Project Memo

Acoustic Messenger*

Version 1.0

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Contents

1 Introduction

This project memo defines the purpose, workflow, requirements, and grading in the project in the course Communication Engineering, SSY121. **It is essential to read this memo before the first project team meeting.**

1.1 Purpose and background

There are two main reasons for doing this project. First, it is mandatory to pass the project in order to pass the course. Secondly, you might learn something useful for your future studies and career. We hope that you will not only gain *technical* insights through the project but also learn about *development projects* and about *working in teams.*

The *technical* aim of the project is to develop the physical layer of a message transceiver (simple transmitter and receiver for digital transmission over a real-world communication link). The theory learnt in literature, lectures, and exercises will be employed in a real world scenario. Once you have completed this project, you should understand some of the general concerns of digital communications:

- Message formatting: how to form the message to facilitate synchronization.
- Modulation format: how to choose a set of waveforms that are compatible with the design specifications and the hardware constraints.
- D/A and A/D conversion: how to convert between digital data streams and analog waveforms.
- Demodulation and detection: how to distinguish between the waveforms even in a very noisy environment.
- Testing: how to verify that subsystems, and finally the whole system, work as required.

Equally important is how to work in *projects.* This project resembles a development project in industry, and it should be carried out in a similar manner. An expert from the local communications industry is available to teach these issues from a real-world perspective. After completing this project, you should understand some important aspects of project-based work methodology:

- Teamwork: how to interact with new colleagues, possibly with different backgrounds and competence, in a professional manner.
- Common values: how to enhance the efficiency and the working climate by deciding what you can expect of each other *before* the work begins.

- Planning: how to formulate an initial plan for project work, possibly with limited initial knowledge, and to realize when the plan should be revised.

- Task splitting: how to divide a complex task into subtasks, solving the subtasks independently, handing over and interfacing with each other, and assembling the result.

- Customer interaction: how to deliver documents and products under given conditions on formats, contents, and deadlines.

1.2 A role-playing scenario

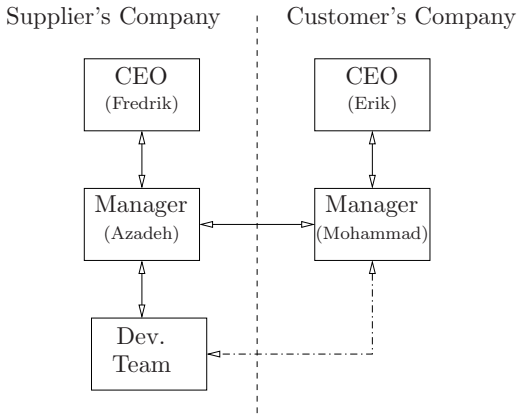
To mimic an industrial project, an imaginary company (customer) intends to purchase a software-defined communication system over a very noisy link. In this imaginary purchase, the roles are played as follows:

- The *customer*'s company is formed by a chief executive officer (CEO) and a manager. The CEO role is assigned to Erik Svenske and the manager role to Mohammad Farsi.

- The *supplier*'s company is formed by a CEO, a manager, and a development team. The CEO role is assigned to Fredrik Brännström, the manager role to Azadeh Tabeshnezhad, and the development teams to the group of students.

- Of course, everything regarding *price and costs* is fictive. No real money is involved.

In the following figure, the role-playing structure for this project is presented. We also include connections which represent the way of how the different roles usually communicate between each other. For example, the teams should report either to the manager of the supplier's company (which they belong to) or sometimes to the manager of the customer's company. Since there is no connection between the teams and the CEOs, teams are not allowed to contact the CEOs except by using the appropriate channels (through the Managers). This is how it usually works in a real company.



Students will work together in teams of three or four, randomly selected. This is the normal situation in industry too, where employees are supposed to cooperate efficiently even with colleagues who are not their friends. See [2, Sec. 2.4] for some effects of working in new constellations.

The groups must report any kind of problem to their manager (technical or team-related) and are allowed to ask for advice during the development stage of the project.

2 Schedule and deadlines

Continuous examination is applied in this project. This means that the quality of the project work will be judged not only based on the final result but also on the process followed to obtain the final result. Hence, the process needs to be reported to the Manager, just as in industrial projects. One meeting including both managers and the team will be held to discuss the submitted proposal.

The project workflow is defined in the following schedule. Exact deadlines are defined in the course memo.

Week	Phase	Deliverable/event
2	Preparation	Registration, forming teams
2	Preparation	Start-up lecture, first team meetings, common values, RFP
3	How-study	Proposal, hearings
4	Execution	Status report 1
5	Execution	Status report 2
6	Execution	Status report 3
7	Execution	Project quiz, test report and software, sign up for demonstration
8	Wrap-up	Demonstration, experience report, Ericsson workshop

It is absolutely necessary for a successful result that the members of a team meet regularly with each other. Such meetings are scheduled by the teams themselves.

3 Execution

Many of the conditions for how to conduct the project are stated in the Request for Proposal (RFP). The team shall handle all parts and aspects of running the project. The team shall prepare a proposal according to the RFP, and when selected as a supplier perform the development and make the requested delivery.

A *deliverable* is a document or result that the team is required to submit, usually to the manager in charge or to the customer directly. In this project, the deliverables (defined below) shall be submitted through the Canvas course web page. They shall be uploaded no later than the deadlines given in the course memo. If not specified, **PDF** format shall be used (except for the time report Excel file .xls), and the number of pages shall meet the requirements below and in the RFP; no less and no more pages. The deliverables for your line manager are defined in App. B and the deliverables for the customer in the RFP.

3.1 Deliverables

- **Deliverable 1: Common values.** See template in App. B.1 of this memo. This is where the rules are defined for how the group members should work together. It is a good habit to decide on such group rules before initiating any teamwork, especially with people you do not know very well already. In particular you should discuss and make agreements on what you expect from each other during the project work. It will reduce the risk for conflicts, and if a conflict would occur nevertheless, it will guide the group members on how to handle it.
- **Deliverable 2: Proposal.** See template in App. B of the RFP. The proposal is the supplier's response to the RFP.
- **Deliverable 3: Status report 1.** See template in App. B.2.
- **Deliverable 4: Status report 2.** See template in App. B.2.
- **Deliverable 5: Status report 3.** See template in App. B.2.
- **Deviation report.** In case a supplier discovers a significant deviation from the initial plan, regarding technical solution and/or execution of the development, a deviation report must be submitted. This report must be sent to Azadeh Tabeshnezhad(*azadeh.tabeshnezhad@chalmers.se*) and it should state details about the deviation and a revised plan.

- **Deliverable 6: Test report.** The test report is to be delivered to the customer comparing the performance with each requirement in the requirement specification, cf. App. C of the RFP.

- **Deliverable 7: Software.** The MATLAB programs of the receiver part shall be attached as M-files packed into a zip file. M-files should be structured and commented enough to be readable.

- **Deliverable 8: Experience report.** See template in App. B.3 of this memo. During the wrap-up phase of the project the team shall reflect upon the experience from the project, and provide an Experience Report. The focus of the Experience Report is to comment on how you would handle a similar project in the future. Consider how the work was performed, particularly aspects on cooperation within the project. The experience of all teams will be discussed, anonymously, at an experience workshop after the course. Please help making this workshop interesting by sharing all kinds of experiences. You won't get a higher grade by claiming that your team worked well—see Sec. 4.

- **Deliverable 9: Time report.** A time report (excel file) should be *uploaded every Friday before noon* detailing the number of hours spent by each group member. You should mention the accumulated number of hours worked on the project, and the total amount of hours should be reported in the experience report. The first report should be uploaded at the end of week 2, and the file should be updated every week until week 7. A template of this report can be downloaded from the course homepage.

In the following table a summary of the deliverables is presented. The points awarded to each of the deliverable is also mentioned. Half of the points of each deliverable are awarded for submission on time and the remaining half of points are awarded if the deliverable is approved. All the deliverables should be uploaded to the Canvas course web page. We also include a column with the format name of the files to be submitted, where N must be replaced by the group number.

#	Deliverable	Name	Points
1	Common Values	CommonValues_G*N*.pdf	1.0
2	Proposal	Proposal_G*N*.pdf	1.0
3	Status report 1	SR_1_G*N*.pdf	0.5
4	Status report 2	SR_2_G*N*.pdf	0.5
5	Status report 3	SR_3_G*N*.pdf	0.5
-	Deviation report	DR_G*N*.pdf	–
6	Test report	TR_G*N*.pdf	0.5
7	Software	Software_G*N*.zip	1.0
8	Experience report	ER_G*N*.pdf	0.5
9	Time reports (updated weekly)	TimeR_G*N*.xls	0.5

3.2 Meetings with the Manager/Customer

3.3 Hearing

While evaluating the proposals, the customer may decide to call selected suppliers to a hearing, in order to discuss the proposal. When necessary, the customer may request a supplier to make changes to the proposal.

3.4 Demonstration

The customer will request a demonstration of each supplier's solution. The purpose is to test that it really works as intended. *Everyone in the team shall be able to operate the product and explain the function of all parts. Everyone shall be able to explain the selected design based on a scientific base;* in this case, based on digital communication theory and channel properties. Various plots are often useful to illustrate the product's internal operations and relate it to the scientific base. See, e.g., [1, Sec. 2.4.2, 3.2.4], [3, Sec. 5.4] for examples of such plots.

3.5 Recommended internal documents

The teams are advised to prepare the following documents as internal working documents. They should not be delivered to the customer or your manager, but parts of their contents may be included in above deliverables.

3.5.1 Design specification

This is a specification with relevant requirements on each part of the design and interfaces between the parts. The purpose is to support the distribution of the design work on the team members. The technical description to be included in the proposal is an early version of the design specification.

3.5.2 Test plan

The purpose of testing is to ensure fulfillment of the design specification and the customer's requirement specification. An early (short) version of the test plan shall be included in the proposal. The test plan should comprise a logical order of steps for performing tests, and a brief description of how to perform the tests, of subsystems as well as the final communication system.

3.6 Commercial aspects

In the real world there would be a commercial relation between the customer and the supplier. In order to give an image of what this means to a development project and to add some excitement to the project work, we have created a commercial scenario as the following steps.

3.6.1 Price bids

Each supplier (team of students) will bid for the job by offering a price as part of the proposal. The teams will therefore have to estimate the amount of work expected and calculate a bid price based on this estimation.

The price shall be calculated by using the following formula:

1. Calculate the direct cost by multiplying estimated working hours by SEK 800 (typical entry cost level for an M.Sc. employee in Sweden, including office space, computers and other equipment, taxes, and social security)

2. Since the customer requests a 1 year warranty period in the RFP, an estimate, in this case 5 % of the direct cost, is added to the price to cover expected future cost during the warranty period.

3. Add 15 % of direct cost to cover the overhead cost of the supplier's company.

4. Decide within the group a suitable profit margin to add. Imagine that the company owner wants to earn a profit from the operations, and the need for a risk margin in case the estimated working hours is too low. But you must also consider that your offer shall be competitive.

3.6.2 Contract

The customer will normally compare received bids and accept the most favorable. In this unreal situation where all bidders will actually be selected we have decided to determine the agreed price (contract price) as the average of all received bids.

At the hearing the customer may request changes in the proposal. When the customer is prepared to accept a proposal, the supplier is offered a

contract at the price calculated according to the rule above. That is, the team will be asked to go ahead with the project.

3.6.3 Reporting of hours worked

In order to determine if your project will be profitable or not you must keep track of the time you spend on the project.

3.6.4 Final payment

If delivery fulfilling all requirements is done within the deadline full payment (according to contract price) is granted. If the delivery is delayed and/or the performance is reduced, the customer will demand a payment reduction in the range 5–25 % depending on the situation.

3.6.5 Business outcome

The imaginary business outcome for each supplier can be determined by relating the hours worked to the final payment (contract price with or without reduction). At the experience workshop, all teams' total working hours and final payment will be anonymously presented, so you will be able to compare your performance to others and to what extent the teams have been profitable.

Please note that the commercial performance is not part of the grading for the project. The purpose of the commercial exercise is only to give an understanding of the business implications.

4 Grading and examination

Passing the project is **mandatory** for passing the course. A maximum of 40 points (including the individual quiz and bonus points) can be obtained from the project.

4.1 Project points

Evaluation of the project is based on:

- **The customer approval (6 points)**. It means how well the product meets the RFP requirements. You should provide the proper testing scenario for your product and method. This testing scenario should fully reflect your product's compliance with the RFP technical requirements. If it does, and the supplier (you) can demonstrate it using suitable tests, then the customer will be satisfied and you get full credit for this part. Deviations will cause point reduction. The reduction is

less if the expected deviation is negotiated with the customer in advance. Every team member should be able to operate the product and to explain the design of all parts of the product.

- **The teamworking skills (8 points)**. For full teamworking skills points, the team should work together in a professional manner. This means that responsibilities should be divided within the team. Everyone should contribute, and no one should do everything. Disagreement or conflicts in the team are sometimes unavoidable and do not reduce the points, if the problems are handled according to the agreed common values in a professional manner (see Sec. 3.1 and [2, Sec. 2.1–2.2 and 2.11]). Promoting the team is positive, promoting yourself is not. Furthermore, your proposal should, possibly after revisions, be followed, including the individual roles of the team members.

- **The deliverables (6 points).** It is essential in every industrial project, and therefore also in this project, that the deliveries are done as the recipient expects. This includes meeting the requested page counts, deadlines, and contents. Failure to meet a deadline will reduce the points. Inform the recipient of a delivery as soon as possible about expected delays; this will minimize the penalty.

- **Bonus points (10 points).** Bonus points are awarded for satisfying the additional requirements. The specific requirements and bonus points for each of them is stated in the RFP.

- **Project quiz (10 points).** Project quiz is answered by the group members **individually**. The quiz is 20 minutes long, and it is composed of 10 multiple choice questions which evaluate the understanding of the scientific base of the project.

4.2 Final grade for the project

The final project points for each team member will be calculated as the sum of the points obtained in the quiz (individual, max. 10) and the points awarded to the team (max. 24) as well as the extra points if the team completes the part of the project related to quality (max. 6). *To pass the project, a minimum of 20 points is required* (including the individual score in project quiz).

The final grade in the course is computed as detailed in the Course Memo. In addition, at least one problem in the written exam will assess knowledge learnt in the project.

4.3 Things that do not influence grading

The following project elements are also mandatory, but they are not graded. This is to encourage teams to report them honestly, for the benefit of an interesting workshop.

- The *cost estimate* and the reported *work hours*.
- The *experience report.* The purpose is to identify common problems and insights and thereby share the learning experience between teams; no experiences will be traced to any particular teams or individuals. The project points are decided immediately when you upload the experience report (it may affect your delivery points) but before it is read.

4.4 Rules

All teams should write their own deliverables. It is OK to share knowledge and general ideas between teams, but **copying any material for a deliverable (text or MATLAB code) is strictly forbidden**. It is also forbidden to use MATLAB code from any other source, such as the Internet or the MATLAB toolboxes. When you are using any specific book or paper for developing your methods and algorithms, you should give proper reference to that source.

Any violation of these rules will be reported as cheating, and may lead to suspension of studies for the parties involved. The course staff will archive and compare the submitted deliverables with each other and also with documents from previous years.

References

[1] J. B. Anderson, *Digital Transmission Engineering,* 2nd ed., Wiley, 2005.

[2] P. Mattisson, *Working in Projects Rev. C,* Göteborg, Sweden, Rev. C, 2011. [available via Dept. of Signals and Systems, Chalmers University of Technology]

[3] R. E. Ziemer and R. L. Peterson, *Introduction to Digital Communications,* Upper Saddle River, NJ: Prentice Hall, 2001.

A Hints and advice

A.1 Design methodology

When designing a transmitter and receiver, it is common to use the following flow of activities.

1. Scrutinize the required specifications
2. Find a sufficiently accurate model of the channel
3. Make a transmitter and receiver design based on the channel model
4. Test the design by simulations (using the channel model)
5. Test the design in practice (using the hardware channel)

If the hardware channel is readily available and easy to access, step 4 can often be neglected. There is no need to implement the channel model in software if it would not facilitate the design. An analytic channel model is however needed in any case (step 2) to guide the receiver design (step 3).

The process is often iterative in practice. For instance, it is quite common that it is difficult or even impossible to make a perfect design at step 3. We then have to make an approximative design which may fail when tested at step 4 or step 5, and we are forced to redesign the system (step 3) or to refine our channel model (step 2).

There are many ways to meet the requirements in the RFP. How to design the system is your decision; no solution is particularly recommended by the course staff. We expect most teams to come up with different solutions and there is not *one* best solution. There is no penalty for using an unnecessarily sophisticated system design, but there is no reward either.

A.2 Teamworking hints

The background and ambition level must be discussed within the team, but not necessarily reported outside the team. Some students are new to digital communications whereas others have already studied deeper courses than this one. Some might even have done a similar design project elsewhere. Be open with your teammates regarding your strengths and weaknesses. This will greatly facilitate the assignment of tasks and responsibilities. Also, the risk of conflicts is reduced if the team members know from the beginning what to expect from each other.

Some guidance is given in [2, Sec. 1.3] regarding how to divide the responsibilities within a team. Looking at the general digital transmission block diagram [1, Ch. 1] may help to further subdivide the system design part. Do not forget the support functions. In a team of only four persons, it is likely that each individual will have several responsibilities. The interfaces

between responsibilities are important [2, Sec. 2.5]. If they are well defined, the team members can carry out their roles (almost) independently.

At the first team meeting, it is recommended to discuss only nontechnical issues, such as:

- Names and contact information
- Background, ambitions, and expectations (see above and [2])
- Common values (see Sec. 3.1 and [2])
- Future meetings

A.3 Hardware hints

It is necessary to use the full experiment setup (defined in the RFP; essentially the PCs connected with the hardware channel) during most of the stages of the system development. Recorded waveforms may be saved for later offline processing or sending a short file to make the testing faster is also an option. All such simplified environments, however, are for the development phase only. Remember that the final product should be tested and demonstrated in the setting defined in the RFP, which may require some unexpected modifications compared with your development environment.

For some PCs, particularly laptops, the power supply may be very noisy, which causes interference on the microphone input. Such interference can be mitigated by connecting the laptop to some grounded equipment or by running on batteries during transmission.

The power level can be adjusted in software via the volume controls. Most PCs have two volume controls for playback (wave and master) and one for recording. The attained volume depends on the type of sound card, for the same volume control settings.

A.4 Examples of MATLAB functions

`HELPDESK` A help browser with overviews and tutorials for MATLAB beginners.

`HELP, HELPWIN` Display help text for a MATLAB command. Type `help help` for documentation on how to use `help`.

`LOOKFOR` Find a MATLAB command from keywords in its help text.

`TRANSPOSE` Transpose a matrix. `transpose(x)` is equivalent to `x.'`

`RESHAPE` Transform a matrix to a new size by taking its elements columnwise.

`FIND` Find indices of nonzero elements.

`ZEROS, ONES` Array where all elements are 0 or 1, respectively.

`CHAR, DOUBLE` Convert between a string and an integer vector.

`STRCAT` Concatenate strings. See `help strings` for more string-processing functions.

`BASE2DEC, DEC2BASE, BIN2DEC, DEC2BIN, BI2DE` Convert between decimal numbers and other bases.

`DOUBLE` Convert to double precision.

`ROUND` Round towards nearest integer.

`CONV` Convolution and polynomial multiplication.

```
[ x(1,1)*y  x(1,2)*y  x(1,3)*y
  x(2,1)*y  x(2,2)*y  x(2,3)*y ]
```

`SAVE` Save workspace variables to disk.

`INPUT` Prompt for user input from an M-file.

`KEYBOARD` Invoke keyboard from M-file. This is very useful for debugging.

`CLEAR` Clear variables and functions from memory.

`IMREAD` Read image from graphics file.

`IMSHOW` Display image in Handle Graphics figure.

`PWELCH` Power Spectral Density estimate via Welch's method.

`FIGURE` Create a new figure window.

`PLOT` Plot a vector as a function of another vector.

`HOLD ON` Hold the current plot and all axis properties so that subsequent graphing commands add to the existing graph. The plotting mode returns to normal after `HOLD OFF.`

`AXIS` Set axis scaling and appearance.

Relational operators: `==  ~=  <  >  <=  >=`

Logical operators: `&&  ||  &  |`

B Internal deliverables templates

B.1 Common values template

Page count: 1–2. See Sec. 3.1.

The following are examples of what can be covered in this document. Delete and add items depending on what is relevant in your team.

Decisions. How are decisions made? Are they documented?

Internal delivery problems. If a team member discovers that an agreed internal solution or deadline will not hold, should he or she make appropriate changes or first discuss it in the team?

Meeting procedure. How are meeting times and agendas decided? Is there any chairman? May a team member be late or absent? Is it OK to answer the phone during meetings?

Adherence to team rules. Which actions should be taken if someone does not follow the team's agreed common values and rules?

Organization. The roles and responsibilities of the team members.

Other common values and team agreements.

B.2 Status report template

Page count: 1. See Sec. 3.1.

This document should include:

- Achieved results since last report. Refer to work break-down and time schedule
- Expected results during period until next status report (or delivery).
- Identified problems or risks that may lead to changes, in technical solution or project plan.

B.3 Experience report template

Page count: 2–4. See Sec. 3.1.

The following checklist may be useful. Delete and add items depending on what is relevant in your team.

- Project organization
- Planning process (work breakdown and time planning; deviations from initial plan and why)

- Cooperation and motivation (selected common values and their impact; how conflicts if any where handled)
- Interaction with customer
- Profitability (compare estimated work effort with actual, and the resulting profitability according to the cost model)
- Learning during the project. Changes made due to learning during the execution of the project
- Suggestions for improvements the team would consider if it would execute a similar project in the future
- Other matters