Grading Rubric for the Final Paper

Topic	Expected content	Grade 1	2	3	4	5	6
Mission statement (weight = 10%)	**Goal(s), Mission and (Science) Objectives**	Goal, Mission and Objective(s) are not mentioned	Goal, Mission and Objective(s) are very vague or unclear	Goal, Mission and Objective(s) are mentioned but are not SMART	Goal, Mission and Objective(s) are SMART	Goal, Mission and Objective(s) are SMART and clearly flow down from one another. That is, the Goal indicates the overall ambitions, the Mission details how these ambitions will be met and the main (and secondary) Objective(s) show what should be done for the mission.	Goal, Mission and Objectives flow down clearly from customer requirements and from literature findings. Efforts have been made to show how the goal, mission and objectives compare to other similar missions
	Stakeholders	No mention is made of stakeholders	A vague mention of stakeholders is made	Some stakeholders are mentioned, but not the most important ones, or not in an extensive way	The key stakeholders and actors are summarised and their interest in the mission is explained	The key stakeholders and actors are listed, and their needs are well distinguished from one another and flow down into the requirements.	The students show a simple stakeholder value network (SVN) to indicate the interactions between stakeholders. This can be done through a small Hub & Spoke Diagram or in a text format.
Mission design (weight = 10%)	**CONOPS**	CONOPS is not mentioned	CONOPS is unclear or vaguely discussed	Only some aspects of the CONOPS are mentioned	The CONOPS is discussed, with a list of key elements of the mission (e.g. duration, 'phases, trajectory and orbit, launch vehicle, launch windows etc)	The CONOPS is sufficiently detailed, showing that the mission is well designed and understood. The CONOPS follows well from the Mission Statement. The different mission phases are well explained along with their main activities and driving design constraints.	The students make an effort to make the CONOPS visually easy to understand, without overcrowding the infographic. The students make the links with the stakeholders and actors.
	Project Timeline	The project timeline is not discussed	The project timeline is unclear or not well thought-through	The project timeline is clearly shown but does not make the link with any of the system engineering phases (Phases 0-A to E) discussed in class	A clear project timeline is given, from the earliest design phase to the end-of life	The project timeline is achievable and realistic. Where needed, links are made with the risk assessment..	The students look beyond the current project's timline and give an indication on extension or follow-up projects
	System modes	No modes are described	The system modes are poorly described (e.g. hey do not flow down from the CONOPS, their design implications are not given)	The modes are given but the link with the CONOPs is unclear.	The system modes are given in relation to the CONOPS	The system modes are detailed enough to indicate what design aspects they drive, in terms of (sub)system or componenent design	The students show that the system modes are used to define and update the budgets
	End-of-Life (EOL) Strategy	No EOL considerations were made or discussed	The EOL is not clearly shown.	The EOL considerations are included	The EOL strategy is logical and feasible	The EOL strategy follows from a tradeoff between technical considerations and sustainable guidelines	The students highlight what the technical implications, risks and sustainability advantages are of the chosen EOL strategy.
Systems engineering (weight = 15%)	**Functionality analysis**	The functionality analysis is not mentioned	A vague functionality analysis is shown or mentioned	The functionality analysis of the space mission has been presented clearly	The discussed mission's functionality follow from the Mission Statement	The mission's functionalities flow from an extensive functional breakdown	Special care has been put into explaining the reasoning behind certain functions, linking them with the CONOPS, customer requirements or other relevant aspects.
	Mission requirements	The requirements are not mentioned	Some **key** requirements are mentioned, but they are not formulated in the correct way or clearly lack a reasonning	The **key** requirements are given and are mentioned. They are written in the correct way (i.e. using the verb " shall", and using an ID)	The **key** requirements are SMART. The link with the functional breakdown is clear. A good reasoning for them is shown.	Relations between **key** high-level and lower-level requirements are shown. The students show a good reflection of the requirements. That is, the students highlight the requirements which drive the design the most and their associated risks are discussed if relevant	The selections of **key** requirements shown in the paper is logical and aids to answer the paper's research question.The paper provides insight into what the other (not shown) requirements pertain to and, where needed, how they affected the design.
	Mission constraints and limitations (environment)	Mission constraints and limitations are not discussed	A very vague discussion of mission constraints due to the spacecraft's environment is given	Key mission constraints and limitations are given and linked to the spacecraft's environments	Clear research on the spacecraft envronments throughout its life cycle has been shown. The essential mission constraints and limitations have been distilled from them.	The listed mission constraints and limitations flow into the requirements and the risks.	The students make it clear how the environmental constraints are adressed in the mission design.
	Mission sucess criteria and measures of success	No success criteria or measures of success are mentioned	Unclear what the mission success criteria are or how the success is to be measured.	Mission success criteria are clearly mentioned and logical	Mission success criteria and measures of success are SMART and logical	The mission success criteria are clearly reflected in the requirements	The mission success criteria and measures of success are clearly mapped onto the CONOPS. That is, they are linked with the mission phases. Secondary mission success criteria are given, in case the primary ones cannot be met
	Interface analysis	No interface analysis is done	A vague or rushed interface analysis is shown	The interfaces of few subsystems are analysed	An analysis is done of the most important interfaces between subsystems. This is done in a text form or using tools such as a design structure matri (DSM)	The effect of the interface is discussed. Where relevant, risks associated with subsystems interfaces are discussed.	It is clearly shown that requirements have been derived from the interface analysis and how they influenced the design.
Mission Architecture (weight = 10%)	**Alternative conceptual solutions**	No alternative conceptual solutions are mentioned	One or more alternative conceptual solution(s) are presented. No relevant detail is given on them or they are only quickly mentioned.	One or more alternative conceptual designs are mentioned. Sufficient information is given on them to support the final mission concept choice	It is clear that a trade-off was performed between each conceptual solutions, using at least one of the trade-off methodologies given in the lectures.	The alternative conceptual solution(s) is (are) presented with preliminary implications for budgets and mission duration. The trade-off was clear, using amongst others quantifiable parameters that are relevant for the chosen mission.	A preliminary, yet more detailed, study of one of the most promising alternative conceptual solutions is shown. The tradeoff between this alternative concept and the chosen concept has also been further detailed
	Budgets	No budgets have been shown or mentioned	Some budgets have been show without further explanations	Budgets have been shown, but they are not quantified well	The most relevant budget has been shown and is well quantified.	More than one relevant budget breakdowns are given, showing how the budget was computed. The breakdown is logical and based on research	The budgets are linked to the overall systems engineering process (requirements, etc). Some budget margins are shown and discussed. The technical implications of the most critical budgets are mentioned.
	Risk assessment	No risk assessments have been made	A vague risk asessment has been done	A clear risk assessment has been made	The risk assessment is well-explained and uses a system engineering methodology with clear legends for symbols and/or colours.	The risk assesment methodology is chosen wisely, ensuring that the most mission-ending risks stand out. Mitigation are proposed for the most critical risks.	A detailed analysis is done for the most critical risks. The new level of risk after the mitigations are applied is discussed and it is shown how the mitigations affect the Mission Design. Moreover, it is clear that the students reviewed and improved the risk assessment from the previous presentation, if applicable.
Baseline Design (weight = 35%)	**Payload components**	No payloads have been mentioned	Some payloads have been mentioned in a very vague and unclear way	The types of payloads needed for the mission and how they will fill the mission's functions are presented	The types of payloads needed and specifics on some of the payload types is given (e.g. some comparisons with existing payloads, some requirements, etc)	Budgets for key payloads are given. Where possible, some comparable payloads are used as a source of information	The students show a critical mind regarding their choice of payloads. They indicate which ones are the most important, which ones are avalable as COTS components and which ones require most research and developments.
	Spacecraft configuration	No effort is made to show a breakdown of the spacecraft	A vague breakdown of the spacecraft is provided with no dimensioning.	A system breakdown is given partially or without much details. No effort is made to size any elements.	A system breakdown is provided in a text form or in the form of a small graphic, indicating the spacecraft's configurations throughout its mission. An initial volumetric sizing is done to ensure that all susbsystems fit within the spacecraft.	The system breakdown is clearly linked to the CONOPS, showing how the configurations or functions change per mission phase. It is visually shown that the susbsystems and mechanisms would fit within the various constraints (e.g. through 2D sketches).	Details is given on the operations and configuration of the spacecraft's subsystems during the most critical mission phases. This is also flown into the requirements A detailed look on the critical interfaces of one or more subsystems is given, or it is shown clearly that a mechanism would function properly (e.g. ensuring it does not get in conflict with other parts of the S/C during operations)
	EPS	No information on the spacecraft's EPS is given	Only some information on the spacecraft's EPS is given	The information provided on the EPS is vague or is missing key elements	All relevant information on the EPS is discussed. Most are detailed.	The EPS is sized and the relevant characteristics are highlighted following a more detailed analysis. The subsystem is compliant to the (high-level) requirements.	It is clear that the EPS susbsystem was iterated upon. The students dive into detail on some more relevant elements for the mission. The key drivers for the subsystem design are clear and the most evident single-point of failures are highlighted
	Thermal subsystem	No information on the spacecraft's thermal subsystem is given	Only some information on the spacecraft's thermal subsystem is given	The information provided on the thermal subsystem is vague or is missing key elements	All relevant information on the thermal subsystem is discussed. Most are detailed.	The thermal subsystem is sized and the relevant characteristics are highlighted following a more detailed analysis. The subsystem is compliant to the (high-level) requirements.	It is clear that the thermal susbsystem was iterated upon. The students dive into detail on some more relevant elements for the mission. The key drivers for the subsystem design are clear and the most evident single-point of failures are highlighted and the most evident single-point of failures are highlighted
	Propulsion and AOCS	No information on the spacecraft's propulsion and AOCS is given	Only some information on the spacecraft's propulsion and AOCS is given	The information provided on the propulsion and AOCS is vague or is missing key elements	All relevant information on the propulsion and AOCS is discussed. Most are detailed.	The propulsion and AOCS subsystem is sized and the relevant characteristics are highlighted following a more detailed analysis. The subsystem is compliant to the (high-level) requirements.	It is clear that the propulsion and AOCS susbsystem was iterated upon. The students dive into detail on some more relevant elements for the mission. The key drivers for the subsystem design are clear and the most evident single-point of failures are highlighted
	CDH (Command and Data Handling)	No information on the spacecraft's CDH is given	Only some information on the spacecraft's CDH subystem is given	The information provided on the CDH sunsystem is vague or is missing key elements	All relevant information on the CDH is discussed. Most are detailed.	The CDH subsystem is sized and the relevant characteristics are highlighted following a more detailed analysis. The subsystem is compliant to the (high-level) requirements.	It is clear that the CDH susbsystem was iterated upon. The students dive into detail on some more relevant elements for the mission. The key drivers for the subsystem design are clear and the most evident single-point of failures are highlighted
	Spacecraft's and launcher's structure and mechanisms	No effort is made to show the strucrure or mechanism characteristics	The students only provide a vague description of the structure and mechanisms	Some aspects of the structure and mechanisms are detailed.	The key aspects of the structural components and mechanisms of the spacecraft and interface between the launcher and the spacecraft(s) are discussed	The key design drivers behind the spacecraft's and launcher's structure and mechanisms. These are linked with requirements	The students go in detail on some relevant aspects of the spacecraft's structure and mechanisms, including single points of failures. Where logical, students highlight risks and risk mitigations.
	Launch Segment	No effort is made to discuss the launch segment	The students only provide a vague description of the launch segment	Some aspects of the launch segment are detailed	The launch segment is discussed in sufficient detail	The key requirements for the launch segment are discussed, along with the requirements for the spacecraft due to the launch system (launcher and ground facilities)	The students go in depth on the effect of the launch segment choice for the spacecraft. Some of the driving aspects are discussed and it is shown how this is taken into account in the design and/or in the developement (testing & analysis requirements)
	Telecom and Ground Segment	No effort is made to discuss the ground segment	The students only provide a vague description of theground segment	Some aspects of the ground segment are detailed	The ground segment is discussed in sufficient detail	The key design drivers for the ground segment are discussed and linked with requirements	The students go in depth on the link budget and ground station requirements based on calculations and literature. It is clear that some iterations were performed
Scientific Writing skills (weight = 20%)	**Structure and content**	The paper is not subdivided in any sections, providing no structure to the text.	Not all elements of a typical structure of an academic paper are visible	Only the abstract, introduction and conclusion are clearly indicated. There is no structure given to the content of the work (e.g. the methodology and results) or discussion, or future work	All the basic elements of a typical academic paper are provided. Depending on the topic of the paper, these are: the abstract, introduction, content (structured as deemed logical in e.g. literature review, methodology and results), discussion, conclusion and future work. The paper clearly goes from a broad perspective at the beginning, to a more narrow discussion on the topic of the research, followed by a broadening of the discussion again at the end.	The aim, importance and novelty of the research is clear and the conclusions are logical. The content is structured logically, with all the necessary sections and including sub-sections for better readability. The structure of the paper is introduced concisely in the introduction and any substructure of a section is introduced briefly at the start of said section.	The text is split up logically in paragraphs. Efforts is put into clearly indicating the contents of the paragraph through its first sentence. The readers can thus know at a quick glance what to expect in each paragraph. Titles of subsections are chosen to speed up the clearly indicate the contents in order to speed up the reading. The Abstract can be read as a completely stand-alone text, including a brief summary of the introduction, the paper's content and conclusions. If relevant, the most essential paper's conclusions are quantified in the abstract. For readers with little time, the introduction and the conclusions should provide enough information to understand the paper.
	Respect of scientific paper guidelines	The paper does not follow any scientific writing guidelines	Not all paper guidelines are respected	Most guidelines are respected, but they are applied inconsistently throughout the paper	The general guidelines for the paper are respected throughout the paper. The page limit is respected.	Particular attention is put into the figures and tables and their captions. They are readable without needing zooming in or using reading glasses (e.i. a font size close to the paper's font size). The captions enable an understanding of the figures and tables on their own. The students have put care into the title, list of authors and possible headers and footers. The list of authors should be complete, with the corresponding author(s) indicated and the affiliated institutions.	The students put effort in making their figures accessible to all. This includes, where possible, to use grayscale colours or colours of different brightnesses, use of symbols (with associated legends) and annotations. If equations are used: all symbols are explained and the formulas are presented clearly.
	Citations and quality of sources	The paper does not include any sources	Sources are included, but some do not support the statements for which they are cited	Sources are included but their formatting is either inconsistent, or do not allow one to find the orginal source material	Sufficient sources are included to support the statements in the paper. The formatting of the bibliography is consistent accross sources.	Some sources are recent. Some articles cited are peer-reviewd. Some websites cited are credible. It is clear when statements are paraphrased or directly quoted. Quotations marks are used for direct quotations, while rephrasing of the original quote is done when paraphrasing. In each case, the source is provided.	Most sources are recent (within the last 10 years) and up to date. When URL (not DOI links) are added, the date of last access is mentioned. All websites used as sources are authoritative. Any popular knowledge sources or general (less thrustworthy) websites are ackowledged as such in the text Most sources are peer-reviewed articles

The grade is calculated by rounding to the nearest quarter the outcome of the following formula:

Final grade = ROUND[Avg(Mission statement) * 0.10 + Avg(Mission design) * 0.10 + Avg(Systems Engineering) * 0.15 + Avg(Mission Architecture) * 0.10 + Avg(Baseline Design) * 0.35 + Grade(Scientific Writing Skills) * 0.2]

Note: "Avg" stands for "Average" and is composed of the average grade of a given topic