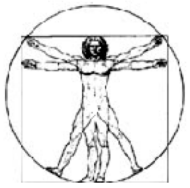
Electrical and Computer Engineering

ELEC 391
Electrical Engineering Design Studio II



Technical Communications and Project Management

Introduction to project management. Problem definition. Design principles and practices. Implementation techniques including circuit design, software design, solid modeling, PCBs, assembling, and packaging. Testing and evaluation. Effective presentations. [2-0-4]

- During this lecture, the instructor will bring up many points and details not given on these slides. Accordingly, it is expected that the student will annotate these notes during the lecture.
- The lecture only introduces the subject matter. Students must complete the reading assignments and problems if they are to master the material.

Introduction

A scientific experiment, no matter how spectacular the results, is not completed until the results are published. The research scientist [and professional engineer], perhaps uniquely among the professions, must provide a written document showing what they did, why it was done, how it was done, and what was learned from it. The key word is reproducibility. That is what makes scientific [and technical] writing unique.

- Robert A. Day, 1988

"*Enhancing technical communication skills of engineering students: An experiment in multidisciplinary design" (2001)*

- *A multidisciplinary team of chemical engineering and computer science students collaborated to design a plant capable of producing commercial quantities of citric acid.*
- *A previous attempt at student collaboration on a similar project produced less than stellar results.*
- ***The most significant challenge to project success was establishing effective teamwork and appropriate technical communication across the two disciplines**.*
- *This paper describes the results of the most recent multidisciplinary team experiment, in which emphasis was placed on developing communication between student teams.*

Objectives

Upon completion of this module, students will be able to:

- Use the SQ3R technique to improve their ability to assimilate information in technical documents.
- Describe the factors that affect the manner in which the listener, reader or viewer interpret a message.
- Identify ways in which miscommunication can be avoided.
- Explain why technical communications is important to society, your company and your career.
- Describe the form and structure of a typical lab report.
- Summarize best practices for producing and improving technical writing.

Outline

1. The Challenge of Technical Communication
2. The Importance of Technical Communication
3. Experiments, Log Books and Lab Reports
4. Structure of a Lab Report
5. The Challenge of Technical Communication
6. Project Management & Specifications

   Summary

1. The Challenge of Technical Communication

Survey, Question, Read, Recite, Review – SQ3R

- **A 'best practice' for assimilating the contents in detailed technical documents!**
- **Survey** the document highlights, including section headings, key definitions, key equations, key figures, and example problems.
- Turn section headings and key issues into **Questions**.
- **Read** each section with an aim to answering these questions and mastering specific types of problems.
- After reading a section, **Recite** the key points and techniques without referring to the text or your notes.
- **Review** the entire document, then, as applicable, attempt to: (1) answer the review questions and (2) solve the example problems without reference.

The Challenge of Technical Communications

- Many factors affect the manner in which the listener, reader or viewer interpret a message.
- There's often a significant gap between what was meant and what was understood.
- Misinterpreted communications can be costly!
- How can we avoid this?

What was meant.

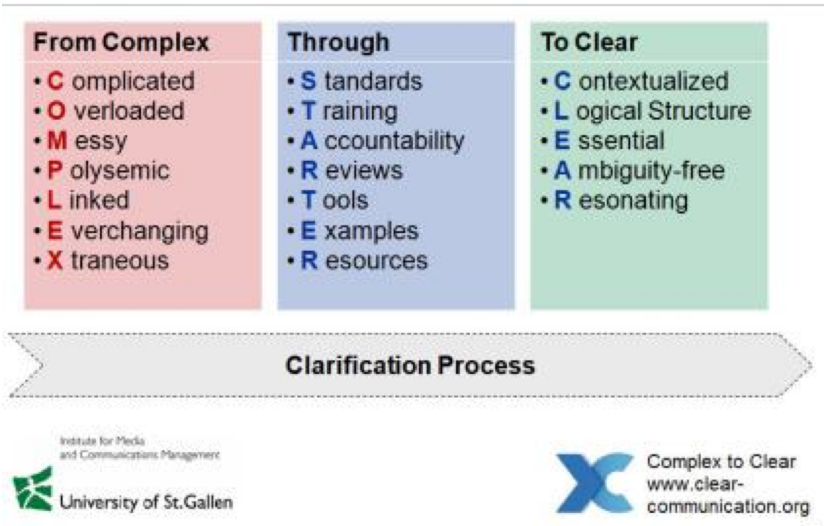
What was understood.

Factors That Affect Interpretation

- What factors affect how an individual interprets a conversation, document or presentation?
  - Knowledge of the Topic or Issue
  - Experience with the Topic or Issue
  - Exposure to Similar Previous Communications
  - Interest in the Topic or Issue
  - Stake in the Topic or Issue
  - Relationship to the Speaker, Writer or Presenter
  - Clarity of the Communication.
- Accordingly, it's vital that we make every effort to understand our audience and their *background and expectations*.

Clarity of Communication

- Of the factors mentioned on the previous slide, there's only one that we, as communicators, have any real control.
- What steps can we take to improve the clarity of our technical communications?

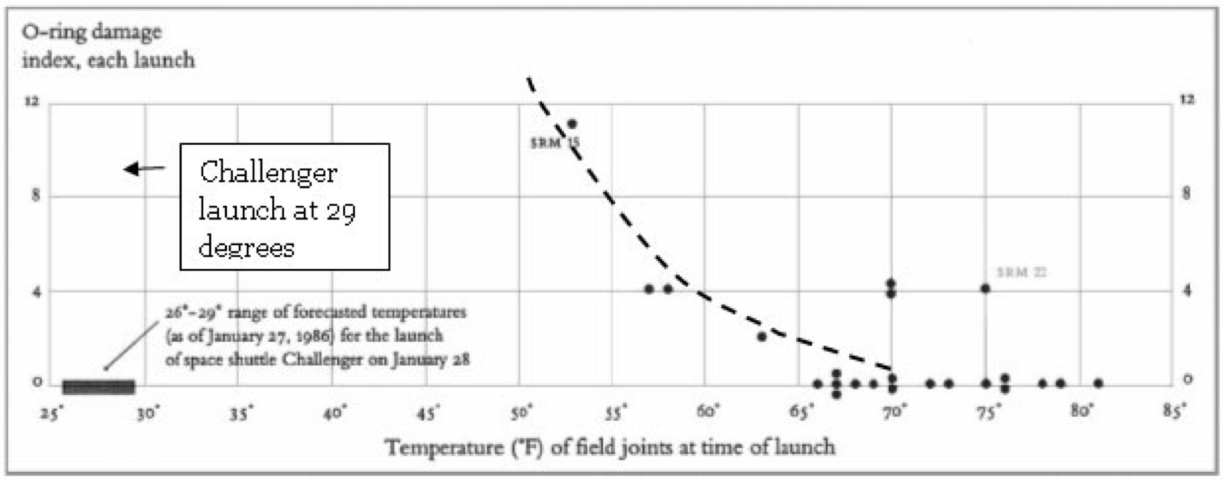


Clarity of Communication

- Of the factors mentioned on the previous slide, there's only one that we, as communicators, have any real control.
- What steps can we take to improve the clarity of our technical communications?
  - **State the request, claim, or contribution up front!**
    - Follow up with supporting evidence that convinces the listener, reader or viewer of the validity of our message.
  - **Acknowledge your readers' background(s)** when designing the flow of arguments, points or evidence that will draw the listener, reader or viewer into your case.
    - Take control of the organization of your document.
  - **Make use of standard presentation formats.**
    - Surprise with the conclusions and evidence not the sequence or method of presentation.

The Role of Presentation Graphics

- Edward R. Tufte, *The Visual Display of Quantitative Information,* 1982 + multiple editions.
- Clear presentations graphics builds insight and supports effective decision making.

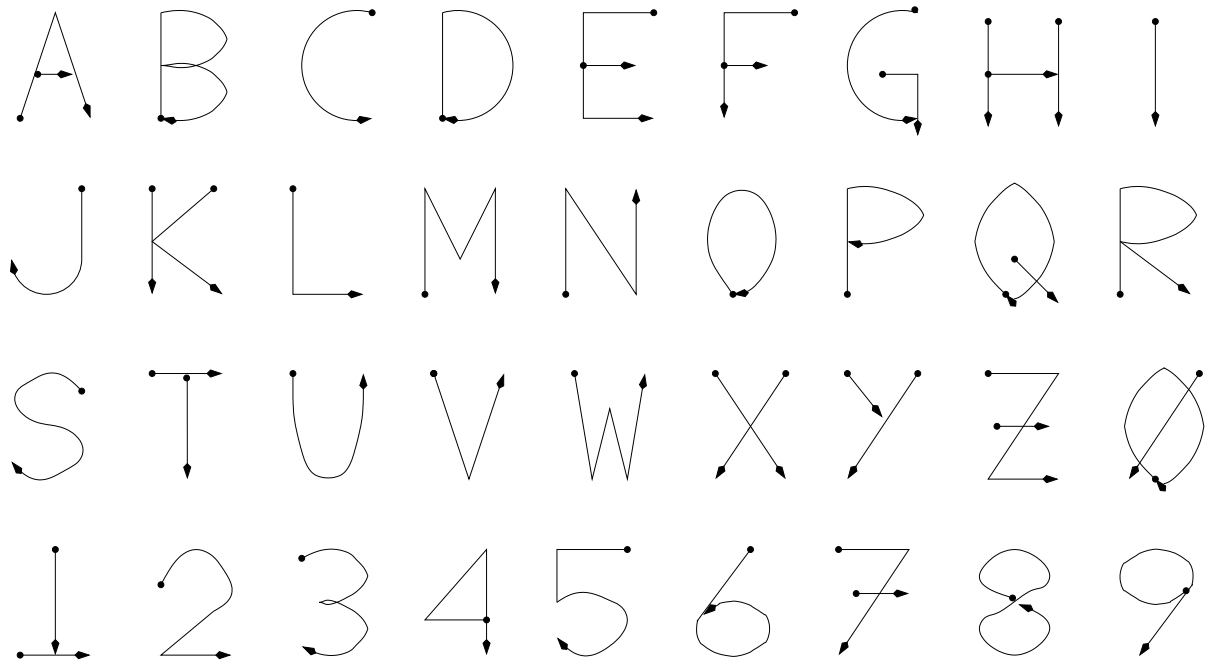


The Role of Freehand Writing and Sketching

(or the Importance of Informal Technical Communications)

- As an engineer, you won't always have the luxury of preparing technical notes or documents using a word processor.
- At meetings, in the shop, or in the field, you will often be required to record data or prepare memos, notes, plans, and other documents freehand.
- First impressions count, and your technical writing often precedes you.
- Make your freehand documents easy to read and understand:
- Learn to organize your thoughts, block or speed print quickly and neatly, and draw a straight line, box, or circle without a ruler or compass.

Block or Speed Printing



Do Your Freehand Documents Stack Up?

- Do you think and plan ahead before you write?
- Are your notes, solutions and other documents neatly laid out and well-organized?
- Will others (colleagues, superiors, subordinates) be able to understand your work?
- Will you be able to understand your own work (long) after you wrote it?

Organization and layout are key, but don't overdo it!

The Ultimate Challenge

- One doesn't become a good technical writer just like that!
- One has to feel the need, have the desire, and make the commitment.
- Three ways to become a good technical writer:
  - Read technical articles and then reflect on what you like and don't like about their organization and presentation.
  - Seek out and read tutorials on technical writing and then reflect upon the advice and wisdom they contain.
  - Devote time and effort to technical writing. Seek to create works that meet your increasingly rigorous standards.

2. The Importance of Technical Communication

Why Technical Writing is Important to Society (and your Company)

- It documents objectives, procedures, data and results for the benefit of current and future researchers or engineers.
- It provides a complete story that can be subjected to peer review by other researchers or engineers.
- It persuades others to accept or reject hypotheses based upon the data presented and the interpretation provided by the author.
- It contributes to the accepted body of scientific and technical knowledge within a lab, a company or a profession.

Why Technical Writing is Important to Your Career

- It provides you with an opportunity to influence the opinions of others by formally presenting your facts, results and arguments in a logical manner.
- The lab reports, memoranda, progress reports or project reports that you prepare and submit to management, clients and colleagues provide the basis upon which others will judge both you and your effectiveness.
- A technical writer can only help by revising individual sentences and paragraphs and ensuring that the format of the report conforms to specification.
- Organization of the report, formulation of the logical arguments, and provision of technical content are your responsibilities!

3. Experiments, Log Books and Lab Reports

The Purpose and Design of Lab Experiments

A lab experiment involves observation or measurement of a phenomenon, usually under controlled conditions, for the purpose of:

- Discovery.
- Verifying theoretical predictions or testing a hypothesis.
- Measuring a parameter or quantity.
- Empirical modeling of the relationship between parameters or quantities.
- Proof of performance or verifying compliance with standards.
- Determining the limitations of test and measurement equipment.

Why Log Books are Important

For both legal and practical reasons, lab data should never be recorded on loose or scrap paper. Instead:

- All data and notes should be recorded in a bound log book which should be reviewed and signed periodically by one's supervisor.
- Sketches and graphs should be drawn using good engineering technique.
- Mistakes and errors should be neatly crossed out, never erased or obscured.
- Serial numbers of all major equipment should also be recorded in case it is later suspected that poor results may be due to faulty equipment.
- Results of analysis or reduction of the data, including quick sketches of results and names of data files, should also be recorded.

Why Lab Reports are Important

A lab report is a formal document that describes the results of one or more experiments in a form suitable for distribution to management, clients and colleagues.

- It is based upon the results and analysis contained in the laboratory log book.
- It complements but does not replace the follow on progress reports, memoranda, project reports, and primary research articles.
- Its organization is rigidly defined, although section titles may vary from discipline to discipline.
- It is *not* expected to be great literature, but it *is* expected to be carefully and clearly written.

4. Structure of a Lab Report

Structure of a Lab Report

Most lab reports have eight sections:

- Title
- Abstract
- Introduction
- Methodology (or Procedure)
- Results
- Discussion
- Conclusion
- References

- Additional material that is too detailed or voluminous to be included in the main report may be presented in one or more appendices.

The Title and Abstract

- The Title should accurately reflect the specific subject matter of the report in less than ten words.
  - It should contain keywords that a researcher would be likely to submit to a searchable index or search engine.
  - It should not attempt to be “cute” or incorporate slang.
- The Abstract should summarize the objectives, methodology, results and major conclusions of the study in a single paragraph of between 100 and 250 words.
  - It should be written in the past tense, because it refers to work done.
  - It should never give any information or conclusion that is not stated in the report.

The Title and Abstract - 2

- Experience has shown that:
  - a good Abstract is often followed by a good report while a poor Abstract is often a sign of bad things to come.
  - most readers and reviewers form their first impressions of a report after reading only the Abstract.
- Professional scientists and engineers spend more time honing and perfecting the abstract than any other section of their report.
- When writing an Abstract,
  - assume that the reader is fairly knowledgeable concerning the topic.
  - choose every word very carefully; the most common fault is inclusion of extraneous or unnecessary detail.

The Introduction Section

- Introduces the topic in general terms.
- Summarizes the goals or purpose of the experiment, including:
  - the problem(s) that were considered and why they're important.
  - any relevant background information or theory, including limitations of previous work that will be overcome here.
- Summarizes the approach(es) that were used to:
  - solve the problems.
  - measure the quantities of interest.
  - evaluate the quality or characteristics of the devices under test.
- Is normally between 1/2 and 3/4 of a page in length.

The Methodology (or Procedure) Section

- Describes the approach(es) and techniques mentioned in the Introduction in greater detail.
- Lists the specific equipment and materials used in the experiment.
- Should be sufficient to allow “one skilled in the art” to reproduce the experiment at a later time.
- Should be worded rather tersely and in the third person.
- Should make good use of sketches and diagrams; a well-organized and carefully drawn sketch is often worth a thousand words.

The Results Section

- Accurately presents:
  - the data collected,
  - the graphical presentation or analysis of the data, and,
  - the reduction techniques applied to the data.
- Reveals any quantities extracted from the data, *e.g.*, mean and standard deviation of distributions, slope and intercept of regression lines, *etc.*
- Should accurately indicate units, measurement uncertainty, and significant figures.

The Discussion Section

- Presents your interpretation of the results.
- Comments on the similarities and differences between theoretical predictions and experimental observations.
- Offers suggestions concerning possible sources of experimental error or shortcomings in the theoretical model.
- Resolves the issues raised in the Objectives section, *e.g.*,
  - parameters to be measured.
  - hypotheses to be verified.
  - insights to be gained.
- Does not re-state material already presented in the Introduction and Methodology sections!

Conclusions

- Are not a summary of the entire lab report!
- Summarize the essential outcomes and implications of the work that are of interest to others.
- Are largely based on material presented in the Discussion section, *e.g.*,
  - parameters measured.
  - hypotheses verified.
  - insights gained.
- May also offer recommendations for follow-on work that will overcome any limitations or shortcomings of this work.

References

- References should be formatted according to standard practice.
- In Electrical and Computer Engineering, this usually means following the IEEE convention.
- *Cf*. the IEEE style guidelines for technical papers at
  - IEEE Editorial Style Manual http://www.ieee.org/documents/stylemanual.pdf
  - IEEE Information for Authors http://www.ieee.org/documents/auinfo07.pdf

5. Best Practices for Technical Communication

Best Practices

- Don't lose sight of the objectives of your work.
- Immediately after analyzing and reducing your data, draw preliminary conclusions in point form and, if possible, discuss them with your colleagues.
- Plan your document or presentation before you start to write. Develop an outline that includes the major points that you plan to make in each section.
- Focus on the structure and flow of ideas in the document or presentation, not individual sentences.
- Recognize that your main goal is to organize your facts and arguments in a logical and persuasive manner, not to produce great literature (although the latter would be a bonus!)

Best Practices - 2

- Use your log book to assemble your results before finalizing your outline.
- Ensure that each point is included in the appropriate section (*e.g.*, don't include a description of your procedure in the results section.)
- Ensure that there is good correspondence between your objectives and conclusions.
- Ensure that you don't attempt to restate or summarize the entire report in your conclusions section. Focus on outcomes and implications, instead.
- Recognize that technical writing is inherently difficult, and that practice makes perfect.

How to Approach Technical Writing

- Ron Blicq's *Technically Write!* approach can help you make short work of memos and other short documents.
- Get right to the point: The key message (be it an observation, statement, conclusion or request) should appear in the first paragraph.
- The first paragraph should make sense:
  - if it stands alone
  - if preceded by the words "*I want to tell you that…*"
- The paragraphs that follow should contain only the supporting evidence or remarks that support the key message.
- Each paragraph should focus on a single issue. Don't change in mid-stream! Be concise!

References

Because virtually everyone in the sciences, applied sciences and medicine writes technical reports and gives technical presentations, there is a large body of literature concerning their preparation and delivery. Avail yourself of them!

- R. A. Day and B. Gestel, *How to Write and Publish a Scientific Paper*, 6th ed. Oryx Press, 2006.
- R. A. Day and N. Sakaduski, *Scientific English: A Guide for Scientists and Other Professionals,* 3rd ed. Westport CT: Greenwood Publishing Group, 2011.
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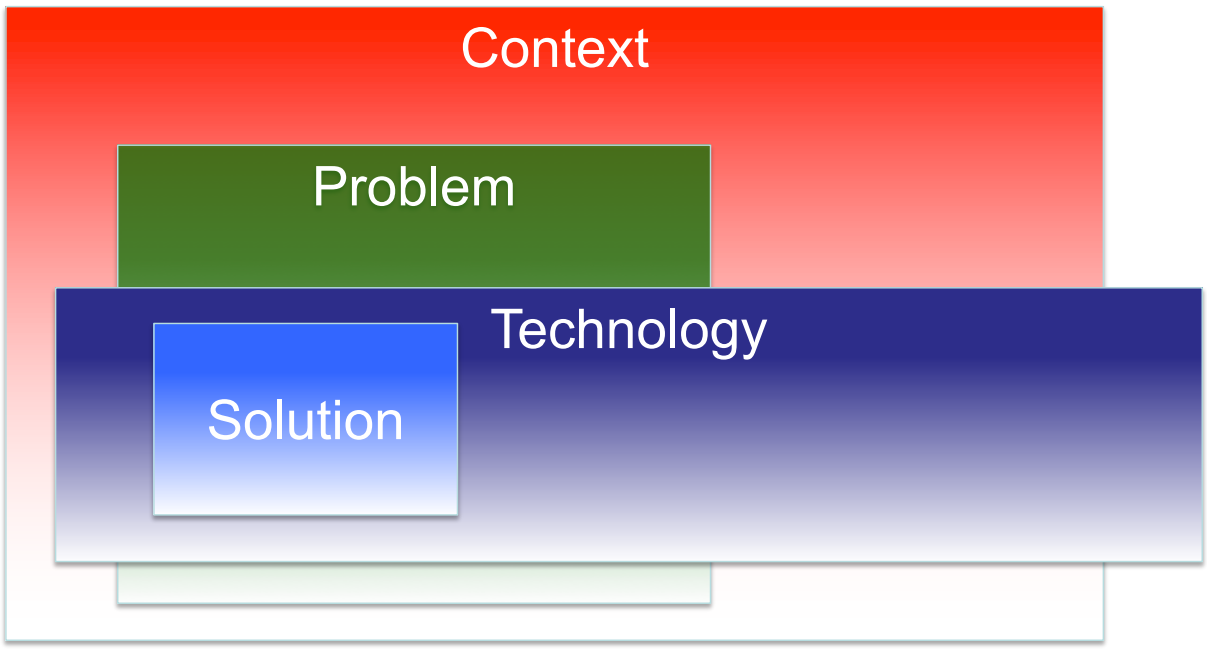
- Engineering Communication Centre Staff, “Online Handbook,” Univ. Toronto, Toronto, ON. [Online] Available: http://www.engineering.utoronto.ca/Directory/students/ecp/handbook.htm
- D. Kowalski *et al.*, “Introduction: Electrical Engineering Lab Reports,” Colorado State Univ., Fort Collins, CO, 2005. [Online] Available: http://writing.colostate.edu/guides/documents/eelab/

6. Project Management & Specifications

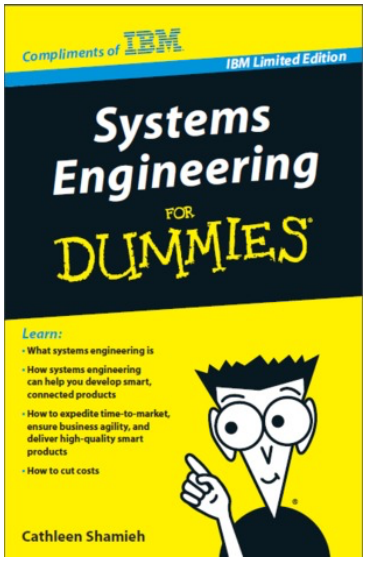
Four Elements of the Problem Solving Scenario

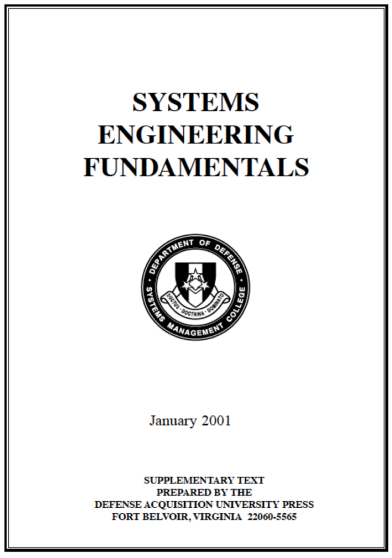


Project Management

- Effective time management is vital
  - It's much more difficult as a professional than as a student.
  - Develop good habits now!
- Planning involves identification and ordering of tasks.
  - A *Work Breakdown Structure* is used to divide a project into manageable tasks.
- Scheduling involves assignment of tasks to resources and time.
  - A *Gantt Chart* is used as a visual aid to scheduling.
- A *Systems Engineering* approach allows a logical and methodical approach to:
  - testing and troubleshooting, and
  - management of large numbers of people.

Electrical & Computer Engineering involves system level design much more than, say, Mechanical or Civil Engineering do.

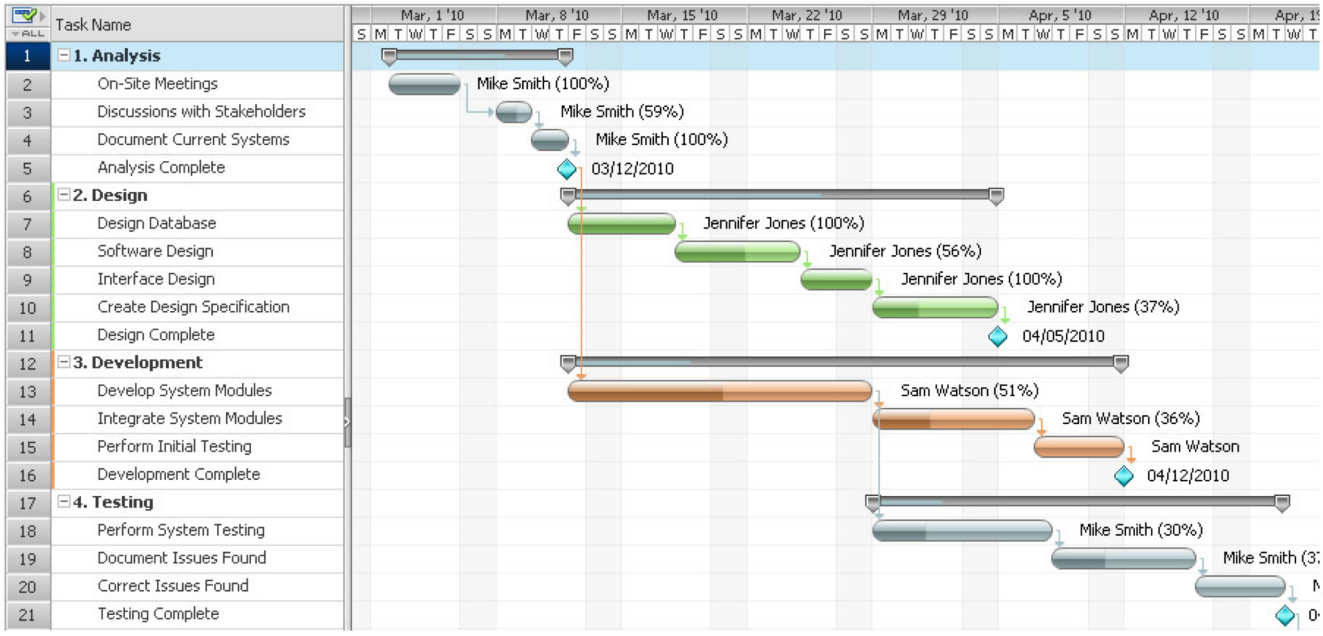




Major Stages in the Development Life Cycle

- **Background Phase**
  - Interview the client/user
  - Review the literature
  - Set overall requirements and specifications
- **Systems Phase** (one core group oversees the project)
  - Propose a configuration or architecture
  - Set requirements or specifications for each functional block
- **Implementation Phase** (possibly many activities in parallel)
  - Implement each functional block
  - Verify function and performance; troubleshoot as required
- **Integration and Test Phase**
  - Combine functional blocks
  - Verify function and performance; troubleshoot as required
  - Deliver result to client/user

A Typical Gantt Chart



Work Breakdown Structure Schedule

Major Decisions over a Project Life Cycle

- **Performance**
  - The design process must set specifications that can be used to verify that performance goals have been met.
- **Time**
  - Be careful not to let the initial tasks consume more than their share of the allotted time!
- **Cost**
  - Keeping costs and resources within budget is an essential task for the project manager.
- **Risk**
  - All new work involves risk; contingencies must be devised.

Summary

- Technical Communication involves fundamental challenges; what was meant isn't always what was understood!
- Technical Communication is important to society, your company and your career for a variety of reasons.
- An Experimental Proposal or Plan, entries in a Log Book and a completed Lab Report are three important stages in the documentation of technical work.
- All Lab Reports follow a common structure with specific types of information restricted to specific sections.
- Adopting best practices for Technical Communication and Project Management is a way to become more effective, more efficient and more confident.