Inside the First Light House

Interior design for New Zealand's entry into the
U.S. Department of Energy's Solar Decathlon 2011

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Unless otherwise stated, images are the author's own.

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As I mention in this writing, the First Light bach was the result of a collaborative, hard-working, dedicated and competitive team. Contributions of ideas, resources, materials, time, labour, leadership and emotional support were invaluable to making the bach an internationally award-winning building. Thank you to everyone involved for bring such qualities to the team. Thank you to Victoria University for providing the forum for a project of this magnitude to take shape. Thank you to the project sponsors for making the project happen in material terms, and to the sponsors in the interior department who I was lucky to work with and learn from. Thank you to the wider student team who made work life in the office busy, involved and exciting, and who made the time in Washington DC an enjoyable and rewarding experience.

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INTRODUCTION

This thesis documents a two year journey to design and build a most unconventional kiwi bach. It reports on the applied research undertaken in order to meet the specific requirements of a particular construction project: the development of a transportable, modular, demountable, entirely solar-powered house built in New Zealand to compete in the US Department of Energy's 2011 Solar Decathlon, held in Washington DC. This challenge was initially taken on by a small team of undergraduate students with very little previous experience in the construction process. The team faced a set of technical and logistical hurdles that would have been daunting for even the most experienced practitioner to negotiate, let alone a group for whom an architectural career was just beginning.

Such challenges included:

- Creating a house design that would comply with two sets of building codes, endure 18,000 kilometres of transport over two months, expedite assembly by a team of unskilled labourers, and enable comfortable inhabitation after seven days;

- Optimising the thermal performance and liveability of one building for two climates in two hemispheres;

- Using architecture, landscape and interior design to explain New Zealand and its lifestyle to an American audience of 200,000;

- Realising an entire and complex project that required 100% external funding and in-kind support from as-yet unknown parties.

By predisposition, then, the project was not going to be simple: very little of the process and very few of the construction details were going to be standard in any way.

This thesis focuses on the critical design developments of the house interior, from a hypothetical design to the full-scale assembly of a 'kiwi bach' in the heart of Washington DC. The research and outcomes presented here are not necessarily all precedents for future building projects, but rather 'best-fit' solutions for the highly particular and constrained design situation brought about by the interaction of the range of logistical, legislative and economic controls, the dynamics of the wider team, and the demands of the Solar Decathlon competition.

The project as a whole can, and should, act as a valid precedent for future architectural projects with regard to research into modular construction, prefabrication, and the collaborative building process. The students that were involved will embark on their professional careers with the Solar Decathlon experience as a foundation for their future contribution to the construction industry.

0.1 The Solar Decathlon: A brief history of the competition, its goals and outcomes to date

In 2000 the United States National Renewable Energy Laboratory [NREL] partnered with the US Department of Energy to create what would become one of the world's leading architectural competitions in the fields of innovation and renewable energy technologies. Its goal was to encourage the building of 'a 21st century clean energy economy by helping to train the next-generation of American engineers and architects'[1] and by educating the participants and public alike about the potential for renewable technologies available on the domestic market.

The competition was named the Solar Decathlon, due to the ten sub-contests which made up the event. These contests were designed to showcase a holistic approach to renewable energy buildings; evaluating the houses on architectural design, efficiency and convenience of appliances and systems, thermal and visual user comfort and energy generation capabilities; with the ultimate goal of proving that solar-powered homes can be cost-effective and energy-efficient while also being attractive and easy to live in.

Proving a home's liveability ensured a significant focus on the interior features of the proposed designs, namely; a spatial layout expressing good design flow through comfortable, attractive and functional living areas; the social life of the inhabitants catered for with sufficient technologies and appliances and capacity of spaces for entertainment (tested via dinner parties and movie nights during the competition week itself); attractive and ample use of diffuse and direct natural and artificial lighting; and the inclusion of an ergonomic desk space enabling a home/ office scenario.[2]

September 2002 saw the first fourteen houses constructed on Washington DC's National Mall. From September 19 to October 6, 2002, more than 100,000 people visited the National Mall in Washington, D.C. to see the first-ever Solar Decathlon.[3] The event was a success and continued biennially from then on, growing in popularity, international participation and media buy-in. Breaking all previous records, the 2009 event attracted more than 300,000 house visits and more than two million website page views.[4]

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[1] US Department of Energy, EERE News (2011) *Department of Energy Considers New Venue for Solar Decathlon 2013: Competition Trains the Next Generation of Clean Energy Engineers and Designers.* August 01, 2011. http://apps1.eere.energy.gov/news/progress_alerts.cfm/pa_id=582 Page last viewed 14-08-11

[2] This was a required feature in the 2002-2009 competitions and a recommended feature in the 2011 competition.

[3] US Department of Energy Solar Decathlon *Solar Decathlon 2002 Overview: Visiting the Solar village.* http://www.solardecathlon.gov/past/2002/overview.html Page last viewed 18-04-12

[4] King, R. *Epilogue: Solar Decathlon Daily Journal - October 19, 2009*. http://www.solardecathlon.gov/past/2009/daily_journal_1019.html Page last viewed 18-04-12

0.1.1 Competition objectives

As can be seen in table 0.1 below, the ten contests and their weighting have been adjusted slightly over the years, with a trend towards more emphasis on communications, functionality and efficiency.

	COMPETITION YEAR + DISTRIBUTION OF POINTS									
	2002	pts	**2005**	pts	**2007**	pts	**2009**	pts	**2011**	Pts
SUB-CONTEST	Design & Liveability	200	Architecture	200	Architecture	200	Architecture	100	Architecture	100
	Presentation & Simulation	100	Dwelling	100	Market Viability	150	Market Viability	100	Market Appeal	100
	Home business	100	Documentation	100	Engineering	150	Engineering	100	Engineering	100
	Graphics & Communication	100	Communications	100	Communications	100	Communications	75	Communications	100
	Comfort zone	100	Comfort zone	100	Comfort zone	100	Comfort zone	100	Comfort zone	100
	Refrigeration	100	Appliances	100	Appliances	100	Appliances	100	Appliances	100
	Hot water	100	Hot water	100	Hot water	100	Hot water	100	Hot water	100
	Lighting	100	Lighting	100	Lighting	100	Lighting design	75	Affordability	100
	Energy balance	100	Energy balance	100	Energy balance	100	Home entertainment	100	Home Entertainment	100
	Getting around	100	Getting around	100	Getting around	100	Net metering	150	Energy Balance	100
	Total	1100		1100		1200		1000		1000

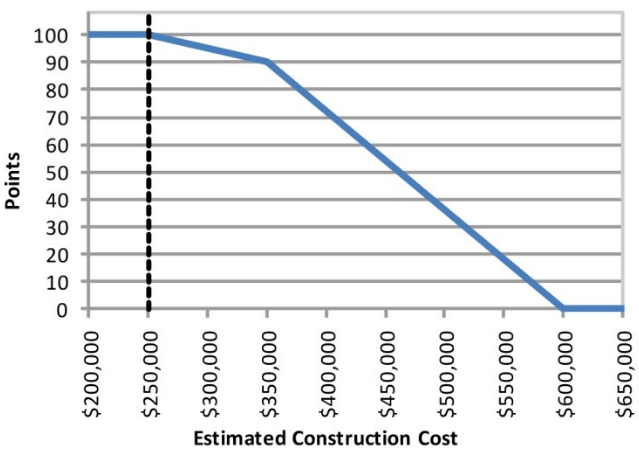
Table 0.1 Sub-contests and points distribution in the US Solar Decathlons 2002 - 2011

The early competitions' focus on surplus energy generation (50 bonus points in 2009 and an extra 100 point sub-contest, '*Getting Around*', in 2002-2007, won by a house-charged electric car travelling the greatest distance) meant that increasingly high-specification and high budget houses were being entered into the competition. In the 2009 Decathlon, two of the entries were categorised in the USD$650,000 to $850,000 price range. Only 35% of the houses were valued below USD$450,000, and only one of the twenty houses cost less than USD$250,000 to build.[5]

[5] US Department of Energy Solar Decathlon *Solar Decathlon 2009 teams*. http://www.solardecathlon.gov/past/2009/teams.html Page last accessed 05-03-12.

The Department of Energy had set the maximum house footprint at 90m^2, which meant that construction costs were averaging USD$6000 per square metre for the 2009 entries. This trend was severely limiting the potential market uptake of such designs and jeopardising the whole ethos of the competition, which was to show the general public the relative ease of converting to a zero-energy housing option.

To remedy this, a new sub-contest was introduced in 2011 and the houses opened up to a wider market. The '*Affordability*' contest would award the full 100 points to houses valued below USD$250,000. Any construction above this limit would be penalised with proportional points deduction. As a result of this, 95% of the 2011 entries came in under $450,000. In tandem with the new sub-contest, '*Net Metering*' became '*Energy Balance*'. It was no longer a strategic benefit to produce great amounts of surplus energy but rather to balance energy production with consumption. The design focus shifted to energy reduction and efficiency rather than excessive generation.



Full Points:		Cost	≤	$250,000
Reduced Points (shallow):	$250,000 <	Cost	≤	$350,000
Reduced Points (steep):	$350,000 <	Cost	<	$600,000
No Points:		Cost	≥	$600,000

Figure 0.1 Affordability sub-contest scoring criteria for the 2011 Solar Decathlon

0.1.2 The competition evolves beyond the USA

In 2007 a memorandum of understanding was signed with Spain, and in July 2010 the first European Solar Decathlon was held in Madrid, which included teams from Europe, the USA and China. The second European event, in 2012, will be the most international edition held so far, with twenty teams from fifteen countries taking part: Germany, Brazil, China, Denmark, Egypt, Spain, France, Hungary, Italy, Japan, Norway, the Netherlands, Portugal, the United Kingdom and Romania.[6]

Yet the Solar Decathlon competition grows ever more global: in 2011 a memorandum of understanding was also signed with China's National Energy Administration, with a view to the first Asian Solar Decathlon being hosted in Beijing in 2013, and plans are in place for an Australian Solar Decathlon to be held in the future.

[6] Solar Decathlon Europe: *Competition 'More with Less' [emissions].* http://www.sdeurope.org/?p=2955&lang=en Page last viewed 11-08-14

Figure 0.2 The global development of the Solar Decathlon brand

0.2 The Solar Decathlon reaches New Zealand

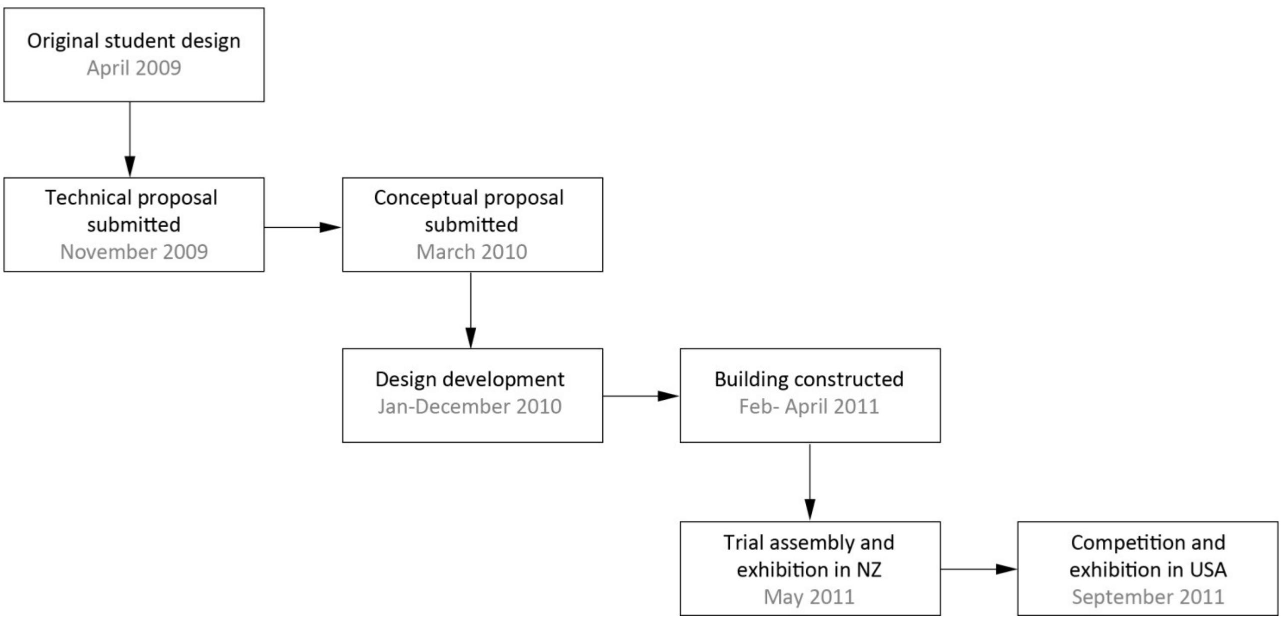


Figure 0.3 Overview of New Zealand's involvement in the Solar Decathlon

In Wellington at the start of 2009, Professor Roy Fleetwood[7] introduced a Bachelor of Architecture paper built on the concepts underlying the Solar Decathlon competition. He saw real opportunities to boost the profile of New Zealand design and to use good design to compete in the global market.[8]

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[7] Professor Fleetwood (Head of the School of Design at Victoria University Wellington from 2005-2007) is a keen innovator, renowned architect and design strategist with an array of significant research, design and structural projects around the world, including the Namerikawa Manufacturing and Engineering Centre for YKK Architectural Products Inc. and the Setagaya Museum of Literature in Tokyo (http://en.red-dot.org/561+M5c3462656bc.html, Page last viewed 07-05-2012). As the Managing Director of Foster Associates Architects and Engineers in Hong Kong and Sir Norman Foster's associate in London, he was responsible for the New Headquarters building for the Hong Kong Shanghai Banking Corporation and the Sainsbury Centre for Visual Arts at the University of East Anglia in Norwich.

(http://www.royfleetwood.net/Office_for_design_strategy/Roy_Fleetwood_Hong_Kong_Bank.html Page last viewed 07-05-2012)

(http://www.fosterandpartners.com/Projects/0188/Default.aspx Page last viewed 11-05-2012)

[8] Designers Institute of New Zealand, character profile for BEST design awards judges, 2004. Last accessed 05-03-2012 http://archived.bestawards.co.nz/2004/judges_product.html

SARC 383 required students to apply the lateral thinking and problem solving needed to develop a house design that met the complex brief posed by the US Department of Energy's Solar Decathlon. The students were required individually to research components of solar architecture. They were then assigned to design teams to prepare hypothetical entries to the international competition.

While the elective paper was merely intended to raise awareness about the issues related to solar architecture, and provide a chance for students to use the Decathlon as a framework for applying these to a design, the enthusiasm and encouragement from the outgoing Head of the School of Architecture, Professor Gordon Holden, meant that the university began to think seriously about the possibility of a New Zealand entry to the 2011 Solar Decathlon.

The selected hypothetical design for this entry, which will be discussed in the Chapter 2, took the kiwi bach as an inspiration. From this start, the typology was evolved and its performance improved by adding solar and sustainable technologies that would make the home self-sufficient. This became the basis for a 30-page New Zealand proposal, submitted to the US Department of Energy in November 2009. The original project, entitled 'Life style' - a building styled on the way of life enjoyed by New Zealanders, was re-branded 'First Light' to reference the solar nature of the competition, and to highlight New Zealand's geographical location.

> *"New Zealand sits on the edge of the world – the first country to receive the sun each day. Our house will be powered by this 'first light', and will address all aspects of the ten Solar Decathlon contests, across their economic, environmental and social dimensions.*
>
> *Our concept ensures that our house is not only zero-energy and affordable, but also fits with what is renowned internationally as the New Zealand way of life. We are a society that takes pride in being self-reliant, family-minded, and with a love of the outdoors. We also like things to last."*[9]

In January 2010 the team received feedback from the organisers: New Zealand had been shortlisted into a group of 35 potential finalists who then needed to submit further information for the advanced selection process.

After a two-month development phase, the team submitted three panels representing a developed conceptual design, and a 1:50 scale model. This gained them a placement in the final twenty teams, and a site on the National Mall on which to showcase their proposed solar house.

[9] Victoria University of Wellington (2009) *New Zealand Solar Decathlon Technical Proposal*, p1

Figure 0.4 Conceptual design model submitted to the US Department of Energy in March 2010

So began nine months of intensive research and development into products, performance and buildability, which saw the eventual construction of the New Zealand Solar Decathlon house undertaken between February and May 2011. The changes made to the original student design, with a focus on the interior, and the development that led to the realised building on exhibition in Washington DC during September 2011, will form the body of this thesis.

0.3 Summary of the development of the New Zealand Solar Decathlon entry

0.3.1 Team developments

The student team behind the hypothetical design and the November 2009 and March 2010 submissions were four architectural undergraduates: Ben Jagersma, Anna Farrow, Nick Officer and Eli Nuttall.

Now that New Zealand had been confirmed as a Solar Decathlon 2011 competitor the project was real, and infinitely more complex: the team's organisational structure, until then a flat hierarchy, needed to develop, and the team itself needed to grow.[10]

Not only did all the 'normal' processes involved in designing and detailing a house have to be undertaken; the house had to be completely funded by sponsors; logistics had to be put in place to construct the house, disassemble it and move it to a test site in Wellington, and then, following a second disassembly, to transport the house and its landscaped setting from New Zealand to the United States. Further considerations were that the structure and electrics needed to comply with the code requirements of both countries; and on arrival in Washington DC the home was to be ready to live in after seven days. In

[10] Refer to Officer, N. (2012) *Everything but the building* for an in depth discussion on the project's organisational and management structures

addition the interior had to be fitted out with fit-for purpose furniture and equipment, all of which needed to be selected or specifically designed.

The original four team members took on postgraduate status, and assumed leadership roles for separate aspects of the project, as shown in table 0.2 below. From now on these four students will be referred to as the 'project team'.

Managerial role	**Student leader**	**Responsibilities** (the competition's ten judged sub-contests have been highlighted)
PR and communications	Nick Officer	Communications, Sponsorship, External relations
Structure and envelope	Eli Nuttall	Architecture, Logistics, Code compliance, Affordability
Technologies and building services	Ben Jagersma	Engineering, Comfort zone, Hot water, Energy Balance
Interior and landscape	Anna Farrow	Market appeal, Home entertainment, Appliances

Table 0.2 The First Light project divided into four leadership categories

Due to the complexity of the project, the volume of work to be undertaken, and the relative inexperience of the project team, this structure was essential, but non-standard: where in a conventional design process there would be one person making the design decisions for the building, there were now three.[11] The division of responsibility enabled focused support teams of undergraduates to be 'drafted' for each specialisation, the majority of whom would see the project through to its conclusion on the National Mall. Because this thesis chronicles the work done by the students working on the interior design, any mention of 'design team' will refer to this specific group of students from here on in.

At times this division of labour proved to be an amazingly effective way of working; roles and responsibilities were clearly defined, allowing each of the team leaders to concentrate exclusively on the tasks and problems that fell under his or her leadership role. However there were occasions when this arrangement caused difficulties. Management structures above the project team failed to schedule the project timeline effectively. In July 2010 this management issue was addressed; however the former time slippages resulted in a condensed and highly stressful period of time for detailed design.[12] It was often hard to coordinate certain house items that fell into two categories, as decisions were being made independently, under pressure, and at different stages of the process as needed by their respective managers. One of the most difficult design overlaps, or the least-successfully coordinated, was the central module. Conceptually this was the overlap between the exterior and the interior and, until the construction was taking place, it was not decided whether this was to be detailed as an outdoor space, or

[11] The four original students comprised the 'project team', of whom three were now responsible for the architecture of the future building.

[12] Officer, N. (2012) *op. cit*. p68

an indoor space. This lack of definition meant that a lot of decisions and drawings were made on-site, causing more stress than was necessary in an already tight timeline.

Again, as the purpose of this text is to focus on the interior developments of the First Light house, the diagram below shows (relative to the interior) the key overlaps in responsibilities of the three design leaders, and lists those that required the most coordination and negotiation, many of which will be discussed in the following chapters.

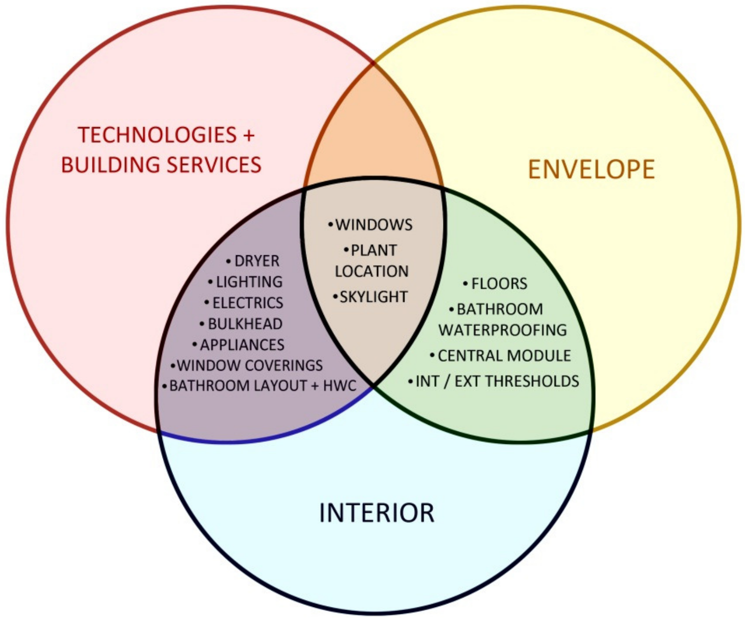


Figure 0.5 Design responsibility overlaps between the interior and the envelope and building services categories

By the end of the construction process, over forty students had worked directly on the First Light house, and more than five hundred students across the university had used aspects of the project as the basis for their undergraduate assignments.

Figure 0.6 (left) The original four student team members with their conceptual model. PHOTO CREDIT: ROBERT KITCHIN, DOMINION POST (right) The thirty-strong competition team in front of the finished house in Washington DC.

0.3.2 Building developments

The original SARC 383 design adhered to the general principles provided by the Solar Decathlon competition details but as it was initially intended to be no more than a hypothetical investigation, the intricacies of the rules had mainly been overlooked.

Acceptance into the Solar Decathlon brought with it the realisation that a lot of development was needed for two main reasons: to get the house successfully from NZ to Washington DC and assembled in 7 days; and to comply with, and excel in, the many requirements of the competition.

The changes required to carry the design ethos successfully from concept to realisation ranged from the fundamental structure of the building, to the systems utilised in the day-to-day operation of the house, to the materials, finishes and articulation of the interior components. This text will focus on the processes which influenced the interior design development of the house. The three other managerial students mentioned in table 0.2 have reported on the applied research undertaken within their respective leadership areas, and their findings have been cross-referenced in this text.

The changes to the interior can be grouped under two main influencing factors:

- A change in the construction and transportation method for the house
- Strict and comprehensive adherence to the competition requirements

These altered, respectively:

Construction / transportation method	**Competition requirements**
Base unit for construction	Interior and landscape levels
Ceiling height / overall dimensions	Internal dimensions
Location of plant	Wall / glazing ratio
Articulation / access to services	Articulation / access to services
Material selection	Material selection
Detailing	Detailing
	Capacity of house
	Furniture design

Table 0.3 Significant changes to the original student design needed due to construction, transportation and competition requirements for the house

This unique design process and the chain reaction of changes and developments caused to the building's interior will be reported on in detail over the following chapters, through written and graphic analysis. The thesis is broken into four parts, representative of chronological blocks of time corresponding to the major stages in the process:

- hypothetical design[13] (2009) to conceptual design (early 2010)
- developed design (2010)
- detailed design (late 2010)
- realised design: construction, competition and post-occupant evaluation (2011)

Part one discusses the project beginnings: the cultural importance and the typological characteristics of the traditional kiwi bach, the hypothetical design completed in early 2009 for SARC 383, the team's acceptance into the 2011 Solar Decathlon competition, and the first major design revolution due to this.

Part two explains the fundamentals of the bach design: its interior spaces, capacity and overall layout; revisited and redeveloped so that the house could be optimised for transport to the United States.

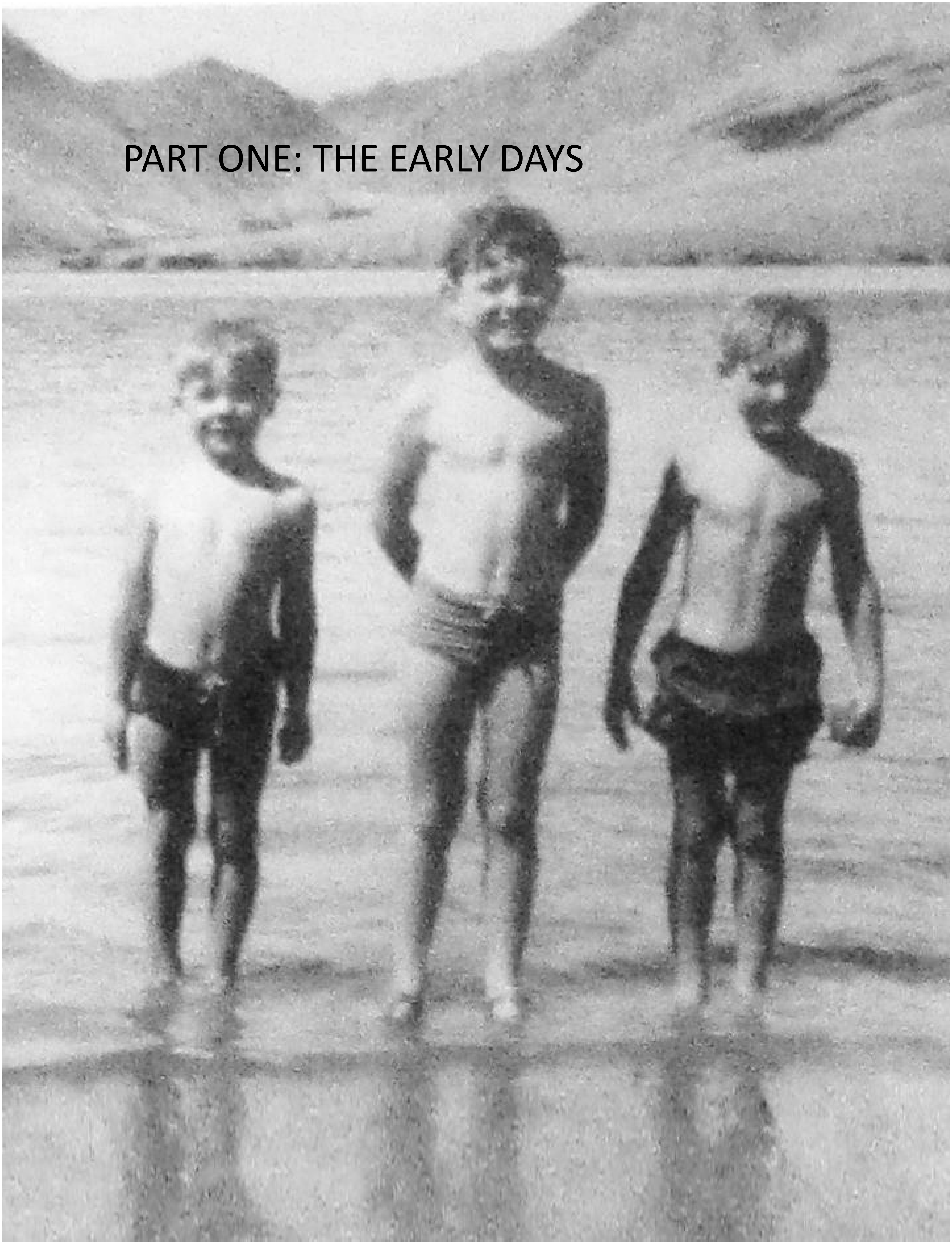
The details are described in **part three**, focusing on the interior design and material specifications made complex due to the thermal performance, modularity and public accessibility of the house.

In **part four** the final building will be presented and critically assessed in relation to the original student design of two years earlier. The concluding chapter will highlight the significant learnings occasioned by participation in the First Light house project, including some of the wider ramifications.

[13] 'hypothetical' and 'original' are interchangeable terms throughout the text. Both refer to the initial design generated by the four original undergraduate students for SARC 383 in 2009.

Figure 1.0 Detail of artwork by Kate Adolph, commissioned for the bedroom of the First Light House

PART ONE: THE EARLY DAYS



1.1 A New Zealand entry to the Solar Decathlon

> *"The starting point for our design proposal is the reinterpretation of the historic New Zealand holiday home, the iconic "Kiwi bach". From its origins in the 1930s as the simplest of shelters, sitting unobtrusively in the natural environment, it transformed over time to an expensive lifestyle choice, accommodating owners' demands for a wide selection of materials and rising comfort levels. Paying attention to the essential soul of these modest shelters, we now look at reclaiming the bach as an affordable option. Employing the principles of simplicity and self-sufficiency and combining these with innovation, our design addresses energy issues for contemporary residential houses."*[14]

From the moment the US Solar Decathlon was introduced in SARC 383, the team wanted their hypothetical New Zealand entry to present a uniquely kiwi vision to the previously Northern Hemisphere dominated competition. The bach as a design generator was immediately adopted.

1.2 The bach in / as a part of NZ culture

Figure 1.1 Original bach on Lake Tarawera PHOTO CREDIT: *Time regained.* Home New Zealand Jun/Jul 2008

> *"The archetypal kiwi holiday plays out in the minds of nostalgic New Zealanders like a blotchy, sun-exposed film. Everyone can remember a holiday – or a childhood – packed into the family bach: living on top of one another, eating simply, making up games to pass the time and venturing into the dark night for a trip to the infamous 'long drop.'*

[14] Victoria University of Wellington (2009) *New Zealand Solar Decathlon Technical Proposal*, p1

> *New Zealand is a country of extremes: from its balmy North Island beaches to its frozen Southern fjords; and right down the entire length of the country the bach - or crib as it is called in the southern South Island - can be found, regardless of climate or topography. It is a part of the New Zealand holiday life, seen as a sleeping post at the end of a long day in the sun OR as a shelter in which to huddle while waiting for the ski field to reopen after the snow. It has risen to icon status in the national culture."* [15]

In pioneering times, the verb *to bach* described a simple, uncivilised way of living: "a kind of domestic living arrangement typified by being temporary, uncivilised, communal and independent."[16]

Bach, therefore, came to signify the various huts and sheds around the country; places to house the activity of baching. Baches came into existence, or at least wide recognition, in the 1940s. They were traditionally small, unassuming dwellings cobbled together from materials of or near to the site in which they were constructed. As a result, New Zealanders from all walks of life began to share a common interest in – and ownership of – an unpretentious, economical, 'back-to-basics' holiday experience in the New Zealand wilderness.

At the time of the inception of the bach, ostentation and 'showiness' were not acceptable societal traits; simplicity and modesty were preferred.[17] A great number of New Zealand citizens owned a bach; indeed, in 2002 it was believed that there were still almost 40,000 baches around the country.[18] Baches came to mean equality.[19]

The 1960s and 1970s saw a second generation of baches evolve. These were set further back from the beach, largely due to the occupation of the prime beach land by the earlier generation.[20] Owning land by the sea became desirable in residential terms, and the price of coastal properties started to climb. New holiday 'suburbs by the sea' started developing. The 'bach' acquired a fence, a mown front lawn, an additional couple of bedrooms and a driveway leading right up to the front door. Consequently, the traditional bach seemed to be in decline. Nigel Cook remarked, "Its [the bach's] day has gone as surely as that of the villa and the mid twentieth century state house."[21]

However it eventuated that the traditional bach, although no longer experiencing the construction boom it did in earlier times, is still an important concept in the national culture. The idea of the simple life and pioneering spirit is still seen in such articles as Skinner's investigation of 'Man Alone".[22]

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[15] Farrow, A (2009) *The Simple Life,* p6

[16] Wood, P (2000) *The bach. The cultural history of a local typology,* p53

[17] Thompson, P (1985) *The Bach,* p9

[18] Cook, N (2002) *Living in the view,* p64

[19] Walker, P (2001) *The bach,* p44

[20] Lowe, P (1995) *Survival of an icon: the great New Zealand bach,* p5

[21] Cook, N. *ibid.* p65

[22] Skinner, R (2008) *The Whare in the bush: Unpacking a twentieth Century tradition.*

"Detached, simple living quarters, often a single room without conveniences...
A no frills place"[23]

1.3 Typological characteristics of the bach

As precedent for the original hypothetical design, research was undertaken on the kiwi bach. A literature review investigated the design of a series of contemporary baches featured in recent architecture periodicals, and a range of New Zealanders were interviewed about their experiences and perceptions of the bach and bach life. This research, entitled 'A simple life' defined the following typological characteristics of the bach.

1.3.1 Form

In keeping with (or perhaps as a precursor to) the national 'pragmatist' stereotype, and due to the out-of-the-way locations, the materials of which a bach was constructed were generally carried to the site with, and constructed by, the same hands. As a result the baches were simple, boxy constructions with minimal interior partitioning and sparse embellishment.

The majority of the baches studied were single level, predominantly monopitched structures. Linear plans and rectilinear, boxy volumes (whether single storeyed or not) were combined to create simple, uncomplicated forms. There were a few deviations from the rigid linearity of the plan, such as angled walls or bedroom wings, or curved rooflines, but on the whole the constructions were long and low slung with an emphasis on horizontality rather than verticality.

Figure 1.2 Bach in the Coromandel PHOTO CREDIT: New Zealand Home and Entertaining Dec/Jan 2003

[23] The Oxford Dictionary

1.3.2 Layout

Almost all of the baches studied were concentrated around an open plan kitchen/ living/ dining/ outdoor deck arrangement. In many cases the deck doubled the living space available to the inhabitants. Bi-fold or sliding doors opened right up, creating a seamless extension of the living area into the outdoors. It is clear that the deck is a major part of the atmosphere, life and daily routine of the bach. It faces the views and the sun, and often there is a second deck out the back for different weather conditions.

An absence of corridors and circulation space was evident. Another common feature was external access to the bedrooms, either by way of the deck, or by a pathway to a separate bedroom pavilion.

The number of bedrooms varied according to client brief, bach size and budget but most baches included a bunkroom, nook and/or areas that had the potential to double as sleeping spaces when visitor numbers increased. The ability to accommodate varying numbers of inhabitants was an important factor in the bach layout.

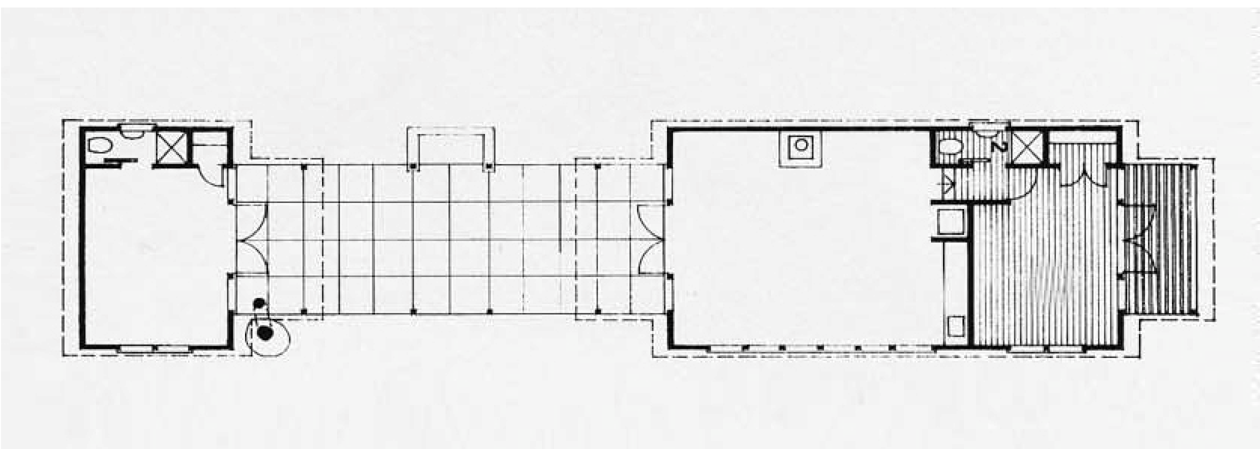


Figure 1.3 Bach in Martinborough PHOTO CREDIT: New Zealand Home and Entertaining Dec/ Jan 2005 pp116-120

1.3.3 Levels

The floor level of the bach tended to be raised slightly off the ground, even if the overall image of the bach is long and low-slung. The outdoors is very much acknowledged and brought into the house by way of extensive glazing, sliding doors, walls and deck areas, but the ‘inhabitation’ threshold is signified by having a step or two up from natural ground level.

The extension of the deck along and/or around the house dissolves the definition between inhabited space and the natural environment, often wilderness.

"There was an ordinary timber deck with corrugated translucent corner balustrades. The rest of the balcony was open. It was one step up from the ground, and level with the interior of the house." [24]

Figure 1.4 Bach in Pauanui; a modern reworking of the concept PHOTO CREDIT: House NZ Issue 2, 2006 pp76-82

1.3.4 Relationship with the environment

The form of various baches remains remarkably standard. However, each seemed to respect its particular environment. Baches in beach environments tended to take on a sandy or tussocky appearance with textured (slatted and louvred) envelopes in naturally weathered materials. Bush environments were complemented by darker baches that receded into the foliage.

A general respect for the colour and the nature of the sites was observed in the majority of the constructions.

The fact that the bach was built for, and looking towards, the views was a major consideration. Indeed, it was the second most mentioned characteristic of the contemporary bach design, regardless of whether the view faced north or south. The view took precedence and the design had to provide a solution for daylight and sunlight access to the interior.

Many baches had a direct relationship with the immediate landscape through the way the interior literally opened up. The dissolving of the enclosure and boundary between outdoors and indoors meant that the surroundings had a definite influence over the exterior appearance and the interior living quality of the baches.

[24] Whare Timu describes his childhood bach at Lake Taupo. Farrow, A. *op cit*. p16

"You look out to the landscape- it's "straight out there." –it's a part of the bach, the wind, the waves crashing on the beach can always be heard inside. It is as much a part of the environment and it has a good view."[25]

Figure 1.5 Bach at Lake Tarawera PHOTO CREDIT: Home NZ June/ July 2008 pp104-114

1.3.5 Materials

Simple, durable materials such as corrugated iron, fibre cement sheeting and timber have been used throughout the bach's history. Indeed, the material palette was the single most standard characteristic of all the baches in the contemporary magazines. There was a predominance of natural plywood sheet lining on the interiors. Cedar was used widely for cladding in board and batten or weatherboard form.

Nowadays, the recycled, D.I.Y. nature of the traditional bach is disappearing, but there seems to be a determination to stick to traditional materials in the contemporary bach. Perhaps the use of materials is not just a romantic adherence to the bach tradition of old, but a realisation that these materials were used because a bach had to be built to last. Low maintenance, robust, practical materials and spaces were important considerations to the bach owners in the Simple Life study.

Figure 1.6 Typical bach materials, inside and out. PHOTO CREDITS (L-R): New Zealand Home and Entertaining Dec/Jan 2001/02, Dec/ Jan 2005, Dec/ Jan 2001/02, Dec/ Jan 2006/07

[25] Gill Godfrey describes the special relationship the bach has to the New Zealand Landscape. Farrow, A. *op cit*. p18

1.4 Areas needing development in order for the bach to remain a viable building type and therefore continue to be culturally significant in the 21st century

The bach was a perfect candidate for redevelopment into a Solar Decathlon showcase of New Zealand architecture. Its iconic status and New Zealanders' affection for the simple building means that the bach will remain an important typology in NZ culture for years to come. However its tradition and the simple approach to life determined by this, means the bach typology needs an evolutionary change for it to remain a viable building type in the 21st century. The traditional bach was not sufficiently thought through or constructed in such a way that allowed for year-long inhabitant comfort.

The team saw this as a challenge, and an important goal of the project became to improve the sustainability and functionality of this popular building stock item. With New Zealand's developing construction industry many of the design problems inherent in the classic bach can be addressed. Materials can be used that are capable of withstanding the annual climate swings. Solar technologies can be employed to provide comfort and services to the bach's inhabitants. The bach can become environmentally friendly, make less of an impact on its surroundings and incorporate mechanisms that enable the bach to *give back* to the environment. Remote baches can utilise technologies that enable them to function autonomously.

1.5 Outline of the resultant brief for a NZ solar decathlon house

The aim of the project became: To reconfigure or reinterpret the bach so that it can function autonomously in a 21st century environment, while also retaining its quintessential 'bachiness'.

This aim echoed Cook's words of achieving "a tool to inhabit our places of peaceful freedom."[26]

[26] Cook, N. *op cit.* p65

For the original design the team of four contributed individual research on phase change materials, smart technologies, hydrogen energy, and the New Zealand bach, which when combined, resulted in the following two design drivers for a Solar Decathlon house:

1. **"A bach for the 21st century"**

The 21st century bach was to be an evolved form of the traditional kiwi building type, with energy efficiency and generation technologies added as both part of this evolution and to meet the requirements of the Solar Decathlon.

2. **"Passive solar design with a focus on phase change materials"**

The design was to be based on the concept of realising inhabitant thermal comfort through the use of radiant surfaces in the form of phase change material linings. The layout, glazing and material characteristics of the interior and the house envelope had to work together for optimum PCM performance.

At the same time the design was guided by the requirement for transportation to the United States, so the **prefabrication of the house and its components** became a key consideration in the design articulation.

In the preceding research on the New Zealand bach (discussed in chapter 1) the typological characteristics of a bach had been defined, and were to be used as a starting point for the spatial design. These are set out below with those related to the interior in bold:

- A **low, single-storied rectilinear form**, slightly raised off the ground
- A light connection with the ground
- A simple roof form
- **A simple layout with open plan living spaces and minimal circulation**
- A sensitivity to the environment through display of
    - **the blurring of the indoor/ outdoor definition**
    - **the use of colours, materials and forms that were sympathetic and respectful to the natural surroundings**
- **A simple palette of robust, low-maintenance, everyday materials.**

The very first conceptual sketch done by the team (figure 2.1 below) shows an immediate desire to create a central, pivotal space as the basis for the design:

Figure 2.1 The initial conceptual scribble, whose basic form and intention bear remarkable resemblance to the realised design of two years later

2.1 The LifE Style bach

The LifE Style design, as presented for SARC 383, had a long, linear plan which consisted of a simple interior layout with minimal circulation.

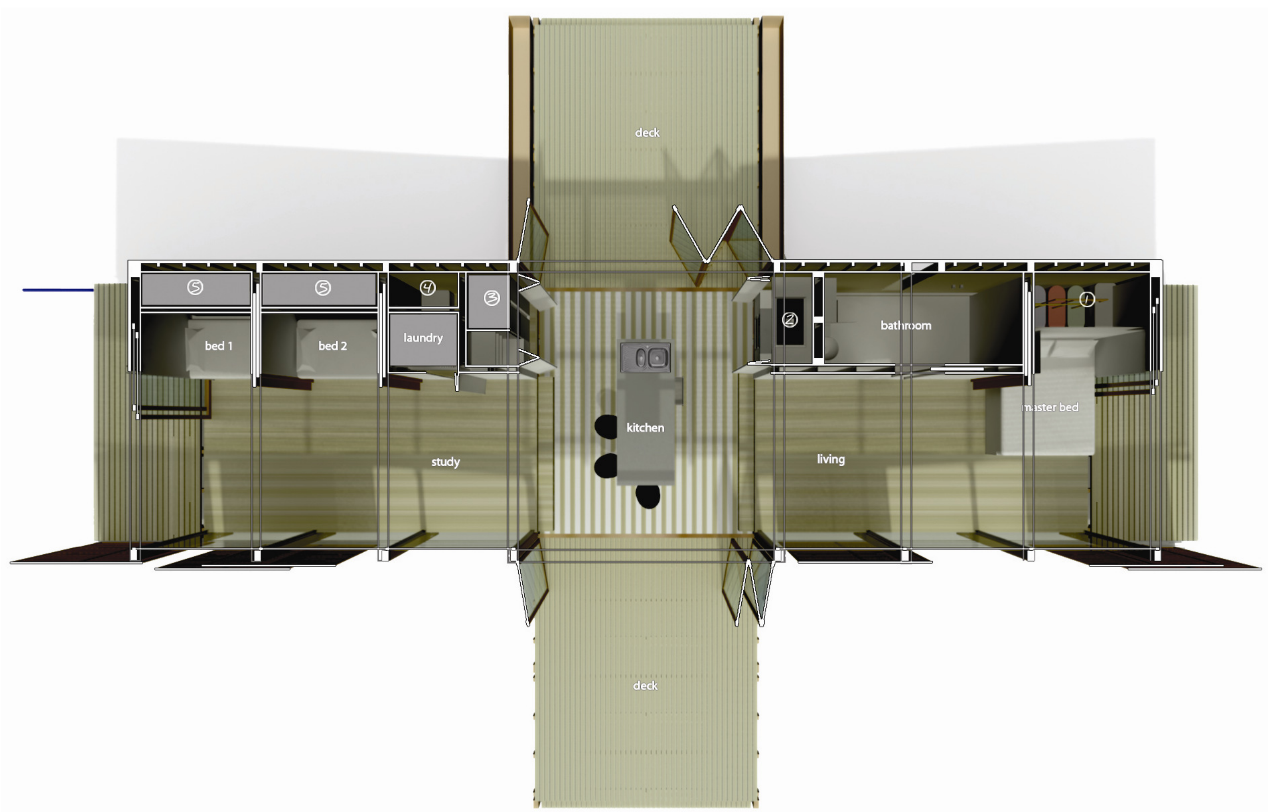


Figure 2.2 The original plan for the Solar Decathlon bach

The proposed design was uncomplicated in form. A shallow butterfly roof brought focus into the centre of the building, which was a fully glazed, fully opening pavilion containing a large kitchen island. This was to be the heart of the house, or the 'hearth' as it was described in the design report, where cooking, eating and gathering were to take place. In addition to being the social focus of the design, the central space was also the focus for passive services elements: rainwater was collected from this central roof; the glazed roof allowed sun penetration into the central flooring cartridges which contained custom-designed PCM inserts, and large bifold doors to the north and south opened to provide cross-ventilation to cool the interior spaces.

The rest of the interior layout comprised a long, open plan space to the north, intended to be a versatile, fluid living and sleeping area, and an enclosed services zone along the cooler southern side of the plan, which contained all equipment necessary for water storage, heating, delivery and filtration; energy generation and storage equipment; and functional spaces such as the bathroom, laundry and built in seating and sleeping areas. The northern wall of this services space was lined with microencapsulated PCM gypsum board, to act as the thermal mass.

Fully glazed to the north and two thirds glazed to the east and west, the bach's living spaces opened out to spectacular views of Lake Wakatipu in the valley below. Moveable shading systems and built-in louvres were incorporated into the exterior of the north elevation to control glare and to divert the sun from reaching the PCM surfaces during the summer. The low angle winter sun reached into the house interior, to fall on the phase change material on the services wall. This lining would store the heat energy from the sun and radiate it back into the house interior as the temperature dropped in the evening. Phase change material was used as a lining in the parts of the house that would affect the inhabitants' comfort the most, such as in the built in sitting and sleeping nooks.

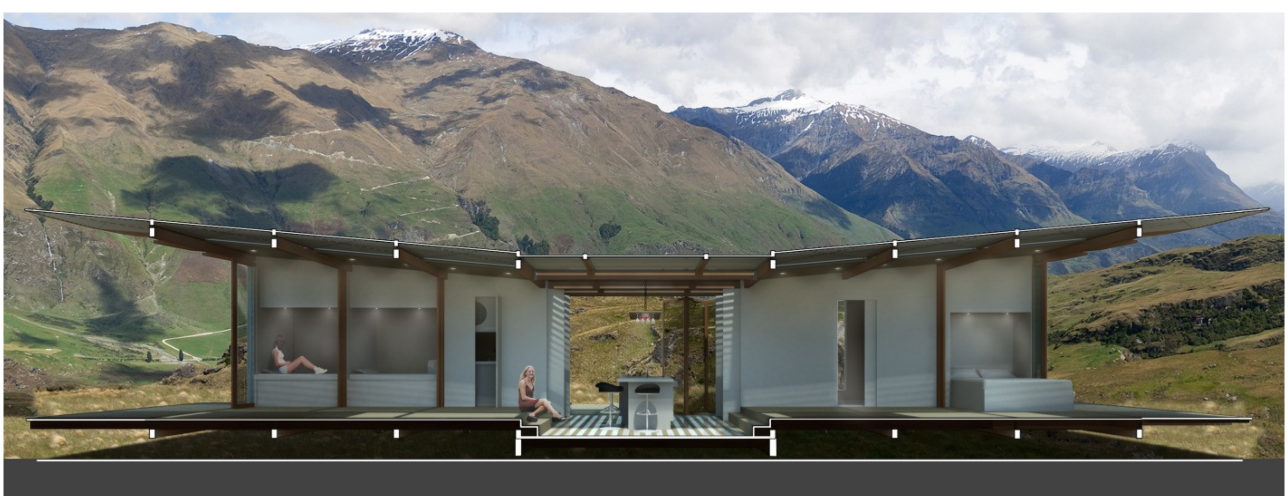


Figure 2.3 Sectional perspective showing the sitting and/or sleeping nooks in the services wall

2.1.1 'bachy' features

A bach is often shut down over winter or when not in use. The hypothetical design played with this idea, and kept the plan versatile by incorporating opening and closing features to partition or shut off space; to control sun access; and to keep the compact, minimalist interior tidy.

Another characteristic of the bach is its surprising capacity to accommodate a crowd within a small envelope. By increasing the versatility of the layout, the interior space could be maximised. It was for this reason that the northern part of the plan was left open and free of fixed furniture; the whole space could be used as a living room, or furniture could be moved to allow for the sequential partitioning off of bedrooms. The availability of sleeping spaces could also increase as the 'single bed' sitting nooks could fold out to become double beds.

While the images below demonstrate everything closed at once, it was intended, or imagined, that a combination of open and closed features would be employed to accommodate inhabitant needs at any particular time.

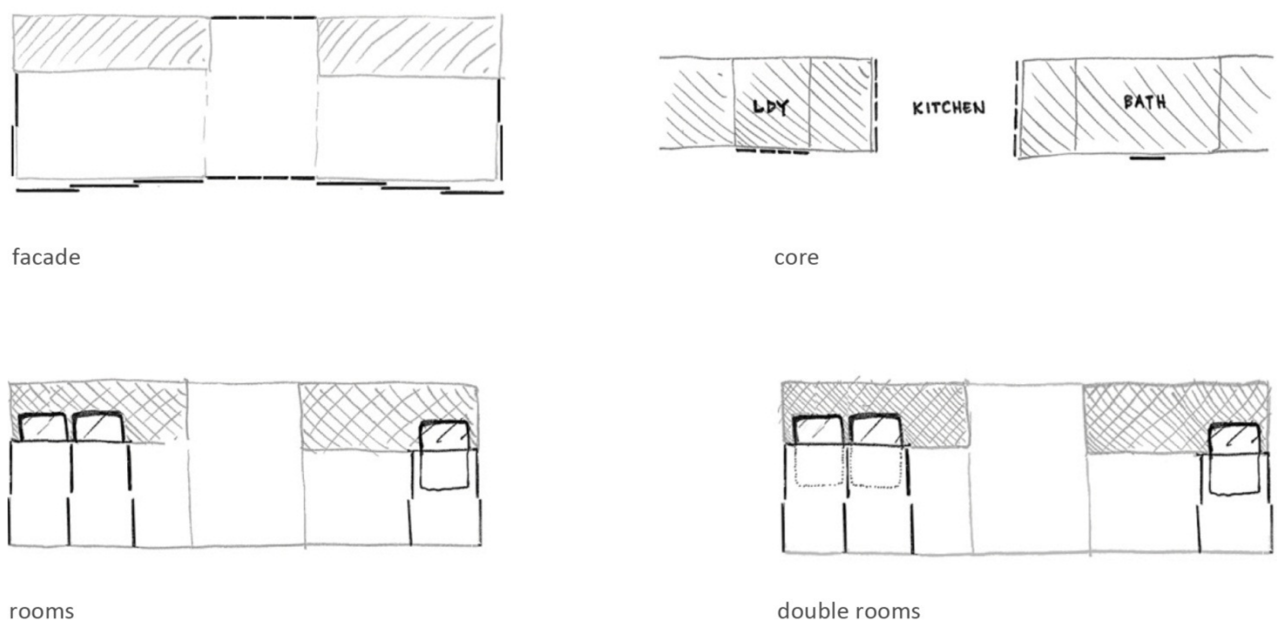


Figure 2.4 Clockwise from top left: an entirely closed envelope can be achieved by closing the glazed doors to the north, south east and west of the plan and by pulling the sliding screens over the north façade; the kitchen, bathroom and laundry can be closed into the services core; the services nooks can be screened off to cut down space or to provide privacy; and the 'single beds' located in the services nook can fold out to become double beds.

2.2 A bach evolution

An evolutionary step was achieved for the bach in a number of ways.

Firstly, the all-important relationship with the landscape was developed by directing the outdoors straight through the middle of the building. As can be seen in figure 2.4 below, this action has a dramatic change on the building's focus, and potentially on the way life is lived in the bach. The connection with the surroundings is strengthened as the inhabitants can be both inside and outdoors at the same time.

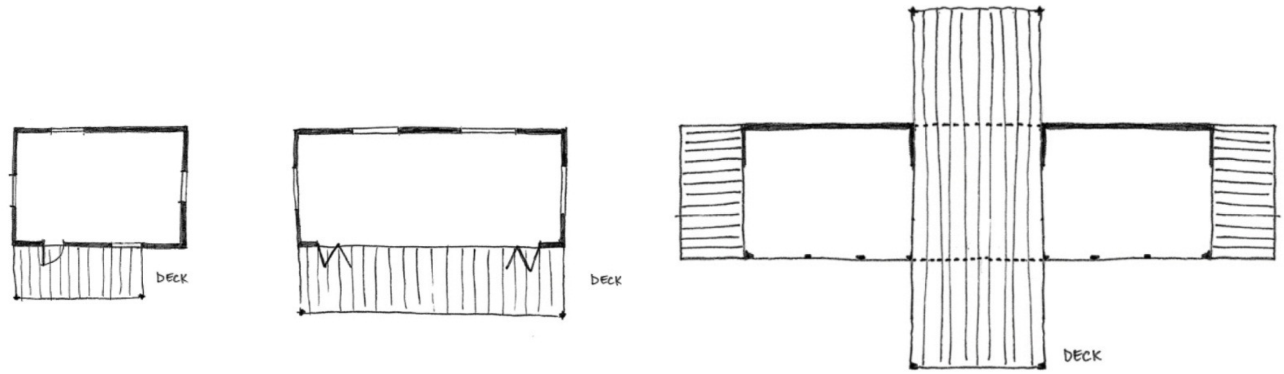


Figure 2.5 An evolved relationship with the outdoors: the traditional bach of the 1940s with its entry verandah (left); the contemporary bach with its deck as a seamless addition to the interior space (centre) and (right) the 21st century bach, where the outdoor space literally continues *through* the building

The definition between outside and in was dissolved further by the extensive use of [triple] glazing. External louvred screens could slide over this glazing; visually unobtrusive from the inside they would create an interplay of light and shadow on the interior, and allow activation of the PCM wall during the winter.

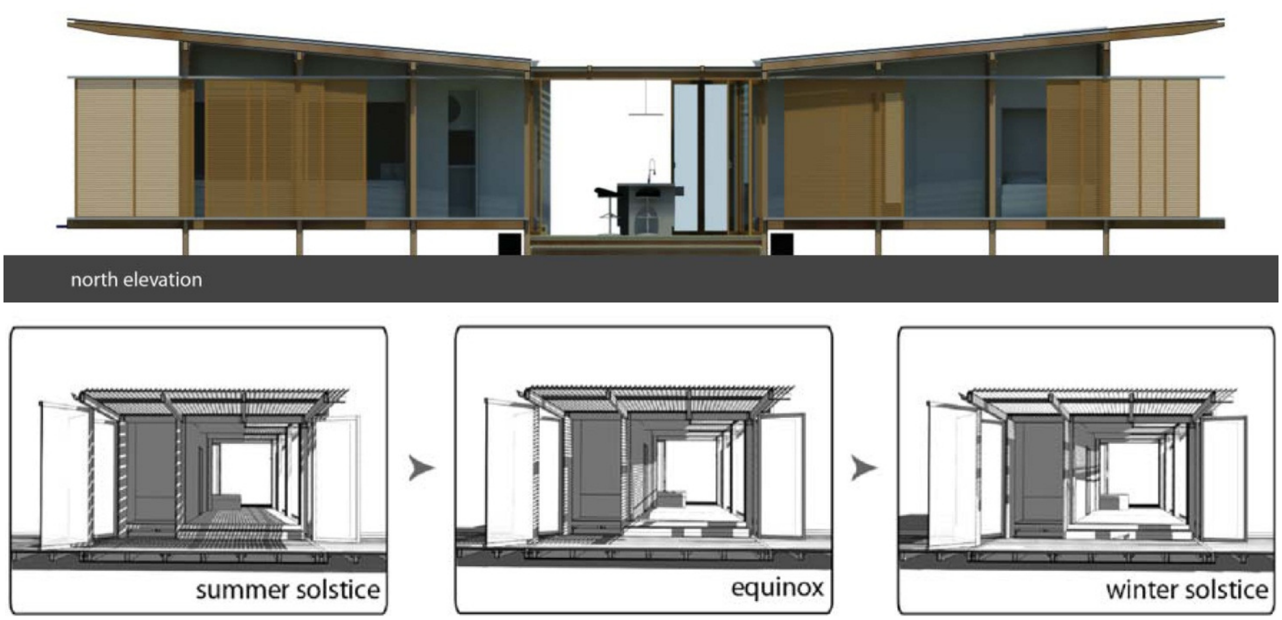


Figure 2.6 The sliding louvred screens on the north façade (above), and direct sunlight into the interior over the course of a year, shown without the screens (below).

Secondly, the bach was made autonomous through the design and specification of:

- Rainwater collection and storage
- Greywater filtration
- A composting toilet to eliminate blackwater production
- Solar water heating via a PCM heat exchanger
- Electrical generation; using thin-film solar laminates on the roof: it was proposed that enough energy could be produced to power a hydrogen electrolyser, splitting water and using the stored hydrogen as a ‘battery’ for when electricity was needed after sun down.
- Smart systems for home operation and security, such as sensors to turn lights off when not in use and to operate the external louvres in changing sun conditions

2.3 Construction

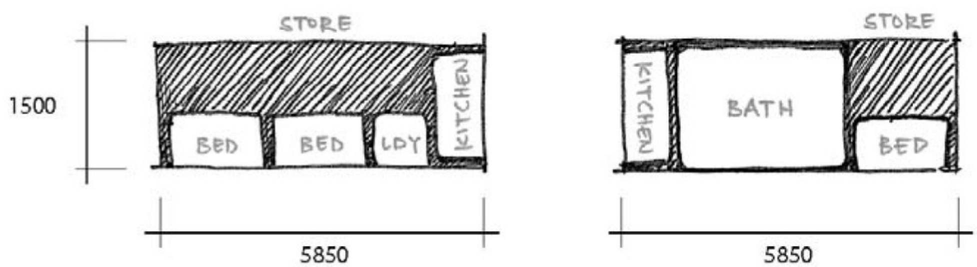


Figure 2.7 The services are prefabricated into two cores, sized to fit into a standard shipping container

The services space, divided into two parts by the transparent central pavilion, became the base unit for the construction, designed to be fully prefabricated off-site and transported complete in standard shipping containers. The rest of the house envelope was to be panelised and constructed around these cores once on the competition site.

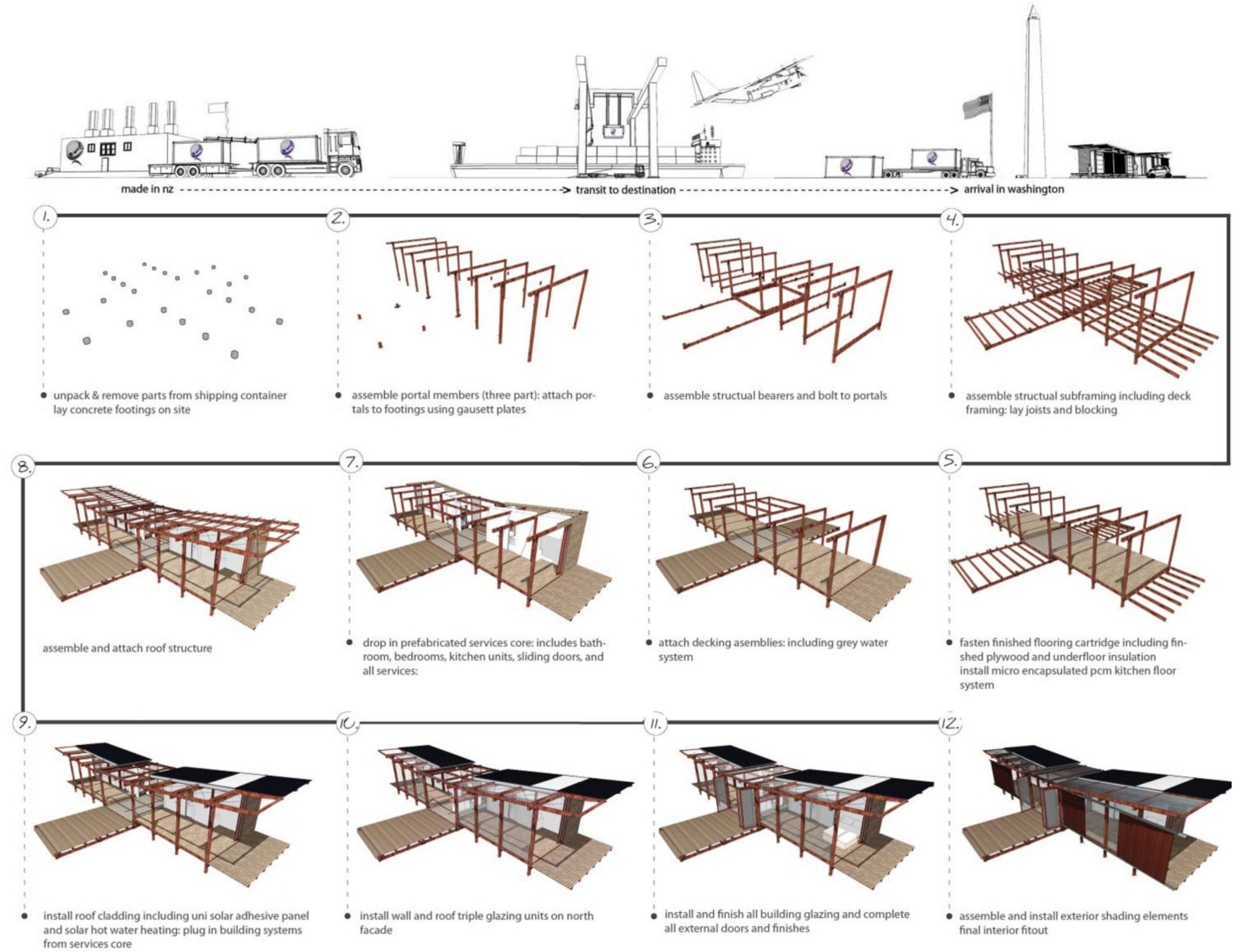


Figure 2.8 The assembly sequence, showing an LVL portal frame structure which supports a panelised envelope and into which the services cores are slotted. House assembly had to be complete within seven days.

2.4 Discussion

The original design demonstrated an attractive reinterpretation of the traditional bach. It remained true to the bach typology but presented an evolved form, where the key foci were emphasised and where the problems inherent in the traditional building were addressed using low-impact, self-sufficient solutions. A predominantly panelised construction with fully prefabricated services cores presented a credible construction process, and suggested ease of transport and an achievable assembly in the specified timeframe on site in Washington DC.

The house thus fitted within the Solar Decathlon framework and showed potential for a competitive entry to the 2011 event.

However the presentation's alluring imagery helped to conceal the fact that the project was still very under developed. From the exterior the simple, streamlined form was beautiful but its transparency, though attractive on paper, would not be practical for a contemporary home, nor for a competition whose main foci were thermal performance and energy efficiency. The layout and the materials specified had not been sufficiently considered with regard to liveability.

The transparency of the house bestowed a feeling of impermanence on the interior. The layout and the surfaces did not lend themselves to easy furniture placement. There was no wall space to hang paintings or install hooks; nor on which to mount a television [should the contemporary bach dweller desire one]; nor even to locate electrical sockets or light switches.

The entirely glazed living section meant that the occupants would lack privacy. During the day the louvered shades could provide an element of screening, but at night with the interior illuminated, they would provide an unbroken view from outside in. A lack of internal window coverings meant daily routines would be influenced by the sunlight; potentially causing inhabitants to wake up at sunrise as if on a camping trip. These omissions might be acceptable in the bach during the summer holidays, when the openness of the façade could be celebrated due to the expanse of rugged, unpopulated wilderness beyond the glazing, but to an American audience there was a probability that such 'qualities' would be perceived negatively.

The design was also very conceptual in terms of compliance with the Solar Decathlon requirements, whose intricacies were not explored or developed in any depth. The proposal adhered to the fundamentals of the competition with regard to the in-house systems and solar technologies specified, however it presented no hard data on the climatic characteristics of Glenorchy or Washington DC, or proof of the building's performance in these locations. The abundance of glass would probably have posed problems for the *'Comfort Zone'* competition, and even in New Zealand where the culture encourages acceptance of a wider internal temperature range, passive strategies alone would have struggled to maintain a comfortable interior environment. The lack of active thermal controls also suggested a naivety in the face of Washington DC's climate.

The *'Home entertainment'* competition specified the requirement for a greater entertainment capacity than that allowed for in the original scheme. In Washington DC the house would have to host up to eight guests at a time for 'neighbourhood' dinner parties; and the same number of visitors again for a movie night. The proposed design had no formal or structured dining space and only sat three in an informal situation around the kitchen bench. In the true manner of the traditional bach, a television had been deliberately omitted.

Most significantly, although the competition organisers encouraged innovation (and the solar technologies and energy storage systems proposed for the house were indeed innovative) the specification of a house powered by a hydrogen fuel cell was not likely to be granted permission on Washington DC's National Mall.

Overall, the original student project was an attractive design which showed potential for a successful New Zealand entry to the US Department of Energy's Solar Decathlon. It was, however, still in the very conceptual stages of development, and would need a lot of development work both to be accepted into the competition and be a legitimate contender for a top position in the 2011 event.

With acceptance into the Solar Decathlon came the realisation that a lot of development was needed.

The major changes made to the house following the conceptual submission can be attributed to two determining factors:

- A fundamental change in the construction and transportation method for the house
- The implementation and development of services and features necessary for compliance to the comprehensive - and strict - set of competition rules.

Finally, the aim was to excel in all aspects of the competition.

3.1 Construction and transportation method

The first major and fundamental change to the design of the house was the way it was to be constructed.

The conceptual design was proposed based on a flat-packed system, with solid services modules acting as the base components and determining the overall length of the building, and with the envelope being assembled around these base components.

The team's investigation into logistical considerations for the cost of transport and time of construction, which was only seven days for assembly in DC, and the required and available skill base of the potential construction team, led to the decision that this form of construction was potentially much more complicated and with more components than other approaches. As a result it would be more prone to delays or setbacks than a fully prefabricated modular system. The modular approach was therefore taken.

Table 3.1 below outlines the main comparisons between the two construction methods that led to the decision to go modular:

Prefabricated construction options for the First Light house	
Flat-packed construction	**Modular construction**
Services cores fully prefabricated with panelised house envelope constructed around services cores on site.	Greater level of prefabrication possible, on a bigger scale; less on-site construction required
Panelised envelope system suggestive of SIPs or similar custom-designed construction method	No preconceived limitations on module makeup - conventional timber construction a possibility
20 foot [6m] container defined length of services core and therefore length of house segment either side of central space	20 foot [6m] container defined length of module, max width of completed house <6m Total height of unit limited to 3.4m

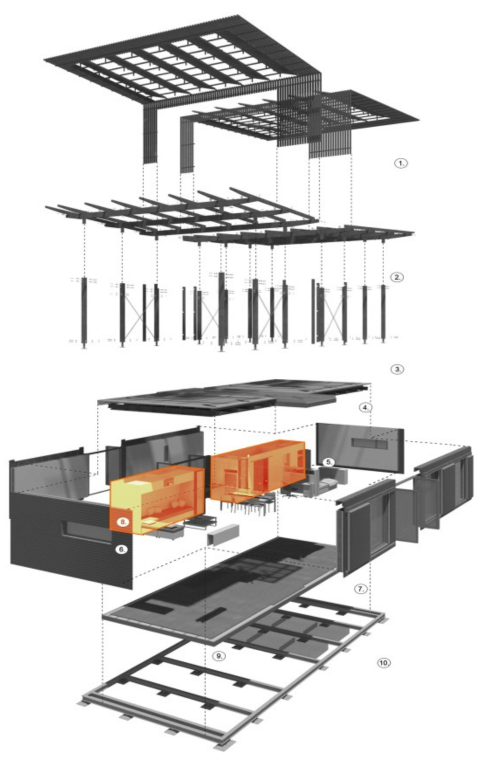
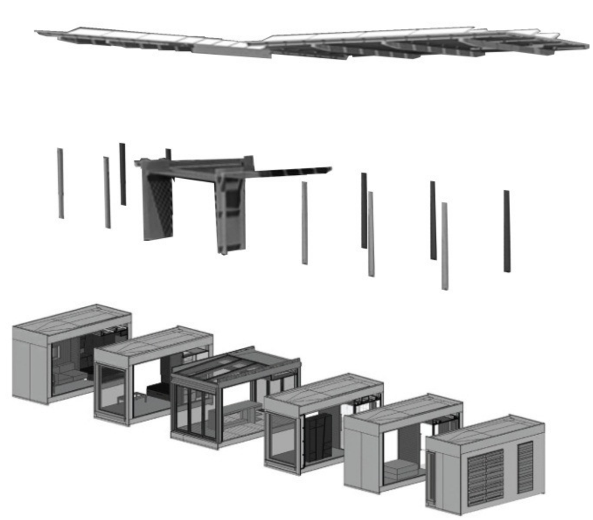
Base unit for canopy structure and repeating wall segment relatively arbitrary, only limited by what fits through doors of container in terms of panel size	Base unit for canopy and wall segment defined by maximum container width [2.44m] – length of house a multiple of this
Multiple unique joint details required [or at least numerous standard joints]	Small number of standardised joints repeated through design
Lowest common denominator relatively small – multiple unique components [wall, floor, roof, furniture] – possible to construct with manual labour alone	Lowest common denominator relatively large [wall + floor + roof] – not possible to assemble manually; mechanical labour required
Lengthy construction timeframe	Potential for construction timeframe to be very rapid
'Fine grain' assembly – all interior components packaged and transported individually and installed once envelope is complete	'Course grain' assembly – potential for much of the key interior componentry to be built in to module and transported as such
 Exploded schematic of the conceptual design showing panels ready for construction around services cores n.b. floors, walls and roof are shown post panel assembly (western wall in foreground would have comprised multiple panel units)	 Exploded schematic of the developed design showing fewer, larger components

Table 3.1 Comparison between flat packed and modular prefabrication options

All through the subsequent design development the time and skill level of the assemblers guided, or even dictated, the decision making process.

The aim of the prefabricated module was to reduce the number of loose components. This was beneficial for the interior of the house, saving assembly time at the DC site, and with the finishes and large furniture pieces built in they were less susceptible to major damage than if they had been individually packaged and stored in the container. On arrival in Washington DC the kitchen was practically ready to go, with its plumbing, wiring, cabinets and even handles installed. All that remained to do on site was to install the appliances, which demonstrates the time-saving capacity of the module over a panelised system.

This being said, the modular option increased the need for cautious consideration of the interior components throughout the project. During the initial build, precise detailing of situations where components were to come together across module joins was needed, as were strong or multiple fixings so that built-in components could withstand lateral and vertical movement in transit. When packaging the modules for transport, hinged components needed to be taped closed and all the edges protected. During on-site assembly the finishes needed to be treated with care while larger components were shifted about inside the building.

Figure 3.1 Lifting of the first module in Wellington; emphasising the need for care of edges and pre-installed furniture PHOTO CREDIT PAUL HILLIER

3.2 Competition requirements

The competition rule book, updated for 2011, was the other major factor to bring about change in the original design.[27]

As a part of the US Department of Energy's Solar Decathlon, the house was not only to be a good piece of architecture, but an international expo piece; one that had to communicate its liveability to a live audience of 200,000 and accommodate five to ten percent of this crowd over the ten day competition period. In effect the team was designing a 2 person home for 20,000 people, which required the interior and the landscaping to be fully accessible to American disability standards. This meant it had to be roomy enough to allow for the comfortable manoeuvring of a wheelchair through the space, but not so 'human traffic' oriented that the architecture appeared to be merely an exhibition setting, potentially compromising the home's market appeal, which was worth 100 points in a sub-contest of the same name.

The 'C*ommunications'* contest required not only a display of the liveability of the house but also an expression of its context. This meant its setting, its underlying principles, its form and its interior needed to tell the story of being a 'New Zealander'. From a series of brainstorming sessions undertaken prior to the developed design phase, where the original design intention was dissected and distilled, three main values were determined that would comprise the philosophy behind the First Light project's expression of 'New Zealandness'. These values were inherently linked to the typology and lifestyle of the kiwi bach, which favoured time and space for socialisation; a connection with the natural landscape; and a personal connection with the immediate built environment, the catchphrase for which became 'humanisation'.[28]

Not only did the house have to present a credible narrative of New Zealand and its lifestyle, it had ***to work*** in terms of thermal performance on a specified number of days in Washington's September. It needed to make visible the mechanical engineering behind the liveability as it was no longer possible to rely on the kiwi reaction of 'throwing the doors open' as a way of regulating the interior comfort of the building. In order to meet the requirements of the '*Comfort Zone'* contest the internal temperature was to remain between 21.4 and 24.7 degrees Celsius at all observable times during the competition week.

Based on the evaluation of the original design in chapter two, the amount of glass in the house needed to be reduced significantly. Now it was necessary to physically close the building too, and to keep the air inside it at a higher temperature than that most kiwis would traditionally recognise as comfortable.

This was going to require much work on the building envelope, and the installation of sophisticated building services. The 'bach' was growing in complexity… and the interior was going to have to change considerably to allow for the necessary technologies to be included.

Chapters 4 to 10 chronicle the challenges, solutions and chain reaction of design decisions that transitioned an undergraduate student project into a high performance building worthy of an international competition.

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[27] The Solar Decathlon 2011 rules relevant to the interior design, development and operation of the house can be seen in Appendix A.

[28] These underlying principles are discussed in detail in chapter 11, preceding the explanation of the final, built design.

3.3 Factors causing development of the house design

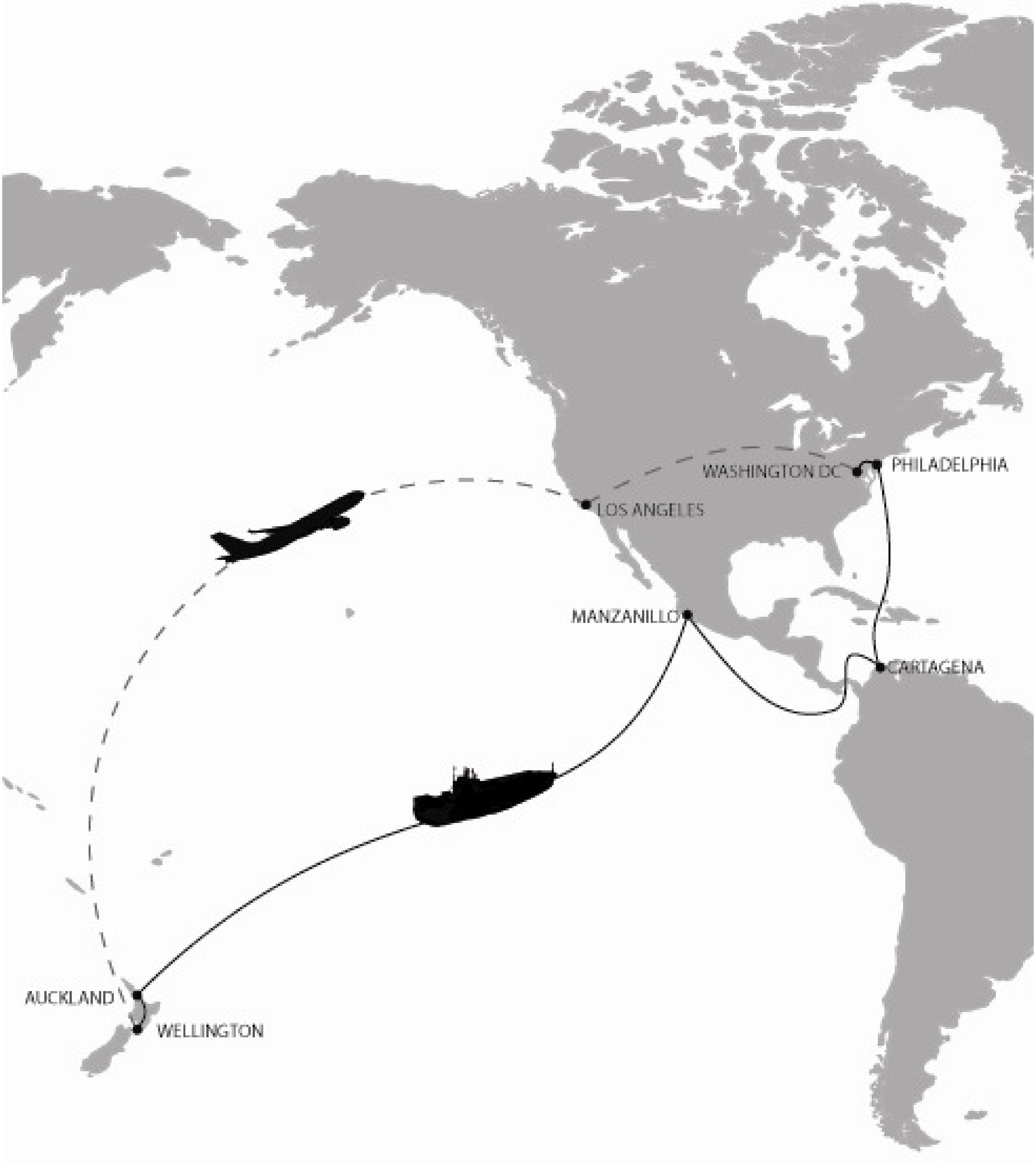
chap	MAIN INFLUENCING FACTOR	SIGNIFICANT CHANGE	DEVELOPMENTS / RESULTANT EFFECTS	CONSIDERATIONS	CONTRIBUTING FACTORS
4	Construction	**Flat packed > modular**	Optimum module size	Transport limitations [size]	
			Optimum house layout	Comfortable size of individual interior spaces	Market appeal : liveability Accessibility Home Entertainment Public tours
5	Market Appeal	**Capacity of House**	3 bedroom > 1 bedroom	Cultural expectations [size vs capacity] Number of modules	Home Entertainment Affordability Transport
				Aesthetics - form [symmetry?]	Architecture
6	Construction	**Location of plant**	Permanent setup of plant Dedicated plant space	Bulkhead Inter-module joins in services	
		Joins in services	Kitchen bathroom laundry water services kept to M4 - M6 to minimise water connections	Useable space in kitchen [sink no longer in island]	Market Appeal Architecture
7	Building Performance [Comfort Zone; Engineering; Energy Balance]	**Optimum thermal performance**	Window : wall ratio Glazing specification	Location of windows Downsizing of skylight Bulkhead continues over M3	Architecture - lighting MA - privacy
			Lightweight floor > massive floor		Construction
8	Construction	**Standard details for inter-module joins**	Natural interior linings	Design for air tightness Electrical services Access to bulkhead services	Building performance
			Tolerances	Detailing Material selection	Affordability
9	Construction	**Window coverings**	In-wall roller blinds	Aesthetics Continuity through house Future maintenance	Building performance
		Bathroom spans module join	Waterproofing details Removable components	Assembly Sequence Code Compliance	Accessibility
		Module three details	Flat-packed system	Assembly sequence	Architecture
10	Accessibility	**Public tour route**	Stepped levels into central space > no level change	Size and perceived size of central space Detailing of thresholds	Architecture
			Services core dimensions	Bathroom Layout Laundry layout Internal door type	Market Appeal
				Furniture Design	Architecture

Table 3.2 Major factors acting to change the original student scheme into the final design for the First Light house

A lot of these developments happened simultaneously but have been detailed chronologically in this thesis.

Figure 4.0 Transport methods for getting the First Light house and team to Washington DC for the Solar Decathlon competition

PART TWO: DESIGN FUNDAMENTALS



Transport to, and construction and assembly limitations in, the USA had indicated to the project team that the house needed to be modular rather than shipped flat-packed: the challenge was how to make it so. In the first instance this involved translating the original design into a modular configuration by reassessing spatial requirements and assigning logical module breaks to the floor plan.

There were a number of pre-defined limitations within which to work. In order to be shipped as standard cargo, a module would have to fit within the dimensions of a standard shipping container, with a maximum width of 2.44m, length of 6.0m and height of 3.5m.

The transport logistics described above meant that, because it would be very difficult to design a modular building that was cut lengthwise, the width of the building became the prime consideration – and that it could be no more than 6.00m wide. The length of the building would therefore be a multiple of 2.44m x 6.00m, or close to it. That is, the services core would need to be sub-dividable rather than being the prime determinant of the dimensions of elements as originally conceptualised.

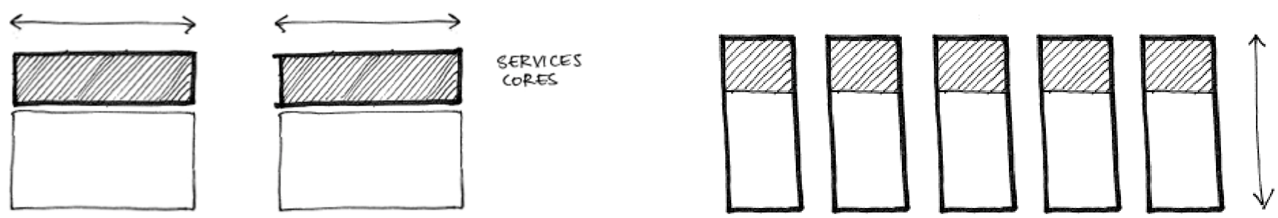


Figure 4.1 Plan diagrams showing a fundamental change in the structural makeup of the building from longitudinal to lateral.

NB: For the purposes of this thesis, all plans and plan diagrams are drawn with the north point facing straight up the page. The plans are oriented for the northern hemisphere and the living spaces therefore face south.

Far from a traditional design / build situation where the site, budget and client desires were the only factors to consider, there were additional unconventional factors influencing First Light's design decisions. The interior could not simply take up the space the design team desired. Instead, minimum comfortable spatial dimensions were used as the starting point. These were overlaid onto possible module configurations until a 'best fit' scenario was achieved. Furthermore, the internal space had to be configured so as to facilitate maximum public visitation and flow, with predicted volumes of 10-20,000 people over the competition week.

The layout, module size, and number of modules needed went through a number of schematic iterations and were ultimately determined according to the decision to make the construction as simple as possible. This was to be achieved through minimising the number of major joins involved. In addition cost considerations based on the cost of shipping a standard container unit meant that the total number of modules was limited. This was a stage of development in which the interior and envelope teams worked together side by side in a close, iterative process. Options investigated included configurations comprising four, five, six and seven modules of varying widths and lengths.

While the interior team worked on possible layouts and potential module sizes, the envelope team was investigating construction of module permutations. It was during this time that standard structural details were defined. These included inter-module connection details and the engineer's specification of a stainless steel tension cable to hold the modules together. It was not until later that a standard set of interior details was developed, however these early structural decisions formed challenges to the resolution of such details, which will be discussed in Chapter 8.

Following the extensive development done for the conceptual submission to the Department of Energy in March 2010, the rough configuration of the house was to remain the same, though some initial minimum-space development was done that involved using the study space as part of the lounge. Graphic investigations into the minimum space required, and resulting optimum layout of the house, are documented in this chapter.

While the minimum dimensions of the component spaces were being decided upon, the house layout as a whole was overlaid onto a series of different module dimensions. The module length was less critical than its width, as the house width had only to fall below the 6m (20ft) trailer deck limit. Having said this, a change to the length of the final module of even 100mm meant a footprint increase or decrease of approximately 1.4m^2 impacting the cost of the construction of the house and hence the affordability competition.

Many different module / layout best-fit options were investigated in CAD and, for various reasons, rejected as suitable solutions. Those decisions were moderated by the underlying values the team had established for the dwelling (and the project as a whole) in the initial developed design brainstorming sessions, discussed in chapter 3.2.

Of the options investigated, a selection has been presented here, starting from the smallest footprint the design team was comfortable with and working up in size as was deemed necessary. As can be seen in the following working drawings, it was difficult to get a best fit between the bedroom and module divisions: a bed of 2000mm length did not fit into one module on its own, but two modules provided too much space. This meant that at least two modules were necessary for the eastern half of the building but this configuration did not adequately separate the bedroom from the public areas of the house. Three modules and the inclusion of a study space on the eastern side meant too much space for this half of the house. The best fit involved using 'half modules' and it was proposed that they could be shipped together on one 2.44 x 6m trailer as if they were one complete module. With this solution the bedroom and living rooms could occupy one and a half modules each. However due to a perceived increase in difficulty during packaging, transporting, and on site assembly, this concept was eventually dismissed.

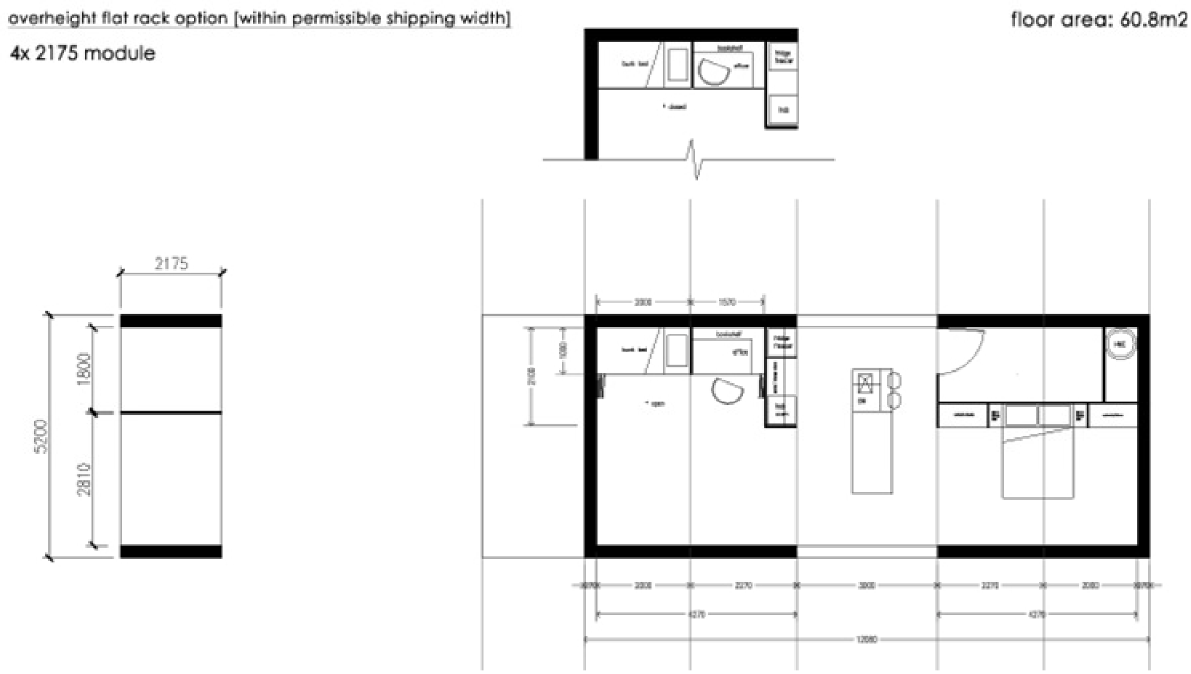


Figure 4.2 Configuration option comprising four 2175x5200mm modules

In figure 4.2, four prefabricated modules provide a 'comfortable minimal'. However, absolute minimum requirements for the kitchen did not present a good case for market appeal, nor did the direct access from bathroom/ laundry to the kitchen. The proximity of the dining area to the master bedroom meant privacy had not been adequately addressed.

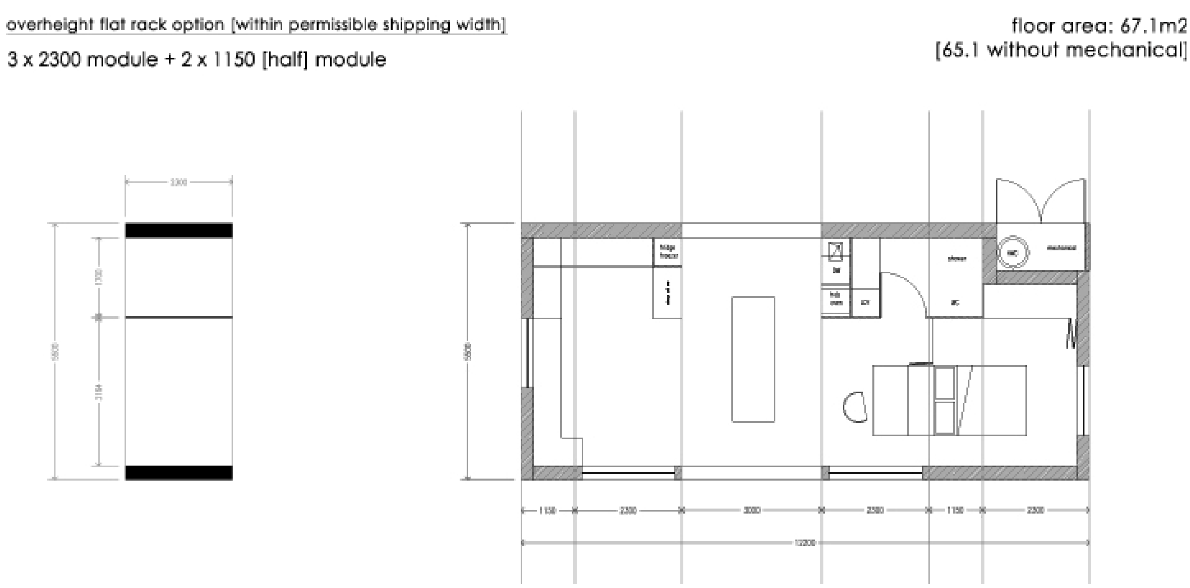


Figure 4.3 Configuration option comprising two 'half modules'

Employing one-and-a-half modules, the living room in the configuration above is reduced to its minimum comfortable dimensions, and opened up to the kitchen with a bar counter to connect but divide the spaces. Bathroom access has been improved, and the master bedroom is now one module away from the living spaces.

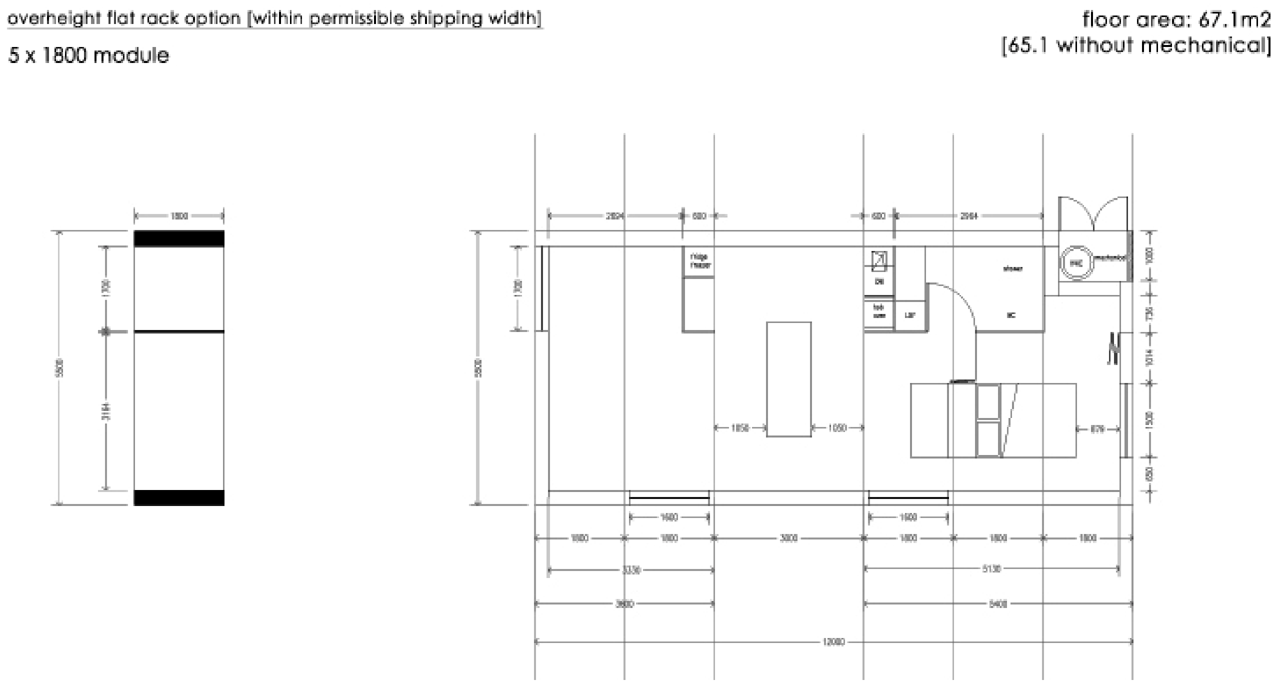


Figure 4.4 Configuration option comprising five 1800x5600mm modules

In figure 4.4 a narrower module keeps the dimensions to a minimum without having to employ half modules (but increases the construction by a whole module for the same footprint size). The spaces are compact but appear comfortable, though there is very little provision for mechanical equipment in the plan.

4.1 Solar Decathlon: specific considerations which influenced the final interior layout

4.1.1 Bedroom

Because space minimisation was an important factor in keeping costs down, even the idea of a non-permanent bedroom was discussed. This had been seen in previous entries, where the bed folded out or rolled away to provide living space during the daytime. This idea was dropped relatively quickly however, as it was deemed a significant inconvenience to have to set up and put away the main bed of the house every day. The decision to stick with a permanent bedroom was made with market appeal in mind.

Changing the orientation of the bed became a way of maximising visitation and accessibility to the bedroom. With the bed on the eastern wall, visitors did not have to circumnavigate the bed to complete the tour, thus shortening the overall time spent inside the house. Flipping the bed allowed for permanent bedside tables, allowed the partition furniture piece to be utilised on both sides, and strengthened the conceptual basis of the design by facing the furniture elements towards the centre and focal point of the building.

As such, the minimum spatial requirements for the bedroom, as seen in the investigative sketches below, were what determined the width of the living part of the house.

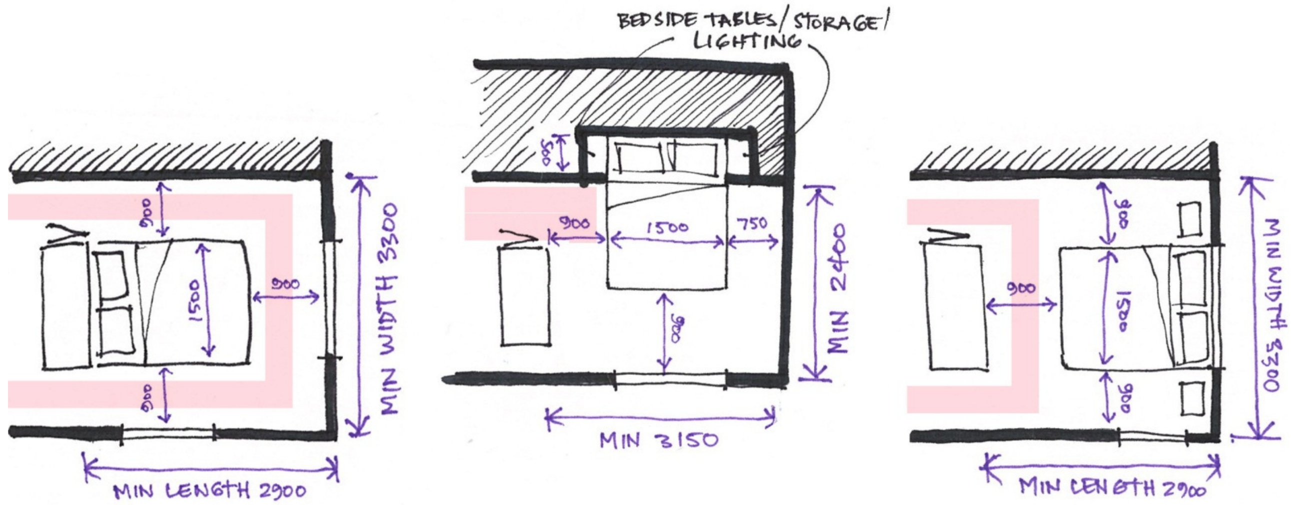


Figure 4.5 Different bedroom configurations test minimum dimensions needed, user comfort and ease of public visitation. The potential public tour route is highlighted in red.

4.1.2 Study

Until 2011, a home office had been a specified feature of the houses and was judged on functionality, ergonomics, lighting levels and even outlook. It was for this reason that a study space was included in the First Light conceptual submission. This addition also served to provide some much needed privacy for the main bedroom, a 'luxury' omitted in the original design.

The study space itself did not have much bearing on the final dimensions of the house nor the size of its modular units, however its design was subject to multiple iterations in the quest for home accessibility. It was intended to work with the bathroom and southern wall as a fully-closable partition between the bedroom and living spaces; this too changed later in the design process. The development of this all-important piece of furniture is discussed in chapter 10.

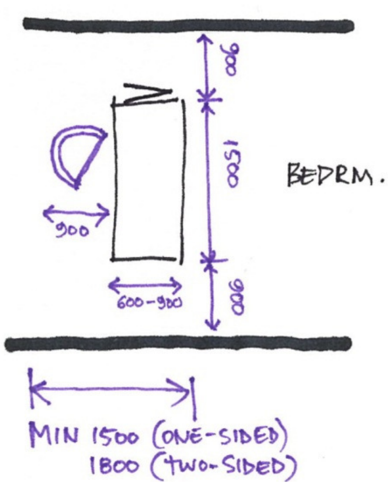


Figure 4.6 Spatial requirements for the study

4.1.3 Bathroom

In the original design, the bathroom was given an arbitrary width of 1500mm, one third of the width of the house. It remained so for most of the developmental stage and only changed due to accessibility requirements.

Access to the bathroom ended up defining what space was allowable for the study, and ultimately determined the module width. It was important to the design team that the bathroom could be accessed easily from the master bedroom, but that access from the rest of the house did not require going into the bedroom at all. As it was originally intended that the study unit would include a door of some description, this partition would shut off the master bedroom from the rest of the living space, leaving the bathroom doorway in the latter. Combining the threshold between study and bedroom with the module join made sense in conceptual, spatial and practical terms. It meant that there would be a defined 'bedroom module', or possibly two, and a 'study module'.

The 'study module', as mentioned previously, was less about the study itself and more about what else it contained; namely the eastern part of the kitchen, the utilities on the western bathroom wall, and now the bathroom door, including frame and lintel. The kitchen and bathroom benches were to be back to back in order to streamline the plumbing services. Because the kitchen's width was limited by the width of the services core, it was decided to increase the depth of the bench to improve its capacity and useability. A depth of no less than 700mm was deemed necessary.

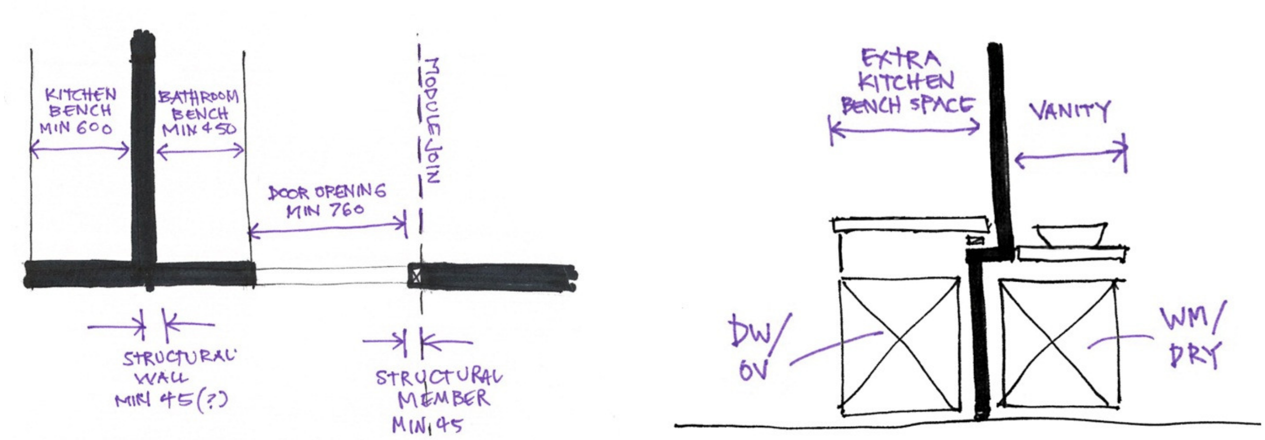


Figure 4.7 Sketches documenting minimum dimensions for a module that includes the kitchen and bathroom benches and the bathroom door (left) and minimisation of kitchen/bathroom utility width (right)

At a time when the laundry utilities were still expected to be housed in the bathroom, this dimension became so critical that a 'step' was suggested in the shear wall between kitchen and bathroom to accommodate all appliances (as can be seen in the right hand element of Figure 4.7).

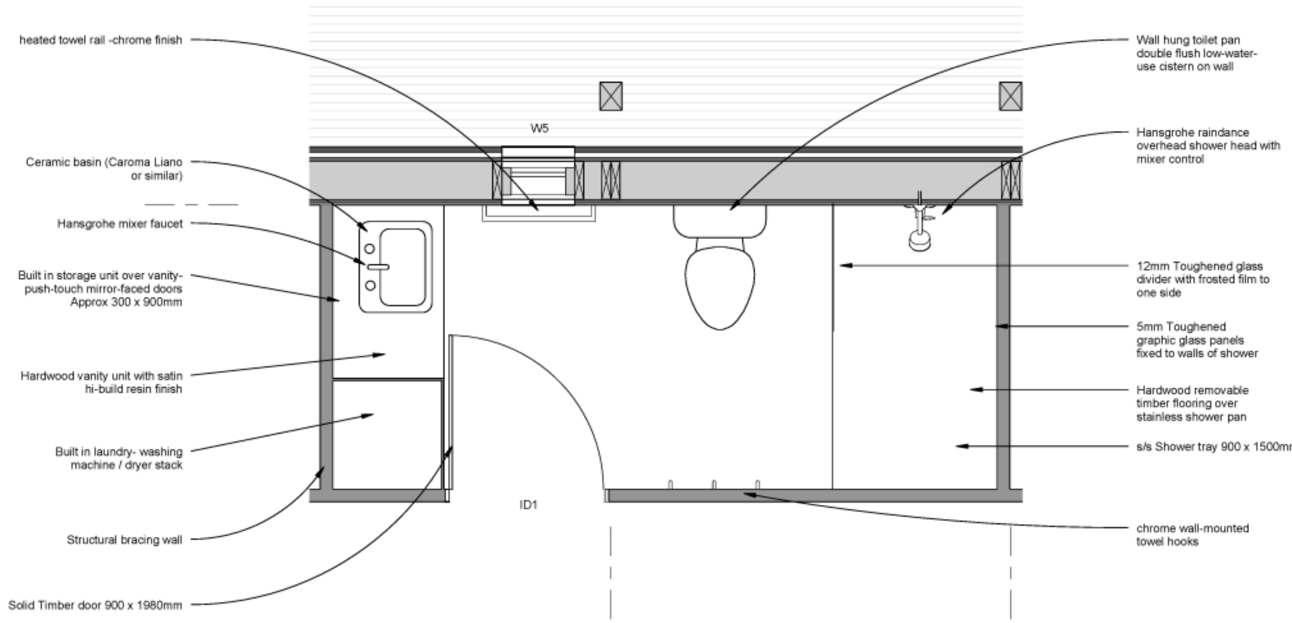


Figure 4.8 The bathroom and laundry configuration stayed the same from the conceptual submission till late in the design development phase.

The bathroom retained the configuration in Figure 4.8 until much later in the design stage. It changed when the plant was relocated (refer chapter 6), the laundry given a room of its own, and accessibility considered. All these factors altered the original dimensions mentioned above. These had been based on standard code requirements rather than American accessibility requirements (refer chapter 10).

At the end of this process however, the bathroom played an important role in determining the module size: it defined the width of the services (north facing) part of the house, and the dimension from the kitchen bench to the edge of the bathroom defined the width of the construction module.

4.1.4 Kitchen / dining

The central space was the founding basis and defining feature of the project and it needed to be detailed as such. The Solar Decathlon competition requirement to be able to host up to ten people for a meal was also a fairly important consideration for the required size of the dining space. After investigations into configuring the central module as a standard 2.2m prefabricated box it was decided that the consequent reduced width of this very important space would not be beneficial to the realised project and as such it was determined that the kitchen/dining module could not be a “standard module”.

Further to this, at this stage the kitchen/dining area was an empty space, open on both long sides and with no built-in fixtures. It seemed appropriate – and achievable – to devise an alternative method of construction and transportation to allow a more generous width for this module.

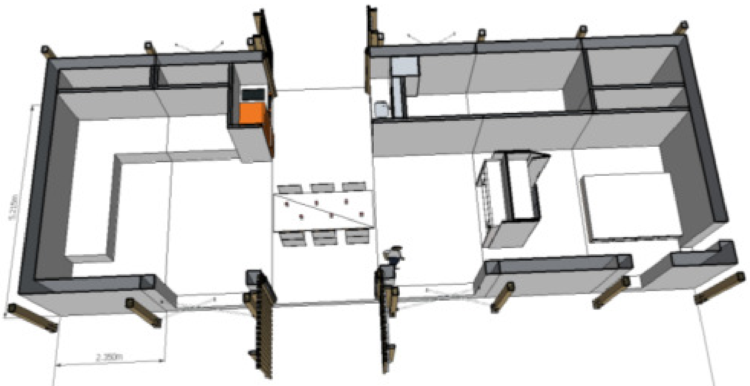


Figure 4.9 The central space as a 2200mm module. IMAGE CREDIT Eli Nuttall

In the configuration above the narrower space does not accommodate a north-south oriented table as was featured in the original design and still desired by the design team. The axis of the space is rotated and the feeling of an open, transparent breezeway is lost. The dining table effectively blocks the entranceway and the kitchen and dining activities are separated.

While 2200mm was too narrow for the space to be utilised as intended, it could not be so wide as to render the kitchen space un-useable; the triangle between food storage, cooking and cleaning, and preparation space needed to be easily and comfortably traversed. It also needed to include easy access to the two necessary emergency exits and comply with the spatial requirements defined by the American accessibility code document. With the furniture in its original intended configuration, minimum dimensions meant the width of the central space was 2700mm.

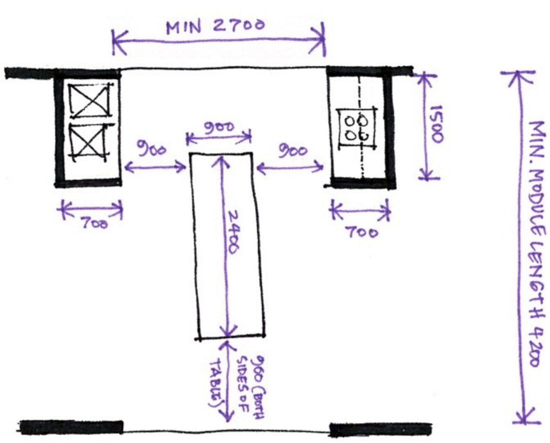


Figure 4.10 Minimum dimensions necessary to accommodate preferred kitchen/ dining configuration

It was finally decided that the width of this space should be increased to 3.0m. For an in-depth report on the alternative construction and transportation of what became module three (the kitchen/dining module), refer to chapter 6 of *First Light House: Logistics and construction.*[29] The interior issues related to module three are documented in their own chapter, later in this thesis.

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[29] Nuttall, E (2012) *First Light House: Logistics and Construction,* Master of Architecture Thesis, Victoria University of Wellington

4.1.5 Living room

The '*Home Entertainment*' contest influenced the living room by, firstly, specifying the need for a television – something the traditional bach would not have had. With the TV came the guests for the requisite 'movie night' and for this the living room needed to accommodate up to ten people in comfort. Had this been a traditional kiwi bach, 'accommodate in comfort' could be loosely interpreted as a couple of armchairs, beanbags and additional chairs brought through from the rest of the house. However, because conceptually the First Light house was a bach, the living room also needed to provide some sort of temporary guest accommodation and the spatial needs for this justified the size increase that made it suitable for the movie night capacity.

Just how the services core would accommodate extra sleeping space was a cause of some consternation during the design process, as it seemed that for any of the module options the module width was fractionally too short to accommodate a standard bed length. The final iteration of this piece of interior design is discussed in chapter 11.

4.2 Finalising the module dimensions

Once the project team was relatively happy with the layout, the proposed plan was taped out in the university atrium to evaluate its spaces at 1:1 scale.

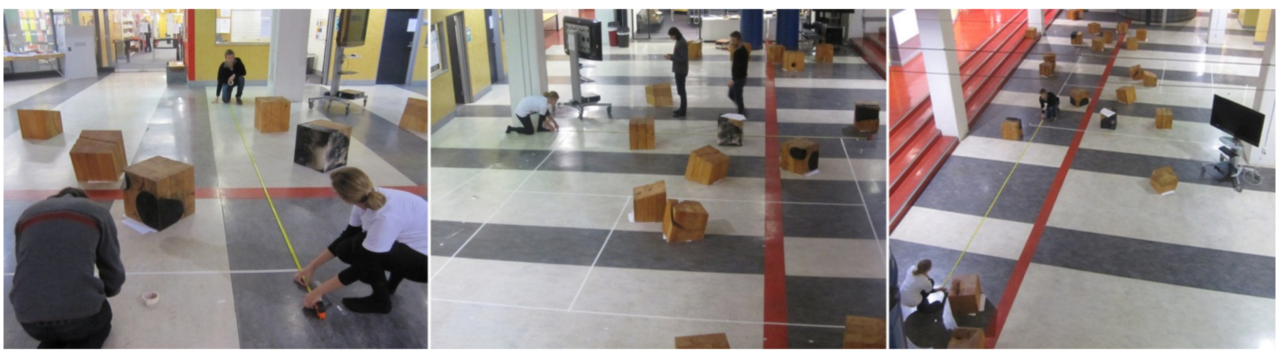


Figure 4.11 **F**inal layout investigation at 1:1 scale

4.3 Conclusion

The final working module size was defined as 2200W x 5400L x 3500H with interior dimensions of 2200W x 1500L (clear services space) + 3300L (clear living space) x 2500H. The somewhat unconventional internal height of 2500mm came about because it was the maximum that could be accommodated. The design team wanted to push the interior space beyond the standard 2400mm but, given the transportation limitations shown in figure 4.12 below, a height of 2500mm was all that was attainable.

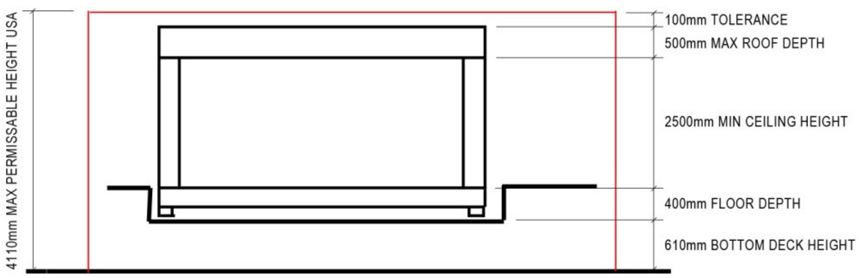


Figure 4.12 Module height limitations IMAGE CREDIT Eli Nuttall

In hindsight, using minimum dimensions to determine the module sizes was an optimistic, or even naïve, strategy on the part of the First Light team. A generous contingency should have been added to these measurements, to allow for discrepancies and unforeseen changes in the construction of the house. This would have relieved tension in the lead up to the accessibility inspection process in Washington DC!

The final layout required a minimum of six modules: three to the east and two to the west of the central module, which was to be detailed and constructed differently to its standard counterparts. At the specified module size, three modules to the east made for a very large bedroom. However two modules did not provide enough space for the bed and study unit, and if the study unit had been moved to the centre of its module, access to the bathroom would have been through the master bedroom. It was therefore decided to go for three modules and utilise the extra space somehow. Fortunately, there was an easy and logical resolution to this spatial issue, discussed in chapter 6.

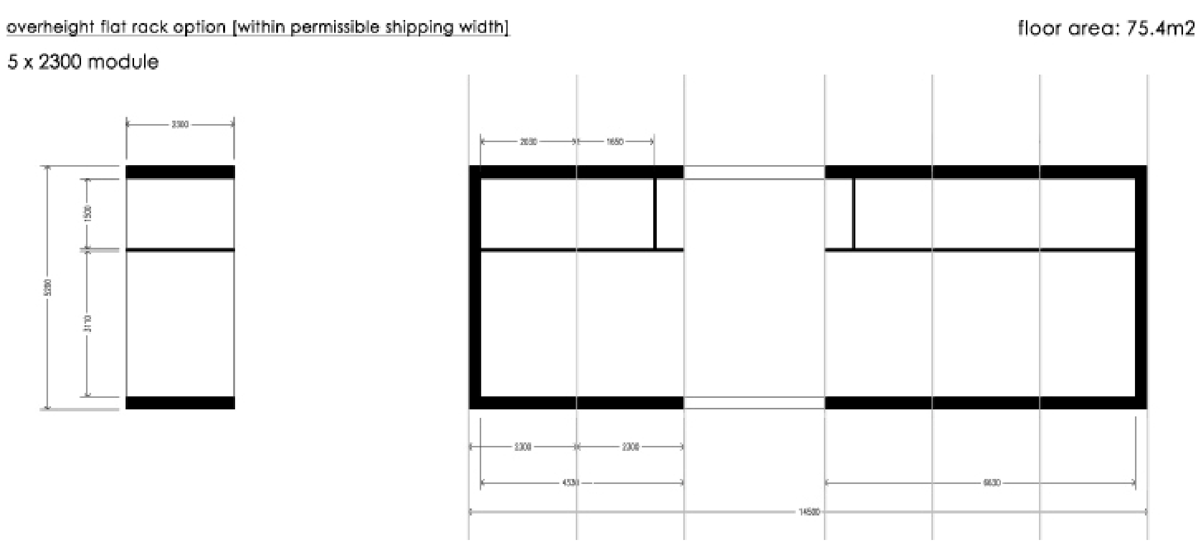


Figure 4.13 Final working module configuration

The Solar Decathlon's unique parameters played a part in developing the layout of the First Light house for the better. By flipping the bed to sit against the eastern wall, a more conventional bedroom layout was achieved, where the occupants could survey the entrance to the bedroom. This move also streamlined the proposed public tour route through the house. The study unit, while no longer needed for the competition itself, was a valuable addition to the interior, providing privacy to the master bedroom, increasing storage space and contributing to the market appeal of the home.

For a house that was not originally modular, the team achieved a logical and conceptually acceptable module breakdown; assigning two 'bedroom modules', one 'study module', one 'dining [or central] module' and two 'living modules'. The modular joins aligned with the exterior canopy's post and beam structure, linking the architectural language of the interior and exterior and creating a stronger overall design.

Having agreed that the master bedroom and study configuration at the eastern end of the house required three modules, the discussion now shifts to the western end of the building.

Following the least-space requirements investigated in the previous chapter, and because half modules were not an option, it was decided that the living room needed two modules. The question was whether there was validity in the seating area (or study area) being, or becoming in the future, a permanent bedroom.

This brought about the need to define the target market for the competition, an important criterion for the *Market Appeal* contest, but something the team had up to this stage been reluctant to do. In a competition to do with sustainability, the team felt it preferable to enter a permanent home design rather than a holiday home, since the latter is an inherently unsustainable lifestyle option. It was time to confirm whether the First Light house was a permanent home or a bach.

It was mooted that a permanent home would need two permanent bedrooms for market viability, whereas a bach would need only one permanent bedroom with temporary accommodation space for extra people. A permanent living room occupied two modules; therefore if another bedroom, or even just the framework for a future room, was to be included in the design, an extra module would be needed. With a proposed prefabricated module size of 2200W x 5400L, this would add 11.9m^2 to the plan, increasing the footprint from 75.6m^2 to 87.5m^2.

The layout configurations presented below show only two modules to the east of the central space but due to the comment in the first paragraph, this apparent graphical inconsistency can be overlooked: the investigation into whether a second bedroom (and a third module) should be added to the western layout was happening concurrently to the developments mentioned in chapter four. Once the decision had been made to specify three modules in the east, however, the addition of a third module on the western side would push the First Light footprint to the upper limit of the size allowance for the competition, and a debate as to whether this was a cost-effective or strategic design move ensued.

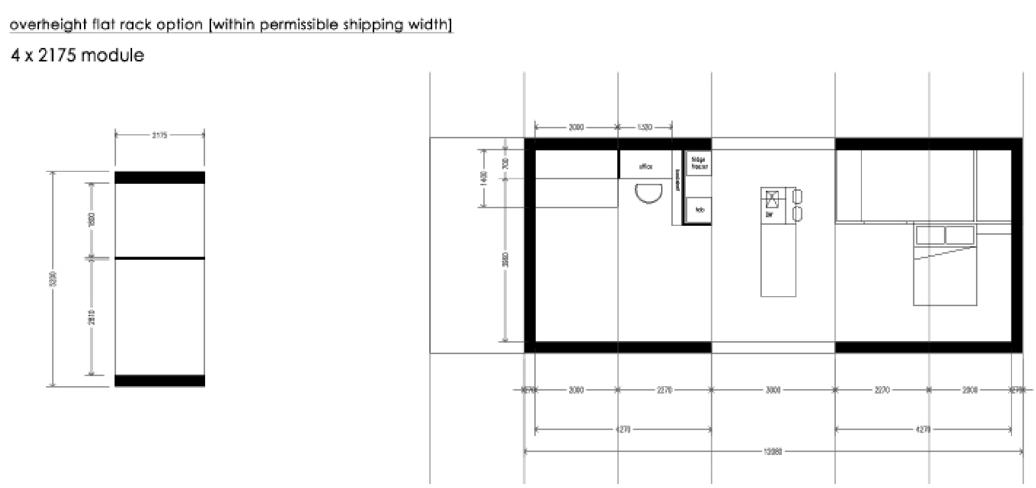
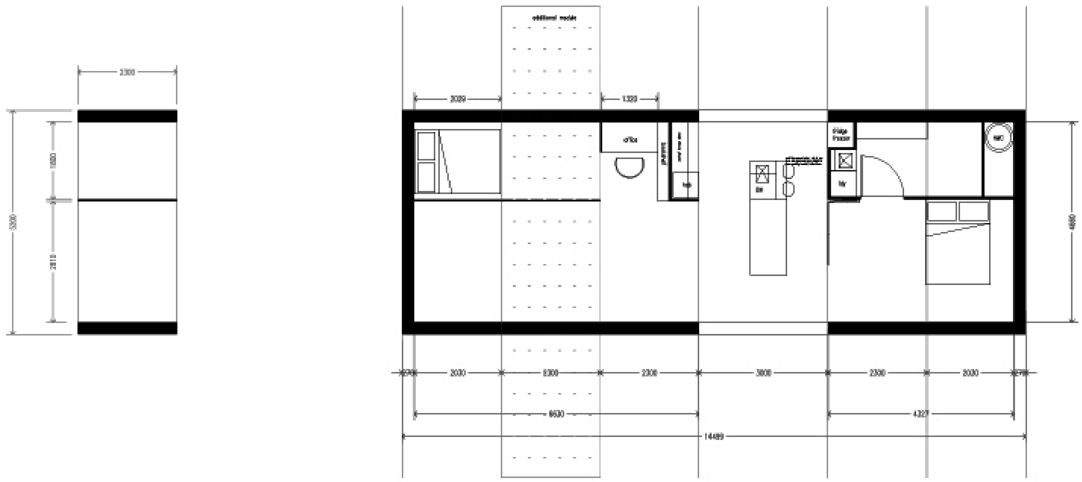


Figure 5.1 An early 4-module layout with a spare bed and study as part of the living room

overheight flat rack option [within permissible shipping width]

5 x 2300 module



overheight flat rack option [within permissible shipping width]

5 x 2175 module

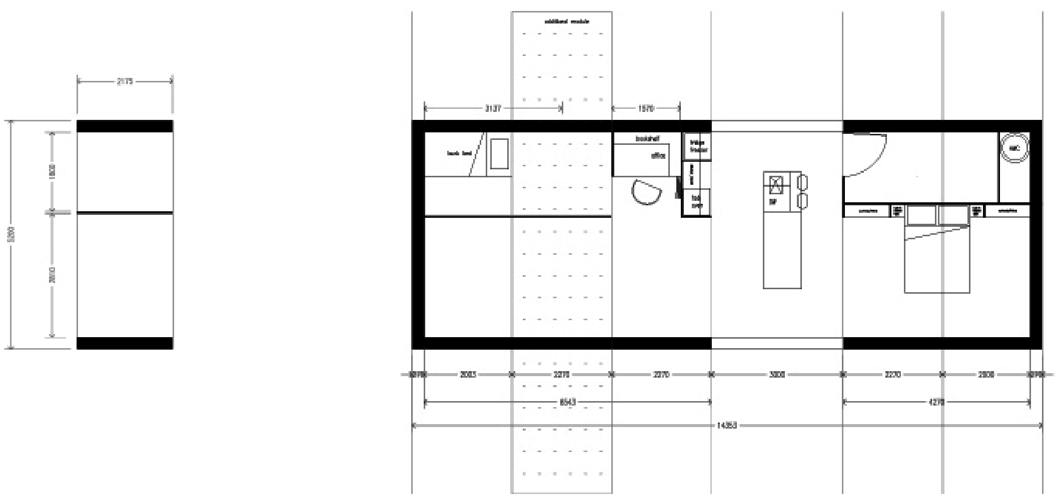


Figure 5.2 Possible two-bedroom arrangements made by inserting a module between the two existing living room modules in **Figure 5.1** [to be set up for the competition, *or* for the easy future expansion of the house] *note: envelope shown without windows.*

5.1 Cultural expectations regarding house capacity

As space is perceived and inhabited differently across the world, an investigation into cultural expectations needed to take place. Would a predominantly North American audience believe two permanent bedrooms to be acceptable in a home of 88m^2?

Based on property information figures from April 2011, a new house in New Zealand has an average floor area of 149 m^2, though this average size varies considerably across different regions of the country, from a high of 181m^2 in the Selwyn and Queenstown Lakes Districts to a low of 112m^2 in Wairoa and 110m^2 offshore in the Chatham Islands.[30] The average household size in 2006, the time of the last NZ Census, was 2.6 residents[31]. In comparison to this the average floor area of single family houses constructed in the USA in 2006 was 2,469sf (229m^2) for the same average household size[32]. Metropolitan areas, particularly those in northeast USA (of which Washington DC is a part) consistently push the higher limits of the statistics. In 2006 the average new house footprint in the northeast was 2,613sf (243m^2)[33].

With a footprint range between 614 and 970sf (57 and 90m^2) the average house size in the Solar Decathlon village was to be considerably smaller than that of either country. What household size would this acceptably accommodate for the competition?

A background investigation into minimum space dwellings online and in contemporary literature revealed some very small living spaces around the world, and showed the creative ways in which the perception and useability of these confined spaces had been maximised. One particularly interesting online article showcased the interior design of a Parisian apartment whose 40m^2 footprint accommodated a family of four and their dog. The apartment demonstrated resourceful and highly efficient use of space, although the online discussion it generated was as interesting as the interior design itself. This was a public blog site, and many of those commenting on the design displayed a lack of specialised knowledge in the fields of design and building legislation. However the discussion provided insight into differing world attitudes towards minimum space requirements, particularly the differences between European and US-American spatial expectations. The comments on the blog ranged from abject denial that this could be someone's permanent home, let alone a family's, to the debate about whether accommodating children in small spaces was 'cruel' or 'natural'.

> *"431 square feet is roughly a space 21'x21'. I find it difficult to believe that a family of four plus Labrador are living in a space that small, no matter how well engineered it is. The children's "room" has no exterior windows while the dining table only has three chairs for a family of four. This is their city apartment and they actually live elsewhere."*

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30 Quotable Value, *Property Information.* Page last accessed 12-03-2012
http://www.qv.co.nz/propertyinformation/KnowledgeCentre/Averagehousesizebyarea12042011.htm

31 Statistics New Zealand, *Demographic trends 2009* Page last accessed 28-04-2012
http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/demographic-trends-2009/chapter9.aspx

32 US Census Bureau, *America's Families and Living Arrangements: 2007,* Report released 2009. Page last accessed 12-03-2012
http://www.marketingcharts.com/topics/demographics/census-data-average-us-household-size-declines-to-26-10679/

33 US Census Bureau, *Median and average square feet of floor area,* Page last accessed 12-03-2012
http://www.census.gov/const/C25Ann/sftotalmedavgsqft.pdf

> *"Living in a super small space seems fun until kids get involved. Then I feel like it might be kind of cruel to them? [sic]"*
>
> *"The idea that everyone in the family needs their own personal room seems to be a very American one. … I grew up in Eastern Europe too, four people in 42 square meters. I played in the living room (and sometimes in the bathroom) and we were all very happy together. Children are smaller people and really like smaller spaces."*[34]

The discussion served to highlight the extremely varied perceptions of 'liveable' in terms of the ratio of occupant numbers to dwelling size around the world and, along with the literature review, which featured many appealing, tiny residences (the majority of which were located in Europe and Asia), provided evidence that a two-bedroom home with a footprint of under 90m^2 might be perceived as too small by an American audience.

5.2 The capacity of previous Solar Decathlon houses

In addition to the background investigation above, an enquiry into the preceding Solar Decathlon houses was made. As the majority of entries into the 2002 – 2009 competitions were by North American teams, the competition itself would provide a good indication of the perceived appropriate capacity for a house within the size limitations of the Solar Decathlon.

> *"The 800sf house might be small for full-time inhabitation, but would be ideal for a getaway in the rural wine country of Upstate New York."* [35]

In the 2009 competition, one hundred percent of the houses were single-bedroom prototypes. Thirteen of these featured a permanent bedroom, seven featured a fold-down 'Murphy' bed for studio apartment-type living, and only one, entered by Team Germany, whose two-level house was the biggest on the Mall that year, included reconfigurable space for accommodating overnight guests.

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[34] Côté maison: *40m2 pour 4 et un chien* http://www.cotemaison.fr/maison-reve/atelier-loft/diaporama/40-m2-pour-4-et-un-chien_4507.html Page last accessed 30-05-2010. The entire article and blog conversation has been included in Appendix D

[35] Cornell University Solar Decathlon, *Construction Document, target market description* p G-006 All of the construction documents and project manuals from previous Solar Decathlon teams can be found on http://www.solardecathlon.gov/history.html

5.3 Competition-specific implications of adding a module

The effects the proposed additional module would have on the separate competitions within the Solar Decathlon are tabulated below.

Type of effect	**Effect of an extra module on logistics and sub-contests**	**Beneficial or detrimental?**
Logistics	Increased cost of construction and transportation to the USA	Detrimental
Logistics	Increased assembly time on site	Detrimental
Affordability	Increased house valuation	Detrimental
Architecture	Three modules on either side of the central space rather than two, resulting in architectural symmetry	Subjective, though the First Light team believed asymmetry to be more appealing.
Market appeal	Increased permanent capacity of house	Seemingly unimportant
Net metering	Increased energy use to heat, cool and light the module	Detrimental

Table 5.1 Analysis of the effect of adding an extra module to the First Light house

5.4 Conclusion

In a traditional New Zealand bach context, a dwelling of $88m^2$ would preferably have two permanent bedrooms (and therefore three modules either side of the central space) to justify its greater footprint.

In North America, it was thought likely that an $88m^2$, two-bedroom house would be looked upon as small and perhaps cramped. Indeed, the majority of past Decathlon entrants had submitted a single bedroom prototype.[36]

A cost benefit analysis for the competition showed that an extra module to accommodate the extra bedroom would provide little strategic benefit; in fact given logistical and financial factors, such an addition would be likely to prove detrimental to the First Light project.

Based on these competition considerations the First Light house was confirmed as an autonomous ***bach*** to host the getting together of immediate and extended family; the target market was defined as middle-aged second home owners whose children had grown up and established families of their own. This market was thriving at the time of the last New Zealand Census. Baches, cribs and other holiday homes were included in the 1996-2006 Censuses under 'Occupied Private Dwelling Not Further Defined' and,

[36] This trend was in fact reversed in 2011, with eight teams submitting a dwelling with two permanent bedrooms.

along with 'dwellings adjoined to or part of a business or shop', totalled 74,334 units in 2006. On the night of the 2006 Census there were 17,571 'occupied, private dwellings with no usual resident(s)'.[37]

The confirmation of the house as a bach also validated the final specification of the five prefabricated modules mentioned in the conclusion of chapter 4, which would allow for one permanent bedroom and temporary, reconfigurable accommodation in the living room.

The blog discussion above also highlighted the inherent correlation between the size of a living space and the need for a connection with the external landscape, which was a key strategy for keeping the bach interior compact:

> *"I currently live in a one bedroom apartment with my husband and our two children (2 and half years and 9 months). …We live a 5 minute walk from the beach in the Caribbean. My point being that for us, like the family in Paris, life is as much about accessing your environment and community as it is about spending time indoors."*[38]

The literature review revealed many ways of making very small homes, comprising significantly less space than the proposed First Light house even without its 'extra' bedroom module, functional, liveable spaces. Many of these principles were adopted during the design of the interior; namely the maximisation of natural light, the specification of ample storage and multifunctional elements within the house, and a strong connection forged with the exterior environment.

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[37] Statistics NZ, *QuickStats about housing: types of dwelling,* 2006 Census [most recent census due to CHCH earthquake in 2011] Page last accessed 12-03-2012 http://www.stats.govt.nz/Census/2006CensusHomePage/QuickStats/quickstats-about-a-subject/housing/types-of-dwelling.aspx

[38] Côté maison: *op cit*

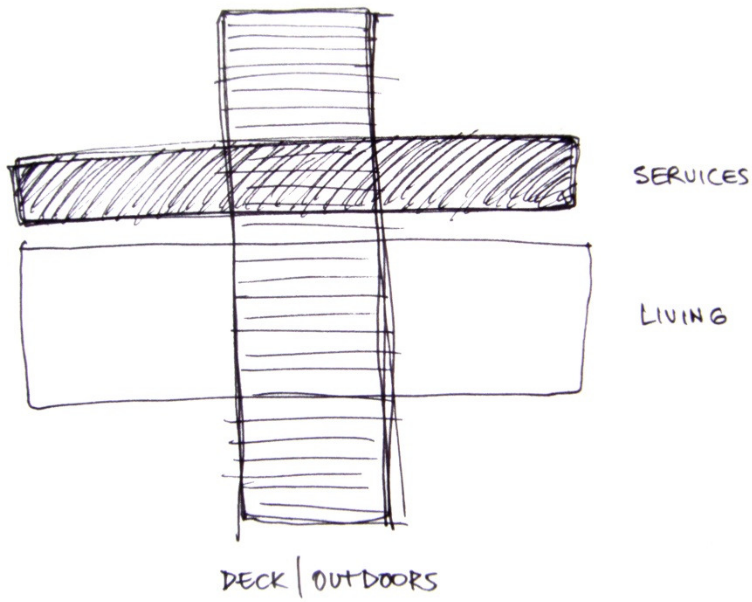


Figure 6.1 A conceptual sketch of the plan divided into three parts

From an early stage in the design process it was decided that the three distinct parts of the building: the living space, the services core, and the transverse deck or central space, would be treated differently. Across these zones, changes in construction detailing, spatial organisation, colour, materials, and lighting would highlight and differentiate their functions.

	House zone		
Intended atmosphere and treatment	**Services**	**Living**	**Central deck**
	Closed interior space	Open interior space	Outdoor/ indoor interior space
	Private	Public / private	Public
	'Dense' construction – solid forms, built in furniture	'Light' construction – open plan, moveable furniture	'Light' construction – open to all sides, including ceiling
	Darker, denser colours and materials	Light, airy colours and materials	Outdoor materials
	Textured	Smooth	Textured
	Artificial light	Natural light from south	Natural light from north, south and above

Table 6.1 Stylistic differences in the three key zones of the house

The services core was to be denser than the south-facing living space, containing the electrics, the functional spaces such as kitchen, bathroom and laundry, the water outlets, and the built in furniture and storage spaces.

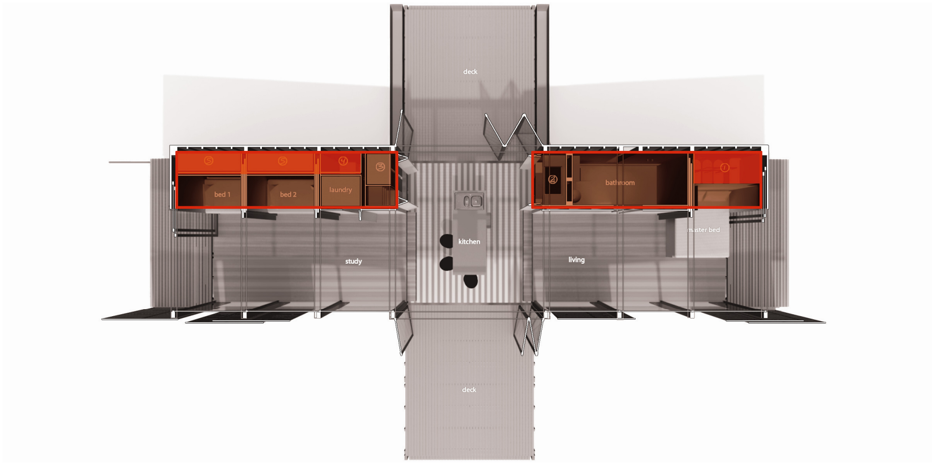


Figure 6.2 Original floor plan showing prefabricated services cores [outlined] and physical space for plant [dark red]

A change in the structural design of the house meant that fully prefabricated services cores along the northern edge of the house were no longer an option. The proposed prefabricated cores had been sliced into five pieces, which meant the original spatial and conceptual reasoning behind this layout was lost. With the initial services layout as it was, the decision to go modular made for complex engineering at the construction stage and a difficult services setup on site. At the same time, due to strict comfort zone requirements, the team was faced with the need for increased mechanical services to regulate the temperature and humidity within the house. The traditional bach was typified by its lack of sophisticated heating and cooling technologies and it was intended that this simplicity would carry through into the Solar Decathlon house. Passive heating and cooling were promoted and as a consequence, little space was allocated for plant. The high humidity levels in Washington DC, coupled with a requirement to keep the interior below 60% humidity, meant that passive ventilation was not a viable option for temperature regulation during the competition week.

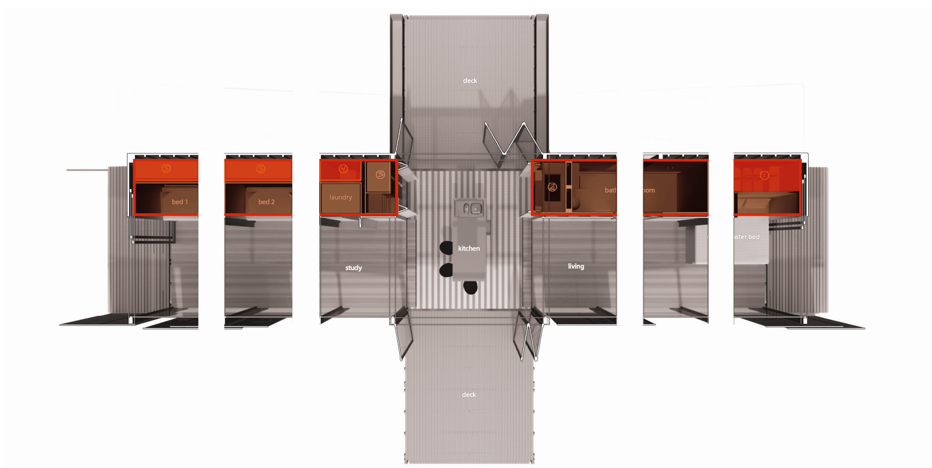


Figure 6.3 Module cuts complicate the all-in-one plan for services cores and make the original reasoning behind its layout obsolete

The challenge at hand was to reorganise the services layout so that it would make sense in the new construction. Ensuring the proximity of related services and outlets in the interior, minimising the number of on-site connections needed and integrating the engineering systems into the architecture of the house would all be important aspects of this reorganisation. Given the importance of the house services to the competition, there was a need to draw attention to the plant and building services, so ease of access for the public and for the judges was another important consideration.

The re-thinking of the services would provide a valuable opportunity to apportion more space in the plan for the necessary plant enlargement. Now that the cores running along the northern edge of the house were not to be fully prefabricated, the team would also need to apportion space in the vertical section to allow for threading the services through the house.

6.1 Making space in the plan

The water storage was removed from the living room services core area. This was to reposition supply and waste tanks closer to the water outlets, which were all on the eastern side of the house. This also served to open up the space for interior use.

In order to minimise piping connections, water outlets were limited to modules four, five and six. This had the added benefit of freeing up the kitchen island as bench space.

In the preliminary design configurations discussed in chapter 4, the nominal space for the plant was an externally accessed 'cupboard'. This was to house all mechanical equipment in one place, and was intended to be contained within one module to allow for maximum prefabrication. Positioning the cupboard along the short edge of the module was limited by the module width which, in the case of the 1800mm module option (figure 6.4 far left), did not allow much space at all.

Figure 6.4 Modular layout trials showing the space allocated for plant highlighted in orange

One day, the engineering team came up with a breakthrough. It was suggested that instead of sitting along the short edge of the module, the services could be laid out along the long side of the module and as such, create a ‘shed’ at one end of the house. The hot water tank would go inside the house and the mechanical part of the shed would house all the electrical and HVAC equipment.

The presence of a ‘kiwi shed’ would help with the storytelling aspect of the New Zealand exhibit. It would illustrate the outdoor lifestyle of the bach through the housing of surfboards, tennis racquets and assorted sporting equipment. It would also reference the kiwi ‘DIY’ mentality by housing gardening equipment, pots of nails and basic tools.

Altering the layout in this way reduced the bedroom by half a module and immediately solved the issue around too much space at the interior’s eastern end. It did however mean that the east-facing window and the bedroom’s relationship with the rising sun were lost.

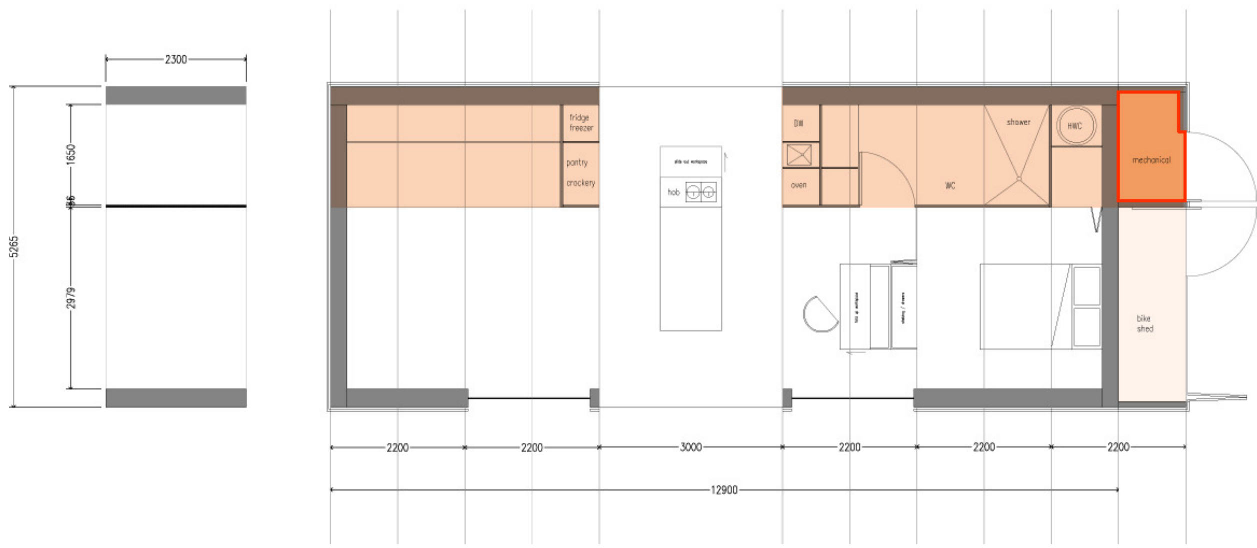


Figure 6.5 Working floor plan with the plant in its final location at the eastern end of the house. As the highlighted area shows, in the plan the plant room is still a part of the ‘services core zone’ running along the back wall; the original concept was in fact strengthened by this adjustment.

6.2 Making space in the section

The plant room was aligned with the services core in plan and now the design team turned to the section to figure out how the services would run along this linear core.

The services needed to be accessed from the interior during assembly to minimise penetrations in the exterior envelope. The walls, therefore, were not an option for transporting major services. The floor was also a difficult option due to the proposed flooring and built in furniture covering the majority of its surface. This left the ceiling space as the easiest and most logical place to house the services. A bulkhead was decided upon: a lowered ceiling in this zone fitted conceptually with the denser, more focused, built-in spaces of the services core. It was initially intended that this bulkhead would be a sealed plenum.

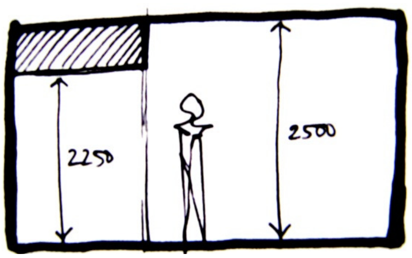


Figure 6.6 Sectional sketch showing relative ceiling heights due to bulkhead

6.3 Conclusion

The concept of the 'shed' at one end of the house reinforced the idea of the kiwi bach, and the DIY kiwi spirit inherent in its construction. The idea was that this shed would not only contain plant and building management services, but also sports equipment, tools and gardening paraphernalia.

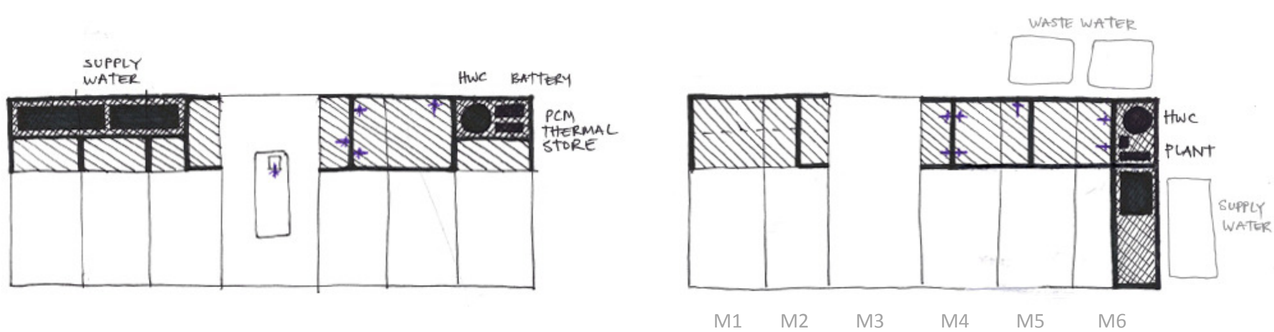


Figure 6.7 Original services layout (left). Realised services layout (right) shows the increase in useable interior space (white and hatched) caused by relocating the plant

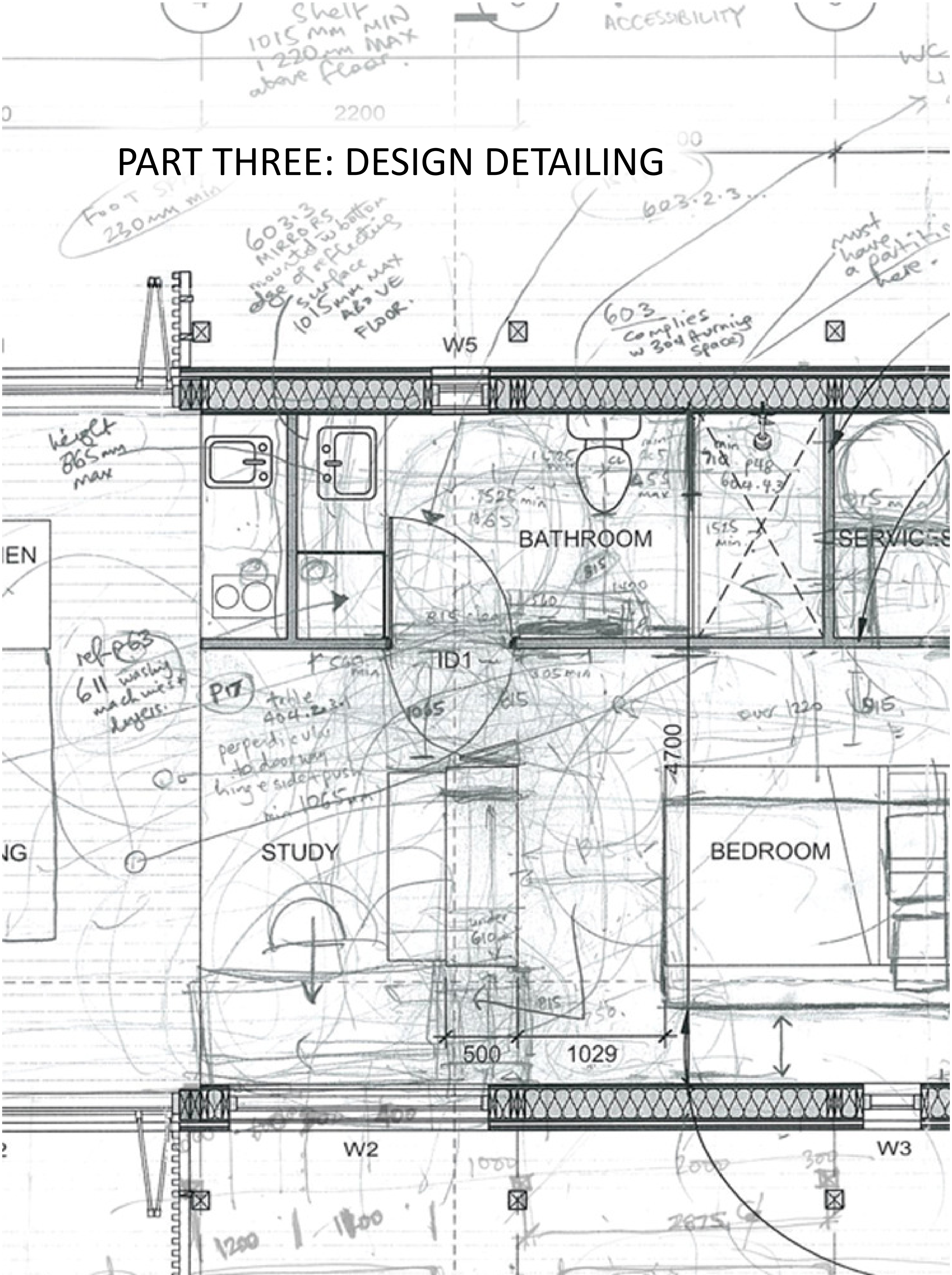
A dedicated plant space meant that all technologies and services would be contained in one convenient prefabricated location, easily accessible to maintenance workers, judges and visiting public. As the engineering team developed the house services, the plant took more room than had been expected. The 'shed' became more of a token display item than a practical storage space for tools and sports kit.

However, inside the house the plant relocation freed up the space along the northern wall for practical use. As can be seen in figure 6.7 on the previous page, the change in the services location allowed for a cleaner plan and an increase in useable interior space. The bedroom's eastern outlook was lost, which was the one notable negative side to the layout readjustment.

The house's water outlets were limited to the three east modules (M4, M5 and M6) and the whole kitchen island became useable bench space. In hindsight, though the central bench maximisation was a bonus, trying to minimise water connections was a fruitless endeavour, as public visitation regulations required sprinklers throughout the house. The final layout specified piping to span the central module and reach into M2, so there was at least one water connection at every module joint.

A nominal dimension of 250mm was allocated for the services bulkhead, which lowered the ceiling level in the services areas to 2250mm. This dimension seemed acceptable, both for the plenum and for the spaces below. However as the development progressed it became apparent that 250mm had been a conservative estimate for a space expected to contain the requisite cables, pipes and ducting, while also allowing room for structural ceiling members! The difficult process of designing the access to and structure of this ceiling space is documented in chapter 8.

PART THREE: DESIGN DETAILING



CHAPTER 7 – CHALLENGE 4: material specification for passive performance

Part two of this thesis dealt with the primary changes to the original design that were necessary to get the First Light house from New Zealand to Washington DC.

In part three the level of engagement with the design is increased, and the materiality, performance and liveability of the house interior are investigated seriously for the first time. The more detailed design decisions made to optimise the house for the competition, particularly in terms of thermal performance and ease of on-site assembly, are described. Those that impacted directly on the interior and its detailing are focused on, starting with the larger-scale material choices which would have a significant impact on the internal atmosphere.

Chapter 7 introduces the macro decisions that defined the parameters within which the interior design team would need to work. Chapter 8 deals with the finer implications of the potential material specifications, and in Chapter 9 the design team overcomes specific problem points in the interior detailing. Chapter 10 describes the complexities of creating a show home for an expo setting.

Figure 7.1 Interior perspective of the original SARC 383 bach design. View to west from master bedroom, showing a lightweight floor, with three glazed facades and part of the roof glazed

The first challenge was to make the interior of the developing First Light house as passively efficient as possible. Reducing the energy needs of the house through appropriate material specification was important before any active energy technologies could be considered.

The original design was notable for the extent of its glazing. It was the display of a pure concept; a total expression of the design intent in the form of a minimalist, modernist glazed box with a dissolving façade between inside and outside. In its presentation images the design appeared serene, with clean lines, a lack of built detail and an ephemeral envelope. The imported surroundings create a focus for figure 7.1 above; and the scenery demonstrates the openness of the house envelope. The undergraduate team's 2009 render is attractive but presents an unrealistic, or naïve, design for a high-performance house. In reality there would have been many issues surrounding the liveability of such a proposal if built. The tension between such a 'pure concept' and liveability was demonstrated by Mies Van der Rohe's glass-walled Farnsworth house.

> *The Farnsworth House may have approached Mies van der Rohe's ideal conception but it seems to have been a mismatch with that of Dr Farnsworth and her reasonable desire to inhabit her own house in practical and physical comfort and security.*[39]

Together with leaks in the flat roof, the failings [of the thermal performance of the house in both summer and winter] were Dr Farnsworth's justification for not paying Mies his fees and formed the basis of court actions in 1953.[40]

In developing their visualisation for the SARC 383 submission, the project team used glass used wherever they felt it was desired, arguably in a careless manner, given Dr Farnsworth's testimony above. In a New Zealand context, the high levels of UV and bright summer sunlight would almost certainly have caused problems with glare. Heat loss through the glazed areas would have been a considerable concern in winter and, even with passive ventilation, overheating in summer was inevitable. Because of the predominance of glazing, there was little solid wall area and, therefore, very little insulation. What solid walls there were would need an R-value increase to ensure thermal performance in the range necessary for the Solar Decathlon competition. The lack of solid walls meant that furniture placement would also be difficult, and such liveability features as artwork, a television, power outlets or switches had nowhere to be located.

Microencapsulated PCM gypsum board, the thermal mass specified in the hypothetical design, was not sufficient to regulate the temperature to the precision needed for the competition week. It is also a very expensive product, which would have affected the affordability of the house.[41]

In summary, the hypothetical design did not allow for enough reliability or control to guarantee remaining within the temperature range necessary for the 10-day competition period. The elemental building blocks of walls, floors, windows and openings needed to be re-thought and re-developed with a view to increasing the overall passive performance of the house, while retaining the original design intent for the building. Such a fundamental redesign of the building envelope would have significant ramifications for the interior design, which the design team would subsequently have to address.

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[39] Unwin, S (2010) *Twenty buildings every architect should understand* p73

[40] Ibid, p74

[41] Harland, A (2011) *Just a Phase,* Master of Architecture Thesis, Victoria University of Wellington

7.1 Window : wall ratio (WWR)

> *The total window area must be ≤ 30% of the total exterior wall area.*
>
> *The combined window area of the east, south and west walls must be ≤ 30% of the combined area of these walls.*[42]

The original house design had a window : wall ratio of approximately 6:4; more than twice as much glazing as allowed by the New Zealand Building Code. Given that code compliance grants consent for a standard building rather than a high performance one, the glazing ratio needed to be reduced by considerably more than the Code recommendation in order to perform at a high level.

The design team had to choose where light and views were needed. The window and door locations needed to be more strategically placed to where light, and the concept of light, were important for useability, overall internal illumination, views, and the daily routine of the inhabitants. Having to distribute windows sparingly meant more consideration of the importance of these particular openings; their function; and a focus on how to keep the *feeling* and *intent* of the pure concept with 60% less glass.

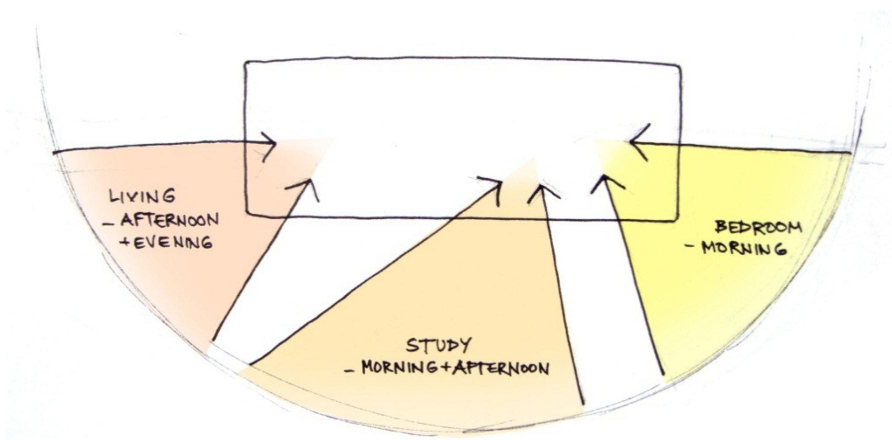

Figure 7.2 Interior spaces and their daily requirements for natural light and direct sunlight

The layout of the house was set up so as to benefit from natural light over the course of a day: the inhabitants were to wake up with the rising sun and then utilise the lounge in the evening enjoying the rays of the setting sun. In the 2009 Solar Decathlon the study spaces were critically assessed with regards to their lighting qualities and outlook so it was deemed important to maximise the natural light in the study area. Good natural lighting would make this space an extra room or living area in its own right. The design team had already conceptualised that the central space needed to be flooded with light at all times, as if it were an outdoor area. The living room, typically occupied in the afternoon and evening, would need southern and western sun. For both the central and lounge spaces, there was a need to ensure this did not lead to overheating.

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[42] Department of building and housing, *Building code requirements: house insulation* Page last accessed 30-03-2012 http://www.dbh.govt.nz/quick-energy-guide

The design team determined that these requirements did not necessitate a fully-glazed façade, however. It would be possible to achieve the lighting requirements for the rooms (as shown in figure 7.2 above) with far less glazing than was specified in the original design.

In the realised design the project team planned to use light much more strategically by using it to allude to public and private spaces in the interior. The centre of the house, the entry and gathering point, was to be, as originally conceived, the lightest, airiest part of the plan. As the layout extended to the east and west of this space, the lighting levels diminished slightly to give the feeling of more intimate, cosy living spaces. This lighting concept was replicated in the artificial lighting specification as well (see figure 7.3 below).

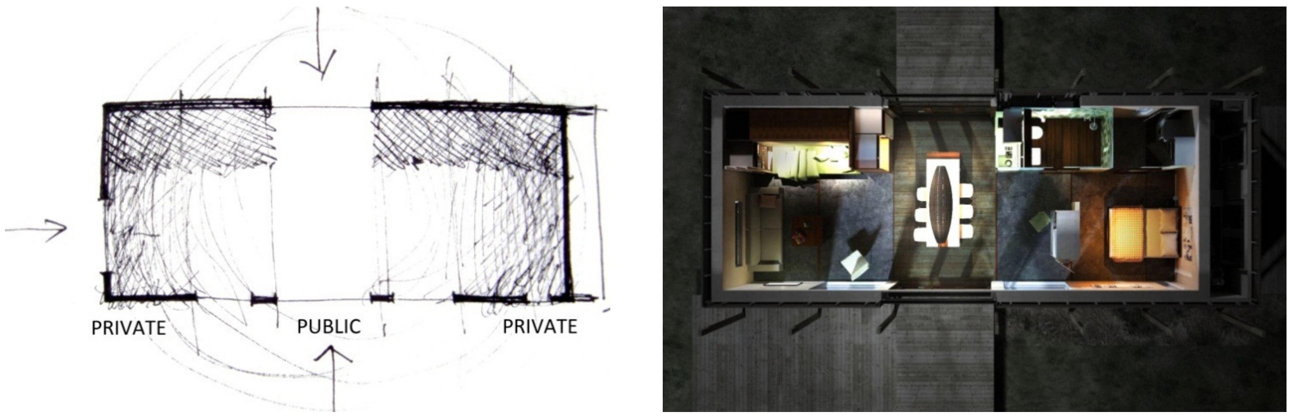

Figure 7.3 Graduated natural and artificial light help to define public areas from the more private spaces of the house RENDERED IMAGE CREDIT JAE WARRANDER

In designing the realised building the absolute need was to ensure that internal environmental conditions could be maintained within Solar Decathlon defined parameters. The western window was, therefore, studied in great detail, due to the risk of late sun causing the interior to overheat. A window on this end wall was important to the design team; keeping the connection with the external surroundings for as many aspects of the home as possible was central to the original concept. This was especially so, given the loss of the bedroom window in the eastern wall (see chapter 6). In the original design the western wall was almost entirely glass. Having more seriously considered New Zealand building standards and the Solar Decathlon requirements, and after thermal simulations and style discussions, the project team resolved that the glazing on this wall should be minimised to a window of 800x1800mm to be placed horizontally in the wall. While there was no longer direct access to the deck through the western façade, reducing the glazing to these dimensions made for a more useable interior space. The wall could now have a chair against it, and the interior team took this opportunity to design a window / chair combination that would enable the inhabitants a western view from their position on the couch.

7.2 Glazing specification

The interior team was concerned with the placement of the windows in the wall and in the rooms and the atmosphere such glazing would provide.

For a comprehensive report on the trials that led to the glazing specification in the First Light house, refer to *The 10 day bach*[43] and *The First Light House: Logistics and Construction.*[44]

7.2.1 Window glazing

For construction and design purposes, the windows were centred on their module. Because the walls were so thick, and the finished floor area for the competition was measured to the outside wall, the interior team wanted to push the glazing as far towards the exterior as possible. This would increase the perceived space inside the house, and also gain a little extra physical space.

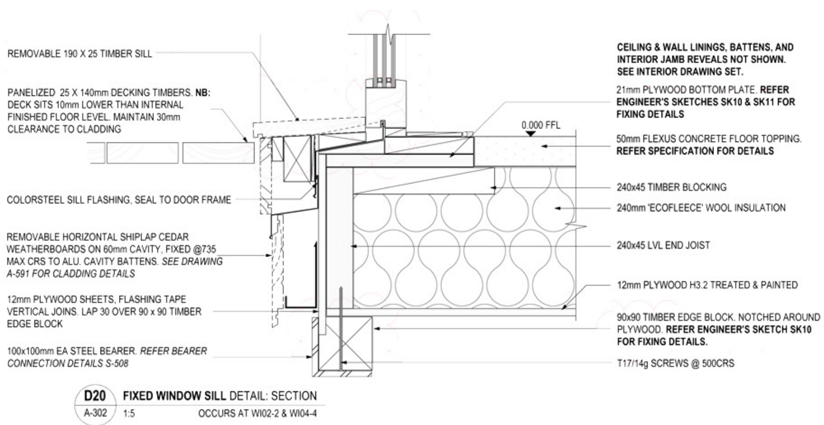

Figure 7.4 Sectional detail showing window flush with FFL (left) and living room window with its sill at floor level (right)

The final specification for the window units was a 32mm thick triple glazed IGU, (6mm panes of glass with 8mm air gaps) with a UV tint and argon fill. The glass was to be supported in custom-made cedar frames. The specification of an all-timber frame was made due to the aesthetic and material preferences of both interior and envelope teams, as well as a recommendation from the engineering team due to the superior thermal performance of such joinery.

The UV tint caused the glazing to be much darker than expected. The interior looked especially dark when the house was first constructed inside the warehouse at Lyall Bay. This was a concern because despite the reduction in the south facing glazing, the design team still wanted a very open, airy feeling interior with a strong linkage to the exterior.

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[43] Jagersma, B (2012)*The 10 day bach: A net zero energy home,* Master of Architecture Thesis, Victoria University of Wellington. pp65-83

[44] Nuttall, E (2012) *op. cit.* pp90-91

Once the house was taken outside this effect was reduced, and the tint became less of a problem. It did have its benefits for the interior design as the darker glazing caused more reflection during the day, which provided more privacy inside the house. The UV tint also meant that the soft furnishings inside the house would not be subject to sun damage and fading.

Figure 7.5 Glazing units awaiting installation (left) and living room window appears darker than expected (right)

7.2.2 Skylight glazing

> *The total skylight area must be $\leq 1.2m^2$.* [45]

The original skylight measured $19m^2$ and was the house's main thermal weak point. However its openness and the internal light qualities it created were fundamental to the design concept, as well as being the New Zealand team's point of difference in the competition: never before had a Solar Decathlon team submitted a house with a skylight as its main feature. The team, therefore, felt it was very important to retain it, and a long process of optimisation began. Materials investigated were:

- Single / double / triple / quad glazing
- Danpalon Polycarbonate
- Pilkington Profilit glass channel with Nanogel
- ETFE pillows

For each material, trial details were drawn, heat loss and gain simulations were undertaken, the financial and logistical implications were compared, and the potential internal atmosphere was discussed and simulated.

[45] Department of Building and Housing, *op cit.*

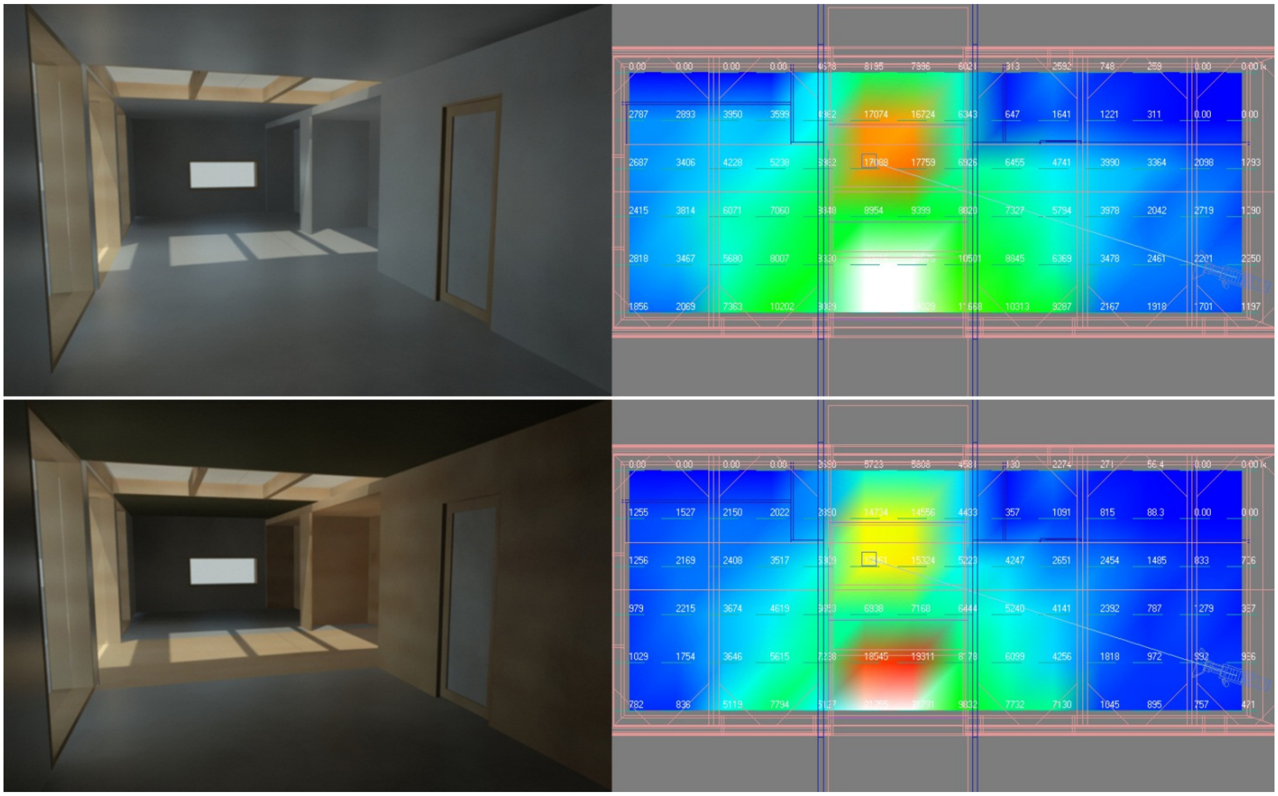

Figure 7.6 Preliminary daylighting study showing effect of different materials on internal illuminance IMAGE CREDIT JOHN MUNRO

The interior and envelope teams both wanted a clear view of the sky from the interior. Though it did reduce direct sunlight levels and glare in the central space, the semi-opaque polycarbonate roofing was turned down due to its optical qualities. An ETFE covering was an option investigated seriously, though it was eventually dropped due to its high cost and the feeling that it would not present the rustic, DIY bach atmosphere desired.

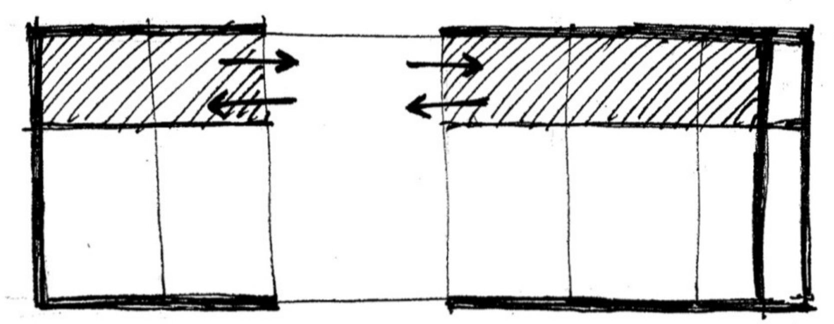

Figure 7.7 Services bulkhead terminates at either side of the glazed central module and pressure or forced airflow transfers heating and ventilation across the open space

Meanwhile the bulkhead was being investigated too. Initially designed as a plenum, it was to finish on either side of the central module and complex engineering would ensure adequate airflow from the eastern side to the west. This was a feat more challenging than initially expected, and achieving a sealed plenum across five modules would be very difficult. A compromise between the architecture and engineering teams was made: the bulkhead would continue over the central module, and would be converted from a pressurised airspace to a generic bulkhead that could house ducts and pipes without needing to be hermetically sealed. The services connections between the two sides of the house were simplified significantly, and the skylight was reduced by a third.[46] This was a successful move from all aspects: the skylight and the open feeling of the central space could be kept; the engineering team could work with a continuous bulkhead to transport air, water and electrics; the thermal performance of the house was improved by reducing the amount of glazing; and the services core was articulated more clearly with the kitchen zone of the central module well-defined.

7.3 Thermal mass

The original design focused on panelised construction of the floor and flooring. Timber floorboards throughout meant that there was no thermal mass on the ground (except for the PCM flooring solution for the central space hypothesised by the team) and the construction was very lightweight.

Thermal mass was intended to be included by way of PCM gypsum board on the internal service core wall but, following acceptance into the competition, this idea was discarded due to the lack of NZ availability of such a material and its prohibitive cost. The house, therefore, had no thermal mass at all.

The engineering team presented thermal simulations showing that the presence of thermal mass in the interior could help to regulate the internal temperature by +/- 10°C.[47]

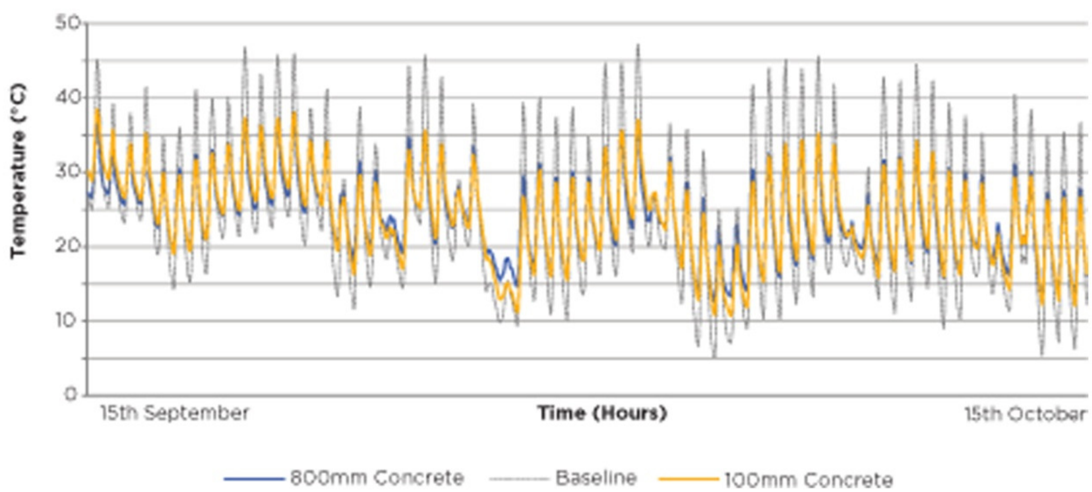

Figure 7.8 Thermal simulation showing the passive effect a 100mm thick concrete floor has on the internal temperature of the First Light house IMAGE CREDIT ANDREW MUNN

[46] The skylight ended up being 38mm thick triple glazing (7mm panes of glass with 10mm air gap) with a UV tint and an argon fill.
[47] Jagersma, B (2012) *op cit*. p61

Due to this a massive floor was discussed, and further simulations showed that while the optimum thickness for a massive surface was 100mm, this topping need not be more than 50mm deep for an adequate effect on performance for much less weight.[48]

Concrete is the first thought when considering a massive floor, but this house was to be transported across the world, lifted and shifted, and the likelihood of a concrete slab cracking in this process (especially at a depth of only 50mm) was very high. The subfloor structure had been designed so that, for the competition, a crane could hoist the modules into place, and for domestic use, a forklift could lift the modules. Control joins and cuts were discussed, but the design of the structure was such that concrete was still too risky a material choice.

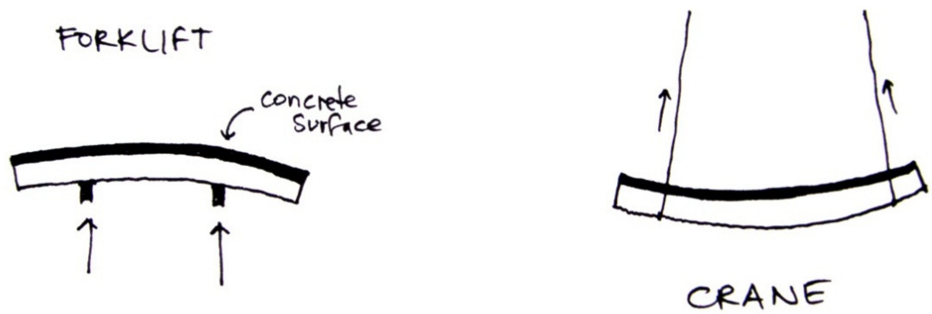

Figure 7.9 Tensile and compressive forces on the top surface of the floor panel due to specified lifting options

It was at this stage that the team was alerted to Flexus, an innovative concrete product reinforced with polyester fibres. This reinforcement, and the compositional makeup of the product, allows the slab an element of ductility through flexing and bending. In the extreme case these cause tiny stress fractures rather than the dramatic, and very visible, cracking caused by a brittle failure in standard concrete. This material sounded perfect for use in the First Light house, and negotiations with the material supplier began.

> *Reid™ Construction Systems …now brings a major technological leap using "bendable concrete". Flexus™, a fibre-reinforced engineered cementitious composite (ECC), provides the structural integrity of reinforced concrete but without the weight or thickness.*[49]

The specification of Flexus meant that the desired 50mm topping could be achieved, as thicknesses as low as 30mm were proposed by the manufacturer.

Changing the floor from its original timber floorboards to a concrete finish made for a potentially large change in the interior atmosphere. The design team did not want an industrial look or feel inside the house. It was therefore decided to add a neutral pigment to soften the appearance of the concrete, and the concept of the interior / exterior dissolution continued with a sandy, textured ground being specified.

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[48] The weight in the floor would serve an extra purpose in helping to anchor down the house, the foundations for which were not allowed to penetrate the ground of the National Mall by more than 457mm. *Solar Decathlon Rule 4.3: Ground Penetration,* p10

[49] Reid Construction Systems, *Flexus Bendable Concrete* http://www.flexus.co.nz/ page last accessed 02-04-2012

Figure 7.10 Conceptual and proposed finish for the concrete floor, and the neutral pigment #156 added to the ECC mix IMAGE CREDITS (centre & right) PETER FELL

7.4 Conclusion

Figure 7.11 Although the overall form is similar, the development from original design (top) to Solar Decathlon proposal (bottom) presents a much boxier and more closed-in elevation

As described above, the window: wall ratio was not given a lot of consideration in the original design, at least in terms of code compliance or thermal performance. Glazing was used in the way that only a paper project could, or probably should, do. Over the conceptual development phase the windows were reduced in size and the wall thickness increased so that the final WWR was closer to 20%. This altered the appearance of the house quite considerably; the alluring transparent skin gave way to a much chunkier, boxier, enclosed alternative. Although the house retained its overall form, it would need thoughtful design to maintain the original interior feel, through the careful specification of finishes and lighting (which will be discussed in Chapter 8 and 11 respectively).

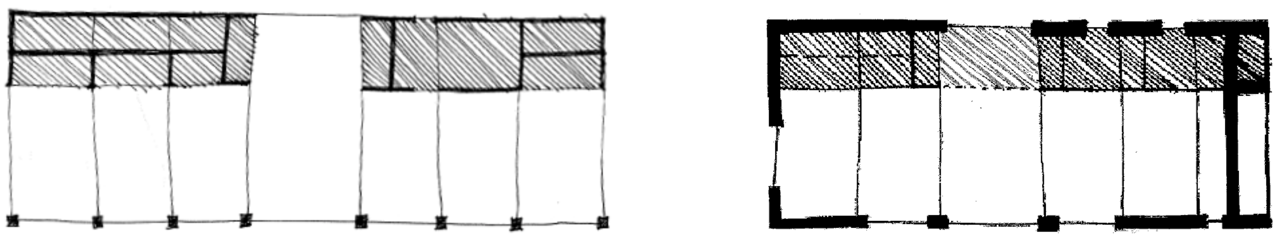

Figure 7.12 Plan views of original design (left) and realised design (right) showing relative window: wall ratios

The decrease in glazing had its benefits. The liveability of the dwelling was upgraded through increased privacy and a marked improvement in thermal performance. The strategic placement of windows and natural light in fact strengthened the design outcome by providing varied lighting qualities through the interior, and by introducing different levels of public and private interaction with the spaces. The focus on the central space, with its light and openness, was enhanced as it now contrasted with the rest of the envelope.

The specification of a concrete floor provided the recommended thermal mass for passive temperature regulation, and the introduction of a new material – the flexible, suitably pigmented concrete – added richness to the design.

CHAPTER 8 – CHALLENGE 5: A set of standard interior details

8.1 Interior linings

Interior finishes were not defined in the concept so there was a clean palette with which to work. Indeed, as was mentioned in the preliminary research, most time was spent *outside of* the bach and not in it at all. It was a place to sleep and maybe use on rainy days, so much so that 'rainy day at the bach' is an understood expression in New Zealand. The design team did, however, have a number of aesthetic preferences, or preconceived notions, of interior finishing suitable for a bach-type home. The finishes needed to be simple; clean but not minimalist; and natural but not rustic.

> *"It was made of ply and fibre cement. The bach was an ordinary stud, timber frame house. The roof was corrugated steel. The kitchen was ply with a formica benchtop and a gas stove."* [50]

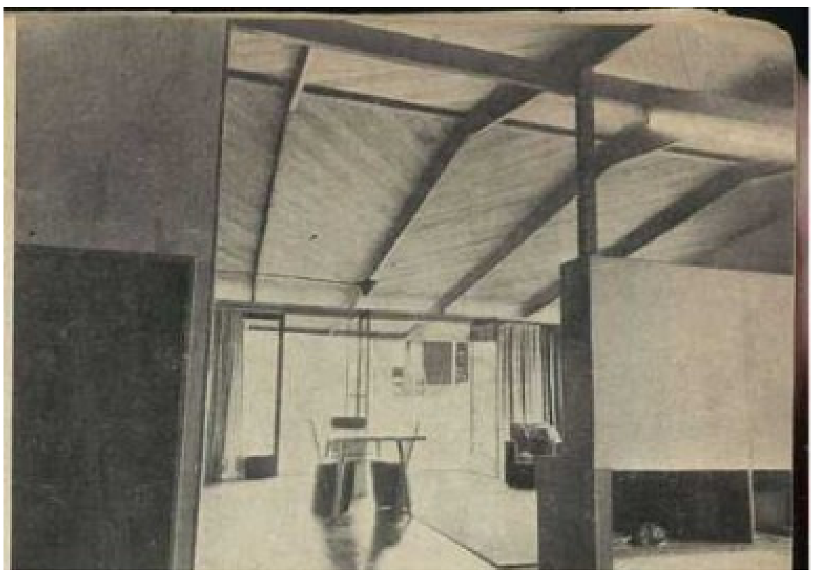

Figure 8.1 Interior of a Group Architects house in Takapuna IMAGE CREDIT NEW ZEALAND DESIGN REVIEW

Originally, the team had imagined a plywood internal lining in reference to both the traditional bach aesthetic and the early Group houses, which have been 'sold' as being iconic NZ architecture. [51]

The first option investigated was a fully panelised lining system, perhaps as a continuation from the original all-panel construction concept. An interior panelised system had many conceptual and practical benefits: the panels could be protected during transport and assembly and installed at the end of the coarse structural work; they could cover the module joins and conceal the modular nature of the construction; and looking at the design of the house in a long term, commercial way, it made the interior easy to customise for individual tastes, and even exchange if those tastes were to change at a later date. The panels themselves would come in any number of variations – those looked at by the interior design team were:

[50] Whare Timu recounts the materials in his childhood bach on Lake Taupo. Farrow A (2009) *op. cit.* p16
[51] Gatley, J [ed] (2010) *Group Architects*, Auckland University Press. p3

- natural, lacquered or stained plywood
- hessian, canvas or fabric covered board
- painted or wallpapered board.

The hessian, ‘pin board’ coated wall panels were discussed with reference to the very back-to-basics baches in remote locations; with good detailing these could provide a playful, contemporary finish with the added benefit of some acoustic baffling. Due to the boxy, perpendicular, and predominantly hard surfaces of the interior, acoustics were considered a potential problem in the First Light house. Grooved plywood ceiling panels were also detailed and these were included as far as the developed design submission.

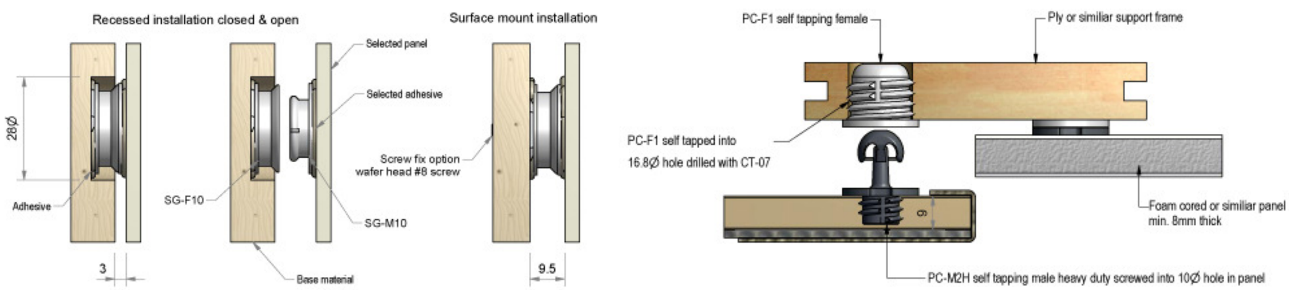

Figure 8.2 Forman *Fastmount* panel clips for panel mounting IMAGE CREDIT FORMAN MOUNTING SYSTEMS

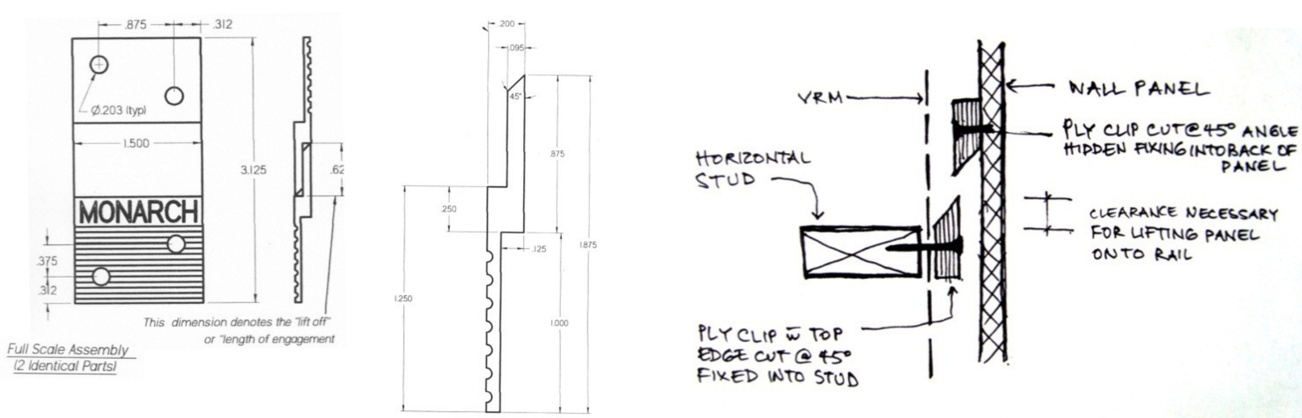

Figure 8.3 Gravity-based panel mounting systems: American Monarch Z clip (left) IMAGE CREDIT MONARCH METAL FABRICATION and (right) custom ply split rail

A range of panel mounting systems were investigated, from horizontal clip mechanisms to gravity-reliant hooks and rails and four examples are shown in figures 8.2 and 8.3, above. The framing on the interior side of the wall structure comprised 70x45 horizontal studs, which would enable clips or rails to be attached to the timber. Gravity systems allowed a degree of tolerance that the horizontal clips with their fixed spacings did not. However these systems required negative detailing to allow clearance to lift the panels on and off their rails. Visually, there would not be much tolerance as slight angle changes between the modules would become very apparent in vertical, parallel panels. Even though the modules were even in width, on the interior, due to the thickness of the end walls, there was no obvious repeatable dimension for the panels. It was hard to get a rhythm along the length of the interior (figure 8.4 below). Detailing around the windows would also be difficult with such a system. In the end, it was decided that the negative detailing required would need to be too precise and did not allow the tolerance necessary for the type of assembly that would be needed. In use negative detailing is also difficult to keep clean. It was decided the idea of an interchangeable wall finish would have to wait until commercial prefabricated options were investigated in the future.

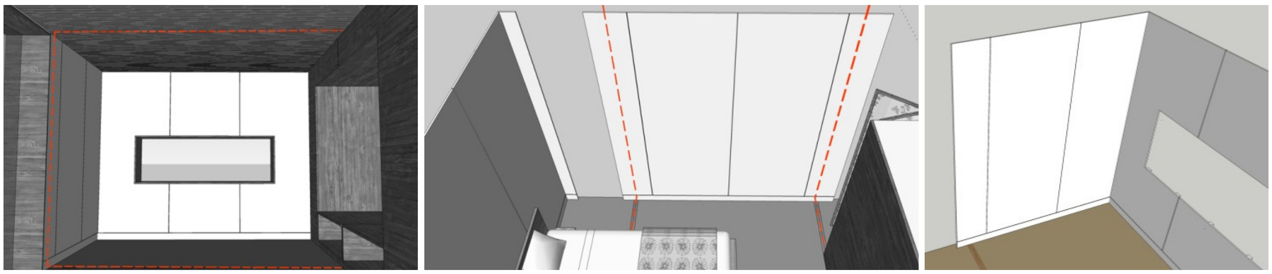

Figure 8.4 Panelised lining system trials in the living room end wall and across the module joins in the bedroom, module junctions shown as dotted red lines. (far right) variations in panel modules make an internal rhythm difficult

On advice from Proclima New Zealand[52] and in order to make the house air tight, the engineering team wrapped a ***vapour release membrane*** (VRM) around the interior surface of the thermally-broken timber frame. This envelope, an air-impermeable membrane, allows water vapour to diffuse through it when humidity is high within structural elements, either due to seasonal change or unexpected moisture intrusion. When the average humidity is low, the membrane resists the penetration of vapour into structural elements, preventing interstitial condensation.[53] It was applied to the frame facing *outwards*, or towards the *interior* of the building; any excess humidity inside the home was then to be dealt with by the energy recovery ventilator in the services shed. More importantly, the membrane was air tight to prevent heat loss through air infiltration from any small gaps in the construction.

Figure 8.5 Proclima Intello vapour release membrane: properties (left) and (right) VRM applied to the internal walls of the living room IMAGE CREDIT (left) PROCLIMA NZ

For this membrane to work optimally, the VRM supplier recommended a breathable interior lining which would allow water vapour to track through its structure. The glues between the layers of the desired

[52] Pro Clima New Zealand has been operating since 2006 and is a subsidiary of German-based Pro Clima, set up by building physicist Lothar Moll who specialises in airtightness systems http://www.stuff.co.nz/the-press/news/6629609/Keeping-Kiwis-snug-is-about-education

[53] Greenspec UK *Airtightness and Intelligent membranes* http://www.greenspec.co.uk/airtightness-membranes.php Pages last accessed 14-05-2012

plywood lining would prevent this osmosis occurring, and the vapour would not be released from within the wall structure. A lining on an internal cavity was drawn up in the hope that gaps at the top and bottom of the wall would provide sufficient airflow to release the moisture (figure 8.7 below), but the VRM supplier did not believe this solution would be successful. Alternative linings were therefore investigated.

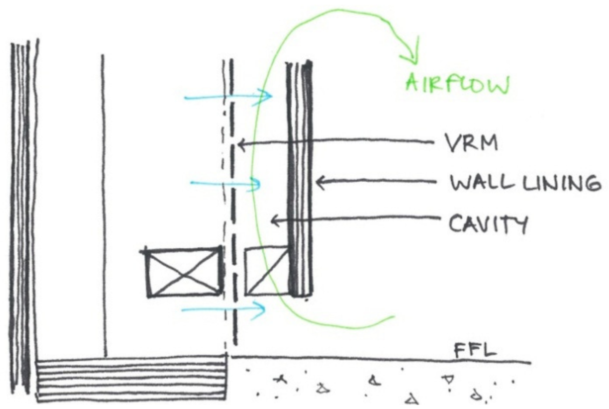

Figure 8.6 Trial detail of an interior 'vented cavity'

Options for a natural, permeable lining were:

- GIB plasterboard
- Timber paneling

GIB was deemed too fragile for an international journey, and its detailing too permanent for a demountable modular house. Therefore the team turned to timber panelling as an option. This would allow a natural wood finish, and would provide an internal atmosphere similar to that of plywood. Timber boards could also be laid in line with the module cuts to create a discreet module join.

Figure 8.7 Finland's 2010 European Solar Decathlon house showing the interior timber finish in line with the module join

8.2 Electrical services

The ‘vented cavity’ idea mentioned in the previous paragraph was not immediately dropped, but instead adopted to house the wiring. This meant that the entire wall structure could be insulated and permanently closed; electrical cables would not need to penetrate the membrane, which might interfere with its airtightness. This approach allowed maintenance or repairs to be undertaken by removing only the wall lining rather than opening the airtight wall structure. This option also meant that the construction of the walls could go ahead while the electrical services and interior design were still being finalised.

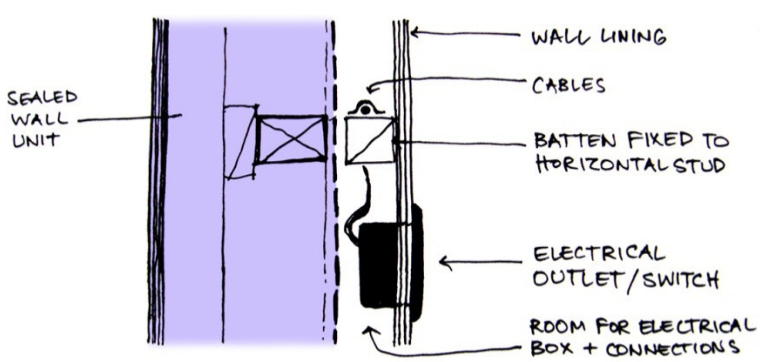

Figure 8.8 An interior cavity means electrical cabling and outlets do not penetrate the airtight wall structure

8.3 Inter-module joins

After working with and discarding the demountable wall panel system, the design team decided on a house aesthetic that was not obviously modular but rather referenced its modularity subtly through design details. It would prove easier, and more successful, to enhance the module join rather than try and disguise it completely. It was important for the design, and for ease of assembly, to develop a standard set of simple, repeated interior details.

8.3.1 Wall and ceiling joins

A coverboard at the module join was an obvious solution for quick and easy assembly. This would allow for tolerance in the case of movement or slight height discrepancies between modules and would neatly cover over a potentially raw edge.

A ‘rib’ aesthetic was trialled, where a thin coverboard was fixed over the linings at the module junction. This ‘rib’ was to line up with the columns of the canopy structure outside the house. This expressed the module join rather overtly and competed with the sills, jambs and architraves of the large, fixed windows in Modules 2 and 4, which were less than 200mm from the module join.

The vapour release membrane needed to be taped at the module join to ensure a continuous airtight envelope. The specified finish would need to provide access to the structure at the join so that taping could be done. A fine coverboard (figure 8.9, far left) did not allow this access, and a coverboard that did was too coarse (figure 8.9, centre).

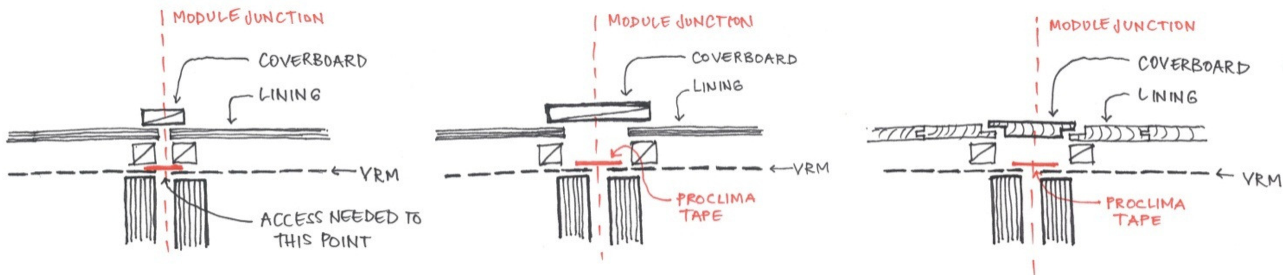

Figure 8.9 Sketches trialling possible lining solutions at the module junction

A natural timber lining fixed vertically to line up with the module join meant that the majority of the wall finish could be permanent. Only a small part of the wall at the join would need to be removable to access the wall structure for taping. The vertical tongue and groove boards, with specials rebated at the module join, enabled a much more discreet join than had been possible with plywood panels, though they still subtly referenced the join and provided a degree of tolerance. The new orientation of the wall lining meant that it could continue with a 90 degree join to line the ceiling as well. This simplified the detailing, and the interior palette, though it meant that the acoustics, initially to be deadened with grooved plywood ceiling panels, would have to be tempered by the soft furnishings.

This was not an off-the-shelf solution: special boards for the module join (profiles 2 and 3 in figure 8.11 overleaf) had to be milled which increased the time of construction and raised the price of the lining.

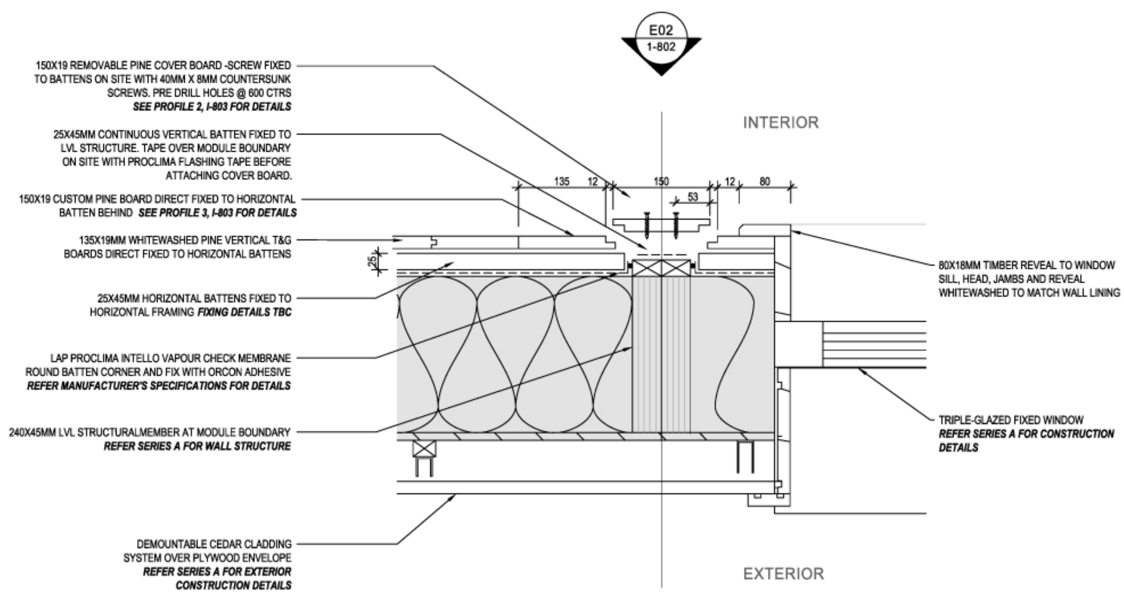

Figure 8.10 Final working drawing showing standard lining detail at the module junction

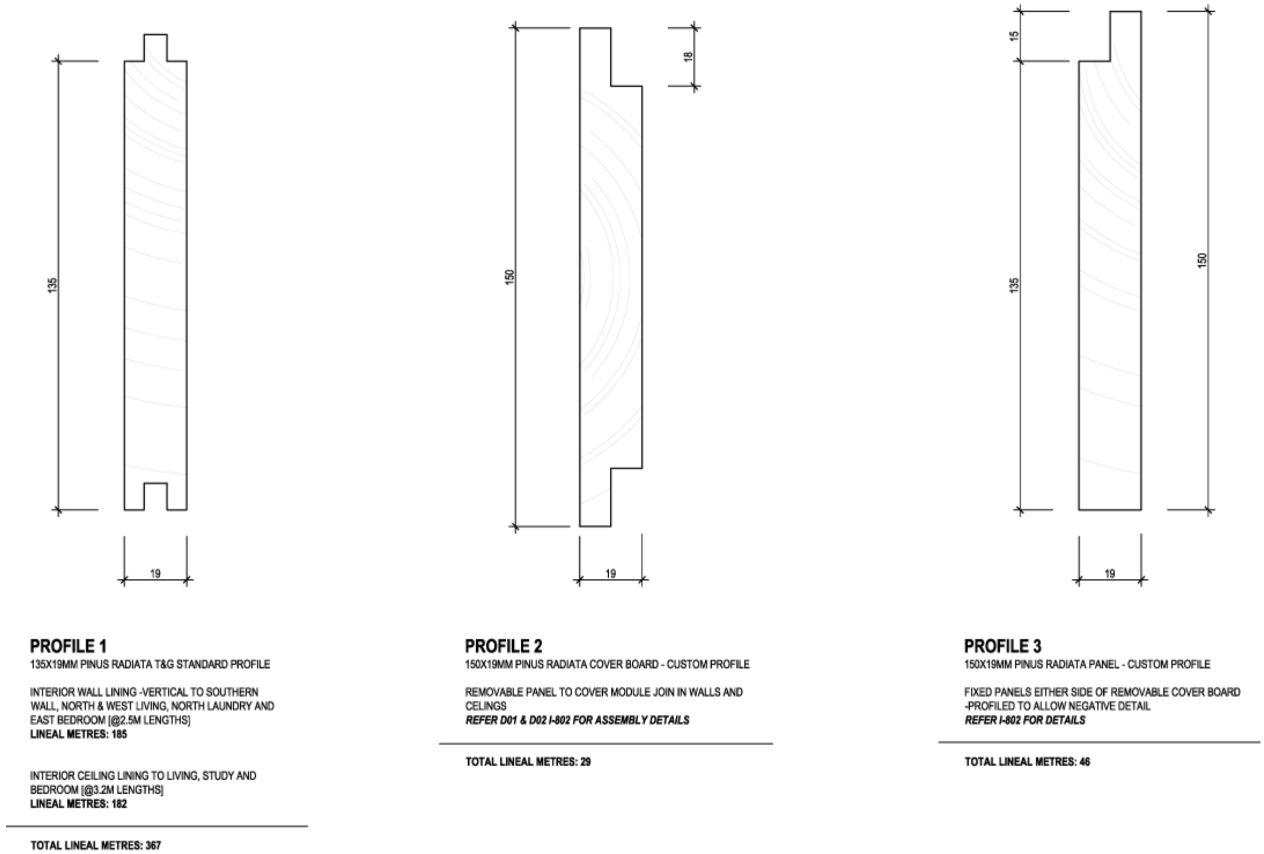

Figure 8.11 Profiles for pine interior lining including custom milled boards (profiles 2&3) to cover the module joins

Figure 8.12 Photos during construction of (left – right): fixed panels either side of the module join; the module join taped at wall and ceiling to complete the airtightness envelope; and the finished ceiling lining at the module join

8.3.2 Skirtings and scotias

Specifying a removable wall panel at the module join brought about the necessity for having removable skirtings and scotias. Apart from the coverboard at the module joint, the scotia had to be removable to allow access to a stainless steel tension wire, which was specified by the engineer to pull the modules together at the top edges. This needed to be installed and tensioned once all the modules were in place and so precluded a pre-finished interior wall/ceiling junction.

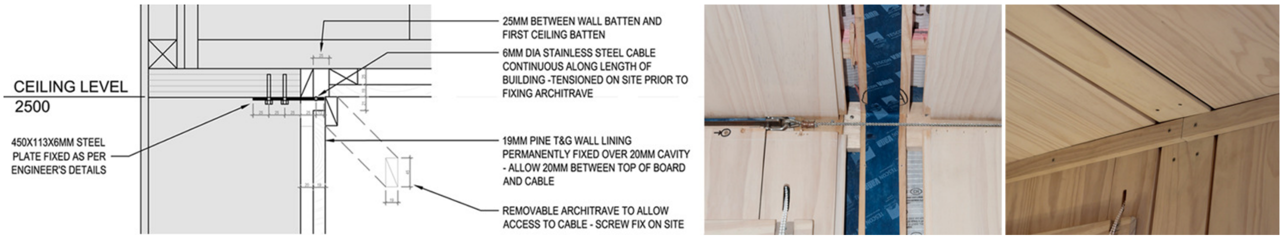

Figure 8.13 Detail for removable scotia (left) and stainless steel tension cable exposed (centre) and covered (far right)

It was initially hoped that the wall lining would carry on down to the floor with no skirting whatsoever. This would require much more precision work at the construction stage, to get the floor/ wall junction looking straight and tidy, but would require no further work on site. The removable panel at the module joins would do the same. However as the construction schedule grew ever more compressed, troubles with the floor construction were delaying other parts of the finishing process. The wall lining could not proceed until the floor finish was complete unless a design change specified a skirting that could be attached at a later date. This option was taken up so the wall lining could get underway. It was decided that the skirting would remain a removable component so it could be continuous over the module join.

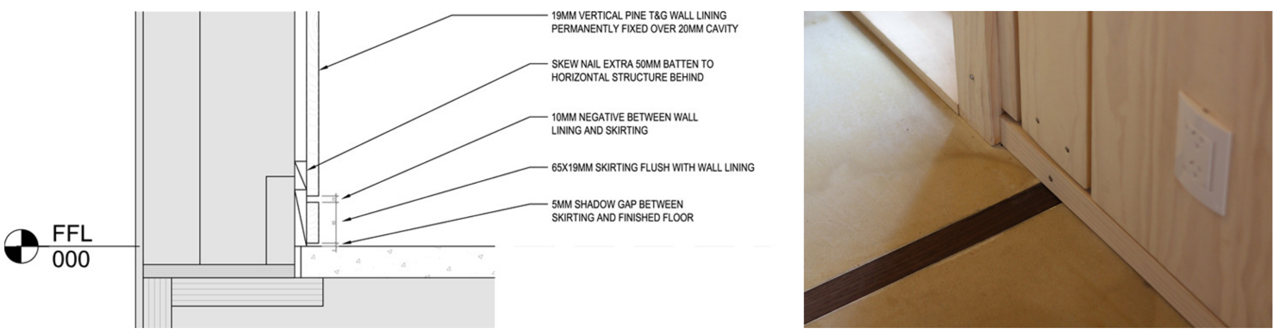

Figure 8.14 Detail for removable skirting (left) and photo showing continuous skirting over the module join (right)

8.3.3 Joins in the services core

A stylistic choice meant the design team preferred not to reference the modularity of the house in the services core detailing. The design intention, perhaps carrying through from the original prefabricated cores, was to create the feeling of a continuous services box inserted into the modules, and to further distinguish the services space from the living space in this way. This meant the lining material would be fixed horizontally to connect the core with the longitudinal axis of the house.

8.3.3a Wall joins

In keeping with the bach aesthetic and the specification of a natural timber lining, dark, textured, recycled Rimu T&G was selected for the services core. This was intended to accentuate the longitudinal services, and wrap or fold into the individual functional areas. Its finish, a plant-based oil, would bring out the deep, rich red-brown tones of the wood grain, and would provide a water resistant coating in the wet areas.

Making a six-part services core appear continuous was a rather difficult feat, especially when the lining was perpendicular to the module join. Options for minimising the modular appearance were investigated at length.

Due to the location of the module joins in the wall, a negative detail above the doors and the central bulkhead space made for a credible break in the lining, without it being overtly modular. A negative detail at each cut was felt to be too difficult as there was not enough tolerance provided for assembly mishaps, and this option required a lot of precise work during construction. It would also be hard to protect the edges of the lining at the module break, if the lining went right to the join.

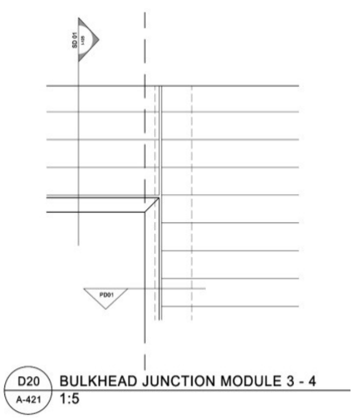

Figure 8.15 Trialling a negative-detailed 'panel' above the doorways and central services space. This did not achieve the look the design team desired, and its construction allowed little tolerance in the assembly stage.

However as can be seen in figure 8.15 above, there was only a small area – perhaps no more than three boards – that would express the modularity in the south facing services wall, as all the other boards terminated naturally due to the various openings in the wall itself. In the living room there was a sitting 'nook' that the boards folded into; then the wall gave way at the edge of the open kitchen and dining area, and finally the doorways of the bathroom and laundry finished off their respective modules. This meant that there was the potential to pre-finish the lining up to the height of the architraves, and attach the final boards above the architraves when on site. They could run over the module joins and fixings could be staggered so that there would be no feeling of modularity at all. This idea was finally overturned on the premise that there was already enough on-site work and as much of the finishing as possible should be pre-done during the construction stage.

In the meantime, with construction going at full capacity on site, lining had begun and the builder had decided on his own module join detail! This provided a neat finish to the module edge, but allowed for no tolerance at all. A 'negative detail' would be created if there was any movement between the modules, which was certainly not ideal. A timber block was attached to the back of the framing so that the two modules could be mechanically pulled together at this point if need be.

Fortunately, as mentioned above, every module had an opening at its edge, so the 'expressed architrave' detail could be continued along the interior. Despite initial reservations and a slight gap between M1 and M2 at Frank Kitts Park, this detail worked successfully for the competition assembly.

Figure 8.16 Treatment of the module junctions on the services core wall – modules 4, 5 and 6 during construction (above) and modules 1, 2 and 3 finished (below)

8.3.3b Ceiling joins in the bulkhead

As with the wall, a ceiling that seemed continuous in the services space was desired. However, unlike the wall, access was needed behind the lining. Therefore more than a small part of the ceiling would need to be removed at every module join. Initially the idea of a trapdoor was trialled, at the same time as the negative 'panel' detail was being trialled in the wall.

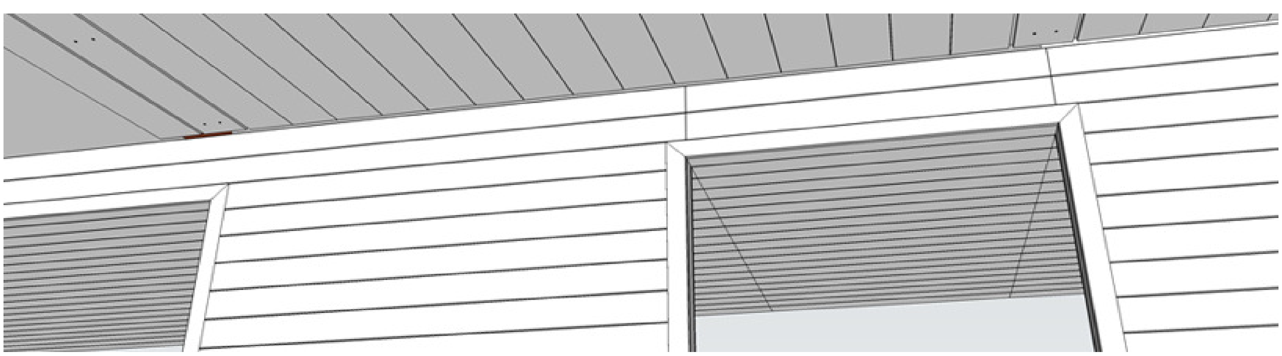

Figure 8.17 Lining up a removable hatch in the bulkhead space with the door and module join

Services in the bulkhead were becoming increasingly complex. Once it had been decided not to go with a plenum, the services space, which had previously felt generous, was filled with a large duct. This took up the majority of the space and divided the bulkhead into two parts. In addition to this, as a public building on the National Mall the house needed sprinklers. This required additional piping, and a cable tray was added so that the heavy multi-core electrical cables could be better supported. Added to this was the fact that the services connections were not necessarily located directly above the module join, and the suggestion for a completely removable ceiling to the bulkhead space started sounding a plausible option.

The easiest and most logical structure for the ceiling lining would have been permanent timber joists spanning the services space, into which ceiling panels could be fixed. However this structure would need at least 90mm of structural thickness, which was not available. A nominal space of 50mm had been left below the duct for the bulkhead ceiling structure. This was the point at which the interior team should have taken a stronger stand; 50mm was certainly not enough for ceiling framing spanning 1550mm, and not immediately questioning this led to a long, avoidable process of investigating ways to support the ceiling.

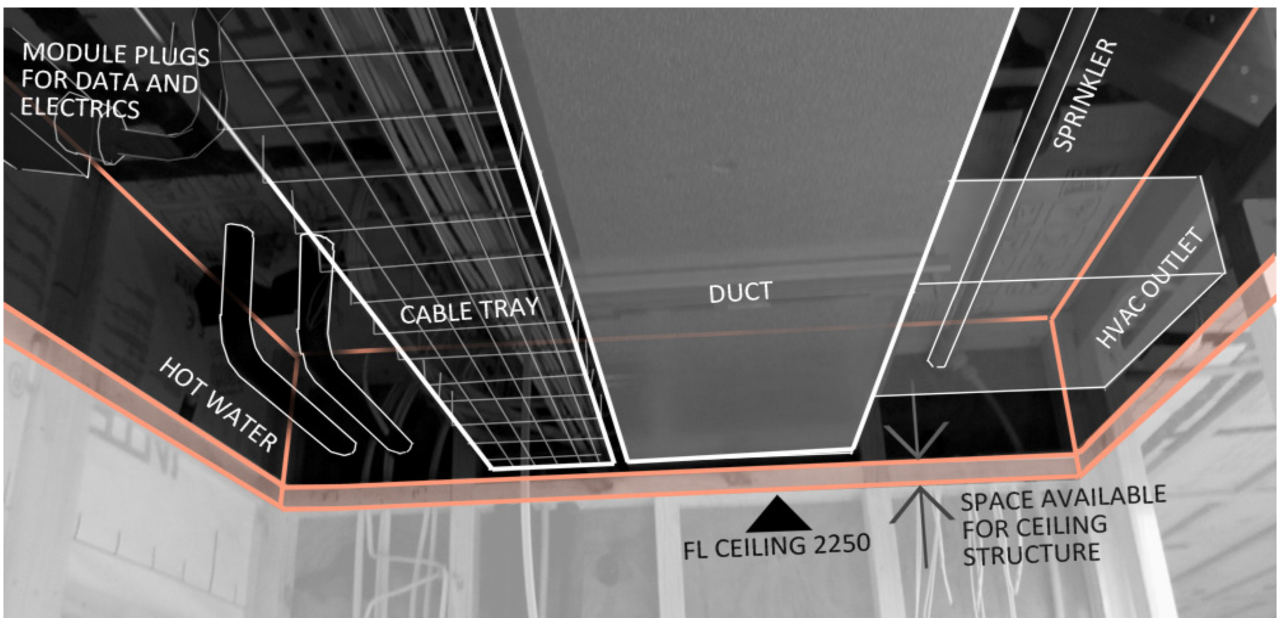

Figure 8.18 Photo during construction: the installed bulkhead services above the kitchen at the time the removable ceiling was being developed

The services were specified, and some were already installed, so the structure for the ceiling would have to work around these. As can be seen in the annotated image above, the main services were located near the middle of the bulkhead and took up its whole depth. The ceiling structure had to span this distance, or find a way of suspending structural members between the cable tray and duct. Due to the depth of these services, there was very little 'wiggle room' to lift the panels onto clips or similar suspension systems.

The first solution dealt with each section of the bulkhead separately, as their varying sized spaces had been created along its length, with the denser, more tightly packed services at the western end. This solution fitted structural members around the existing services, but was rather complicated. The construction schedule was already very condensed, with the builders working seven days a week. Another joiner was employed to help meet the fast-approaching deadline, but even so, it was thought that this initial solution would take too long to construct.

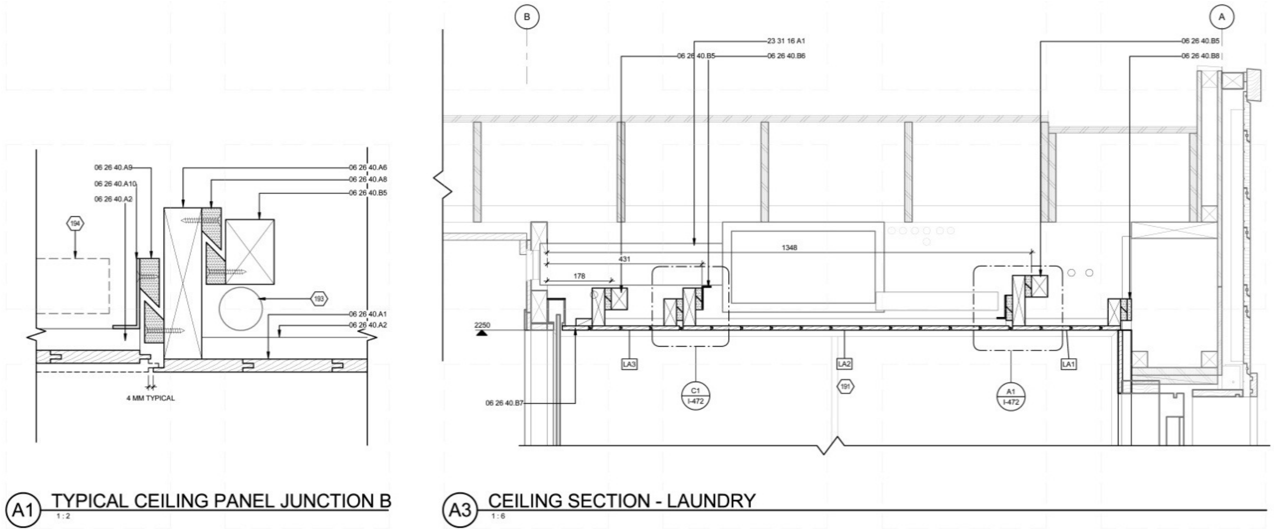

Figure 8.19 Original design for hanging ceiling panels

The builder suggested an alternative solution based on a commercial suspended ceiling construction. He proposed that the ceiling panels could be part of the Rondo suspension system. The construction team trialled it in the living room services core, where the services were the lightest and most flexible, and the solution worked remarkably well. Ceiling panels were put together with Rondo channels as their structural battens. These could then clip into a Rondo clip, suspended by wire from the roof structure. Where a timber strut was too big, a wire could fit between the duct and the cable tray, at the ceiling's mid span. What was additionally helpful was the fact the Rondo batten could span a greater distance than a timber batten, but it was only 16mm in depth. This meant that there was a little bit of room to move when lifting the panels up and onto clips.

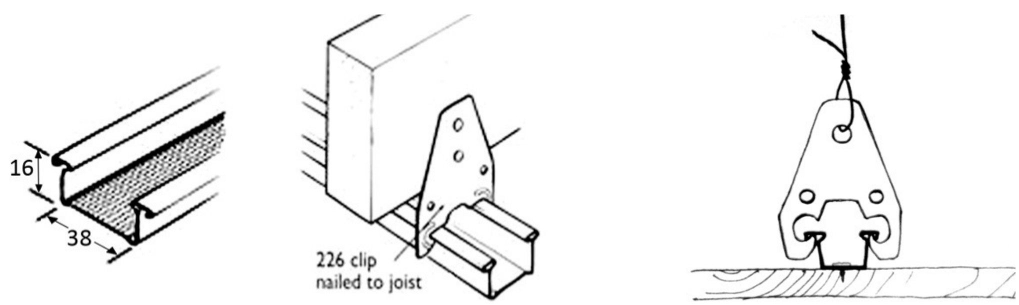

Figure 8.20 16mm deep GIB Rondo batten and metal clip (left) and detail for suspending the ceiling panels (right)
IMAGE CREDIT (left) GIB RONDO

Figure 8.21 The use of the Rondo system to support the removable ceiling was trialled in the living room 'nook', the end of the bulkhead with fewer services. Instead of a solid rectangular duct, the engineering team specified a flexible duct for this area, so that plywood struts could be attached to the roof structure above. Rondo clips were fixed into the plywood.

8.3.4 Floor joins

Creating tidy, deliberate, tolerance-allowing joins in a series of concrete floor slabs was also to prove challenging. The detail needed to maintain a neat junction and to protect the concrete edge while in transport. It also had to allow for movement between the modules from East to West, and to deal with possible height differentials between one module and the next. Ideally, it would also allow for the structure to be taped together at the joint to complete the airtightness envelope from the inside, although taping here was only precautionary, as the joint was also taped from underneath.

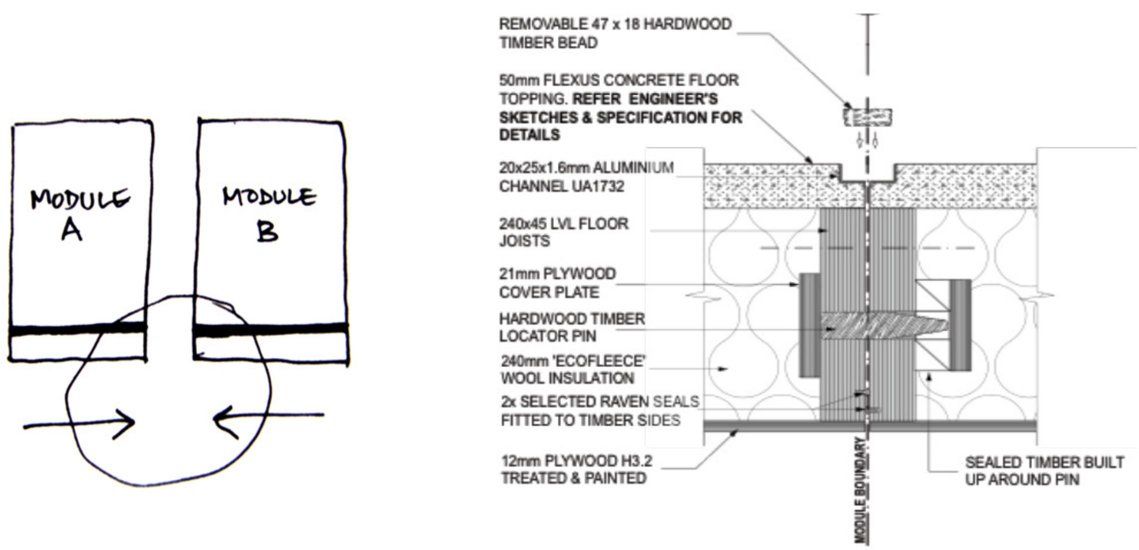

Figure 8.22 The final detail drawing for the module junctions at the floor (right)

The specification certainly seemed easier than it eventually transpired. An aluminium angle was detailed for the purpose of protecting the concrete edge in transit, and to provide a neat, clean line at the edge of the module. This meant that, below the finished floor level, the aluminium angles could be taped together with Proclima. A wooden bead was to cover the tape and fill the gap between the aluminium angles. This could be packed and planed to compensate for height and width differentials. This was an aesthetically appealing solution, as well as a seemingly easy construction solution.

When the prefabricated concrete floors arrived on site they were without the protective aluminium angles, which had been removed from the slabs prior to delivery. Removing the angles had ripped away some of the concrete edge so the module joins were raw and jagged. There were more problems: the concrete slabs themselves were uneven and were not level with each other when placed side by side. In the worst case, there was a height difference of 17mm across the 3m interior length of a module. This was not a good start to the construction: if the modules did not line up before they were finished, they would never fit together properly during assembly! The floor needed to be leveled inside with the aluminium angles set back in to the edges.

As mentioned previously, this led to a setback in the already tight interior construction timeline. The wall lining could not go ahead as planned, and in an effort to advance the progress, a skirting was specified so that the lining could start while the floor surface issues were fixed. In the meantime a new company, Ardex, made contact with the First Light team and offered to sponsor a floor leveling product[54]. This product was strong and could be laid reasonably thinly without the risk of cracks. Using the same concrete colour as was used in the original ECC floor slabs was not recommended, but instead a compatible pigment from the same supplier was used. The team liked the original colour selection and so began a series of trials with the raw flooring mix to match the preferred neutral tone. After a long and stressful process which included spraying a cement based product into a partly-finished interior, the floors were level and ready to take the hardwood timber beads as initially specified.

Figure 8.23 The module edge that arrived on site (left) and the finished floor join after a long process of remediation (right)

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[54] The ARDEX Group is a world supplier of specialist building materials. Based in Witten, Germany, the Group has branches all over the world, including New Zealand, where the Southern Hemisphere's only rubber manufacturing plant is located. Engineered solutions for tiling and flooring are also offered by ARDEX New Zealand Ltd. http://www.ardex.co.nz/about_us Page last accessed 14-05-2012

8.4 Conclusion

The original design did not present materiality in any sophisticated sense. An undeveloped palette consisting of a nondescript white material, exposed timber structural members, and glass, represented the limited investigations into material specification for the original design. The developed design therefore had plenty of room for improvement, and this was realised with natural timber linings reminiscent of the plywood used in traditional bach interiors. Plywood was discarded as an option on the advice of one of the project sponsors, so profiled timber boards were the 'next best option'. In hindsight, the specification of timber boards was beneficial to the assembly process, as well as to the appearance and feel of the finished interior. Early investigations into a panelised plywood lining identified potential difficulties in the articulation of the module join, which were easily addressed with the profiled coverboard solution specified.

These linings were permanently fixed to the wall over a services cavity. The specification of such a cavity enabled the wall structure to be finished and made airtight, and then for the electrical services to be completed later in the construction phase, without compromising the building's airtightness. The removable coverboards allowed access to the primary structural framing at the edge of each module so that the join could be taped. The design of these boards to include a negative detail on either side of the board also permitted a certain amount of tolerance between the modules.

Module coverboards provided a quick, easy and tidy way to finish to the linings throughout the interior, and a similar, but sacrificial, solution for the floor was also specified

Removable timber ceilings in the bulkhead, however, were not an easy solution in terms of design or construction. Increased communication between the services and interior teams during the development of this part of the house should have precluded the necessity for such a specification.

CHAPTER 9 – CHALLENGE 6: The non-standard details

As described in chapter 8, developing a set of standard details (or at least repeated details, for many were not standard in terms of a conventional house construction) took a lot of time, but it was the non-standard details that were to be a real challenge for design and implementation. Here, the architecture team had no direct precedents and had to come up with brand new, previously untested details. Those of particular interest for the interior were the thermal blinds developed to lock a layer of air between the blind and the window; the team's solution for a two-part, watertight bathroom; and the details developed to put a fully panelised module three [the central module] together on site.

These solutions were all necessary, and successfully realised, but perhaps should not be repeated if possible. However the particular requirements for the project brought about its unique solutions. These were challenging, and helped the design team to push what was possible in terms of high-performance, non-permanent detailing. They were investigated, developed and implemented, and worked very successfully during the two assemblies undertaken for the competition.

9.1 Window coverings

Having optimised the structural envelope, the airtightness envelope, and the wall linings for thermal performance, the engineering team requested thermally-backed coverings for the glazing, which was always, but now more than ever, the weakest link in the thermal envelope. The engineering team required a covering that would produce a 'seal' – or at least a solution that would significantly diminish airflow around its sides. This would work to trap a layer of air between the covering and the glass, creating another thermal buffer between the interior and exterior air temperatures.

The house had two large floor-to-ceiling, full-module windows; one 400mm wide floor-to-ceiling window; one horizontal window measuring 800x1800mm; two 2700x2400mm bifold door sets, and a 3000x3000mm skylight. Specifying a covering that would uniformly fit over each of these window types was to prove a difficulty, both in terms of aesthetics and functionality.

There were a number of available options on the market for covering the windows. Options including standard heavy drapes, rolling or roman blinds, concertina blinds and venetians were looked at, and sketched out to compare their aesthetic and performance features, as in figure 9.1 below.

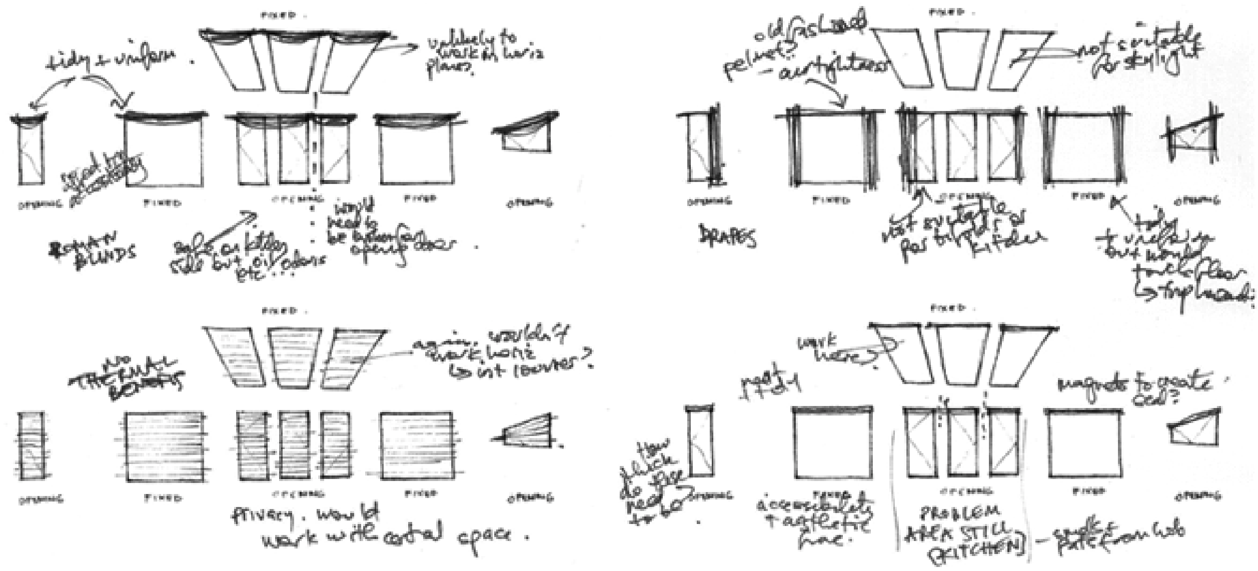


Figure 9.1 Sketches comparing possible window coverings and their stylistic effect on the interior [view to south from inside the building]

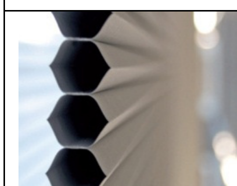
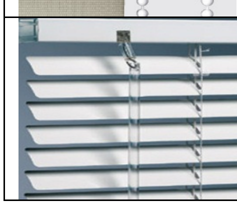
Type of covering		**Comments**
	**Pleated or concertina blind**	Would perhaps slow movement of air between glass and interior if in a special bespoke bracket, otherwise thermal performance would be limited. Aesthetics also not entirely favourable.
	**Standard drape**	Not contemporary enough for the bach's more minimalist aesthetic. Takes up space and because it touches the floor there is the potential that it will get in the way of foot traffic and could be a hazard during public exhibition period. Not suitable for M3.
	**Roman blind**	Neat, and could be repeated throughout the building. Would have to be in two or three parts across the central module to allow for opening of hinged entry door, which is a slightly messy detail. Still a little bulky at ceiling level and risky in kitchen area
	**Roller blind**	Neat, similar properties to roman blind. Segments needed across M3 entry doors. Would need to roll backwards [as shown in image]; when rolled up thermal backing would be exposed. Creating an air seal against the wall or architrave might prove difficult. Magnets?
	**Venetian blind**	No thermal properties; would provide privacy only. The only window covering that would be suitable in the M3 entry/ kitchen space: micro blinds could be attached to individual doors – solves issues around allowing for opening of entry door and fire risk next to the hob on the kitchen side of the module

Table 9.1 Images and comments regarding different blind options

A visit to Window Treatments brought up the option of 'in line security blinds' – a blind set into the window frame. The option available on the market was a heavy blind with an institutional feel that was installed in an existing window frame, decreasing the overall opening as can be seen in figure 9.2 below. The supplier did not believe the existing system could be customised to suit the First Light house; and if the frame was to be recessed into the window reveals, the blind would have to be operated by remote control. This was not desired for two reasons: firstly, it went against the bach concept of simplicity and manual operation, contradicting the 'humanisation' of the interior design[55], and secondly, by adding an unnecessary electrical load to a system that was aiming to use as little power as possible was contradictory to the team's approach.

However the concept of a blind within the window cavity was a promising one so the team took the idea away to develop in-house.

Figure 9.2 Window Treatments' Securo Blind IMAGE CREDITS WINDOW TREATMENTS

Fortunately, due to prior developments described earlier[56] there was a cavity behind the interior lining, which made it easier to recess a blind and its mechanism behind the wall. The lining had not been finished but, unfortunately, the main wall structure had, complete with its sealed airtight membrane. This would need to be opened again above the windows and the wall construction altered slightly to accommodate the blind roll. The insulation packed into the wall cavity would need to be cut down and retained so as not to get caught up in the rolling mechanism or the blind itself. There were small plywood gusset plates at mid span and at each end of the wall space; the engineer was contacted to sanction the notching of these (see figure 9.3, far left).

It was a complicated task at this stage in the construction… but a possible one.

In order to progress the construction in an already tight schedule, removable panels above the windows were specified so that the lining could be finished. The blinds would then be installed once fabricated, and in the meantime were not affecting the critical path for interior completion. Maintenance access to the blinds in the future would be necessary in any case, so the extra work to detail and fabricate removable panels was a valid expenditure.

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55 For a comprehensive explanation of the values underlying the final bach design, refer to chapter 11.

56 Chapter 8.2: Electrical services, p95

In order to accommodate the cylindrical blind, to contain the insulation, and to keep the interior envelope airtight, a rigid, semicircular restraint was required. Originally it was thought that a PVC pipe could be cut and stretched to fit between the existing structure. However on a visit to the building supplier a perfect product was encountered; plastic guttering in long lengths, already semicircular in shape (meaning no further preparation was required) would be perfect for the job. This was bought and installed as can be seen in figure 9.4 below.

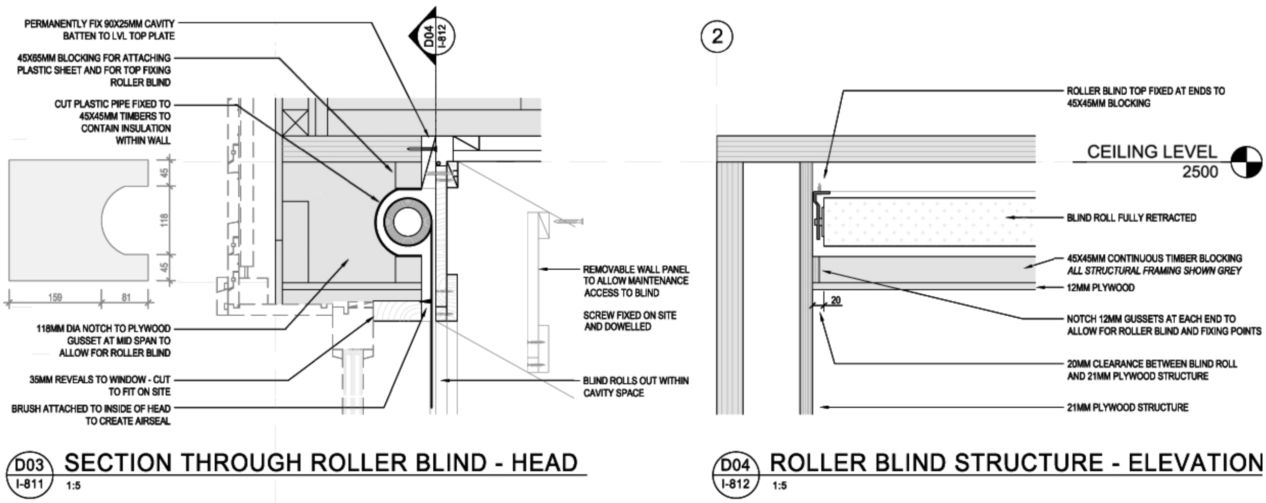


Figure 9.3 details for the in-wall roller blind, showing removable panel and the need to notch structural gusset plate

Figure 9.4 (left) The airtightness membrane was reopened and some of the insulation removed to accommodate the blind within the wall. The gusset plate at mid span can be seen notched. (right) the guttering profile was fixed into the cavity, and sealed with [green] adhesive to ensure airtightness. The lining panel was then fixed over this to await blind installation at a later date.

The only detail to be resolved now was the operation of the blind. Given the team's prior decision to forego a mechanised blind, a pull-cord was needed. Unfortunately the pull-cord was part of the roller mechanism so there was no possible substitute for it. A notch in the removable panel was designed so that the cord could be pulled through, the architrave was notched and a small metal plate attached to allow the pull cord free movement.

The necessity for a pull cord was an unfavourable feature of this configuration but could not be avoided. Given the situation, the blind was successful and as neatly detailed as possible.

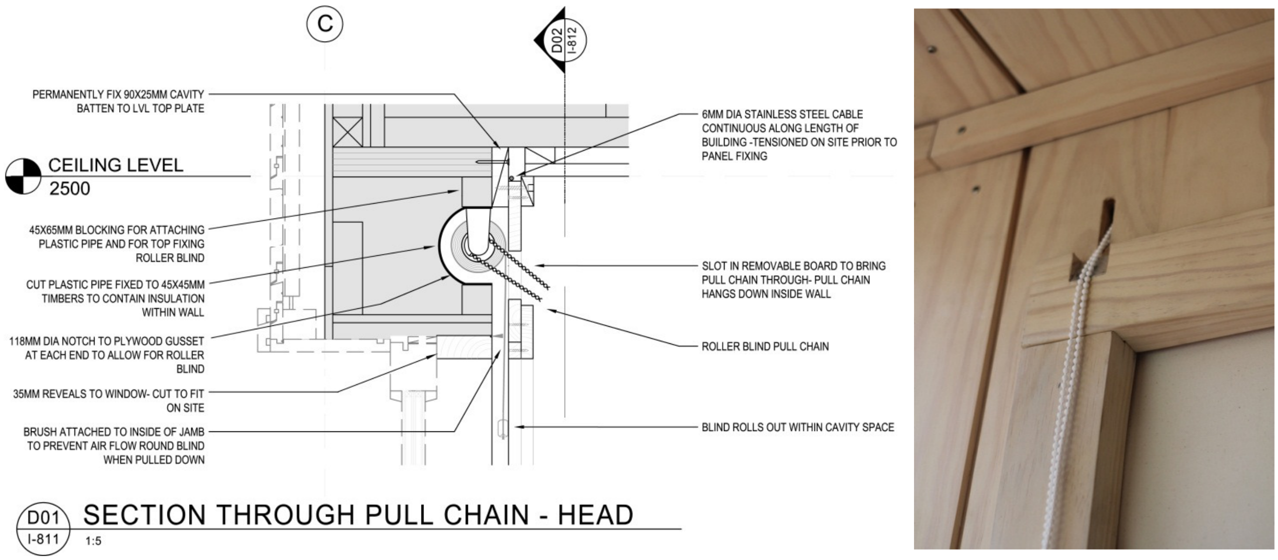


Figure 9.5 Detail for getting blind pull cord through the removable lining panel and (right) photo of constructed detail

9.2 The bathroom

The decision to change to modular construction resulted in an entirely wet bathroom spanning two modules, requiring on-site waterproofing that would need to be disassembled again soon after. The spatial limitations on the envelope meant this was the only feasible option for the bathroom's configuration; however this was certainly a challenge that the design team would work to avoid in any future project. Because of its diminutive size, and its two-part nature, the bathroom was one of the most challenging parts of the interior design process. Once the specification of a separate laundry room pushed the shower wall westward and the shower closer to the module break, it was necessary for the whole space to become a wet room. A room unbroken by a shower screen or curtain would have the added bonus of increasing the perception of space in the small area, and had the potential to allow for an accessible bathroom. It did mean that the floor on both sides of the module break would have to be waterproofed, and special attention would have to be paid to the floor and walls at the join to ensure water tightness. The window opening would also need to have a waterproof membrane and lining.

9.2.1 Floor

The floor detail at the module junction was either going to have to be a high point, with the water draining away to the east and west edges of the room; or a low point, with water draining into the middle of the room. The waste water outlets were to be built into the lower northern wall to make on-site connection to external piping easy and hidden behind the landscaping.

The initial intention was to set the necessary falls into the existing concrete topping; creating a clean and seamless transition from the study into the bathroom, as was to be done from the bedroom into the laundry, but without the falls. However the Flexus surface only needed to be 50mm in depth, and creating falls in such a thin slab would have meant the tapered edge was too thin and fragile to support any weight.

If an accessible bathroom was desired, then a shower tray that sat proud of the floor surface was not an option. The waterproofing layer would have to be at or below the finished floor level. Therefore the decision to make the bathroom accessible had major implications: the concrete floor surface would have to be completely removed to allow for an alternative drainage surface. This would alter the structural design for the floor as the concrete formed part of a composite system; without the concrete, the LVL floor joists would have to be doubled up, as can be seen in figure 9.6 below.

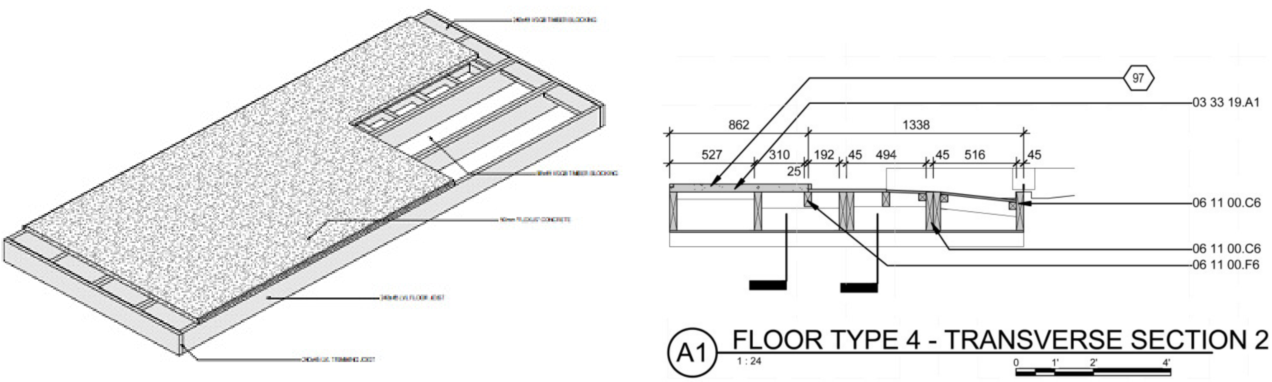


Figure 9.6 Isometric and section of M4 floor construction, showing double joists where concrete has been removed

At this stage it was decided that the easiest and neatest way to achieve accessibility was to specify a waterproof layer below grade, and then cover this with a permeable surface to bring the bathroom floor level with that of the rest of the house.

In terms of wastewater connections, it was easier to fall the shower trays towards the middle of the room and locate the drainage holes on either side of the module join. The engineer's report specified that the perimeter LVLs were to be left untouched for structural integrity. The trays therefore became increasingly complex components; folding up and around the perimeter LVLs and also some way up the bathroom walls. Fortunately the project had a stainless steel provider as a sponsor.

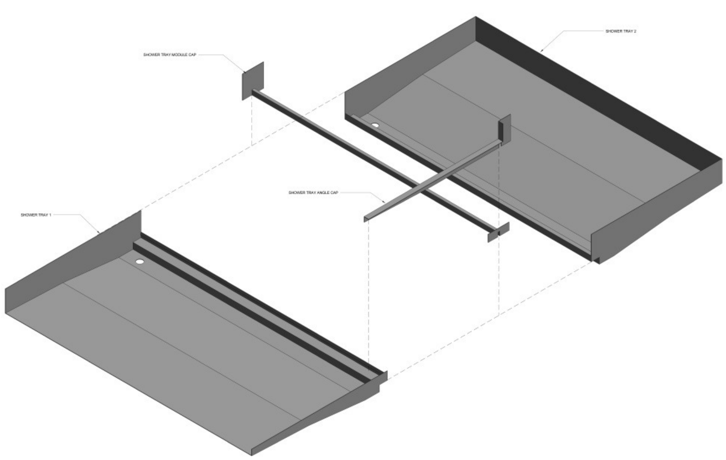


Figure 9.7 Individual custom-formed stainless steel floor components necessary for waterproofing the bathroom

The final floor design comprised four individual pieces: two shower trays to be permanently fixed to the floor structure, and two flashings. The first of these, a cap flashing, was for sealing over the upstands of the trays at the module join. This had saddles at either end- the one to the north much larger than its neighbour, due to the fact that the door opening began right at the module join to the south. Over this was placed another perpendicular stainless member to flash the door opening and up the wall.

9.2.2 Walls

The next waterproofing focus was the wall join. As with the timber panelling in the living spaces, it was preferred to have the wall lining as finished as possible off-site, with only a small panel to be fixed over the join once the modules came together.

With an all-wet bathroom, tiles were an immediate consideration. Tiles, although a little bit complicated, also made a panelised option possible, as a section of tiles fixed to a removable substrate could be sealed into place on-site. The risk was that the movement of the bathroom modules in transit would cause breakages, so steps were taken to mitigate the movement of the wall sections. A thick, rigid substrate was specified, a flexible grout was used between the tiles, and a tile contingency order of +20% was fabricated.

Unlike the removable panels in the living spaces, the bathroom finish was impermeable and so could not be fixed into place from the front surface. The split rail hanging system discussed in chapter 8 was revisited as it was a simple, gravity based support mechanism. Given that the whole ceiling was to be removable, the clearance needed to lift the panel up and over the supports was not a problem. The backing panel would also need to be removed to allow tape to be applied as with the other module joins.

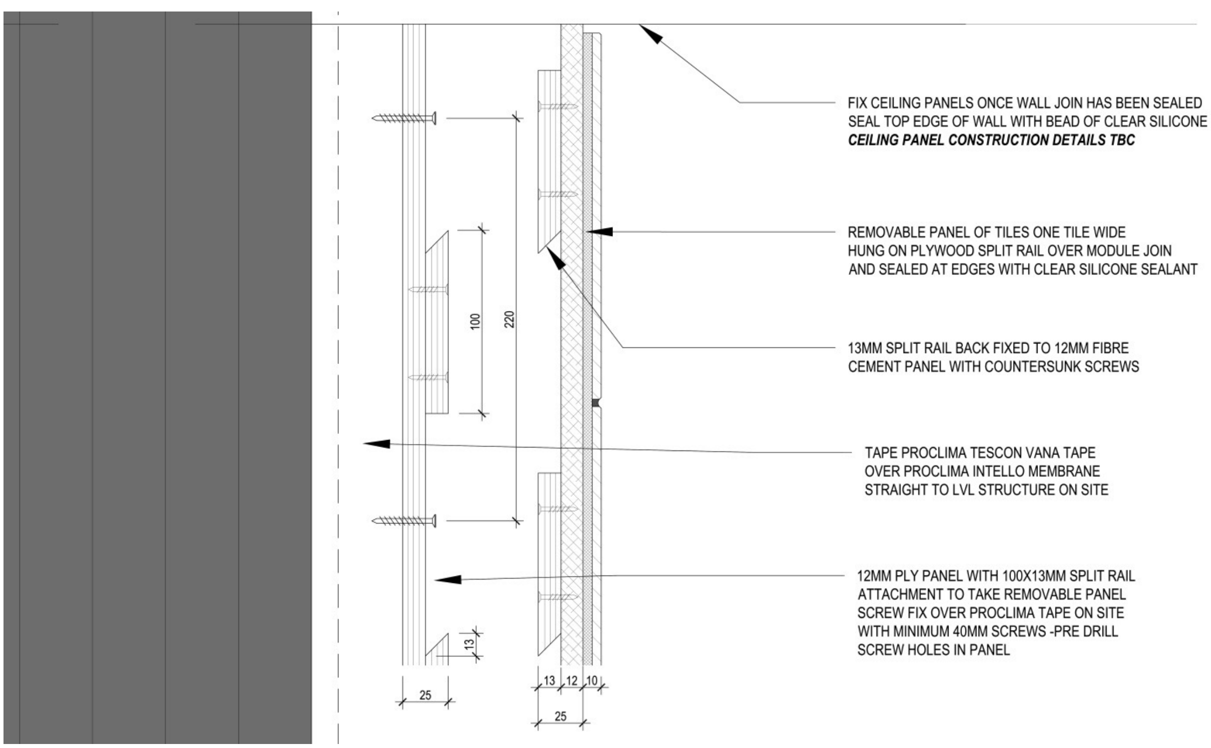


Figure 9.8 Sectional construction detail for removable tile panel and split rail

Full height flashings were required behind the wall panel so if water should get through the seal it would drain back into the shower tray.

Figure 9.9 A full height flashing slots behind permanent lining on either side of the module join (left) and (right) photo of the bathroom after installation of stainless steel shower trays. The full height flashings and the cap flashing can be seen leaning against the wall in the corner.

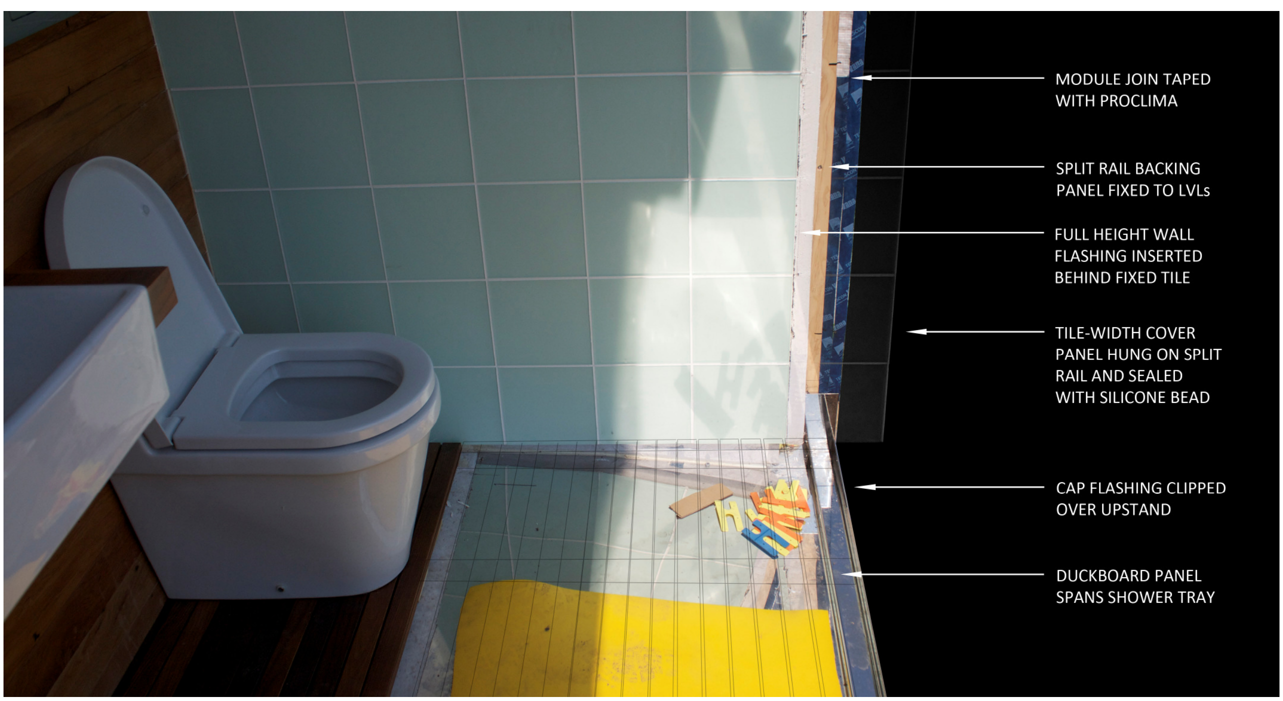


Figure 9.10 An overview of the bathroom finishing sequence

9.3 Module three

Where the rest of the house was modular, 'module' three in fact comprised entirely flat-packed panel and stick construction. Due to the earlier design decision not to limit the central dining space to 2200mm as described in Chapter 4, the complete module would not fit within standard cargo dimensions. There was a significant price jump between shipping standard units and over-width cargo, so the decision was made to transport the central module as large panels that would fit into a standard container. These panels would then be 'prefabricated' into module three once in the United States, and the complete module trucked to the assembly site and craned into place, in the same manner as the 2200mm units.

Considering the central space was distinctive for its *lack* of solid construction, this was a deceptively complex module to detail and construct. The envelope had to be designed in parts that could then withstand craneage. It was intended that the majority of module three would be completed off-site; this was achieved for the basic exterior structure and envelope but, due to the resultant interior assembly sequence, it was not possible for the inside to be pre-finished at all. This meant that the assembly of module three, in interior terms, reverted to the risks associated with the panelised construction the team had specifically chosen to avoid by changing construction methods for other parts of the structure at the project's inception.

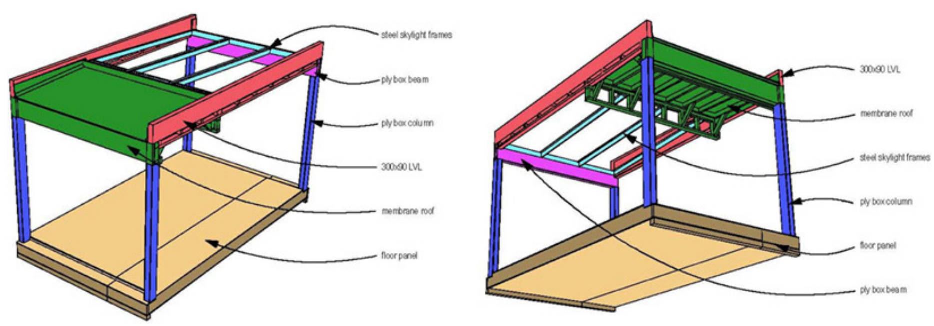


Figure 9.11 Module three, showing individual structural components

9.3.1 M3 interior design

As mentioned in the introduction, this was a part of the house that was problematic with regard to whose responsibility it actually fell under. As the overlap between indoors and outdoors, it was originally thought that its detailing would be more like an outdoor space, despite the fact that it already displayed inherent indoor features. Therefore the interior team put the detail design and material specification to one side, unaware that the exterior team was doing the same. This led to most of the practical detailing being figured out on site during the construction of module three!

At this stage, and standing within the structural skeleton, it was decided that using the exterior detailing would give too heavy an appearance. From the interior, there was only 200mm of solid structure on either side of the doors and skylight, and so detailing this area as entirely separate from the rest of the interior would lead to too many materials in a small area, compromising the clarity and simplicity of the design to date. It made sense to fold the existing interior linings around and into the module. M3 therefore became more of an interior space in terms of material specification, though its details would be slightly altered to subtly reference the transition from full interior to interior/ exterior. For example, as for the window reveals, whitewashed pine was used for the doors, and the architrave given the same offset distance from the wall lining, but as can be seen in figure 9.12 there was a variation in their articulation.

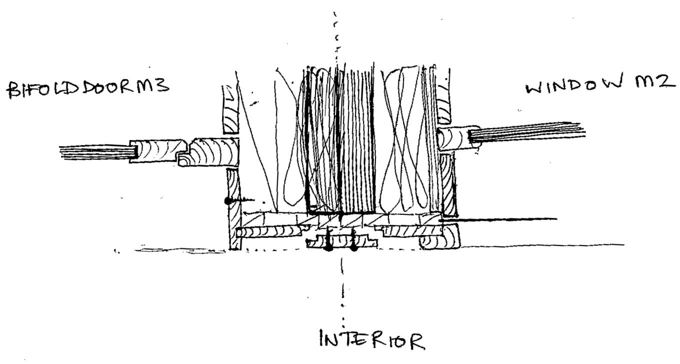


Figure 9.12 (left) Plan detail for both the door architrave and the window architrave and the constructed detail (right)

9.3.2 Construction of M3

The design intention was only one step in a complicated process: realising these details was to prove a challenge when all the finishes needed to be removable. Rather than fixing linings permanently, they had to be hung, clipped or tacked into place, even though the aesthetic was one of permanence and non-modularity. The design of the joints needed to blend with the existing details, the majority of which were permanently fixed into their modules.

9.3.2a Floor finish

The floor substructure was constructed in two pieces and sat 50mm below the finished floor level. There was therefore 50mm in which to construct the interior deck. This needed to be in removable panels rather than built onto the substructure, so that the decking boards would span the full width of the central space.

It was intended that the floor would be laid during the off-site prefabrication process, but in the end it was decided to install the panels at the very end of the assembly process, in order to protect the timber finish. This resulted in thirteen extra M3 components being transported, stored, and handled on site.

Figure 9.13 Decking panels being removed during disassembly of M3

9.3.2b Skylight

The interior detailing in and around the skylight also became increasingly complex, compounded by the fact that the module was being constructed at the time that critical design and performance decisions were still being finalised.

There had been a prolonged internal debate as to whether the skylight detailing would include a thermal blind on the interior to prevent heat loss; a retractable screen or louvred system on the exterior to prevent heat gain; or both of these systems. Specifying the two systems together was naturally going to provide the best performance in terms of heat transfer through the glass, but there was a feeling that two necessarily mechanised systems overly complicated the design in terms of aesthetics, assembly, and energy use.

It was eventually decided that the more important function was to avoid heat loss. While not as effective on the interior, a blind could be utilised as a sun shade, but an external system could function in one way only and would not provide any insulating benefits. Therefore, as with the vertical windows in the living spaces, the skylight was to feature a covering that sealed a layer of air between its surface and the glazing to provide a thermal buffer. Such a specification was complicated at this late stage in the process: the preferred and only suitable supplier of mechanised horizontal interior blinds was based in Australia; communications and material samples went back and forth, and once a decision had been made there was a long lead time for fabrication. This meant that the completion of the central module would go ahead without the blinds or their components. As a result, the design team relied on the details provided by the manufacturer and left space for the components to be installed at a later date.

The specification of such blinds did however alter the developing details for the skylight space. Now room had to be left (or made) for tracks, wiring, and rolling mechanisms at both the north and south ends of the skylight. The need to house the blind rollers below the glazing brought about the decision to treat the skylight as just another window in the house, as if a hole had been punched out of the existing living space ceiling. The ceiling lining from the living spaces continued into M3 and keyed into skylight reveals of the same material. This helped to define the separate design areas in the central space, but complicated the assembly process with additional components.

Figure 9.14 Sketch showing space needed for blind rolls at either end of the skylight, and photo of rollers installed (right)

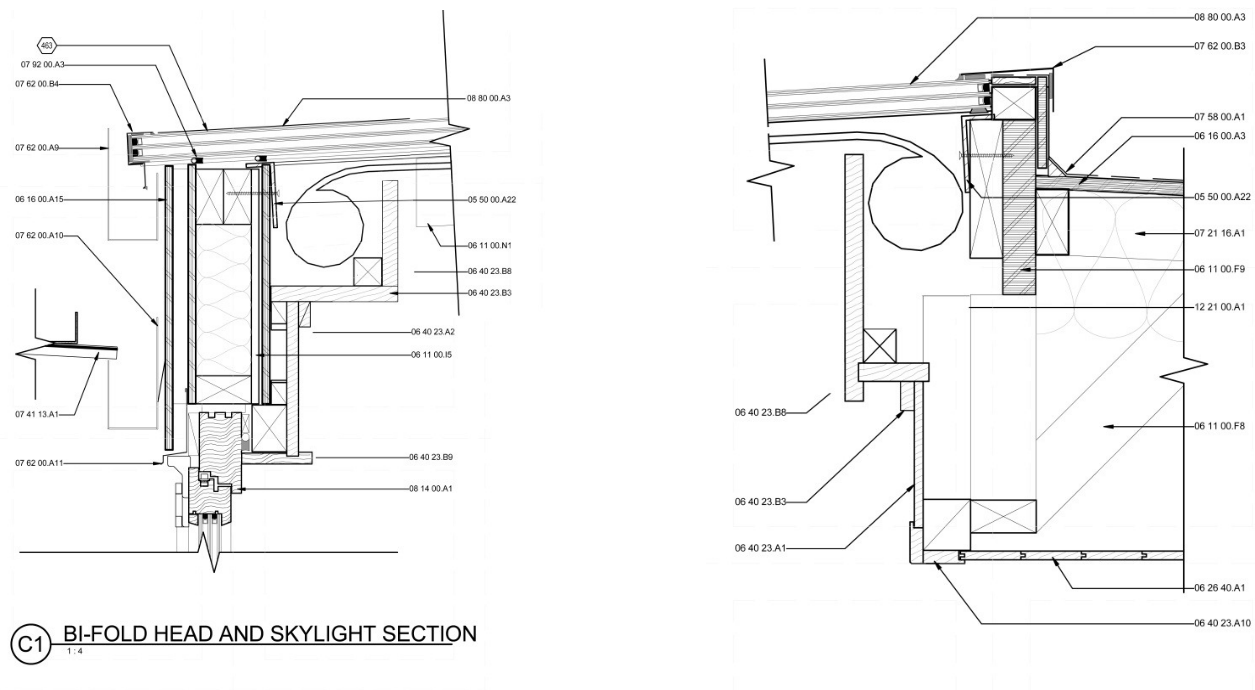


Figure 9.15 Working details showing room required for housing blind rolls at north (right) and south (left) of skylight, and panels needed to conceal these

9.3.2c Walls

As with the ceiling, the wall lining was to continue across the central space. To the south, this meant that a lining panel needed to be created for the space above the doors. To the north, the doors came up to the bulkhead ceiling so all that was needed was a slim head detail, and wall lining panels to either side of the opening. In both cases, the reveal detail became a part of the lining, to create L-shaped components. These were useful for reducing the number of separate pieces but produced difficult shapes to package and protect during transportation.

Figure 9.16 Northern [kitchen] M3 wall section without lining (left) and (right) with L-shaped lining/reveal component attached

Figure 9.17 (left) L-shaped lining panels on the south side of M3 are simultaneously door head (yellow) and reveal (red) and (right) the L-shaped panel, detailed the same, as the skylight reveal

An important part of the house design was its 'visitability' – as the Solar Decathlon's aim is to get as many public visitors through the competition site over the expo period. This meant that the two-person kiwi bach needed to accommodate up to fifty to sixty visitors at a time.

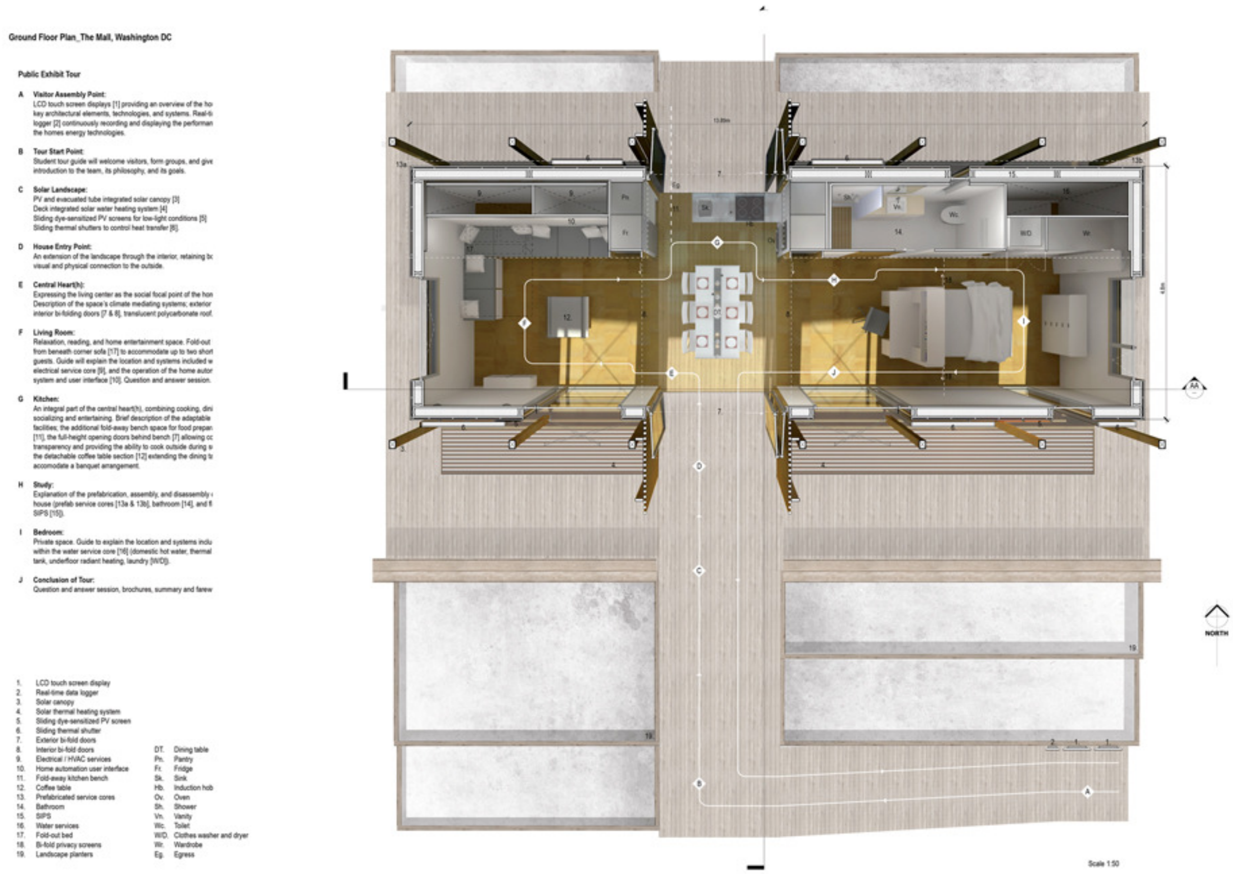


Figure 10.1 The public tour route proposed in the conceptual submission

From a visit to the New Zealand house, visitors were to gain an understanding of the kiwi lifestyle and bach culture. Expressing as much of this in the house design and layout was essential for this understanding. The route taken by the visitors through the house, outlined in the final submitted drawings, determined what could be seen by the public. This would influence both the public choice award and the communications jury's verdict, which was only based on the information and features of the house made available to every visitor. For the duration of the Solar Decathlon, the First Light bach would be a public building, so there was a requirement for the public tour route to comply with the International Building Code compliance document ANSI 117.1, which specified the minimum dimensions allowed and the necessary safety features.

There was a minimum level of compliance expected. Greater levels of accessibility were optional and could help gain subjective points in the competition, depending on the entrants' target markets. Given that this was a small home for the occasional use of a small family, the First Light team had to be objective with its decisions about accessibility. The house had to make it from Wellington to Washington DC and every extra millimetre counted against the project’s affordability. Therefore, only the baseline level of accessibility, the ‘visitable’ category, was opted for.

There were a couple of non-compliant features in the original design which needed to change. The first design feature to require alteration was the step down into the central space. Under ANSI 117.1, no stepped level changes over 16mm were permissible, and steps were not allowed in the landscape designs at all.

The bathroom was too small for a wheelchair turn, so this part of the services core needed to be reconsidered.

10.1 The proposed route

The design of the landscaping on the New Zealand site was key to the accessibility and successful visitability of the First Light house. The aim was to get as many people through the home as possible during the competition week; this required directing them off the competition ‘highway’, through the site and up into the house.

As the exterior of the First Light house was visible from all around the competition site, the real reason the public queued for tours was to get inside the homes. It was the interior that would ultimately sell the concept of the solar house: visitors wanted to see whether these technologically advanced designs were still comfortable and homely places that they could imagine themselves living in.

Statistics from the past competitions influenced First Light’s goals. In the 2009 Solar Decathlon more than 300,000 people visited the exhibition village; sites were inundated with 8,000 to 12,500 visitors over the week and queues lasted up to two hours. First Light aimed to host at least that many visitors and needed to strategise how this could be achieved.

The tour needed to provide visitors with the best, and longest, experience of the interior as possible within a very limited timeframe. Part of this strategy needed to focus on minimising the time spent queuing to get inside, or at least to minimise the perceived wait time.

The physical capacity of the house - and physical capability of the tour guides - needed to be taken into account with regard to tour group sizes and people flow. It was thought the most important strategic move was to ensure the visitors had an insight into the interior workings and layout of the house before getting inside.

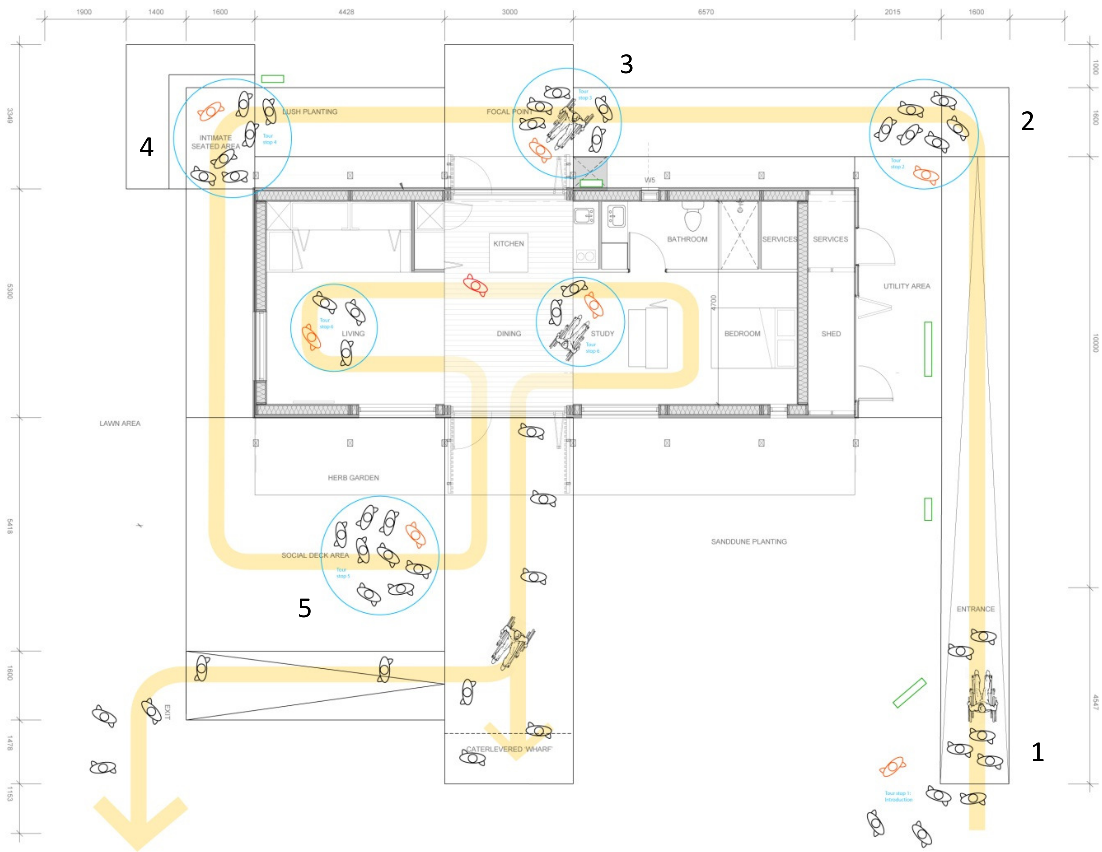


Figure 10.2 The concept for First Light's public tour route, showing a strategic decision to use the whole site, to stop at locations around the site (stations numbered 1-5) and to conceal the queue behind the building, while also explaining interior features at available opportunities on the exterior [such as on the northern side of the central module, station 3, and the southern 'living' deck, station 5. IMAGE CREDIT VIVIEN CHONG

It was decided to explain the features related to the interior before entering the house so that people knew about them and only needed to sight them once inside. The hope was this would expedite the journey through the interior. From figure 10.2 (above) it can be seen that the design of the house was open enough for the interior to be introduced from the outside. The central space and its indoor-outdoor concept was used to the team's advantage. The bifolding doors to the north were kept open so that the First Light design philosophy could be explained and displayed at this side of the house while the public was still waiting to get inside. The southern 'living' deck was used in the same way; to corral visitors at the front entrance and 'bring them into the interior' via the floor to ceiling window in the lounge, where the guide's explanation could save time when it came to the living room description once inside.

10.2 Levelling out the experience

10.2.1 Getting rid of drastic level changes

The original design focused attention on the central space in a number of ways, not the least being the step down into it from the living area. This drew the eye into the centre, and meant that once there, the feeling of the space was more impressive due to the higher ceiling. The change in level also served to highlight the difference between interior-interior and interior-exterior, and reinforced the relationship between interior-exterior and the exterior deck. Removing the level changes meant that the conceptual emphasis on the central space would need to be achieved in another way. In response to the raising of the floor, the ceiling was raised and the same lofty, uplifting feeling expressed in the original design was achieved, but effectively in reverse and without causing problems to the accessibility of the building.

10.2.2 Detailing to mitigate subtle level changes

The design team's 'fine tuning' focused on the detailing of doorways, thresholds and module junctions so that falls in levels in construction could be minimised as much as possible, and discrepancies between modules in assembly could be tolerated in a compliant manner.

The major area for accessibility design was the landscape as the home's interior FFL was optimised at 500mm above ground level. Due to the uncertain nature of the exact terrain the house would be sited on, the adjustable foundations enabled a FFL of, at the best case, 350mm and at the worst, 700mm. Landscape ramps would have to accommodate any eventuality within this range seamlessly and compliantly.

While NZS3604 was used as the structural and detailing basis for the conceptual submission, the standard 150mm drop between exterior and interior decking surfaces had to be removed and the necessary weathertightness achieved another way.

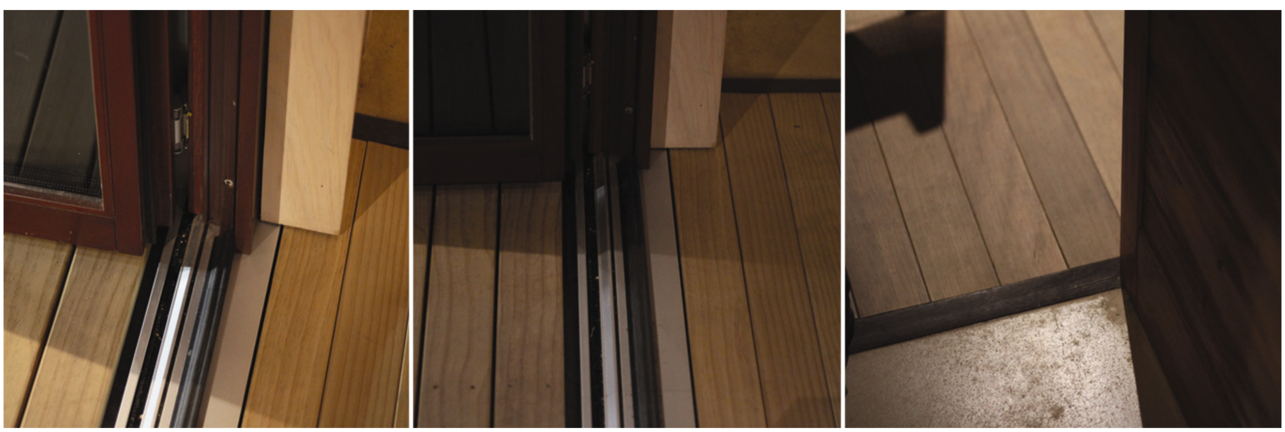


Figure 10.3 The interior/ exterior threshold with as little level change as physically possible and (right) the inter-module join

The maximum permissible stepped level change was set at 16mm. In order to avoid the threshold between interior and exterior exceeding this dimension, the bifold door frames and structure had to be recessed as far as possible into the central module's construction. The exterior decking was brought up to the interior FFL less 10mm to allow the bifold doors clearance when open. The interior decking was brought level with the interior door flashing, and this also had to sit flush with the inter-module joints. The timber beads, mentioned in chapter 8, could be planed and packed to fit the module join but had limited tolerance in the vertical axis (see figure 10.4).

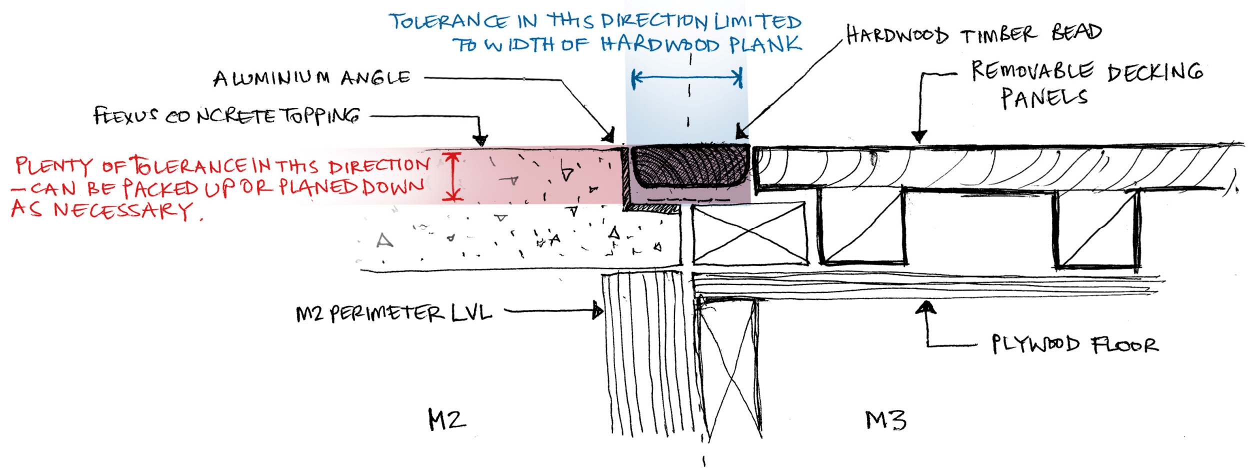


Figure 10.4 Sectional detail sketch showing tolerance limits for the harwood timber inter-module beads

10.3 Adjusting the services core dimensions

10.3.1 Finalising the bathroom and laundry designs

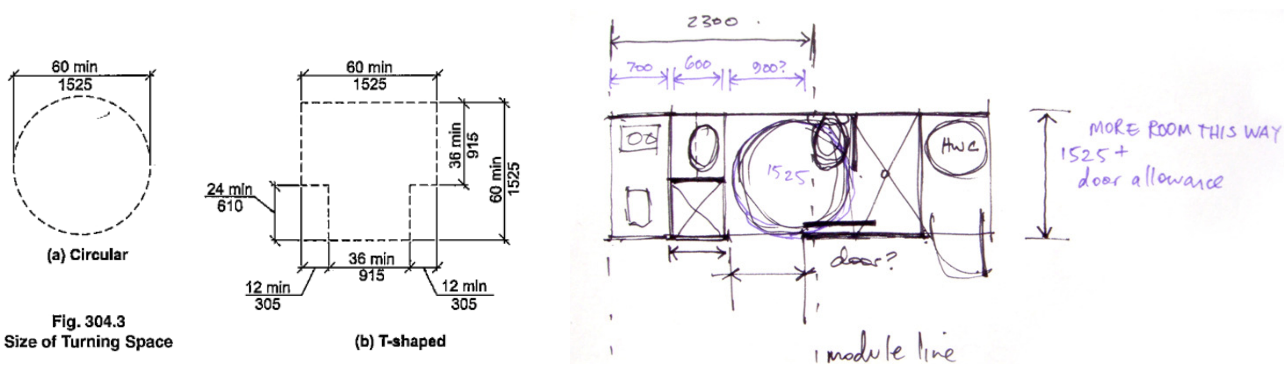


Figure 10.5 ICC/ANSI permissible dimensions for an accessible turning space

The engineering team was in the process of developing a dryer that connected into the solar hot water system and, once finished, this unusual appliance would be a show piece of the New Zealand house. The team wanted to maximise visitability to the services core so that the dryer could be part of what was exhibited. For this the services core needed to be wide enough to allow a wheelchair to manoeuvre in and out, which required a clear space 1525mm in diameter.

The bathroom in its conceptual layout did not allow this as the services core was slightly too narrow to include fittings, a door, and a 1525mm clear space. The toilet encroached on the turning circle, blocking an accessible entry to the shower; and its unfortunate position was such that with the bathroom door open, there was a direct line of sight from the front door to the toilet! In order to get the required turning circle into the bathroom, the toilet and shower would have to be pushed westward, leaving a narrow, inconveniently-shaped space for the bedroom wardrobe (top left, figure 10.6 below). Compounding this issue was the unresolved laundry; it was not considered appropriate from a design point of view to step the shear wall for the washing machine as mentioned in chapter 4.

The relocation of the plant helped to solidify the requirements for the wet area(s) but, critically the layout had not been developed when the decision was made. The available area was long and thin and up until this stage had been treated as one single space.

Figure 10.6 The evolution of the bathroom and laundry layout from original (top left) to final design (bottom right, 8)

As the design for the dryer was still underway, how this appliance would work, or look, was not completely understood. In terms of interior layout, the dryer was initially trialled as a hot air cupboard adjoining a built-in wardrobe. Access to this would, however, render a part of the wardrobe useless, and located at the back of a storage unit it would not attract the marketing potential this important piece of equipment probably deserved. It was preferable to locate the laundry appliances together for useability, and the washing machine as part of the bathroom with the dryer in a separate space did not make for a comfortable or easy layout. It was at this stage that the dryer adjoining the wardrobe evolved into the wardrobe/ dryer space becoming a room in its own right. The washing machine moved into this room and the laundry eventually found its final location on the end wall of the services core, directly adjacent to the services shed behind. There was just enough room to make both spaces accessible, if the shower wall was pushed westward. It made the bathroom much smaller and clever use of finishes would be needed to prevent it feeling too tight. The complete development of the bathroom is detailed in chapter 9.

Where the bathroom and laundry layout had once struggled to come together in one long, awkward space, there were now two simple rooms each with their own purpose. They were both accessible and maximised the smallest space available, which was fitting for a small, functional, transportable home.

10.3.2 Detailing and material selection

The bathroom and laundry rooms were designed so that their entry doors would utilise the same construction detail. The doorways were both adjacent to the module break. As was mentioned in chapter 4, it was intended that the entire door frame would be located in a single module, but the kitchen, bathroom vanity and wider door opening all located in module 4 became an impossibility. The lintel was therefore hung from the roof structure and the eastern framing member to the door became the first stud in the adjoining module. It meant that more finishing was required on-site as the jambs and architraves had to be removable.

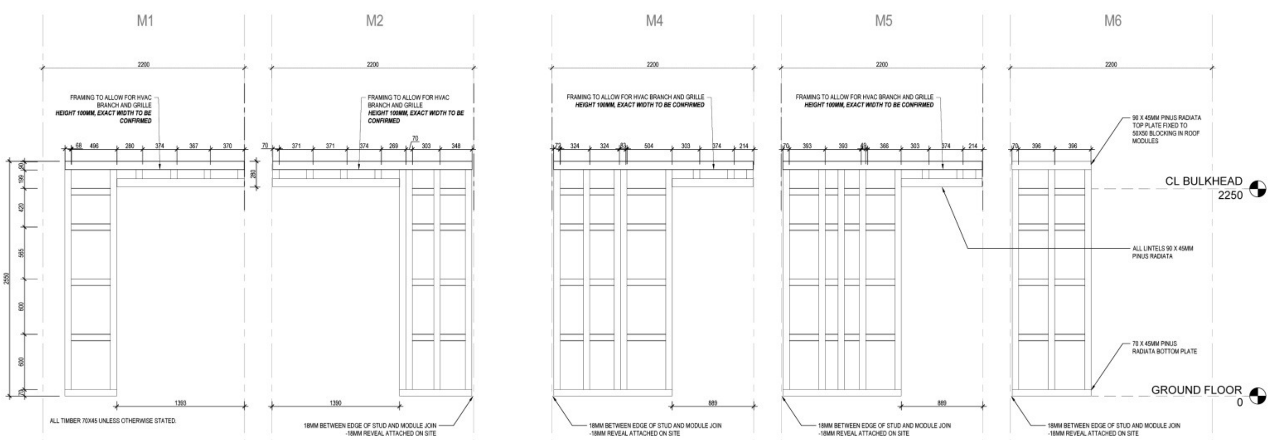


Figure 10.7 The services core wall framing, showing the bathroom and laundry door openings spanning the module join

At this stage in the development process, space was very tight and the design team did not want to extend the envelope unless it was absolutely necessary. In order to allow for the necessary turning space in the bathroom and laundry, it looked as though the wall between the services and living spaces would need to be moved, which had implications for the accessible space in the southern facing living area. At the same time, the doors themselves were being developed. It was suggested that minimising these could in fact avoid a change in the location of the wall. ICC/ANSI 117.1 restrictions precluded a hinged door in the space but, even so, it made sense in such a small area to specify sliding doors to these rooms, as had been done in the original design. Again, the wall construction was too slender to allow for a cavity slider. A 35mm standard timber door was originally specified, but the challenge was to find a solution that was thinner than this. The solution turned out to be a 10mm solid glass slider which would allow the services wall to stay where it was.

10.4 Furniture design

The furniture was treated as part of the architecture of the First Light house with key pieces being built in as these were thought integral to the home's functionality. There were to be three large, signature pieces; the study unit, the dining table and the lounge unit. There were also a small number of bespoke items such as dining chairs, a couch and a bed. The internal atmosphere desired was simple and bachy but contemporary. Furniture pieces were selected, or designed, to a brief. Each piece had to reinforce the First Light bach narrative and due to the volume of people predicted to visit the house, only that furniture necessary for this story, and the operation of the house over the competition week, was taken to DC.

The two furniture items that posed a potential threat to the accessible nature of the interior were the study unit, which affected access into the bathroom and the bedroom; and the dining table, which could affect access to the entry and emergency exit, as well as easy travel between the east and west ends of the house. These furniture pieces had to comply with ICC/ANSI 117.1 without compromising their individual design briefs and without altering the small, intimate two-person feel of the home.

10.4.1 Study unit

The intention for the study unit was firstly that it form a partition between the bedroom and adjacent living areas, and secondly that it create a small additional living space to the east of the central module, suitable for reading or working.

> ***OFFICE***
>
> *The office unit is built in. It has to provide visual privacy from the bedroom, but must not cut off the bedroom space [as this will make the room feel too small.] It needs to:*
>
> *Comfortably accommodate a worker for a whole day – refer to metric handbook for dimensions and 2009 competition rules for past requirements*
>
> *Receive daylight and incorporate electric task lighting*
>
> *Contain power/ communications outlets for the computer and phone*
>
> *Fold away when not in use [with a minimum of hassle- it shouldn't be necessary to move all the work paraphernalia each time the desk folds up or down.]*
>
> *Incorporate storage on both sides of the unit- office storage on the west and bedroom storage on the east.* [57]

---

[57] Design brief for the study unit, July 2010

The first concept investigated proposed a desk that would slide out of a vertical unit, either to the east to work as a 'breakfast-in-bed' table, or to the west as a work table. This was an idea the team liked very much due to its unexpected multifunctionality and ability to maximise a small amount of space.

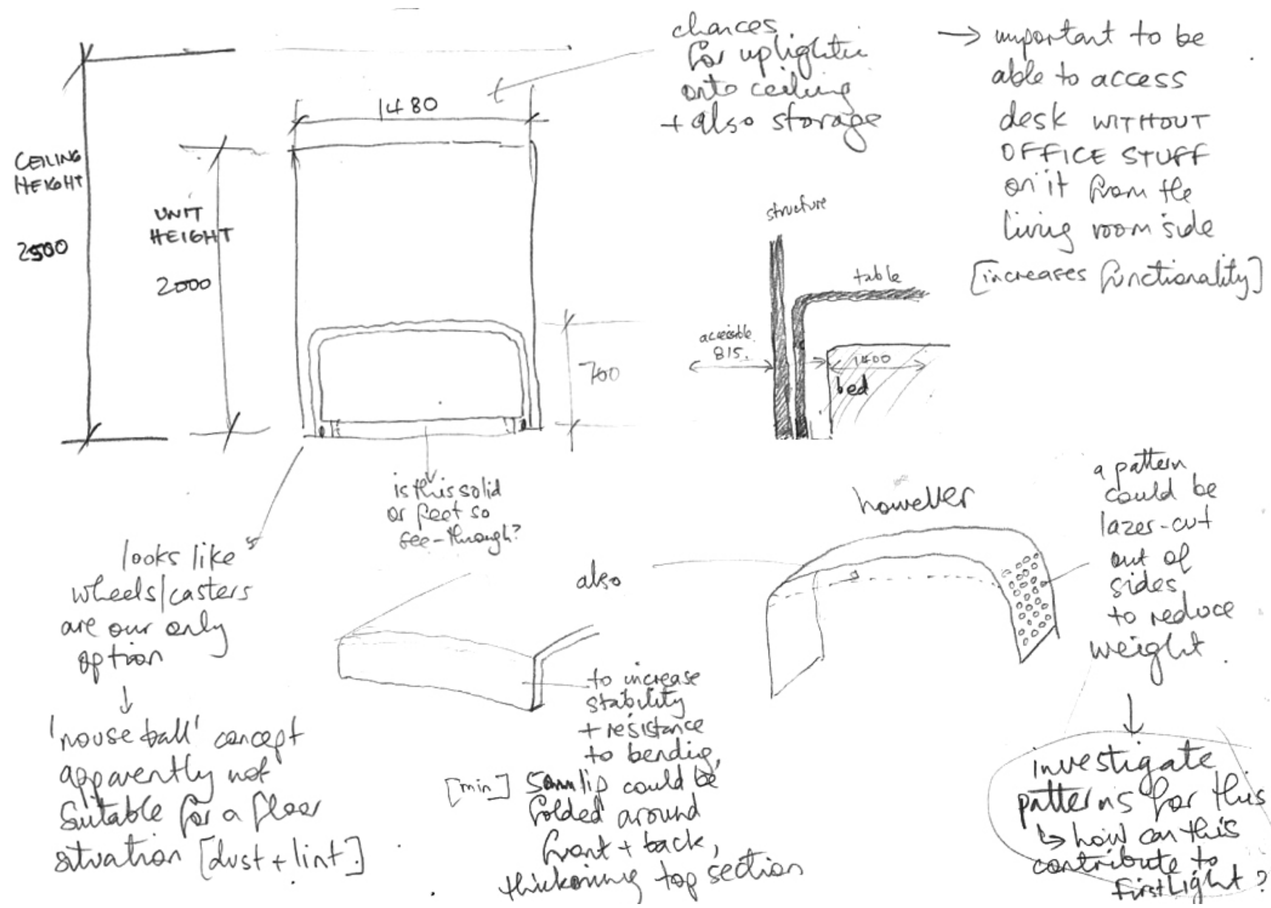
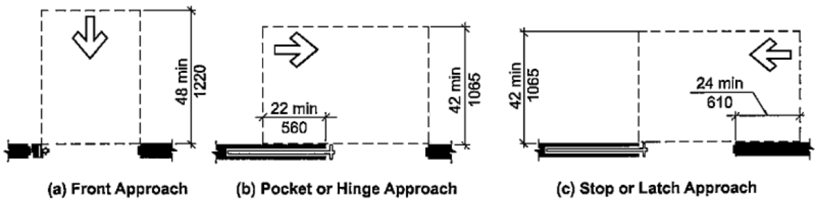


Figure 10.8 original concept sketches for the study unit with a moveable desk

The furniture design was being done in parallel with the rest of the design development so the initial concept had been proposed before accessibility checks were done. Unfortunately, applying adjustments arising from these requirements meant that the study unit could not be significantly wider than the bed, as had initially been hoped for, and meant that a sliding breakfast table was physically not an option. In order to make the bathroom and laundry accessible the bed needed to be pushed towards the south wall so it was no longer centred on the east wall, and the study unit needed a similar shift to create a 1065mm wide approach to the two services spaces.

Approach Direction	MINIMUM MANEUVERING CLEARANCES	
	Perpendicular to Doorway	Parallel to Doorway (beyond stop or latch side unless noted)
From front	48 inches (1220 mm)	0 inches (0 mm)
From nonlatch side	42 inches (1065 mm)	22 inches (560 mm)[1]
From latch side	42 inches (1065 mm)	24 inches (610 mm)

[1]Beyond pocket or hinge side.



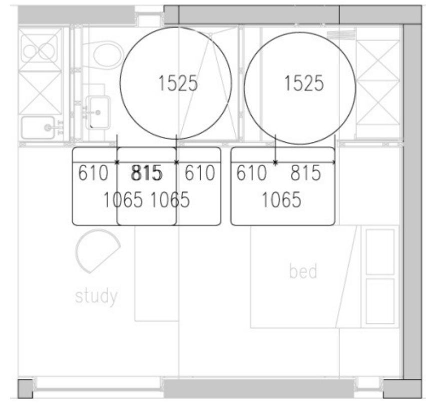


Figure 10.9 ICC/ANSI 117.1 Table 404.2.3.2 minimum dimensions for an accessible approach to a sliding door opening (left) and (right) those dimensions applied to the working layout of the First Light house

After this step a new concept was proposed for the study unit. This option comprised a solid unit sized to the new, restricted dimensions. It included partitions to the north and south to shut off the bedroom from the living space and featured a diagonal detail, borrowed from the pitch of the First Light canopy to provide a subtle link between the interior and exterior designs. The unit was now positioned asymmetrically within the room to allow for 1065mm on its north side. This posed a challenge for the partition design because there were two different dimensions to design for. The concept worked around this by proposing completely different partitions for each side. The first was a sliding door that would shut off the wardrobe when closed, and act as a door to the bedroom when open. The partition on the south side was a slatted, bifolding screen which mimicked the language of the study space.

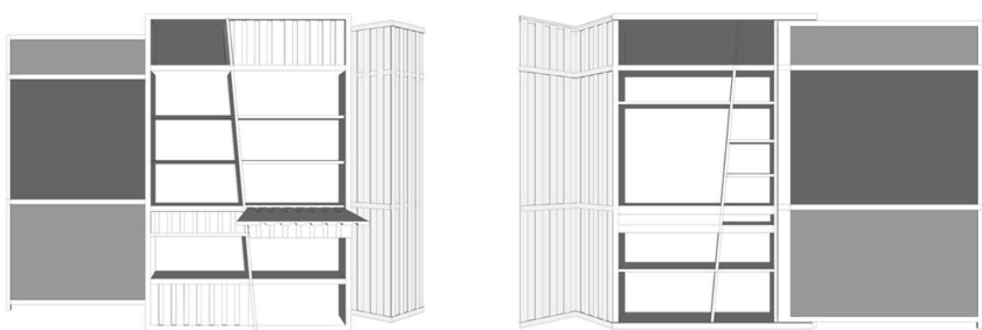


Figure 10.10 Developed concept for the study unit from living room (left) and from bedroom (right) IMAGE CREDIT SARAH MOKHTAR & TANYA MAZURKEWICZ

The developed design was submitted to the organisers, including the ADA-compliant public tour route below.

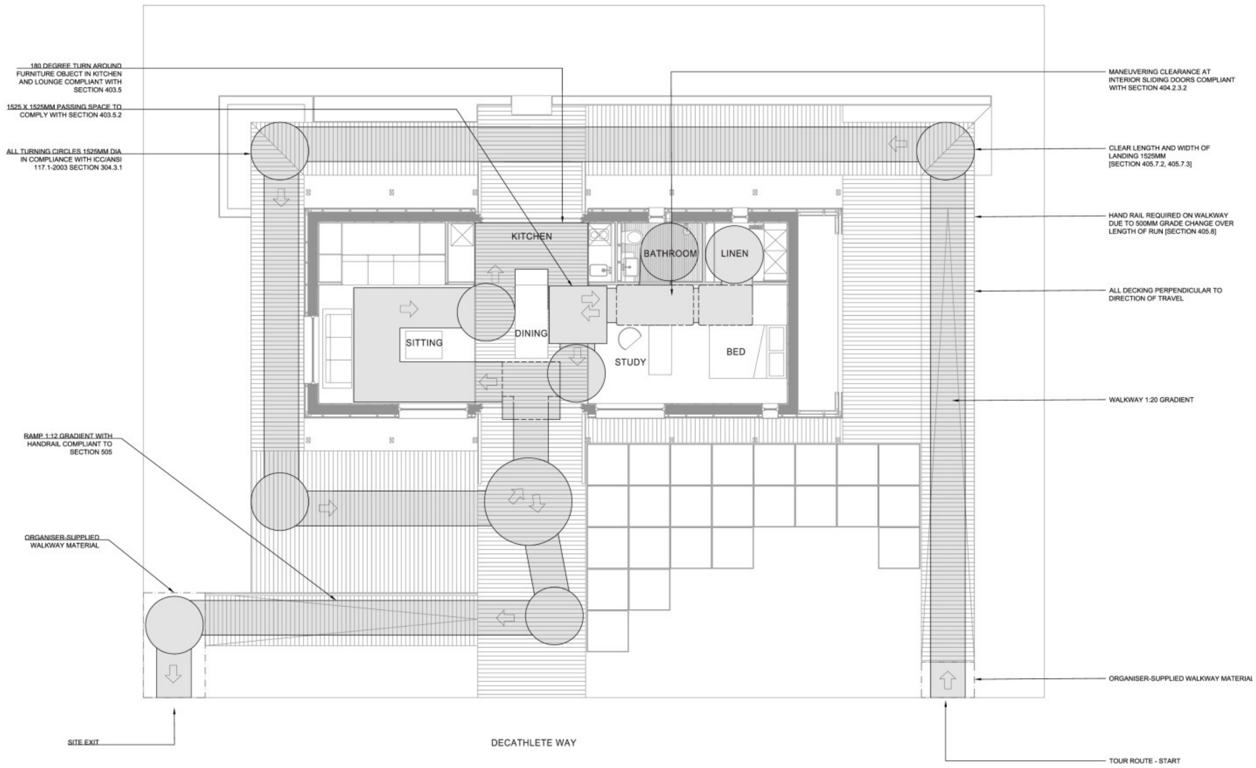


Figure 10.11 Accessible route submitted to the Department of Energy to meet the developed design deadline

The feedback from this submission provided another impediment to the design of the study unit: the organisers were not prepared to sanction a two-way path between the bedroom and living space, even though it complied with the ADA accessibility regulations, due to a perceived 'bottle-neck' affect. In addition, and to the chagrin of the design team who had worked hard to ensure compliance in the services area, the same bottle-neck restriction was applied to the bathroom and laundry rooms, disallowing visitor access into these spaces. The bedroom would not be visitable unless a continuous one-way route was proposed. This would have to be into the bedroom and out again, around the other side of the study unit.

> ***clear width at turn*** *– where an accessible route makes a 180 degree turn around an object less than 1220mm [48 in] in width, clear widths shall be:*
>
> > ***1065mm [42 in] approaching the turn***
> >
> > ***1220mm [48 in] during the turn***
> >
> > ***1065mm leaving the turn.***[58]

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[58] ICC/ANSI 117.1 – 2003 clause 403.5.1 *Accessible routes* p16

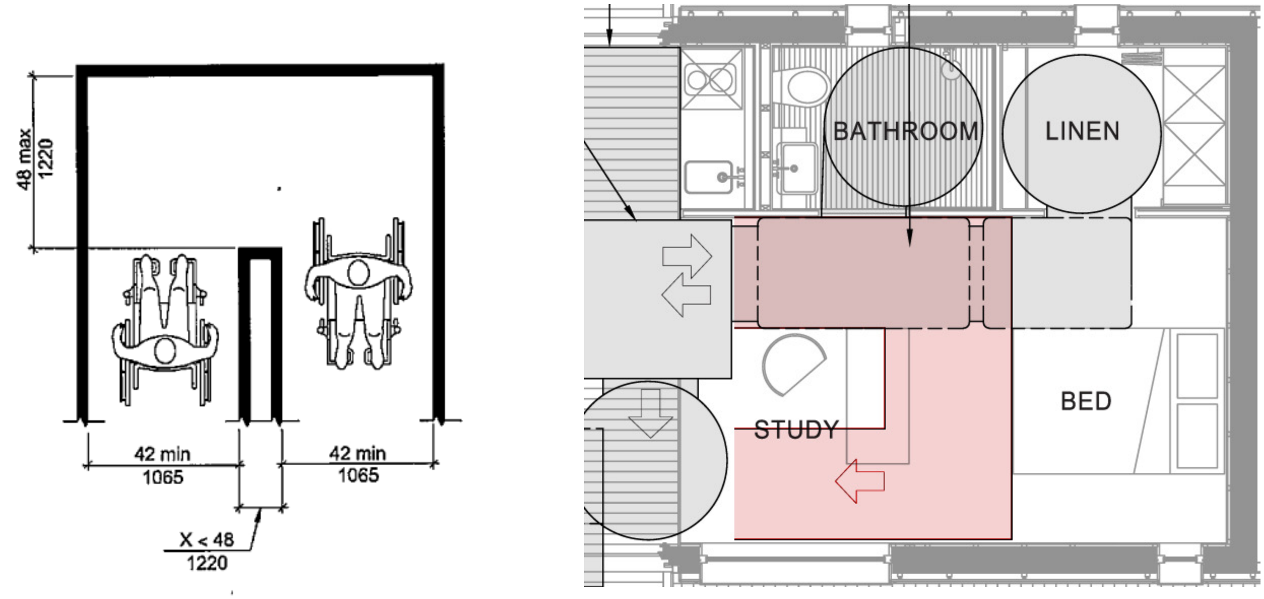


Figure 10.12 ICC/ANSI 117.1 defined clearances when making a 180 degree turn (left) and those clearances applied to the First Light house study space (right)

For the study unit to enable an accessible route around its perimeter, it would need another significant reduction in width, so much so that its existence was brought into question. However, as mentioned earlier, accessibility had to be strategically considered in conjunction with the other aspects of the house and the competition. A ten-day exhibition period should not compromise the overall design or functionality of what would essentially be a two-person home. The study unit was a very important part of the design as it was the only spatial partition in the open plan space, and it provided an additional living and storage area. It was considered vital to the market appeal narrative. The study unit would need to stay, and its design would have to find a way of allowing accessibility during the ten days of public exhibition.

The third and final study unit concept kept the style of its predecessor, however its detailing was simplified and it became a two-part unit, which would provide a bed-width partition when complete and the required accessible route when part of it was removed. As with the previous proposal, the unit featured a drop-leaf desk but this time incorporated a custom bent-steel leg that folded into the structure.

The permanent, built in unit would contain all the services: the lighting, data outlets, power points and switches for the bedroom lights. The second part of the unit would need to be free from connections and provide storage only. The intended position of the permanent unit would need to be altered for the exhibition period and so the services would need to come through the floor at the point where the intended and exhibition positions overlapped. As the data and services cables needed approximately 100mm of separation, there was only a little patch of floor where this overlap happened (see figure 10.13).

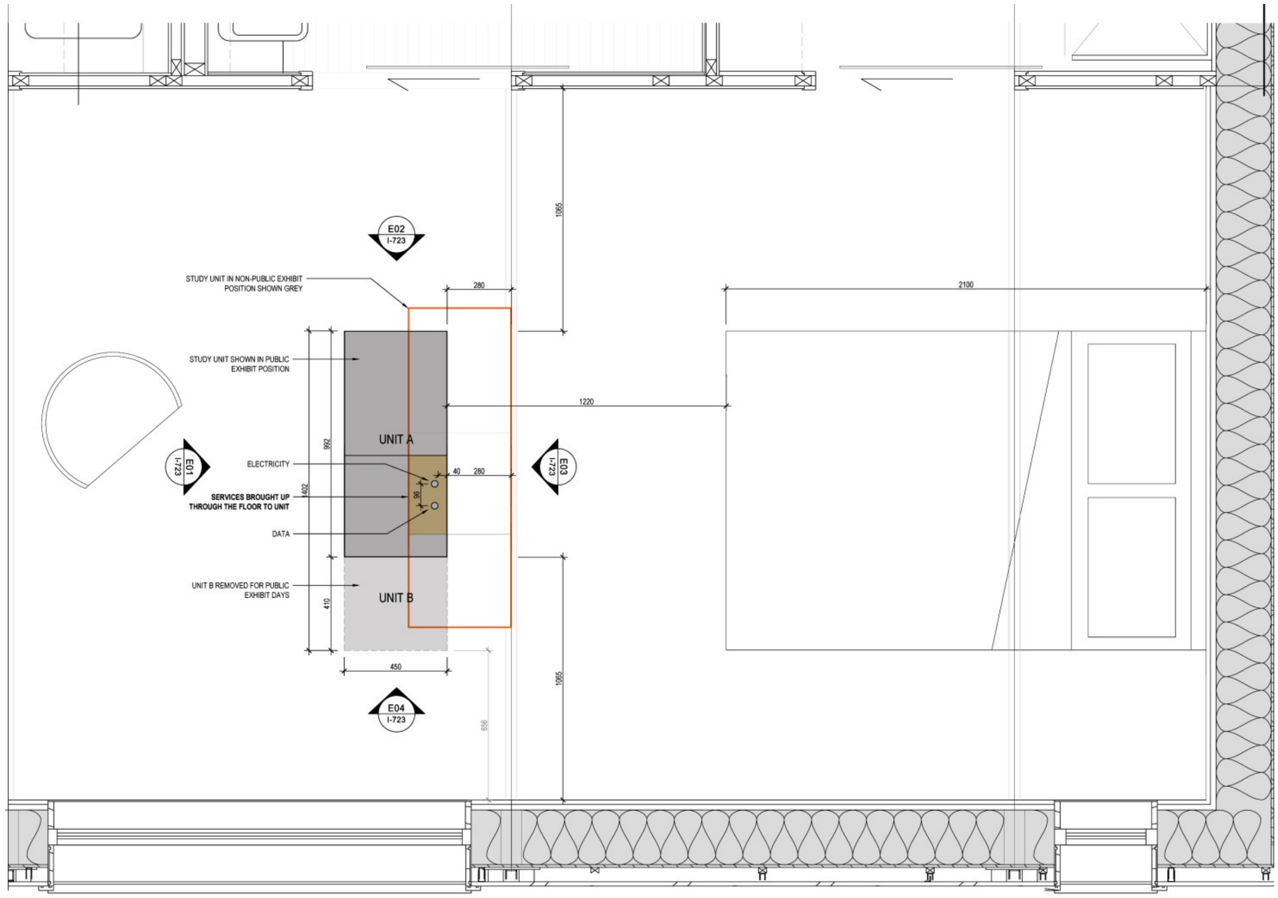


Figure 10.13 Final plan for study unit showing its intended normal position outlined in orange, its exhibition position (unit A, dark grey) and the area of floor where services could be brought up into the unit (orange shading)

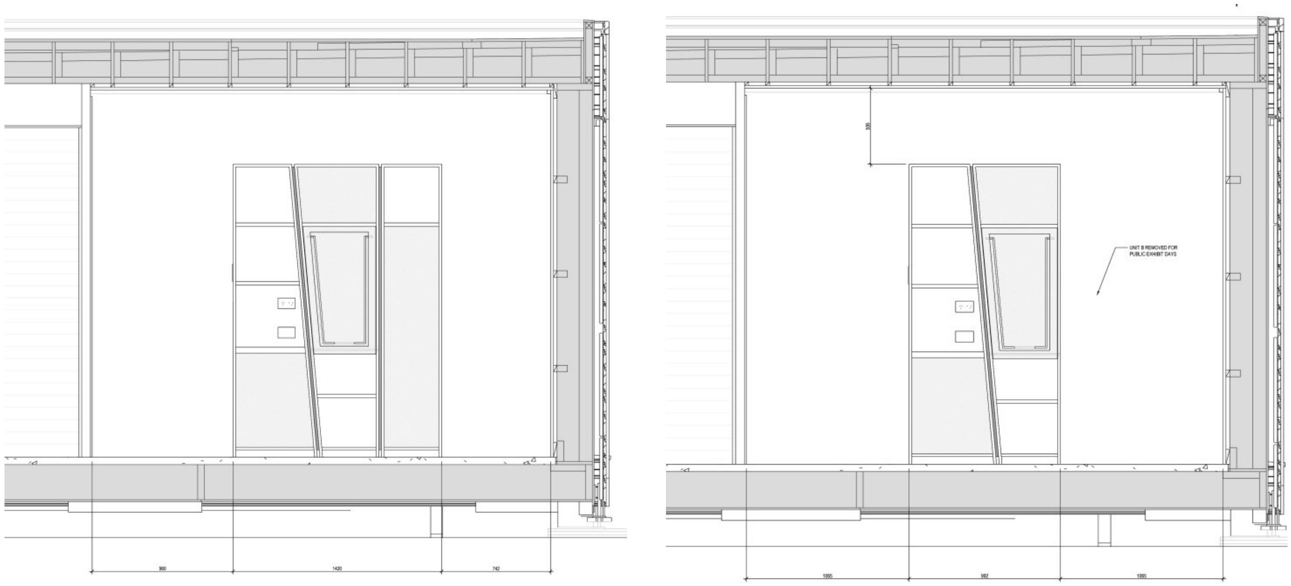
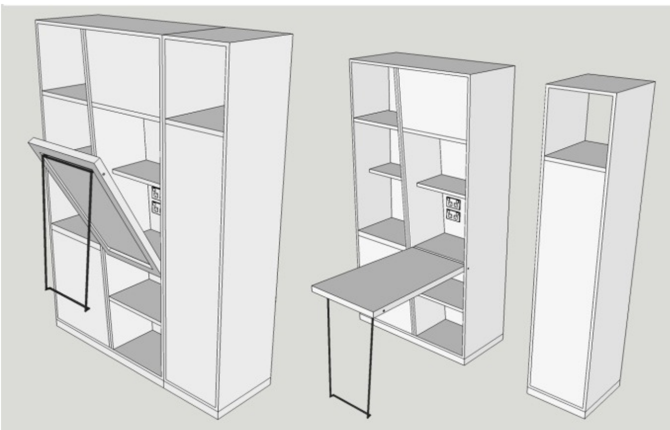


Figure 10.14 Final elevations of study unit showing its intended normal position (left) and its exhibition position (right)

The realised study unit was a two-part plywood unit measuring 1300W x 500D x 2000H when complete, but which shifted and deconstructed to allow a 180° wheelchair turn around the unit from the living room to the bedroom and back during the public tour phase. Due to this need to move position and reduce in size, the unit could not incorporate sliding or bifolding doors as was outlined in the brief. However it was wide enough to visually partition the interior space, while still allowing ample light into the bedroom around its sides and over its top. It incorporated additional wardrobe and shelving space in the bedroom and extended to provide a self-contained home office that was comfortable, well-lit and had a pleasant outlook. It contained lighting, electrical and data wiring so the house could be controlled by a laptop from the home office if desired in the future.



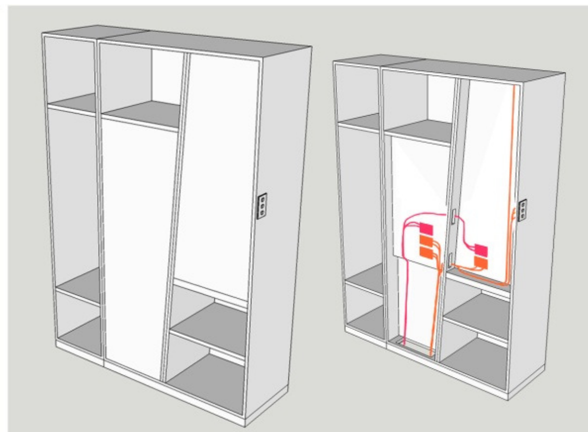


Figure 10.15 Digital model of study unit with removable module and fold down work desk (left) and shelf and wardrobe space for the bedroom with removable panels for wiring data and electrical outlets

10.4.2 Dining table

Ensuring accessibility compliance for the dining table was easy compared to the study unit, though its design was nonetheless challenging, as such a big, permanent piece of furniture had to be right – there would be no altering it on the day of assembly!

> ***DINING TABLE***
>
> *The dining table should be the home's centre of gravity. It needs to:*
>
> *Be freestanding*
>
> *Seat 6 with the option of seating 10*
>
> *Incorporate a bench at the northern end, so that there is more prep space for the kitchen. This bench could also move around the space/ shift outside* [59]

---

[59] Design brief for the dining table, July 2010

It was important that there was easy access along both sides of the table and, if possible, around both ends even when both sets of exterior bifold doors were closed. For the home entertainment contest the team had to invite up to ten people for a dinner party in the space. The table therefore needed to fit ten comfortably.

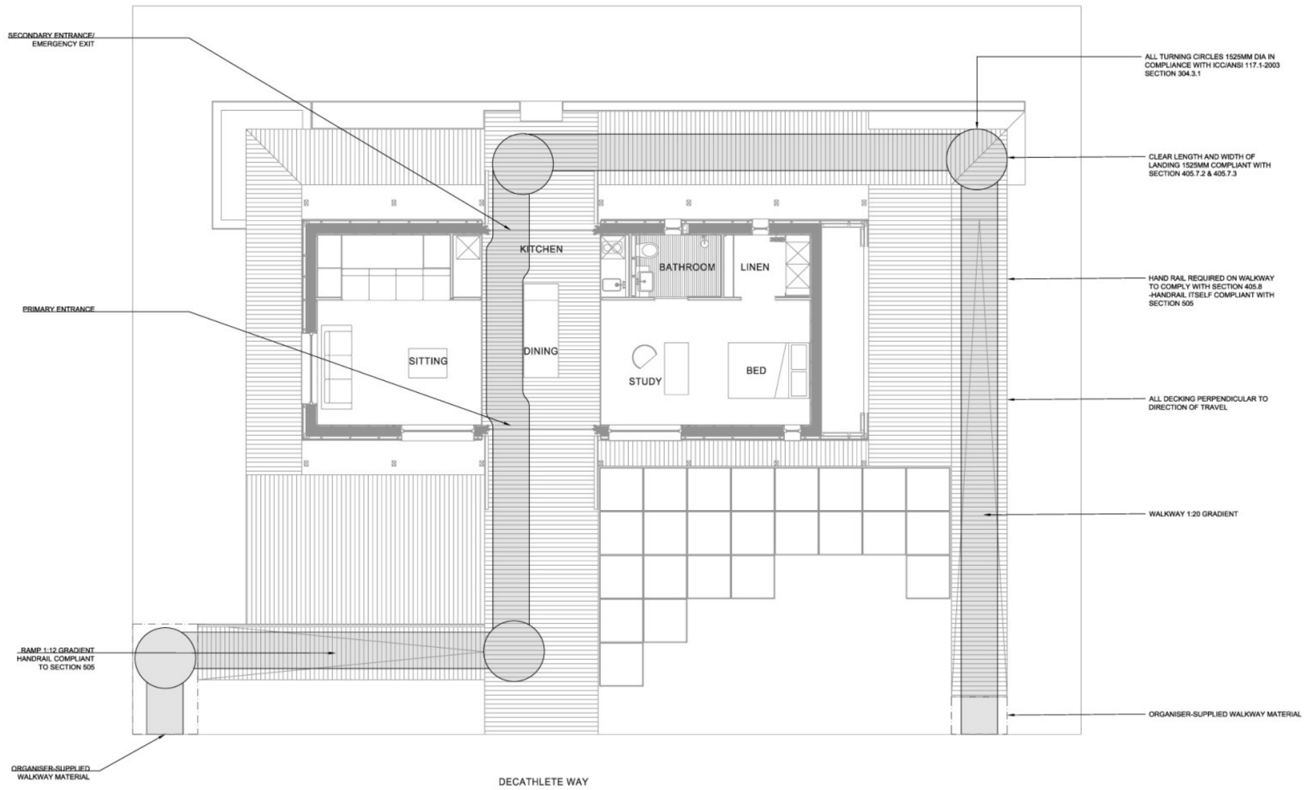


Figure 10.16 Emergency egress plan, showing the importance for the dining table to comply with the accessibility regulations

Ergonomic research suggested a 600mm width of table top was needed for each person dining. Therefore the optimum length for the table would be 2800mm, with four people along each side and one at each end. This was possible in the space available, but only left 950mm of clearance at each end of the table which did not allow the interior to be accessible with the bifold doors closed. After design development, the table was designed at 2400mm, which was more than comfortable for six in its usual configuration. In accordance with the brief, the design incorporated a multifunctional unit which pulled out from beneath the kitchen end of the table. This provided storage and additional bench or servery space for the kitchen, and extended its length by 500mm to accommodate two more guests. In the end, the design was perfect for eight diners but could accommodate ten at a squeeze. It was decided that the space at either end of the table was more important than having the right amount of room for ten people. In a bach setting people are used to ‘squeezing in’ and to have a much bigger table for the occasional family dinner party would have compromised the spatial quality of the central space.

10.5 Conclusion

Changing the finished floor of the house so that it was all on one level did not prove detrimental to the final design. By lifting the ceiling rather than dropping the floor, the design team achieved the same feeling as was intended in the conceptual design. The interior and envelope design teams had worked together to detail the interior/ exterior thresholds so that any level change was less than the 16mm limit, or so they thought. In reality, the rubber seal at the bottom of the door, unaccounted for in the detailing, sat fractionally too high and was picked up at the inspection stage. A tiny, purpose-built ‘ramp’ was constructed to mitigate this, but had to be removable as it stopped the bifold doors closing.

The services core dimensions were altered to allow accessibility into the bathroom and laundry, only for the organisers to deny access into these spaces later in the process due to a predicted bottle-necking of visitor flow. However the developments led to the final layout of the bathroom and a separate room for the laundry appliances. This was a beneficial exercise based on this result alone, and the overall house layout was better for it. Even though accessibility compliance in the bathroom became obsolete due to the decision above, the specification of thin frosted glass doors meant that a lot of natural light could diffuse into the darker, north-facing services core, something that previously had not been considered. This diffusion created a beautiful lighting quality in these wet areas.

The design of the key furniture pieces in the house was heavily affected by the accessibility requirements of the public tour route. The study unit suffered the most from this and the design team despaired at every setback. For a while it seemed as if the construction of the unit would not go ahead. However it was important to maintain the design’s integrity for its true purpose: it was not worth making serious design compromises for a ten day exhibition, and the interior team set about finding solutions that would work in both exhibition and standard living conditions. The finalised study design satisfied all the conditions of the brief, although it could not achieve a way of closing off the bedroom completely. In the end, this was not a significant loss as, due to the incorporation of a unit that was removed during the exhibition period, the unit could be wider than at first believed.

Figure 11.0 Interior detail of the developed design model submitted to the US Department of Energy PHOTO CREDIT PAUL HILLIER

PART FOUR: LOOKING BACK

CHAPTER 11 - The final design

The final New Zealand Solar Decathlon design took its cues from the original student design of two years earlier, but refined the intentions.

After a process of distillation, the project team extracted the hypothetical scheme's underlying values and used them to form the basis of the New Zealand proposal across the board- from the design of the cladding and shading, to the interior layout, to the services specification, to the appearance and feel of the project communications.

The branding was to feel personal, family oriented and warm, but also fresh and cutting edge.

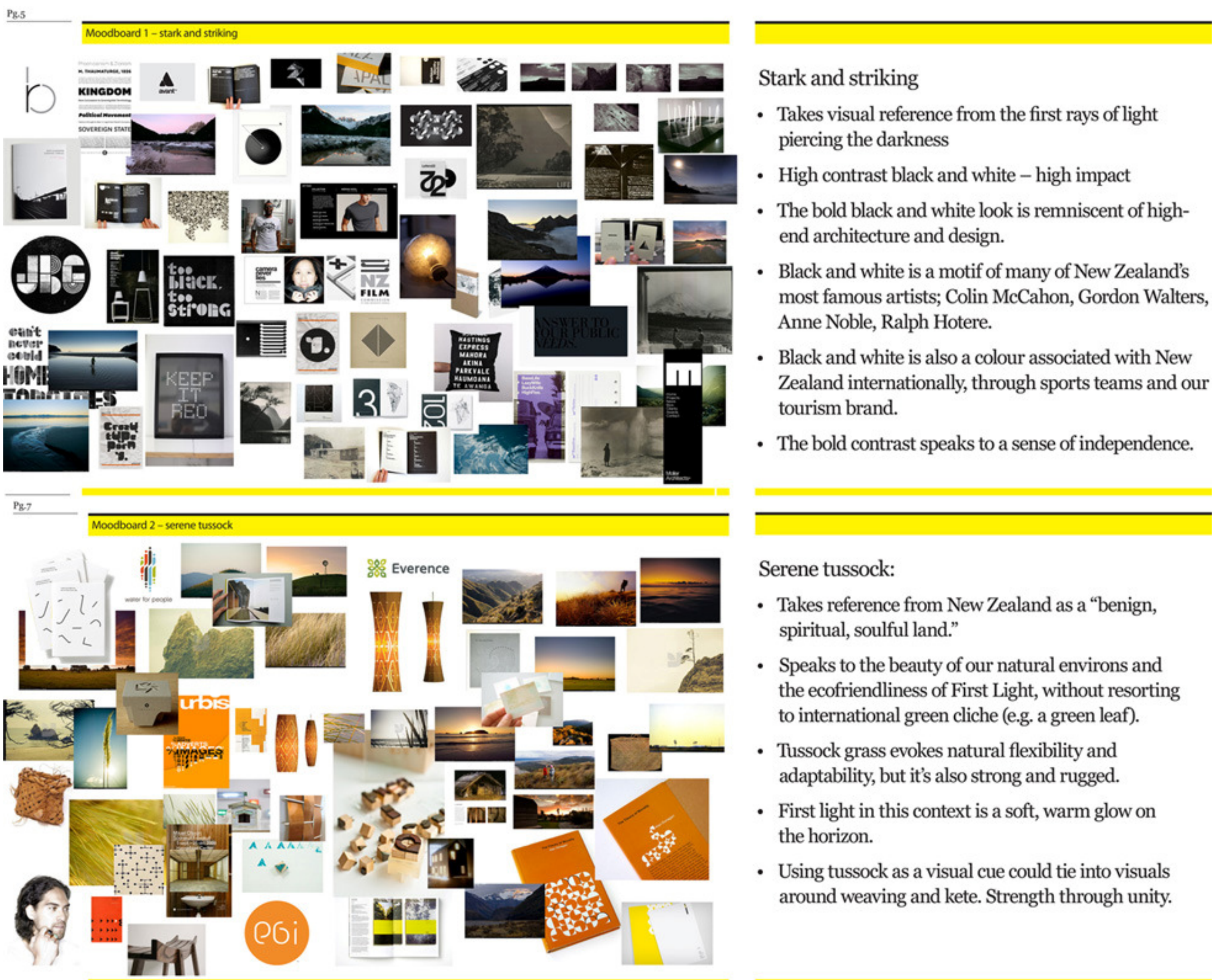


Figure 11.1 Original mood boards for the First Light brand IMAGE CREDIT DESIGNWORKS

Figure 11.2 The First Light brand in print communications

> *"New Zealanders have a deep relationship with the natural environment, it is central to how we live and relate to each other. Our land is the first to see the light. It shapes who we are as people who are welcoming, friendly and relaxed. The land gives us a fresh perspective, an innovative spirit that compels us to create housing that nurtures our way of life and the environment we live in.*
>
> *First Light connects you to New Zealand living through design that places interactions between people and the outdoors at its heart. Houses that embody the spirit of being a New Zealander, and reflects our belief that technology and sustainability should not only be affordable, they should also meld around how we live."*[60]

11.1 The First Light values

The First Light design philosophy became attributable to three core values that had been identified from the original scheme's intentions:

11.1.1 Socialisation

The bach has always been a very social place due to the relaxed holiday lifestyle spent in close quarters with family and friends. All milestones during the day are events for social interaction, from waking up, eating, and heading to the beach, to cooking a communal meal and playing board games in the evening. Personal space requirements are foregone during the bach holiday, or at least significantly reduced, and private space makes way for a home in which the majority of its space is shared.

The communal, convivial atmosphere of the traditional bach is one of its greatest qualities, and helps to influence the national affection for this building type. The encouragement of socialising within and around the house was therefore an important part of the design brief.

[60] First Light brand story, featured in the brochure handed out to visitors on the National Mall

11.1.2 A strong connection with the landscape

New Zealand is a country where coastline and mountain wilderness abound, and it hosts a race of people who are traditionally in touch with this wilderness; proud of it; and who have grown up spending time in the outdoors.[61] A low population relative to ground mass has led to the development of a natural, wild, adventurous image abroad that has long been used as a marketing strategy in the tourism sector.

Figure 11.3 2002 (left) and 2003 (right) images from the international '100% Pure New Zealand' marketing campaign demonstrate the kiwi attachment to the landscape. IMAGE CREDITS TOURISM NEW ZEALAND

The national attachment to the landscape, and the way the traditional bach typology has evolved over the past fifty years to embrace its natural surroundings by way of views and outdoor living spaces, was a starting point for the final First Light design.

Bach life tends to be spent as much outdoors as indoors, reducing the need for large interior living spaces and resulting in a smaller house footprint. As in the original student design of 2009, the First Light team wanted to take the contemporary 'indoor/ outdoor' relationship one step further by designing the house around a living space that was *both* indoors and outdoors.

11.1.3 Humanisation

'Humanisation' was a term coined by the First Light team to reference the low-tech, 'do-it-yourself' origins of the bach typology. One of the features of the traditional bach was its lack of a television. At best, the dwelling might have possessed a transistor radio, and the occupants would pass the evenings by reading or playing board games instead of watching TV. Appliances and technologies were limited to those that were absolutely necessary, and many original baches did not even have a flushing toilet.

Although First Light's bach was to be a contemporary, high-specification building, the team wanted to clearly reference the traditional bach lifestyle and as such aimed to make the design as human-centric as possible. This would enable the inhabitant(s) a direct physical relationship with the home through predominantly manual operation of systems and technologies, such as opening windows, doors and blinds, and turning lights on and off by hand. Technology would be specified where needed for the competition

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[61] Farrow, A (2009) *op.cit*. p12

and not 'just for the sake of it' as had been increasingly seen in previous Solar Decathlon competitions. Minimising automated or remote control operation of things that could easily be done by hand would keep the systems as low-maintenance as possible, eliminate unnecessary energy use, and would give a 'human' feel to the house.

11.2 Physical realisation of the First Light values

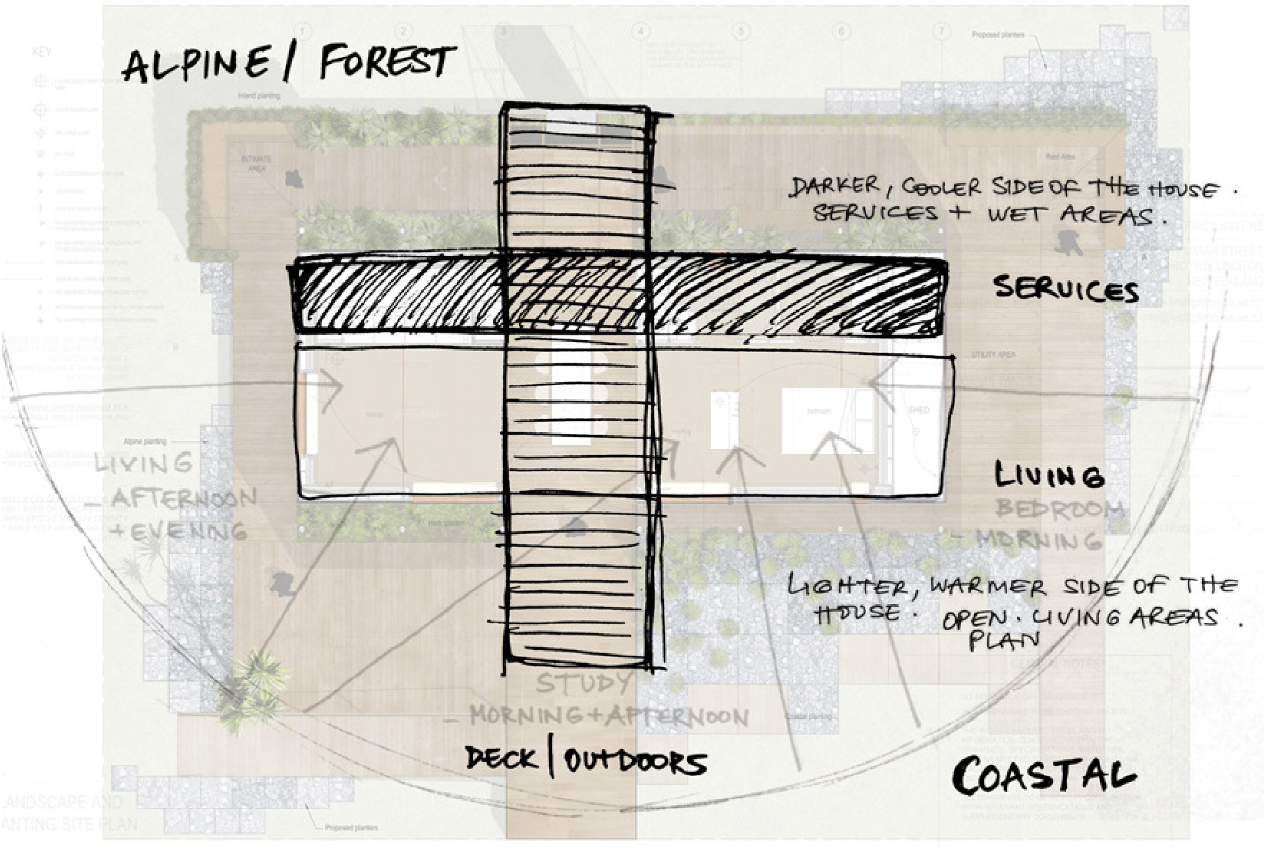


Figure 11.4 Conceptual sketch for the First Light interior overlaid onto the developed landscape plan, highlighting links between the interior and landscape schemes

True to its name, the First Light house was designed to take advantage of the sun's heat, light and energy. Its layout was configured with the bedroom in the east and the living room in the west, so the daily routine of the inhabitants matched the passage of the sun across the sky, naturally lighting the interior spaces adequately until sun down. Because of this, all the living spaces were positioned to the south of the plan, for the northern hemisphere. As with the original design, the functional spaces and services were located along the northern wall, providing a temperature buffer between the living spaces and the colder side of the house.

In effect, three distinct parts of the house were created, as can be seen in figure 11.4 above. In order to highlight the unique functions of each space, and to add a layer of complexity to the conceptual intention, the design team treated each space with its own set of details and materials.

11.2.1 The central space

Figure 11.5 Photo of final design model, showing the focus on the central space

The central 'deck' is the most important part of the design, with all building elements in plan and elevation drawing the focus into the middle of the building. The exterior canopy angles inwards to where it gives way to an almost entirely glazed structure. It appears light in weight, and due to its glazing, it is the brightest interior space. This is the first part of the home that visitors come in contact with and as such is the most public part of the building.

The central space is the focus for the social functions of the house – where cooking, eating and playing board games take place. It was described as 'the heart of the home' during public exhibition in both New Zealand and the United States, and indeed it functions as a heart would- it is the entry and exit to the dwelling, it provides circulation between the two halves of the house and separates the more private bedroom and study to the east from the more public living room to the west.

Figure 11.6 Dining and socialisation become the focus of the home

Centrally located, and with the design features mentioned above, the heart of the home is a natural gathering point. At 920mm high, the central table provides a casual bench that people can stand at, but also makes more of the dining space than a traditional table at 750-780mm high would provide. The raised tabletop is paralleled by the raised, glazed ceiling, intended to provide a ‘celebratory space’ and instilling in the occupants a feeling of elevation in this area. The table surface extends the kitchen’s preparation space into the centre of the room, and cooking becomes part of the entertainment during social occasions. When it is time to dine, a timber unit slides out from beneath the northern end of the table to accommodate up to ten people for dinner.

Figure 11.7 The kitchen/dining table (left) and with storage unit pulled out (right)

The central part of the house is also where the building and the landscape meet. Three large bifold doors open to the north and south, providing a direct physical relationship with the exterior by turning the central space into an outdoor room and drawing fresh air through the home. These doors are fully glazed so that even when closed, there is a visual relationship with the natural surrounds. In addition to this, the glazed skylight overhead allows the sight and sound of rain falling; brings sunlight in from above; and enables view of the stars from one’s place at the dining table.

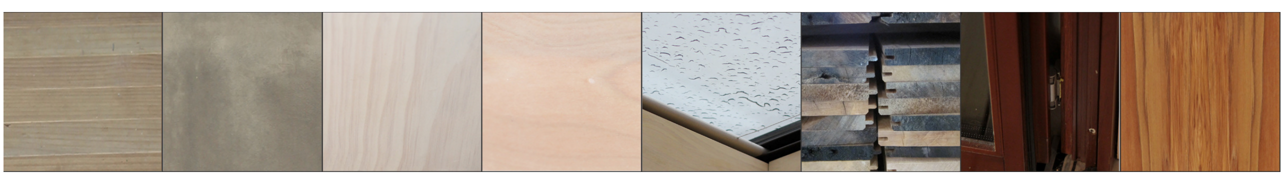


Figure 11.8 Material swatch for the central space, showing an overlap between neutral interior tones (left) and the richer exterior materials (right)

The material treatment reflects the conceptual overlap between interior and exterior. Above, the skylight is treated as a large window punched out of the top of the house envelope- its detailing mirrors that of the windows, even down to its in-line roller blinds. Underfoot, the exterior decking continues through the space as the interior flooring.

Figure 11.9 The skylight is treated like a large, horizontal window IMAGE CREDITS RON BLUNT

The lighting concept for the central space reinforced the inspirational, celebratory nature of this zone. It features a large custom-designed light fitting suspended above the dining table which provides both diffuse, ambient illumination and task lighting to the tabletop below. It was crafted in a light oak veneer (similar in tone to the New Zealand beech dining chairs), which reveals an intricately engraved pacific motif when lit up. While sitting around the dining table at night, its suspended position creates the perception of a lowered ceiling, increasing the intimacy of the dining space. It is a piece of functional artwork that draws focus into the centre of the house, day and night.

Figure 11.10 The central lighting feature; by day it appears to be made of solid veneer (left,bottom), but when illuminated at night reveals an intricate pattern (top left and centre) , and produces a shadow play on the dining table at midday (right)

11.2.2 The living space

The internal living areas are located to the east and west of the dining room, and to the south of the plan, with increasing levels of privacy and enclosure graduating outwards from the central space.

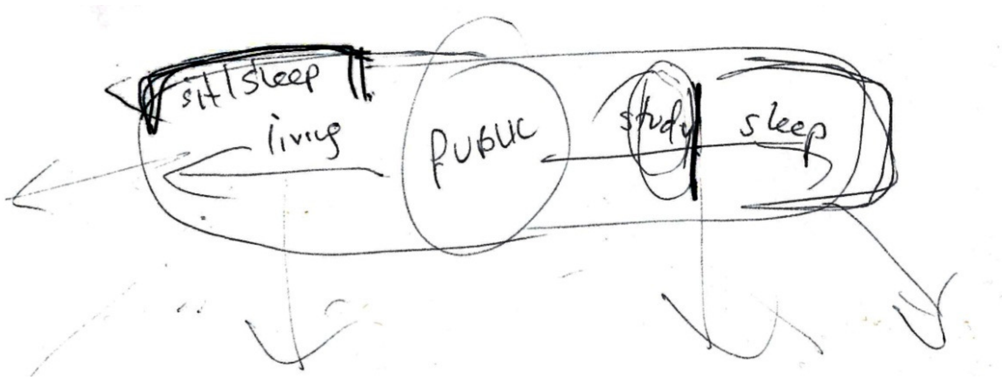


Figure 11.11 A conceptual sketch of the interior spaces in terms of public and private focus

All the living spaces are open to the sun and the views and laid out so that the programme coincides with the sun's path over the day. The layout is open plan and, with the exception of the study unit, there is no fixed furniture. The layout of the individual spaces can be changed around and the furniture can be taken outside. Furnishings that could function as either/ or pieces were specified to accord with the bach's compact space philosophy. For example, the steel coffee table could double as an outdoor bench seat, and likewise, the matching steel bedside tables are the right height to act as stools at the dining table.

Figure 11.12 The coffee table that is simultaneously a magazine rack and bench seat (left) and bedside tables used as seating when a dinner party is happening (right)

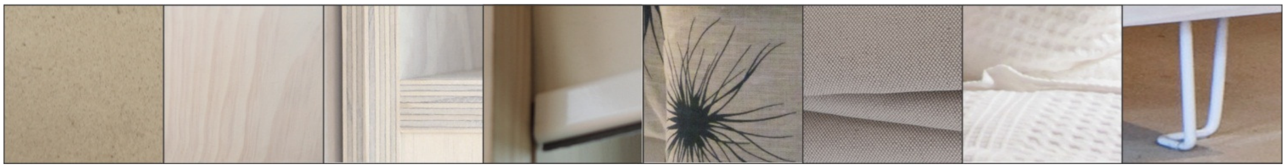


Figure 11.13 Material swatch for the living areas, showing sandy, neutral and sun-bleached tones. New Zealand's sand-binding grass *Spinifex Sericeus,* printed by Hemptech NZ, was used as a motif to link the interior with the landscaped duneland at the front of the house, and conceptually to the communications material seen in fig. 11.2. Metal components of furniture pieces such as the bed, couch and desk are powdercoated in an off-white tone.

The lighting scheme for the central space was for light to bounce off the whitewashed pine interior surfaces and provide ambient illumination (in contrast to the services lighting). Freestanding uplighting was specified, continuing the open plan, non-fixed concept. Although the wiring and operation of the bedroom lighting was hard wired, the lights themselves were freestanding table lamps plugged into sockets behind the bed.

Figure 11.14 Ambient uplighting in the living room (left) and bedroom (right) IMAGE CREDITS RON BLUNT

11.2.2a East of the central space: Bedroom and study

To the east of the central space is the more private side of the interior, housing the study and bedroom [and bathroom and laundry].

Occupying one and a half modules and utilising light, bright materials, the bedroom is comfortably spacious in feel. With the bed head against the eastern wall the inhabitant is granted a view back towards the sky-lit central space, and out a floor-to-ceiling window over the dunescape to the south. The bedroom has easy access to the bathroom and the laundry, which doubles as a walk in wardrobe with ample storage and full-height mirrored cupboard doors.

Figure 11.15 The bedroom IMAGE CREDIT RON BLUNT

The study is a necessary part of the architecture, partitioning the bedroom from the rest of the open plan living space. However when considering the partition, a standard wall between living and bedroom was not desired by the design team. In order to keep the bedroom as light and spacious as possible, and as small as possible, it was important that light could filter around all sides of the unit. Its height was therefore set at 2000mm, allowing a 500mm clearance between its top and the ceiling. This also allowed for an LED strip to be set into the top surface, hidden from view on the ground, for illuminating the ceiling at night.

Instead of being a simple wall, the study unit became a functional space in its own right; providing additional shelving and hanging space in the bedroom, and creating a workspace, or alternative seating area on the western side.

In elevation, its angled detailing references the four degree slant of the exterior canopy [a motif also taken up in the design of the living room unit and by the communications team for graphics and signage]. To minimise its thickness, the study unit is only the depth of a single shelf, so access is from either the bedroom or the study. This provides a textured façade of open and closed segments, which adds interest to the design.

Figure 11.16 The study unit's outlook; task-lit by night, and (right) detail showing one segment of the shelf accessible from both sides

On the living side of the unit, a small plywood desktop sits below shelving and office storage. The shelving has inset LED task lights, operated by a switch on the side of the unit, and the storage space includes multiple electrical and data sockets for laptops, modems and phone [chargers]. The workspace faces a large floor-to ceiling window which provides natural light by day and a pleasant outlook. In this way the home office links with the outdoors and the inhabitant's workspace extends into the landscape.

During social situations, the desk can be folded up into the unit to keep the living space looking tidy and to increase the available living space, and due to the wiring set up, the study can be hooked into the home entertainment system, enabling music and video to be controlled from the eastern side of the house.

With the desk retracted, the study area becomes a small seating space in which to enjoy the morning sun while reading a book or the newspaper.

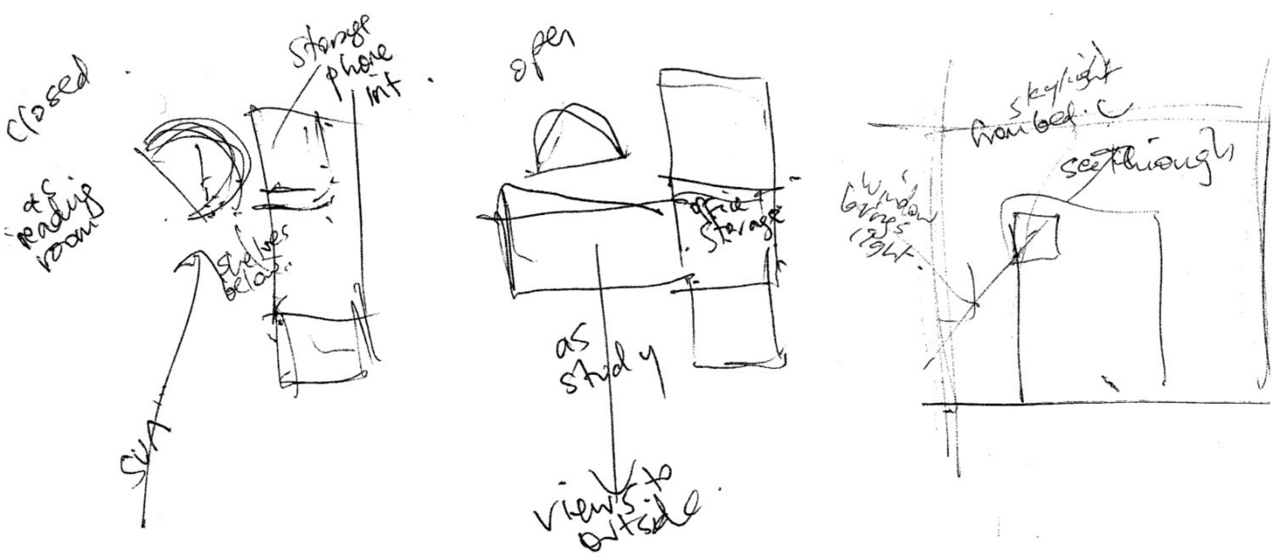


Figure 11.17 Conceptual sketches of the study unit, in its open and closed configurations

11.2.2b West of the central space: Living

The living room is the quieter shared space in the home. It is designed to get ample light during the day through its south facing, full module, floor-to-ceiling window. The custom couch and horizontal western window were designed as a 'set' – the couch at the same length as the window and the window at a height so as to provide an exterior view for a person seated on the couch. This gives the feeling that the couch is a part of the architecture, without it being built in.

There is a lot of storage provided by the services area, and when in its 'closed' or 'normal' configuration, a visitor may be unaware of the hidden potential for accommodating extra guests. It is here in the living room that the living and services areas of the plan work together, designed so that both open and closed configurations seem perfectly natural [and as if there were no other configuration]. The cushions of a built-in couch rest against rimu panelled doors. These open to reveal an elevated squab that can function as an additional seating space in a movie-watching situation and as a grandstand from which to watch the All Blacks – an anecdote used during the US competition while the rugby world cup was playing out on home ground – or as a bunk bed for one or two children. The built in seat rolls forward to become a double bed, the back half of which was concealed beneath the bunk bed and storage unit above. Finally the couch beneath the western window was designed as an extra sleeping spot; removing the backrest squab increases the width to that of a small single bed. In this way the bach conception was kept alive; allowing a compact single bedroom home to comfortably accommodate seven.

Figure 11.18 The built in seating unit [part of the services core in stylistic definition] shown closed (left) and configured for three or four overnight guests (right). The storage space also contains a small wardrobe for keeping guests' clothes in (far right compartment).

11.2.3 The services core

The services core lines the cooler northern wall of the plan and contains all of the home's functional, or task, areas. Conceptually it is treated as the denser, damper, forested part of the design, with built-in furniture and fixtures and all of the plumbing services. The lowered timber ceiling to accommodate the bulkhead enhances the dense, enclosed nature of the spaces, and its solid appearance belies the fact that these panels are completely removable for accessing and maintaining the services.

The detailing for the services core led on from the original and conceptual schemes where the services would be constructed as fully prefabricated, discreet units to be slotted into [or have constructed around them] the panelised house envelope. In the modular realisation of the design, where the house came together as a series of transverse, fully prefabricated slices, the design team wanted the services cores to retain a longitudinal expression. The lining was therefore fixed horizontally and all openings were treated in the same way, regardless of whether they were the bathroom or laundry doorway, the living room nook, or the kitchen 'cut out'. In contrast to the material specification for the living areas, and the original and conceptual schemes where the services were undeveloped but light in weight and texture, the realised services core was articulated in a rich, ruggedly textural way.

Figure 11.19 The recycled Rimu lining folds around corners and into the ceilings of the services spaces

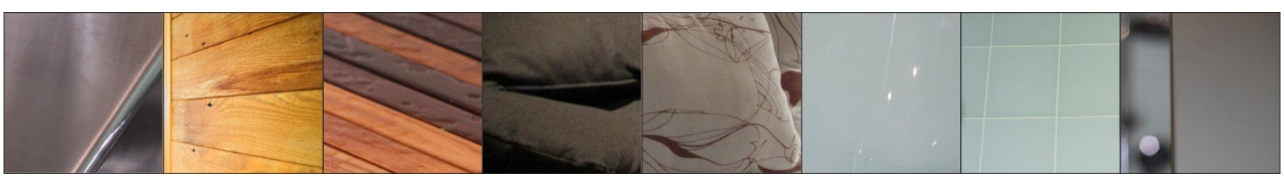


Figure 11.20 Material swatch for the services core. With its knotty, nail-stained Rimu, dark felt, and limpid tones, thi zone makes a bold statement in an otherwise light and neutral interior. In contrast to the living space, the [stainless] steel components featured keep their metallic appearance

The services core's lighting scheme was designed for functionality, and to contrast with the softer, more ambient lighting of the living spaces. The services zones featured built-in, recessed LED task lighting to adequately illuminate the seating unit for reading; the kitchen surfaces for food preparation, and the bathroom and laundry rooms brightly.

Figure 11.21 Recessed task lighting in the living room nook (left) IMAGE CREDIT RON BLUNT; over the bathroom sink (centre) and in the eastern kitchen workspace (right)

11.2.3a Kitchen

Figure 11.22 Space is used economically in the very compact kitchen

The kitchen was designed for two, with compact workspaces and compact appliances. Despite its size, it is packed full of as much storage and as much functionality as was possible in the limited space. The specification of a bench-height dining table increased the useable space and also the storage capacity of the kitchen. It houses power points for plugging in a blender or a mixer, and its detailing was intended to subtly delineate the 'kitchen' part of the bench from the 'table' section. The timber shelving unit underneath the northern end of the furniture piece slides out to act as a servery surface when people are seated around the table.

11.2.3b Bathroom and laundry

Once the bathroom and laundry were developed to occupy separate rooms, the detailing was developed to maximise the perceived size of the compact spaces. Mirrors were specified to bounce light [and reflect the space], and the frosted glass doors allow light to play between the interior and the living room; creating a visual barrier but not a solid enclosure. The small services windows are set into the northern wall directly opposite the doorways, but the majority of natural light diffuses through the southern-facing glass doors. At night this interplay reverses, and the stronger task lighting glows through the frosting of the bathroom and laundry doors into the living space.

The bathroom was detailed as a forest-feeling all-wet space, with lichen-coloured glass tiled walls, hardwood timber duckboards underfoot and an overhead 'rainshower column' from Methven NZ, to reference the outside shower at the bach. As with many of the details in the First Light house, the internal door handle fulfils a secondary function as a towel rail for the showering inhabitant.

Figure 11.23 Frosted glass doors transfer light between the services and living spaces (far left); the bathroom looks and feels like an outdoor shower (left) and mirrors increase the perceived size of the small spaces (centre and right)

11.3 The landscape [and the interior]

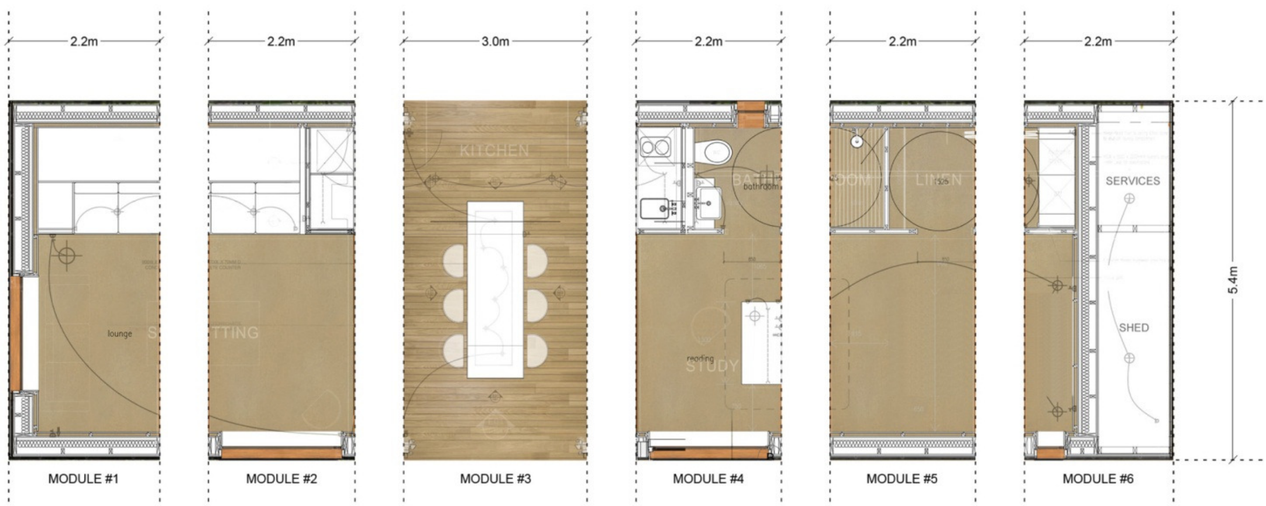
The landscape scheme went hand in hand with the interior scheme, and the two design teams worked to highlight the links between these design areas. The interior material specifications for the services core, living areas and central space created an immediate conceptual connection with the plant specification outside. However the spaces themselves were also designed to be both interior and exterior. The northern edge of the central deck featured a concrete table, similar in design to the kitchen island but with landscape material references, such as the dark steel structure, which tied in with the ramp balustrades. The kitchen was designed to occupy the whole space between this exterior table and the central island, rather than just stopping at the edge of the house envelope. The exterior table was intended for use as a barbeque space, or for filleting freshly-caught fish, and in summer the northern bifold doors would be opened to accommodate a crowd of pre-dinner guests around the barbeque.

The dining room made an obvious connection to the outdoors, as with the bifold doors open to the south, and north if desired, the dining space extended indefinitely.

The house essentially had two southern-facing living rooms; one inside the house and one directly outside on the south western deck. The interior furniture was lightweight and versatile, intended to be moved between the two living areas at different times of the day.

Finally, a small living space was created to the northwest of the house, designed for use in the evenings when the late sun reached around the side of the house. This was designed to engage with the dense, forested planting, and increased the useability of the bach insofar as it provided another separate space for the adults, or children, to spend time away from the greater family group.

11.4 Construction and assembly



The final building comprised six modules: five fully prefabricated building blocks and one flat-packed panelised module. The intention was to have at least 90% of the interior pre-finished off-site, with only small removable sections to cover the module joins.

The modules were designed to be moved around by crane or forklift, so the materials specified needed an element of tolerance, such as the flexible grout specified between the tiles in the bathroom. Timber, the predominant interior lining, has a natural flexibility, and the concrete floor topping used is an innovative 'bendable' cementitious composite. A lot of spare timber, and a whole set of glass tiles, were taken to Washington DC as contingency supplies. Surprisingly, the only casualty was one broken tile in the two months of transportation!

The assembly planning forecast the modules to be in place and the house waterproofed in one day, after which the interior work could begin.

CHAPTER 12 – Critical analysis of the realised design

There are a number of ways to evaluate the success of the final First Light house.

Firstly, did the house meet the criteria set out by the Solar Decathlon competition rule book? This is the most formalised evaluative process, given that a panel of US American building professionals were tasked with this assessment. The competition results and qualitative observations from this panel will be reported on below in Section 12.1.

Secondly, what was the response to the house on home ground? Did New Zealanders see the First Light house as a credible "kiwi bach"? The lessons learnt and feedback gained from the trial assembly and exhibition on Wellington's waterfront will be discussed in Section 12.2.

Finally, and perhaps most importantly, did the project team achieve what it set out to do, and deliver on its original vision, established in early 2009? This is the most subjective of the three assessments, but comment can be made on the realised design in terms of the bach typology, the performance of the building, and the experience of the construction and assembly processes. This will be discussed in Section 12.3 below.

12.1 Feedback from the National Mall

The Solar Decathlon competition organisers presented a strict and comprehensive set of rules to follow, and criteria to meet. The rules and criteria have been discussed throughout the body of this thesis and those relevant to the interior of the house have been appended [See Appendix A].

On entering the competition week, the logistical requirements, which acted as prerequisites to the competition but were not judged themselves, had been accomplished. The First Light house shipping consignment arrived in Philadelphia in good time. The containers and container-sized modules were duly transported to a pre-assembly site where they were checked for damage, and where important components such as module 3 were put together. That allowed the First Light house to be transported to the competition site on the Mall, and to be assembled and certified within the seven day time limit, by a team of predominantly undergraduate students, in a smooth process.[62]

A New Zealand bach was now sitting on the National Mall in Washington DC. The First Light house's most important testing period then began.

[62] In fact, given that this was the second chance at assembly, and that all the problems had been experienced and addressed in the first assembly at Frank Kitts Park, the house was finished by the end of the sixth day. All that remained to be done on the final day was a site clean up.

12.1.1 Architecture

Overall, the jury believed the bach to be 'a stunning house… inspiring and functional' and awarded it 95 points out of a possible 100. Of the 19 houses that reached the Mall, the First Light team were placed second in the *Architecture* sub-contest overall.[63]

Lighting was a key component of the *Architecture* sub-contest in 2011.[64] The design team failed to pick up on this inference in the rules book: references to lighting design took up one bullet point in the architecture criteria, seemingly assuming the same importance as the other criteria to be considered. However, given that an individual lighting sub-contest had featured in the previous Solar Decathlon competitions, but had been removed to make way for the *Affordability* sub-contest in 2011, the team should have considered the importance of artificial lighting, or its weighting in the architecture contest, more thoroughly. This is not to say that the lighting of the First Light interior was bad; just that the low-level ambient light, characteristic of the kiwi bach, was appreciated in conceptual terms but was criticised in practice for 'verging on dark' and consequently lost the team a number of points.

Apart from the criticism in this design area the architecture jury was most complementary, praising the thoughtful and thorough attention to detail, and the consistency between the interior and exterior languages. Inside the house, the plan organisation was commended for being 'very strong and unique'. Noted characteristics included the design's flexibility; the way the spaces felt 'private, yet open'; and the emphasis on warm, natural, and organic materials and surfaces that begged to be touched.'

12.1.2 Market Appeal

The Market Appeal jury was similarly very complementary in its feedback. The judges awarded the bach a score of 93 out of 100 points, which placed the First Light team third overall in this sub-contest. The liveability and marketability expectations were 'eclipsed'[65]: the judges made particular reference to the 'outstanding social spaces', the 'breathtaking' central area, and the marketable nature of the house due to its warm, natural and recycled finishes and use of local materials. In spite of a 'compact' plan, the house was deemed a most functional and enjoyable space to be in.

The jury interpreted the recycled Rimu and Radiata pine interior linings and the wool insulation as successful references to the home's New Zealand origins, and commented on the outstanding way the house took into account the indoor-outdoor lifestyle of its target market.[66]

Once more, the two ends of the interior were criticised for being dark, and the team lost points for practical reasons such as failing to supply shop drawings (detailed cutting schedules and exterior trims) for the built-in joinery.

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[63] The feedback from the Architecture and Market appeal juries can be seen in full in Appendix B.

[64] Lighting quality and lighting control evaluations were also conducted by the Market Appeal and Engineering juries.

[65] 'Eclipsed' was the top category in the scoring table the judging panels used

[66] See Appendix B for the full Market Appeal feedback.

12.1.3 Home Entertainment

The home entertainment tests were successful, enjoyable evenings around the competition site. The compact appliances specified in the First Light kitchen performed successfully, both in the cooking simulations and in the preparation of the kiwi-inspired meals which were received well by the dinner guests. All the teams scored highly in the Home Entertainment contest, so even though the New Zealand team achieved 96 points out of 100, they were placed eighth in the contest overall!

12.1.4 Affordability

In the United States the First Light house was valued at USD$303,467.92, losing 5.3 points for its budget overrun of almost $54,000. That placed it ninth in the affordability contest. The interior certainly contributed to the points deductions but there was no sole source, in the interior or otherwise, attributable to the expenditure over and above the $250,000 limit. As is discussed in Chapter 13, the construction budget was dealt with strategically. It had been decided that for the potential points lost in this sub-contest, there would be gains elsewhere in the competition to a greater value than those deducted.

Indeed, the market appeal jury commented, “Whereas this house has a high pricepoint, the quality of the design and execution and the materials used make this house a good value for the target market.” That suggests that the decisions the design team made when balancing cost versus utility were validated by the judging panel.

12.1.5 The other sub-contests

The interior design and articulation comprised a significant part of the sub-contests focused on above. The interior was relevant, and significant, to all of the sub-contests of course, and influenced the final scores of each one. However the focus of the remaining sub-contests was on technological or performance based criteria rather than applied design. As such, they have not been discussed individually for the criteria used is not relevant to the applied research for this thesis. For example, the interior layout and the materials specified contributed to the home’s passive thermal performance, which had a bearing on the results of the Comfort Zone sub-contest. This said, the weather conditions in Washington DC during the competition week, reported in Chapter 13, meant that the maintenance of a stable and comfortable thermal environment was principally dealt with by the engineering team, as the space conditioning relied on active controls over and above those passive design features discussed in Chapter 7.

Similarly, the Energy Balance contest was influenced by the interior specification of LED lighting which consumed less than 200W in total, and the energy efficiency of the kitchen appliances and the washing machine were also specified.[67]

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[67] The house performance during the competition week is reported on comprehensively in Jagersma, B (2012), op cit.

At the end of the competition week, the New Zealand house had accumulated 919.058 points out of the potential 1000, placing it 3rd in the 2011 Solar Decathlon village. This demonstrates that the competition criteria, across the board, were met more than satisfactorily: the house can be deemed a success in terms of the competition. The final scores and rankings for each of the sub-contests are reported in figure 12.1 below, along with the final score totals for each of the houses in the competition village.

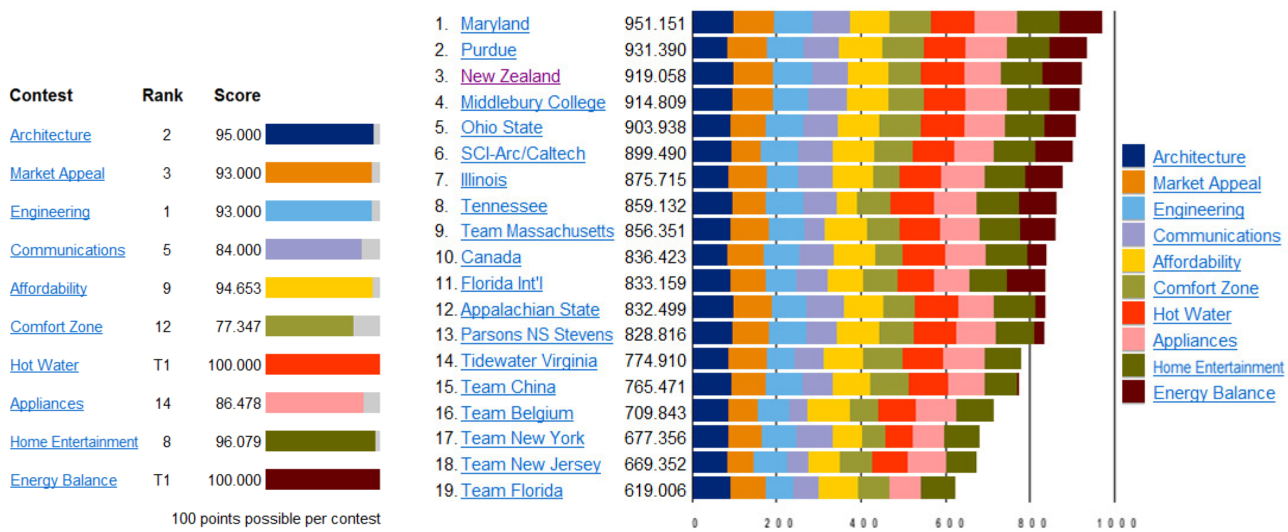

Figure 12.1 New Zealand's final scores for the ten sub-contests (left) and New Zealand's score in the context of the Solar Decathlon village (highlighted 3rd from top) IMAGE CREDITS US DEPARTMENT OF ENERGY

12.2 Feedback from Frank Kitts Park

In early 2011 a test assembly was undertaken on Wellington's waterfront to make sure all construction and logistical issues were ironed out before both the house and the team tested in the United States. Following assembly, the First Light bach was open to the public for 18 days, between 7th May and 24th May inclusive.

The construction of the house was not complete when the modules were required to be broken apart and transported to the assembly site for the first time so that the building could be displayed in Frank Kitts Park on Wellington's foreshore. The builders and students continued to construct the interior during this assembly and disassembly period so the true timing and sequencing of a modular assembly was not given a fair test. Even on the opening day much of the finishing was not done. Components such as the in-wall and skylight blinds, and even the central concrete table, were missing.

Figure 12.2 The interior, three days before the grand opening of the house in Frank Kitts Park, without the finishing details of scotias, skirtings, blinds, fascias for HVAC and ERV systems, surface treatments such as concrete sealant, rimu oil and pine whitewash, or impermeable linings such as the kitchen's glass splashback and bathroom tiles.

However, in the 18 days that the First Light house was exhibited on Frank Kitt's Park, the positive public response to a modular, net-zero, transportable bach was unexpected in its scale: an estimated 20,000 people walked through the bach's bifold doors during this time.[68]

A brief survey was undertaken by members of the marketing department of the student team, which asked questions about the interior design and the perceived viability for modular housing options and domestic solar energy generation.

The interior space and its components rated highly as one of the most enjoyable features of the house. The materials used also scored highly. The built-in lounge unit was a stand-out favourite; the functionality of this space was particularly popular with visitors.[69]

In various strategic locations around the built landscape of the First Light house's site (at the first five numbered points in figure 10.2, Chapter 10), the team positioned interpretation signage. This was consistent with the branding strategy, imagery and material specification of the rest of the project. However, once inside the house, the project team felt it would be distracting and spatially unwise to utilise signs. The interior would therefore have to 'speak for itself'.

Figure 12.3 Interpretation signage located amongst the planting of the landscaped site (left) and (right) the interior on display, but without explicit signage

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[68] Handley A & Meyers, Z (2011) FKP Media Analysis: discussion on key findings. This was an internally circulated document and as such has been appended to the thesis. (See Appendix C)

[69] Ibid.

As reported in the research project referenced above, there was strong agreement amongst the visitors to the Wellington waterfront exhibition that the interior design reflected and communicated the 'true kiwi bach'. Nevertheless it was commonly commented that more 'kiwiana' needed to be featured in the house to tell the New Zealand story. Although this may have been true, the design team was not sure about the deliberate specification of 'kiwi bach kitsch' in a contemporary design, nor whether this would be understood by an American audience.

The media response during the exhibition was also comprehensive: the team, the university, the design and the sponsors appeared in 35 unique print, radio and online articles around the country. One of those articles dealt solely with the interior design, commenting on the efficient planning that went into the small building's interior, and comparing the multifunctional features to those seen in another traditional kiwi 'holiday home'; the campervan.

> *"The plan is a marvel that stands up to interrogation. The constraints of sustainability… have led to an economy of planning that breaks new ground in the small house. Seriously. A long box, cut in half, creates a living end and a sleeping end. In the cut, the bi-section, lie the dining room and the kitchen (the eating bit). Architects have been wrestling with these three zones for years but nowhere have they been so carefully delineated and seamlessly assembled.*
>
> *The living end is close, snug and yet light-filled. The built-in couch transforms into additional bunks like a grounded campervan but does so far more comfortably. The sleeping end has a bed open to the rest of the space with privacy controlled through the cautious placement of a room divider. Service rooms tuck neatly away.*
>
> *But the masterstroke is the eating bit: a kitchen reduced to two small opposing benches (because who has time to cook, really?) and a massive concrete table which provides passive solar energy. All this on an internal deck blurring the lines between inside and outside, proving that indoor/outdoor flow means a whole lot more than simply a set of French doors.*[70]

All in all, the Frank Kitts Park test was a success: kiwis evidently 'bought' this representation of a contemporary bach concept and in fact wanted to buy the building, too: by the end of the exhibition there were over forty recorded expressions of interest to purchase the house.

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[70] Honey, T (2011) Hot House: *Urbis* Aug 2011 issue 63 p

12.3 Self evaluation

Because of the nature of this project external evaluation of the First Light bach was unavoidable. As described above, in terms of both the Solar Decathlon criteria and the response to the earlier showing in Wellington, the First Light house had been successful. However, an even more important critique of the success of the project, at least for those who conceived and developed the house, centres on whether or not the built First Light house displayed in both Wellington and Washington DC realised the concept that the design team articulated at the beginning.

12.3.1 The First Light bach in the context of the traditional bach typology

The First Light bach assumed the typological characteristics of its predecessors, as described in Chapter 1. The structure sat lightly above the ground, yet engaged fully with the surrounding landscape. Inside, a simple, open plan layout avoided any dedicated circulation space and, although compact, the interior allowed for the comfortable accommodation of many inhabitants. The furniture and spaces could expand and contract with the number of occupants. The design encouraged socialisation and communal time through the focus on shared spaces [there was essentially only one space] and the artificial lighting scheme reinforced these areas for group inhabitation. The use of wood further supported the bach aesthetic.

All of these features kept the First Light bach feeling bachy, and the key values of socialisation, landscape connection and humanisation that underpinned the design guided and focused the final articulation of the original intention.

In conceptual terms, seeing the design work in the way that it was intended was one of the most rewarding parts of the two year process. Right from the moment the skylight panels were lifted into place a sense of magnitude was felt within the central space – and that was when the building was inside a warehouse. This space continued to impress as the bach was translocated to Frank Kitts Park and as the central table was installed – firstly in the form of a chunky Rimu ‘placeholder’ and then in the form of the custom-designed concrete bench top when it was positioned on-site in Washington DC. The physical features were rewarding enough but the ephemeral features instilled a greater sense of achievement in the project team. As soon as the central space was complete, people gravitated towards it. This was where the competition organisers stood and signed off the final compliance documents, and where the judging panels sat to deliberate on the scores in the subjective sub-contests. They were not directed to do this; but the focus of both the building form and the interior design meant it was the natural thing to do.

This sense of achievement was again experienced when observing the reactions to the built-in living room unit. It begged to be sat on. On the first night in Frank Kitts Park, after the opening ceremony, the entire First Light student team piled onto the bed and bunk, as can be seen in figure 12.5 (right image).

Figure 12.4 The skylight panels in place for the first time in the Lyall Bay warehouse (top left). The gravitational pull of the central space is felt as soon as the interior is complete in Washington DC (bottom left and right).

Figure 12.5 Killing time in the bach in Washington DC (left); and (right) the First Light student team tests the true capacity of the built-in lounge unit after the Frank Kitts Park opening.

In terms of the relationship fostered between the house and its landscape, the design delivered on its intention to create a new and unique connection with the outdoors. Even while the building envelope became simultaneously weightier and much less transparent, this exterior connection was retained and in fact strengthened due to the greater contrast created between the solid prefabricated modules and the transparent, panelised, predominantly glass module 3.

The realised design did not cause the rest of the interior to lose its connection with the landscape either. Strategic placement of the windows meant that the study space enjoyed views from the desk, and the western view could be enjoyed from a seated position on the couch against the western wall. The consequence of the decision to create the “shed” at the eastern end of the building was the removal of the eastern window in the bedroom. The loss of this connection with the outside was regretted by the design team and it was commented on by the architecture jury. Here, the connection between the occupant and the rising sun was lost, which weakened the concept of the sun and the occupant following each other through the day. The bedroom would also have benefited from an eastern window for the extra light it would have afforded.

None-the-less, the way the house embraced its exterior surroundings through the extension of the interior spaces towards the outdoors, both physically and visually, as documented in chapter 11.3, reinforced the unique perspective on, and treatment of, a common architectural theme.

Where possible, the bach was kept as low-tech as the competition requirements would allow. This was not very low-tech, however. The term ‘humanisation’ was originally coined to reference the person-centric nature of the bach: the way the simple construction enabled a physical connection between the building and the inhabitant in its day-to-day operation. The realised design endeavoured to keep manual control of as many features as possible, and in the drier climate of New Zealand the space conditioning technologies specified would rarely need to be used. Where ‘true’ simplicity became impossible, measures were introduced to increase the ease of home operation, such as the ‘master off’ switch at the entrance door and the simple, playful graphics that communicated real-time energy use in the house via an in-wall touch screen.

Therefore, although the design, construction and operation became infinitely more complex than what might be expected in a traditional bach, or even a traditional home, the First Light bach managed to retain its ‘human feel’.

The core values of socialisation and landscape connection were addressed and worked well in the context of the bach; however the tension between the performance requirements of the competition and the qualities suggested by the term ‘humanisation’ was not a natural fit and the design team felt that the bach therefore failed to deliver comprehensively on its third core value.

12.3.2 Reflection on the operation of the interior as experienced during the competition week

Hosting a dinner party for ten tested the true capacity of the kitchen and dining designs. The acknowledgement following this experience concluded that the kitchen was not entirely suitable for a large, formal group of diners, especially if those guests were restricted to occupying the interior ‘dining’ space as the competition specified. With regard to the kitchen; the small western bench space was not big enough to cook dinner and accommodate used entrée and dinner dishes at the same time. When hosting the dinner parties it was hard to keep this space tidy. This was because it was felt to be unsatisfactory to clear plates into the dishwasher, and thus reduce the clutter, in such close proximity to the guests.

The dining table was only just big enough for ten- it was a bit of a squeeze to get the required number of diners around a 2800mm table where the ends could not be occupied. However, in a bach formal dining rarely, if ever, happens. ‘Formal’ is not a word that is associated with any part of the bach typology or lifestyle. Diners would certainly not be restricted to a place at the table either, and if the dinner parties were to be tested again on competition soil, it would be much better if there was greater flexibility, so as to enjoy the different stages of the meal in sequential spaces of the house as the layout and indoor/ outdoor flow inspires. For example, entrees could be prepared and eaten in the outdoor kitchen space by the barbeque table – this would comprise more informal finger food, perhaps not needing plates at all – and any dishes used could be left in this space to clear up after the departure of the guests. In a bach, unless bad weather precluded it, the kitchen island would probably be used as a ‘prop’ on which to lay out all stages of the meal at once; during the bach holiday diners serve themselves and often head outside. In First Light’s case this would have been to eat on the front deck with the view and the setting sun.

12.3.3 Reflection on the construction method and the assembly process

The idea to convert from a panelised method of construction to a modular one proved beneficial in terms of time and ease of assembly, as the complexities of repeatedly fabricating module 3 revealed. Although the house was still in a state of construction during the Frank Kitts trial assembly, the task proved invaluable in preparing the whole student team for the competition process. This was demonstrated by the subsequent ability of the project team to undertake highly comprehensive Human Resources planning prior to arriving in the USA, and the consequent smooth, organised coordination of the student assembly team on-site in Washington DC.

However, for all the design team’s attempts to create a ‘modular prefabrication’, the interior had a high proportion of stick and panel components. This came about due to a number of factors:

- The initial decision to go for a non-modular aesthetic, which meant removable coverboards rather than expressed joints.
- Structural requirements, such as the stainless steel tension cables running internally along the top of the long edges of the building which, in addition to the specification of the removable coverboards above, necessitated removable scotias.
- Delays in the construction process which pushed certain interior decisions, such as the need for removable skirtings as mentioned in chapter 8.
- A lack of adequate communication, negotiation, or advanced interdisciplinary planning – particularly between the interior and the engineering design teams. These failings resulted in the necessity for not only all the bulkhead ceilings to be removable, but also for much of the joinery in the services core, designed to be built-in permanently, to be removable.

The design team was not successful in achieving the level of prefabrication it had initially envisaged. A near total level of off-site prefabrication should have been possible however, and more work was needed to develop this aspect of the design and detailing.

Figure 12.6 A module-by-module breakdown of the individual components required for the completion of the 'built-in' components of the First Light interior. (ie the 36 components comprising the large, free furniture items such as bed, couch, dining chairs, coffee table and southern living room shelf unit are not included in this breakdown)

However, the individual details developed performed very successfully. Tolerances were allowed for, and accommodated. Even after the original construction and disassembly, the Frank Kitts Park trial assembly and disassembly, an international journey of 18,000km, and the competition assembly, the interior finishing, and indeed that of the entire project, looked neat and deliberate. The high quality of the finishes and the finishing was commented on in a number of forums.[71]

Complex, seemingly counter-intuitive, details such as the two part bathroom came together most successfully, and came apart just as well. Even after the detailing of the bathroom wall join, the design team was sceptical that it would be possible to remove the coverboard panel of glass tiles in one piece. Nevertheless, this was achieved. Furthermore, the panel when in place created a seamless, almost invisible join between the modules.

The quality of the design articulation can be attributed to the whole student team, as the individual students involved all had an eye for, and a dedication to, detail.

Figure 12.7 Detailing in the bathroom makes the module join almost invisible (left); the attention to detail in every component of the house, such as the hand-made brass mechanisms of the dining chairs, made the overall quality of the construction very high

In summary, the original student team of four did feel that they had achieved what they had set out to do. There were certainly things they would do differently the next time around, and the team is keen to address these problems, most of which were caused by the need to transport internationally, and to perform in a hot, humid environment, unlike that of the traditional bach climate. In a New Zealand context, transportable modules could be much bigger, allowing a bathroom in one piece, and potentially even the whole house as one module! The team would certainly increase the permanent capacity of the home, and would endeavor to reduce the cost of construction by developing greater levels of prefabrication, reducing the reliance on active technologies, and getting rid of the features that existed solely for the purpose of fulfilling Solar Decathlon criteria, such as the dimensions required for public accessibility and adjustable foundations.

[71] Comments on material specification can be seen in both the Architecture and Market Appeal feedback forms in Appendix B

CHAPTER 13 - SUMMARY

This thesis details the changes to the interior required to turn a 2009 undergraduate student paper design into the First Light house, a fully realised building that competed in the U.S. Department of Energy's 2011 Solar Decathlon. It examines the forces that acted during the design process to account for those changes. The experience of participating in a post-graduate project focused on turning an undergraduate design concept into a fully-functioning dwelling has prompted consideration of the limitations of current architectural training. The experiences gained during that 'concept to built' process have also prompted consideration of the efficacy of collaborative approaches to the design and realisation processes. Both are discussed below, as is the changing nature of the Solar Decathlon since 2002. The changes to the competition rules are relevant to important factors relating to the design and realisation of sustainable dwellings, of which the First Light house is but one example.

Inevitably, after two years of development, the realised design of the First Light house was an improvement on the original proposal in terms of all the major project concerns: layout, liveability, functionality, energy efficiency and ease of assembly. The latter was proven on-site with a team of primarily 'unskilled' undergraduate students successfully putting the house together in six days.

Despite many, often fundamental, changes, the realised dwelling retained the original intention of the architecture and the 'gut' feeling of the house. This was due to:

- Predetermined parameters surrounding the New Zealand bach typology
- Focused sessions of distillation at the beginning of the developed design, which led to a branding philosophy for the project, and the establishment of a set of underlying values.

The awards the original design received indicate that it was a well-rendered and researched design compelling in its imagery and its 'New Zealandness': the initial research underpinning the design had laid the foundations for that. For an American-centred competition, 'New Zealandness' was an important characteristic to celebrate, in order to differentiate the only southern hemisphere entry ever from its competitors. As reported earlier, the Solar Decathlon judging panels accepted the concept the house was designed to deliver.

The nationalist approach to architectural style and imagery that was adopted no doubt helped the design's appeal in New Zealand as well, demonstrated by attendance at and responses to the First Light house's Wellington waterfront debut.

The crucial observation about the original design is that it was remarkably undeveloped, untested and very academic in its approach. It was the drawn representation of a 'pure' concept. Such is not, as the design team has found, the end of the matter. As Bryan Lawson has commented:

The drawing is in some ways a very limited model of the final end product of design, and yet in a world increasingly dependent on visual communication it seems authoritative. [72]

Lawson also highlights the difference between an 'ideal design' and an 'ideal home'; the latter arguably not often, if ever, investigated by the undergraduate architect.

The designer can see from a drawing how the final design will look but, unfortunately, not necessarily how it will work. The drawing offers a reasonably accurate and reliable model of appearance but not necessarily of performance. [73]

It could be claimed that, at university, undergraduates prioritise the design processes of drawing, printing, and conceptual presentation, which is forgivable since they have very little or no experience in the practical processes of detailing, specifying, or developing past the concept phase. However this limited view of the design process is evident in current university output. Notable or celebrated undergraduate work seems to favour a certain austere, crisp, monotone aesthetic that lacks evidence of consideration for the materiality, liveability or constructability of the spaces designed.[74] The presentation images submitted for the SARC 383 paper in 2009 were no different.

Students can brush over unresolved challenges or design deficiencies by producing alluring images, but in doing so, never learn to resolve critical underlying problems. This can be partly attributed to the short timeframe of design projects at university; there never seems to be time enough to get to the bottom of a design problem. But mentoring and guidance should push simultaneously the conceptual development *and* the actualisation of a buildable, **liveable** piece of architecture.

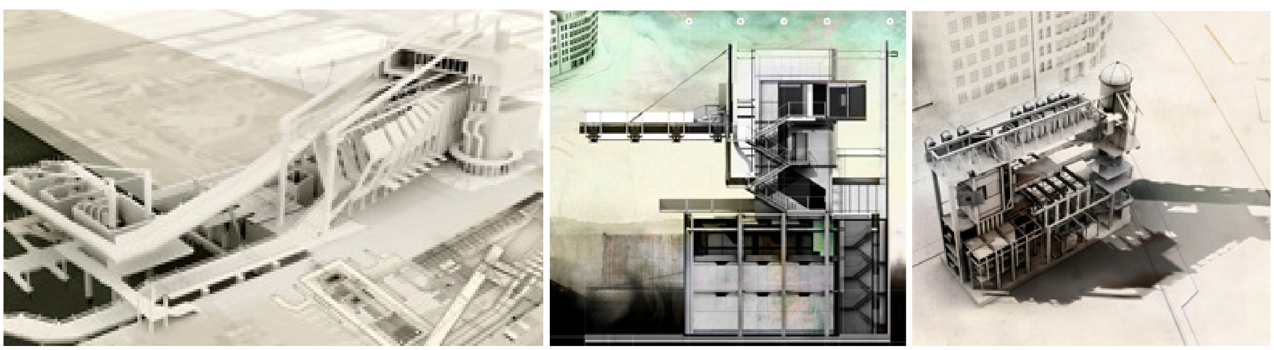

Figure 13.1: Interior architecture projects on the VUW School of Architecture and Design website (2012).[75] The presentation images are striking but do not display evidence of in-depth consideration for the materiality, liveability or constructability of the spaces presented. IMAGE CREDITS CHLOE WALBRAN (left) WEN TING (centre and right)

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[72] Lawson, B (1990) *How Designers Think: The design process demystified* p25

[73] Lawson B *ibid* pp24-25

[74] Officer, N. (2012) *op. cit* pp82-83

[75] Victoria University of Wellington: Interior Architecture http://www.victoria.ac.nz/architecture/study/student-profiles/interior-architecture Page last accessed 18-05-2012

Figure 13.2: The original student design for a New Zealand Solar Decathlon house.

Figure 13.3: A digital render of the final First Light house design, two years after production of the hypothetical figure 13.2 above, displays warmth and materiality and does not rely on a striking background image to enhance its appeal.

The Solar Decathlon project challenged the designers to live in their design: physically, through hosting dinner parties and movie nights for the competition week; and conceptually with regard to performance, through empirical testing of thermal comfort, services functionality and energy use. This invariably led to deeper consideration of the layout, lighting, and material qualities of the interior components, and the overall house footprint, the envelope and the services design.

Moreover, the team had to put the building together in a very restricted window of time, which led to the need to consider the nuts and bolts of construction details; the size and weight of components; their connections; their volume for packaging and transportation, and the sequence in which these separate components went together.

The students involved in the Solar Decathlon project could no longer fall back on imagery alone: any unresolved issues would be very obvious in the testing and judging of the realised design. This introduced a broader view of the design process, for which the real world challenges of cost, quality and time competed with the conceptual concerns presented initially.

Figure 13.4: interior components are put together by students (above), and a dinner party is prepared and hosted in the central space during competition week in Washington DC (below)

That said, the students were being introduced to the ‘real world’ of architecture with a project that was not entirely real-world, for a number of reasons.

Firstly, the competition’s methods of testing the designs were very limited in scope. For example, all the teams in the competition had undergone similarly comprehensive processes of performance optimisation, and in the ethos of sustainability, and on-sale potential, these houses were to perform uniformly across the climatic variations of an entire year. But the competition only judged the results presented in the ten days spent on the National Mall. Neither the time nor the site was necessarily representative of the real year or the real house performance.

The New Zealand team, working to develop a proposal a hemisphere away from the competition site, had to make sure its house would not only achieve all the performance requirements set by an unpredictable ten days in Washington DC, but also all those necessary to create a liveable, and marketable, home back in New Zealand. The 2011 event exemplified this strategic difficulty, with seven out of the ten days being sunless, wet and humid. The First Light technologies, which would have performed admirably over a year, suffered from the weather conditions experienced during the judging period. Similarly, the hydronic dryer, a strong point in the team’s R&D output in New Zealand, became one of the First Light house’s weak points when operating in the very high humidity conditions experienced during the competition period.

Secondly, the design process itself was not entirely realistic.

The students were working both as designer and as client, at least where spatial and material preferences were concerned; there was not the normal to-ing and fro-ing between two parties [client and architect] when discussing specifications. If the design team wanted a particular material or feature, it could have it – within reason, but this was vetted much more loosely than would be the case within a conventional project. This made for a visually appealing, high-quality resolution of the interior, the exterior, and even the services for the house, all of which elicited universal commendation. The finalised project would probably have been different in a more real-world client/architect situation, however.

The budget for construction was not set out at the beginning of the design. The affordability sub-contest encouraged a build cost of USD$250,000 but its scoring function was calibrated such that going 'over-budget' up to an additional USD$100,000 was not significantly penalised. Spending then became strategic; if potential points gained outweighed points lost by the additional sum expended, it was usually worthwhile to increase the overall construction cost of the house. This was also, and only, possible because of the large amount of in-kind sponsor support for the project. Faced with the complexities of fabrication, the cost of components, or the cost and time of labour, particular features would certainly have been foregone in a real-world project. The fact that the project was directed by students, with access to the university's resources, meant that many of the components that would be unfeasible in a traditional build could be fabricated in-house and much time was spent that was not accounted for in the budget. In fact, the man hours worked on the design and development of the house would have blown any budget and likely bankrupted an architecture firm in a real-world situation. However, because universities are charged with undertaking research, which is then fed into teaching, this situation was made possible.

Figure 13.5: Detail of the 1:25 scale model created for the developed design submission to the US Department of Energy (left); a large team of students spend many hours in the project office and in the workshop (centre and right)

In the design of the house envelope there were very few standard details. The majority of the details inside and out were non-standard and often with no direct precedent. The range of legislative and economic controls, construction requirements and the demands of the competition all interacted to generate a highly constrained situation for the design team. Therefore the developed design was based on problem solving, much more so than the design of a traditional house. Every detail had to be drawn, modelled, or prototyped with consideration of:

- Size
- Connections
- Tolerance
- Material
- Number of fixings and/or components
- Accessibility
- Assembly
- Disassembly

Through all of its unconventionality, for the students the project represented 'a normal project on speed' – everything was dramatised, exaggerated, and more complex. Due to the need for repeated transport of the modules, including across the Tropics, the effects of time and movement on a building became evident almost immediately. This provided insight into material properties and behaviours, fixings, and highlighted the importance of designing tolerances into a building construction.

At the same time, the unconventional nature of the project afforded the students many learning opportunities they would not have experienced otherwise. They were on site for much of the original construction of the building, and then were in charge of the on-site assembly in two different locations over 14,000km apart.[76]

> *"Thanks to the Solar Decathlon, I gained experience, knowledge and personal growth that probably would have taken years to develop if I had not been a Decathlete."* [77]

Working on site presented a myriad of learning opportunities not experienced in the classroom, or office, such as material properties and what can and cannot be achieved with certain materials; tolerances and assembly; how details actually function; the time and labour needed to construct certain design features and the cost implications of these, and the interpretation of information on design drawings.

Design became much less 'obscure' in the mind of the designer when faced with the design; coming together in a 3D, full scale version; and the other practitioners in the field. Interacting and collaborating with the engineers, builders, electricians, joiners, and the funders meant that the project was no longer just an isolated exercise in the specification and production of drawings of an 'ideal design', but a colourful, two-way process in the quest to produce an 'ideal building'.[78]

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[76] This is the distance between the two assembly sites 'as the crow flies'. In the introduction the distance travelled by the modules between Wellington and Washington DC was reported as approximately 18,000km. This represents the 'ground' covered by the freight liner, which travelled via Manzanillo in Mexico, and Cartagena in Colombia before berthing in port in Philadelphia, USA. The two distances can be seen in the title age for **part two**, where the airline journey taken by the First Light team, and the sea freight journey taken by the First Light house are diagrammed on the same world map.

[77] Testimonial from Ingrid Arocho, a member of Puerto Rico's 2005 team, in *Building the Future* National Renewable Energy Laboratory (2008) p3

[78] Working with others also highlighted the fact that 'ideal' was a subjective term, interpreted differently across the different fields, and could refer to: cost; ease of construction; balancing the often competing ideals of low cost and high performance; or just getting the job done.

As reflected on in Chapter 12, the implications of the design decisions made during the interior development were made evident to the designers as they ran through the tests during the competition week. This was a valuable and privileged insight - a designer is not often given the chance to self-evaluate the performance and liveability of his/ her design first hand.

The Solar Decathlon project encouraged students to engage in a deep and meaningful way with their designs, in a way that most universities arguably do not. Moreover, the intention of the competition is wider reaching than just the *designing* itself: through the Solar Decathlon the US Department of Energy aims to foster a hands-on, holistic view of a building, from its design and construction to its operation. This inevitably introduced the students to the concept of the integrated whole building design process (IWBDP).[79]

The extreme constraints of the project coupled with the inexperience of the project team made it necessary to envisage the whole process and its players from the outset, even if the students did not know that such a concept as the IWBDP existed, or that they were embarking on such a process. Throughout the developed design phase, workshops were held with the engineers, performance engineers, design strategists and the building company, so that options could be evaluated, to ensure the specific requirements for each and every component were understood, and so that the best way of constructing a high performance house could be decided upon in an informed way. Once-weekly sessions at the Mainzeal offices were coordinated so that the designers and the builders could brainstorm details, how these would go together, and how the house would come together during the initial construction of the house 'off-site' in the warehouse. This was firstly to make sure the designers could detail the building in a buildable way, and secondly to prepare the building team in advance for what the construction would entail.

> *The artist's self-conscious recognition of his individuality has a deep effect on the process of form-making. Each form is now seen as the work of a single man, and its success is his achievement only.* [80]

Unlike Alexander's observation on the traditional design process, in the integrated whole building design process the architect is not an autonomous or authoritarian design generator; rather the design is undertaken in collaboration with all the parties associated with the building in all its stages. This collaborative environment should be developed early, and continued throughout the process; enabling an iterative design phase to take the place of a reactive construction phase. There is less acknowledgement of the individual in this approach and more of the sum of the individuals.

For this to be universally adopted a culture change in the construction industry would be needed, from the conventional approach described above, that tends to encourage the segregation of the disciplines, to a

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[79] National Institute of Building Sciences, *Whole Building Design Guide: Engage the integrated design process* (2010) http://www.wbdg.org/design/engage_process.php Page last accessed 10-05-2012

[80] Alexander, C. (1964) *Notes on the Synthesis of Form,* cited in Lawson B p

holistic, design-led approach that seeks to recognise the interconnectedness of disciplines and of the project's goals.[81]

The six phases of a design project:

1. Enthusiasm
2. Disillusionment
3. Panic
4. Search for the guilty
5. Punishment of the innocent
6. Praise for the non-participants

Figure 13.6: Notice on the wall of the Greater London Council Architects Department, according to Astragal AJ, 22 March 1978 [82]

Instead of the process described in figure 13.6 above, humorous, but indicative of a system infamous for its dysfunctional interrelationships, the integrated whole building approach could work to foster a better, more cooperative atmosphere in the construction sector.

Research into this process currently advocates the IWBDP for larger-scale buildings especially, where increasing efficiency and cross-discipline collaboration during the design process can create significant reductions in the cost of the design and construction work, the on-going operational costs of such projects, and an increase in the the health and productivity of the many occupants. However small-scale building projects that have adopted the IWBD approach have proven to be much more cost effective during construction and also over the lifetime of a building.[83] The experience of the First Light house project demonstrated that an integrated approach can certainly also benefit the residential client, especially in the field of high-performance houses like those featured in the Solar Decathlon competitions.

The interior was not worked on in isolation; in dealing with such an energy efficient building it was vital that the layout and the interface between the interior and the services were developed collaboratively. In fact, it would not have been possible for the First Light house to be as well-functioning or energy efficient without the team working as it did, making all the important decisions regarding space, materials and performance as a cooperative, collaborative whole.

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[81] eCubed Building Workshop Ltd (2008) *Integrated Whole Building Design Guidelines* p5

[82] Lawson, B *op cit* p 29

[83] US Department of Energy (2001) Whole-building Design Increases Energy Efficiency in a Mixed-Humid Climate http://www.nrel.gov/docs/fy01osti/30504.pdf Page last accessed 16-05-2101

This has particular relevance to the success and efficiency of construction of the interior of such a building. In a traditional build, the internal 'fitout' is often left till last, with certain larger scale projects leaving the interior to be fitted out independently after construction. The IWBDP highlights the importance of considering the whole rather than a collection of the parts. In new buildings, the interior should be addressed early and with a view to helping shape the building, rather than just 'lining' the space within the envelope after the fact.

The First Light project was not by any means an exemplary model of the IWBDP: communication breakdowns within the management hierarchy led to procedural inefficiencies and time delays which resulted in cost increases during construction. Nor was the potential for price efficiency immediately evident in the bach as the prototyping and construction costs were very high. However, without the involvement of a wide range of specialists from early in the design process the construction costs would no doubt have been higher, and the construction itself would have been more difficult.

The lessons learnt through the input and feedback from the other building professionals, and through observation of the physical processes required were valuable. Those lessons also highlighted the importance of continuing professional development via concurrent, collaborative, practice and research; particularly in the new and rapidly evolving fields of sustainability, energy efficiency and home autonomy.

The experiences of the student team further served to show not only the potential for the IWBDP but also the benefits of practical experience for the student. By being immersed in a holistic process, the students learnt not only about design in its pure form, but about the vagaries of achieving – or not achieving as the case may be – such a design.

This suggests that a shift in the teaching methods for architecture, and indeed many disciplines, could be beneficial. Business centres in the UK certainly indicate this would be a favourable idea, and many tertiary institutions follow the 'sandwich course' model where the academic years are interleaved with two semesters of mandatory practical training in a firm as a prerequisite for graduation.

> *Work is a major part of most people's lives – so all universities have a clear responsibility to equip their students with the skills they need to succeed in the labour market. Many jobs require specialist or technical knowledge, but all jobs require generic employability skills. Students – undergraduate and postgraduate, UK and international – look to their universities to help them gain these skills alongside the specialist knowledge their academic studies supply.*
>
> *There is one clear message: we must all – employer, university and student – raise our game. … we must ensure more undergraduates have the opportunity to experience the world of work – through work placements, summer internships and more contact with business during their studies.* [84]

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[84] CBI & UUK (2009) *Future fit: preparing students for the world of work*. p10

The Solar Decathlon itself is also learning and has continued to develop and change based on the experience of consecutive competitions. It has shifted to a more holistic view of “sustainability”.

Since its beginnings in 2002, *Architecture* has always been an important category, as has the generation of surplus energy, seen in the disproportionate points representation in the first four competitions where two categories rewarded maximum production of electricity.[85] The 2011 competition was the most ‘progressive’ event: both architecture and energy generation were readjusted to compete equally with the other sub-contests, which were all given the same weighting. It is much easier and has recently proven more marketable to *reduce energy* than to *generate it* (this approach is simpler, cheaper and less resource-hungry) and the competition’s focus has readjusted accordingly.

This was a fortuitous and timely change as far as the New Zealand bach was concerned: a system that created only the power it needed rather than attempting to provide for its neighbours too (of which there are quite possibly none anyway) sat much better in the context of the typology and the ‘as needs’ philosophy of the traditional baching lifestyle.

The perceived capacity of a small home may also be changing with the competition. The small footprint set by the US Department of Energy has, until now, appeared to limit the production of anything but a one-bedroom house. This precedent informed the single-bedroom nature of the First Light bach, against the judgement of the project team who felt a dwelling with a footprint in the upper limits of the permissible range should have two bedrooms. Interestingly enough, and perhaps following the inaugural European Solar Decathlon in 2010, to which many of the 2011 competitors went for research purposes, a significant change was seen between the capacity of the houses in the 2009 and the 2011 events on the National Mall. In 2011 almost half of the prototypes included a second bedroom.

The bach in fact turned out to be a building type that fitted the Solar Decathlon parameters well, and as such, the kiwi prototype performed competitively in the 2011 event.

Back in New Zealand the public response to the First Light bach demonstrated the continuing kiwi attachment to this iconic building type[86] and the evolution of this typology demonstrated the capacity, marketability and viability of bach-style living in the twenty-first century: a lifestyle that values living small and efficiently by maximising the functionality of spaces and furniture and by utilising the outdoors. Respecting the surrounding landscape (whether it be the natural or built environment) through appropriate material use, energy reduction and generation – and by living in it too – enables a smaller house footprint in terms of both interior space and impact on the planet.

It is a pleasure to report, then, that the kiwi bach culture lives on as strong as ever. The principles underlying the traditional bach: to live simply, to live small, to build locally and to touch the ground lightly, are as topical and important today as they ever were.

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[85] The sub-contests and their weightings are tabled in the introduction, table 0.1 p17

[86] One of the questions underpinning the *The Simple Life* research undertaken early in SARC 383, as discussed in Chapter 1, enquired into the significance and relevance of the bach in contemporary New Zealand culture. The local response to the First Light bach appeared to verify the conclusions made in *the Simple Life* report.

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APPENDIX A: Solar Decathlon Rules

SECTION III: CONTEST CRITERIA

The Solar Decathlon competition consists of 10 separately scored contests. Each contest contains one or more subcontests. For example, Contest 8: Appliances consists of five separately scored subcontests. The team with the highest total points at the end of the competition wins. Table 2 shows the competition structure.

Table 2: Competition structure

Contest Number	Subcontest Number	Contest Name	Available Points	Subcontest Name	Available Points	Subcontest Type	Brief Description
1	n/a	Architecture[4]	100	n/a	n/a	Juried	Architecture Jury reviews and evaluates the drawings, construction specifications, audiovisual architecture presentation, and final constructed project
2	n/a	Market Appeal[4]	100	n/a	n/a	Juried	Market Appeal Jury reviews and evaluates the drawings, construction specifications, audiovisual sales presentation, and final constructed project
3	n/a	Engineering[4]	100	n/a	n/a	Juried	Engineering Jury reviews and evaluates the drawings, construction specs, energy analysis results and discussion, audiovisual engineering presentation, and final constructed project
4	n/a	Communications	100	n/a	n/a	Juried	Communications Jury reviews and evaluates the Web site, video walkthrough, onsite public exhibit, and public exhibit materials
5	n/a	Affordability	100	n/a	n/a	Juried	Cost estimator reviews the drawings and construction specifications to estimate construction costs
6	6-1	Comfort Zone	100	Temperature	75	Measured | Monitored	Keep zone temperature in 71°F – 76°F (22°C – 24°C) range
	6-2			Humidity	25	Measured | Monitored	Keep zone relative humidity below 60%
7	n/a	Hot Water	100	n/a	n/a	Measured | Task	Deliver 15 gallons of water at average 110°F (43°C) temperature within 10 minutes; 16 water draws during contest week
8	8-1	Appliances	100	Refrigerator	10	Measured | Monitored	Keep refrigerator temperature in 34°F – 40°F (1°C - 4°C) range
	8-2			Freezer	10	Measured | Monitored	Keep freezer temperature in -20°F – 5°F (-29°C to -15°C) range
	8-3			Clothes Washer	20	Measured | Task	Successfully wash 8 loads of laundry (one load = six bath towels) during contest week
	8-4			Clothes Dryer	40	Measured | Task	Return 8 loads of laundry to their original weight (one load = six bath towels) during contest week
	8-5			Dishwasher	20	Measured | Task	Successfully wash five loads of dishes (one load = six place settings) during contest week
9	9-1	Home Entertainment	100	Lighting	40	Measured | Task	All interior and exterior lights on at full levels at night
	9-2			Cooking	20	Measured | Task	Successfully perform four cooking tasks (one task = vaporize 5 lb of water in less than 2 hours) during contest week
	9-3			Dinner Party	10	Juried	Host two dinner parties for up 8 guests; teams score each other
	9-4			Home Electronics	25	Measured | Task	Operate a TV and computer during specified hours
	9-5			Movie Night	5	Juried	Invite neighbors to watch a movie on the home theater system; teams score each other
10	n/a	Energy Balance	100	n/a	100	Measured | Monitored	Produce at least as much electrical energy (kWh) as is consumed during contest week
TOTALS			**1,000**	**515 total juried points and 485 total measured points from 19 individually scored contest elements**			

[4] Lighting quality and lighting control evaluations are conducted by the Architecture, Market Appeal, and Engineering juries.

There are three ways to earn points:

- Task completion
- Monitored performance
- Jury evaluation.

Subcontests based on task completion or monitored performance are called measured subcontests; subcontests based on a jury evaluation are called juried subcontests.

Points for task completion are awarded as a function of “closeness to completion.” Points for measured performance are either awarded at the end of each scored period throughout contest week or at the conclusion of contest week when performance requirements are met or partially met.

The scoring of the juried subcontests is more flexible than the scoring of the measured subcontests described above. However, for the sake of fairness, consistency is important. To increase the consistency of the scoring in juried subcontests, the jurors shall use the evaluation method described in Appendix B-1.

Contest 1. Architecture

A jury of architects shall assign an overall score for the design’s architectural merit and implementation by reviewing the team’s drawings, construction specifications, and audiovisual architecture presentation (see Appendix D), and by performing an on-site evaluation of the competition prototype (see Appendix B).

The jury shall consider the following specific criteria in its evaluation:

Design and implementation

- Was the team effective in its use of architectural elements including, but not limited to: scale and proportion of room and facade features, indoor/outdoor connections, composition, and linking of various home elements?
- Did the team create a holistic design that will be comfortable for occupants and compatible with the surrounding environment?
- Are the lighted spaces rich and varied? Do they have adequate light for tasks? Do they have good color rendition? Do the luminaires properly distribute light? Is the admission of direct and diffuse sunlight effectively controlled?
- Will the overall architectural design offer a sense of inspiration and delight to Solar Decathlon visitors?

Documentation

- Did the drawings, construction specifications, and audiovisual architecture presentation enable the jury to conduct a preliminary evaluation of the design prior to its arrival at the competition site?
- Did the drawings, construction specifications, and audiovisual architecture presentation accurately reflect the constructed project as assembled on the competition site?

Contest 2. Market Appeal

A jury of professionals from the homebuilding industry shall assign an overall score for the house’s market appeal by reviewing the team’s drawings, construction specifications, and audiovisual sales presentation (see Appendix D), and by performing an on-site evaluation of the competition prototype (see Appendix B).

The jury shall consider the following specific criteria in its evaluation of the responsiveness of the design to the characteristics and requirements of a team-defined target client (see Table 3 for examples of target client characteristics and requirements).

Livability

- Does the design offer the occupant(s) a safe, functional, convenient, comfortable, and enjoyable place to live (see Table 4 for examples of livability considerations)?
- Is the operation of the house’s lighting, entertainment, and other controls intuitive?
- Are the unique needs and desires of the target client met by the design?

Marketability

- Does the house demonstrate curb appeal, interior appeal, and quality craftsmanship?
- Do the house's sustainability features and strategies make a positive contribution to its marketability?
- Does the house offer a good value to potential homebuyers?

Buildability

- Are the drawings and construction specifications of sufficient quality and detail to enable a contractor to generate an accurate, detailed construction cost estimate?
- Are the drawings and construction specifications of sufficient quality and detail to enable a contractor to construct the building as the design team intended it to be built?
- Are all the house's materials and equipment commercially available, such that the house can be immediately built in the private sector?

Table 3: Examples of target client characteristics and requirements

Characteristic or Requirement	Example #1	Example #2	Example #3
Location of permanent site	New Orleans, LA	Folsom, CA	Boston, MA
Housing type	Emergency relief	Single family	Investment property in an urban college setting
# of occupants	2	3	1
Client demographic	Middle-aged married couple	Mid-30s married couple with infant	Graduate student
Client annual income	$35,000	$100,000	$75,000
# of bedrooms	1	2	1

Notes:

1. These examples show the *minimum* required level of detail for the target client characteristics and requirements.
2. The target client characteristics and requirements shall be included in a prominent location in the audiovisual sales presentation (see Appendix D-5).
3. Other examples of housing types include, but are not limited to, the following: retirement cottage, vacation retreat, university housing, home office/studio, studio apartment, mobile home, barracks, penthouse, and loft.

Table 4: Examples of livability considerations (NOTE: This list is not exhaustive, and all considerations do not apply to all projects.)

Aesthetics	How well does the design respond to aesthetic tastes of the entire range of people within the target market? How are the views to the outside?
Maintenance	Will snow block the PV or solar collectors? If so, how will the homeowner remove the snow? How do the exterior surfaces hold up to environmental conditions? How frequent and convenient is required maintenance? How will water and dirt affect the floors and countertops? Are they easy to clean with standard household cleaning products? Are there interior surfaces, corners, or crevices that are difficult to keep free of dirt or dust? How is the oven cleaned? How is the freezer defrosted? How frequently must vegetation be watered? Is watering convenient? Is the car protected in inclement weather? Can appliances and furniture be easily moved for cleaning or maintenance? Is mold or rust likely to form anywhere in or on the house? When a house component or finish breaks or is damaged, is it easy to find a replacement?
Comfort	Is the tub or shower floor comfortable on a cold winter morning? Is it easy to sleep or listen to quiet music when there is heavy precipitation, high winds, lots of street noise, or a party next door? Are there any uncomfortable drafts? Is there a uniform temperature distribution throughout the house? Is the house comfortable for a tall person? A short person? A person with allergies, respiratory, or other physical problems? Do any of the house systems or appliances generate annoying or unpleasant sounds or smells? Is the furniture comfortable? Is the workstation comfortable during a long work day?
Privacy	Do the bathroom and bedroom offer visual and auditory privacy from other rooms and outside? To travel from the bathroom to the closet to change clothing, is it necessary to travel through public areas? Can all the windows in the house be covered so the occupants can achieve total privacy if they want it? Do the outdoor living spaces offer sufficient privacy?
Convenience	Are the appliances appropriately sized? Is the toilet paper dispenser easy to operate and conveniently located? In inclement weather, it is necessary to put on shoes and a coat to retrieve the mail, put out the trash, or walk from the house to the car? How many remote controls are needed to operate the home theater system and control systems? Are they intuitive? Are electric, network, phone, and other outlets conveniently located? Are wastebaskets and recycling bins conveniently located?
Functionality	Is the bathroom mirror foggy after a shower? Where does one air-dry a towel in the bathroom or bedroom? Is there an effective means for people to clean and dry their shoes when entering the house in inclement weather? Do the windows block UV rays that could damage interior finishes or furnishings? Does the smoke alarm sound when stir-frying is happening in the kitchen? How is moisture managed in the bathroom and kitchen? Do the high-tech or ultra-efficient devices perform as well as advertised? Is there sufficient storage space for clothes, food, cookware, linens, toiletries, books, CDs, tools, etc.? How fast and consistently do the various water fixtures respond to different temperature settings? Does the workstation contain equipment and features sufficient for a home office? Do low-flow shower heads, sink faucets, and toilets perform their respective functions satisfactorily?
Special Features	If people with disabilities are included in the target market, is the house fully accessible? If young couples are included in the target market, could the house accommodate a baby? If the design is targeted toward a niche market, how well are those unique requirements met?
Flexibility	If the house is sold to new owners with different tastes or needs, how difficult would it be to redecorate or rearrange the interior or exterior? If the target market includes people with varying incomes, would less-expensive appliances or furnishings detract significantly from the house's appeal? Is the house wired to accommodate future breakthroughs in consumer electronics and/or home controls?
Safety	Is it difficult for a potential thief to break in? Do daily or seasonal maintenance tasks present any hazards? Do appliances pose any hazard to children? Is the workstation ergonomically comfortable? Does the workstation offer a convenient opportunity to relax one's eyes after staring at the monitor for a while?

g. The organizers will consult the operation manual to identify appropriate cycle settings. “Normal” or “regular” settings shall be selected, if available. Otherwise, settings most closely resembling typical “normal” or “regular” settings shall be selected.

h. The dishwasher may be run empty, partially loaded, or fully loaded; the load may be soiled or clean.

Contest 9. Home Entertainment

9-1. Lighting

All available points are earned for keeping all interior and exterior house lights on during specified periods of time. See Appendix A-3 for specific details regarding the number of points per house lighting task and the time periods designated for house lighting tasks.

a. All dimmers shall be adjusted to their highest positions and all other lighting control equipment shall be disabled or overridden so that the controlled lamps are fully and continuously on during the specified periods.

b. Partial credit will be awarded for partial compliance.

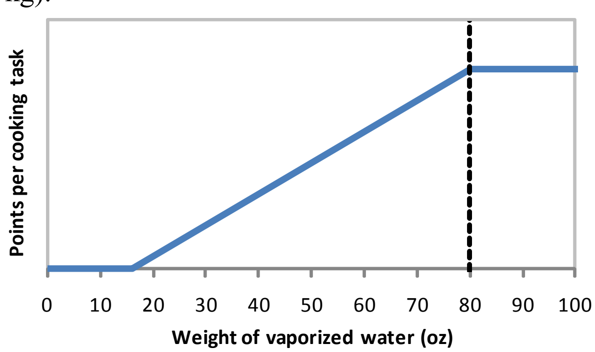
9-2. Cooking

All available points are earned by using a kitchen appliance to vaporize 5.000 lb (80.00 oz or 2.268 kg) of water within a specified period of time. See Appendix A-3 for specific details regarding the number of points per cooking task and the time periods designated for cooking tasks.

a. Reduced points are earned if between 1.000 lb (16.00 oz or 0.454 kg) and 5.000 lb (80.00 oz or 2.268 kg) are vaporized. Reduced point values are scaled linearly, as shown in Figure 9.

b. Any kitchen appliance may be used, but it must operate in its normal configuration as it is vaporizing the water.

c. The water shall be vaporized in a single pot and the starting water weight shall be at least 96.00 oz (2.721 kg).



Full points:		Weight ≥ 80 oz (2300 g)
Reduced points:	16 oz (450 g) <	Weight < 80 oz (2300 g)
No points:		Weight ≤ 16 oz (450 g)

Figure 9: Scoring function for the Cooking Subcontest

9-3. Dinner Party

Each team shall host two dinner parties for its neighbors during contest week. See Appendix A-3 for the dinner party schedule and the number of available points per dinner party. Dinner parties will feature a pair of guest decathletes from each of three neighboring houses, and each pair of guest decathletes shall assign a score to the host team after each dinner party. The quality of the meal, ambiance, and overall experience shall be considered in the evaluation.

a. To maintain consistency among the juried contests and subcontests, guest teams shall use the scoring methodology described in the “Phase 3: Deliberation” section of Appendix B-1. Each of the three pairs of guest decathletes shall submit three percentage integer scores, i.e., one score for quality of the meal, one score for ambiance, and one score for overall experience, to the contest officials by 10 p.m. These nine scores will be averaged and multiplied by the maximum available points in the scoring server to generate a final score for each dinner party. Percentage integer scores may range from 0% (lowest possible score) to 100% (highest possible score).

b. The village will be organized into five small "neighborhoods." Each neighborhood consists of four neighboring houses. The guest list for the dinner party shall be limited to eight people—two people from each of the three neighboring houses and up to two VIP guests. VIP guests may include organizers, media, government employees, family members, or other individuals approved by the organizers to attend the dinner parties.

c. See rule 11-1d for house occupancy rules during the dinner party.

d. Each host team shall prepare dinner for exactly eight people—six decathlete guests and two host team members or VIP guests. Guest decathletes are encouraged to deduct points if too much or too little food is prepared. Guest decathletes of the second dinner party are strongly encouraged to deduct points if the second meal is similar to or the same as the first meal. The intent of this subcontest is to serve a unique meal at each dinner party.

e. Host team decathletes in the house during the dinner party must be performing one or more of the following four functions: 1) eating the meal; 2) cooking/preparing the food; 3) operating the house during scheduled Contest 7, 8, or 9 activities.

f. Non-decathletes are prohibited from preparing the meal or instructing decathletes in any way on the competition site.

g. Teams shall prepare and cook all food and beverages in the house during the period of time indicated in Appendix A-3. A file describing eligible and ineligible ingredients is posted in the "/Files/Rules/Dinner Party" folder on the Yahoo Group.

h. The meal shall be served and eaten in the conditioned space at the eating area designated in the drawings.

i. Before and after the dinner portion of the party, the host team is permitted, but not required, to serve hors d'oeuvres and/or beverages, which may be served outside.

j. Teams are required to submit detailed dinner party menus to the organizers. The organizers will review each menu for compliance. If corrective actions are required to meet all safety requirements, a team must submit an updated version of the menu. Guest decathletes are encouraged to deduct points if the meal isn't consistent with the menu.

    (i). Teams shall submit a single, bookmarked PDF file (see Appendix G-2 for PDF formatting and file-naming requirements) containing a restaurant-style menu, cookbook-style recipes, and comprehensive ingredient list for each dinner party.

    (ii). Revised menus may be submitted to the subcontest official by noon on the day of the dinner party. Teams are responsible for providing these revised copies to guest decathletes. Guest decathletes are encouraged to deduct points for inconsistencies between the revised menus and the original menu submission.

k. Teams hosting dinner parties shall comply with the following safety requirements:

    (i). The use of flames, including candle flames, is prohibited during contest week (see rule 8-2b).

    (ii). No alcoholic beverages may be stored in the house, used in meal preparation, served, or part of a meal in any way.

    (iii). All water used for cooking and drinking shall be drinking water purchased in sealed containers.

    (iv). All dishes and cookware shall be washed with hot water and soap and rinsed prior to use.

    (v). Normal domestic wastewater may go into the wastewater tank.

    (vi). All beverages and food must be stored properly and according to the instructions on the packaging, e.g., beverages and foods marked "refrigerate after opening" must be refrigerated appropriately after opening.

    (vii). To help prevent allergic reactions among dinner party guests, teams shall create a list of ingredients for each of the items being served at each meal. Common food allergies include milk/dairy products, eggs, peanuts, tree nuts (walnuts, cashews, pecans), fish, shellfish, soy, and wheat.

    (viii). Outdoor cooking and grilling equipment may be incorporated into the competition prototype, but the use of such equipment is prohibited on the competition site.

9-4. Home Electronics

All available points are earned for operating a TV and computer during specified periods of time. See Appendix A-3 for specific details regarding the number of points per home electronics task and the time periods designated for home electronics tasks.

a. The TV display shall be a minimum of 19 in. (48.3 cm) according to the manufacturer's stated display size. The computer display shall be a minimum of 17 in. (43.2 cm) according to the manufacturer's stated display size. The computer may be a laptop or desktop computer. The TV and computer displays shall be able to be operated simultaneously and controlled independently of each other.

b. The organizers will supply content that must be shown on the TV display during the home electronics tasks. On the Yahoo Group, the team shall declare its desired format for the supplied content. There is no required volume setting, but the brightness of the display shall be set to at least 75% of maximum. Observers will conduct spot checks to verify that the TV is showing the supplied content and that the brightness is at the required level.

c. The organizers will supply content that must be shown on the computer display during the scored periods. On the Yahoo Group, the team shall declare its desired format for the supplied content. A decathlete may temporarily suspend the supplied content to use the computer for other practical purposes, but the playing of supplied content shall be resumed whenever the computer is not being used for other practical purposes. The brightness of the display shall be set to at least 75% of maximum. Observers will conduct spot checks to verify that the computer is either showing the supplied content or is being used by a decathlete, and that the brightness is at the required level.

9-5. Movie Night

Each team shall host a movie night for its neighbors during contest week. See Appendix A-3 for the movie night schedule and the number of available points for movie night. Each guest team shall assign a score to each host team after the movie. The quality and design of the home theater system, ambiance, and overall experience shall be considered in the evaluation.

a. To maintain consistency among the juried contests and subcontests, guest teams shall use the scoring methodology described in the "Phase 3: Deliberation" section of Appendix B-1. Each of the three guest teams shall submit three percentage integer scores, i.e., one score for the quality and design of the home theater system, one score for ambiance, and one score for overall experience, to the contest officials by 10 p.m. These nine scores will be averaged and multiplied by the maximum available points in the scoring server to generate a final score for movie night. Percentage integer scores may range from 0% (lowest possible score) to 100% (highest possible score).

b. The village will be organized into five small "neighborhoods." Each neighborhood consists of four neighboring houses. One or more decathletes from each neighboring house shall spend at least 15 minutes during the movie in each of their neighbors' houses.

c. The Comfort Zone Contest is suspended during movie night. Therefore, the occupancy rule, rule 11-1, is not in effect on movie night.

d. Whereas take-out and prepared over-the-counter food items are permitted to be served as snacks, movie night guests are encouraged to assign higher scores to teams that use fresh ingredients to prepare the snacks and those that prepare and cook the snacks entirely in the house.

e. Prior to the event, team members signed up for the Yahoo Group will have the option to vote for one of three movies selected by the organizers. The movie receiving the most votes shall be provided by the organizers on the day of movie night and shall be the movie shown in all houses on movie night. The selected movie shall be available in several of the most popular video formats, so that each team may request the format most suitable for its home theater system.

f. The audio/visual equipment settings to be used on movie night shall be declared to a designated organizer prior to movie night. Observers or a small team of organizers, or both, will verify that these settings are maintained on movie night. Guests are encouraged to evaluate the usability of the home theater system and its controls, but the host team is responsible for returning the equipment back to the declared settings after the guests have finished their evaluation(s).

APPENDIX B: Architecture and Market Appeal Feedback from the Solar Decathlon juries

New Zealand

ARCHITECTURE

	CONTEST CRITERIA	APPROACH 0-60%	EQUALS 61-80%	EXCEEDS 81-90%	ECLIPSES 91-100%	POINTS /100	OBSERVATIONS/COMMENTS
A.	**DESIGN & IMPLEMENTATION**						
1	Was the team effective in its use of architectural elements including, but not limited to:						
	Scale and proportion of room and façade features				X		Interior layout and parti strong. Interior and Exterior language consistent. Solar panels could be better integrated with exterior butterfly roof form.
	Indoor/outdoor connections				X		Harmonious blending. Strategially open.
	Composition				X		Parti consistent and strong
	Linking of various home elements				X		Good job on having spaces feel private, yet open. Lots of flexibility in small compoents.
2	Did the team create a holistic design that will be comfortable for occupants and compatible with the surrounding environment?				X		Great job. Built in sleeping area throughfully executed.
3	Lighting						
	Are the lighted spaces rich and varied?				X		lovely in general. Some harsh. Bookcase lighting very nice touch.
	Do they have adequate light for tasks?			X			appreciate idea of lighting power density, but some spaces verging on dark. (kitchen, bathroom, and closet)
	Do they have good color rendition?				X		consistent with warmth of house
	Do the luminaires properly distribute light?			X			wonderful custom fixture, but hard glare. A lens at bottom could help
	Is the admission of direct and diffuse sunlight effectively controlled?			X			Additional window to sleeping area would have been beneficial. Missed oppurtunity to incorporate ventilation into skylight. Very nice varying levels of daylighting for drama.
4	Will the overall architectural design offer a sense of inspiration and delight to Solar Decathlon visitors?				X		Strong, harmonious, accessible design
B.	DOCUMENTATION						
1	Did the drawings, construction specifications, and audiovisual architecture presentation enable the jury to conduct a preliminary evaluation of the design prior to its arrival at the competition site?				X		Video well done.
2	Did the drawings, construction specifications, and audiovisual architecture presentation accurately reflect the constructed project as assembled on the competition site?			X			
Total						95	

ADDITIONAL COMMENTS

Overall, this is stunning house that is inspiring and functional. The attention to detail was thoughtful and thorough. Plan organization very strong and unique. High quality materials and surfaces that beg to be touched with an emphasis on warm, natural, and organic materials. The clothes drying chamber is interesting and unique.

New Zealand

MARKET APPEAL

	CONTEST CRITERIA	TEAM SCORE: APPROACH 0-60%	EQUALS 61-80%	EXCEEDS 81-90%	ECLIPSES 91-100%	POINTS /100	OBSERVATIONS/COMMENTS
A.	**LIVABILITY**						
1	Is the operation of the house's lighting, entertainment, and other controls intuitive?				X		Switches for shades and lighting were intuitive and very functional. Operation of shades was smooth.
2	Does the design offer the occupant(s) a safe, functional, convenient, comfortable, and enjoyable place to live				X		It was compact but the social areas were outstanding. The house was very approachable. The way the living area accomodated multiple guests made it very comfortable for this second home application. The kitchen offered a lot of functionality for a small space. There was adequate storage. The bathroom was functional and enjoyable. The laundry drying area was unique but might not be functional for a full laundry load. The living room and bedroom were a bit dark.
3	Are the unique needs and desires of the target client met by the design?				X		The way this house took into account the indoor-outdoor lifestyle of this target market was outstanding.
B.	**MARKETABILITY**						
1	Does the house demonstrate curb appeal, interior appeal, and quality craftsmanship?				X		This house demonstated extraordinary curb appeal. The central gathering space that welcomes the vacationer was breathtaking. The combination of the skylight over the table and special light fixture that reflected the culture stood out. The quality of the finishes and the craftsmanship were top notch.
2	Do the house's sustainability features and strategies make a positive contribution to its marketability?				X		Sustainability features including wool insulation, reclaimed wood flooring and wall covering, made a strong contribution to its marketablity, showing a deep respect for nature.
3	Does the house offer a good value to potential homebuyers?				X		Whereas this house has a high pricepoint, the quality of the design and execution and the materials used make this house a good value for the target market.
C.	**BUILDABILITY**						
1	Are the drawings and construction specifications of sufficient quality and detail to enable a contractor to generate an accurate, detailed construction cost estimate?			X			A few design details were omitted from the plans and specs. For example, the lighting fixture were not called out. Structural drawings were not drawn to scale.
2	Are the drawings and construction specifications of sufficient quality and detail to enable a contractor to construct the building as the design team intended it to be built?			X			Built-ins did not include shop drawings. Exterior trim was elegant and well executed, but lacked accurate detailed drawings to execute.
3	Are all the house's materials and equipment commercially available, such that the house can be immediately built in the private sector?				X		There was very good use of local materials including recycled rimu, and as such there was good local availability of materials. Modularity adds to this home's buildability. Recycled wool is locally available, as is the radiata pine.
Total						93	

APPENDIX C: Post Frank Kitts Park Analysis Package

meridian

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

Frank Kitts Park Media Analysis

1.0 Visitation:

Display Period (General Public):

- 7th May – 24th May, 18 Days, 93 hours.
- Approximately 9000 brochures distributed.
- Estimated 20,000 + visitors.
- 27th April – 15th June, 50 Days – Entire site period
- Over 40 recorded expressions of interest for purchase
- 180 guests for the opening night

Special Visits (Public Sector):

- Department of Housing and Building Delegation (DHB)
- US embassy delegation including, US Ambassador to New Zealand David Huebner
- German ambassador: H.E Thomas Meister
- Canadian ambassador: H.E Caroline Chretien
- French Senators: Marcel Deneux & Catherine Morin-Desailly
- Mayor Celia Wade Brown
- Charles Chauvel (MP)
- Hon Dr. Nick Smith (MP)
- Chester Burrows (MP)
- Chris Hipkins (MP)
- Mike Underhill (CEO of EECA)
- Tim Lusk (CEO of Meridian)

Special Visits (Education):

- Whitireia Polytech: 75 Students
- Sustainable Architecture Students
- School Groups: 500+ Students (Ages 5-14)

Sponsors Groups:

- 18 individual sponsor groups over two days.
- 19 company displays

CPD (Continued Professional Development)

- Architects were accredited CPD points through the visitation of the First Light House on Frank Kitts Park

FIRST LIGHT NZ

2.0 Web Impressions (Apr 26 – May 26):

Website:

- 12,014 visits, 37,277 page views, 44.61% bounce rate.
- 8726 Unique visitors

Facebook:

- Total of 4202 page visits
- 1145 page 'likes' (30% growth rate).
- Monthly active user rates consistently above 2000

Youtube:

- Total upload views of 11,000
- Combined views of 6300 on Meridian First Light Flythrough Video (Since Mar 2011)
- 1000+ views of assembly sequence since launch

3.0 Media

25/4/11 – 2/5/11

- "Bright Future for Vic Students' Solar House" – Salient – 2/05/11
- "Solar-powered Bach On Show At Wellington Waterfront" – Voxy.co.nz – 2/05/11
- "Teamwork builds solar bach for global comp" – Education review – 01/05/11
- "S&T proud to support the NZ First Light Solar Decathlon Team" – stephensonturner.com – May 2011
- "Meridian First Light house" – Leap Australasia Limited – 2/05/11
- "VUW students' solar-powered house attracts Meridian as a sponsor" – scoop.co.nz – 28/04/11
- "A new burst of energy for Victoria's Solar Decathlon team" – meridianenergy.co.nz – 28/04/11
- "A new burst of energy for Victoria's Solar Decathlon team" – campusdaily.co.nz – 28/04/11
- "First Light house nears completion and gets set for Wellington debut" – Design Daily – 26/04/11
- "Meridian First Light house – Solar Powered Bach in Action" – viewwellington.co.nz
- "Meridian First Light house – Solar Powered Bach in Action" – Grown ups.co.nz
- "Meridian First Light House – Solar Powered Bach In Action" – eventfinder.co.nz

- “Meridian First Light house – on display” – WellingtonNZ.com
- “First Light house – A Solar Powered Bach in Action” – NZ 2011

3/5/11 – 10/5/11

- “Sunshine house draws wet weather crowds” – Taranaki Daily News – 09/05/11
- “Solar So Good” – Live Magazine – May 2011 p.1 p.2 p.3
- “Students’ solar bach becomes hot property” – Dominion Post – 09/05/11
- “Solar bach becomes hot property” – Stuff.co.nz – 09/05/11
- “Eco-bach” Radio NZ – Chris Laidlaw – 08/05/11
- “Solar –powered bach to showcase overseas” – One News – 07/05/11 Click here to watch
- “Kiwi bach headed for the US” – Marlborough Express – 06/05/11
- “Visit Kiwi bach in middle of Wellington City” – NewsWire.co.nz – 06/05/11
- “First Light NZ to compete internationally” – sustainablefuture – 06/05/11
- “Solar bach” – Radio NZ – Our Changing World – 05/05/11
- “LEAP proud to supply the First Light house” – Master Plumbers E News – 05/05/11
- “On the Rise” – Idealog – May 2011
- “Light House in the Park” – Capital Times – 04/05/11
- “Meridian First Light eco-house shows way forward for NZ homes” – eeca.govt.nz – 04/05/11
- “Solar powered – a Kiwi bach like no other” – Dominion Post – 03/05/11
- “Everything under the sun” – Dominion Post – 3/05/11
- “Solar-powered House” – Absolutely Positively Wellington – 03/05/11

11/5/11 -18/5/11

- “We’re sending a Green House to the White House” – Dominion Post – 18/05/11
- “Solar bach drawing the crowds” – Manawatu Standard – 17/05/11
- “Cool Concept” – Gisborne Herald – 14/05/11
- “Meridian First Light house” – Productspec Newsletter – 11/05/11

- “Solar-powered bach” – Northern Advocate – 11/05/11
- “Kiwi’s bank on bach” – Independent Herald – 11/05/11
- “Kiwi’s bank on bach” – Cook Straight News – 11/05/11
- “Solar-powered bach now open” – NZ Herald – 11/05/11

19/5/11 – 30/5/11

- “Tommy Honey – Urbanist” – Radio NZ – 30/05/11
- “The Meridian First Light House, Solar Decathlon / Team Victoria University of Wellington” International Business Times – 27/05/11
- “The Meridian First Light House, Solar Decathlon / Team Victoria University of Wellington” – Arch Daily – 27/05/11
- “Solar Decathlon Design Places People and the Outdoors at its Heart” – Energy.gov – 26/05/11
- “The humble Kiwi bach goes high-tech” – Good – 25/05/11
- “’First Light’ house pulls the crowds” – NZ Herald – 25/05/11
- “Putting a clean technology Kiwi bach on the world stage” – Victorious – Autumn 2011
- “Speed is of the essence as First Light house makes its Wellington debut” – Design Daily – 20/05/11
- “You. Me. Free solar coffee” – Dominion Post – 20.05.11
- “Free Solar coffee with Jeremy Wells” – Dominion Post – 19/05/11

4.0 Additional Exposure

Frank Kitts Park Signage:

- 4 large fixed signs (1200 x 1800) located around FKP site
- 2 smaller semi permanent signs (1200 x 900)

Wellington Airport Display:

- Permanent fixed display and digital component.
- 6th - 25th May: 20 days.
- Peak visitor flows of up to 2000 an hour.

APPENDIX D: 40m2 pour 4 et un chien – Côté Maison blog site discussing minimum living requirements

40m² pour 4 et un chien

http://www.cotemaison.fr/maison-reve/atelier-loft/diaporama/40-m2-pour-4-et-un-chien_4507.html

Le réfrigérateur est caché derrière une porte située le long des marches sur la droite. Ces marches mènent à la chambre des enfants, au coin douche et aux toilettes. Au premier plan, le bureau de Cyril (chaise Arne Jacobsen), sous lequel est installé le coin de Scott, le chien. Au fond, le salon composé d'une capsule sous laquelle se glisse le lit du couple.

Dans la capsule qui loge la chambre des enfants et la douche, une alcôve abrite le canapé sous lequel est glissé le lit du couple. Entièrement revêtue de skaï, cette niche est protégée des bruits de la chambre des enfants. Au-dessus, le projecteur vidéo " le point noir que l'on aperçoit " qui se commande à distance, projette des films sur un écran qui se déroule sur le mur d'en face. La table (design Gaëtane Raguet) et les deux fauteuils vintage des années 60 viennent de la boutique 1961.

Tous les murs abritent des rangements, comme ici dans la cuisine. Pas de poignées: placards et tiroirs s'ouvrent d'une simple pression.

A family of four and their dog live in this tiny, all-white apartment. Located in the Marais district of Paris, the space measures 40 meters squared, or about 431 square feet.

Every imaginable place has concealed storage, including stairs with drawers used to store shoes and bags. Each living space has multiple uses: the living and dining room also serve as the master bedroom, complete with a Murphy bed. Almost every item is hidden, including the fridge, to keep the clean, white design of the space as open as possible.

The children, aged 8 and 11, sleep on a bunk bed and keep their toys in hidden cupboards. The dog is a big, black Labrador named Scott who photographs very well in the white apartment.

The father, Cyril Aouizerate, lived in this space alone before having a family. He bravely turned it into a home for his family of four and a dog! Aouizerate says his home happily reminds him of an astronaut's space ship.

Aucune place perdue : les marches menant à la mezzanine sont des tiroirs pour ranger les couverts, les chaussures et les sacs poubelle. Là aussi, elles s'ouvrent d'une simple pression.

Magique: avec ce système de coffres dans le sol de la chambre des enfants, non seulement c'est la fin du capharnaüm, mais c'est pour les bambins un bonheur de ranger. Sur la gauche, la ventouse bleue (BHV) permet d'ouvrir la trappe.

Sur le palier, en haut des trois marches, deux portes mènent à la chambre des enfants, avec leur lit en mezzanine, (création Jessica Label). Une cloison coulissante (la seule de l'appartement) installée sur des rails permet de séparer la pièce en cas de conflit.

FALLOUT FROM 40m2 pour 4 et un chien:

I don't know if I could do it (I need private space), but this is one of the best small apartments I have seen. I hate white, but it seems to do OK in this setting.
A few years back, I was offered a job in Paris (which fell through) and the apartments they were showing me were 10 sq meters. I guess this is kind of normal there?
I start to get comfy around 650 sq ft or so... posted by **Jason** on April 30th 2009 at 9:12am

They must have a summer home, I don't believe anybody could live like that year round. How would you entertain?
posted by **sdnyc** on April 30th 2009 at 9:17am

Well, I doubt everyone feels the need to entertain - we have people over for dinner occasionally but that just involves a table and chairs - LOL.
I do find this unbelievable - I feel sorry for the children since they barely have anywhere to play and weather is not always willing for them to be outside. In the US, the children would be taken.
posted by **ChrisGal** on April 30th 2009 at 9:29am

Living in a super small space seems fun until kids get involved. Then I feel like it might be kind of cruel to them?
posted by **kiljoywashere** on April 30th 2009 at 9:35am

431 square feet is roughly a space 21'x21'. I find it difficult to believe that a family of four plus Labrador are living in a space that small, no matter how well engineered it is. The children's "room" has no exterior windows while the dining table only has three chairs for a family of four. This is their city apartment and they actually live elsewhere.
posted by **John H** on April 30th 2009 at 9:45am

Families of four can and do live full time in apartments this size in big cities. I just moved out of an apartment building where all the apartments were around 400-450 square feet. There was one family of four with two young kids (maybe 4 and 6 years old) living in a single bedroom apartment. I always wondered how they set it up to work for them.
posted by **home body** on April 30th 2009 at 10:26am

The US-dwellers' lack of awareness is mind blowing. Child cruelty, or they must have a summer house because people can't live like this? Wow. In Europe we lived in a studio apartment until my baby sister was two, and then in a one-bedroom well into secondary school. There was no choice, it never occurred to us that it would be cruel, and believe me none of these places were as well-planned an luxurious as this. And we still had it much better than many third worlds families of 12. Perspective, people.
posted by **wally3** on April 30th 2009 at 11:13am

The idea that everyone in the family needs their own personal room seems to be a very American one. I think it's great that a family of four has found a way to inhabit such a compact space and make it work for them. I shared a small room with my siblings growing up and I would hardly call it cruel.
posted by **MrsMittens** on April 30th 2009 at 11:23am

To all the commenters who doubt this is their main home, just for the record:

When I was a kid, my parents, by brother and I lived in a 40 sq. meters apartment in Eastern Europe. That was typical; that was a common size of an apartment for a family of four. One can say that people had to do without a lot of basic necessities living in the Communist bloc, and while this is certainly true, and while I remember wishing for Levi's jeans and good sneakers when I was little, we were all perfectly happy with our apartment. Now, looking back at it, I'm really starting to appreciate the ingenuity my parents put into making the apartment not only livable, but also lovely.

And we weren't even in Paris, and the outside wasn't nearly as nice.

Oh, and my parents "entertained", too - sometimes having a dozen people over for dinner. They just folded up their bed and unfolded a large table in the middle of the "living room".

I think I'm almost offended by the comments saying that this is cruel for children. A 40-sw-mt apartment is perfectly fine - it's the love and care and ingenuity you put into making the place work that really matters.

posted by **flipper** on April 30th 2009 at 11:27am

I agree that the comments about being cruel to children are offensive. It's very US-centric of us to fetishize space and waste. It's that kind of thinking that have gotten us into this mess of an environment in the first place.

I think this space is clever, efficient, warm, beautiful and full of love. Kudos!

posted by **mariss** on April 30th 2009 at 11:47am

saying this space would be cruel to children is insulting. Give your head a shake.
I'm not crazy about the aesthetics of this place but I love all the hidden storage.

posted by **truenic** on April 30th 2009 at 11:57am

I grew up in Eastern Europe too, four people in 42 square meters. I played in the living room (and sometimes in the bathroom) and we were all very happy together.
Children are smaller people and really like smaller spaces. Like under the table or something:)
The small space taught me to be naturally tidy.
Looking back, I cannot imagine how we fit in the apartment (on today’s standards) but it was great back then.
Oh, and my parents entertained too.
We had an expanding couch, a folding table and a folding bed in the kitchen.

posted by **mihaela** on April 30th 2009 at 12:30pm

One thing commenters haven't (yet) mentioned is that Paris is *extremely* expensive. I live in the next-most-expensive French city for real estate, which is Nice and surroundings. I have several friends with families of 4 who live in 50 to 60sq.m apartments (about 500-600 sq.ft) and who were overjoyed to be able to afford them. I myself am extremely lucky to have a 45sq.m (450sq.ft) apartment all to myself (got it for 115K, usually they start at 160K), when this size is considered good for couples or families of three. It's considered a luxury to be able to purchase anything 75sq.m (750 sq.ft) or more; they start at about 500-600K.

It's so odd when single family members back in the US complain about not having enough room in their 1,000 sq.ft places... I never know what to say. 450 sq.ft feels huge to me. With 4 people it would be cramped, but definitely doable if I were as creative as this man!

posted by **fraise** on April 30th 2009 at 2:41pm

to continue the "cruel" conversation:
I have seen so many small American families (2 kids tops)
rolling around in huge, sterile, boring homes.
now that's cruel.

posted by **baba yaga** on April 30th 2009 at 3:54pm

A lot was said, but I will add to it. I am also from Eastern Europe, where basically all apartments were small. We were really lucky - we had the biggest apartment that we could possible had in the so called "modern buildings" - 72m2. That is with 3bedrooms.... You can imagine how small the bedrooms were. I was lucky that I had my own room (since my brother went to school and it was decided he needed his own room). it was tiny - a queen bed would not fit, only narrow twin, some closets and desk. that's it...

And anyway - were weren't even spending that much time inside. Everyday after school we were out for a few hours running around the neighborhood, running bikes, playing ball... then coming back to do homework and so on.

My neighbors were family of four. they lived in 1 bedroom apt, about 45m2. They lived there happily for almost 30 years... at one moment one of the daughters had a baby, so they lived in living room bedroom, 4 adults baby.... And I think these were the most wonderful people, very good, decent and loving. They entertained, having often family over for home-cooked goodies. The home was very well organized, always perfectly clean. The family each day had to clean the beds (put away all bedding) as they had sofa-beds. It's doable... And I am not even talking about families who live for very long time in one room, sometimes dozen of people. It's not cruelty. It's life.

posted by **Offtza** on April 30th 2009 at 7:36pm

I think the biggest thing with children is in some states, if a room does not have a window, it is not a bedroom. So a lot of these folks who cram their children in would definitely get into some huge trouble. I know in Indiana there has to be so many square feet per person.

posted by **ChrisGal** on May 1st 2009 at 6:29am

I may not know a ton about France - mostly since it's a place I have never been and am not sure I want to go if they toss money this easily. But yes, if I had two children, no matter where I lived, I would find somewhere suitable to fit everyone. At the very least somewhere I could afford two bedrooms. It's common sense - children do have to play indoors at least a third of the time and like this they have no where to. Plus they don't even have a dining table to fit all four people in the family. I thought the point of a dining table was so the family could SIT DOWN TOGETHER and eat.

JosieDaisy - the usual requirement per person in the US is 150 sq feet apiece, which is law. So unless they could pull another 170 sq feet out of their butt, the children would either be removed or they would be forced to move.

posted by **ChrisGal** on May 3rd 2009 at 6:28am

The apartment is beautiful and a wonderful use of space. And in the Marais - what an amazing location! I think it would be my first choice in Paris.

There are no national US laws pertaining to "Sq feet apiece". There are certainly no roving bands of abductors pulling children from small homes. If that were the case, most of the large families in New York and Boston would have been broken up years ago.

I don't know if I should encourage ChrisGal to get out of Indiana for her own education, or to remain forever in Indiana, in order to prevent the perpetuation of the "Ugly American Tourist" stereotype.

posted by **MsLorie** on May 3rd 2009 at 9:14am

I think this is a fascinating discussion: what amount of square footage per person is considered "normal" or "legal" in the U.S. My father grew up in the U.S. In New York City. He and his brother and sister lived in a 1 bedroom apartment that was roughly 500 square feet. Everyone had enough to eat, was loved, played a LOT (indoors and out) no one was mentally maimed by this situation and each child lived there until he or she got married or moved out. I would caution people not to be classist. "normal" or "correct" should not be associated with what you have, it should correlate to how you treat other people.

posted by **videonerdann** on May 3rd 2009 at 5:32pm

This space is brilliant and I would say the size really contributes to their familial closeness and interaction. This is a much healthier way to live than in a massive McMansion.

I currently live in a one bedroom apartment with my husband and our two children (2 and half years and 9 months). We moved into this 300 sq ft space two months ago from a sprawling 3 bedroom apartment and I have found the shift to be radically life altering in the best of ways. I will never live in a big space again and when I come to build my own home I will do it with tiny in mind. It's the key to family cohesion and intimacy.

I love to cook and spend alot of time in the kitchen, my husband is a DJ and spends a lot of time on the computer and with his gear. We continue to pursue our interests invidually but now we do it in the same space (kitchen, living, dining and office is militarily arranged in the one room while we have a queen bed, a small child's bed and a cot in the bedroom). There is much more togetherness living like this and that is priceless for any family in any environment!

We live in 5 minutes walk from the beach in the Caribbean. My point being that for us, like the family in Paris, life is as much about accessing your environment and community as it is about spending time indoors. Living tiny makes for a much more balanced lifestyle, it leaves a much smaller footprint both in terms of energy use and consumption (eg no space for storing heaps of junk therefore stop buying it) AND it only takes 10 minutes for two people to do a cleanup (1 hour for a deep clean including mopping and the bathroom!!)

I recommend it to anyone and everyone - particularly those people who think that this is cruel to children and pets.

posted by **looboo** on May 3rd 2009 at 7:43pm

oh the american obsession with private space. . .

The Europeans (and NYC'ers) truly understand that the city is an extension of the home. The neighborhood, (a true

neighborhood, not a bland american suburb), is a wonderful place to grow up.
it's a totally different mindset that someone from Indiana is not likely to grasp anytime soon.

posted by **jac7890** on May 3rd 2009 at 11:59pm

FYI

This is the New York City statute pertaining to minimum floor area per person in an apartment:

Sec. [D26-33.03] 27-2075 Maximum permitted occupancy
a. No dwelling unit shall be occupied by a greater number of persons than is permitted by this section.

(1) Every person occupying an apartment in a Class A or Class B multiple dwelling or in a tenant-occupied apartment in a one- or two-family dwelling shall have a liveable area of not less than 80 square feet. The maximum number of persons who may occupy any such apartment shall be determined by dividing the total liveable floor area of the apartment by 80 square feet. For every two persons who may lawfully occupy an apartment, one child under four may also reside therein, except that a child under four is permitted in an apartment lawfully occupied by one person. No residual floor area of less than 80 square feet shall be counted in determining the maximum permitted occupancy for such apartment. The floor area of a kitchen or kitchenette shall be included in measuring the total liveable floor area of an apartment but the floor area for private halls foyers, bathrooms or water closets shall be excluded.

There are addition NYC statutes defining minimum ceiling heights (8') and floor area (80 sq ft), windows, window locations, and window sizes.

It is notable that the Paris apartment would not comply with NYC statutes due to the children's bedroom lacking an exterior window, and may not comply with the minimum square footage per person ratio depending on the size of the bathroom, kitchen, and connecting hallway.

posted by **John H** on May 4th 2009 at 4:06pm

John H -

Ever wonder why these marvels of design appear in Europe and not the US? Because our building codes are also ameri-centric.

posted by **CPArch** on May 5th 2009 at 1:40pm

This is a beautiful apartment that makes great use of available space and light but the debate that it has sparked is almost as fascinating!

As a place to live, it exemplifies the point made elsewhere about the European lifestyle where the city itself is the extension of the home. Marais is only a few minutes walk to the Louvre, the Tuilleries Gardens, the Pompidou Centre - why have and pay for a 200sqft yard, overlooked and overshadowed, as it inevitably would be in a city, when you have those options on your doorstep? It's only a generation or two since whole families living in one or two rooms was commonplace, particularly in urban environments, so its interesting to see how our expectations of a home have changed in that time - what we now consider to be normal.

For example, the issue of raising children in a small home. By choosing to live in the city, these parents are probably within an easy commute to work, possibly even walking distance. Perhaps they are able to walk their kids to school, come home to make them lunch and dinner. They'll certainly have more time available for their children and for themselves in the evenings. On the weekends, they are within walking distance of any number of interesting places to take their children, in order that they might understand where they live, it's history and their own.

At a time, when suburban living has become the norm, where these suburbs are located in places only accessible by car, where we drop our children in daycare at 7.30am and don't see them again until bedtime, in order to commute for several hours at a time from our shiny, spacious, empty homes, what does it say about our expectations if we then regard the Marais option as unnatural and cruel?

And what about privacy? Well, privacy is easy to find if you can step outside your door and go sit for an hour in a cafe, or take a walk in the park or by the river or visit a museum or... The reason we've had to build it into our homes is because they are increasingly being built in places where there's nothing to do and nowhere to go.

This debate really strikes at the heart of the problems that we face at the moment about how and where we choose to live. As the question of how we heat and light those large suburban homes and how we fuel the multiple cars required to take us to and fro, becomes more pressing, I think that the options and limitations explored in this family home will become easier to understand.

posted by **living:room** on May 6th 2009 at 5:26am

This is a beautiful home! All space and materials should be used so well... and all environments should provide the opportunities outside the home apparently available in the Marais area of Paris.

As for the comments regarding building codes, zoning issues and local or state statutes requiring a certain amount of space per person in a dwelling unit, I don't believe there is a building code issue in any of the national model codes nor in any state building codes still in use. Any locality or state may have an ordinance or statute dealing with whatever is a perceived issue of too many occupants for too small of a dwelling unit, but that doesn't make it right. More effort should be exercised in changing laws that lead to consumption of more resources.

Taking a good look at the photos and axonometric drawing one can see there are two tables with chairs (in the kitchen and the living/dining/master bedroom area) and there is shared daylighting (if not a window) for the children's bedroom above the clever storage wall with built-in seating and pull-out bed. In most urban lofts in the US this daylighting solution is allowed for a sleeping area in lieu of a window and ventilation, and the normal egress window requirement is excepted for smaller spaces.

We do need to learn that less is more so we can be freer of the impositions of indebtedness. Please see/read: http://www.littlehouseonasmallplanet.com/ to get a new perspective on the "American Dream" paradigm.

posted by **brucej** on May 6th 2009 at 10:47am

I am watching my 6, 5 and 3 year old play in the front room of our small apartment in "urban" Nebraska. The authorities are in no hurry to come and get our children. They are not neglected, abused or forced to live in substandard housing. Why is a small space cruel? I'll admit at first I missed a back yard, and the excessive space, but I now enjoy the benefits of efficient living. The cost of living is affordable were we live but I don't need to make excuses to anybody about our living arrangements. Our midwest neighbors look at us strangely, even friends are curious as to how we make it work as if it's bizarre. I appreciate good design. The longer we live here, the more ideas we find to make it comfortable and surprisingly fuctional. Along with space comes "stuff," and the cost and time and worry to keep it all up. I don't miss this a bit -and we moved from a large house with a huge yard on the edge of town. The wonderful alternative to.... interior space?(and privacy??) is going out and doing things -we do so much more together with outings, parks, walks, cultural and social opportunities, etc. The only thing that would make it better is if our city didn't have such a bad case of sprawl, then we wouldn't have to be so car-dependent. Nevertheless, this apartment is a gem. Functionality and personal expression come together well, bravo!, bigger is not better.

posted by **kpope** on May 7th 2009 at 1:30pm

I grew up with 4 silblings in a very small older home in Texas. I never had my own bedroom or bathroom until after college. I usually shared a room with 2 other siblings and sometimes friends or cousins who would come stay with us as well. In comparison to my friends who grew up in a "traditional" American sense having their own bedroom, I think I have the advantage. These kids got to college and had to share tiny dorm rooms, etc. and were constantly stressed because they didn't know how to cope with someone else in their space. I flourished because I had gained the skills to respect others and live peacefully even if it seemed crowded. I think the size of a home does not matter to children at all as long as it is clean and happy and full of love.

Also in regard to certain size restriction laws in America, this is the explanation for this and before you chew me out for thinking I agree with them, let me assure you I don't agree, I just know how they work.

These laws are in place because many times illegal immigrants who come to the US will often live 15-20 people in a small 1 or 2 bedroom apartment because they can not legally get housing and this is their easiest option. I have personally seen a family of 16 people living in a 900 sq foot apartment.
So...the government uses this as a way to more easily monitor who is in the home and if they are legally allowed to reside there. Also many apartment complexes have allocated utilities where each apartment unit pays an equal share of utilities to the complex based on the size of the apartment. These will often do random inspections to make sure there are only a set number of people living in a certain space because it would seem to reason that 15 people living in a 2 bedroom apartment would use more resources than 2 people living in a 2 bedroom apartment.

Housing size is RARELY ever a factor when determining child neglect or abuse. Cleanliness and safety are generally the most examined. Worst case scenario a government agency would encourage the family to get a larger government aid house with more space, but would probably only do this if it was determined as a direct impact on the children.

Overall I think learning to manage living in closer spaces with family teaches children tolerance and vital social skills to adapt to new environments and to be comfortable and stress free in a variety of living situations.

posted by **poppyfieldrainbow** on February 21st 2010 at 10:48pm