Improving the Accessibility and Efficiency of the Referral System from General Practitioners to Specialist Doctors in Australia

ENGN2225
Systems Engineering Design
Individual Portfolio

Australian National University
25 May 2015

Emily Campbell
u5182326

Abstract

This portfolio is an application of systems engineering methods to the improvement of the accessibility and efficiency of the referral system from general practitioners to specialist doctors in Australia. Methods used include problem scoping, requirements analysis, system functions definition, subsystem integration, life-cycle analysis and initial testing and verification. This portfolio uses these to analyse the problems with the current and proposed systems in order to put forward an argument for its implementation by the government of Australia. The proposed solution is to regulate and fund the architecture of electronic referrals in order to allow existing secure message providers to securely send referrals from general practitioners to specialists.

Table of Contents and Outcomes

1.0 Introduction

This portfolio proposes an improvement to the current referral system for general practitioners (GPs) to specialist doctors in Australia using a systems engineering approach. The aim of this portfolio is to detail the improvement, justify its appropriateness and outline the role of the government in its implementation. It does this through the analysis of old, adapted and new systems to determine what is required of the system and how best to meet these requirements. The system is designed to be universal (though not compulsory) in order to enable the government to provide every GP in Australia the opportunity to efficiently, securely and cheaply improve the way they refer their patients and therefore improve the quality of care they can provide.

1.1 Consultation

This report is based on a variety of sources. Consultation was conducted with 6 general practitioners and 3 medical receptionists. The data from this can be found in appendix 1. This was supported by information from Accenture's 2013 GP survey that surveyed 500 Australian GPs. Consultation with secure message providers Argus and Medical Objects was also conducted and can be found in appendix 2.

1.2 Current System

The most common method used to send referrals used by Australian GPs is paper based. GPs enter information into a referral letter in the patient's electronic medical file (EMF) using their own GP software, print the referral, sign it by hand and then send it via fax or post to the specialist or give it to the patient to deliver themselves at their appointment. In 2012, 15% of Australian doctors electronically sent or received referrals (Accenture 2013). This includes email and through the three Australian secure messaging providers (SMPs), also referred to as vendors. This includes Argus, Healthlink and Medical Objects. SMPs send secure messages and documents directly from the GP's software to the specialists but can only be used when both doctors use the same SMP. A rare variation on this is to handwrite the complete referral before sending. Approximately 7% of Australian GPs still use paper files (Accenture 2013) and would fall into this category.

1.3 Overview of the Problem

Each of the above methods available to doctors has specific problems and when viewed as a whole system, the sheer variety and overwhelming combination is a problem in itself. The most important issues are with reliability, time consumption and incompatibility. Often referrals do not make it to the specialist because they are lost by the patient, contact details are incorrect or the GP and the specialist do not have compatible SMPs. Filing, re-doing referrals or tailoring them to a particular mode of communication can be time-consuming for doctors and their staff. The evaluation matrix in section 6.0 compares the current system and some generated concepts against the customer requirements generated in this portfolio. The low score against the GP's requirements (97 out if a possible 150) indicates that the current system is definitely not reaching the the GPs' needs. The

above issues are not only problematic for the doctor, they compromise the level of care and security that patients receive. For this reason, the improvement of the referral system is in the public interest.

2.0 Proposed System Outline

The proposed system is based on the improvement of interconnectivity between SMPs. This can be easily achieved by enabling more compatible referral architecture to be created by the GPs' software. Currently GP software in Australia follows the Health Level 7 (HL7) standard of referral letters. This defines the structure, content and semantics that the letters should follow (HL7 2015). While this means that the referrals created by different software packages are similar, each is created by different templates in a way that means they are not compatible enough to be swapped between SMPs. By regulating this to make them more compatible, the referral letters could be easily swapped (Crawford 2015). This compatibility would come from the update of templates by GP software companies to follow the same structure. This structure includes features such as the number of characters, fields included, specific semantics and spacing.

This will open the use of SMPs to all doctors, as SMPs are already used to receive pathology results by GPs and specialists. This means there is no additional cost to GP surgeries and no change to the time or method of completing referrals, which in turn means the GP can still verify their identity through their software program logins and electronic signature. In order to send a referral using an SMP, a GP only has to check one box after writing their referral in their software. A detailed description of how this system would function is included in section 7.0.

This portfolio justifies the need for the government to play the role of facilitator. This role is defined, evaluated and explored in sections 3.4, 6.0 and 8.0, respectively.

3.0 Project Scope

Definition of a project's scope is useful to identify the stakeholders, boundary and goals of the system. This is the most extensive part of this portfolio as this is of particular importance due to the large number of stakeholders involved and the different motivations and means available to each.

3.1 Customer Requirements

Seven customer requirements were identified from the consultation with GPs and are given over the page in table 1. These customer requirements were volunteered by the sample of GPs. Once it was clear government involvement would be necessary, requirements were included to investigate the appropriateness of the system for the government too. It is important to note that the government's main interest is in the success of the system (i.e. the doctor's customer requirements being met) and that the government specific requirements focus on the logistics and viability of implementation.

Table 1 - Customer Requirements

Doctors	CR 1	Fast to complete
	CR 2	Easy to learn
	CR 3	Secure
	CR 4	Easy to access
	CR 5	Integrated with EMF
	CR 6	Reliable
	CR 7	Low cost
	CR 8	Uses few resources
Government	CR 9	Low cost
	CR 10	Fast to implement
	CR 11	Uses outside services

3.2 Use Case

A use case outlines the ideal behaviour of the system from the user's perspective. This use case was again based on information volunteered during consultations, but also from tailored questions about the MoSCoW categorisation of requirements (also in appendix 1). In MoSCoW categorisation, the letters stand for "Must have", "Should have", "Could have" and "Won't have" (Waters 2009) and provide a way to see what is and isn't necessary to the user. The primary case was established at the beginning of the project as a starting point for the following applications while the secondary case was added once it was clear that using SMPs was the most appropriate solution.

Table 2 - Use Case

Actors	GP (Primary), SMPs (Secondary)	
Scope	Designing a system to improve efficiency and accessibility of referral methods.	
Level	User goal	
Stakeholders	The GP, the GP's receptionist, the specialist doctor, the patient, the government, the GP software and the 3 SMPs. The role and interest of each stakeholder is analysed in section 3.4.	
Use Cases	**Primary Case** - *GP as the Actor*	**Secondary Case** - *SMPs as the Actors*
Preconditions	• GP has opened the EMF for the patient, has chosen the specialist doctor and written a referral letter in their software program. • GP has at least 1 SMP	• Both the GP and the specialist have a SMP • GP's software is compliant for swapping
Guarentees	A letter will arrive at the specialist's surgery that meets the Referral Standards set by the RACGP.*	
Success Scenario	• The GP sends the referral to the specialist from their own GP software • The referral is saved into the EMF • The referral arrives through the specialist's medical software • If the specialist cannot receive the referral (e.g. is retired or there is a problem with the referral the GP is notified.	• The first SMP obtains the referral through the GP software and encrypts it. • If necessary, SMPs swap the document and decryption instructions. • The referral is downloaded to the specialist's software with the final SMP.
Extensions	Extensions for the scope are given in section 8.3.	

(Developed from Cockburn 2000)

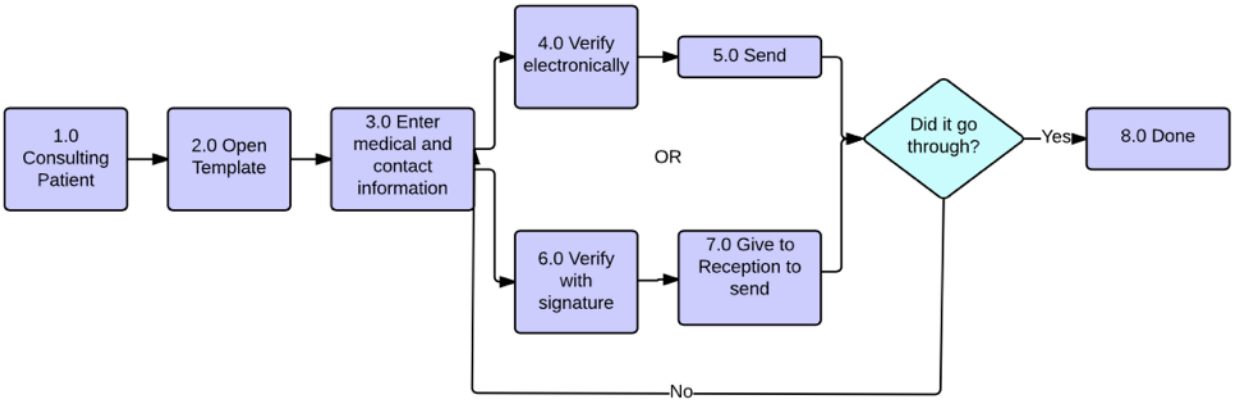
* All practicing GPs are members of the Royal Australian College of General Practitioners (RACGP) whose standards are outlined in appendix 4.

A surprising finding was that doctors were not interested in a directory for specialist doctors. Rather than search a database, they choose to refer through their own networks and base their decisions on reputation rather than information searched. If they were really stuck for a particular doctor and their own contacts couldn't help them choose someone, they were more than satisfied with using google. As such, a directory was not included in the scope of this project.

3.3 Logical Flow for GP

A logical flow diagram outlines the main actions and decisions that a user makes when interacting with a system. Boxes represent the actions and diamonds the decisions. Indicators AND and OR are used to signal when all steps or just one step need to be completed, respectively. A logical flow diagram was created to outline the GP's *ideal* use of the system. This is a representation of the use case as a logical sequence of events. Not only does this provide a basis for concept generation, but it allows analysis of how well the system meets customer requirements that revolve around user interaction later on. For the GP, this includes fast to complete (CR 1), easy to learn (CR 2) and easy to access (CR 4).

Figure 1 - Logical Flow



The flow highlighted two different paths that the GPs are likely to take. The path involving steps 4 and 5 are the most desirable, while 6 and 7 are left as a back up. The decision highlights the importance of reliability. If the answer is that it hasn't gone through to the specialist, then knowing this at the time means that only steps after 3 have to be completed.

Key Outcomes

- The ideal logical flow demonstrates the desirability of minimal change to the GP's current methods. This is particularly important to satisfying customer requirements 1, 2 and 4.
- Time to reach completion is heavily influenced by the speed at which receipt is acknowledged.

3.4 Stakeholders

This system involves a variety of different stakeholders as identified in the use case. The stakeholders and their role were further defined as part of the problem scoping stage before more detailed analysis occurred as this gave context to the analysis. See table 3 on the following page.

Table 3 - Stakeholders

Stakeholder	Role Name	Motivation	Role Description
Government	Facilitator and Client	They want the health system to be efficient, effective and affordable.	The government have the power and finance to enact change in a system with as many stakeholders as this.
GP	User	They want the process to be efficient in order to save their time, efforts and resources.	They use the system through their GP software and any other input devices.
GP Receptionist	Secondary User	They want to help the doctor but also save their own time, efforts and resources.	Their role is included in the GP's for this report as they provide support to the GP by completing filing or contact other providers on their behalf.
Specialist Doctor	Observer	They want to receive the referral reliably and on time.	They play a passive role as they already have any necessary tools setup and they are not as flexible as others involved.
Patient	Observer	They want to receive efficient care.	They play a passive role.
GP Software	Tool	They want GPs to be satisfied with their product while meeting government regulations.	They provide a necessary tool to GPs by giving them the means to create electronic referrals in an EMF.
SMPs (Argus, Healthlink and Medical Objects)	User and Tool	They want GPs to be satisfied with their product while meeting government regulations.	They provide a necessary tool to GPs by providing a secure communication method to other providers.

Key Outcomes

- The government was identified as the facilitator and client for this portfolio due to their public interests and power to facilitate change. This is justified in the evaluation (see 6.0).
- The GP and the SMPs were identified as the users.

3.5 Boundaries

As the government is the client rather than another stakeholder, there are many things within the control of the system. Table 4 outlines the boundaries by classifying which factors the system can control (endogenous), which effects the system externally (exogenous) and which will not be considered (excluded).

Key Outcomes

- The GP software, SMPs and government regulations are able to be adapted for the system.

Table 4 - System Boundary

Endogenous	Exogenous	Excluded
GP Software	GP	Loss of internet connection
SMPs and their networks	Receptionist	Power failure
Government Regulations	Specialist	
GP Practice Proticol	Cost of GP software, SMPs and other outside services.	

4.0 Requirements Analysis

Requirements analysis is the process of taking vague customer requirements and producing clear, measurable design requirements and technical performance measures (TPMs). This is done in order to produce a greater understanding of the importance, details and trade-offs of requirements. (DAUP 2001). This was carried out through pairwise analysis and a House of Quality.

4.1 Pairwise Analysis of Customer Requirements

Preliminary analysis of the customer requirements involved pairwise analysis, a technique that establishes the relative importance of requirements through direct comparison (Dym and Little 2008). The GPs' requirements were ranked based on the ranking provided by the sampled doctors (see appendix 1 for answers). All GPs' requirements were ranked above the government's as is shown by the yellow region. This was because in order for the system to be useful, the user has to be satisfied with it. So while the government's requirements are important, they would become redundant if the system was not useful to the GP. Rankings are included in the House of Quality.

Table 5 - Pairwise Analysis

	CR 1	CR 2	CR 3	CR 4	CR 5	CR 6	CR 7	CR 8	CR 9	CR 10	CR 11	Total	**Rank**
CR 1		1	0	1	1	0	0	1	1	1	1	7	3
CR 2	0		0	0	1	0	1	1	1	1	1	6	6
CR 3	1	1		1	1	1	1	1	1	1	1	10	1
CR 4	0	1	0		1	0	1	1	1	1	1	7	3
CR 5	0	0	0	0		0	0	0	1	1	1	3	8
CR 6	1	1	0	1	1		1	1	1	1	1	9	2
CR 7	1	1	0	0	1	0		1	1	1	1	7	3
CR 8	0	0	0	0	1	0	0		1	1	1	4	7
CR 9	0	0	0	0	0	0	0	0		1	1	2	9
CR 10	0	0	0	0	0	0	0	0	0		0	0	11
CR 11	0	0	0	0	0	0	0	0	0	1		1	10

Key Outcomes

- Security (CR3) and reliability (CR6) were identified as the most important customer requirements followed by fast to complete (CR1), easy to access (CR4) and low cost to GP (CR7).
- All GP requirements are ranked above government requirements.

4.2 Requirements Relationships (House of Quality)

Design requirements and technical performance measures were derived from the customer requirements. The design requirements are a more exact and technical expression of the customer's and are used to construct the technical performance measures (TPMs) of the system. These are metrics in engineering terminology that provide measurable indicators of how well a particular requirement is met. (DAUP 2001). For this system, these are included in the House of Quality.

The House of Quality (see page 7) is a diagram which articulates the relationships between design requirements and TPMs, and also between different TPMs. The lower portion of the table relates design requirements with the TPMs. The numbers indicate the strength of their relationship, with 9,

Table 6 - House of Quality

Correlation(+/-)
9 - Strong
3 - Moderate
1 - Weak
ID = Refernce #
R = Ranking
SS = Subsystem

														TPMs
														13
														12
													+	11
												+	+	10
											+			9
										+				8
									+					7
								+	+	+	+	+		6
							-							5
								-	-					4
					-	+								3
				-		+								2
			+		-	+								1
	TPM ID	1	2	3	4	5	6	7	8	9	10	11	12	13	
	TPMs	Time to prepare referral for sending	Referral travel time	Training time	Referral encryption	Referral validation	Number of resources utilised by GP	Successful transmissions	Initial cost for GP	Ongoing cost for GP	Initial cost for government	Ongoing cost for government	Time to implement	Government employees involved	
	Direction	↓	↓	↓	✓	✓	↓	↑	↓	↓	↓	↓	↓	↓	
	Units	Minutes	Minutes	Minutes	High/Low/None	Yes/No	Amount	%	$	$/month	$	$/year	Years	Amount	

CR ID	CR R	DR ID	Design Requirement													SS
1	3	1	Low time to complete	9		1		1	3	3						A
1	3	2	Low time to get there		9											N
2	6	3	Low time to learn use	1		9		3	9							A
3	1	4	Highly secure				9	9	1						1	LE, N, LD
4,5	3, 8	5	Low number of programs used	3	1	3			9		3	3	3	3		A
6	2	6	High success rate							9						All
7	3	7	Low setup cost for GP						3		9	3	3	3	1	A
7	3	8	Low ongoing cost for GP						3		3	9	3	3		A
8	7	9	Low amount of paper used					3		3		3				All
9	9	10	Low setup cost for government						1		3	1	9	3	9	A, N
9	9	11	Low ongoing cost for government									1	3	9	1	N
10	11	12	Low implementation time												9	A, N
11	10	13	Low number of government-run programs						3				3	9	3	N
11	10	14	Low number of government depts involved										3	3		A, N

u5182326

3 and 1 for strong, moderate and weak relationships respectively. The "roof" of the House of Quality indicates the correlation between TPMs. Negative correlation (-) indicates that a trade-off between TPMs is needed while positive correlation (+) indicates that the TPMs reinforce each other. (Hausser, Clausing 1988). The constructed House of Quality can be seen over the page.

Negative correlation was only identified for TPMs relevant to patient security - referral encryption (TPM 4) and referral validation (TPM 5). This is extremely relevant to the project as security was identified as the top customer requirement as indicated by the yellow cells. Positive correlation occurred most frequently in relation to TPM 6 - number of resources (programs or websites) used by the GP. Eight of the twelve other TPMs were identified as having a positive correlation. This is reinforced by the high number of design requirements that have a relationship with this TPM, indicated by the blue cells.

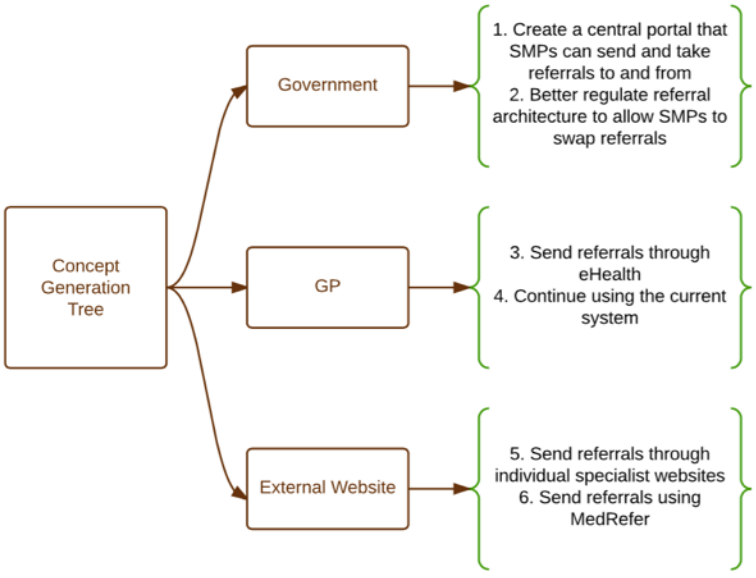
Key Outcomes

- Referral encryption and validation cannot be compromised in the final system.
- A system that requires a GP to use fewer resources is likely to increase the performance of the system in many other measurable areas.

5.0 Concept Generation

Initial concept generation involved researching current systems, researching systems used for different (but similar) purposes and designing new ideas. Ideas were generated free from analysis and then categorised based on who would be the primary facilitator of such a system. The classification tree can be seen in figure 2 below. Once this was completed, a few ideas were eliminated based on inspection against the customer requirements. Those that were not eliminated were analysed in the evaluation matrix in section 6.0.

Figure 2 - Concept Tree



The solutions were based around multiple different facilitators. Narrowing down the facilitator was therefore an essential early step. Concepts 3, 4 and 5 were eliminated early in the process.

- Using eHealth was not viable as only 7.3% of Australians had a personal eHealth record as of June 2014 (NEHTA 2014). This is too small a population to create a universal system.
- Continuing the use of the current system was eliminated due to the problems given previously. It's lack of appropriateness is further highlighted in the evaluation matrix in section 6.0.
- Sending referrals through individual specialist websites was also not feasible as it would involve specialists creating the system and they are considered to be exogenous. This would also not fulfil customer requirements one to five.

Key Outcomes

- The main concepts that were considered after generation were 1, 2 and 6.
  - A complete numerical analysis of concepts 1, 2 and 6 is provided in section 6.0.
- Concepts 3, 4 and 5 were eliminated. An implication of this is that the GP was not going to be a viable facilitator of the system.

5.2 Summary of Evaluated Concepts

Concepts 1 and 6 were not immediately eliminated and are outlined here.

5.2.1 Central Portal (Government Run)

This solution would act as an online, central portal modelled off the ECLIPSE portal that the government currently runs for medicare, health insurance providers and specialists to swap payment details and patient information (DoHS n.d. and 2004). SMPs would deliver encrypted referrals to the portal where they would be processed and sent on to another SMP.

5.2.2 Central Portal (External Website)

This concept used the MedRefer website as an example. It is a website where GPs can search for specialists (who pay to be advertised on MedRefer) and then send the referral through to the specialist. The website is only compatible with one GP software (Best Practice) and as such, most users would need to use the website external to their own software. (MedRefer 2015).

6.0 Evaluation

Evaluation of the main concepts considered was conducted through an evaluation matrix. This allows the numerical evaluation of concepts against weighted customer requirements. The customer requirements were weighted based on previously established ranks, and then the suitability of each concept was considered. This was originally conducted after the functional analysis of the three concepts, however is included in this section of the report to justify the chosen system's selection before refinement of the system is articulated. Data used can be found in appendix 3 and the matrix is on the following page in table 7.

The proposed solutions of the introduction of architecture regulations scored the highest in relation to GP and overall requirements. It performed equal to or better than all other concepts for the GP requirements, indicating that it is the clear choice from a GP's perspective. This is reflective of its adherence to the GPs' ideal logical flow (see 3.3), which could be used for this system exactly. The Government-run portal was a close second, however it's very low score against government

requirements make it a poor solution. It requires too much government funding, support and energy to be viable. It would also rely on a completely new system being set up, rather than simply adapting the current system. The external portal (e.g. MedRefer) and the current system scored very high on the government requirements but very low on the GP requirements. This is because each would require very little involvement from the government. Unfortunately, this creates systems that are not accessible, affordable or streamlined enough for GPs and so are not appropriate. This justifies the need for change and also the need for the change to come from the government.

Table 7 - Evaluation Matrix

			Architecture Regulations		Government-Run Portal		External Portal e.g. MedRefer		Current System	
Customer Requirement	Rank	Weighting	Suitability	Weighted Value	Suitability	Weighted Value	Suitability	Weighted Value	Suitability	Weighted Value
CR 1	3	4	5	20	5	20	4	16	3	12
CR 2	6	3	5	15	4	12	3	9	5	15
CR 3	1	5	5	25	4	20	5	25	4	20
CR 4	3	4	4	16	4	16	3	12	3	12
CR 5	8	3	5	15	5	15	3	9	3	9
CR 6	2	5	4	20	4	20	2	10	3	15
CR 7	3	4	4	16	4	16	3	12	3	12
CR 8	7	2	4	8	4	8	4	8	1	2
CR 9	9	2	3	6	1	2	5	10	5	10
CR 10	11	2	3	6	1	2	4	8	5	10
CR 11	10	2	4	8	2	4	5	10	5	10
			Score	135	Score	127	Score	101	Score	97
			Score	20	Score	8	Score	28	Score	30
			Score	155	Score	135	Score	129	Score	127

Key Outcomes

- The architecture regulation solution best meets the GP and overall requirements.
- While the external portal and currently system scored the highest against the government requirements, their low scores demonstrate their inappropriateness. This justifies the need to have the government as the facilitator in order to produce acceptable results for the GPs.

7.0 Function of the Proposed System

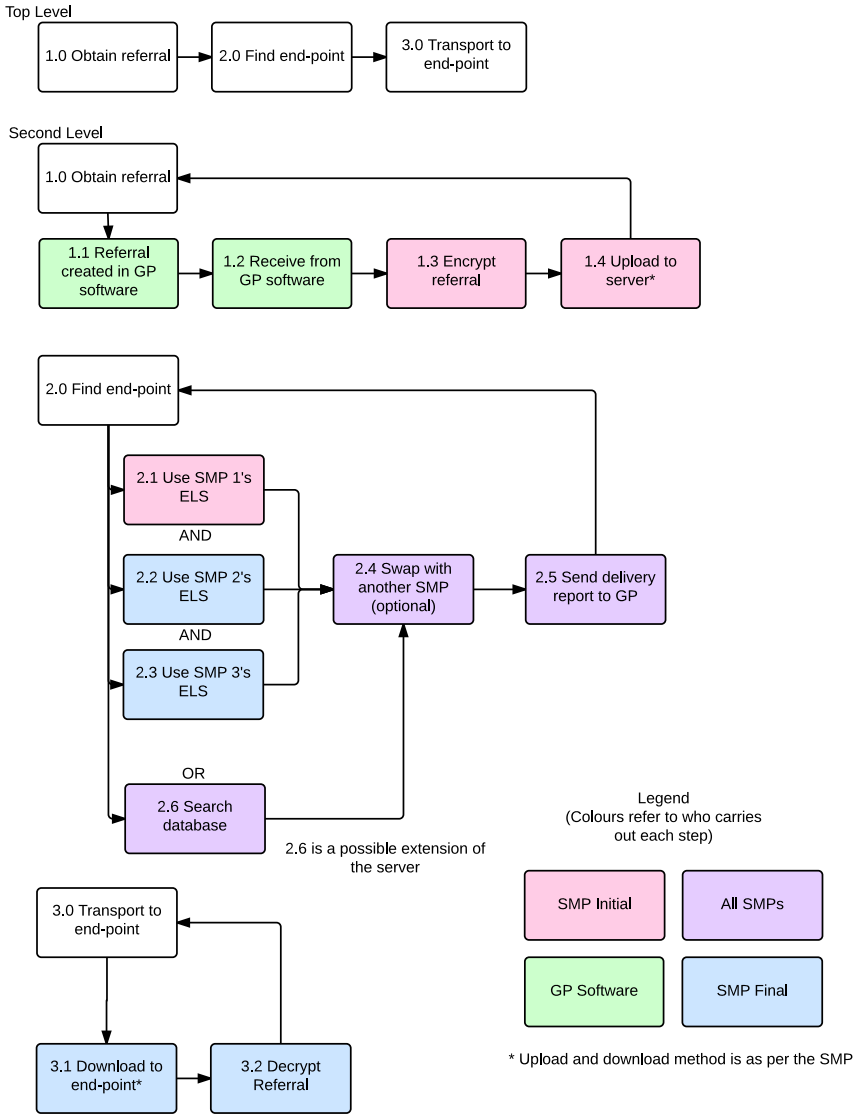
This section of the portfolio details the functions and sub-systems involved in the proposed design, then describes how they interact and apply to design requirements. As all of the concepts generated would create completely different functions and technical diagrams, the technical applications included here apply to the proposed design, though the function of other systems will be referred to as well. These are used to explain the final design and justify the choices made. These also increase the flexibility of the system because changes in requirements can be easily tracked to subsystems.

7.1 System Functions

Functional Flow Body Diagrams (FFBDs) were created for the three concepts considered. FFBDs include the functions that a system will carry out in order to reach its goal. They are divided into

general “top level” functions that are then further broken down into “second level” functions. (DUAP 2001). The FFBD of the proposed design is below.

Figure 3 - FFBD



The majority of functions in the FFBD of the proposed design were functions that SMPs already carry out in the current system. Aside from 2.2-2.4, the SMPs have their own existing methods for encryption and sending referrals through their networks. Argus sends encrypted emails, Medical Objects upload and download from their own server, and Healthlink also utilises its own server through a store and forward pattern. Functions 2.2-2.4 would be new for the SMPs. This is where other SMP’s end-point location services (ELSs) are used and the referral is swapped between networks if necessary. Consultation with two of the three SMPs (Medical Objects and Argus) indicated that this interconnectivity is possible and realistic. (Crawford and Drew 2015).

Function 2.6, “search database”, was included to demonstrate a possible expansion of the system. Rather than searching the existing networks of individual SMPs through ELSs, one ELS could

search a collective database. This could be based on the existing National Health Services or Healthcare Provider Directories. (NEHTA 2013).

The FFBDs for the central portals considered (one run by the government and one by an external provider such as MedRefer) contained functions that were entirely new to this sort of system and as such would be much more complicated and much more expensive to setup and run.

In examining the function of each of the different concepts, it was clear that adapting the system to allow for handwritten referrals to be included was not possible. Each method would require the referral to be scanned and uploaded to the server, portal or network independently of the GP software. This is time consuming and adds a high level of complexity. This led to handwritten referrals being excluded from the scope of this portfolio. This effects a relatively small percentage of doctors (7% as per section 1.2) who are not wiling to abandon their paper files. This lack of interest in EMFs indicates that these GPs would not be the most effective targets for the initial stages of implementation. Adaptation of the system to include handwritten referrals at a later date could be completed, but is beyond the scope of this report.

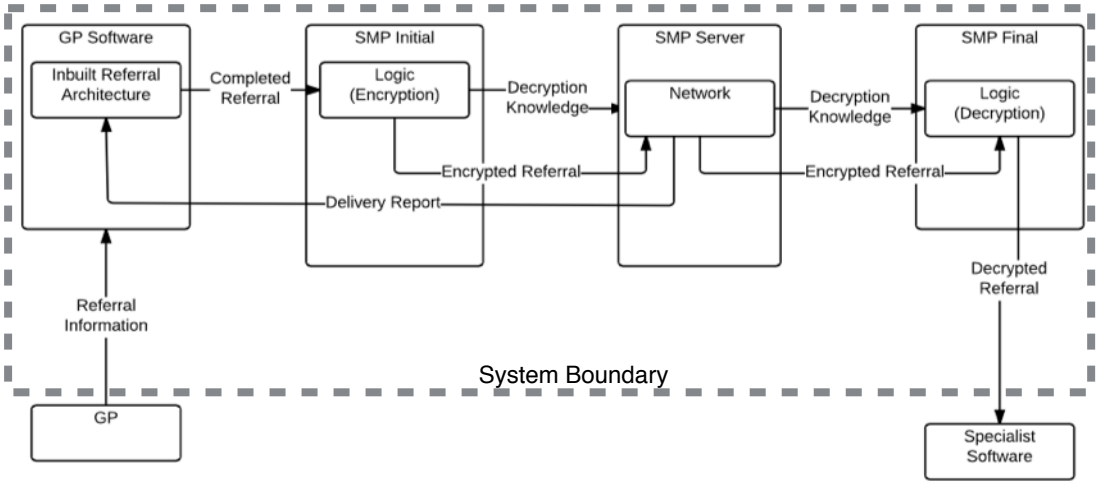
Key Outcomes

- The proposed design introduces the lowest number of new functions to the system, with SMPs already carrying out many of the functions using their individual methods.
- Handwritten referrals have not been included in the scope of this project.
- The system could be expanded to include one single database for SMPs to search.

7.2 Subsystem Interface

A subsystem interface maps out the different components, subsystems and how they interact. An interface was created for the proposed design and is below in figure 4. The components are the GP Software, the SMP server and the SMPs that are used initially (by the GP) and finally (by the specialist). Within these, the referral architecture, network and logic (both encryption and decryption) subsystems were identified. The system boundary is included as defined in 3.5.

Figure 4 - Subsystem Interface



All subsystems interact through the communication of the referral either encrypted or not, and the sharing of decryption knowledge. The interface highlighted the biggest challenge that the system will have during implementation, which is the creation of the SMP server's network subsystem. This server has to be capable of sharing knowledge and encrypted referrals in a way that does not compromise the security of the system - the most important customer requirement. This decryption information will need to be either known by both SMPs before the system is used, or sent securely each time, depending on what is appropriate for their encryption methods.

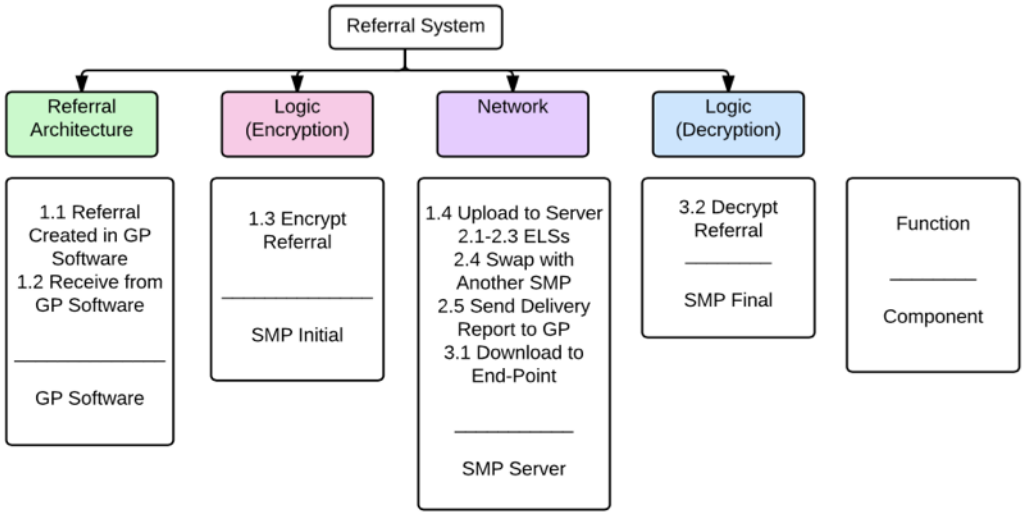
Key Outcomes

- The creation of the SMP server for swapping encrypted information and decryption information will be a challenge during implementation. Patient confidentiality must not be compromised.
- The delivery report enables immediate notification of delivery failure, saving the GP time as was suggested by the logical flow in section 3.3.

7.3 Functional Allocation

The functions defined previously are able to be allocated to subsystems in a functional allocation diagram. For the proposed design, this is shown in figure 5 below which contains both the functions completed by the subsystem and the component that subsystem belongs to. Numbers of functions refer to the numbers given in the FFBD.

Figure 5 - Functional Allocation



The identification of the network subsystem as the subsystem containing the most new functions to the system in the subsystem interface is reinforced here. Functions 2.2, 2.3 and 2.4 are not functions that are already carried out by SMPs and so this subsystem is higher risk than the logic subsystems.

Key Outcomes

- The network carries out the most complex functions and will pose a challenge to SMPs.

7.4 Requirements Mapping

Requirements mapping is the process of allocating the subsystems to design requirements. This enables relationships between outcomes and components to be identified and also means that if changes are to be made to the system, then it is easy to isolate subsystems to make the relevant changes and improvements. The requirements mapping was incorporated into the House of Quality.

The network and both logic subsystems were identified as the most important when it came to security, while all subsystems were attributed to reliability of the system. These were the 2 most important requirements. This highlights the importance of cohesion and interaction between the subsystems. As these subsystems are generally run by different stakeholders, careful government supervision of their interconnectivity will be important to maintaining the integrity of the system.

With the exception of the low paper use requirement, the referral architecture and the network were the only subsystems attributed to remaining requirements. As the referral architecture will enable GPs to continue using their current referral creation method, the relevant customer requirements (7 of the 9 design requirements) will be addressed by the regulation change. As such, this small change to the current system through the GP software has a profound impact on the system.

Delays and complicated logistics surrounding setting up the network will have the most significant impact on the government's requirements. This highlights the importance of forward planning, consultation and further systems engineering applications.

Key Outcomes

- All subsystems and therefore their interaction will relevant to meeting the top 2 requirements (security and reliability), so focus needs to be given to each.
- The regulation of referral architecture addresses most GP requirements effectively.

8.0 Life-Cycle Analysis

The life-cycle of the proposed system began during the design process initiated in this portfolio and will end once the system becomes redundant. This section outlines the steps for each stage and comments on the flexibility, challenges and stakeholders in each.

8.1 Design and Production

The key outcomes of this report have continually noted important considerations for the design and production steps that would include consultation, regulation creation, software update, testing and communication. Consultation will have to be ongoing, but the tools used in this report, in particular the House of Quality, set out requirements and subsystems that are flexible if changes need to be made during any of these steps. As the design is focused on software and uses a lot of functions set up already it uses few physical resources. The government will have to provide funding to the GP software companies and SMPs during the adaptation and testing phases. The systems testing stage is detailed in section 9.0.

8.2 Operation

The implementation of these changes will lead to a significant reduction in the waste of paper resources. Successful transmissions will not require any paper. Maintenance can occur by the SMPs and GP software as per their current methods.

8.3 End-Of-Life

While there are no materials to be recycled, it is important to consider the long term prospects of such a system. There is huge potential for the expansion of the system to include the sharing of other important health documents (results, letters and EMFs). Medicare may be able to utilise the central network to better keep track of referrals sent. This would enable them to spend less time gathering data for auditing specialists. The end-of-life of the system is uncertain due to the emergence of online software and storage of medical information on the cloud. Once this technology reaches a certain prevalence, the SMPs will be forced to adapt.

9.0 System Testing and Validation

In order to check the system will function well, this final section indicates relevant testing to be completed in order to complete validation the design. These are indications only as the testing methods will depend greatly on the technical knowledge and decisions made by the GP software companies and the SMPs. **Analytical testing** has been demonstrated throughout this portfolio. This involved the application of models and theory to the theoretical system to demonstrate its function was possible. This can be found in analysis of the FFBD, section 7.0, and also in the evaluation, section 6.0. **Proof of concept testing** would involve the testing of the network and referral architecture subsystems. It would be most appropriate if the referral architecture was be tested by the software companies using the techniques they implemented when first creating their templates. An example test has been devised to test the network's processing time for a high volume of referrals. This is found in appendix 5. These sorts of tests would be devised and run by the SMPs, but facilitated by the government. **Model testing** would be a collaboration between the SMPs and GP software to test the operation of the whole system, in order to establish the performance of and potential improvements to the interfaces. **Operational Testing** would test the system in operation with a small number of GPs and specialists. These would be doctors who are interested in a health information exchange and contributing to IT health. **Support Testing** would continue to be carried out by SMPs monitoring their networks as per their current methods.

10.0 Conclusion

Systems engineering applications have been used to establish the appropriate boundaries, requirements and priorities relevant to improving the accessibility and efficiency of the referral system between GPs and specialists in Australia. The function of the system was constructed, challenges were highlighted and the future roles of the stakeholders were identified. The result is a final proposal that satisfies the requirements of all stakeholders, especially those of the GPs.

11.0 References

Australian Bureau of Statistics (ABS) 2011, *Australian Social Trends,* Retrieved 20/5/15 from http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4102.0Main+Features20April+2013#p2

Accenture 2013, Doctors Survey: Australia Country Profile. Are Austrlian Doctors on Board With Healthcare IT? Available from: Accenture [13 April 2015]. http://www.accenture.com/SiteCollectionDocuments/Local_Australia/PDF/Accenture-Doctors%20Survey-Australia-Country-Report.pdf

Accenture 2010, Effective Health Information Exchange. The First Step Toward Connected Health. Available from: Accenture [13 April 2015]. http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture_Effective_HIE_read.pdf

Benjamin S Blanchard, Wolter J Fabrycky, and Wolter J Fabrycky. Systems engineering and analysis, volume 4. Prentice Hall Englewood Cliffs, New Jersey, 1990.

Cockburn, A 2001 'Writing Effective Use Cases' Published by Addison-Wesley.

Department of Human Services, n.d., ECLIPSE Medical and Eligibility User Guide V2.2 for Medical Practitioners, read 20/04/15.

Department of Human Services, 2004, Annual Report 2003-2004, Published October 2004.

DUAP 2001, Systems Engineering Fundamentals, Fort Belvoir, Virginia, USA.

Dym and Little 2008, Engineering Design: A Project Based Introduction, Published by Wiley.

Hausser. J., Clausing. D., 1988, The House of Quality, Harvard Business Review May-June '88.

HL7, 2013, *Version 2.5 Standard: Chapter 11 - Patient Referral,* Published by Health Level Seven, MI, USA.

MedRefer 2015, *How it Works,* Retrieved 20/04/15 from https://www.medrefer.com.au.

NEHTA (National eHealth Transition Authority) 2013, Overview of eHealth directories for Health Care Providers, Published August 2013.

NEHTA 2014, Annual Report 2013-2014, Published October 2014, Sydney, NSW,

RACGP 2015, Criterion 4.2.3 Transfer of patient health information. Retrieved 10/04/15 from http://www.racgp.org.au/your-practice/standards/standardsprisons/standard4-2/4-2-3/

RACGP 2015, Referral Standards. Retrieved 10/04/15 from http://www.racgp.org.au/your-practice/standards/standards4thedition/practice-services/1-6/referral-documents/

Waters 2009, 'Prioritsation using MoSCoW'. Retrieved 10/04/15 from http://www.allaboutagile.com/prioritization-using-moscow/

12.0 Appendices

12.1 Appendix 1 - GP Consultation Results

"Do you think these things essential?" - MoSCoW or not necessary (43210)

Requirements	Doctor 1	Doctor 2	Doctor 3	Doctor 4	Doctor 5	Doctor 6	**Result**
Requires proof of ID from GP	4	4	4	4	4	4	**4**
Patient's information is available only to the Doctors/Staff	4	4	4	4	4	4	**4**
Ability to copy patient details (medical or contact) directly into a referral letter	0	3	4	4	3	4	**4**
Having a purely electronic system	0	3	3	3	3	3	**3**
The patient having a copy of their referral	3	4	3	3	4	4	**3**
Only using one program (e.g. just Genie)	4	4	4	4	4	4	**4**
Contains a directory for specialist doctors	0	0	0	1	0	1	**1**
Accommodates handwritten referrals	4	1	0	0	0	1	**1**

* Note that Dr 1 handwrites referrals. Once this was removed from the scope, this doctor's feedback was largely excluded.

Ranking of Requirements by GPs

ID	Description	Doctor 1	Doctor 2	Doctor 3	Doctor 4	Doctor 5	Doctor 6	Average (Drs 2-6)
CR 1	Fast to complete	3	3	5	5	4	5	4.4
CR 2	Easy to learn	5	5	8	6	6	6	6.2
CR 3	Secure	4	2	1	2	1	1	1.4
CR 4	Easy to access	2	6	4	1	5	4	4
CR 5	Integrated with EMF	8	4	3	7	8	8	6
CR 6	Reliable	1	1	2	3	2	2	2
CR 7	Low cost	6	7	6	4	3	3	4.6
CR 8	Uses few resources	7	8	7	8	7	7	7.4

Additional Information

Additional Information	Doctor 1	Doctor 2	Doctor 3	Doctor 4	Doctor 5	Doctor 6
Maximum time willing to donate to learning about the system (minutes)	10	10	20	10	5	5
Current average time to complete referral (minutes)	5-10	5				
Standard consultation time (minutes)	15					

12.2 Appendix 2 - SMP Correspondance

12.2.1 Email Correspondence with Lyndon Crawford - CEO of Medical Objects

(See next)

Date	Sender	Message
17 May 2015	E. Campbell	Good morning, My inquiry is brief. I am a medical receptionist and Engineering student. I am wondering about the communication of documents between you and other secure messaging providers (i.e. Argus and Healthlink). Do you think you will be able to communicate with each other in the future so that medical providers who use Argus can send a letter to another provider that uses Medical Objects? This seems like something of importance for medical providers who wish to subscribe to your product. Thank you for your help! Emily
18 May 2015	L. Crawford	Hi Emily, Thank you for contacting us. To answer your question 'Do you think you will be able to communicate with each other in the future?' Yes messaging vendors are working towards interconnectivity and do plan to send clinical messages across other networks. There is a fair of bit of complexity involved in achieving interconnectivity between vendors. I am happy to discuss further if you require. Kind Regards Lynden Crawford CEO
18 May 2015	E. Campbell	Hi Lynden, Thank you so much for your quick response! I've been talking to my general practice manager more specifically about the capability to send referrals to specialists over these networks. Currently it's not really worthwhile because lots of specialists use different vendors and in order for us to send it via vendors, 1. we need to have their vendor details (e.g. Medical Objects ID number) in our address book and 2. the doctor needs to know which vendor they use when they're writing the referral so they can select the right vendor for sending. We use Genie, so it may be a little different for other software programs. Basically, it would be better if all the GP had to do was choose the specialist and then the process of finding the vendor details for the specialist was done externally. Is that realistic? In order to achieve interconnectivity, will you be utilising the National Health Services Directory? Does it have gateways set up that you can use? Or would it purely be an initiative from the main vendors? Thank you again for your help! Emily

18 May 2015	L. Crawford	Hi Emily,
		
		Basically, it would be better if all the GP had to do was choose the specialist and then the process of finding the vendor details for the specialist was done externally. Is that realistic?
		>>> Yes that is the way it is envisioned to work.
		
		In order to achieve interconnectivity, will you be utilising the National Health Services Directory?
		>>> Yes that is a possibility to used the NHSD, although it is not the only way it can be accomplished as messaging vendors have there own end point location services (ELS) that can be used in conjunction with the Health Provider Directory Service (HPD)
		
		https://www.nehta.gov.au/component/docman/doc_download/1705-overview-of-ehealth-directories?Itemid=
		
		Does it have gateways set up that you can use? Or would it purely be an initiative from the main vendors?
		The gateways are mentioned in my previous answer. Vendors ELS and HPD
		
		NEHTA is working with Messaging vendors to accomplish this.
		
		Kind regards
		
		Lynden Crawford
		Chief Executive Officer

19 May 2015	E. Campbell	Hi Lynden, Last email, I promise! You mention NEHTA. Is this the only way the government could be involved? Do you see government playing a financial role setting this up? Or some sort of facilitation role? Or a more hands-on role in creating whatever the central inter-connectivity mechanism/technology/software is? Is it pretty much guaranteed that all specialist doctors use at least one vendor? Or will some specialists be unavailable through this? Could an online fax option be used as part of the ELS (or something similar) to find doctors who don't have a vendor...if they exist? The purpose would be to save our GPs from having to remember who does and doesn't have the vendor system set up. Perhaps just a message back to say "this specialist doesn't have a vendor, you'll need to fax it". I'd like to say that Medical-Objects have absolutely been the most comprehensive and useful company that I have contacted. I really appreciate your time in helping me understand how this might look. Thanks, Emily
20 May 2015	L. Crawford	Hi Emily It is fine and I am happy to answer. I think for these next questions I would prefer a phone conversation as it will be easier to explain. My number is in my signature you can call anytime on my mobile. Kind regards Lynden Crawford Chief Executive Officer

12.2.2 Notes from telephone call with L. Crawford - CEO of Medical Objects
20/5/15 10:00-10:40am

The SMPs have different methods of sending data.
Medical Objects - 30 second uploads and downloads to central server.
Healthlink - store and forward method, “piling” 30 mins send to central service. This means it could take 0 to 60 minutes.
Argus - sends emails that are encrypted.

HL7 messages are given in different ways to the SMPs, therefore changes need to be made in order for it to display properly elsewhere. e.g. different amounts of characters.

“We don’t know what we’re being given or how it is being structured”
Modify STRUCTURE not CONTENT.

With standard products/templates it wouldn’t be a problem.

NEHTA could ensure software is compliant.

Have had meeting with NEHTA confirming viability. Timeline is dependent on them - up to 2 years.

I asked, is it possible to send a msg back to doctors when it does not go through?
Routing is checked before they release it which means there is a time and date stamp for sent and arrived. If it doesn’t go through straight away then the doctor will be notified immediately.

12.2.3 Email Correspondence with S. Drew - Argus Admin Assistant

Date	Sender	Message
9 May 15	E. Campbell	Message: Hi there, I'm an engineering student and medical receptionist. I am wondering how the communication between different medical centres works when they each use a different secure messaging service. So, if one uses Argus and the other Health Link, how do those two communicate? Many thanks for your help.
11 May 2015	S. Drew	Good Morning Emily, At this point in time we do not communicate with the other secure messaging providers. We are working on SMI system which will allow Argus, Healthlink and Medical objects to communicate.
12 May 2015	E. Campbell	Morning Samantha, Thank you so much for your reply. So, if one doctor uses Argus to send a result/letter/message but the doctor they're sending it to uses Healthlink or Medical Objects, how will it send between those 2 different providers? Thank you again for your help, I really appreciate your response. Emily
18 May 2015	S. Drew	Yes when this is up and running we could be using the NHSD and its ‘gateways’ to swop information.

12.3 Appendix 3 - Data for Evaluation

		Architecture Regulations (Crawford 2015)	Government-Run Portal (DoHS n.d. and 2004)	External Portal (MedRefer 2015)	Current System - Based on consultations
TPMs	Unit	Value	Value	Value	Value
Time to Prepare Referral for Sending	Minutes	Negligible	Negligible	0-5 *	0-2
Referral Travel Time	Minutes	1-30	5-35	Negligible	1 - Many Days
Training Time	Minutes	Negligible	<5 minutes	< 20 minutes	Negligible
Referral Encryption	High/ Medium/ None	High	High	High	Variable
Referral Validation	Yes/No	Yes	Yes	Yes	Yes
Number of Resources Used by GP	Number	1	1	2	Variable
Successful Transmissio n	%	High *	High *	Low (as barely any users) *	Medium *
Initial Cost for GP	$	Negligible	Negligible	Negligible	Negligible
Ongoing Cost for GP	$/Month	Negligible	Negligible	15	20
Initial Cost for Government	$	Moderate	High	Negligible	Negligible
Ongoing Cost for Government	$/Year	Low *	High *	Negligible	Negligible
Time to Implement	Years	2 *	5 *	Negligible	Negligible
Number of Government Employees Involved	Number	Few *	Team of People Required *	Negligible *	Negligible *

12.4 Appendix 4 - RACGP Referral Standards - Criterion 1.6.2

► A. Our practice can demonstrate that referral letters are legible, contain at least three approved patient identifiers, state the purpose of the referral and where appropriate:
- are on appropriate practice stationery
- include relevant history, examination findings and current management
- include a list of known allergies, adverse drug reactions and current medicines
- the doctor making the referral is appropriately identified
- the healthcare setting from which the referral has been made is identified
- the healthcare setting to which the referral is being made is identified

- if known, the healthcare provider to whom the referral is being made is identified
- if the referral is transmitted electronically then it is done in a secure manner
- a copy of referral documents is retained in the patient health record.

12.5 Appendix 5 - Example Test

- Attribute: Processing Time
- Test person: SMPs in Collaboration
- Pass / fail criteria: Referrals move through the network in under 1 hour. Health link runs on 30 minute upload and download schedules, so 60 minutes is the longest a referral should take.
  - Send through a large number (230,000*) of “test” referrals over 10 hours via the message services.
  - Measure time taken to process these referrals.
  - Check portion that make it through.

*230,000 is based on 200 GPs per 100,000 people in Australia (ABS 2011) sending 5 referrals a day.