EE3L11

Bachelor Graduation Project

Business plan
Ethics and technology
Bachelor graduation thesis

Year 2019–2020

Delft University of Technology

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Challenge the future

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DELFT UNIVERSITY OF TECHNOLOGY

FACULTY OF ELECTRICAL ENGINEERING, MATHEMATICS
AND COMPUTER SCIENCE

ELECTRICAL ENGINEERING PROGRAMME

This manual has been prepared with contributions from:

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Contents

Chapter 1

Introduction

This manual gives a complete description of the **EE3L11 – BSc graduation project**, hereafter referred to as **BAP** (acronym derived from the original Dutch name of the project "Bachelor afstudeerproject"). This educational activity is scheduled in either the second quarter (BAP-Q2) or the fourth quarter (BAP-Q4) of the academic year. Please note that the entry requirements for BAP-Q2 and BAP-Q4 *are not the same*. As a rule, the BAP is expected to be carried out in the Q4 of the third year of the BSc curriculum, with BAP-Q2 being offered as an alternative for expediting the access to the MSc programme for those students who were not enrolled in the BAP-Q4 *of the previous academic year*.

The manual provides the *general framework* for the BAP, by also specifying the mandatory overall applicable deadlines and milestones: the **Green-light assessment** and the **Grand Finale**. Nonetheless, as concerns the specific activities to be carried out, the manual should be seen as a set of (occasionally, strong) recommendations for setting the students on a propitious course towards completing a rewarding, educative, scientifically relevant and, eventually, enjoyable BSc graduation project, with its pertaining deliverables. The formulated requirements should never be interpreted as binding demands. Moreover, possible deviations from this manual, primarily minor adjustments of the indicated timelines, may occur. Any such deviation will be timely communicated via Brightspace.

The authors express in anticipation their gratitude for any suggestion for improvement and/or for signaling possible inaccuracies.

1.1 General concepts

The following general terms will be used throughout this manual:

BAP coordinator: Ioan E. Lager, i.e.lager@tudelft.nl
Bachelor graduation thesis coordinator: Ioan E. Lager
Business plan coordinators: Koen Bertels, k.l.m.bertels@tudelft.nl and Victor Scholten, v.e.scholten@tudelft.nl
Ethics and technology coordinators: BAP-Q2: Egbert Bol, e.w.bol@tudelft.nl BAP-Q4: Pilar López Cantero, p.lopezcantero@tudelft.nl
Director of Studies: Nick van der Meijs, n.p.vandermeijs@tudelft.nl

BAP assignment: A project assignment given to a group of up to 6 students yielding up to three BSc theses and one business plan.
Project proposer: A (legal) person proposing a BAP assignment.

BAP group: A group of up to 6 students that cooperatively address a BAP assignment.
BAP subgroup: A subgroup of a BAP group consisting, typically, of 2 students (possibly, 3).
Group supervisor: A member of the EEMCS faculty staff member acting as supervisor of a BAP group. In the case when the project proposer is an EEMCS faculty staff member, (s)he automatically becomes the group supervisor.
Daily supervisor: A person acting as direct supervisor of a BAP subgroup.

The general idea of the BAP is that a group is given an assignment that, via a combined design and research effort, will lead to: (i) two documents, namely a ***BSc graduation thesis*** and a ***business plan***; (ii) a ***prototype*** (more often than not, a concept demonstrator). The assignment is subdivided into 3 (or 2) subtasks that are then effectuated by 3 (or 2) subgroups. Each subgroup prepares *individually* a BSc thesis and defends it in front of a jury. The group, *as a whole*, prepares the business plan and defends it in front of a specialised jury. The prototype can be prepared cooperatively, by the complete group or, alternatively, each subgroup can produce its own prototype. Which of the two options is more opportune depends on the concrete assignment, the choice being completely of the group's competence.

1.2 Educational objectives

1. Apply, integrate and deepen the electrotechnical knowledge and skills accumulated in the previous BSc education.
2. Account for the societal facets of the electrical engineering.
3. Identify relevant literature sources and critically assess their suitability.
4. Prepare an elaborate scientific report over a technical topic, by also illustrating the accompanying design process.
5. Meet scientific publications standards (at a moderate or higher level).
6. Make a technical presentation in front of a specialised audience.
7. Critically and pro-actively explore the possible ethical aspects in exerting the electrical engineering profession.
8. Work together in a larger, multidisciplinary team for addressing a complex, open assignment.
9. Work according to a project scenario.
10. Apply, monitor and report on a design process according to the established procedures.
11. Design, develop and validate a prototype.
12. A basic training in the starting of an own company.
13. Draw a simple business plan.
14. Pitch a business plan in front of your peers and/or of a (fictitious) financing entity.

1.3 Entry requirements

The entry requirements for BAP-Q2 and BAP-Q4 *are different*:

1. **For BAP-Q4**: the full completion of the BSc curriculum of the first 2 years – the reference point is the end of the first semester of the third year in the BSc curriculum.
2. **For BAP-Q2**: the full completion of the BSc curriculum of the first 3 years, except for EE3L11 "BSc graduation project" – the reference point is the start of the academic year.

All students fully complying to the entry requirements are automatically enrolled in either BAP-Q4 or BAP-Q2, as applicable. The students who *marginally*[1] miss the entry requirements may apply for admission via an online procedure (see Section E.2.2 for details). Should the application be favourably assessed, the relevant student will be admitted to the project. It is stressed that submitting an application *presents no guarantee for admission to BAP*.

[1] "Marginally" is understood as "except one or, at most, two courses", with applications for admission with more than two missed courses being, as a rule, rejected. Note that open courses with exams in Q4 weigh harder in denying access to BAP-Q4.

1.4 Discipline's structure

Reaching the discipline's learning objectives are achieved via a combination of self-study, training within the frame of taught courses and learning-by-doing. To this end, BAP comprises the following components:

- **BSc graduation thesis** (**BScTh**) (10 ECTS),
- **Business plan** (**Bp**) (3 ECTS),
- **Ethics and technology** (**E&t**) (2 ECTS).

The final BAP grade G_{BAP} is computed as

$$G_{\mathrm{BAP}} = 10/15 \times G_{\mathrm{BScTh}} + 3/15 \times G_{\mathrm{Bp}} + 2/15 \times G_{\mathrm{E\&t}}$$

in which G_{BScTh} is the **BScTh** grade, G_{Bp} is the **Bp** grade and $G_{\mathrm{E\&t}}$ is the **E&t** grade. The final grade is calculated, *providing all partial grades are at least 6*. The partial grades and the final one are all rounded off to half points.

1.5 Supervision

The coordination of the BAP, as a whole, falls under the responsibility of the BAP coordinator. Each of the 3 BAP components has its own coordinator, with the BAP coordinator being also the coordinator of the BSc graduation thesis.

The activity of a group is supervised by the BAP supervisor. Should an assignment be proposed by an EEMCS faculty staff member, that person automatically becomes the supervisor upon her/his proposal being accepted by a group. In the cases of assignments proposed by (legal) persons outside Delft University of Technology or by the groups themselves, a (senior) EEMCS faculty staff member must act as group supervisor. Immediately after being given an assignment, the group must contact the supervisor for being instructed on the detailed expectations, agree on the general strategies (the possible prototypes, among others) and make agreements as concerns logistics, reporting and feedback.

The current practice is that the supervisor will delegate the responsibility of the daily supervision of (at least a part of) the group to colleagues in her/his section (usually, PhD students). The relevant persons will then become daily supervisors.

In the case of difficulties and/or disfunctionalities, the (sub)group will firstly contact the supervisor. Should a suitable solution not be found at that level, the (sub)group can approach the BAP coordinator or, in extreme situations, the Director of Studies.

1.6 Project evolution

A conditional aspect for ensuring the success of a project is a constant monitoring of its progress. This section focuses on a number of instruments for implementing this.

1.6.1 Planning & reporting

As with any project, the BSc Graduation project should start by preparing a project plan, with [1] giving guidelines to drawing such a document. The preparation of the plan ***must*** start by properly understanding the project's *goals* and *boundary conditions* – these are agreed upon at the very beginning with the project proposer. It is the students' responsibility to make the goals *clear* and *measurable*. It is also imperative to set clear boundary conditions that delimit the project's scope such that to preclude unnecessary effort investments in directions that do not contribute to the final goals. Only once these aspects are sorted out may the group proceed to plan activities by observing the basic timelines, deadlines and deliverables that are summarised in Appendix D – these are mandatory milestones in the BSc graduation project.

The progress within the scope of BAP is primarily monitored via the group's interaction with its supervisor and, when applicable, with the project proposer. A good practice to this end is to present regularly (advisably, weekly) the supervisor with reports structured along the following lines:

- goals of the week;
- what was achieved;
- what was not achieved *and why*;
- objectives for the next week.

These reports add up to a cyclic process, that starts in the project's first week and is concluded when the thesis is completed (in most cases, this will be *after* the final Bachelor thesis exam, upon accounting for all observations made by the exam juries). The reports can be issued per group or subgroup. They must be *concise* and *measurable*.

1.6.2 The **Green-light assessment**

The progress in the project is *formally* assessed during a so-called **Green-light assessment** session that should be held in the weeks 5–6 of the BSc project (the recommended timing for these meetings is indicated in Appendix D). The **Green-light assessment** session is organised *per group*, but the assessment concerns *each subgroup, individually*. Each of these sessions is managed by *a jury* and will typically require 1¼ ÷ 1 ½ hours per subgroup (the assessment of all subgroups in a project should be done, inasmuch as possible, on the same day).

The following activities must be carried out in preparation of the assessment meeting:

- Submit the following documents: (i) a *one-page*-long report *submitted by the complete group* – it must introduce the purpose of the project, the general strategies and choices for reaching the goal, and the division of the tasks over subgroups; (ii) a *one-page*-long report *submitted by each subgroup, individually* – it must describe succinctly the subgroup's targets and deliverables, the currently achieved level, and the tasks still lying ahead, complemented with a clear plan for finalising them. These two documents must be submitted to all jury members electronically[2], *at least two working days before the* **Green-light assessment**.
- Assemble the juries that must consist of: the supervisor (who also chairs the **Green-light assessment** session), the daily supervisor(s) (if applicable), the project proposer (if applicable) and an external assessor who is not directly involved in the project and, preferably, comes from outside the section in which the project is embedded. The external assessor should be a senior member of the faculty staff who can offer an objective assessment of the achieved progress and of the chances for a successful completion of the project. Please note that the external assessor does not have to participate in the **BSc graduation thesis** exam juries (although experience shows that this can prove beneficial).

  In view of acquaintance with the project's specificity and with the students' profile, *assembling the juries falls under the responsibility of the supervisor*. The students may also support this process by making suggestions for potential external assessors. Since the **Green-light assessment** is organised per group, as a rule, the same jury will assess all project subgroups – nonetheless, inviting different external assessors for different subgroups is possible when deemed opportune.
- Make the logistic arrangements for the sessions: (i) book a suitable room, send the formal invitations to the jury members; (ii) inform the BAP coordinator on the jury members (this is needed for preparing the **Green-light assessment** forms that will be handed over to the supervisor). Making the logistic arrangements *is the group's responsibility*.

During the **Green-light assessment** session, *each subgroup* will give a 5 ÷ 6 minutes long pitch, followed by an approximately 15 minutes long questioning (Q&A). Whether or not the other members of the group will be allowed to participate in the presentation and Q&A is up to the jury and should be communicated in advance.

Based on the submitted documents, the presentation and the Q&A, the jury can take any of the following decisions:

- **Go**: The progress is deemed sufficient such that, with the still to be effectuated work, it can be reasonably expected that the group will produce a defendable thesis until the submission deadline.

[2] Preferably, in Portable Document Format (PDF) format.

- **Defer**: The achieved progress raises doubts that the group will produce a defendable thesis until the submission deadline, but the situation may be reversed if a number of measures are taken. An action plan is drawn and the group must redo the **Green-light assessment** in front of the same jury, within at most 1½ weeks, when a definitive **Go** / **No go** decision must be taken.

- **No go**: The achieved progress does not present any reasonable guarantee that the project will yield a defendable thesis until the submission deadline. The subgroup's exam is deferred until August (BAP-Q4) or February (BAP-Q2). A clear action plan must be drawn for ensuring that a defendable thesis can be produced at the new term. The students receiving a **No go** can still round off the Business plan and can participate in the Grand Finale (BAP-Q4). Nonetheless, their final EE3L11 grade will only be established after the successful defence of their thesis.

1.6.3 The **dry run**

For better preparing the exam it is possible to organise, in consultation with the supervisor, a so-called **dry run** (rehearsal) of the **BSc graduation thesis** exam. Such an 'exam' will be organised per subgroup and will be a shorter version of the actual exam, with all elements included. **Dry runs** can provide the students with valuable feedback and have no effect on the final grades obtained by the relevant subgroups. The 'jury' of such an 'exam' *will be assembled by the group's supervisor*. It will operate according to the general conditions concerning the real exam, the use of the official evaluation form given in Section A including – the assessment of the thesis' quality may be skipped in view of the thesis still having to mature at that moment. **Dry runs** may only be organised *after* the mandatory **Green-light assessment**.

1.6.4 The final assessment

The assessment of the BSc thesis is achieved via exams in front of an appointed jury. *Assembling the juries falls under the responsibility of the BAP coordinator.* Each jury will consist of 3 or 4 members[3]: a jury chair, the group's supervisor, an assessor and, possibly, a forth member, for example an external assignment project proposer or a daily supervisor.

The assessment of the business plan is achieved via a presentation in front of a specialised jury. Ethics and technology is assessed via an essay and the personal activity during the course's seminars.

1.7 Group dynamics

Although BAP is a group activity, the educational objectives apply to each student, *individually*. The realisation of this goal is only possible when each student is equally involved in the completion of the assignment, throughout all project's phases. This is the more so justified when one realises that each member of the group must be capable to explain *in detail* all elements in the subgroup's BSc thesis and the group's business plan.

As indicated in Section 1.1, the group is subdivided into 3 (or 2) subgroups. Several years of experience with BAP showed that groups of 6 students, subdivided into 3 subgroups of 2 students, offer the most adequate balance between diversity and breadth of investigations, on the one hand, and manageability of the process, on the other hand. Consequently, as a rule, the groups will consist of 6 students, with 3 subgroups of 2 students. Nevertheless, deviations from this rule will be accepted under certain circumstances. In any case, since team work is one of the BAP educational objectives, the minimum size of a group is 4, subdivided into 2 subgroups of 2. Please note that in the case of subgroups of 3 students it is expected that the scope of the BSc thesis is visibly broader than that of a subgroup of 2.

BAP is a team activity and, thus, requires an effective use of a range of dedicated instruments such as project tracing, time management, keeping minutes, team-building or conflict management. Useful tips in this respect can be found on the site http://iwp.cs.utwente.nl/. Occasionally, the dynamics of the BAP groups may be unsatisfactory. The best remedy in such cases is an open, honest discussion within the group. Should the desired results not be reached in this way, the (sub)groups have the options of firstly consulting the supervisor, then the BAP coordinator and, in extreme cases, the Director of Studies.

[3] In exceptional cases, the jury may consist of 5 members.

1.8 Information and communication

The main instrument for disseminating information to students is the **EE3L11 Bachelor Graduation project Electrical Engineering** Brightspace site, its principal elements being illustrated in Fig. 1.1. Please note that there are separate sites for BAP-Q4 and BAP-Q2 – differences between the two sites *do* exist! The site's main page accommodates announcements and a list of upcoming events. The information on this page is both general, for the complete EE3L11 discipline, and component specific. The "Contents" section (accessible via the home page's upper ruler) comprises all general purpose and component specific documents, its main modules being:

- "Course Information" – it contains general purpose information;
- 3 modules, named "Bachelor Thesis", "Business Plan" and "Ethics and technology" – they contain the component specific information.

After assembling, the groups are offered specific Brightspace communication and file-sharing instruments. The groups are free to use these instruments but must be aware of the fact that the relevant data will be removed after the completion of the BAP.

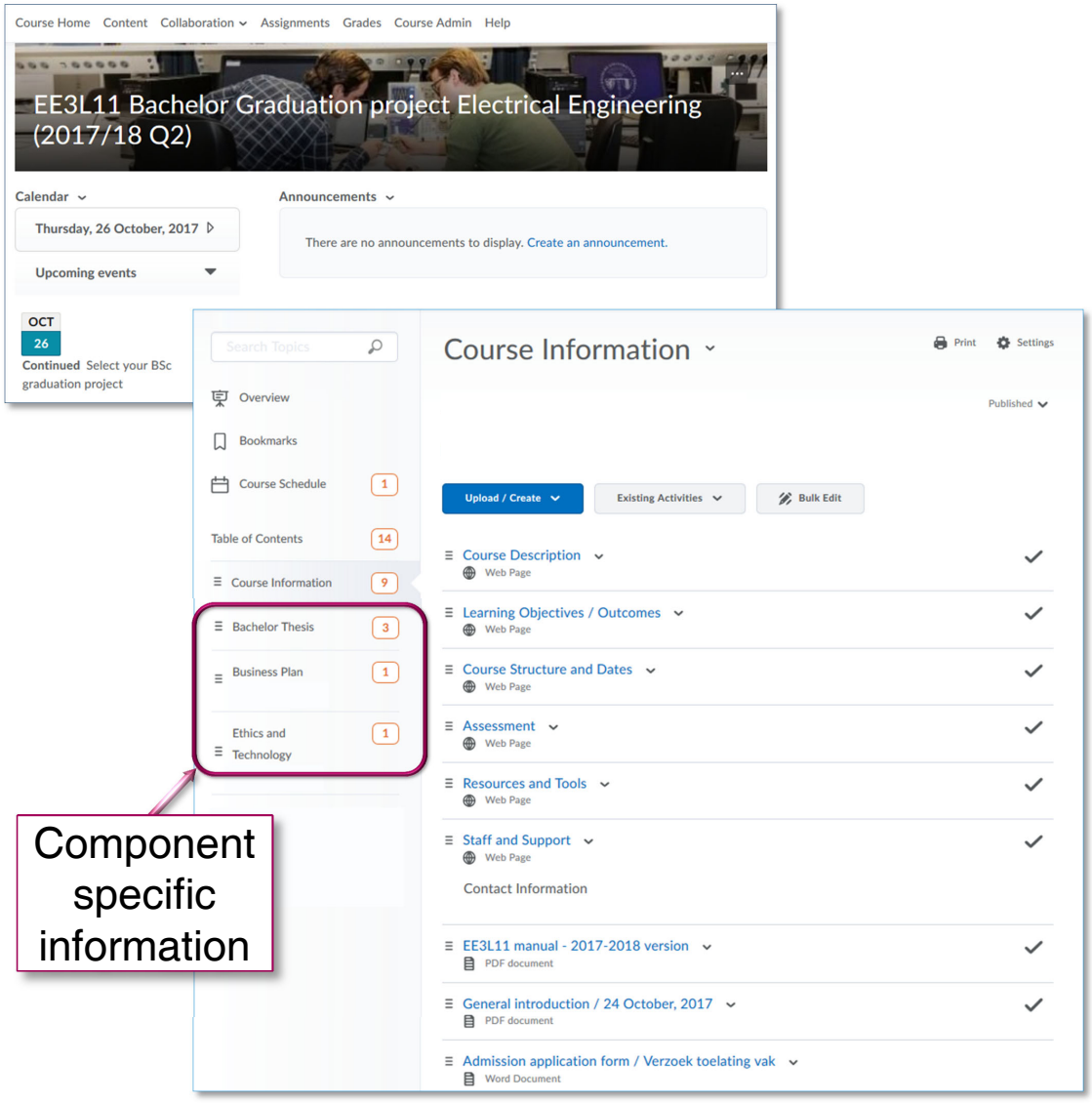

Figure 1.1: The EE3L11 Brightspace site. The figure contains the site's home page (background image) and the "Contents" page, with the "Course Information" module being expanded (foreground image). The rounded box indicates the entry points to the component specific information modules.

Chapter 2

Business plan

2.1 Goals

This component focuses on inducing an entrepreneurial spirit in the graduating BSc students. The breadth of the EE education offers an extremely fertile background for venturing into marketing audacious technical and technological ideas. The **Business plan** (**Bp**) component will guide the students through their initial steps in setting up an own business, will offer useful tips to this end and will be concluded by putting the students in the situation to pitch their business plan in front of a jury of (potential) sponsors.

The end-goal of this component is drawing a (simple) business plan containing (without being necessarily reduced to) the following elements:

- description of the product;
- market analysis, concentrating on the competition, the potential clients and the price strategy;
- management;
- investment analysis, based on the cash flows – net present value and return on investment;
- societal cost-benefits analysis, by making use of the concepts discussed in **Ethics and technology**.

2.2 Study material

For supporting the drawing of the business plan, the students are recommended the following bibliographic sources:

- J. V. Chelsom, A. C. Payne, and L. R. P. Reavill, *Management for Engineers, Scientists and Technologists*, 2nd edition, Chichester, UK: John Wiley & Sons Inc., 2005, ISBN: 0-470-02126-8 *please consult your instructor before purchasing the book*;
- P. Tiffany, S. D. Peterson, *Business Plans For Dummies*, 2nd edition, Hoboken, NJ: John Wiley & Sons Inc., 2005, ISBN: 0-7645-7652-6;
- the websites www.newventure.nl and http://iwp.cs.utwente.nl (for project competencies).

2.3 Deliverables

The business plan must be prepared as a PowerPoint presentation containing not more than 20 slides.

As stated in Section 2.1, the business plan must touch upon the ethical implications of the proposed business. The **Ethics and technology** provides to this end a checklist of points of concern that must be dealt with. The students are expected to formulate a strategy for addressing those points of concern.

2.4 Assessment

In the case of BAP-Q4, the assessment of the **Bp** is done during the BSc graduation project's closing event, the **Grand Finale**. Within the frame of this event, the students will have to defend their business plan in front of a jury of (potential) sponsors by means of:

- an oral presentation concerning the highlights of the business plan – specific instructions concerning the manner in which the presentation must be given, such as language, number of students to give it (commonly, the complete group), etc., will be timely communicated via Brightspace and may vary over the years;
- a poster presentation (see Appendix C for some guidelines for drawing the poster) combined with a product/service demonstration. Please note that printing the poster falls under the group's responsibility and, as a rule, the faculty does not offer printing facilities.

The jury assesses the students' work based on a scoring system. This, in turn, serves as basis for determining the **Bp** grade and yields a ranking of the presented business plans. The winner of this competition is awarded the *IEEE Award for Best Business plan*.

The **Grand Finale** is a public event, where the students' families and friends are welcome. The event offers an agreeable opportunity for the students to present their work to a large public and allows an informal platform for a social interaction between the students, their supervisors and/or project proposers, and the students' families and friends.

Submission of the final version of the Bp:
- BAP-Q2 – Before 20th of December, 2019
- BAP-Q4 – 29th of June, 2020

Format: PowerPoint (PPT) or Portable Document Format (PDF) files.
Length: Maximum 20 slides.
How: Per e-mail, to k.l.m.bertels@tudelft.nl or v.e.scholten@tudelft.nl

Grand Finale: 3rd of July, 2020
Location: EWI building
Presentation: You must focus on the essential points of your business plan and advocate and/or demonstrate your product. The general timeline is:
- 10 minutes: Business plan presentation + 5 minutes questions by jury
- 10 minutes: demonstration of your product
- 10 minutes: questioning from the jury.

The assessment of the **Bp** for the BAP-Q2 will focus on the same elements. However, no **Grand Finale** can be organised, the students being given the possibility to defend their plan during an ad-hoc event.

Chapter 3

Ethics and technology

3.1 Goals

This component deals with the responsibilities and reasonable choices within the scope of technical occupations. The relevance of ethical considerations often becomes clear in practice. Confronted with such situations, people become aware of the fact that they can easily become the subject of obnoxious circumstances, this awakening the interest for the available philosophical theories in this field. Such theories provide the outlines for the analysis of ethical issues and open the path towards finding answers for questions such as:

1. How can one justify her/his ethical choices?
2. How can one reach a consensus on what a responsible policy is?
3. How can one find adequate arguments for being convincing when talking about ethical aspects?

With this in mind, **Ethics and technology** (**E&t**) sets itself the following educational goals:

- identify moral questions in the professional practice;
- assess moral questions via ethical reflection.

The **E&t** consists of a series of lectures complemented by *seminars* moderated by an **E&t** tutor. As a rule, these seminars consist of a presentation given by one or two students on a topic related to one of the textbook chapters, followed by a discussion on the presentation. The seminar groups consist of two or three **BSc graduation thesis** groups (depending on their sizes).

3.2 Study material

The **E&t** component makes use of the following study material:

- I. van de Poel and L. Royakkers, *Ethics, Technology, and Engineering: An Introduction*, Chichester, UK: Wiley-Blackwell, 2011, ISBN 978-1-4443-9571-6;
- M. J. Verkerk, J. Hoogland, J. van der Stoep, and M. J. de Vries, *Philosophy of Technology: An Introduction for Technology and Business Students*, London, UK: Routledge, 2016. ISBN 9781138904392. [Online] Available for preview: https://books.google.nl/books?id=EOmPCgAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false (supplementary reading).
- the material posted on Brightspace, with an emphasis on the texts concerning the four types of responsibility and the four types of ethics (**E&t**, themes 1 and 2).

This component has a strongly applied character, with the theoretical concepts being practiced with during the seminars and in the students' presentations. Participation in these seminars is requisite to progressing through the **E&t** component and, hence, *presence in those classes is mandatory*. Any missed seminar will be compensated via an individual additional assignment.

3.3 Deliverables

E&t results into two deliverables:

A. *A group essay*

Each group doing together the **E&t** seminars prepares an essay of approximately 5 pages under the supervision of a **E&t** working group tutor. The purpose of the essay is to summarise the outcomes of the **E&t** component. Possible aspects to be reflected upon may be:

1. How would you formulate, in retrospect, the goals of **E&t**?
2. What are the most important lessons learnt?
3. Is your perception of ethics, technology and the activity of engineers changed? If so, how?
4. What are the positive/negative sides of the discipline? What are your proposals for improvement?

B. *An ethical paragraph to be included in the business plan.*

Note that including ethical considerations in the BSc graduation thesis is always appreciated. Nonetheless, including a stand-alone ethical paragraph in the thesis *is discouraged*.

3.4 Assessment

The assessment of **E&t** is based on a combination between the grade for a concluding essay and the personal activity during the seminars. Details on the various elements and their weights in the final grade will be provided via Brightspace.

3.5 The ethical paragraph in the business plan

As stated in Section 3.3, the students are supposed to include an ethical paragraph in their business plan. Note that this paragraph is one of the 20 slides of the handed in as business plan. The assessment of this paragraph *is part of the* **Business plan** *grade* and will be done by the **Business plan** coordinator. The following points of concern must be addressed in this ethical paragraph:

1. What are the foreseeable societal implications of the proposed device and/or technology?
2. What are the societal values that are catered by the use of the relevant device and/or technology? To what degree is this good or questionable? To what degree does the product prevent questionable effects of different *existing* solutions?
3. Which interests and which stakeholders are (legally) affected by the product? To what extent are the envisaged company's interests justified? Are there any limitations that should be imposed based on possible moral considerations?
4. How shall the envisaged company attend to possible environmental effects? Is this justifiable?
5. How shall the envisaged company address possible safety risks? What are the acceptable margins and how can (or cannot) they be justified?
6. How does the device and/or technology position itself in a globalised society? What are the moral boundaries should production be outsourced to low-income countries?
7. What is the implicit and/or explicit moral code of the envisaged company? What are the (moral) values promoted by the company's culture? How shall that be made a part of the management style? Does this management style fit in the company's nature, by also considering the envisaged output, the production scale, such as mass-production or just high-tech (niche) prototyping, etc.
8. How should a morally responsible personnel policy look like? Which trade-offs are expected between, for example, market effectiveness (competition) and morally responsible personnel policy?

9. How will the envisaged company attend to issues concerning equal chances for promotion, gender equality, cultural diversity and rewarding inequality?

Furthermore, the assessment will also consider aspects such as:

1. The policy, as outlined by the business plan, must be SMART (**S**pecific, **M**easurable, **A**ssignable, **R**ealistic, **T**ime-related).
2. The safety $\leftrightarrow$ costs, environment $\leftrightarrow$ cost-effectiveness, high long-term ideals $\leftrightarrow$ market viability, etc., trade-offs must be openly and realistically discussed. An adequate business plan will have to find the right balance between such conflicting requirements.
3. All considerations and choices must be supported by moral norms and, inasmuch as possible, by ethical theory strategies. In other words, even when ideal conditions cannot be guaranteed, the implemented policies must still rest on moral foundations.
4. Each of the four ethical background theories must be invoked at least once in the discussion of the points of concern above referred to.

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BAP-Q4: Pilar López Cantero, p.lopezcantero@tudelft.nl

Working group instructors (BAP-Q4):

- Pilar López Cantero, p.lopezcantero@tudelft.nl
- Tom Coggins, t.n.coggins@tudelft.nl

Lectures and working group sessions:

- BAP-Q2: will be communicaterd via Brightspace
- BAP-Q4: will be communicaterd via Brightspace

Preparation: See the suggested bibliography.

Chapter 4

BSc graduation thesis

4.1 Goals

The **BSc graduation thesis** (**BScTh**) represents the largest component of the BSc graduation project. Its main objectives are drawing the BSc thesis and realising the accompanying prototype. As such, this component can be construed as a true corollary for three years of BSc training and development of practical and applicative skills. Apart from illustrating the level reached by the students in mastering the theoretical and applicative disciplines included in the BSc curriculum, the thesis must also demonstrate an above average maturity in drawing scientific publications of a significant extent.

4.2 Deliverables

This component results into two main deliverables:

- the BSc thesis, according to the framework given in Appendix B;
- the prototype acting as a (concept) demonstrator for the solution arrived at via the project.

The thesis is prepared and defended *per subgroup*. Depending on the specificity of the BAP assignment, the prototype can be developed by the group in its entirety or by each subgroup, separately. Moreover, the students are also expected to draw, *per subgroup*, a preliminary literature survey (handed in after the first week of the project) and to participate in the **Green-light assessment** (see Section 1.6.2).

The BSc graduation thesis is drawn in English.

Submission of the BSc thesis:
- BAP-Q2 – Before 20th of December, 2019
- BAP-Q4 – 19th of June, 2020

Length: Maximum 30 pages, appendices excluded, but abstract, preface and bibliography (plus lists, index, glossary, etc., if applicable) included → *mandatory*.
References: Minimum 20, *relevant and effectively cited* references → *strong recommendation*
How: In hardcopy, to each member of the jury, personally (unless otherwise indicated by the jury members); a copy of the thesis must also be sent in PDF format, per e-mail, to the BAP coordinator at i.e.lager@tudelft.nl (unless he is also a member of the jury).

4.3 Assessment

The assessment of the **BScTh** is performed by a specially appointed jury consisting of 3 or 4 members[1]. The jury is chaired by either a Full Professor or an Associate Professor. Furthermore, the jury comprises

[1] In exceptional cases, the jury may consist of 5 members.

the group's supervisor and an assessor. The jury may be supplemented by a fourth member: the proposer in the case of assignments given by an external proposer or, possibly, a daily supervisor. The Faculty's Examination Commission may also delegate one of its members to participate in BAP exams. Should that be the case, the delegate is considered a legitimate member of the jury and, thus, should receive a copy of the thesis and is entitled to ask questions.

The students are **strongly recommended** to do their defence in English. In the case when the students do not feel secure enough to do their defence in English they may opt to do it in Dutch[2]. In that case, they must contact **in advance** all members of their jury and make suitable agreements with those members who are not proficient in Dutch.

The examination of the thesis is done *per subgroup*. The exam consists of a 10 minutes long presentation[3] given by *all* subgroup's members. Although not required, the subgroup may supplement the presentation by a brief demonstration of the prototype – this time is not included in the time reserved for the presentation. Subsequently, the jury proceeds to a detailed examination (Q&A) of the students. The Q&A covers the complete contents of the thesis and of the delivered presentation. The questions aim at elucidating the theoretical and practical justification of the choices made during the design and/or research process. The choices and their outcomes are constantly gauged against the performance indicators in the Program of requirements (see Section B.3). The examination also aims at assessing the scientific foundation of the selected strategies and obtained results. Here, the students may always expect questions directly related to specific disciplines in the BSc curriculum, such as general math, physics, signal processing, etc.

As a norm, the Q&A is about $40 \div 45$ minutes long, but this period can be longer in the case of subgroups consisting of 3 students.

The evaluation of the thesis, of the activity during the project and of the performance during the BAP exam is done on the basis of the form in Appendix A. The results are communicated at the end of the exam. The students may request copies of the official, signed, exam forms. After the exam, the students are expected to effectuate the thesis revisions requested by the jury. In most cases, the level of compliance to the requested revisions is assessed by the supervisor, only, but the jury members who requested substantial revisions may also solicit a preview of the thesis' final version. After being checked by the supervisor, the subgroup must upload its thesis on the institutional repository. In some cases, in view of confidentiality considerations, proposers may request placing the thesis under temporary embargo, in which case the copy of the thesis on the institutional repository is not made public – the responsibility for placing the thesis under embargo is *entirely* with the students.

The* BScTh *grade will only be validated in Osiris once the thesis was uploaded on the institutional repository. To this end, the students must notify by email the BAP coordinator about the successful uploading (preferably by also attaching the link to the uploaded thesis).

[2] Defences in Dutch are in the process of being phased out and will only be accepted under special circumstances that must be agreed upon with the BAP coordinator.

[3] The extent of 10 minutes of the presentation is mandatory, exceeding the allotted time resulting in diminishing the grade for the presentation. In the case of subgroups of 3, the presentation can be longer, but it should not exceed $13 \div 14$ minutes.

Appendices

Appendix A

BSc thesis assessment criteria

The assessment scale comprises "excellent" (++), "(very) good" (+), "(largely) sufficient" (0), "insufficient" (-) and "bad" (–), this corresponding to a scale $9.5 \rightarrow 8 \rightarrow 6.5 \rightarrow 5 \rightarrow 3.5$. Additionally, bonus points are granted for exceptional performance and malus points are deducted for inadmissible flaws or scientific misconduct (plagiarism). The bonus/malus points are agreed upon before assessing the items (I)–(V) and are added/deducted to/from the grade of the relevant chapters. The specified bonus/malus points must be considered as a maximum, the jury being allowed to also consider fractions of those numbers. The resulting grand total must be divided by 10 and then rounded off to 0.5 points, thus yielding the final grade. The maximum grade is 10 and the minimum one is 2.5.

(I) Performance during the project's progress: The student's individual contribution, creativity, proactive attitude and responsiveness. Cooperation with the team members and interaction with the supervisor. Bonus for exceptional participation and initiative.

Bonus	++	+	0	-	–
(1)	(25)	(21)	(17)	(13)	(9)

(II) Reporting of the project process: Quality of the proposed alternative solutions as validated against the PoR (Programme of requirements), quality of the (system) analysis and the pertaining synthesis, functional scheme and its discussion.

++	+	0	-	–
(10)	(8)	(6)	(4)	(2)

(III) Depth, soundness and theoretical justification of the (main) choices yielding the proposed design *as given in the thesis*: Originality of the employed methods, validity of the effectuated analysis, efficiency of the proposed algorithms and/or implementation, effectiveness of the validation procedures. Bonus for extremely innovative and original conceptual contributions; malus for inadmissible conceptual flaws.

Bonus	++	+	0	-	–	Malus
(2)	(28)	(23)	(22)	(19)	(16)	-4

(IV) The thesis and its drawing: Clarity, legibility, quality of the employed references, structuring and completeness of the thesis. Soundness of the advanced conclusions and recommendations. Malus for plagiarism and for late submission.

++	+	0	-	–	Malus
(12)	(10)	(8)	(6)	(4)	-4

(V) Individual performance during the BAP exam: The student's responses to the questioning of the jury, assessed according to the criteria stated at items (II) and (III). Bonus for exemplary presentations or for exceptional responses; malus for unacceptably poor preparation for the exam and for inadmissible conceptual flaws in the responses given during the graduation exam.

Bonus	++	+	0	-	–	Malus
(2)	(20)	(16)	(12)	(8)	(4)	-2

For ensuring a transparent and (inasmuch as possible) uniform assessment of the thesis, a rubrics system is employed, its elements being given in Fig. A.1.

Exam evaluation rubrics

The indicated criteria should be taken as a reference for the (++),…,(--) levels, with possible intermediate assessments translating into scores in between those quoted for (++),…,(--). *Example:* In case of Element III, fulfilment of the criteria for (+) with the thesis also containing solutions that go beyond the level of the BSc curriculum is a basis for granting a score between 24 and 28.

Element	++	+	0	-	--
(I) Performance during the project's progress[1]	The students demonstrate a lot of initiative, they proactively look for new paths and solutions; the student-supervisor interaction is (very) good	The students demonstrate initiative; the student-supervisor interaction is good	The students essentially follow the path drawn by the supervisor; the student-supervisor interaction is good	The students have a passive attitude and fail to meet some agreed targets; the student-supervisor interaction leaves to be desired	The students perform well below expectations and consistently fail to meet the agreed targets; the student-supervisor interaction leaves to be desired
(II) Reporting of the project process	The PoR[2] is very well written and fully concurs with the proposer's expectations; all choices rely on PoR arguments; all conclusions are drawn based on PoR arguments	The PoR is well written and mainly concurs with the proposer's expectations; all choices rely on PoR arguments; most conclusions can be mapped on PoR arguments	The PoR is reasonably correct and defendable; most choices rely on PoR arguments; some conclusions can be mapped on PoR arguments	The PoR is incomplete; there are choices that cannot be traced back on the PoR; the conclusions do not reflect the PoR	The PoR is largely insufficient as a basis for making choices; the made choices are not argued
(III) Depth, soundness and theoretical justification of the choices yielding the proposed design ***as given in the thesis***[3]	The students generate solutions that go beyond the level of the BSc curriculum; all technical results, derivations, etc. are irreproachable	The students generate solutions that are at the BSc curriculum level; most technical results, etc. are irreproachable; some correct, but insufficiently well-argued elements may occur	The students generate solutions that are at the BSc curriculum level; the derived technical results, etc. are correct but possibly superficial; some small technical flaws may be present	The students generate solutions that are below the BSc curriculum level; the derived technical results, etc. are superficial and there are more technical inaccuracies	The students generate solutions that are well below the BSc curriculum level; there are recurring technical inaccuracies
(IV) The thesis and its drawing[4]	The thesis is very well structured; figures, tables and math are fully according to standards; the layout is very good; the text reads well, the grammar is at par	The thesis is well structured; figures, tables and math are fully according to standards; the layout is very good; the text reads reasonably, with few grammar issues	The thesis is well structured; most figures, tables and math are according to standards; the layout is good; the text reads reasonably, although grammar may be improved	The thesis' structure is incomplete; figures, tables or math deviate from standards; the text reads with difficulty, the grammar leaves to be desired	The thesis is badly structured; figures, tables or math are (well) below standards; the text reads with difficulty, the grammar leaves a lot to be desired
(V) Individual performance during the graduation exam[5]	The presentation is irreproachable; the students give well-argued, to-the-point responses to all questions	The presentation is good and informative; the students give argued, to-the-point responses to all questions	The presentation is good but not fully informative; the students give responses to most questions and the arguing may, occasionally, be shallow	The presentation leaves to be desired and is not informative; the students leave more questions unanswered or some of their responses are wrong	The presentation leaves to be desired and is not informative; the students leave most questions unanswered or most given responses are wrong

[1] Bonus for exceptional participation and initiative.
[2] Program of Requirements.
[3] Bonus for extremely original conceptual contributions that may form the basis for scientific publications; malus for inadmissible conceptual flaws.
[4] Malus for plagiarism and for late submission.
[5] Bonus for exemplary presentations or for exceptional responses; malus for unacceptably poor preparation for the exam and for inadmissible conceptual flaws in the responses given during the graduation exam.

Figure A.1: The rubrics employed for assessing the BAP thesis.

Appendix B

Bachelor thesis framework

B.1 Guidelines for drawing the BSc thesis

The BSc graduation thesis is prepared and examined *per subgroup*. This document is expected to:

- provide a complete description of the background of the research and/or product development, as required by the BAP assignment;
- the problem definition (see Section B.2 for details);
- the Programme of requirements (see Section B.3 for details);
- a full description of the identified solutions.

The thesis must contain a thorough technical analysis of the formulated problem and a scientific justification of all choices in the design process. Furthermore, the thesis must give a complete overview of the prototype's development and testing/validation, with the key performance indicators being illustrated via *adequately commented* tables and/or plots. The thesis must be drawn in a clear, structured, consistent and scientific manner. All choices and the discussion of the obtained performance must be based or gauged on the performance indicators in the Programme of requirements.

As any large scientific document, the thesis must contain the following elements:

- Abstract (this part is meant to be technical; although not recommendable, the Abstract and Preface can be combined into an extended 'Preface')
- Preface (this part is primarily meant for giving an overview of the project and for accommodating the acknowledgements)
- Table of contents

1. Introduction (including state-of-the-art analysis, problem definition and thesis synopsis)
2. Programme of requirements
3. Chapters describing the design process and the justification of the choices
4. Prototype implementation and validation results
5. Discussion of the results
6. Conclusions, recommendation and future work

- Appendices
- References

The thesis is aimed at the electrical enguneering community and, consequently, it must follow the drawing format most widely employed in that community, namely the Institute of Electrical and Electronics Engineers (IEEE) style. A full description of this style is provided in the document "Information for Authors" that is available in Brightspace. Please note that this requirement concerns *the style* (cross-referencing, rendering of equations, figures, and tables, referencing and assembling the list of references, etc.) *and not the layout*! The above indicated document is provided for preparing IEEE-styled papers, for which a double-column format is required → such a format is evidently inadequate for a report/book, this type of documents are *always* drawn in a single-column format.

The BSc graduation thesis is drawn in English. The students are advised that the quality of the employed language is an important element of the thesis' assessment for the **The thesis and its drawing** criterion (see Appendix A). Consequently, they must endeavour to use a clear, idiomatic and grammatically correct language. While there is no need for a dry, stiff style, colloquial formulations are to be avoided.

The BSc thesis can be typeset in either MS Word or LaTeX – it is recommendable to consult your supervisor on this aspect. Bare in mind that large documents containing a lot of mathematics lend themselves much better to being typeset in LaTeX.

In view of the size and complexity of the BSc graduation thesis it is of the utmost importance to maintain a permanent dialogue with the supervisor during the drawing of this document. The supervisor is best positioned for providing guidelines and feedback on the prepared texts.

NOTE: As stated above, it is desirable to include in the thesis also ethical considerations, as applicable. Such considerations are best made a part of the Programme of requirements but may also appear in other chapters. Nevertheless, a separate ethical paragraph should be avoided, as this is supposed to be a part of the business plan, where it will be also graded.

B.2 The problem definition

Defining (or formulating) the problem is the most critical step in solving any problem, as well as one of the most difficult *and rewarding* parts of any design effort. Although it is a relatively small part of the total time and effort invested in a project, its importance can never be underestimated. The problem definition is crucial because any deficiencies or inconsistencies in it will propagate into the next (design) steps. Poorly formulated problems will eventually affect the project's implementation phase and are likely to entail a (substantial) penalty on valuable resources such as time, money, materials, effort, etc.

The following general questions are quintessential to properly defining a problem:

1. What is the situation surrounding the problem? → *the situation assessment*.
2. What does the product[1] actually want to accomplish + does the problem definition adequately reflect the needs of the customers? → *the scoping analysis*.
3. What are the limitations during the design process? → *the bounding analysis*.

These elements are henceforth analysed in detail.

B.2.1 Situation assessment

The first step in formulating the problem is assessing the situation surrounding the problem. An in-depth situation assessment is crucial to ensure that the customer's needs will be fully satisfied. Three elements are here of relevance [2]:

1. Identification of the past → *what was?*
2. Examination of the current status → *what is?*
3. Achievement of the future desired state → *what ought to be?*

[1] The term "product" is henceforth used in a generic sense. Depending on the BAP assignment at hand, it can actually mean a product, a system, a technology, a methodology, etc.

Note that there is a large variety of environments in which various products must operate. As a result, a number of different factors: technical, economic, legal, political, cultural, social, etc. can be very relevant in order to understand the situation surrounding a problem. All these elements must be accounted for in the situation assessment.

B.2.2 Scoping and bounding

Any problem definition can be subdivided into two generic analyses, namely *scoping* and *bounding* [2].

Scoping a project aims at determining whether the developed product achieves its goals and, thus, satisfies the needs of the customers. The following items are of relevance for this analysis:

- **Needs:** Why is the project necessary? What are the needs for this project?
- **Objectives:** What do the end-users and stakeholders want to achieve by the end of the project?
- **Criteria:** To what extent did the project achieve its objectives (success should be measured via well-defined, SMART[2] criteria).

Bounding a project aims at highlighting the limitations related to the project. The following items are of relevance for this analysis:

- **Constraints:** What are the limits that must be observed and always respected?
- **Parameters (alterables):** What are the factors required to create alternatives ?
- **Variables:** What are the measurable quantities for monitoring the performance of the product during its operation?

The process of identifying the needs (scoping analysis) and constraints (bounding analysis) implies addressing a wide range of the issues, such as:

1. **Situation:** What is the design situation of the product, is it a fully new product or is it intended to improve an existing one? If this project improves an existing product, which life cycle aspects (e.g., detailed design, operation and maintenance) are needed to be improved?
2. **Expertise:** What tracks and professionals are needed for the project?
3. **Frequency and severity:** What are the frequency and severity of a given need for the project?
4. **Urgency:** How urgent is the need for the end-user?
5. **Limits:** What are the practical and physical limits associated with the need?
6. **Spillover effects:** What are the potential expected effects of the final product on other systems or at other locations?
7. **Knowledge:** What is the current state-of-the-art with respect to the developed product and what are the existing available technologies?
8. **Viewpoints:** What are the different views of various stakeholders about the product to be developed?
9. **Experience:** How much experience should exist in the design team for developing the product?
10. **Kind of need:** What kind of needs would the stakeholders and the product have?

[2] **S**pecific, **M**easurable, **A**ssignable, **R**ealistic, **T**ime-related.

B.3 The Programme of requirements

The Programme of requirements (PoR) comprises the description of the *features* of the product to be developed, namely:

- its key performance indicators (KPI) and
- the conditions applying to its development, production/implementation, exploitation and discarding.

It is important to bear in mind that all choices made during the design process and the assessment of the suitability of the proposed technical solutions must be based on the PoR. From this perspective, it is clear that the PoR elements, the performance indicators in the first place, must be *specific* and *measurable*. Vague formulations, e.g., "The whole system must be as efficient as possible." or "The system must implement [...] in the best possible way." offer no real basis for making choices or assessing the final results and may never be used in the PoR → please use *quantitative* performance indicators instead. The PoR should be, inasmuch as possible, self-contained and, thus, it is advisable to start the PoR by giving a brief, general description of the product requested via the assignment. It is also useful to state whether the product is meant for the consumer market, the professional market, etc., this inherently resulting in a number of requirements that are specific to those target areas.

This section now proceeds by firstly discussing the general principles to be followed for compiling an adequate PoR, followed by a s study-case in which the main groups of requirements will be illustrated. Please note that the selected case-study (possibly perceived as factitious within the scope of EE BSc graduation) offers the framework for cataloguing all (reasonably) conceivable PoR entries that may apply to a thesis → clearly, an actual thesis will only comprise an applicable subset of these entries.

B.3.1 Specifying requirements

The first step in any design effort is translating the needs of the stakeholder and customers into a set of requirements. A requirement is defined as *a statement that determines a capability or a function which is required by the system to satisfy the needs of the end-users*. According to the Capability Maturity Model Integration (CMMI), a requirement refers to a condition or a capability that is needed to accomplish an objective or that must be provided by a design product to satisfy a contract, standard, or specification [3].

In a nutshell, the requirements definition must highlight:

- Why a system or a product is required considering current and future conditions?
- What system characteristics are served and satisfied?
- How the system shall be built up?

Requirement formulation

The requirements shall be formulated based on a *well-defined problem* (see Section B.2). They can be formulated based on the capabilities or the top-level functions that the product will perform. For instance, a requirement can be stated as "The product shall hold together 20 papers of my report". Based on this requirement, the possible solutions are a staple, a paper clip, etc. However these are likely to be based on an assumption that the report shall be on paper [3], *that may simply not apply*. It is then clearly better to firstly identify the need or the deficiency. For the above example, the deficiency is "The papers of my report are falling apart". This immediately opens a range of possible new solutions, such as electronic filing, video, etc. This example conclusively demonstrates the need to formulate requirements formulated based on the needs or the deficiency, and not based on preconceived solutions.

In general, the requirements are divided into two groups as follows:

1. **Mandatory requirements or constraints** (hereafter denoted as **MR**)
    - the product must always comply with these requirements, otherwise the design is not good or not acceptable;

- **MR**s are described as binary where the design either complies or not (so no scoring or scaling schemes will be involved);
- **MR**s can never be a part of the trade-off;
- **MR**s are typically formulated using "The product shall" or, even better, "The product must".

2. **Trade-off requirements or objectives** (hereafter denoted as **ToR**)

   - the end-users become increasingly satisfied as these requirements are satisfied;
   - **ToR**s are described by scoring or ranking functions (therefore it can measured to what extent these objectives are achieved);
   - **ToR**s are typically formulated using "The product will" or "The product should", or "The product should preferably";

Note that whether a requirement is a **MR** or a **ToR** is fully the (subjective) choice of the designer. In many cases, there is a relation between **MR**s and **ToR**s, with a **MR** being an upper or a lower bound of a **ToR**. For instance, if the requirement is "The product shall be affordable, with the total costs below X €" then either of the variants is possible:

- **MR**: the maximum limit over the total costs is... ($\rightarrow$ Costs$<$X €);
- **ToR**: minimise the total costs of the product ($\rightarrow$ *min*(costs)).

The requirements can be also classified as:

- **Functional requirements:** These are the things which the product has to do, and they exist due to the subject matter within the context of the product. For instance, "The system shall cook the food using microwave".
- **Non-functional requirements:** These are the qualities or attributes which the product must have, such as performance, security, usability, maintainability, etc. For instance, "The display of the system shall be visible to a person within a 5 m range".

How to formulate properly a requirement

As always, a clear and precise formulation is crucial to (later) avoide ambiguities. Some important conditions on specifying requirements are enumerated below [3]:

1. A well-formulated requirement always addresses *what* the product has to do, and not *how* the product will actually do it.
2. The requirements must directly point out the product, *and not the functions* of the product. In other words, the requirement must state what specifically the product has to do. The aspects concerning the functions of the product has to do will not be addressed in the requirements, and will be mainly addressed in the design document.
3. Each requirement must be *atomic*, namely unitary or single-minded, by always linking *one* idea to *one* element/feature of the product. For example, "The system needs to be cheap and sustainable" or "Table legs and table top should be strong" are not atomic (and accordingly not well formulated).
4. The requirements must be *unambiguous* and *verifiable* $\rightarrow$ *quantitative values* must be given. By that token, "The system will be low cost" is not well formulated. On the contrary, "The system will have a reliability of 0.99" is a good requirement, as it is verifiable and testable.
5. *Words like optimise, maximise, minimise, "high", "low" must be avoided at all costs!*

Sources for the requirements

There is a wide range of sources which can be effectively used to compile the set of the requirements, with some examples being given below:

- **Functions:** The functions of the product are evidently a good source to describe the functional requirements of a product.
- **Input – output:** Some functional requirements describe explicitly an input – output relationship.
- **Technology:** These are mainly the technology requirements of the product.
- **Performance:** There are many performance requirements including the quantity (how many, how much), the quality (how well), the coverage (how much area, how far), the timeliness (how responsive, how frequent), and the readiness (reliability, availability).
- **Cost:** There are a variety of costs, such as investments, maintenance, labor, resources, etc.
- **Trade-off:** There is a clear trade-off between the costs and the expected performance of the product that can be considered as a source for the requirements.
- **Safety and environment:** There are safety and environments considerations which can be translated into requirements.
- **Ethics:** Ethical considerations are an important source yielding many requirements; note that ethical aspects are a highly relevant component of the BAP (see Chapter 3).
- **Business practices:** Corporate business policies and practices might need a work breakdown.
- **Laws or standards:** Requirements can specify their compliance with a certain number of laws, rules, or standards.

Ways to express the requirements

In general, there are two ways of expressing requirements:

1. **Verbal**, with requirements being expressed in sentences and paragraphs:
   - a narrative expression of the requirements like *use case* models; these models (i) feel somewhat vague; (ii) do not contain all requirements and (iii) the completeness of a set of use cases is sometimes difficult to assess, especially for complex products;
   - a list ("the system must…", "the system will…"); this model is useful for acceptance testing but may be difficult to write;
   - combined / hybrid approach, which uses both narrative expression and lists of [4] (see Fig. B.1).

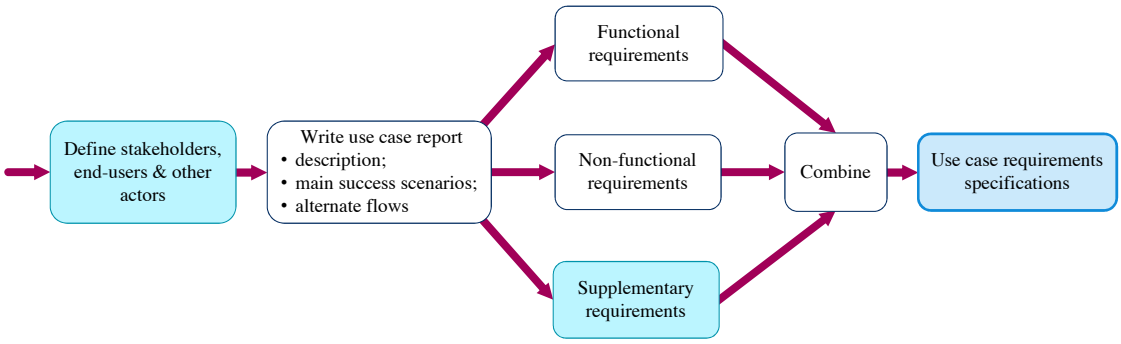

Figure B.1: Hybrid approach of "use case" models and list of "the system shall" to obtain requirements specifications.

2. **Non-verbal** with the requirements being illustrated using graphs, tables, etc.; this approach is suited to defining models, prototypes, sequence diagrams, etc.

Requirements trawling techniques

Many techniques can be effectively used to elucidate the requirements: interviewing, brainstorming, mind mapping, abstraction, use case workshops etc [5]. In view of BAP's specificity, interviewing and brainstorming techniques within the group seem the best suited for compiling your PoR and, consequently, some recommendations on these techniques are given below:

1. **Interviewing:**

   Helpful indications are given in [1, Chapter 7], including a three-phase plan. Preparing an interview must be done carefully, with an accurate investigation of the interviewee's background and field being mandatory (web-based research may prove instrumental to this end). More suggestions for a successful interview are given in [5]:

   - talk to the people who have hands-on experience with the subject;
   - use models and sketches to feedback and improve your understanding;
   - listen to your interviewee;
   - thank the interviewee for giving you the time.

2. **Brainstorming:**

   The purpose of brainstorming is to use the group for generating good ideas and for solving problems [5]. Some guidelines for brainstorming [6] are:

   - do not evaluate and criticism is not allowed;
   - do not clarify or seek clarification;
   - go for zany ideas;
   - expand on each other's ideas and try to support other ideas;
   - list all ideas;
   - avoid attaching individual names to ideas.

B.3.2 Study-case

This section will catalogue, without any claim of exhaustivity, the features that are most likely to occur in a PoR. For clarity, these features will be numbered. Please note that the opportunity of these elements depends on the specificity of your assignment and, thus, including all of them in your PoR is not mandatory. The various groups of requirements will be illustrated via a study-case involving the design of a working place in a call-centre of a bank.

Functional requirements

The requirements in this group concern the purpose of the product to be developed. As a rule, requirements are constructed following a [*subject*]–[*attribute(s)*]–[*predicate*] pattern. Attention should be paid to the fact that the functionality description concerns:

- a product with given characteristics;
- the environment in which the product will operate;
- the operation prescriptions following from the combination of the above two items.

Please bear in mind that the specific conditions and features are elaborated upon in the subsequent sections, *not here*.

Example:

[1.1] The system must display for each client a window in which all data needed for effectuating a payment are available.

[1.2] The data in the client's account, such as account number, type of account, the client's address and her/his identification data must be shown in this window.

[1.3] The system must keep track of the data input during an editing session.

Ecological embedding in the environment

The requirements in this group concern environment, safety (in operation), social aspects, esthetics, logistics, etc.

Example:

[2.1] The system's operational elements must be amenable to individual adjustment according to the prescriptions of the Occupational Health and Safety Office (in Dutch, ARBO-dienst).

[2.2] The electromagnetic radiation from the screen may not exceed 1 mW/cm^2 in the broadside direction.

System requirements

The requirements in this group concern the main features and functionalities to be implemented, with the pertaining performance indicators. For clarity, these requirements are further subdivided over the three phases in the product's life cycle.

Utilisation features

These features comprise:

- functional requirements concerning functions, performance, etc.;
- requirements concerning the product's production, assembling and installation;
- maintenance requirements concerning efficiency, exploitation, replacement, repair, disposal.

Example:

[3.1.1] Credited amounts must be displayed in red, and debited amounts must be displayed in white. (functional feature)

[3.1.2] Replacement of a defective computer and re-installation of a full back-up must be carried out within two hours. (production/installation feature)

[3.1.3] The system must keep track of the period when each computer was online. (maintenance feature)

[3.1.4] The lifespan of the computers must be at least three years. (maintenance feature)

[3.1.5] The supplier of the computers must offer support and maintenance at least five years after purchasing. (maintenance feature)

[3.1.6] The product must comply to the requirements for receiving a CE-qualifier. (maintenance feature)

Production and putting into use features

These features comprise:

- requirements concerning the product's production, assembling and installation;
- requirements concerning testing, handing-over and deployment of the product.

Example:

[3.2.1] Operational software must be installable at the user's premises; additional software must be pre-installed and must have the needed licenses. (installation feature)

[3.2.2] The loading of the system's master computer may not exceed 60% of its capacity with 40 operators attending to clients simultaneously. (testing feature)

Discarding features

This section refers to requirements concerning the amount of waste generated at discarding the product and the recycling possibilities. Examples of such features are:

- requirements concerning the dismantling of the product;
- requirements concerning recycling;
- requirements concerning the sustainability of the product;
- requirements concerning the environmental friendliness of the expected discarding procedures and the (possibly hazardous) materials resulting in the process.

Example:

[3.3.1] The equipment must be easily dismantlable. (dismantling feature)

[3.3.2] 80% of the materials in the equipment must be amenable to recycling. (recycling feature)

[3.3.3] Beryllium may be present in the employed monitors. (environmental friendliness feature)

Development of manufacturing methodologies

The manufacturing of a product requires in most cases (dedicated) tools, devices, testing facilities, supporting equipment, etc. When applicable, these must be specified in the PoR.

Example:

[4.1] The operational software must be developed in standard ANSI C++. The employed compilers must be validated according to the ANSI/ISO/IEC standards.

Within another context, one can imagine a requirement as "The components in a pin-grid packaging must be amenable to placement at a pin spacing of 0.1 inch." Such a requirement may have a direct consequence on the type of pick-and-place machines used for soldering the needed components.

Liquidation/recycling methodologies

The requirements in this group concern the minimisation of the amount of hazardous materials resulting during the discarding of the product and ensuring a high level of recycling of the constituting materials. Note that the discarding features were already mentioned at Section B.3.2. This section only concerns the requirements on the system to actuallly effectuate the discarding of the product.

Example:

[5.1] At the end of the product's lifespan, the discarding of the equipment must comply to the norms referring to processing of small chemical waste.

Business strategies, marketing and sales opportunities

Example:

[6.1] The needed computers must be delivered within 3 months when ordered in a batch of 100 pieces.

B.4 The literature study

The preparation of the literature study is an important element of the project and has a significant impact on its progress. An adequately prepared study can expedite substantially the group's work! Students are strongly encouraged to consult their supervisor for drawing this study. All group supervisors are experienced researchers and educators and they are excellently prepared for guiding them through this process.

It is important to recall that, while the literature study is requested as a separate document, *there is no such chapter in the thesis*! The material included in this study finds its place in the thesis as follows:

1. A large part of the references are used in the state-of-the-art analysis that will be placed in the thesis' Introduction. This is a crucial element of the thesis, since it addresses the following basic aspects:
    - what one wants to do;
    - what has been done in that direction – this will elucidate whether the envisaged task is relevant and precludes solving an already solved problem;
    - what is still needed, this laying the basis for the problem formulation.
2. More references will be used in support of the choices throughout the thesis (theory, implementation aspects, etc.).
3. The study will also provide the basis for comparisons occurring in the solution validation.

The literature study will consist, primarily, of a bibliography list, possibly supplemented with short comments indicating where the relevant bibliographic topics are to be used. Compiling the bibliography according to the thesis requirements saves a lot of time, the list being amenable to be included, as such, in the thesis' references list.

Although it is quite likely that more bibliographic sources will be added as the project progresses, the literature study will yield the bulk of the final bibliography. It is then recommendable to come close in the study to the minimum recommended number of publications, namely 20. It is important to recall that references to peer-reviewed publications are clearly to be preferred to non-reviewed entries (Wikipedia and such). Actually, the only non-peer-reviewed publications that are generally acceptable in the list op references are user manuals and data sheets of the employed materials and/or devices.

Appendix C

Designing the poster

A poster is a widely employed presentation instrument. Poster presentations differ in many respects from written reporting and standard presentations. One should bear in mind that a *scientific poster* is no advertisement instrument but still, to some extent, a business-line undertaking – the specific implementation is just different. Moreover, a poster must be catchy but, above all, its contents must be irreproachable.

A poster is primarily an invitation for a discussion with the viewer. Its contents can never be exhaustive, neither is that its purpose. On the contrary, the poster must trigger and support a dialogue between the presenter (who, evidently, must be present) and any potentially interested person. A short verbal explanation must always be prepared in advance – if this explanation cannot be concentrated in a small number of sentences, than the poster contains quite likely too much information. The golden rule is: poster + short explanation = main message to be conveyed. Of course, the poster can also contain technical details → these will be the basis for an ensuing, more "technical" discussion that can follow the statement of the main message. Nonetheless, if the interlocutor is not convinced by the main message, the discussion will never reach the moment when technical details can be elaborated upon.

Some useful hints on the preparation of posters can be found at https://ai5.wtb.tue.nl/doccontent/vaardighedenBMT/default.php, under the **Rapporteren** tab. A number of general recommendation for drawing a poster are hereafter provided.

C.1 Contents recommendation

Ensure that the poster carries a short, informative and catchy title. The title must be prominently visible at the top of the poster, together with the group's number and the TU Delft logo. A powerful, easy-to-remember slogan placed immediately underneath is highly recommendable.

The poster should be read in a natural way, starting from left-up and ending right-down. A two-column format is more frequent, although a one-column format may also be opportune, depending on the subject at hand (using more columns will result in too much unused space). As with any (scientific) document, posters contain the following main elements: introduction, methods, results, discussion, conclusions – although, except for "conclusions", this terming ought not be used verbatim in the section headings. Section headings must be clearly visible. These main elements may be supplemented by a short list of well-selected references (this list is positioned right-below).

Use compact, but clear formulations (slogan-like). The available editorial space is (very) limited, but the message must still be conveyed and must present sufficient attractiveness. It is important to critically select what to include in the poster. Select the most important elements giving a clear big picture and lending themselves to a logical combination without needing much explanations and details. In particular, be very cautious about the employed math → recall that all formulas must be clearly visible and all intervening symbols must be explained, this requiring a lot of editorial space. Detailed math can always be provided as handouts! The basic rule is: not everything must be on the poster, you are there to explain.

C.2 Lay-out

The main rule is: make the poster clear and comprehensible.

To begin with, a "calm" background colour is advisable. Vivid colours may catch the attention (although they may have an opposite effect on some people!) but have the tendency of shifting the focus from the contents. Furthermore, a dark background requires the use of light text. This combination is more difficult to read and, thus, it requires the use of larger fonts for ensuring legibility.

The composition is very important – a scientific poster is not a work of art, it must logically lead the reader through the poster's elements for conveying the main message. A good strategy is to arrange the main elements as "blocks", possibly enclosed in a frame or using an unobtrusive, individualised background. Numbering the blocks may foster navigation through the poster in the intended sequence. In any case, place the blocks in the logical sequence, from left-up (introduction) towards right-down (conclusions + references).

The employed fonts must allow reading the poster from at least 1 m. A good practice is:

- titles: $50 \div 60$ pt fonts;
- group number + slogan: $30 \div 40$ pt fonts;
- section headings: 48 pt fonts;
- text: at least 24 pt fonts.

Sans serif fonts are more adequate for posters – consider the Arial or Helvetica families of fonts.

Make use, inasmuch as possible of figures – a well-chosen figure can tell more than 1000 words! Figures can be anything: photos, diagrams, plots, etc. Nonetheless, restrict the number of figures to the absolute minimum, too many figures will end up in distracting the reader. It is crucial to ensure the quality of the employed figure, both as concerns their contents (they must be functional and, evidently, absolutely correct) and as concerns their graphic quality (especially for plots, use vectorial graphic formats as opposed to bitmapped graphics). Provide short, but informative captions for all employed figures or tables.

Ensure a good overall "artistic" quality – present day graphic software packages provide a myriad of options in this respect. Nevertheless, keep in mind that in the case of (scientific) posters, form must support the contents and not the other way around.

Appendix D

Timelines, deadlines and deliverables

The timelines[1] provided in this appendix concern the BAP milestones. They were chosen based on previous experience and the structure of the current academic year such that to ensure an adequate progress in, and completion of, this educational activity. Occasionally, due to objective reasons, these timelines may have to be subject to minor adjustments – all modifications will be timely communicated via Brightspace.

The timelines given on Brightspace must always be taken as reference.

D.1 BAP Q2

First quarter / Weeks 6 ÷ 10

- **Activities:** BAP-Q2 kick-off meeting with the *enrolled* candidates: basic concepts, requirements, information on group activity, information on group forming, etc.; groups forming; BAP proposed subjects are discussed with the groups – selection and allocation of project subjects; first contacts with the group supervisor, agreements on the workplace and general strategies; subdivision of the group into subgroups of two (if applicable); *carrying out of the literature study*; technical pre-studies; market surveys; drawing the project plan.
- **Deliverables/deadlines:** (Draft) literature study submitted to the supervisor/ project proposer – to be agreed upon.

Second quarter / Weeks 1 ÷ 4

- **Lectures:** Lectures and/or workshops for the components "Business plan" and "Ethics and technology".
- **Activities:** Bachelor thesis and Business plan group activities; setting up the date for the **Green-light assessment** – to be agreed upon; **Green-light assessment** – to be agreed upon.
- **Deliverables/deadlines:** –

Second quarter / Weeks 5 ÷ 10

- **Activities:** Bachelor thesis and Business plan group activities; completion of the Bachelor thesis; final Bachelor thesis exams – Before 20th of December, 2019; completion of the Business plan; presentations of the business plans and posters – Before 20th of December, 2019; representative prototypes and posters should be preserved for publicity ends, such as Open Days, etc.
- **Deliverables/deadlines:** Submission of Bachelor thesis to the jury – Before 20th of December, 2019; submission of the Business plan to the discipline's coordinator – Before 20th of December, 2019.

[1] The timelines typeset in colour are definitive, those typeset in colour are tentative while those typeset in colour are token ones.

D.2 BAP Q4

Third quarter / Weeks 1 ÷ 3

- **Activities:** apply for admission to the BAP via the dedicated online tool; BAP proposed subjects are posted on Brightspace; BAP-Q4 kick-off meeting with the (potential) candidates: basic concepts, requirements, information on group activity, information on group forming, etc.
- **Deliverables/deadlines:** apply for admission to the BAP – 23rd of February, 2020

Third quarter / Weeks 4 ÷ 9

- **Activities:** Group forming; selection and allocation of project subjects; first contacts with the group supervisor, agreements on the workplace and general strategies; subdivision of the group into sub-groups of two; technical pre-studies; market surveys; drawing the project plan; *starting the literature study*.
- **Deliverables/deadlines:** –

Fourth quarter / Weeks 1 ÷ 4

- **Lectures:** Lectures for the components "Business plan" and "Ethics and technology".
- **Activities:** Bachelor thesis and Business plan group activities; setting up the timetable for the **Green-light assessment** – 11th ÷ 15th of May, 2020.
- **Deliverables/deadlines:** (Draft) literature study submitted to the supervisor/ project proposer – 27th of April, 2020.

Fourth quarter / Weeks 5 ÷ 10

- **Activities:** Bachelor thesis and Business plan group activities; **Green-light assessment** – 25th ÷ 29th of May, 2020; completion of the Bachelor thesis; (practical) completion of the Business plan.
- **Deliverables/deadlines:** Submission of Bachelor thesis to the jury – 19th of June, 2020.

Fourth quarter / Weeks 10 ÷ 11

- **Activities:** Preparation for the exams; final Bachelor thesis exams – 29th of June÷ 2nd of July, 2020; theses to be uploaded on the repository *after* revising according to the comments received during the exams; Grand Finale – 3rd of July, 2020, with the presentations of the business plans and the poster session and awarding the "IEEE best business plan award"; representative prototypes and posters should be preserved for publicity ends, such as Open Days, etc.
- **Deliverables/deadlines:** Submission of the Business plan to the discipline's coordinator – 29th of June, 2020.

Appendix E

Group forming

The assembling of the BSc graduation project groups is done via the EE3L11 Brightspace site – *the group forming procedures applicable to BAP-Q2 and BAP-Q4 differ*. All interested students are allowed to self-enrol in Brightspace for EE3L11. Once the group enrolment is initiated, only those students that are formally admitted to the project will be allowed to join a group. However, all Brightspace information will remain visible to everyone, including for the students (temporarily) excluded from joining a project group.

E.1 Group forming in BAP-Q2

In view of the reduced number of BAP-Q2 students, the group forming is in that case straightforward:

1. The eligibility of the students is checked at the beginning of the academic year (see Section 1.3 for the applicable entry requirements):
   - the students that comply to the entry requirements are automatically admitted to the project;
   - the students that *marginally* miss the entry requirements are admitted contingent on a positive assessment of their individual applications.

   Tentatively, the students' eligibility check should be finalised in the fourth week of Q1.
2. All students admitted to the project are informed by the BAP coordinator and enrolled in Brightspace.
3. All admitted students are invited to participate in the BAP-Q2 kick-off meeting.
4. All available project proposals will be discussed with the enrolled students – as a rule, this is done either during the BAP-Q2 kick-off meeting, or in the next few days. The admitted students may also propose themselves a BAP assignment.

If no students qualify for BAP-Q2, the steps $2 \div 4$ in the above scheme are, evidently, not applicable.

E.2 Group forming in BAP-Q4

BAP-Q4 is the primary manner of effectuating the BSc graduation project and, consequently, it involves a large number of students. The group forming is more elaborate, the relevant steps being henceforth given.

E.2.1 Project proposals

All approved project proposals formulated by faculty staff members and external proposers are posted on Brightspace within the **Course Information** module. This list should be available in the first week of Q3.

Additionally, students are allowed to propose themselves BSc graduation projects, providing the proposals' suitability is favourably assessed. When drawing a proposal, the students must have in view the following requirements:

- the project proposal provides sufficient scope for a group of 6 students, subdivided into 3 subgroups of 2; *proposals not offering this scope will not be considered*;
- the students must find a faculty (senior) staff member who is willing to supervise the group; it is advisable to think already from the beginning of a potential supervisor or, at least, of the best possible embedding of the project in one of the faculty's sections;
- BAP has no own budget and, hence, the group itself is responsible for providing, if needed, the financial support of the intended activity (basic, standard components can be, and usually are provided by the university).

The following steps are required in the case of self-proposed projects:

1. An initiative group must prepare a document (about one page) containing the following elements:
   - a title;
   - a description of the envisaged goal, preferably supported by a very brief background and/or state-of-the-art analysis;
   - a description of the technical challenges;
   - a list of the expected technical deliverables (e.g., the expected prototype).
2. The proposal is discussed with the BAP coordinator. The main aspects to be assessed are:
   - is the expected project at par with the EE BSc graduation project level;
   - is there sufficient scope for all subgroups to effectuate a quality design/research activity;
   - are the objectives realistic and achievable within 10 weeks.
3. Should the proposal be assessed favourably (possibly after some revisions) the students must find a group supervisor.
4. Once the supervisor is appointed, the project is formally assigned to the group.

Note: When proposing an own project it is advisable to readily assemble a group of 6 – please consider carefully *each of the envisaged member's eligibility for effectuating the BSc graduation project!* Should a group be incomplete, it can ask the inclusion of the project proposal in the general BAP list of proposals – this can only be done after steps 1÷3 above were completed. Once a proposal is included in the general list, the initiative group can make no objection concerning the additional students joining the group. Furthermore, if after all students have opted for a project the number of students for the proposed project remains insufficient, the self-proposed project may have to be discontinued.

E.2.2 Group forming and allocation of project assignments

The group forming process is fully embedded in Brightspace and consists of the following steps:

1. For allowing a proper information on the contents of this educational activity, the BAP Brightspace is open well in advance of the actual commencement of the group forming. At that point, all students are allowed to self-enrol in the BAP Brightspace platform.
2. The eligibility of the students is checked at the beginning of Q3 (see Section 1.3 for the applicable entry requirements).

   All students *must* apply for admission to the BAP, this being done via a dedicated online tool that is made available on both the BAP Brightspace platform and on the general BSc Brightspace platform. The deadline for submitting this application is 23rd of February, 2020, and failing to submit this application will automatically exclude the relevant student from BAP! Upon submitting the admission application, the following situations may occur:
   - a student fully complies to the entry requirements → automatic admission to BAP;

- a student *marginally* misses the entry requirements → (s)he will have to apply for an *exception from the entry requirements* in the form of an explanatory letter substantiating the admission to BAP; each application will be assessed *individually* by the Director of Studies and the BSc Academic councillor, whereupon a decision on the admission will be taken; the students having more than one open course will also be invited for an interview with the Director of Studies and the BSc Academic councillor.

A first list of admitted students *may* be presented during the BAP-Q4 kick-off meeting.

3. Immediately after the deadline for submitting the applications for enrolment (23rd of February, 2020), the status of the students who are already enrolled in Brightspace but did not (yet) receive the formal admission *will be switched to "read-only"*. With this status, those students will still be able to see all documents posted on Brightspace *but will not be able to enrol in a project group*.

   Note: In order to prevent ambiguities, the self-enrolment to the BAP Brightspace platform will be turned off at that moment. The students still wanting to enrol in the platform afterwards must contact the BAP coordinator by email, and will be manually enrolled with a "read-only" status.

4. The next step will be the assessment of the still open applications for exception from the entry requirements (primarily of the students that will be invited for an interview). This phase is expected to be finalised in about one week.

   All students receiving a favourable decision for their application to exception will be expeditiously informed by e-mail and their Brightspace status will be reversed to "student", thus allowing them to join a group.

5. Once the status of all students was clarified, a sufficient number of groups will be created in Brightspace. All groups have 6 seats and the enrolment is closed once all seats are occupied.

   Note: At the moment of the groups becoming available, all admitted students will have a "student" status, and all not admitted ones will have a "read-only" one – the reminder of this protocol does not apply to the students in this category.

6. All students may self-enrol in any group, as long as a group has open seats. Students may at any time un-enrol from one group and move to another one. The BAP coordinator will set a hard *group forming deadline* for group enrolment – it is expected that the group forming should be completed within 3-4 days.

   After the group forming deadline, all groups of less than 4 students will be merged into groups of 4, 5 or 6 students. This process will be *mediated* by the BAP coordinator.

7. Each group is entitled to formulate a *fivefold preference* for any of the BAP proposals on the Brightspace list or for a "Free elective" one (an own proposal). These preferences must be indicated via the group's Brightspace "Discussion area" (preferences expressed via e-mails to the BAP coordinator will not be considered). Should a group opt for an own proposal, its eligibility must be discussed with the BAP coordinator (see Section E.2.1). The deadline for expressing preferences will be set after the completion of the group forming and merger (as stated above) – this deadline will be announced via Brightspace. Note that preferences may be expressed already before the group forming deadline, this primarily applying to groups with complete occupancy.

8. After the deadline for expressing preferences, the BAP assignments are allocated according to the expressed preferences[1]:

   - project proposals that appear as first preference for only one group are automatically allocated to the relevant group;
   - in the case of assignments indicated as first preference by more groups, there will be a negotiation process *mediated* by the BAP coordinator.

9. The final list of groups and their pertaining assignments will be posted on Brightspace.

[1] The details of the project allocation procedure will be discussed and agreed upon during the BAP-Q4 kick-off meeting. *Complaints formulated after an agreement was reached at will not be taken into consideration.*

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