... $
G. Total Profit From Increased Sales (D x E x F) ..... = $
H. Average Increased Profit Per Home (G ÷ D) ..... = $
I. Average Increased Profit Per Home Per Day (H ÷C) ..... = $

5. What is a Day Worth?

A. Total Worth of a Day Per Home (1G + 2G + 3L + 4I) ..... = $
B. Number of Homes Per Year .....
C. Worth of a Day for the Company (A x B) ..... = $
D. Current Build Cycle Time ..... days
E. Target Build Cycle Time ..... days
F. Build Cycle Time Reduction (D - E) ..... = days
G. Worth of Target Build Cycle Time per Home (A x F) ..... = $
H. Worth of Target Build Cycle Time for the Company (BxG) .. = $

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CHAPTER 5: PROJECT IMPLEMENTATION

INTRODUCTION:

The implementation of the construction phase of the project generally followed the proposed work plan outlined in the Chapter 3; however, there was a truncation of the time allotted to introducing the overall concept, goals and innovations to the sub-trades which as will be seen impacted the overall project performance.

ACTUAL WORK PLAN

Due to a combination of the weather and marketing conditions, a home which would be suitable for use as a demonstration test unit did not become available until October of 2000. This situation proved to be both an advantage and disadvantage.

On the positive side, not one, but two identical units called the Parkhill model, the main floor plan for which is shown on the following page, Figure 4, were slated for concurrent construction starts. This meant that one unit could be built in a conventional mode as a sort of benchmark unit while the second unit could be loaded to the maximum extent possible with innovations both to evaluate them individually and to test the overall working theory. To maximize the potential of having identical units available to study, it was decided to stagger the construction somewhat to allow the benchmark model to proceed the test model by a couple of weeks in order that the former could be inspected and analysed to identify potential changes and improvements which could be incorporated into the latter.

This decision proved most fortuitous as the opportunity to review existing practices led to a number of framing changes not only on the test home but within the contractor's general framing guidelines. An example of this was the use of outrigger floor joists to support a fireplace and TV bay extension. Upon detailed review this was found to be unnecessary as the load could easily be carried by more conventional framing carried off of the floor and adjacent walls. This minor redesign led to an overall re-evaluation, and redesign, of the flooring system which took into account the installation needs of the mechanical and electrical trades and as a result the improved integrated overall design was, in the words of one senior manager " as different as night and day"

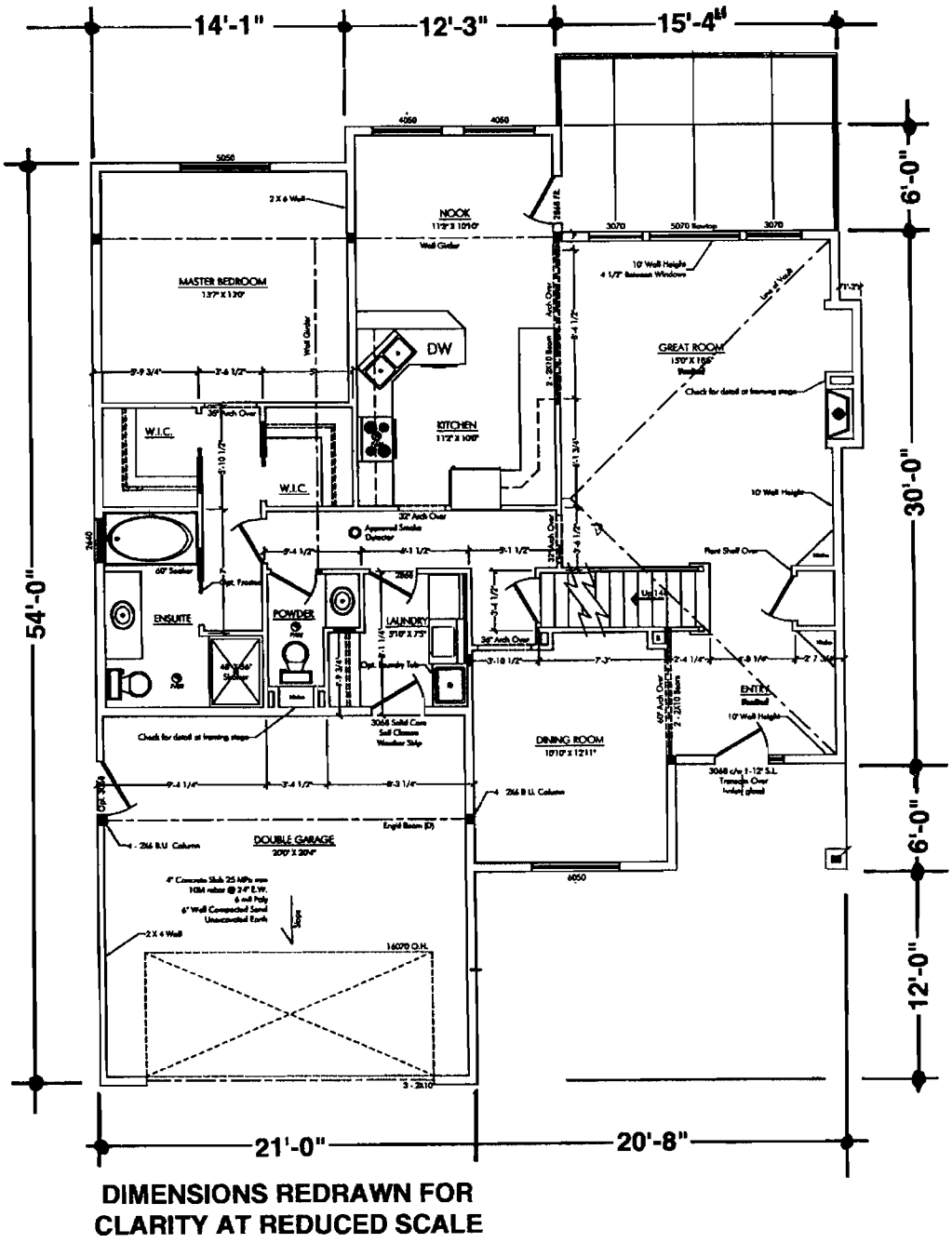
Unfortunately, once the decision was made to utilize these units, the pressure of the impending winter season proved to impact the process negatively. The situation was so forced, that the foundations were poured even before the sub-trades had been introduced to the project. This truncated the amount of time available to introduce the project to the sub-trades and engage them in the work by making them an integral part of the process and thus instilling a genuine sense of ownership and contributing to, and accepting proposed innovative changes. As will be seen, this would constitute a major process failing.

Tasks

The actual implementation process involved the following tasks:

- The project was introduced and discussed with the pertinent site superintendents and senior management.
- The Parkhill model home was chosen as the demonstration unit and the decision made to build both a benchmark and testbed model.
- A meeting with the owner or managers of the major sub-trades and suppliers was held to introduce the project. The meeting attempted a number of tasks:
  - outline the project's goals
  - explain the concept and need for cycle time reduction efforts
  - to reassure the sub-contractors that they were **not** being asked to cut their profit margins but to be more economical and thus reduce their prices and
  - to **invite them and their employees to contribute to the process** by suggesting innovations for exploration and adoption.

Figure 4:
Parkhill Model Home - Main Floor Plan



- The innovation consultant /researcher followed up on the initial presentation with individual meetings or phone calls to each major sub-contractor to again solicit input and to discuss any innovations which the general contractor wished to try on the home.

- The benchmark house was inspected and evaluated at the end of framing to identify framing and servicing strategies for the testbed unit.

- On site meetings were conducted during the course of construction as required.

- The local municipal building inspectors were introduced to the FastFoot foundation system *before* it was introduced on to the site both in order to familiarize them with the system and to smooth the way for its subsequent use. [As more, and more extreme innovations are introduced this role of educating local authorities might be expected to increase in importance.]

- The work concluded with interviews of the primary site superintendent and the contractor's team leader whose comments were combined with the author's observations to establish the findings, conclusions and summary recommendations found in the next chapter.

Benchmarking Time & Cost Savings

This project was initially conceived in somewhat of a traditional mode wherein it was assumed that collecting and reporting information on potential cost or time savings would be germane to understanding or demonstrating the original central objective of studying **information dissemination** or the subsequent central thrust of promoting increased **innovation adoption.**

However, it quickly became evident that this was a flawed assumption from a number of perspectives:

i) benchmarking individual innovations contributes nothing to the understanding of the broader issues of information dissemination or innovation adoption.

ii) benchmarking can be used to *prove* the benefit of using any one particular innovation , but this was not required here as most of the innovations being explored have been extensively tested or reported upon by their manufacturers or inventors while the benefits of others are self-evident.

iii) true benchmarking requires a more extensive, multiple and detailed comparison of options than could be undertaken here in order to provide a reliable comparison of cost or time benefits or charges.

iv) unless conducted across various contractors and skill groups, benchmarking will be site, contractor and time specific and of limited value. That is to say, cost-savings will vary between even very similar contractors based on their own skills, the skills of their sub-trades, local prevailing practices and such external issues as energy costs, material costs, shipping costs and the availability of labour.

Against this background it was concluded that benchmarking (a) could not be conducted at a sufficiently professional level as to be of any value and (b) was totally unnecessary to demonstrate, prove or discuss what became the ultimate project objective of contributing to increased information dissemination or the increased adoption of construction innovations. That said, it is recognized that benchmarking might have played a role in comparing the rate of innovation adoption for a particular innovation within the local housing market. However, such a comparison is clearly beyond the scope of this project.

Despite the above, the general contractor and staff maintained an informed awareness of the performance for each of the sub-trades as they wrestled with any innovative technique or technology and any pertinent findings are noted.

Selected Innovative Technologies

Following a review and discussion of the available innovative technologies, the general contractor elected to explore the following technologies:

Integrated Drafting/Estimating

Though not used for the Parkhill demonstration home the contractor's in-house design department is experimenting with the ArchiCad drafting programme to explore the potential to produce drawings with accompanying automated materials schedules, cut lists and framing diagrams.

Standardized Drawings

Although the need for standardized construction details had been previously discussed within the firm, the project gave new impetus to this management strategy and it is being pursued with renewed vigour.

Site Management / Trade Partnering

Trade Partnering is something of a process title which means working more closely, even co-operatively with one's sub-trades to effect more of a mutually supportive team approach to the construction process and while presented as an umbrella management style under which the project would be implemented, the contractor elected to formalize the concept somewhat and use the project as a vehicle to implement a new mode of inter-trade relationships.

FastFoot & FastPad

This innovative foundation system was utilized on a second testbed home to investigate the potential time and lumber savings associated with this new metal frame and fabric footing or pad system.

Insulated Concrete Forms [ICF]

While still in the investigative stage, the potential use of insulated concrete forms either for the basement or the whole home is being explored with representatives of the ICF and concrete industry.

Item Specific Lumber Ordering

In addition to their own materials estimating, the general contractor has engaged their lumber supplier to develop itemized materials take-offs and estimating as a means to reduce costs.

Optimum Value Engineering Framing Details

Working with the framing contractor and the drywaller, a number of OVE framing details such as 24"c/c stud spacing, were introduced for evaluation. This effort also included reorganizing corner details and top plate blocking to eliminate the backing normally included to support drywall with the intention of replacing same with drywall clips.

Insulation Techniques & Responsibilities

The slope of the vaulted ceilings was reduced to 4.5:12 in order to allow for the use of blown insulation rather than the batt insulation which had previously been required in more steeply sloped roofs. Also, installing rigid insulation above cold garages was moved into the insulator's work thus freeing the general contractor's labour from this task.

Electrical Modifications

Two changes were made to normal wiring practices. First, the meter and the panel were separated with the panel being located towards the centre of the home, and closer to the kitchen, from which they were able to run wires in a less costly star configuration. Secondly, a modified speed wiring approach was adopted which replaced one journeyman electrician working five days with up to three electricians of varying skill levels for just two days.

Drywall Clips

With the removal of most lumber backing from the framing package, drywall clips were introduced to provide the requisite support at some inside corners and at the ceiling-wall junction.

NoCoat Corner Bead

This proprietary product was tested in some areas to provide an evaluation of its installation and finishing potential.

Observations:

While the number of innovative technologies utilized was but a portion of the number available, some 10 out of 30, the process still represented a challenge to the management team and particularly to the site superintendent who had the primary responsibility for encouraging the various sub-contractors to participate in the project and then integrate any innovative materials, with the inevitable accompanying problems, into the standard construction process and existing overall schedule.

However, despite these problems, the home was successfully concluded with a minimum of problems or required site adjustments. In closing it must be noted that some technologies or materials which were offered for consideration were rejected on the basis of the target market.

Items which one might have initially thought of as 'transparent' innovations were deemed to be market sensitive. An example would be the floor sheathing, where the contractor uses Fir T&G ply rather than OSB, because it is thought to be seen as a better product by clients who might tour the homes during construction.

SUMMARY

The selected technologies are summarized in the Table on the following page. However, the reader is reminded that as the project evolved, it became evident that cost comparisons were not particularly critical or even germane to the revised project goal of fostering innovation adoption. Consequently, no post-utilization costs were gathered. However, excepting for the experience with the FastFoot technologies and the NoCoat drywall corner beads, in those instances where various innovations were introduced they were generally found to be less costly or comparable to traditional methods while producing a superior solution. It was concluded that the FastFoot and NoCoat technologies were not as cost-effective as had been anticipated due to the unique nature of the construction environment in these two areas of endeavour as they exist in the project's market area.

Table X : SUMMARY OF SELECTED INNOVATION TRIED IN DEMONSTRATION		
INNOVATION	**DESCRIPTION**	**SAVINGS CLAIMED IN LITERATURE**
Integrated Drafting & Estimating	Many of today's drafting packages allow for automated material take-off and calculation of estimate building costs as the drawing process proceeds This constitutes both a significant time saver, and unique comparison tools for reviewing options and a more accurate approach to material ordering.	**$2,500**
Standardized Drawings	The process of standardizing drawings tends to ensure that repeatable details are well thought out, both over time and as tested in the field and reflect exactly what the builder wants Use of the drawings limits errors as the sub-trades learn exactly what is required of them.	**See the above item**
Trade Partnering	This inclusionary process taps into the sub-trades and workers' pool of field experience and knowledge to benefit all players Further, by engaging trades in developing ideas they take ownership of them and contribute to their success.	**$3,750**
FastFoot / FastPad	A new foundation system which minimizes the use of lumber and in some instances significantly speeds and improves the foundations' construction	**$330**
Insulated Conc Forms	This combination forming and insulation system though primarily found in basements can be used as a forming system on all levels of a home	**Project Specific**
Item Specific Lumber Orders	When combined with 'automated material take offs', this material ordering system results in only the required materials being purchased and delivered to the site	**See the first item**
OVE Framing Techniques	An extensive collection of framing strategies based on the concept of in-line studs and joists, and framing at 24" [600 mm] c/c	**$2,180**
New Insulation Techniques	A modest reduction in roof slopes in areas with cathedral ceilings allowed for the use of blown insulation in all roof areas at a cost saving and utilizing rigid insulation over the garage allowed for a reduced cycle time by the insulator	**$400⁺ [Contractor Est.]**
Electrical Modifications	This component involves two primary strategies: first, the use of more tradesmen over a shorter period to speed-wire a home and reduce the total required man hours The second strategy involves utilizing an electrical sub-panel near the kitchen and bathroom areas to reduce the length of heavy wire runs to these outlet and power demand intensive zones	**$560-$900**
Drywall Clips	When combined with OVE framing strategies, using these drywall supports can significantly reduce the amount of backing lumber required in a home while providing a better finished surface which is also less prone to truss uplift or settlement induced cracking.	**$580**
NoCoat Drywall Bead	This new corner bead claims to reduce the amount of work required to finish drywall corners and thus speed the drywalling process and reduce cycle time	**$1,015**

INTRODUCTION

In general, the research effort was considered a success; however, as a result of the limited time available to engage the sub-contractors in a more personal and informative manner, it was not as successful as had been hoped. Despite this shortcoming, there were a number of findings which are considered to bear on the basic thesis regarding information dissemination and innovation adoption.

OBSERVATIONS:

General Observations

While detailed observations are noted below, the following general observations were found to hold in all instances:

- The various technologies or innovations explored were consistent with general construction practices and easily integrated with other conventional products, processes and systems.

- No exceptional training beyond that normally associated with acquiring a new skill was required to either utilize these selected innovations nor to integrate them into the existing, conventional construction environment.

- While the work was executed on a single, pre-selected home, that home was drawn from the contractor's existing range of available models and the work was executed at a conventional site under normal construction conditionds. Consequently, it is appropriate to state that the innovations were tested and utilized in a *real* construction environment.

- What little manipulation of the payment schedule that was required was well within the contractor's philosophical and managerial capabilities thus it is felt that few, if any, accounting or fee adjustment problems will be encountered by others attempting similar endeavours.

In summary no managerial or site issues were encountered. It is assumed that the ease with which innovative processes and products were introduced is a reflection of the modern business world whereby most, and probably all, new concepts are properly vetted before reaching the market place.

Sub-Contractors

At first there was a measure of indifference, even hostility, towards the project by some of the sub-contractors and trades people. While this was not unexpected, it did somewhat minimize the level of input or contribution coming from the front-line staff. As noted by the site superintendent when one says that they have an innovative way to do something they are in essence saying they have a better way of doing something which in turn suggests that the person to whom they are talking is doing it the wrong way , or at least not the best way possible. Regardless of how delicately the suggestion is made, it still tends to rankle.

However, despite an initial slow start, once the trades were given an opportunity to discuss the issue more fully with the site superintendent who reiterated the project's goals there was a noticeable change from semi-open hostility to acceptance and even participation to the extent that one sub-contractor who had engaged the general contractor to construct his new home ended up insisting upon the inclusion of some innovations even though they had not been fully vetted and accepted at that point as standard contractor practices.

Further, the site superintendent noted that by the end of the exercise the sub-trades were participating more cooperatively not only in the core research project and testbed home, but in the broader general dealings with the general contractor. The sub-trades were seen as definitely more open to future explorations of innovations, ***although it was not possible to determine if they would utilize them further in the general market place*** or merely on the general contractor's units. This lack of determination constitutes a critical shortcoming in this project and is discussed further in the conclusions of Chapter 8.

General Contractor

Although the general contractor exhibited some predisposition to the general innovation concept, it was felt that their commitment was stronger following the research exercise than before. There has been an acceptance of the concept that innovation in general can really result in cycle time reductions and reduced costs was no longer merely a theoretical position but a fact. This resulted in renewed interest within the general contractor's organization for completing some of their own cost-saving strategies which had first been tackled over a year before.

Benchmarking

As notred in the previous Chapter, it was decided that no formal benchmarking would be conducted ; however, the general contractor noted that a number of the proposed initiatives would save time and definitely save money.

In terms of cost savings, the contractor's project manager noted that while the innovative strategies saved time and in some instances money, the current billing practices of unit pricing such as $X per square metre of home framed, did not allow the general contractor to capture the benefits of those savings as they were still paying subcontractors in the traditional trade modes of '$X' per square metre for framing or '$Y' dollars per electrical outlet.

In other cases costs were not recorded as the work was performed at prevailing rates by the sub-contractors who absorbed any time penalties or material costs as their contribution to the investigative effort or retained any benefits which might have arisen.

Consequently, it became evident that if a contractor wishes to introduce innovative products or practices, *and receive the benefits from such,* they will have to work diligently and openly with their subcontractors in a 'Win/Win' environment to develop an equitable profit sharing strategy.

Evaluation of Selected Innovations

Integrated Drafting/Estimating

As of the writing of this report, this investigation is still proceeding with the stated goal of identifying and adopting an integrated estimating system which will enable the general contractor to order lumber more precisely and avoid having to relocate half-used 'lifts' of lumber to the next job site. Further, it is expected that the more precise ordering will cut down on usage as the framers will become cognizant that they have enough lumber to complete the job and any shortages may have to be borne by them.

Standardized Drawings

Some standardized drawings have been produced and the construction details to which they refer have been codified as the framing requirement. Ongoing drawing standardization is proceeding.

Site Management / Trade Partnering

Trade Partnering was considered to have been initiated quite successfully and resulted in a marked improvement in inter-trade communications which have already produced positive results such as a change in practices wherein when discussed, one of the service contractors stated to the effect " Oh yes, that will save you a couple of hundred dollars per home." Obviously, that change was implemented. The overall improvement in pro-active response from the sub-trades is considered by the project superintendent as a clear indication that the concept of trade partnering will continue.

FastFoot & FastPad

This technology did not prove to be either time or cost effective on **this** job site. However, in defence of the system, the supplier noted that local footing production practices were among the most efficient he had viewed and when this was explored in detail one understood how the practices in other referenced jurisdictions were less advanced. Regardless, the FastPad bag as a pad form should still be cost effective and possibly merit further

consideration as might the FastFoot system itself if lumber prices escalate.

As an adjunct to this finding, the general contractor was able to adapt some of the FastFoot techniques to improve the local system; particularly the use of poly as a means to contain concrete in low spots which would normally require the cutting and fitting of a filler piece below the standard 2x6 form. In this regard the exercise was valuable for identifying improvements to the existing system even if it did not result in adoption of the innovative FastFoot system itself.

It must be noted that due to an accelerated construction schedule necessitated by the pending freeze-up, the demonstration home was built on a stockpiled foundation, and the FastFoot technologies noted above were constructed and evaluated separately for another unit the following spring. However, as none of the tested technologies were interdependent with the foundation, the isolated exploration of the FastFoot techniques is considered valid and properly reflective of either a standard or innovative construction process.

Insulated Concrete Forms [ICF]

As of this writing the contractor is investigating the potential of utilizing this technology in the future.

Item Specific Lumber Ordering

Work is continuing to develop a more advanced ordering system and is being pursued in concert with the drafting/estimating software initiative.

This work, like the ICF investigation is considered as a somewhat successful technology introduction in that it has at least opened the firm to consideration of innovations which it heretofore would not have addressed.

Optimum Value Engineering Framing Details

OVE techniques have progressed from the exploratory stage and have been codified as part of the company's standard detailing and there are indications that further refinement of framing practices will be pursued as the system matures.

Insulation Techniques & Responsibilities

The innovation changes in the Parkhill insulation package have been adopted as standard construction procedure wherever the design permits. It bears noting that the suggestion to lower the ceiling slope to accommodate blown insulation was proposed by the sub-trade, the one instance of this and it is expected that it will be repeated by other builders now that a market leader or 'gate keeper' in their peer group has accepted the change.

Electrical Modifications

Not only have all of the proposed changes now been accepted as standard practice, but a previously reticent sub-contractor is now contributing to the ongoing design re-evaluation process and continual innovation upgrade.

While the change in manning requirements may not result in any direct cost savings, the reduction of the electrical schedule from five to two days could constitute a savings of some $700 to $800 based on the cycle time reduction per day savings discussed previously. Further, by concentrating and reducing the electrical schedule, it is anticipated that there will be fewer scheduling conflicts or need for call-backs to conclude work items.

Drywall Clips

Though unexpected, it appears that drywall clips will enjoy an increasing role in the contractor's finishing details. The project superintendent noted that not only did these clips save money but they made life easier for everybody in that they removed the need for blocking in a number of corner locations which also constituted heavy servicing areas. As a result the anticipated up charge of only $100 per home is not only more than offset by reductions in lumber, but the improvement in the job work flow by other trades justifies this change in its own right.

In addition to introducing drywall clips, the process provided an opportunity for the general contractor to evaluate its overall drywalling process and standards and as a result has begun to consider

such other innovations as a combination of glued and screwed board application to improve the quality of the finished wall.

NoCoat Corner Bead

Following a demonstration of this product in select representative test areas of the home this product was not accepted for further investigation as the existing materials being used almost met the finished product in initial quality and the thickness of the NoCoat beads made finishing of the corner joints more difficult and time consuming.

SUMMARY

Based on the findings from the few innovations which were tested, one suspects that had there been a more aggressive and adventurous evaluation process that many more innovations would have proven themselves and been adopted.

Regardless, the work appears to have created a pro-innovation environment and the participants have indicated a strong willingness to pursue a type of continual system re-evaluation and upgrading with innovative technologies.

CHAPTER 7: CONCEPT TRANSFERABILITY

INTRODUCTION

As part of the investigations, the study looked at the potential transferability of the research findings to other contractors, trades, markets, or even non-residential segments of the construction industry. While not studied in detail, an initial overview suggests that the proposed concept should be fairly transferable; however, certain limitations arise due to evolution of the concept as a means to impinge smaller residential construction organizations.

TRANSFERABILITY LIMITATIONS

For convenience throughout the remainder of the report, the concept being explored in this project wherein a general contractor and their sub-trades are loaded with information, support and examples of innovative strategies and materials with the hope of their subsequent use and dissemination of those innovations by the general and sub-contractors in other construction environments will be referred to as the ***Dissemination & Innovation Triggering [DIT]*** system.

Further, it must be understood that when discussing the potential for transferring the DIT system to other firms, industry segments or jurisdictions, it **must** be understood that the individual players and particularly general contractors are key to any success. Consequently, the following observations and comments are dependent upon the basic assumption that the various individuals involved are at least minimally committed to the concept of innovation and while they may retain a normal skepticism towards those innovations that with the education, proof and encouragement which is a central component of this work, that they will become active and supportive players.

Application to Other Contractors:

The DIT system may be utilized to educate and introduce innovations to any number of *receptive* general contractors within a given market area. The key word here being 'receptive'. There was nothing observed in this work to suggest that the general contracting firm involved in this study was unique in any particular administrative, organizational or market-driven fashion save for its willingness to be something of a pioneer in exploring this approach. Further, this observation is reinforced by findings in the literature review which noted that contractors were:

"not willing to innovate to
***gain** a marketing advantage"*
but
*"would innovate to **remain** competitive"'*

Maybe what is being said is that in general, innovation requires an extra effort and the DIT approach provides the impetus or support necessary to trigger what is otherwise viewed as an unnecessary evil.

The DIT concept was developed to enable public agencies acting in society's interest or private entities acting for profit to enhance the ad-hoc spread of individual innovative technologies by working through one key general contractor and relying on the power of competitive market forces. However, there is nothing to suggest that directly competing general contractors may not themselves elect to adopt this strategy to improve their own market position and profits by introducing the full range and potential of the innovative technologies to their operations and sub-trades.

This very scenario is discussed fully in Chapter 8 in the section titled "*Possible Opportunity*" wherein it is suggested that the DIT system of information dissemination might be developed as a viable business opportunity.

Non-Application to isolated Sub-Contractors:

Because so much of the concept hinges on the interrelationship between the general contractors and their various subs, plus the need to organize any cost trade-offs and accommodations in work schedule, it is nearly impossible to envision a scenario in which a sub-trade can implement this type of comprehensive innovation adoption without

the participation and even leadership of the general contractor.

Even the hoped for technology transfer and individual trade adoptions of new innovations, which are the underpinning goal of this work, will require that the sub-trades both sell any innovation to, and coordinate their activities through, their respective general contractors.

Application to Alternate Markets:

The proposed innovation transferal system is ideally suited to application in numerous markets. Because of the high geographic fragmentation of the industry and the relatively clear demarcation of market boundaries, it will be possible to secure non-competitive contractors from adjacent market areas to act as spokesmen for the DIT system. Because these individual contractors are non-competitors they will be able to freely exchange information on a peer-to-peer basis.

The reader may recall the earlier comments that such peer-to-peer endorsement were considered to be one of the critical elements for the successful introduction of a new technology as the contractors tended to be somewhat hesitant to rely on the opinions of academics and consultants who did not share either their responsibilities or hands-on perspective.

In some regards this proposal is similar to an American initiative being undertaken through the PATH initiative wherein PATH, 'Builder' magazine and Fannie Mae are cooperating in a pilot effort called "Hands-On Builder" which sees experienced builders teach other builders how to install PATH evaluated technologies.

The idea of cross-market introduction has an added advantage in that it will facilitate the creation of larger aggregations of non-competitive contractors who can share ideas and experiences in a non-threatening environment. The idea of aggregating groups of like-minded firms to facilitate the development and introduction of certain innovations was proposed in a number of reports and while in those instances it was primarily aimed at the joint funding of innovation by smaller entities, the cross support and idea generation implicit in the concept is equally valid in this scenario. This concept is discussed more fully in Chapter 8 in the section, "*Possible Opportunity*".

Application to Non-Residential Construction:

It is felt that the innovation transfer concept can be applied to small scale, non-residential construction due to its similarities to the residential construction field where they share similar attributes of size, organization, operating norms and a reliance upon sub-contracting. One can readily envision a scenario wherein a consultant works with a small general contractor to identify and introduce many of the same materials and techniques found in the residential construction field.

While not explicitly stated within this report, it is generally understood within the Canadian residential construction industry that many housing initiatives rely in some fashion upon the work or support of CMHC either as an active supporter or as a passive supplier of information through its own publications and reports or through the collected information contained within CHIC, the Canadian Housing Information Centre.

However, when one moves to the non-residential construction sphere other organizations such as the National Research Council [NRC] acting through IRC, its Institute for Research in Construction, could conceivably play a more active role in supplying information, guidance or even support where appropriate. This is discussed more fully in the Chapter 8 section, "*Possible Opportunity*".

Further, as the scale of the projects increases , the general contractor plays less of a pro-active developmental role relying instead on direction from engineering or architectural consultants through the tendering process to determine what materials and processes will be utilized in the construction of the building. While these two groups are not necessarily impediments to the innovative process, their participation merely adds another decision making layer and makes it more

difficult for the general contractor to make independent and pro-active material and process adjustments necessary to achieve an integrated and innovative solution.

This matter of scale is less problematic on larger multi-family construction projects as the materials and processes are often merely scaled up versions of the single family construction process. Studs, components such as windows and finishing techniques all essentially follow the normal home building standards and as such may be similarly manipulated although allowances must be made for consultant approvals and any increased standards such as fire and noise separations.

*Non-Application to **Programmes [R2000 Etc.]***

The DIT system is felt to have **no application** to any of the public oriented programmes such as R2000, EnerSave and the like. This assertion stems from the observation that these programmes primarily promote various, though generally energy-conservation, lifestyle oriented strategies or products to individual consumers. Furthermore, they generally involve approaches which require increased front costs which the consumer is expected to recover over time through some form of lower operating costs.

For the same reason that lifestyle strategies were omitted from the study, required increased front costs versus automatic savings, and because there appears to be no opportunity for consumers to "infect" subsequent consumers and thus to "force" the programmes' adoption on them, it was concluded that the DIT system under discussion has no role in these types of public initiatives.

SUMMARY:

Based on the literature and project observations, the DIT system appears to be highly transferable to other general contractors; although, it would be less transferable or implementable by sub-trades. The reason for the latter being that they will tend to lack the broad perspective, resources or authority to identify and initiate the scale of work contemplated. Further, being sub-trades they will still require the general contractor's approval for any of the material, or process substitutions being considered; consequently, they might as well leave this task to those general contractors.

The DIT concept can be readily transferred to any other markets which exhibit the same basic profit-driven construction environment seen in North America. In fact, cross market introductions may be easier than same market introductions between competing contractors because in the former, one can utilize the experience and support of other non-competitive contractors to demonstrate or even endorse the idea. One will recall that real examples and *word-of-mouth* testimonials are two of the key means by which contractors are convinced of the validity of any innovations.

While the DIT approach is ideally suited to the small-scale, wood-framed residential construction environment, it could probably also enjoy a reasonable measure of success in any smallish type of construction environment wherein the general contractor has a relatively high degree of project control and can make the product substitutions and process accommodations required to make the DIT concept work. On larger projects, engineers and architects will tend to exercise greater authority and hence could stifle the trades' interplay which underlies this work.

However, it should be remembered that even on large projects, the general contractor will still retain the authority to manage and adapt most if not all of the requisite construction and operating managerial process to suit their own needs and it must therefore be recalled from the report that the literature is unequivocal in its findings that managerial or process advances are the ones which will offer the greatest cost savings and increases in profits. Therefore, while the general contractor on a large commercial project might not be able to change the type of paint or drywall bead being used, they will control: the scheduling which can reduce the 'cycle time' and thus increase profits; the work quality which will reduce call backs and warranty issues thus again saving money and

increasing profits; and, they control trade interactions which will reduce conflicts and down or lost time and thus again reduce cost and increase profits.

While the DIT approach may not work on large projects in the form presented here, the idea of an interactive, informed and innovative work site is not denied to any general contractor who wishes to use innovation as a tool to achieve greater profits, and greater success.

Finally, the above recognition of managerial advances can also apply to improving public oriented programmes such as R2000 or EnerSmart where a tightly defined DIT system would fail. Because these programmes are not profit-driven in the first instance; in fact they often require an initial cost increase, they are not transparent to the consumer and thus require additional sales efforts they are generally not widely desired by the market. Consequently, their introduction or offering may not give the typical general contractor a marketing edge which would make their natural spread to other sites somewhat self-driven as is the case with the types of cost-saving innovations and innovative strategies being discussed in this project.

CHAPTER 8: CONCLUSIONS

INTRODUCTION

The project was unable to *prove* the viability of the original basic thesis that of improved information dissemination through 'infection'.

Further, the project was also unable to *prove* the revised thesis of increased 'innovation triggering'.

Despite the foregoing, the project is considered a 'qualified' success as the general tone of the work and gathered data or information, the limited observed results and discussions with various participants suggest that there is an underlying validity to this thesis. Furthermore, no information was found nor actions observed to contradict either thesis or to suggest that they had been previously been investigated and found wanting.

The various findings which are felt to support this qualified assessment are discussed below.

Research Literature

The body of reports studied for this project either identify innovation impediments which the DIT process addresses or, suggests interim steps as part of their more conventional proposed programmes but which are sub components of the proposed approach of adoption through 'infection'.

However, despite the breadth of material on the concept and theory of innovation creating and information dissemination there appears to be little if any current work on the actual finite process of innovation adoption. This work and the proposal outlined in the following chapter "Future Opportunity" seek to address this shortcoming.

Lateral Findings

Behaviour by a number of participants suggests that the proposed DIT dissemination process could succeed:

- the general contractor has begun to set new construction standards based on proposed innovative practices thus creating a continuing pro-innovation environment.

- new attitudes were observed in both the general and sub-contractors' organizations

- the sub-contractors were participating in the process:
  - they were making some contributions of innovative ideas for new materials or practices
  - most demonstrated a realization of, and appreciation for, the innovation process and the innovations themselves
  - most sub-contractors recognized that innovations for the primary benefit of one contractor could produce benefits for other contractors thus demonstrating the merits of a team approach to the process and the value of co-opting either other sub-trades or general contractors in subsequent innovation efforts.

In summary, it is felt that while not conclusive, the work has resulted in a generally positive findings. That said, there do appear to be areas in which even the current work could have been improved and which should be considered by any persons wishing to pursue this work further. These improvements, or observations, are discussed below.

OBSERVATIONS:

Lead Time Allocation

More time must be allocated for introducing the sub-trades to the project and building both their trust and knowledge base so that they may participate unconcerned about the potential risks they may be facing. Further, greater care and time must be shown in introducing any proposed innovations in order to avoid any challenge to their self-perception of the way in which they do their work and how it is viewed and appreciated.

The type of slower and more thoughtful approach to the participants being proposed would give them time to master and mould any innovation to meet their specific needs. This moulding is called re-invention in some works and refers to a process whereby the tradesman manipulates the innovation to make it their own. This conclusion reflects the recommendations in an 1991 NAHB report [20] which when discussing the role of workers made the following two observations;

> ...it is difficult and costly to educate contract designers or craftsmen in the implementation of an innovation that they did not participate in developing" [Pg.23]
>
> " When individuals engage in implementation they are most likely to undertake re-invention if they...have a need for pride of ownership.... [Pg.27]

It is felt that while the end results were generally positive, greater success would have been achieved if the sub-contractors had been given more opportunity to claim 'ownership' of the technologies by re-inventing the innovations.

An example of this involvement could include engaging the sub-contractors at the earliest stages to help select the model home to be used as the testbed unit and as evaluators of the preliminary list of technologies.

It may also have been possible to increase take up by providing tangible incentives and promotional items like the Centre-Point tapes or the Ultra-Square which were previously mentioned in the technology selection or by providing additional information by way of binders and more comprehensive trade literature and supporting articles.

Some innovation specific promotional items like the noted tapes and square are very inexpensive, under $25, and might have the effect of conclusively and cost-effectively demonstrating how even modest innovations can improve productivity. This is somewhat akin to priming the pump. Providing additional or improved information either by way of supporting reports or more extensive trade literature should help to make a more convincing argument, and overcome any shortcomings in any consultant or general contractor's presentation. Further, as noted previously in this report, contractors tend to prefer information which has been validated by other contractors and it is assumed that such reports would significantly enhance the chances that any particular innovation, or even the entire innovation triggering approach might be validated by such additional documentation and hand-outs.

Finally, it is felt that a more extensive introductory process involving the promotional items, increased information and the resulting more extensive or better dialogue might foster a measure of 'ownership' by the involved sub-trades. The reader may recall that this ownership was noted from the literature as one of the more important if not critical elements in any successful technology transfer processes. When the sub-trades and workers accept or adopt 'ownership' of any initiative they are then implementing *their* ideas.

Model Home -or- Contractor Selection

Whereas one of the key underlying criteria of the process was to use cost-saving strategies as a driving force, the project may have been more effective if it had not involved the participation of one of the market's high end builders. Whereas the home buyers in this category are deemed to be both discriminating and demanding, some potential technologies, such as OSB floor sheathing were not even considered by the researcher or contractor on the basis of the target market's *perception* that plywood was unquestionably a superior product. A perception which might have been less critical in a more cost-conscious pricing range such as is generally represented by 'production' builders.

The goal of any future dissemination and innovation introduction programme will have to be clearly articulated. If the object of the sponsoring body or individual promoting such a DIT system is to introduce *as many innovations as possible* then a more receptive end consumer, such as is generally

found in the production housing market would be appropriate. If the goal is to *help any general contractor* then the ultimate target audience becomes less of a critical issue, but the choice of innovations being promoted needs to be more carefully considered.

In terms of increased innovation dissemination, consideration might be given to utilizing the multi-family market as an introductory vehicle. One possible candidate might be the retirement communities wherein the developer or builder tends to create a series of similar units under some form of price constraints thus providing a fertile environment for consideration of most cost-effective innovations. One caveat to this suggestion is that when the DIT system is being offered by an entity other than the project's own architect or designer, that they select projects with a minimum of architectural input or control so as to avoid having to 'convince' another layer of authority of the appropriateness of the innovation.

Competitive Local Practices

As shown by the FastFoot experience, any evaluation of innovations must consider local practices when determining their appropriateness for a specific market. What may be cost-effective in Calgary may not be so highly regarded in Halifax of Vancouver. This gives impetus to the suggestion in the next section on utilizing a series of regionally focussed consultants as participants in any future national programme.

New Pricing Strategy

Whereas much of the pricing in a market is based on general construction standards and unit rates, those firms who introduce innovations and thus make the work easier, more efficient or less costly for their subs will have to develop a new means of negotiating and setting prices or they will not be able to capture any of the savings and benefits their sub-trades are subsequently enjoying from the innovations which the contractor pioneered.

An inherent subsection of this requirement will be a continuing need for the innovative general contractor to remain aware of the types and levels of services and construction being offered by their sub-contractors on other projects. If the general contractor is providing supporting services or equipment not offered by their competitors, to the sub-contractors, then this supporting service must be reflected in lower trade prices.

Soft Technologies

Although managerial innovations, or soft technologies as they are sometimes called, were not a major part of the innovations explored by the general contractor, it quickly became evident from interviews that the new awareness of, and interest in innovation which had been created both within the general contractor's organization and those of the sub-contractors, plus the heightened interaction and trust will over time play a significant role in improving the cost, and quality of the homes.

Consequently, one can only conclude that this form of innovation should be explored and to the maximum extent exploited by all parties. Such a focus has one particular advantage in that many of the managerial or soft innovations available can be implemented at very little cost but more importantly without requiring the concurrence of the sub-trades, workers or inspectors, such as was the case with the Cycle Time Reduction efforts which were discussed earlier. Managerial innovation is an internalized and incremental strategy which is pursued as time and resources permit and inclination demands.

Finally, the research literature is almost universal in its observations that managerial innovations will not only reap the highest rewards, but that most of those rewards will accrue to the general contracting firm which is in essence a process oriented organization focussed on managing a wide range of sub-contractors.

It is against this background that the project is deemed a qualified success and on that basis led to the preparation of the following proposal for development of a national demonstration programme to further develop the overall theory underlying this work.

Agency Roles:

The various North American agencies and institutions involved in construction and primarily residential construction can involve themselves in the DIT system in either a passive or active mode.

In the simplest of these, the passive mode, agencies such as CMHC, NRC/IRC, HUD, CHBA and NAHB or the plethora of educational, provincial or industry groups can contribute in a couple of ways. First, acting as information sources through their library and technical literature holdings. Secondly, as facilitators in a broader networking initiative whereby they might introduce innovators and contractors or like minded consultants as a means to build and foster an innovation driven and consensus building forum.

In an active mode, these agencies and groups are only limited by what they see as their mandates and what they can contribute by way of resources.

While it was not the mandate of this work to suggest new governmental or quasi-governmental programmes, the reader will note below discussion of what is termed a "Future Opportunity" whereby the author has outlined, and briefly discusses, the format, operation, and funding options for a potential business endeavour geared to capitalizing on the introduction of innovation to residential contractors. Naturally, any for-profit endeavour can generally be restructured as a public-supported initiative when public bodies see the work as pertinent to their mandates. In this light, one can envision one of the quasi-governmental agencies, builder's associations or groups noted above as taking on the challenge of bringing greater adoption of innovative products and processes to the residential field as it pertains to their primary mandates.

SUMMARY

Overall Rating:

Although the project failed to conclusively prove the viability of the concept of "dissemination through infection", or actually demonstrate wide-scale triggering of innovation adoptions, it is still considered a **qualified success** for what it did show.

Observations:

This 'qualified' rating is based on an analysis of the literature findings and site observations. The literature rather convincingly indicated two main themes. First, there are, by far, more than enough as yet unexploited construction innovations to meet the needs of all sizes and types of residential construction companies. Secondly, the noted impediments to innovation are **not** insurmountable, but rather reflect more about human nature than technology and can, as was done in this project, be addressed.

The onsite observations showed the following: (i) a pro-innovation atmosphere can be created in a heretofore uninvolved general contractor's operation with them acknowledging the managerial and construction advances and advantages available from innovation; (ii) when invited and properly integrated into the process, sub-trades will not only adopt proffered innovations, but will contribute to the process by suggesting their own range of innovations

Possible Improvements:

The degree of success might have been improved with the following changes: More lead time between presenting the concept to the sub-trades and commencing construction; selecting more production oriented homes which rely less on consumer attitudes towards materials and details; being more accommodating and understanding of local construction practices and what is meant by successes when evaluating and picking innovations. Finally exhibiting a greater focus on the "soft technologies" such as 'cycle-time reduction' and managerial changes which have historically shown the best rate of return.

CHAPTER 9: FUTURE OPPORTUNITY

BACKGROUND:

As discussed previously in this report, there exists what might almost be described as a vacuum in the area of promoting more aggressive adoption of construction innovations in our housing endeavours. Consequently, it is felt that an opportunity, or even need, existed for the development of a formalized means to promote innovation adoption within Canada's small-scale residential construction industry.

The need for more formal or aggressive innovation promotion is perhaps best explained by one of the more relevant quotes to come out of the research is taken from a report on the commercialization of university research [33] wherein the authors note:

> "The economic importance of knowledge manifests itself only when the knowledge is used to improve what we do and how we do it ".

They went on to note that the OECD countries now stress the importance of "knowledge flow and technology diffusion" and therefore are going "far beyond their previous focus" of primarily, and almost exclusively just increasing the stock of available knowledge. This attitude was echoed in some fashion in almost every document reviewed. As John Landis notes in his book "Why Home Builders Don't Innovate" the problem is not the need to pursue more innovations, but rather the lack of diffusion of existing innovations.

What might prosper or even what is required is a bridge between these two parties, the innovator and the builder, but one which is pro-active and even "forceful" in disseminating, promoting and triggering innovation adoption. The following work discuss such an approach or potential programme which could lead to the type of technological and process improvements from which the residential construction industry could benefit significantly.

Given the history of Canada's efforts in the residential construction area, it would not be illogical in the first instance for a reader to assume that any programme of the type being suggested might automatically be a government or quasi-governmental endeavour. However, the potential exists for such an initiative to be a for-profit business venture; consequently, the following proposals is cast in such a manner so as to allow for either a non-profit or a conventional business approach.

PROPOSAL:

It is understood that the issue of innovation is a multi-pronged one involving various aspects of creation, development, dissemination and adoption. However, the following work focusses on one particular segment of that broader topic of adoption albeit, the one which this project considers the most important.

Therefore, it is suggested than an opportunity exists for some form of pro-active entity; henceforth referred to as the "Agency" to develop a programme promoting the innovation triggering concept studied in this project, and that this new programme could be delivered across Canada through a group of industry oriented consultants or "Innovation Champions".

The concept of "Innovations Champions" is fully discussed below; however, in brief this term refers to the individuals who will be working directly with general contractors and their sub-trades to introduce innovative materials and practices. The term is introduced here to allow for a more understandable discussion of the Lead Agency's responsibilities.

The relationship of the Champions to the Agency could take on many forms: employees, sub-consultants or independent consultants working very closely with the Agency. In order to facilitate the broadest discussion, this proposal assumes that the Champions are independent consultants who are compensated through the sale of their services to the construction industry.

Details regarding the roles and activities of the various participants follow. It commences with a discussion of the participants' duties and then looks at such issues as: innovation evaluation techniques, funding options and a proposed implementation strategy.

PROPOSAL DETAILS :

Lead Agency

This proposal suggests that regardless of its ultimate organization, any formal innovation promotion or adoption system, approach or business, will require a Lead Agency which will act as a unifying force and provide the national scope of research and dissemination which isolated proponents, or even the Innovation Champions, will lack the resources or knowledge to offer.

Whether that Lead Agency takes the form of a public initiative sponsored through a quasi-governmental body such as CMHC or NRC/IRC, or is based on a more private enterprise or business model is somewhat irrelevant to the following proposal which in the main only outlines the functional requirements of that position.
The one exception to this approach arises when one considers the fundamental differences between advancing the public good which is the role of such bodies as CMHC or NRC/IRC versus the more pragmatic or limited profit oriented goals of any business based model. Where these differences arise, they will be noted.

Regardless of the eventual model, for discussion in this proposal, the overall managerial body will be referred to as the Lead Agency.

Lead Agency Duties:

The Lead Agency will have three primary duties if a for-profit business and five if publicly oriented.

Business Tasks:
- i Administration.
- ii Collect information on innovations.
- iii Train "Innovation Champions".

Additional Public Agency Tasks:
- iv Conduct research on innovation adoption.
- v Public information dissemination

The anticipated annual effort required to manage the national wide work being proposed can probably be undertaken by one key individual. As the last two duties listed above would probably be contracted out either to other departments or businesses, their inclusion has a relatively limited impact on the work load or time distribution:

- 10% core administrative duties
- 25% outlook function and literature review
- 45% programme and materials development
- 10% management, training & organization
- 10% research initiation & management

Task 1: Administration

This task represents the normal duties associated with any office task ranging from ordering pencils to corresponding with those actually delivering information and services.

Task 2: Outlook Function & Literature Review

It will be necessary for the Lead Agency to stay abreast of advances in the field of residential and small scale commercial construction. Consequently, it should implement a continuing programme of information gathering. Fortunately, the library and information resources available through CMHC and NRC/IRC to name just two sources will simplify this task. This work contains four distinct sub-activities;

- Identify, locate, and gather information on available innovations or evolving. technologies.
- Amplifying the information as required by contacting inventors manufacturers or distributors.
- Evaluating the information at a 'first cut' level as to its appropriateness, but not necessarily eliminating it from dissemination .
  [See below - "Technology Evaluation".]

- Distributing the gathered information to the Innovation Champions

Task 3: Training

This task involves training the Innovation Champions as necessary. Although the Champions will be chosen based in part on their existing roster of pertinent skills, an initial training programme might include;

- innovation or information evaluation in order that they might initiate their own information gathering, feedback and networking [See below - "Technology Evaluation".]

- how to identify and evaluate potential adopters and gatekeepers for subsequent contact as possible clients, speakers or teachers and mentors and

- interpersonal or selling skills on how to sensitively introduce innovations. Saying "I have a new way for you to do your job.' is tantamount to saying

  'You're doing your job wrong.'

  Promoting innovation must be done skilfully.

Task 4: Research:

While it is expected that most if not essentially all of the innovations being disseminated will be existing products from outside sources, there still exists the need for some additional research in this field of study. Unfortunately, the scale of the required work and its extension into related peripheral areas of study precluded anything more than its identification under this existing project.

Given the current nature of Canada's construction research environment or history, it might not be unrealistic to assume that any research in this area will either be undertaken or significantly supported by one of our quasi-governmental agencies, such as CMHC or NRC. Further, given that the research outlined below is in the broadest public interest tends to reinforce that assumption.

Any group, business or agency pursuing research within the context of this proposal might wish to focus on specific issues related to innovation adoption. Initial study topics might include:

- What is the typical psychological profile of an early adopter or gatekeeper in the innovation process and how can they be identified ?
- What is the nature of the actual decision making and adoption process undertaken when individuals or companies make the final decision to adopt a new product or process ?
- What is the nature of the inter-personal and managerial relationship between the general contractor and the sub-contractor as it applies to introducing and adopting innovations and how can this process be manipulated ?
- Is any work or study required to improve the Innovation Champions' marketing efforts.

" Caution "

It is the feeling of this author, that considerable care should be taken to ensure that none of the research under the proposed programme be geared toward the exploration of either products or the actual building assembly process.

Despite the forgoing, it is recognized that the pursuit of innovation in construction products and processes will remain critical to the continued improvement of the residential building environment.

However, these topics already enjoy considerable support from government and industry groups under other programmes. Furthermore, due to their existing familiarity and 'hands-on' appeal these 'hard' topics may come to dominate what should otherwise be a organizational or dissemination focussed activity. It would be unfortunate if the necessary emphasis on the subtle and complex issues of process development were lost to the potential glare of a more easily understood new insulation or waterproofing system.

Task 5: Public Information Dissemination

There exists two potential attitudes towards the public dissemination of information on innovations. A business based Lead Agency will logically wish to limit a broad, general or even free distribution of information on dissemination to the public preferring instead to 'sell' that information to paying customers or contractors. Consequently, in a business environment, public information dissemination will probably not be an issue.

However, when the Lead Agency is a quasi-public or governmental agency, there typically exists very specific mandates to serve a broader public need and to often do so in a free or significantly subsidized manner. Obviously this free distribution will be somewhat at odds with the idea of selling this information to contractors; consequently this dichotomy must be explored.

To respect the divergent needs of both the profit driven Innovation Champions and the general public, it is proposed that any sale or dissemination of information involving new or evolving technologies and processes, which is gathered directly as part of any innovation initiative, be delayed by up to two years in order to give the Innovation Champions and their early adopter clients an opportunity to capture the benefits for which those adopters have paid. Otherwise, it is difficult to imagine a general contractor purchasing the services and investing in the process of innovation if their competitors can get much of the information and advice either free from a Lead Agency booth at a home show or for a modest fee in one of booklets and brochures which will inevitably be published.

However, following an appropriate time lapse, the Lead Agency could utilize its normal information dissemination techniques to bring these innovations to the industry and the general public. The type of dissemination techniques to be used will normally run the gamut from simple newsletters and brochures to home show demonstrations, lectures and interactive Internet presentations. For an example on how such information might be presented on the Internet, the reader may wish to view the PATH web site. To view their current list of innovative technologies go to **www.pathnet.org** and click on the **Inventory** heading.

INNOVATION CHAMPIONS

The "Innovation Champions" are considered to be the main delivery agents in this proposal and as such actually implement the innovation triggering activities within the general contractors' and sub-contractors' organizations. Their role will be that of teacher, mentor and provocateur as they strive to foster, or even force, normally resistant trades to participate in this evolutionary process.

It is estimated that the market will support between 8 and 10 Champions across Canada with 1or2 in the Atlantic provinces, 2 each in Quebec and Ontario, one serving both Manitoba and Saskatchewan, one in Alberta and 1 or 2 in British Columbia. The Northwest Territories, Nunavut and the Yukon can probably be served by the Innovation Champions in the four western provinces and Quebec.

Besides straight consulting, the Innovation Champions will have a range of specific duties related to the overall programme. These include:

i identifying potentially innovative technologies
ii evaluating new technologies
iii identifying potential adopters and gatekeepers
iv selling their services to adopting contractors
v advising building inspectors about innovations
vi evaluating the process
vii providing feedback to the Lead Agency
viii networking with other Innovation Champions
ix networking with the construction industry
x identifying market trends and highlighting any needed innovations for subsequent research and development

These itemized tasks are discussed in detail below.

i) Technology Identification:

This task involves an outlook function wherein information on existing, evolving or even potential innovations is fed back to the Lead Agency for

further exploration, evaluation and dissemination. Hopefully, this function will grow in importance easing the burden on the programme administrator in the Lead Agency as the Champions collectively gather and exchange information.

ii) Evaluation:

The Champions will evaluate innovations which they have tried and report their findings to colleagues and the Lead Agency.

iii) Identify Adopters:

Participating in any research into identifying adopters, the field members will review individuals and companies within their market areas to identify those who might be potential customers.

iv) Marketing:

The Champions must market their services to general contractors as a means of securing work.

v) Advise Building Inspectors:

Many reports identify the regulatory system as one of the impediments to innovation. This means that many local building inspectors are acting as barriers to the broader use of innovative technologies. Therefore, one critical task of the Champions will be to act as both information sources and when necessary arbitrators between contractors and inspectors.

vi) Project & Process Evaluation:

The Champions should evaluate how the process is working and make suggestions on how to improve it. This task could also include identifying potential research topics and shortcomings in the knowledge base regarding innovation adoption.

vii) Feedback:

The Innovation Champions should provide feedback to the Lead Agency on all facets of the innovation dissemination and adoption process. Feedback will include discussion of the innovations themselves plus all aspects of the process for identifying, contacting and marketing to the various contractors. Whereas the Innovation Champions will work in distinct market areas, they should be able to freely exchange even the most intimate of business details and marketing strategies with their colleagues

Another aspect of feedback which should be fostered is feedback from the Lead Agency to the inventors, manufacturers or distributors of the innovations being introduced.

viii) Networking:

Building on the above point, it is desirable for the Innovation Champions to network directly as a means of information exchange and marketing. As noted previously, the residential construction industry tends to favour 'word-of-mouth' communications and peer review as part of the innovation evaluation process. Consequently, in addition to their own networking, and working with the Lead Agency, Champions should encourage and as necessary foster networking between non-competitive contractors in different geographic markets, or serving differing market segments, as a means to validate and improve the use of the various innovations.

ix) Market Trend Identification:

While the main thrust of the work will be to move innovations into the industry in what is normally called 'market push' , the participants must be continually aware of their potential to identify a need and then promote either basic research, product development or product modification to serve that need. This is known as ' market pull'; however, due to the scattered nature of the construction industry this function does not often occur. If the proposed innovation triggering system helps to create a more innovation receptive environment, it is not unreasonable to assume that opportunities will arise, and front line individuals will feel more at ease, to contribute to the overall innovation process. When given the opportunity to make suggestions, workers themselves generate

anywhere from 60% - 80% of the innovative changes made on a progressive site.

Innovation Evaluation:

As discussed earlier in the report, there is no shortage of potential innovations which can be introduced to residential contractors. However, as such introductions must be based on some belief in the general worth of the innovations it will be necessary to evaluate and to a degree, screen those innovations before they are presented to either the network of Innovation Champions or their client contractors. This is necessary from two perspectives; first to eliminate those which are not yet ready for use, but more importantly to preserve the integrity of the dissemination system. The issue of evaluating individual innovations is discussed below in some detail.

Although there was not much information available regarding this evaluation process as it might apply to the residential construction industry, in 1989 the US, National Association of Home Builders produced a report titled "Criteria for Evaluation of Emerging Housing Technologies" under their "Advanced Housing Technology Program" which contains a procedure and evaluation form which one can use as basis of any evaluation process. These form can be found in the Appendix in both a blank edition and completed example.

The forms and underlying approach are somewhat appropriate for the needs outlined herein and merit review and consideration for what they might offer as a preliminary base document; however, considering the general nature of many of the possible technologies listed earlier in the report, it becomes evident that these forms which are designed for use in evaluating such technologies as 'pressure treated wood foundations' or 'low-emission coatings for windows' may not be ideally suited to the many smaller innovations, such as the "Centre-Point" tapes, or the "Ultra-Square" previously described. Furthermore, it is suggested that any evaluation process considered in the context of this proposal should be geared more to generally identifying " *potentially viable* " technologies and not as the NAHB forms intend making a definitive determination as to their suitability. Given the type of outlook function being proposed and the general nature of the work, it is probably reasonable to suggest that most of the technologies with which will be identified have proven themselves well beyond the prototyping and early evaluation stage, or are of such a nature that no complex evaluation is required.

It is important at this point to remember that one of the underpinning goals of the research and this proposal is to present contractors and sub-contractors with a relatively vast array of potentially viable innovations, somewhat akin to a smorgasbord, from which they can select those strategies which meet their needs.

This is done for three very diverse and distinct reasons:

> First to offer a range of solutions which should trigger serendipitous discoveries such as "Oh!, I didn't realize we could do it that way".
>
> Second, to offer options which will appeal to their unique corporate cultures and individual company needs.
>
> Third to present a sufficiently broad range of options so as to create a positive innovation oriented atmosphere somewhat akin to "Look at how much we can implement, and save, if these first efforts are successful."

This broad and often small scale approach has its merit for as noted in a NRC Roundtable Report [28] on innovation in the construction industry,

> " Incremental innovation should be seen as significant as breakthrough innovation for the Canadian construction Industry."

This broadcast approach would be problematic, and probably completely unsuitable for the proposed task, if the client contractors, sub-contractors and trades people were not being guided through the introduction evaluation and adoption phases by the Innovation Champions whose role it is to reduce the confusion generated

by so many choices, to help in the numerous evaluations and to simplify the often confusing technology or instructions implicit in any effort.

Evaluation Criteria

It is suggested that while one might work from the preceding NAHB forms in crafting an evaluation process that it might be desirable to focus on the following evaluation criteria:

Cost-Effectiveness:

As noted, there is no shortage of innovations; consequently for convenience and efficiency all innovations should be initially evaluated for cost-effectiveness and only those which appear to ultimately provide a cost or time benefit to the general contractor should be considered further.

Marketability:

Innovations must be evaluated from two marketing perspectives: first, does the proposed change make the home easier or more difficult to market and secondly, if the later what might one's competitors say about any changes made from normal market standards and how can they be countered.

Examples of both these options can be found in the questions of stud spacing, stud sizing and the insulation. In the first instance one may elect to utilize 2x4 studs and an exterior wrap of rigid insulation. If a competitor makes reference to their own use of 2x6 studs, the countervailing argument is that 2x4 studs were the traditional way of building until the energy crisis hit and then 2x6 studs were introduced for their increased insulation potential however, now the exterior wrap provides a higher insulation value, a better air barrier, fewer cold bridges and in addition the use of 2x4 rather than 2x6 studs is both less expensive and more environmentally sensitive.

Different arguments have to be made when electing to utilize OVE framing strategy with its increased stud spacing of 24" and reduced lumber in such locations as corners and intersecting walls. While a competitor might suggest the home is less solid, one counters by noting that the home is engineered and more carefully thought out and more carefully built to ensure that all loads are carried directly to the foundation. One might add that the use of drywall clips allows the drywall some added flexibility which will reduce the potential for drywall cracks and nail pops. Finally one can note that few studs means fewer cold bridges and the savings in lumber affect both the bottom line and forest conservation.

Invariably competitors will initially fault any innovation; however, in the final analysis, one must point out to consumers the basic truth that if we didn't innovate, our furnaces would still be the old octopus which filled our basements and not the high energy efficient models so prevalent today, or instead of sealed units in our windows, homeowners would be installing and removing storm windows every autumn and spring.

In summary, any individual evaluating innovations, and any contractor contemplating the use of innovations should expect the general contractor's competition to denigrate any departure from the market norm and care must be taken to consider all potential marketing issues and impacts before the innovation are adopted.

Liability:

As noted, liability is considered one of the barriers to the adoption of innovations; consequently, this particular evaluation criteria must be carefully and extensively considered. The adopters' concerns arise from two perspectives: the basic cost often associated with even the most modest of construction systems and the burdensome cost of any remedial construction. For example, we know wood studs work because they have been in use for two centuries, but regardless of any warranties, how will a new roofing membrane actually perform after 20,30 or even 50 years? Therefore, when reviewing a new technology one will have to consider: "How easy might the product be replaced if it fails?". Obviously a freestanding furnace is much easier to replace than a poorly performing plumbing system which is buried in the wall. Next any evaluation must consider the size of the

company standing behind the product , the depth of their warranty coverage and their own financial strength. Lastly, one should ask for references from other independent contractors who have used the material in a standard building environment.

Interactivity

It is critical that any evaluation process also identify all trades and products which will be affected by the introduction of an innovation and what that impact will be. This need is best illustrated by the issue of OVE corner framing and the drywall clip. The two stud OVE corner is both more economical and more energy efficient than the three stud corner which it replaces as it allows for the introduction of more insulation at all exterior corners. However, this technique is usually dependent upon the use of drywall clips to replace the missing backer stud; this in turn costs the drywall installer more money. If one attempts to introduce the first technology at a saving to the general contractor and framer without discussing the impact of the requisite second technology on the drywall sub-contractor, problems will arise and costs may unexpectedly escalate.

Peer Review:

While field performance information is important, references from peers and industry insiders continues to be seen as one of the most critical, and trusted forms of innovation endorsement currently available. Consequently, every effort should be made to identify and if necessary seek endorsement from contractors and firms who have successfully used the product or technology being considered.

Trialability:

The evaluation should also consider how easily, and inexpensively a product can be introduced on a trial basis before a firm must commit to its use. A one-coat, paint with supposed high masking qualities can be readily painted over if the colour is off, or its performance is not acceptable, it is easily triable. However, an intumescent fire retardant paint can only be tested in a fire, hardly a time to be conducting a trial. A new drywall corner product might be used in the bedroom or basement areas on a trial basis while the conventional products are utilized in the more visible living areas until such time as the contractors and consumers demonstrate their acceptance of the newer product.

Performance

Finally, one should attempt to ascertain the long-term performance of any new product. Unfortunately many innovations are too new to have an extended field record and it may be necessary to seek alternate accelerated testing data. However, many of the innovations being considered will only be innovations in terms of their introduction to the contractors and market in question at the time of consideration. OVE framing for example has a history of about 25 years and yet it would probably still be considered innovative on most Canadian job sites. But, there is an extensive existing body of knowledge about this framing technique and it is this information which should be presented as a demonstration of this innovative technology's performance record.

Funding:

Funding plays an unique role within this proposal for it acts as a driving force in that the Innovation Champions are proposed as independent contractors who will be compensated by their general contractor clients on the basis of their marketing and demonstrated innovation implementation skills. However, because this proposal is attempting to consider both business driven and quasi-governmental options, funding must discussed under two separate scenarios.

In the first, the business model, the Lead Agency or business backing this effort will bear all costs and reap all profits. That said however, it must be recognized that in today's business climate many firms seek public-private partnerships or behave in ways which mirror some quasi-governmental practices. Consequently while one can readily envision a pure business, for profit organizational and funding model, a business may also adopt some of the public funding options noted below.

The second funding environment is that of the quasi-governmental or public agency mode wherein funding is often more complex and where here too an Agency may elect to pursue a public-private funding partnership. The following work attempts to explore typical options.

Basic Funding Approach:

The Lead Agency, with possible contributions from government or interested trade associations will provide the initial seed funding to establish an information dissemination and innovation triggering programme plus provide the services of a project manager. The Lead Agency will also fund any required initial research endeavours; however, as noted below, annual license fees from the Innovation Champions will somewhat offset these costs in future years.

Once selected, the Innovation Champions which have been described above, will pay an initial fee to receive preliminary training and to secure a restricted market area. This is somewhat akin to a license fee for a franchise and as such it should be considered as an investment by the Champions. Further, by paying a fee, the Champions will gain a sense of ownership or vested interest in the innovative technologies and an incentive to market those technologies and garner some benefit from them.

To promote the business, the Lead Agency may elect to subsidize the first two general contractors in each market area in order to demonstrate the concept, work out bugs in the system and gather preliminary cost-benefit data.

The Lead Agency may also elect to support the Innovation Champions by paying them a modest retainer to compensate them for their feedback and data collection efforts.

The Champions will sell their services to contractors within their individual market areas as a means of generating their own income, and it is from this income that monies will be returned to the Lead Agency as annual license fees and to cover any on-going training, upgrading or as a contribution to the basic research.

It is felt that the Innovation Champions' services can be sold as proposed because the research has shown that few, if any, general contractors can implement this process themselves. Further, their investment is protected as their collected advances and organizational changes can not be readily duplicated for free by their competitors.

One funding option which might seem appropriate but which was discounted is any fee structure employing a strategy somewhat similar to that used by some Energy Service Companies [ESCo]. In some instances, the ESCo's are compensated for the consulting services and any new energy-saving equipment which they may provide to a client out of the savings in energy costs which result from changes which the ESCo's make to the clients' existing building's mechanical equipment and operating protocols. Though a WIN-WIN scenario in those instances, the concept will not work in the nebulous construction and innovation environment being considered in this report. In the ESCo's cases, there exists well documented pre and post-change energy cost data. Further, with limited variables, such as climate changes and building occupancy rates, it is fairly easy to identify what savings are a result of the aforementioned changes and what are extraneous savings or costs.

However, in the DIT system environment there can be many changes in labour rates, materials, material costs or even personnel changes whereby a highly-skilled manager trained by the consultant might quit or be replaced. Any number of variables can come into play which will effect the general contractor's rate of return and consequently preclude a fair and unquestioned evaluation of increases or decreases in their companies' rates of return thus making it impossible to base any Innovation Champion's compensation on a measure of those rates of return. It is for this reason that the ESCo's funding from savings model can not be adopted.

Free Information Dissemination:

When the Lead Agency is also a quasi-governmental or public body a unique problem arises in that their general mandates tend to include a provision for some form of broad general information dissemination process which is somewhat at odds with the information sales process being proposed. In order to satisfy both their business or funding requirements plus their broad public mandates it is suggested that innovative findings such as are being suggested for sale within this proposal be held for a two year period before they are more generally broadcast in the government's more typical non-profit mode.

Outside Funding:

Opportunities may arise for some additional funding by outside agencies; particularly, from those firms producing innovative products and services and who might consider paying a fee to have their products, processes or technologies introduced, promoted and implemented through the Innovation Champions and the innovation triggering programme. While this could constitute a very effective manner for such groups to effect highly focussed innovation introductions, extreme care must be taken by both the Lead Agency and the Innovation Champions to protect the integrity of the process and avoid any perception that the Lead Agency's evaluation and endorsement process is influenced by undue commercial considerations.

Despite this reservation, this form of financial support should be carefully explored to ascertain if the programme can contribute to broader innovation adoption by acting as a conduit for the development, testing and evaluation of new Canadian technologies while at the same time generating funds to support core activities.

IMPLEMENTATION PROCESS

The following suggested implementation strategy assumes that any Lead Agency has conducted an internal review and evaluation of the proposed programme and that the necessary internal administrative steps have been concluded as appropriate and are assumed to be ongoing as required.

Allowing for the natural variances which arise as any formal programme is developed, an implementation process might involve the following steps and procedures by the Lead Agency:

Develop a broad outline for the proposed innovation 'triggering' programme and prepare a preliminary business plan.

Initiate research studies to identify the profile and categories of early adopters and gatekeepers.

Upon receipt of preliminary research findings and initial business plan advertise for and select the "Innovation Champions".

Conduct orientation training of the Innovation Champions and incorporate their views in completing the business plan.

Launch the first two demonstrations of innovation trigger consultations with contractors in each market and independently evaluate same.

Conclude the research initiated above and combine with feedback from and the evaluation of the first demonstrations. Based on analysis of all the information adjust the proposed programme, research and training initiatives as appropriate.

Implement the full market introduction of the innovation triggering process by the Innovation Champions and begin their feedback and outlook activities.

Explore what role government agencies, construction institutes or academic groups might play in the overall delivery process.

Conduct annual reviews, evaluation and programme adjustment as appropriate.

Conduct a second anniversary evaluation of the process to assess :

i its impact on Canadian home construction
ii its financial viability
iii the potential transferability of the process to either other construction sectors or other industries which face similar lags in the adoption of their own innovations.

SUMMARY:

There appears to exist an opportunity to develop a national scaled business model for an information dissemination and innovation triggering approach such as is discussed in this report. However, the final form of any such entity will vary somewhat depending upon whether it is a public or business-oriented, for-profit model.

In the former, there will be something of a pre-disposition towards broader, free or low-cost information disclosure than will be found in the for-profit model which will survive based on its ability to sell that same information via a consulting process to individual general contractors

The key to either approach rests on the development of a cadre of informed consultants or "Innovation Champions" who will consult directly to the general contractors and who will act as teachers, cheerleaders, coaches and referees depending upon circumstances.

Any national endeavour will initially require the development of a body which could be called the "Lead Agency" and whose task it will be to administer the programme, collect information on innovations, train the consultants or Champions and who if a governmental agency or public body will also undertake or manage research in the topics of innovation adoption and adopters and undertake a general public information dissem-ination effort.

One aspect of the above work which needs to be explored more fully is the whole issue of innovation evaluation with its many diverse components of: product peer review, cost analysis, product marketability, liability and long-term performance.

Concurrently, work also needs to be pursued in the areas of better understanding and identification of prime adopters. Often referred to as 'early adopters' or even 'gate keepers' these individuals and companies will prove to be both the Champions' primary target market and the key to any large-scale innovation introductions.

In terms of actual innovations, the proposed triggering system relies in large part on the simultaneous presentation and application of a very extensive and diverse range of innovative products and processes. This is necessary to take advantage of any serendipitous overlaps, provide sufficient choices to meet diverse firm size and corporate cultural needs and more importantly to lay the foundation for creating a "pro- innovation environment" within the general and sub-contractors' organizations.

Funding for this type of endeavour can arise from many sources both government and private, with the former probably supporting any research efforts and the later sustaining the operational end. However, in either a public or profit driven scenario, the bulk of the monies will be generated by the Champions' sales of their consulting services to the general contractors. To this might be added some monies from companies who wish to see their products and services either field-tested or promoted through the Innovations Champion's services; although, great care will be required to keep the process beyond reproach and appearing to become just another promotional vehicle.

Through the proffered 10 step implementation process of concept development, information gathering, training, delivery and constant evaluation, the "Future Opportunity" explored in this section should contribute to a significant improvement in the rate of innovation adoption in Canada's residential construction industry, and the subsequent wider dissemination of information to its many contributing segments.

CONCLUSION:

The above programme represents one approach by which Canada's residential construction industry might begin to enjoy the benefits of the vast array of innovative technologies and administrative process which are available to them but which have not enjoyed the type of market penetration they merit.

There is compelling evidence in the literature that there is an abundance of innovations to improve construction quality, improve construction profits, and improve buyer options while at the same time lowering costs. Although the literature is equally clear about the number of impediments to the adoption of these innovations, nothing suggests that the current environment can not be improved or even fundamentally and dramatically changed. This proposal offers one suggestion on how that change may be triggered.

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APPENDIX

The Appendix contains three elements. First one finds the original unvetted list of 228 innovative technologies considered for possible inclusion in the demonstration home. This list contains two distinct elements: pages A1-A6 contain essentially construction oriented technologies which formed part of this study. The later half of the listings, pages A7-A12 encompasses some 95 various strategies dealing with marketing oriented items which while not part of the study were culled from the literature for review as to whether they might apply under the more technical category and which were subsequently included for the edification of the reader.

Secondly, the Appendix contains reduced working drawings for the home model which was built as both the baseline and testbed units.

Finally one will find examples of innovation evaluation sheets which were developed by the National Association of Home Builders in the U.S. While these were received too late to be utilized in this project, they are offered here for the use of those who wish to evaluate innovations in their own work.

Table 1:
TECHNOLOGY SUBSTITUTION LIST

The innovative strategies noted in bold, such as shown below, were utilized to some degree by the general contractor in the demonstration home whether as part of this project or as part of their existing construction practices.

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	EXCAVATIONS		
1	Combine basement and service trench excavations at one time		
2	Use one trench for all services to limit of Codes		
3	Stockpile basements or at least excavations for winter or future use on "QUICK DELIVERY" option		(-) 1 to 2 weeks
	FOUNDATIONS & FOOTINGS		
4	Use 6" thick walls to 6' height typical		(-) 25% Conc.
5	Use self-consolidating concrete [IRC Demonstration home foundations]		
6	Eliminate basements use FPSF / Add storage to main floor , add 2' to garage, lockers & hall closets		(-) 4 days
7	Use Frost protected Shallow Footings [FPSF] if only on garage.		
8	Use pressure treated Post & Beam under garages		(-) $600 to $900
9	ANCHORMATE bolt spacers		
10	REBAR Stakes [$.50us/Unit]		
11	Panellized PWF Basements		(-) 2 to 3 days
12	Polywrap in ground posts to prevent soil/frost heave		
13	Stemwall foundations , where possible to eliminate need for footings		(-) $400
14	**FASTPAD footing system**		(-) 66% Mat. & Labour
15	**FASTFOOT foundation system**		(-) $300
16	Split lower end of Sono Tube pile form to provide pad footing and column		
17	BIGFOOT to replace separate pad and pile forms / one pour		(-) 90% Labour
18	Replace anchor bolts with strap ties, easier to locate and install [Simpson Strong-Ties]		
	FRAMING		
19	Lumber delivered stacked in sequence ready to use		
20	Panellize home to reduce construction Time / Waste & Materials		
21	Use portable framing table on site for wall panels and components		
22	Pre-build as many components as possible Headers,Arches,bump-outs,door & window frames		

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	FRAMING (Cont'd)		
23	Use tool advances like CENTREPOINT tapes / ULTRA-SQUARE etc.		
24	Use power tools for all framing and caulking tasks.		(-) 14% Labour
25	EZ SHIMS - won't crack, swell and break easily		
26	Design home in 2' & 4' modules and have odd dimension in centre of home to facilitate centering of windows and doors as required by the home layout and design.		
27	Overhang foundation by 2' all round to reduce concrete ; similar on second floor joint or separate use		
28	No sill plates required if concrete level, use sill gaskets all round.		
29	Off-centre beam if necessary to utilize lumber 12' & 14' rather than 2@13'		
30	Use 2x4 bottom plates on 2x6 walls		
31	Delete rim joist, rely on sheathing		
32	Use ply or 1x material as rim joists		
33	**Frame @ 24" oc. [Basis of Optimum Value Engineering approach.]**		(-) $600 to $800
34	Use 1x material for bottom plates		
35	Single top plate c/w nail plates at intersections, joints and corners		
36	**Eliminate all possible non-load bearing headers in interior and gable end walls**		
37	Align all possible openings to one side of existing on-module [24"] stud		(-) 20 Studs
38	**Eliminate extra stud at wall intersections - Nail Top & Bottom and block with scrap at mid-point**		(-) 15 Studs
39	Use header hangers instead of jack studs		
40	Cut jack studs to accept window sills , eliminate cripples at edges		
41	2x3 interior walls		
42	STUD-LITE for interior walls [1.25"x3.5"]		
43	2x4 exterior wall with insulation wrap [Homes 25 sq.ft. larger & warmer]		(-) $1,100
44	Sheathing used only at corners remainder replaced by metal strapping , insulation over		
45	2x4 plates with 2x6 exterior walls over carry rigid insulation up over set back header & plate.		
46	Ply box headers 1/2" ply one side supports 500# +/- over 3' 1/2" both sides = 6'		(-) $50
47	Ply and 2x combination built-up beam garage headers		
48	Eliminate headers and build into rim joist over. Replace 1.5" Timberstrand with 1.75" micro-lam all round. Cost +$1.25/ft. but saves on labour		Cost neutral ?
49	Use 1/2" foam between headers as filler versus ply, easier to cut and handy		
50	For 3 ply post use 2x4/2x6/2x4 rather than 3@2x6.		
51	**Use drywall clips at all corners and ceiling intersections rather than stud backing**	Drywaller	(-) $400 to $700
52	Eliminate double joists under non-load bearing walls when using 5/8" or 3/4" subfloor		

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	FRAMING (Cont'd)		
53	JOISTER - joist hanger system		
54	Steel interior walls		
55	CARPENTER'S STEEL STUD - Hybrid stud for use with wood plates etcetera		
56	ARCH-RIVAL - Preformed plastic arches		
57	PRO-SLOPE - Preformed slope for under tile in showers and tubs		
58	Design roof in 2' modules both directions to minimize/eliminate cutting of sheathing & waste. Allow for ridge vent as required, or use vent gap as means to accommodate sheathing.		
59	Use attic trusses to replace second floor framing - added space nor costs only $8-$9 / sq.ft.		(-) $200
60	Use 1/2" ply blocking beside stair to create a reveal into which to slide drywall	Drywaller	
61	Build a manifold bar for gang gluing of 3-4 joists as one pass, use powered glue application		
62	INTEGRITY floor tape to eliminate floor squeaks. - use manifold/ ganged roll application		
63	EASY-RIZER stair component system for large scale builder		
	EXTERIOR FINISHES		
64	RAPTOR plastic nails with through colour. Can be cut or sanded as required, use on siding & cabinets		
65	PVC & rigid urethane trim to replace wood , maintenance & ding free.		(-) 15% to 50%
66	Cedar siding panels [Same overall cost but saves 50%-75% in time]		(-) 50% to 75% Time
67	Limit range of window types and sizes to standardize headers over.		
68	Cut vinyl siding with sharpened marking gauge - scribe and then snap.		
	ROOFING		
69	PERFECT CHOICE cedar and slope shingle panels [Material +33% but Labour - 30%-60%]		
70	Roof load shingle bundles to reduce work and theft.		
71	Tarp perimeter of home during shingling; cheaper than cleanup & looks more professional		
72	Frame roof at grade and crane into place . Saves time, cost WCB and produces a better job		
	MECHANICAL		
73	Spray foam under tub & shower to provide better, level base and insulate		
74	Frame exposed ducts with 38mmx38mm angle iron and drywall tied to ducting		
75	Use flexible gas piping [SOFTLEX] cheaper, faster, fewer service conflicts.		(-) 30% to 66% Time
76	Air Chiller combined with whole house exhaust [-50% to install / -30% to run] replaces most AC		
77	UNICO small duct mechanical system. Most cost-effective in renovations and complex units		

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	ELECTRICAL		
78	Upgrade to category 5 wiring [Cost ~ $300+/- perceived value ~$2,000 / Consider fibre optics for future.]		
79	Kerf cut wiring channel in studs at outlet height and protect as req'd with plates- eliminate drilling		
80	Scrutinize every circuit 1@14/2 wire = 1 circuit @15amps, but 1@12/3 wire =2 circuits @ 20 amps. Loop #12 to two circuits		
81	**Consider sub-panel in kitchen area to minimize numerous long wire runs from main.**		
82	Buy pre-drilled studs, drill while in lifts or have work done by labourer/student during off-hours		
83	Locate and coordinate all switches and outlets before wiring and confirm with client walk-through.		
84	**Enlarge work crew to 5@ 1 day -vs.- 2 @ 4 days [Saves 3 man-days or 37% +/- labour].**	All Finishing Trades	(-) 37% Labour
85	Get security subcontractor to wire and offer 3-6 months of free security as their promotion strategy.		
86	VALUE PLUS PACKAGE! Offer a special package of options such as: whole house surge protection, pre-wired DDS, fan-light combo's to reduce cooling costs, full spectrum lighting in make-up and closet areas, pre-wire exterior doors for video, TV & cable near Jacuzzi, Tel. outlet in garage,3 heavy duty outlets in garage, fluorescent over work bench area.		
	INSULATION & VAPOUR BARRIER		
87	VAPOURFORM vb for joist headers		(-) 50% to 75% Labour
88	2x4 exterior wall c/w 2" rigid insulation wrap.	Framer	(-) $1,100
	DRYWALL		
89	Preformed attic access panels		
90	Use the "CLEAT" tool to assist in installing ceiling and wall panels.		
91	CANADIAN GYPSUM claims new drywall saves 10% in easier cutting & better edges.		(-) 10% Labour [$300+/-]
92	Use double layer of glued drywall to almost eliminate mudding requirements.		
93	**NO-COAT drywall corners**		(-) $.52/Ft corners
94	**Drywall Clips- Highly contentious costing process**	Framer	(-) $580 to $700
95	Use fast drying mud to minimize site time / Improve application to minimize /eliminate sanding.		
96	**Cycle-Time Reduction : reschedule drywalling to kitchen and bathrooms first so cabinet installers can begin.**	Finishers	(-) 1 to 2 days
	PAINTING		
97	SHERWIN WILLIAMS "Low Temp '35 Paint" for a longer finishing season & reduced heating costs		
	CABINETS		
98	Provide high toe kick and install drawers under as bonus feature		
99	Offer raised master vanity @ 36" to relieve back strain for most adults.		
100	SPRAX screws do not require any pre-drilling speeding assembly and installation.		

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	WARRANTY & SERVICE		
101	Provide pre-sales & pre-construction manuals to establish roles, ease worries and reduce conflict and misunderstandings with client. Becomes warranty manual as material is added.		
102	Provide a comprehensive warranty manual defining what IS & IS NOT covered by warranty		
103	Provide quarterly reminders of seasonal maintenance issue to preclude warranty issues		
104	Expand warranty work to offer downstream services, radon mitigation, decks, basement finishing; even undertake warranty work of other, smaller contractors.		
105	Video all services and blocking before drywalling and at closing to confirm state of residence.		
106	Provide a comprehensive house warming touch-up kit		(-) 35% Warranty Calls
107	Treat final walkthrough with client not as an inspection, but ass an orientation		
108	On warranty service calls do one or two small extra things which customer didn't notice. These things have to be done anyway and your warranty service appears more friendly and helpful.		
109	Promise and deliver courtesy calls at 30 days, six months and one year. This will lead owner to put off minor warranty items until your scheduled visit. Call at these times to request their warranty list, this way builder sets schedule.		(-) 50% Call first month
110	Budget 16 hrs. [2 days] into warranty schedule for handyman to help with unpacking, touch-ups, etc. Covers many warranty points and appears as value added service. Allow owners to trade for 16hrs. Of painting at end of first year.		
111	Provide REDEEMABLE warranty certificates [$75] which must be used for each warranty call, or which can be redeemed for cash at end of warranty period.		(-) 70% Warranty work.
112	Have warranty manager , NOT client make up one year check list , there will be fewer items.		
113	"TOM Homebuilder 4" Computer track warranty items to ensure follow-up and identify poor sub-contractors.		
	HOME DESIGN		
114	Design future addition and pre-install piers to minimize disruptions. Offer special price for fixed period as a means of generating additional future work which will generally not be tendered.		
115	VALUE PLUS PACKAGE! Offer a special package of options such as: garage shelving & work counter, attic storage, master suite 'breakfast' bar c/w bar fridge & sink, full length mirrors in master suite, built-in spice racks, towel bars on cabinet doors.		
116	Build stud and building paper mock-up of home as a full size laboratory for focus groups, to generate PR, to organize systems with sub-contractors and iron out kinks.		
117	Standardize basements with various house plans over .		
118	Provide a fold down table in the guest room closet as a hobby centre or in-home office even if it means installing a second closet in room.		

No.	Substitution Description	Trade Impacted	Benefit(-) Cost(+)
	SITEWORKS GENERAL		
119	Hire students to do clean-up and minor labour tasks at end of day. Trades left to do full day's work.		
120	Waste Reduction: Grind wood scraps for ground cover. If permitted grind drywall into soil as an additive.		(-) $360
121	Reduce street costs with bioretention treatment, rolled street edges, wet lands and retaining ponds.		(-) $5,000/ Home
	MANAGEMENT PRACTICES		
122	**Focus on reducing construction cycle time most firms can save 3-5 weeks on typical home.**		(-) $3,750
123	Implement an ISO 9000 Quality Programme over time even if not certified.		
124	**Generate & Use detailed SPECIFICATIONS & ESTIMATES for "EVERY" piece of lumber & materials.**		(-) 5% to 15%
125	**ARCHICAD : Use a drafting programme which calculates and generates a DETAILED take off and which generates precise framing drawings for all wall panels.**		(-) 5% to 15%
126	**Provide specialized framing details of all corners, headers, wall intersections , sheathing layout, porches etc.**		
127	At completion of framing on first of a new model have a comprehensive walk-through with service trades to identify any potential conflicts, and as a means to improve plan or project organization.		
128	Reorganize the job foremen into starting and finishing foremen and turn-over the job at the mid-point. These two tasks have differing objectives, trades and require differing skills.		
129	Join/ start a buying group with non-competitive contractors		
130	Larger builders with multiple units plans should secure pre-approval of standard plans and options.		(-) 2 to 3 weeks
131	Establish a 2% reduction for paying invoices in 10 days. [Worth 37% return on money]		(-) $500 to $1,500
132	Utilize employee suggestion boxes in office and on site. Pay 10% up front for cost saving suggestions.		(-) 10% to 20% Time
133	Make alternate employees for bringing in a cost saving suggestion every month.		
134	Follow and price a change order as it moves through system to establish a basis for charging buyers according to a reasonable set formula.		

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	MARKETING AND SALES		
	The following innovative techniques were identified during the literature review process. However, these non-technical issues were never part of the demonstration project and are only offered here for the convenience of the reader.		
	WHAT TO SELL - HOMES		
133	Sell Green c/w lifestyle options and focused adds; particularly in target developments.		
134	Consider upsizing both rooms and home and leaving more space unfinished as bonus space [Attic ?]		
	WHAT TO SELL - OPTIONS		
135	Offer a Safety Package [Coordinate 'free' monitoring trial period with security firm]		
136	Add Sales Centre if volume permits, maybe upgrade to show home or basement area can add 3%-10% to list of options , some Centres secure +20% profit. As interim, possibly cooperate with retail outlet and allow home sales staff to do follow-		
137	Offer upgraded "Waterproofing" as option c/w manufacturer's and provincial warranties.		
138	Make a **massive** effort to market all types of extras and upgrades ranging from special paint, paint combinations, improved rear elevations, patios, porches, more landscaping features both plants and structures such as trellises, gazebos, decks etc. However, must be properly costed [See #132]		
139	Make home theatre and upgraded sound system a standard		
140	Make blinds and draperies options, they are required anyway and become part of mortgage		
141	Offer a n optional energy conservation package.		
142	Provide a "QUICK-HOUSE" option, possibly if they accept a stockpiled basement or as a pure rush order. Requires City pre-approval of standard plans.		
143	Offer vouchers for upgrades if home delivered late or for a special price on next home built in same area.		
	WHAT TO SELL - DOWNSTREAM		
144	Use existing customer list to pursue downstream selling to owners of older units such as rehabs, renovations, maintenance, snow ploughing, pet care, house sitting for snowbirds, mortgage and insurance brokerage, health club, on-site catering, community centre rental casual labour hiring, seasonal touch-ups. Consider running downstream services through warranty division if company size so warrants.		
145	Establish a buyers club for homebuyers with key suppliers for on-going sales such as landscaping materials or lumber supplies etc.		

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	MARKETING & SALES (Cont'd)		
	PROMOTIONS		
146	Give buyers customized change of address cards with picture of their home on front. In this way contractor promotes both with their buyers and those to whom they send the cards. As an extension, provide matching note paper and envelopes.		
147	With competitors and local Association promote a "NEW HOME YEAR" generally resales 2-3 times new home sales and as such constitute real competition.		
148	Give realtors $10/Cash and coffee if they attend a lunchtime open house; cheaper than food and generates higher turnout.		
149	Offer $5000-$10,000 voucher for move-up buyers in your older homes.		
150	Become part of your local lottery system offering homes as prizes-say during "NEW HOME MONTH"		
151	T-Shirt Promo Working with local paper, offer prize for best picture of company T-Shirt		
152	Use modified 1/4" scale real 'blueprints' c/w sales notes as promo tool. Allows for furniture placement		
153	Build showhome with three NEW technologies and have local paper cover from innovation perspective. Work with local suppliers for joint advertising and cross-promotion		
154	If subdivision large, run naturalist walking tours through parks and walkway system		
155	Work with local charities to promote home which they advertise and for which visitors vote. Most popular charity gets prize, $10,000-$25,000 as does one visitor.		
156	Have suppliers participate in new showhome offering demonstrations of their products and related maintenance, use or services.		
157	Design and build a "Working Woman's Showhome"		
158	Hold "SuperBowl" party in clubhouse and have residents bring guests and potential customers.		
159	Offer free consultation with local architect, at reduced fee, and build cost into sales price.		
160	Develop late autumn sales programme maybe with special financing and concierge service to help with over holidays move and shopping etcetera.		
	BUYER CONTACT & RELATIONS		
161	Supply handyman for 16 hrs. at end of first month helps with tough-ups etc. and finds and corrects warranty items.		
162	Provide supply of moving boxes with company's logo on them.		
163	Provide clients with hardhats c/w company logo to show they're welcome during construction		
164	Establish a formal 'protocol' for HELPING buyers through long and generally stressful buying process.		
165	Send candy 'stress' pills at time of closing or move to show buyers that you're on their side.		

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	MARKETING & SALES (Cont'd)		
166	Provide "How-To" moving advice on packing, hiring movers insurance etc. in small booklet or on a floppy disk which homeowners can pass on , with your promotion to friends.		
167	Install tacky floor protectors to prevent damage during move.		
168	Supply 1./2 day of free labour during move; particularly, for seniors, hire students etc.		
169	Buy-down mortgage say at 5.5% then add cost to price of home but market the heck out of the mortgage rate also seek brokerage fee from lender.		
170	Post a quality control card with plans and permit in each home to control sub's and build confidence with buyers that everything is being done, and done properly.		
171	Co-op local paper into providing first month's paper free both as promotion and in return for advertising		
	SELLING TECHNIQUES		
172	Use customized mailing lists to promote homes to the old neighbours of recent buyers		
173	Delete the word 'upgrade' from sales materials. Home is already at top quality; use words like 'personalized' or 'customized' it is more friendly. Develop a special customization process.		
174	Give business cards to **all** employees making them sales people. Tie into a junior staff bonus programme.		
175	Ensure company business card is a 'SALES" tool not just a phone number		
176	Hold "HOMEBUILDER/ NEW HOME BUYER" seminars and construction classes in showhome.		
177	Hold general interest classes such as cooking seminars in show home for both homeowners and potential buyers.		
178	Provide [cardboard] framed picture of favourite house and lot to potential buyers as follow-up technique.		
179	Use satisfied buyers , possibly seniors, to do evening call-backs from company script. They can also do warranty follow-up calls This frees sales people to sell.		
180	Team with local realtors to offer local buyers the fee-free sale of their existing homes.		
181	Use site local transmitters to broadcast to car radios when sales office closed, advertise on yard "For Sale " signs. Use pick-up boxes for brochures, tapes and CD's in 'help-yourself' sales mode.		
182	Give out disposable cameras to potential buyers on their second visit. Take first shot of community gate or favoured home.		
183	Chart sales and advertising efficiency to track successful strategies.		
184	Utilize a 4 days in show home and 1 day community prospecting rotation - greatly increases sales.		
185	Provide sub's with Builder business cards and brochures to hand out to drive-by prospects.		
186	Computerize an automated sales follow-up programme to ensure all leads followed.		
187	Lease rather than buy show home furniture; better cash flow, always fresh and in style. Co-op advertise.		

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	MARKETING & SALES (Cont'd)		
188	Provide some lights in homes under construction for drive-by viewers and as added security.		
189	Hold focus groups to define new products and model changes. Hold meeting in show home or sold models for feel of what to change. Have group define value and then offer it.		
190	Conduct **non-buyer** surveys to ascertain what went wrong. Send to all lost prospects with incentive to return, cash or prize cheaper than non-effective marketing and sales.		
191	Hire people to do mundane work of sales people freeing them to focus on their strength "SALES"		
192	Actively seek referral sales; their cheapest ones as buyers pre-disposed to you. Re-apportion advertising budget		
193	Use as many as five buyer walkthoughs during construction to build customer satisfaction & referral.		
	SALES OFFICE & TOOLS		
194	Use 1/4" models to show homes and room options. More cost-effective than show home and can be more easily/cheaply modified plus gives buyers a sense of power and control of their home		
195	Subscribe to "Sales & Marketing" magazine		
196	Modify and extend topo maps to include surrounding area amenities especially for out-of-town buyers		
197	Use home not garage as sales centre. Less to finish and garage can be shown as storage, work or activity area. People know homes generally furnished use basement areas more effectively.		
	COMPENSATION & BONUSES		
198	Combine salary and bonus into one package to allow for non-sales work etc. under salary component.		
199	Have **outside** realtors draw for bonuses $250-$5,000 upon sales with buyers drawing for up to $2,500.		
200	Use "Profit" sensitive bonuses for sales coming in above a set % below the advertised selling price.		
201	Develop compensation package for **outside** realtors such as free billboard space, free airmiles, stocks in local companies etc.		
	ADVERTISING APPROACHES & MESSAGES		
202	Advertise in non-typical areas: the pet section, sailing pages; lifestyle areas of your target market.		
203	Use non-traditional images to catch attention: giraffes for high ceilings, turtles for storage etc. In one project the introduction of this approach caused sales to jump 450%		

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	MARKETING & SALES (Cont'd)		
204	Develop a "Heart of the Community" campaign based on expanded topo map noted in #196		
205	Combine advertising pitch, showing area attributes, with free change of address cards.		
206	Tap into 'nostalgia' and 'quality' images by using a dad based campaign which compares father and sons with grandfathers etc.		
	OFFICE PRACTICES		
208	Benchmark cost both as internal check and trade comparison. Sources Dun & Bradstreet, accountants etc. Consider working with non-competitors to either combine figures of to fund and industry survey.		
209	Train **everyone** on site & in office to run good meetings both large and small		
210	Post reconciled construction cost and budget for every home where involved parties can see and learn.		
211	Enforce buyer selection timetables and utilize default choices if they don't meet dates.		
212	Allocate general and admin costs to every home to get truer picture of costs.		
213	Set annual goal for company improvement i.e.. cost cutting, set monthly themes to enforce that goal with everyone in company involved.		
214	Consider **EXTENSIVE COMPUTERIZATION** of entire operation from integrating drawg's to bidding and scheduling. Site manage with Palm Pilots, SiteTrack, Buildnet programmes and the like.		
	Site Administration / Business Practices		
215	Pursue TRADE PARTNERING with subs to generate more overall efficiency and profits.		
216	Insist that all sub's have fax machines and begin working towards universal e-mail , especially, if company moves towards extensive in-house computerization.		
217	Introduce **No Punchlist** at closing and insist upon achieving same with 90%+ regularity.		
218	Use detailed construction manual c/w details to ensure uniformity and completeness.		
219	Initiate a job-site safety programme and have safety check list with permit . Get WCB input.		
220	Utilize computerized scheduling w/ auto updating notifications to all affected parties Once it is in place offer speedy construction as an option.		
	PAPERWORK		
221	Develop extensive documentation of base work and identify extra work in 'change order form' and charge for same up-front.		
222	Have pre-construction agreement and payment schedule for initial work which doesn't result in a sale.		
223	Have a good purchase order and payment system Can save 1.5% to 5% of total job cost		

No.	Substitution Description	Trades Impacted	Benefit(-) Cost(+)
	MARKETING & SALES (Cont'd)		
	STAFFING		
224	Have all new staff tour all home and projects to get a good understanding of company scope and ideals and to prepare them to act as part of total-company sales team.		
225	Constantly train staff, particularly superintendents in new management skills		
	SITE ADMINISTRATION & BUSINESS PRACTICES		
226	Don't pay Christmas bonuses. Pay quarterly and tie to overall company performance. If performance was 90% of set goal, pay 90% of bonus.		
227	Pay referral bonus to get all staff motivated as sales team. Tie bonuses to increase in survey of all buyers willingness to recommend company to others.		
228	Consider compensating staff with non-taxable bonuses like increased health insurance or a 4 day week alternating with 4 day weekends every other weekend. In this later case don't allow non-emergency medical or personal appointments during work days.		

FIGURE A1-1 PARKHILL MODEL HOME - ELEVATIONS

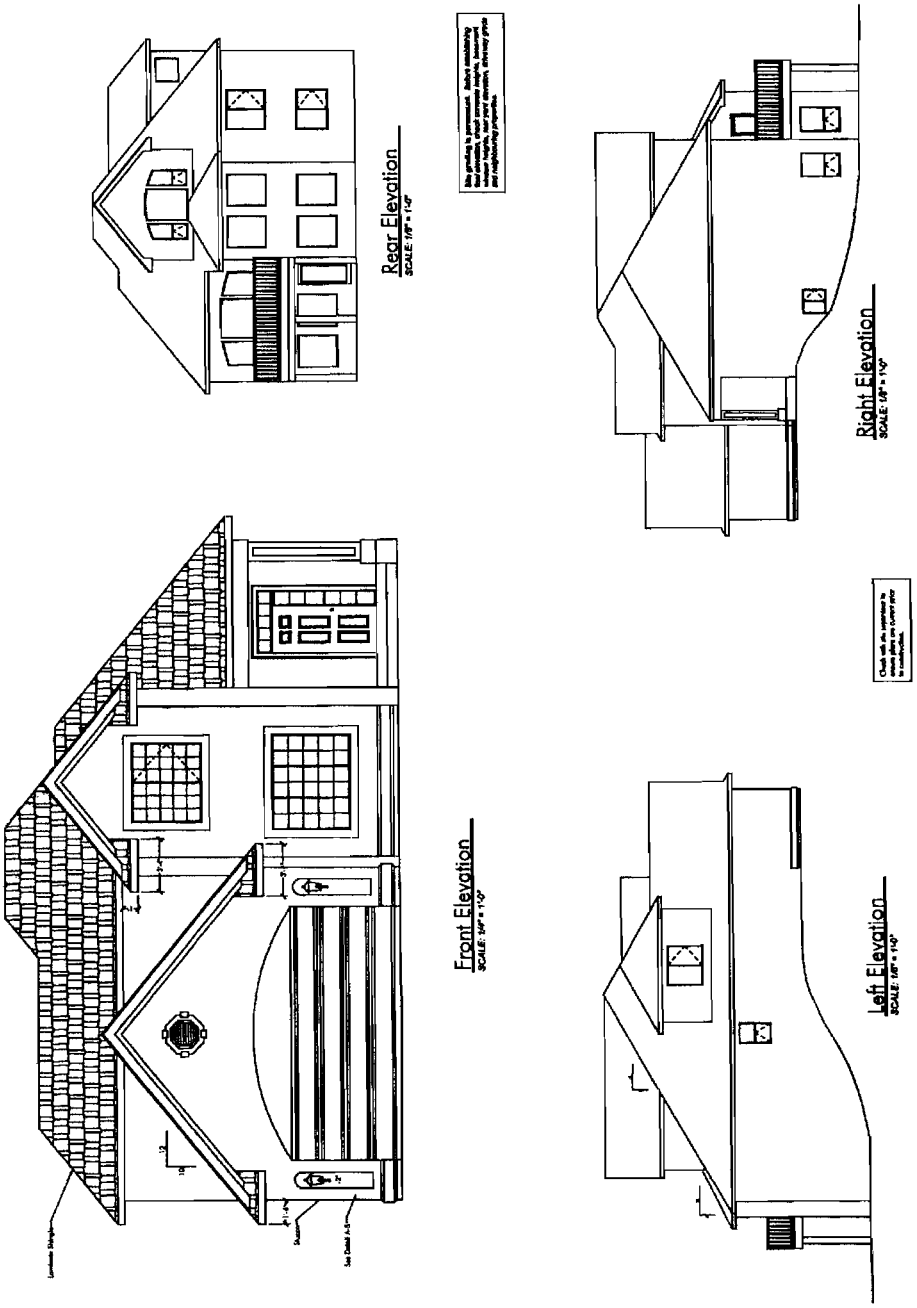


FIGURE A1-2 PARKHILL MODEL HOME - MAIN FLOOR

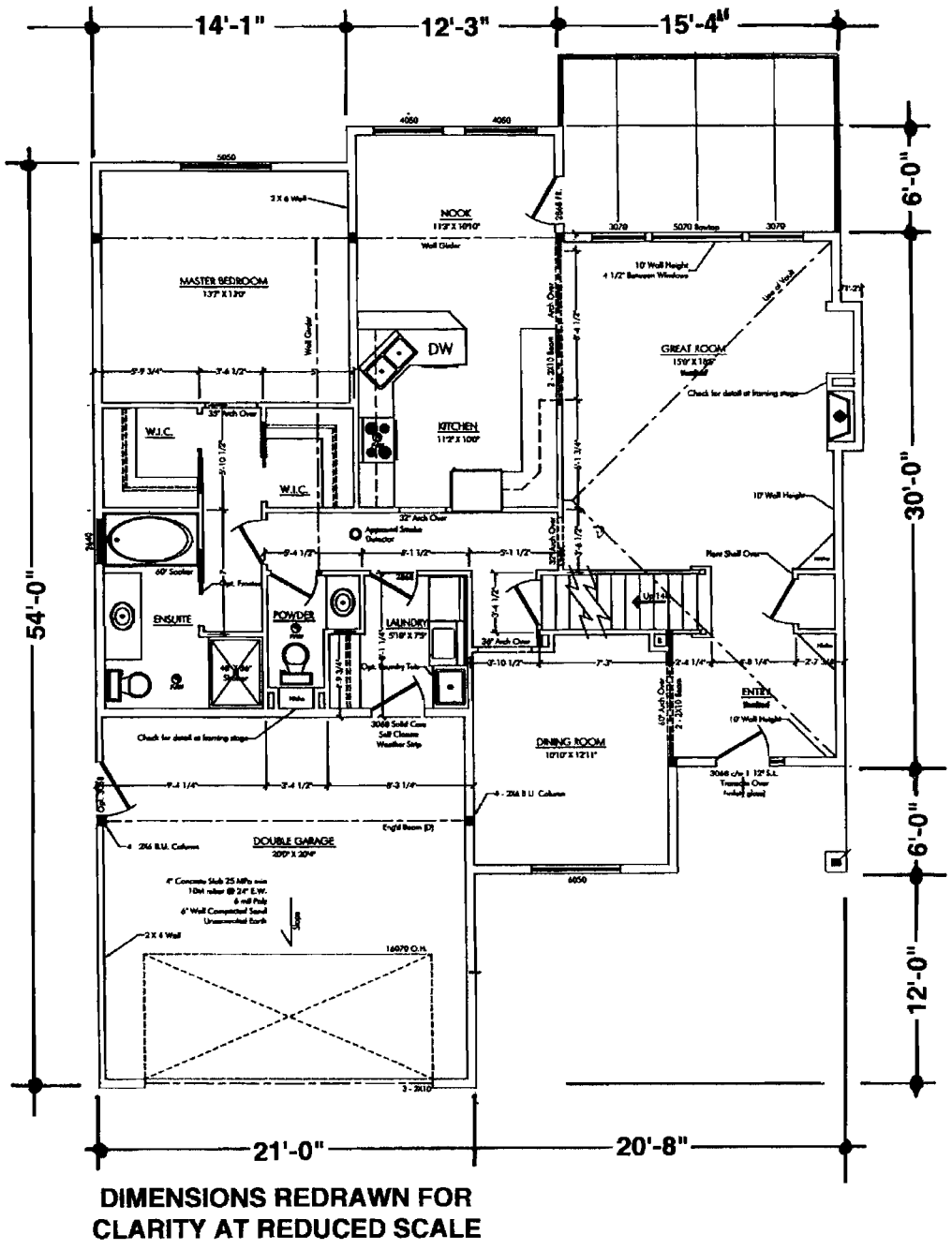


FIGURE A1-1 PARKHILL MODEL HOME - BASEMENT

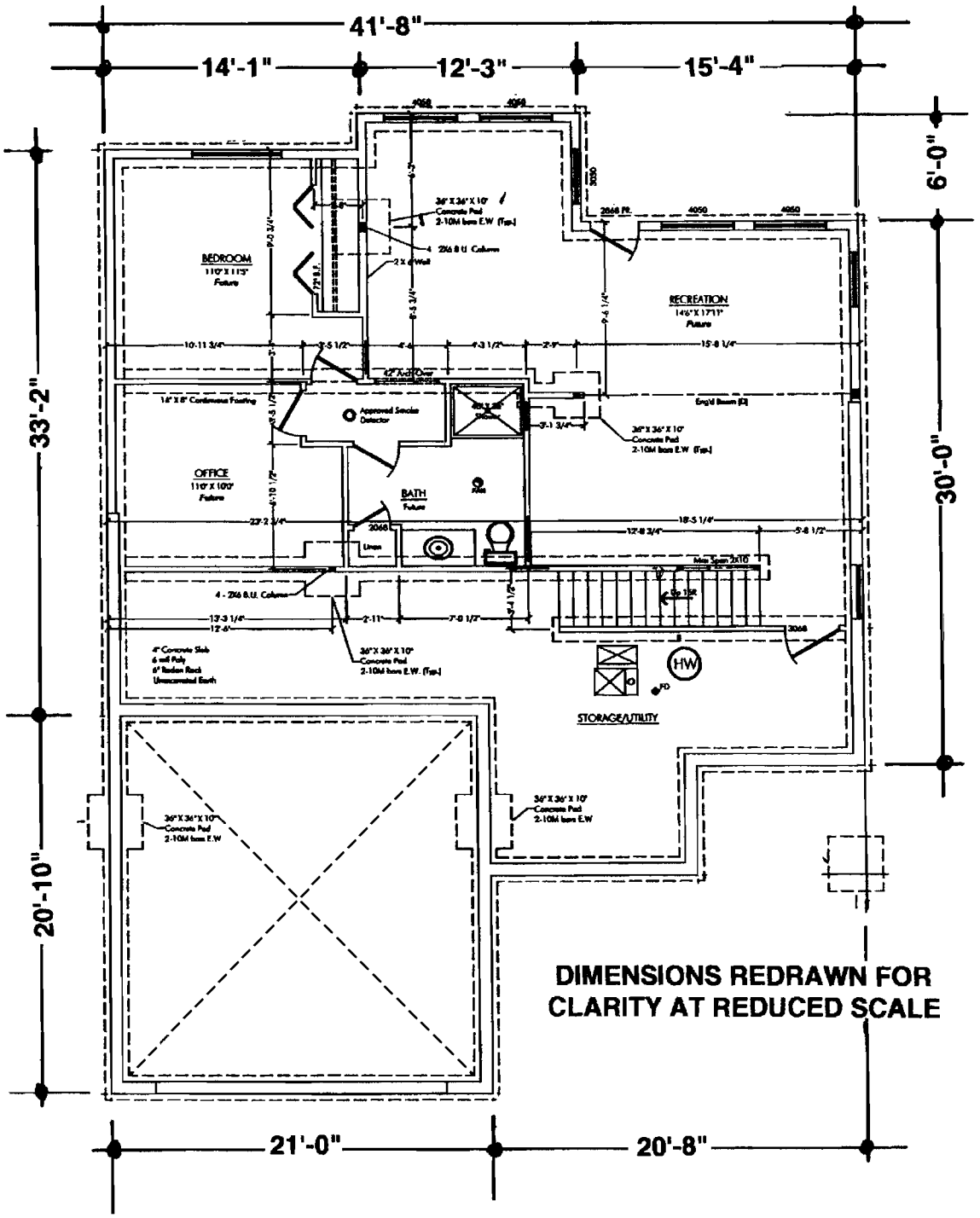
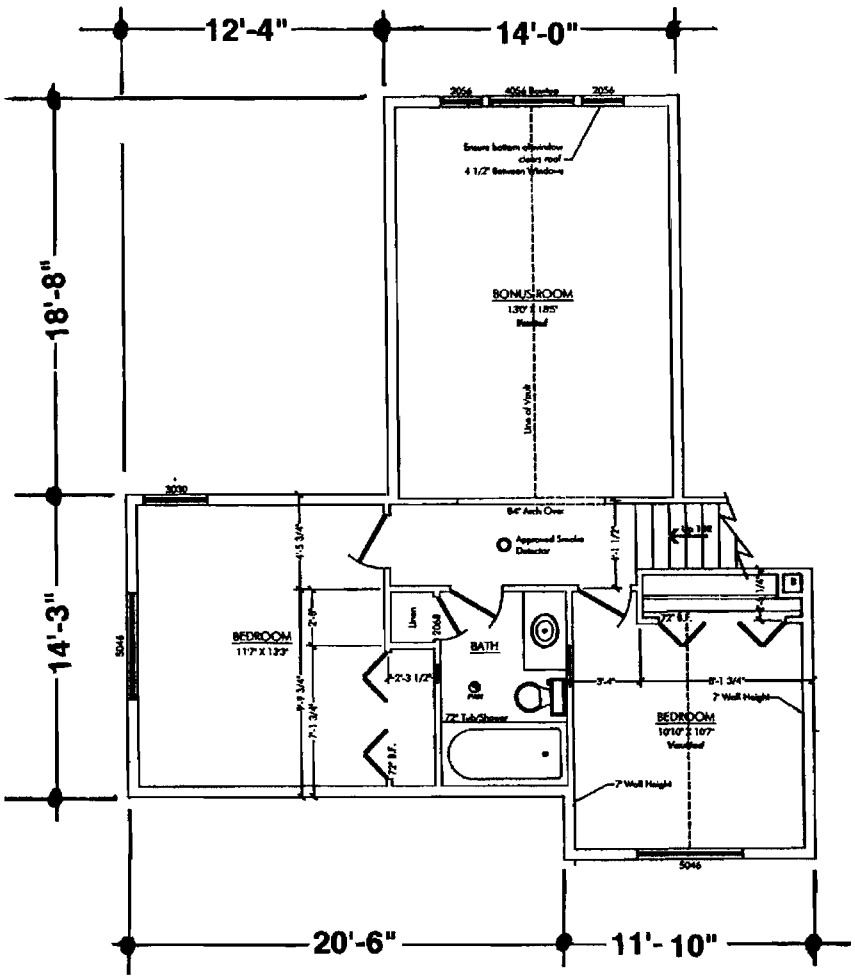


FIGURE A1-1 PARKHILL MODEL HOME - SECOND FLOOR



DIMENSIONS REDRAWN FOR CLARITY AT REDUCED SCALE

FIGURE A1-1 PARKHILL MODEL HOME - SECTIONS and DETAILS

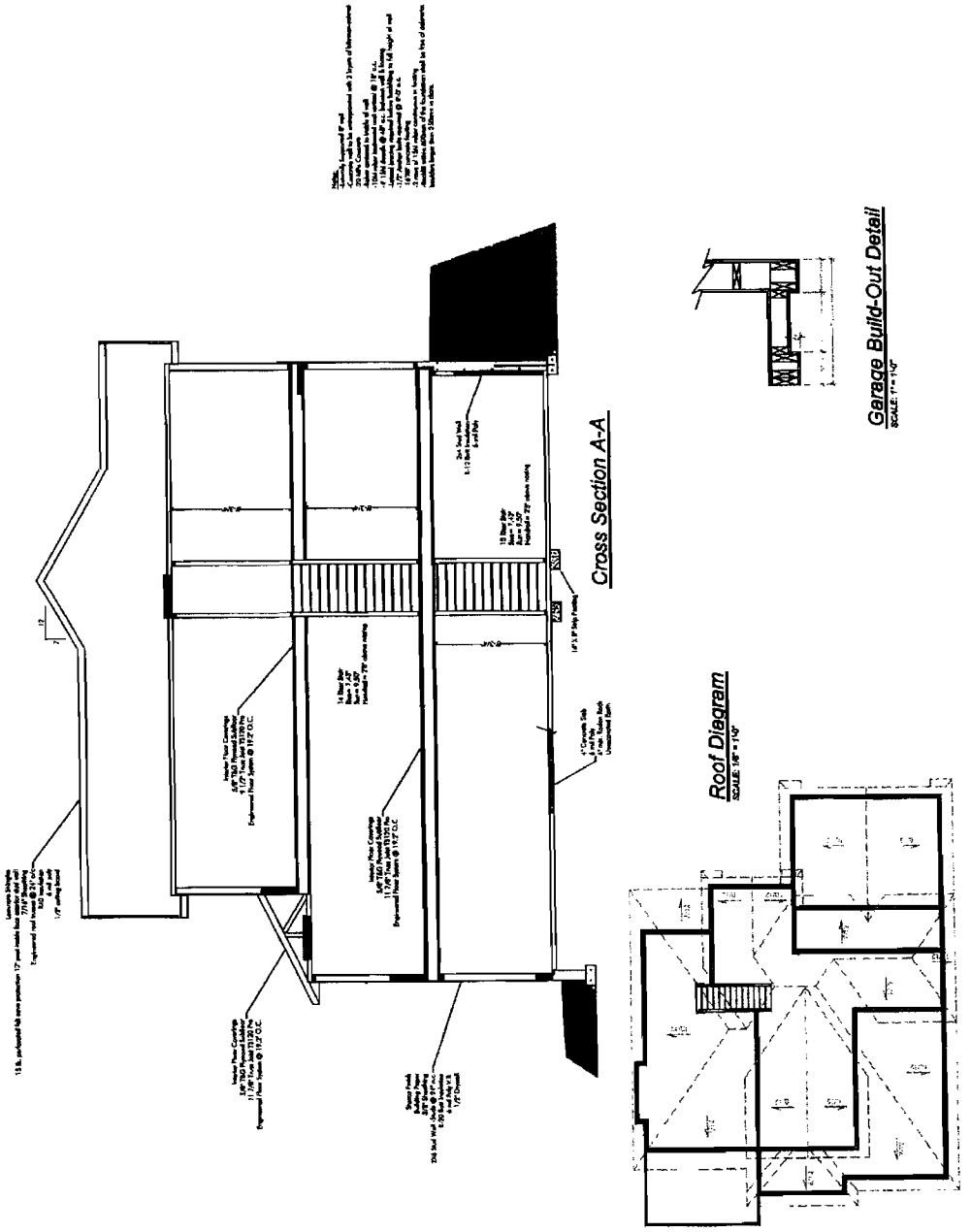


FIGURE A2-1: NAHB -Technology Evaluation Form 1 of 3 / Blank

Innovation Evaluation Form (Figure 2)

1	Name:
2	Description of Innovation and Principal Impacts: Best Current Practice (Standard of Comparison):
3	Principal Advantages:
4	Principal Disadvantages:

Classification:		Embodied Technologies:	
5	System:	11a	First:
		11b	Maturity:
6	Subsystem:	11c	Competitive Impact:
7	Component:	12a	Second:
		12b	Maturity:
Stage of Development:		12c	Competitive Impact:
8	Date of Invention:		
9	Date Proved Practical in Laboratory:	13a	Third:
10	Date of Commercialization:	13b	Maturity:
		13c	Competitive Impact:

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FIGURE A2-2: NAHB -Technology Evaluation Form 2 of 3 / Blank

I FUNCTIONALITY

	Attributes Affected	Direction and Degree of Change*	General Environmental Factors Affected	Building Factors Affected	Additional Comments
14	LIVABILITY				
14a	Safety				
14a.1	Protection From Elements				
14a.2	Security From Intrusion				
14a.3	Safety From Accidents & Catastrophies				
14b	Family Support				
14b.1	Privacy				
14b.2	Recreation				
14b.3	Other				
14c	Livability Totals:				
15	HEALTH & COMFORT				
15a	Comfort				
15a.1	Thermal Comfort				
15a.2	Visual Comfort				
15a.3	Acoustical Comfort				
15a.4	Odor				
15b	Health				
15b.1	Gases				
15b.2	Particulate				
15b.3	Radiation				
15b.4	Volatile Organic Compounds				
15b.5	Other				
15c	Health & Comfort Totals:				
16	OPERATION AND MAINTENANCE				
16a	Maintenance				
16b	Cost of Operation				
16b.1	Energy Costs				
16b.2	Other Operating Costs				
16c	Maint. & Operation Totals:				
16d	FUNCTIONALITY RATING				

* Enter +S for significant improvement in functionality, -S for significant deterioration, +M for marginal improvement, -M for marginal deterioration, or 0 for no change.

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FIGURE A2-3: NAHB -Technology Evaluation Form 3 of 3 / Blank

II PRODUCTIVITY

Cost Summary									
17 Type:	Dollars		Relative Rating						
Initial or Capital Costs	17a		17c	LOW		MEDIUM		HIGH	
Average Production Costs	17b		17d	LOW		MEDIUM		HIGH	
Input Costs Structure									
18 Input:	Percentage of Total Cost (With Innovation)		Magnitude of Change**						
Labor	18a		18d	+S	+M	0	-M	-S	
Materials	18b		18e	+S	+M	0	-M	-S	
Equipment	18c		18f	+S	+M	0	-M	-S	
Total:	100%		18g	+S	+M	0	-M	-S	

18h	Productivity Rating:**	+S	+M	0	-M	-S	
18i	Comments:						

** Circle the appropriate response: +S for significant improvement in input costs, -S for significant deterioration, +M for marginal improvement, -M for marginal deterioration , or 0 for no change.

III MARKETING AND DIFFUSION

Producer/Consumer Acceptability									
19 Innovation Attributes ***	Producer					Consumer			
Compatibility	19a	LOW	MEDIUM	HIGH		19f	LOW	MEDIUM	HIGH
Trialability	19b	LOW	MEDIUM	HIGH		19g	LOW	MEDIUM	HIGH
Simplicity	19c	LOW	MEDIUM	HIGH		19h	LOW	MEDIUM	HIGH
Observability	19d	LOW	MEDIUM	HIGH		19i	LOW	MEDIUM	HIGH
Overall	19e	LOW	MEDIUM	HIGH		19j	LOW	MEDIUM	HIGH

Potential Market			
20 Potential Adoptor	Segment		Estimated Number of Adoptors
Producer	20a		20c
Consumer	20b		20d

IV SIGNIFICANCE OF INNOVATION:

21 ***	Overall Evaluation		
	Major Innovation		Minor Innovation
+4	Significant rise in functionality (+2) & significant decline in input costs (+2)	+1	Marginal decline in functionality (-1) & significant decline in input costs (+2)
+3	Significant rise in functionality (+2) & marginal decline in input costs (+1)	+1	Significant rise in functionality (+2) & marginal rise in input costs (-1)
+3	Marginal rise in functionality (+1) & significant decline in input costs (+2)	+1	Marginal rise in functionality (+1) & no change in input costs (0)
+2	Significant rise in functionality (+2) & no change in input costs (0)	+1	No change in functionality (0) & marginal decline in input costs (+1)
+2	No change in functionality (0) & significant decline in input costs (+2)	0	Significant rise in functionality (+2) & significant rise in input costs (-2)
+2	Marginal rise in functionality (+1) & marginal decline in input costs (+1)	0	Marginal rise in functionality (+1) & marginal rise in input costs (-1)
		0	Marginal decline in functionality (-1) & marginal decline in input costs (+1)

*** Circle appropriate block.

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FIGURE A3-1: NAHB -Technology Evaluation Form 1 of 3 / Completed Example

Innovation Evaluation Form (Figure 4)

1	Name:	Low-Emissivity Coatings for Windows
2	Description of Innovation and Principal Impacts:	Low-E coatings offer high energy savings potential by reducing the transfer of long-wave infrared radiation between glazing elements of a window, reflecting a large fraction of the invisible near infrared energy back to its source while remaining transparent to visible light and admitting useful solar heat gain.
	Best Current Practice (Standard of Comparison):	Tripled-glazed glass
3	Principal Advantages:	High energy savings through reduction of winter heat loss. Transmits 70-80% of sun's light. Reflects radiant heat: Keeps heat inside in winter and outside in summer.
4	Principal Disadvantages:	More expensive than normal windows. Durability of some types of low-e glazing not proven.

Classification:		Embodied Technologies:		
5	System: Structural Frame and Enclosure	11a	First:	Applying films to glass: Sputtering, interpane methods.
		11b	Maturity:	Growing
6	Subsystem: Openings	11c	Competitive Impact:	Key
7	Component: Window	12a	Second	Producing chemical coating
		12b	Maturity:	Growing
Stage of Development:		12c	Competitive Impact:	Key
8	Date of Invention: Early 1970's Europe	13a	Third:	Producing glazed window
9	Date Proved Practical in Laboratory: 1980 Southwall Technologies	13b	Maturity:	Mature
10	Date of Commercialization: 1983 Airco - sputtering process	13c	Competitive Impact:	Base

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FIGURE A3-2: NAHB -Technology Evaluation Form 2 of 3 / Completed Example

I FUNCTIONALITY

Attributes Affected		Direction and Degree of Change*	General Environmental Factors Affected	Building Factors Affected	Additional Comments
14	LIVABILITY				
14a	Safety				
14a.1	Protection From Elements	+M	Sunlight Fading		
14a.2	Security From Intrusion	0			
14a.3	Safety From Accidents & Catastrophies	0			
14b	Family Support				
14b.1	Privacy	0			
14b.2	Recreation	0			
14b.3	Other	0			
14c	Livability Totals:	+M			
15	HEALTH & COMFORT				
15a	Comfort				
15a.1	Thermal Comfort	+S	Temperature	R2 to R3	Equivalent to triple-glazed wind
15a.2	Visual Comfort	+M	Glare		Transmits 70-80% of sun's light
15a.3	Acoustical Comfort	0			
15a.4	Odor	0			
15b	Health				
15b.1	Gases	0			
15b.2	Particulate	0			
15b.3	Radiation	+M	Long-wave Infrared		
15b.4	Volatile Organic Compounds	0			
15b.5	Other	0			
15c	Health & Comfort Totals:	+S			
16	OPERATION AND MAINTENANCE				
16a	Maintenance	0			
16b	Cost of Operation				
16b.1	Energy Costs	+S			
16b.2	Other Operating Costs	-M	Suspect low durability		Higher maintenance and/or replacement
16c	Maint. & Operation Totals:	+S			
16d	FUNCTIONALITY RATING	+S			

* Enter +S for significant improvement in functionality, -S for significant deterioration, +M for marginal improvement, -M for marginal deterioration, or 0 for no change.

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FIGURE A3-3: NAHB -Technology Evaluation Form 3 of 3 / Completed Example

II PRODUCTIVITY

Cost Summary								
17 Type:	Dollars		Relative Rating					
Initial or Capital Costs	17a		17c	LOW		MEDIUM		HIGH
Average Production Costs	17b		17d	LOW		MEDIUM		HIGH

Input Costs Structure									
18 Input:	Percentage of Total Cost (With Innovation)	Magnitude of Change**							
Labor	18a	18d	+S	+M	(0)	-M	-S		
Materials	18b	18e	+S	+M	0	(-M)	-S		
Equipment	18c	18f	+S	+M	(0)	-M	-S		
Total:	100%	18g	+S	+M	0	(-M)	-S		

18h	Productivity Rating:**	+S	+M	0	(-M)	-S	
18i	Comments: Innovation results in a marginal increase in input costs as a result of a marginal increase in material costs. Increases in functionality more than counterbalance this. (see IV below)						

** Circle the appropriate response: +S for significant improvement in input costs, -S for significant deterioration, +M for marginal improvement, -M for marginal deterioration , or 0 for no change.

III MARKETING AND DIFFUSION

Producer/Consumer Acceptability									
19 Innovation Attributes ***	Producer				Consumer				
Compatibility	19a	LOW	MEDIUM	(HIGH)	19f	LOW	MEDIUM	(HIGH)	
Trialability	19b	LOW	(MEDIUM)	HIGH	19g	LOW	MEDIUM	(HIGH)	
Simplicity	19c	LOW	(MEDIUM)	HIGH	19h	LOW	MEDIUM	(HIGH)	
Observability	19d	LOW	MEDIUM	(HIGH)	19i	LOW	MEDIUM	(HIGH)	
Overall	19e	LOW	MEDIUM	(HIGH)	19j	LOW	MEDIUM	(HIGH)	

Potential Market				
20 Potential Adoptor	Segment		Estimated Number of Adoptors	
Producer	20a	Manufacturers	20c	20% of Annual Sales in 1988
Consumer	20b	Home Builders	20d	25-50% of Consumers in 1990

IV SIGNIFICANCE OF INNOVATION

21 *** Overall Evaluation			
Major Innovation		Minor Innovation	
+4	Significant rise in functionality (+2) & significant decline in input costs (+2)	+1	Marginal decline in functionality (-1) & significant decline in input costs (+2)
+3	Significant rise in functionality (+2) & marginal decline in input costs (+1)	(+1)	Significant rise in functionality (+2) & marginal rise in input costs (-1)
+3	Marginal rise in functionality (+1) & significant decline in input costs (+2)	+1	Marginal rise in functionality (+1) & no change in input costs (0)
+2	Significant rise in functionality (+2) & no change in input costs (0)	+1	No change in functionality (0) & marginal decline in input costs (+1)
+2	No change in functionality (0) & significant decline in input costs (+2)	0	Significant rise in functionality (+2) & significant rise in input costs (-2)
+2	Marginal rise in functionality (+1) & marginal decline in input costs (+1)	0	Marginal rise in functionality (+1) & marginal rise in input costs (-1)
		0	Marginal decline in functionality (-1) & marginal decline in input costs (+1)

*** Circle appropriate block.

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