Re-architecting the Telecommunications Program – Initial Proposal

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with [other authors]

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1 Preliminaries

1.1 Background

From informal discussions, it seems that many in Telecoms have felt that the Telecom-specific courses could be revised and improved. Areas of concern include poor or duplicate coverage of certain topics, poor transfer of knowledge to students in certain fundamental areas, and lack of skills in programming and simulation abilities.

Why do it now?

The Telecoms strand has been considering revising some courses for some time now. Since John Reekie is here for a year and as a relative outsider, brings a fresh perspective, and is willing to do the work (in conjunction with other ICT faculty), now seems like a good time.

What is this document?

This document is an initial proposal intended to lay some basic groundwork and to stimulate discussion. If the document and discussion lead to an agreement on further work, then additional time can be spent on the basis of the material in this document. The time spent on this report and the subsequent discussion can be viewed as a cost outlay of approximately 5%. It can be followed by detailed architecture and course design (20%), and finally development out of courseware over several semesters (remaining 75%).

1.2 Scope

The proposed scope of this revision suggested by Tim at the start of this process is the three subjects starting at ITE and ending with the entry requirements to CT.

Some faculty have indicated that they feel that considering the complete set of telecommunications courses as a whole would lead to a more coherent revision. Some of the proposed items for adoption also lean towards this view (for example: content threads (section 2.2), and tactics for achieving particular course qualities (section 1.4)).

1.3 Qualities

In software architecture, *qualities* are properties of the system under consideration other than the more obvious "functional" properties. For example, reliability, availability, usability, and modifiability are qualities that an architect considers over and above the mere production of correct outputs. Satisfying qualities requires prioritizing them and resolving tensions between them.

Analogously, we might consider the "functional" properties of our curriculum to be the material covered (or arguably, the material learnt). The "non-functional" qualities that could be considered for this course revision include the following (in no particular order).

Achievability There is little point in designing a revised course structure if we cannot achieve it. Satisfaction of the *achieveability* quality requires that considerations such as budget, time, staff availability, support for incremental development, and so on be considered.

Substitutability This is the ability for staff that have not previously engaged with a subject to do so. That is, if I have not taught a subject before, then assuming I have a minor understanding of the subject material and am able to learn quickly, this quality enables me to fulfil a teaching or tutoring role in that subject without an unnecessarily large time overhead. Given the incredible breadth of subjects in an "Engineering" curriculum and the tendency for teaching staff to suddenly take PEP leave, this seems like a desirable quality.

Longevity This quality is the ability of a subject to "last" a long time without being scrapped and rebuilt. It is a desirable quality because it reduces the overall cost of subject development. Conversely, a commitment to longevity could be used as an argument for obtaining resources to develop a better (by other measures) subject, on the basis that the *long-term* cost is less.

Modifiability Modifiability is the ability of a subject to adjust to different delivery styles. Some teaching staff, if "taking over" will be happy to teach it the way it was taught before. Others will prefer to modify or re-organize the course to suit their own teaching style and ideas of what constitutes effective teaching.

Adaptability Adaptability is the ability of a subject to adapt to different delivery contexts. For example, adapting a course to undergraduate or post-graduate delivery contexts, or to remote delivery.

1.4 Tactics

In software architecture, a *tactic* is a particular approach or structure that enhances a given quality. A set of tactics is chosen to best meet the prioritized qualities determined to be the ideal for the system under consideration.

In the context of course or subject development, we can consider tactics to be items such as the structure of course material, guidelines (or rules) related to teaching a course, approaches to the "powers that be" for more money/time/resources, attempts to distill particular philosophies into teaching staff, and so on.

The following tactics are a starting set, intended to seed further discussion.

Use content threads Rather than arbitrarily divide content into subjects based on presumed level of difficulty, treat the complete content as a series of (related) threads, and treat subjects as a time-wise slice through some organization of these threads.

Use understanding threads Thread development of different levels of understanding through a series of subjects. Levels of understanding might be labeled intuitive, mathematical, and applicability, for example. By identifying and threading these through a series of subjects, learning can be reinforced and delivered more effectively.

Manage artifacts Manage courseware as a set of artifacts. This tactic implies that course materials are treated as a set of defined knowledge artifacts stored in a known place. The word "manage" implies things such as tracking, version control, quality metrics, and so on.

Budget appropriately Developing (and improving) course materials is a significant cost, and in this tactic this cost is recognized and budgeted for appropriately.

Specify increments of quality Specifying increments of quality allows incremental and visible improvement.

Create subject contracts Create specific levels of knowledge as entry and exit conditions for subjects, so that dependent subjects meet each others entry and/or exit conditions. This could be structured, for example, as a "must-know" set of knowledge items in the precondition of a subject, accompanied by a "will-know" set of post-conditions. That is, if the pre-conditions of the subject are met, the subject guarantees that the post-condition will be met (subject to reasonable assumptions on student participation).

Adopt a lifecycle model Adopting a lifecycle model for course development will increase visibility into the status of a course, improve the chances of identifying where work is needed, and increase the likelihood of achieving the desired results.

Adopt an evolutionary delivery lifecycle Evolutionary delivery (figure 1) is a life-cycle model that allows a project to be "steered" towards the final deliverable in a series of stages. In each stage, customer feedback is used to determine the exact direction of the product for the next stage. The basic architecture, though, is not changed.

Evolutionary delivery may be a good model for course development, if we view "customer feedback" as feedback from students and course review, and a "stage" as one semester of teaching (and refining) the course. See figure 2.

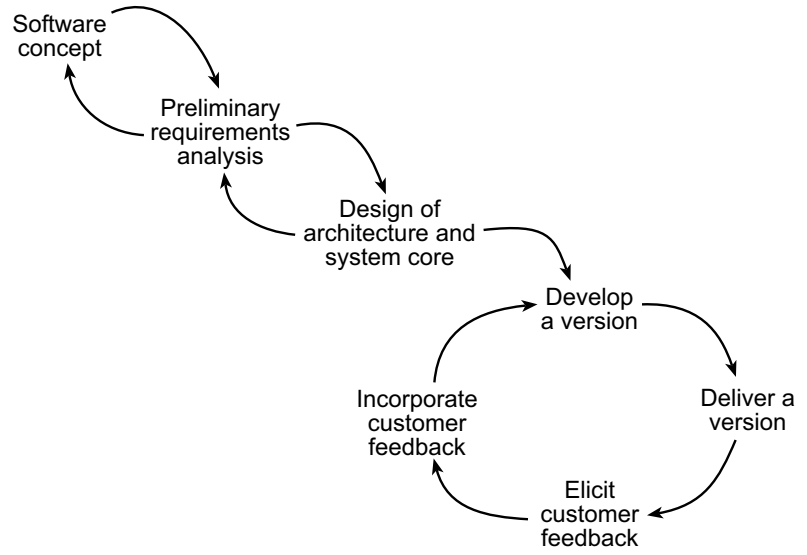

Figure 1: The evolutionary delivery lifecycle

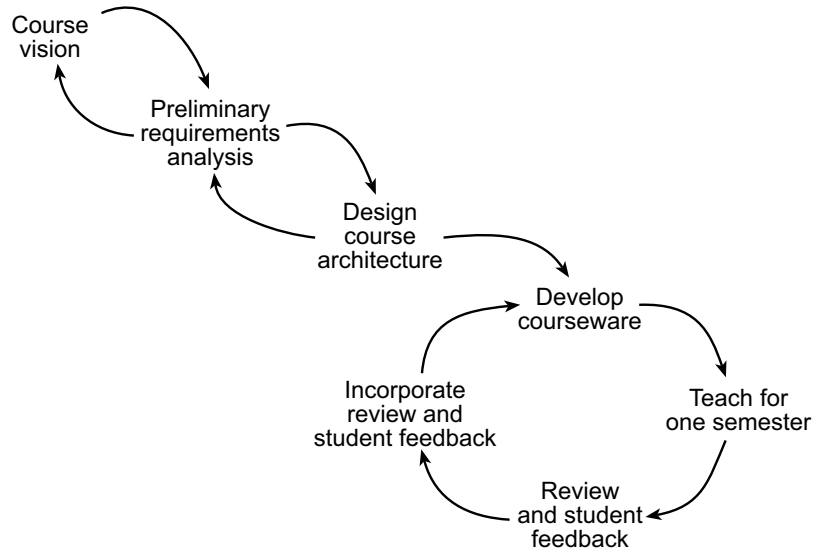

Figure 2: The evolutionary delivery lifecycle applied to curriculum development

Use outside courseware Use of materials from "outside" can range from pinching a few slides from someone else's presentation (not suggesting we do this, just noting that it's done), to adopting a complete course that has been published with the intention of having it reused (such as the MIT open courseware initiative). In between are various other resources, such as:

- Textbooks
- Published course modules
- Published presentations
- Online tutorials and websites

Clarify teaching methods Regardless of chosen teaching methods, they will not be implemented effectively if academic staff do not understand them. For example, the phrase "problem-based learning" appears to have a number of interpretations, one of which could be characterized as "if it's done on a computer, it's problem-based learning." Therefore, ensure that any suggested or encouraged teaching approaches are properly understood by all concerned.

Create a course metric space An extension of the Incremental Quality tactic is to create a metric space in which courses and course materials can be placed. This tactic improves visibility and increases the manageability of the set of artifacts.

Create modules By creating a course as a set of self-contained learning modules, qualities such as Adaptability and Modifiability should be enhanced.

Create self-paced modules A self-paced module is one that a student can undertake in his or her own time, without scheduled lectures and laboratories. Self-paced modules are useful in situations where students do not have required background and need additional learning, or for remote delivery.

2 Specifics

This section contains more specific information for discussion and adoption or rejection.

2.1 Realignment of telecommunications subjects

Figure 3 illustrates the current telecommunications major, with (for clarity) two "choice subjects" placed within the program — that is, OOD and Mobile Communications. Arrowed arcs indicate a pre-requisite dependency.

Figure 4 illustrates a revised course structure. Clearly, other subjects would need to be moved to accomodate this change, to make space in Stage 4 for Signal Theory. The key changes are:

- Break the dependency between Signal Theory and Circuit Analysis.
- Adjust dependencies so that Signal Processing is "between" Signal Theory and Communications Theory.
- Move Signal Theory and Signal Processing forward a year.

2.1.1 Justification

This adjustment of the course structure would have several benefits:

- Students will take an additional course devoted to telecommunications material prior to taking the demanding Communications Theory subject.
- By moving Signal Theory forward a semsester, there is no longer a one-year break between subjects containing any telecommunications material.
- Signal Processing and Communications Theory will no longer need to revise the same material.
- It is an opportunity to develop a strong sequence of inter-locking telecommunications subjects, that is "owned" by the Telecommunications program.

2.1.2 Issues and risks

The following issues would arise from this change.

- Re-scheduling of at least one subject in Stage 4 is required

  There has been some discussion of re-aligning the communications network-related subjects, so this shift could perhaps be tied together with it.
- Signal Theory and Signal Processing cannot depend on Circuit Theory

  Some material that is currently in Signal Theory or Signal Processing depends on material introduced in Circuit Analysis. This is much less than previously, but the remnants of the dependency are still present.

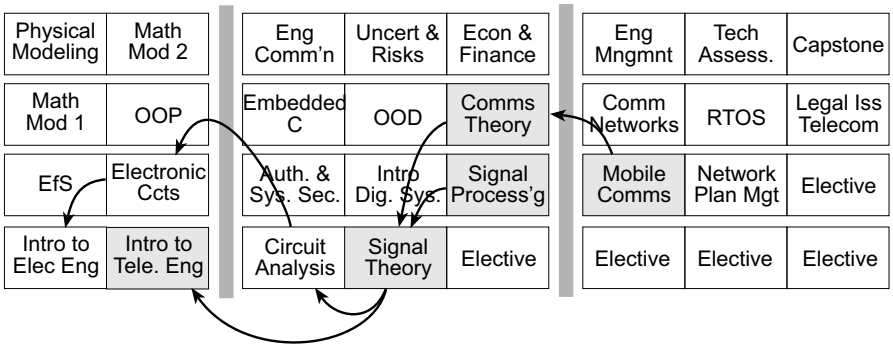

Figure 3: Current course structure

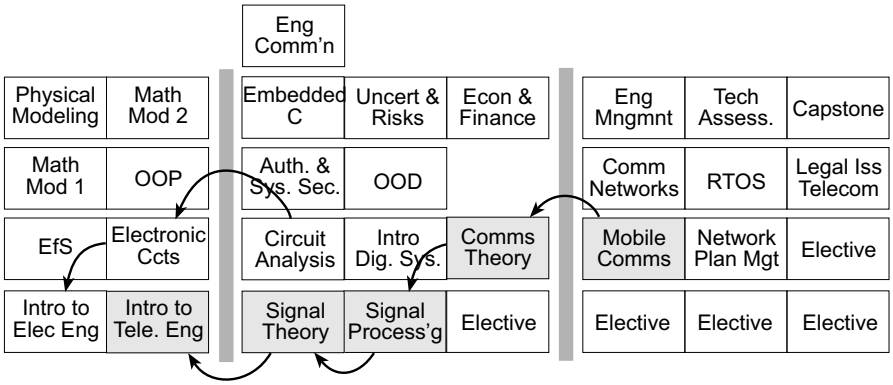

Figure 4: Revised course structure

2.2 Content threads

A tactic suggested in section 1.4 is to thread content through a series of subjects so as to make delivery and learning more effective. This is in contrast to the conventional approach in which key content areas are listed and then allocated to consecutive subjects in presumed order of increasing difficulty.

Given the sequence of subjects proposed above, it should be possible to introduce content more gradually and allow better development of student understanding of key concepts. This should help address current concerns with students being unable to adequately absorb basic but non-trivial concepts (such as Fourier Theory).

Following are a set of content areas proposed as a starting point for discussion and further refinement. Figure 5 illustrates a possible way of threading these through the telecoms subjects.

Signals and systems

- Continuous and discrete signals
- Sampling and reconstruction,
- Linearity and time-invariance
- ....

Frequency and time domain

- Relationship between the frequency and time domain
- Fourier series
- Filtering
- ....

Advanced transforms

- Stability
- Z-transforms
- s-transforms
- ....

Statistical methods and random processes

- Random variables
- Random processes
- Noise sources
- ...

Modulation and transmission

- Modulation schemes
- Signal to noise
- Limits on transmission,
- Complex envelope
- ....

Computation

- Procedural forms of transforms and filters
- State machines
- Hybrid systems
- ....

Physical propagation

- Wave propagation
- Vectors
- Power and fields
- Transmission lines
- Antennae

Systems theory

- Systems integration
- Optimization
- Distributed systems
- Protocols

- Authentication and security
- Capacity planning
- Real examples eg GSM

2.2.1 Justification

Streaming the course material for several subjects into these threads should enable and encourage discourse about their nature and content *before* getting into discussions about what exactly should go into which subject. By doing so, we will be able to allow threads to re-inforce each other when we do allocate specific topics to different subjects.

As an example of why this is needed, consider that at present, modulation is introduced (at an intuitive level) in ITE. There is, however, very little further discussion of modulation until the advanced Communications Theory subject, a full two years later.

2.2.2 Issues and risks

- No suitable textbooks

  This is a real issue, although not one we don't face already (there are no "suitable texts" for ITE or Comms Theory). One way of addressing this would be to consider the possiblity of texts that span multiple subjects.

- Cost of developing materials

  This approach may result in substantial course realignment, implying a high cost in redevelopment of course materials. There are two responses to this, the first being that since we are discussing course revision anyway, we are at least open to this being the case. Also, the cost can be alleviated by adopting some of the tactics in section 1.4 (such as defining quality increments, reuse of materials, and properly managing artifacts).

2.3 Levels of Understanding

Another tactic suggested in section 1.4 is threading the development of levels of understanding through a series of subjects. This section suggests a possible set of levels of understanding as a starting point for further refinement. Figure 6 illustrates a possible way of threading these through the telecoms subjects.

- Intuitive

  An intuitive understanding of telecommunications concepts. Intuitive understanding provides a basis for deeper work such as mathematics or simulation.

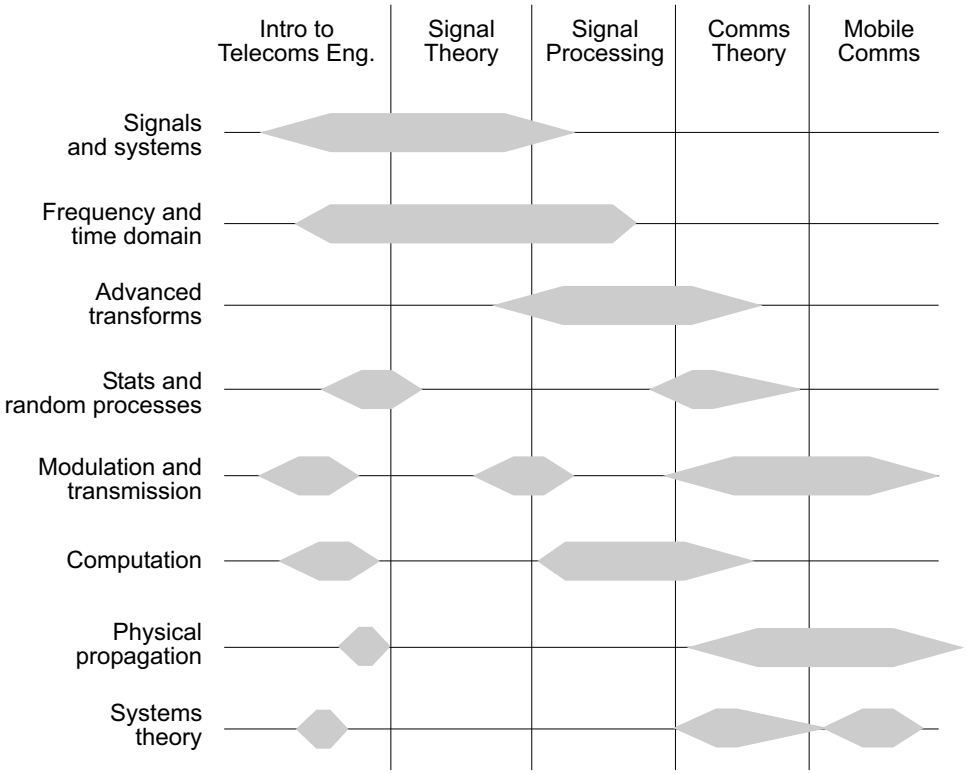

Figure 5: Threading of content through the course

- Mathematical

  Ability to perform and understand the necessary mathematical manipulations in signal and communications theory.

- Applicability

  An understanding of how particular telecommunications concepts are applied in real systems.

- Problem-solving

  Understanding how to approach solving unknown problems at various levels of complexity.

- Simulation

  Knowledge of how to use Matlab (or a related language) to perform simulations of telecommunications concepts and systems.

- Programming

  Knowledge of how to implement telecommunications modules and systems in a conventional programming language such as Java or C, culminating in ability to implement on real-time platforms.

These levels complement and reinforce one another — for example, intuitive understanding is reinforced by mathematical understanding; both can be enhanced with development of simulation skills; programming skills are based on solid mathematical and simulation foundation.

A possible threading through the subjects of interest is shown in figure 6. In overview, intuitive and simulation understanding are introduced in the first subject, ITE. Mathematical understanding is introduced and further developed in Signal Theory and Signal Processing. Programming is introduced in Signal Processing and carried through Communications Theory into the Capstone subjects.

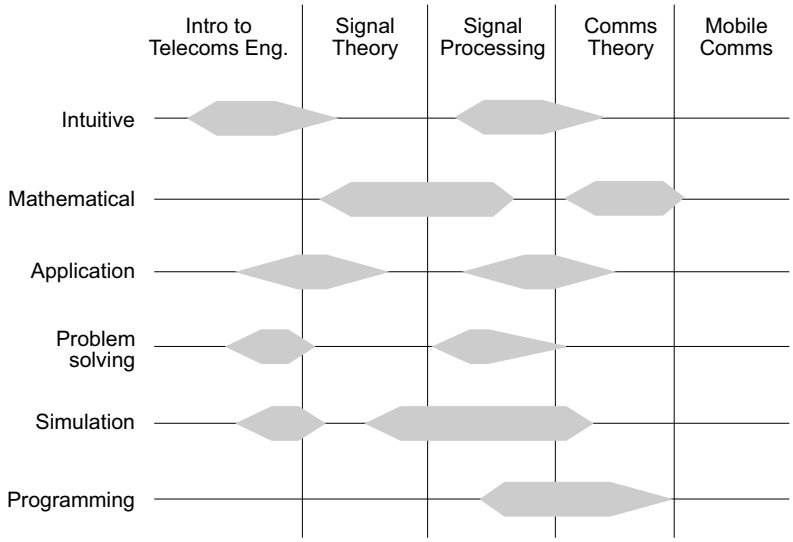

Figure 6: Threading understanding levels through the course

3 Specific Recommendations

At this stage in the re-architecting of this strand, there are only three specific proposals:

- That we change the course structure as described in section 2.1 to create a distinct series of telecommunications-specific subjects.
- That we adopt the notion of content threads as a tool for understanding and structuring the content in this series of subjects.
- That we adopt the the notion of threads of understanding levels as a tool for understanding and structuring delivery of this series of subjects.

Therefore, I suggest that telecoms faculty meet and make the following determinations based on this report:

1. That faculty adopt (or reject) the change to course structure proposed in section 2.1.
2. That a small working group (three people) be created to develop a strategy for course realignment to accomodate the above change.
3. That faculty adopt (or reject) the notion of content threads, and discuss the names and nature of these.
4. That faculty adopt (or reject) the notion of threads of understanding levels, and discuss the names and nature of these.
5. That faculty brainstorm on the course qualities described in sections 1.3 with the goal of producing a revised and extended set of qualities.
6. That faculty discuss the relative importance of the qualities.
7. That faculty brainstorm on the tactics described in sections 1.4 with the goal of producing a revised and extended set of tactics.
8. That a small (four people) working group be formed to consolidate and refine the results of the discussion for items 3 to 7, to be re-presented to the larger group on an agreed date.

Appendix A: meeting notes

August 15th, 2003

The following is from John Reekie's random meeting notes. Please advise him of any additions or corrections required. The items are **not** in chronological order.

Present: John Reekie, Keiko Yasukawa, Martin Evans, Sam Reisenfeld, Anthony Kadi, Tim Aubrey

1. TA proposed that the scope of this course revision proposal cover only ITE, Signal Theory, and Signal Processing, and that the end point for initial review by the pre-requisite requirements of Comms Theory.

2. AK raised the question of whether graduate attributes be considered. TA seemed to be less than keen on pursuing this approach.

3. TA pointed out that the current subjects are now accredited and any proposed changes need to consider this.

4. KY raised the question of how the content in these courses is being taught and learnt. Related pedagogical issues raised included: how to challenge students (in particular the more capable students) without leaving any behind; assessment of student learning; how to give more feedback during the course given our resource constraints. (Structured student study groups were suggested for the last item.)

5. It was suggested that reviewing requirements of capstone projects and/or what papers we expect student to be able to read, would provide input into the revision process.[1] This somewhat runs against TA's scope proposal.

6. KY commented that the statistical content of Uncertainty and Risks in Engineering could perhaps be modified as a result of this process of refining the telecommunications strand.

7. SR raised the question of the objective of any proposed revisions. 1. Well-regarded by international standards? Or 2. To tailor graduates to the Australian market? The former appeared to be favored (TA).

8. TA commented that we see the undergraduate course as the starting point of students' education, not the end point.

9. SR provided a sheet containing recommendations; specifically (summarizing): the need for more mathematics coverage; a coordinated approach

[1] More from KY: One thing I raised which isn't explicitly recorded here, which I think would be useful to record, is to look at the development of student's technical literacy - ie to develop their confidence and skills to access, interpret and evaluate technical sources independently. I think we talked about collecting samples of the sorts of journal articles that would expect students to be able to work with towards the end of their course.

across the subjects Matlab knowledge and skills; a coordinated approach to Math knowledge and skills. He also provided a list of referees for external assessment of proposed changes (to be listed in body of this report).

10. Preliminary report to be completed by JR by September 26th. This day is proposed for the Telecoms staff retreat; if that doesn't occur, the meeting to discuss the proposal will be in the afternoon of that day anyway.

Appendix B: Other material

3.1 Referees

Following is a list of referees who could be used to review our proposed course changes.

3.2 Textbooks and course materials in current use

3.2.1 Textbooks

Kamen and Heck *Fundamentals of Signals and Systems using the Web and Matlab.* The recommended text for Signal Theory.

McClellan, Schafer, Yoder *Signal Processing First.* The recommended text for Signal Processing.

Sklar *Fundamentals of Digital Communications* One of the (two) recommended texts for Communications Theory.

Proakis and Salehi *Contemporary communications systems using Matlab.* The other recommended text for Communications Theory.

3.2.2 Printed/printable material

Signal Theory notes UTS Engineering course notes. (Electronic? author?)

Signal Processing notes UTS Engineering course notes. (electronic? author?)

3.2.3 Online material

3.3 Textbooks and course materials for potential use

3.3.1 Textbooks

Lee and Varaiya *The Structure and Interpretation of Signals and Systems.* This text is used in the corresponding course at UC Berkeley and is in the process of being disseminated to other colleges as part of the CHESS program (http://chess.eecs.berkeley.edu). The text includes extensive Matlab-based exercises and labs, and an instructor's guide[2] An accompanying website contains material used in lectures (see below).

Bateman *Digital Communications*

[2]I don't think the instructor's guide is formally published but I have access to it – JohnR.

3.3.2 Printed/printable material

3.3.3 Online material

EECS20 website The website matching the *Structure and Interpretation of Signals and Systems* text. See http://ptolemy.eecs.berkeley.edu/∼eecs20.[3]

MIT Open Courseware MIT have made the courseware for a number of their courses available online. Most of the MIT course offering is supposed to be going online shortly. See http://ocw.mit.edu/.

[3] If needed, I expect I can obtain permission to place a copy of this site locally.