ENGN2225 Individual Research Project Report

# Getting from A to B – A Systems Engineering Perspective

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# Contents

# Getting from A to B –
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## Abstract

A journey begins with an idea created from an action occurring. The initial meeting of a friend via Facebook (Facebook, n.d.) , Twitter (Twitter, n.d.) and social networking sites, is good for some communication, 'But when we communicate online, whether it's on Facebook or through email, or when we tweet or text, what's missing?' (Nogales, Oct 13, 2010). A real face to face meeting can provide much more of a human connection. Thus the journey plan begins.

This journey could be a few paces to the neighbour, or a vast distance across the other side of the planet Earth, or a meeting between comet 67P/Churyumov-Gerasimneko and ESA Rosetta 404,523,422 km from Earth. (ESA, 6 August 2104).

The journey begins with an idea, and the final goal of the customer and the systems engineer is the same, but getting from A to B from a customer's perspective differs vastly from a systems engineering perspective. The customers visualises a straight line, the shortest distance between two points, as the crows flies (Martin, 1995), the Systems Engineer sees the real connection 'kinks' along the journey.

This report provides a systems based approach on providing a solution to the customer, based on both the customers' criteria and analysing the 'kinks' along the way.


## Introduction

An objective of a customer to go from A to B is safely, arrive on time, travel in comfort, with scenic views and as environmentally as possible. These must be taking into account from a Systems Engineering perspective when developing a solution for the customer.

The description of a straight line does not always state obstacles, including bridges, roads, water crossing, diversions, or method of travel. These must be considered when providing a suitable solution, as well as allow for changes that may occur last minute, such as a diversion form the straight line, but have remainder criteria met.

The primary aim of the solution is to complete the journey from A to B as specified by the customer's requirement.

# Problem Scoping

## System Boundaries

To define the boundaries in which the project will operate, a system boundaries is shown in Table 1. These support and set apart which elements and influencing factors we are able to directly control (included), will have to take note of (excluded), and maybe irrelevant (outside).

*Table 1. System Boundaries*

| Included (Endogenous) | Excluded (Exogenous) | Outside |
|---|---|---|
| ➢ Travel Method | ➢ Travel method emissions | ➢ Traffic congestion |
| ➢ Route taken | ➢ Travel space | ➢ Fuel use |
| | ➢ Road works | ➢ Weather |
| | ➢ Travel noise | |

## Client Requirements

The client requested the following conditions be met for their getting them from A to B:

- ✓ Safe
- ✓ On Time
- ✓ Comfortable Travel
- ✓ Scenery of Travel
- ✓ Environmentally Friendly

## Design Requirements

The design requirements of the solution were abstracted from the given client requirements and set as Engineering units, to utilise and measure the matching and overall accuracy for the client requirements. (Table 2). Comfortable travel is important to the client's requirements, but is difficult to measure objectively. (Program, n.d.) Page 101, thus a cubic space method is used.

*Table 2. Design Requirements*

| | | | |
|---|---|---|---|
| **Customer Requirement:** | **Safe** | **Metric** | **Direction** |
| Design requirement: | Least chance of injury | % | ↑ |
| **Customer Requirement:** | **On Time** | **Metric** | **Direction** |
| Design requirement: | Reliability of travel method | % | ↑ |
| **Customer Requirement:** | **Comfortable Travel** | **Metric** | **Direction** |
| Design requirement: | Space capacity per person | $m^3$ | ↑ |
| **Customer Requirement:** | **Scenery of Travel** | **Metric** | **Direction** |
| Design requirement: | Route taken | km | ↓ |
| **Customer Requirement:** | **Environmentally Friendly** | **Metric** | **Direction** |
| Design requirement: | Low carbon footprint | $CO_2e$ | ↓ |

## Requirements Analysis

The methods of pairwise analysis (PA) and house of quality (HoQ) is applied to the design requirements in to provide a clearer picture of design priorities which the client has specified.

### Pairwise Analysis

A pairwise analysis of the client's design requirements for a getting from A to B is shown in Table 4.

*Table 4. Pairwise analysis of design requirements.*

| | Safe | On Time | Comfortable Travel | Scenery of Travel | Environmentally | Sum | Rank |
|---|---|---|---|---|---|---|---|
| Safe | | 1 | 1 | 1 | 1 | 4 | **1** |
| On Time | 0 | | 1 | 1 | 1 | 3 | **2** |
| Comfortable Travel | 0 | 0 | | 1 | 1 | 2 | **3** |
| Scenery of Travel | 0 | 0 | 0 | | 1 | 1 | **4** |
| Environmentally Friendly | 0 | 0 | 0 | 0 | | 0 | **5** |

### House of Quality

A house of quality is used to visualise interactions and relationships between client requirements and engineering characteristics, and identifies complements and clashes between the requirements and ECs, highlighting areas where improvement is beneficial, or places where trade-offs need to be made as shown in Table 5.

*Table 5. House of quality.*

| | Relative Importance | Least chance of injury | Reliability of travel method | Space capacity per person | Route taken | Low carbon footprint |
|---|---|---|---|---|---|---|
| Safe | 1 | 9 | 3 | | 5 | |
| On Time | 2 | 5 | 9 | | 5 | |
| Comfortable Travel | 3 | | | 9 | | |
| Scenery of Travel | 4 | 5 | | | 5 | |
| Environmentally Friendly | 5 | | 5 | | 5 | 5 |
| | Direction | ↑ | ↑ | ↑ | ↑ | ↓ |
| | TPM | % | % | $m^3$ | km | $CO_2e$ |

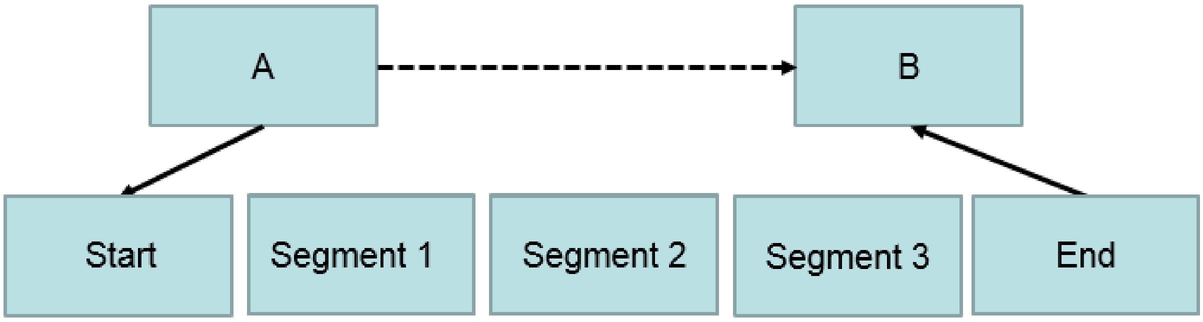
There are several engineering characteristics which can be deemed important to the satisfaction of client design requirements.  The safe method of travel is strongly related to least change of injury and medium to the route taken. The on time requirement is strongly related to reliability of travel. The scenery of travel is medium related to the least chance of injury with the route taken. Comfortable travel is strongly related to the space available for the client.

# Logic and Function

## Functional Analysis

To show individual steps of a system engineered solution a Functional Flow-Block Diagram (FFBD) is shown in Figure 1. This describes and identifies individual steps in the system which will then clarify what methods are required to complete the journey. The diagram shows how journey can be segmented into steps to allow for maximum matching of customer requirements.

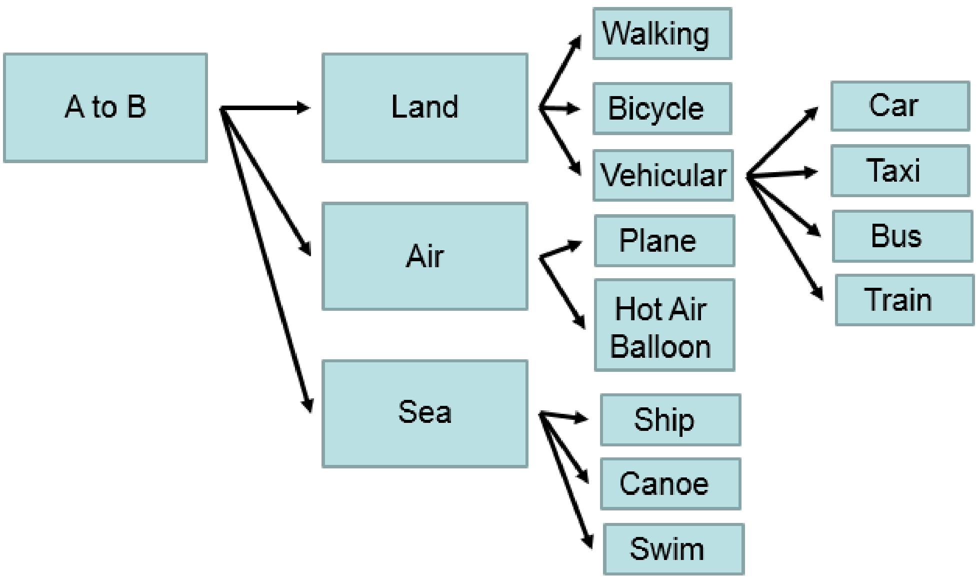
*Figure 1. Functional Flow Block Diagram*




## Concept Generation

A concept generation tree shows possible solutions for each step of the journey in Figure 2, considering all possible solutions for the travel method.

*Figure 2. Concept tree for each travel method*



As can be seen, there are three main methods of travel, with each method of travel broken down into possible methods on how to travel in that category.

## Subsystem Integration

### Functional Allocation

The functional flow block diagram showed that the travel is segmented. Each of the segments can be made into subsystems to clarify and explore the travel methods to best match the client's requirements. Table 5 shows that the subsystem is the leg of each journey, indication effective method of travel.

*Table 5. Subsystems and main sub-functions*

| Subsystem | Sub-Functions |
|---|---|
| Weston - Civic | Walking, Bicycle, Vehicular |
| Civic - Sydney | Walking, Bicycle, Vehicular, Plane, Hot Air Balloon |
| Sydney - Auckland | Swimming, Canoe, Ship, Plane, Hot Air Balloon |
| Auckland - Parnell | Walking, Vehicular |

In separating each leg of the journey, each subsystem can be analysed and developed independently, resulting in a system that is tailored more specifically to customer requirements. It also allows us to segment and insulate each subsystem against external variables such that only a few major events will affect the internal workings of a subsystem.

We see from the concept generation that each leg is limited by method of travel. These are based on the environment on where each leg of the journey takes place.

By listing each of the travel methods, some can be eliminated by not complying with the client's requirements, as shown in Table 6.

*Table 6. Sub-functions and clients travel requirements*

| Sub-Functions | Safety | On Time | Comfortable | Scenery | Environment Friendly |
|---|---|---|---|---|---|
| Walking | Low | No | No | Yes | Yes |
| Airplane | High | Yes | No | No | No |
| Vehicle - Taxi | Medium | Yes | Yes | No | Yes |
| Vehicle - Car | Medium | No | Yes | Yes | Yes |
| Vehicle - Bus | Medium | Yes | Yes | Yes | Yes |
| Hot Air Balloon | Low | No | No | Yes | Yes |
| Train | Medium | Yes | Yes | Yes | Yes |
| Ship | Medium | Yes | Yes | Yes | Yes |
| Swimming | Low | No | No | No | Yes |
| Canoe | Low | No | No | Yes | Yes |
| Bicycle | Low | No | No | Yes | Yes |

Travelling by Airplane is the safest method of travel, (Loewenttheil, 2013). Walking is great for the environment, Ship is has safety, comfort, scenery (Grosjean), 2009). Coach travel is very comfortable and on time (Coaches, 2015), however each has its limitations to meet the client's requirements.

By referring to the client's requirements, Table 7 creates a method of travel most closely related to each of the criteria

*Table 7. Reduced travel vs clients requirements*

| Sub-Functions | Safety | On Time | Comfortable | Scenery | Environment Friendly |
|---|---|---|---|---|---|
| Airplane | High | Yes | No | No | No |
| Vehicle - Taxi | Medium | Yes | Yes | No | Yes |
| Vehicle - Bus | Medium | Yes | Yes | Yes | Yes |
| Train | Medium | Yes | Yes | Yes | Yes |
| Ship | Medium | Yes | Yes | Yes | Yes |

With continuing discussion with the client, the sub-function airplane travel was eliminated, as it failed to comply with all but one requirement.

### Requirements Mapping

With the analysis obtained in the functional allocation, Table 8 shows how the customer's journey legs can be segmented in each travel method.

*Table 8. Requirements and customer journey travel methods*

| Subsystem | Sub-Functions |
|---|---|
| Weston - Civic | Vehicle - Taxi |
| Civic - Sydney | Bus |
| Sydney - Auckland | Ship |
| Auckland - Parnell | Bus |

The options for the travel are based on most suited for the customer requirements.

## Life-Cycle Phases

The life-cycle phase for the clients getting from A to B is from the start of the journey till the end, as then its goal is reached. Feedback after the conclusion of the journey can then be used to gauge the satisfaction of the client's, with the utilization of changing the system engineering analysis.

## Testing and Communication

### Testing and verification

To judge whether the suggested solution is correct, a survey can be done before and after the customer's journey. These can then be used to improve and expand on future solution of similar customer criteria. (Suttle, 2015)

### Design communication

A presentation to the client will display the customer's requirement and a developed story for a plausible solution.

## Conclusion

Getting from A to B from a client's perspective, is often perceived as being a simple straight line. The client then specifies requirements which complicate this method of perception, creating kinks along the way.

From the Systems Engineering perspective, a system of practices are applied with converting the kinks to tangible, smaller straight lines, meeting all of the client specific requirements, and providing a successful outcome.

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