CHESS - Technical requirements specification

Version			
Issue	**Revision**	**Date**	**Person of contact**
1	0	16.01.2023	Samuel Frachebourg
0	0	10.05.2023	Lina Kuhlmann

Types of Requirements		Key Word	Space
Functional	Defines what functions need to be done to accomplish the mission objectives	**Shall**	**Design**
Performance	Defines how well the system needs to perform the functions	**Shall**	**Design**
Constraints	Cannot be traded off with respect to cost, schedule or performance	**Shall**	**Design**
Interface	Structural / Electrical / Data	**Shall**	**Design**
Environmental	Vaccum / Thermal / Electric / Chemical / Mechanical / Radiations / Contaminations / …	**Shall**	**Design**
Reliability	Risks Management	**Shall**	**Design**
Others	All types of relevant illities: Transportation / Personnel / Training / Maintainability / Operability / Safety / Facility / …	**Shall**	**Design**
Objective	Relevant to Project-level requirements (Stakeholders): Education / Scientific / Finance / …	**Should**	**Objective**

Acceptable Requirements	
Each	
Clear & Consistent	Readily understandable
Correct	Does not contain error of fact
Feasible	Can be satisfied within natural physical laws, state of the art technologies, and other project constraints
Flexibility	Not stated as to how it is to be satisfied
Without Ambiguity	Only one interpretation makes sense
Singular	One actor-verb-object requirement
Verifiable	Can be proved at the level of the architecture applicable
Pairs / Sets	
Absence of Redundancy	Each requirement specified only once
Consistency	Terms used are consistent
Completeness	Usable to form a set of "design-to "requirements
Absence of Conflicts	Not in conflict with other requirements or itself

Requirement's ID Structure
Level_System_CategorySubcategory_Counter

Keeper	Legend
Y	Must follow
N	Not Mandatory
~	to the best of our ability but can diverge and keep the idea it reflects
	Need updates/control

Verification Methods
Examination (RoD)
Test
Demontration
Analysis

Keeper	Requirements ID	Title	Type	Requirement Text	Success criterion	Verification Method	Date	Comments
	EPFL Spacecraft Team							
Y	0_EST_13_01	**EST Educational Goal**	**Primary Objective**	Drive the creation of students' space missions in Switzerland with an educational project	Have students participate in a space mission from Phases A-E	**Demonstration**	10.05.2023	
Y	0_EST_11_01	**EST Technical Goal**	**Primary Objective**	Design space systems for a space mission	The project has reached Phase C	**Demonstration**	10.05.2023	
Y	0_EST_11_02	**EST Technical Goal**	**Primary Objective**	Test space systems for a space mission through academia	The project has reached Phase D and is using academia testing infrastuctures for Assembly, Integration and Testing (AIT)	**Demonstration**	10.05.2023	
Y	0_EST_11_03	**EST Technical Goal**	**Primary Objective**	Operate space systems in orbit	The project has reached Phase E	**Demonstration**	10.05.2023	
~	0_EST_24_01	**EST Collaboration Goal**	**Secondary Objective**	Collaborate with partners regarding useful payloads	Payloads from partners are in orbit & in operation thanks to EST's platform	**Demonstration**	10.05.2023	
Y	0_EST_24_02	**EST Collaboration Goal**	**Secondary Objective**	The scientific data shall be distributed amongst the respective partners	Partners are receiving the data from their instruments	**Demonstration**	10.05.2023	
	ETHZ							
Y	0_ETH_11_01	**ETH Technical Goal**	**Primary Objective**	Design a Global Navigation Satellite System (GNSS) module [u-blox ZED-9FP multi-GNSS receiver]	The GNSS project has reached end of Phase D	**Demonstration**	10.05.2023	
Y	0_ETH_11_02	**ETH Technical Goal**	**Primary Objective**	Test the GNSS module in orbit	The GNSS module is working as intended in orbit	**Demonstration**	10.05.2023	
~	0_ETH_22_01	**ETH Scientific Goal**	**Secondary Objective**	Gather atmospheric scientific data with the GNSS module	The GNSS module has gathered data that can be analysed by the ETH team	**Examination**	10.05.2023	
	UniBe							
Y	0_UniBe_11_01	**UniBe Technical Goal**	**Primary Objective**	Design a 1U high-performance mass spectrometer	The CubeSatTOF project has reached Phase C	**Demonstration**	10.05.2023	
Y	0_UniBe_11_02	**UniBe Technical Goal**	**Primary Objective**	Test a 1U high-performance mass spectrometer	The CubeSatTOF project has reached Phase D	**Demonstration**	10.05.2023	
Y	0_UniBe_12_01	**UniBe Scientific Goal**	**Primary Objective**	Analyse temporal atmospheric composition variations with high spatial resolution	The team has received useful atmospheric composition data from the satellite	**Examination**	10.05.2023	
Y	0_UniBe_12_02	**UniBe Scientific Goal**	**Primary Objective**	Analyse the atmospheric escape	The team has received useful data on atmospheric escape from the satellite	**Examination**	10.05.2023	
Y	0_UniBe_12_03	**UniBe Scientific Goal**	**Primary Objective**	Analyse the compositional variations at the day-night terminator	The team has received useful data on compositional variations from the satellite	**Examination**	10.05.2023	
Y	0_UniBe_12_04	**UniBe Scientific Goal**	**Primary Objective**	Analyse the night-side transport	The team has received useful data on the night-side transport from the satellite	**Examination**	10.05.2023	
~	0_UniBe_22_01	**UniBe Scientific Goal**	**Secondary Objective**	Analyse the vertical profile of atmospheric abundances of species	The team has received useful data on the vertical profile of atmospheric abundances of species from	**Examination**	10.05.2023	
~	0_UniBe_21_01	**UniBe Technical Goal**	**Secondary Objective**	Test the CubeSatTOF during deorbiting	The team has received useful data on from the satellite during deorbiting	**Demonstration**	10.05.2023	
~	0_UniBe_21_02	**UniBe Technical Goal**	**Secondary Objective**	Establish TRL 8 for planetary entry probes	The team was able to validate TRL 8 of the CubeSatTOF	**Demonstration**	10.05.2023	
	Beyond Gravity							
~	0_BG_21_01	**Beyond Gravity Technical Goal**	**Secondary Objective**	Perform in orbit validation of new types of solar panels in partnership with Beyond Gravity International	The Beyond Gravity team has reviewed and validated the performance of the solar cells	**Demonstration**	10.05.2023	
	New suggestions:							

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	CHESS Mission Definition							
Y	1_MIS_10_01	**Targeted Orbit**	**Functional**	The CHESS platform shall be launched into a Low-Earth Orbit (LEO)	Successful orbit insertion by the launch provider	**Demonstration**	10.05.2023	
Y	1_MIS_10_02	**Acquisition of Signal**	**Functional**	The platform shall establish communication with the ground segment	Successful AOS for each communication window	**Demonstration**	10.05.2023	
Y	1_MIS_10_03	**Systems Checkout**	**Functional**	The team shall perform a complete system checkout and validation before beginning of scientific operations	Successful validation of health and functionalities of the platform	**Demonstration**	10.05.2023	
Y	1_MIS_10_04	**Operation Modes**	**Functional**	The platform shall follow a pre-design concept of operations and be able to change mode when required	The platform has demonstrated its capability to reach all modes of operations before commision	**Demonstration**	10.05.2023	
Y	1_MIS_10_05	**Main Payload Definition**	**Political**	The main platform's payload shall be the CubeSatTOF developped by UniBe	The CubeSatTOF was successfully integrated with the platform and is functional in-orbit	**Demonstration**	10.05.2023	
Y	1_MIS_10_06	**Secondary Payload Definition**	**Political**	The secondary platform's payload shall be the four u-blox ZED-9FP multi-GNSS receivers coupled with two GNSS patch antennas developped by ETHZ	The GNSS module was successfully integrated with the platform and is functional in-orbit	**Demonstration**	10.05.2023	
Y	1_MIS_10_07	**Payloads Power Supply**	**Functional**	The platform shall supply the payloads with power for the whole duration of the science operations	The payloads are powered and functional	**Demonstration**	10.05.2023	
Y	1_MIS_10_08	**Payloads Data Flow**	**Functional**	The platform shall collect the data generated by the payloads and send it to the ground segment	The operation team has received scientific data from the satellite	**Demonstration**	10.05.2023	
Y	1_MIS_10_09	**Solar Cells**	**Functional**	The platform shall integrate Beyond Gravity's solar cells for its solar panels	The Beyond Gravity's solar cells were successfully integrated with the platform and are functional in-orbit	**Demonstration**	10.05.2023	
Y	1_MIS_10_10	**End of Operations**	**Functional**	The platform shall be decommissioned when unanimous agreement amongst stakeholders is reached	The platform was successfully put into End-of-Life mode	**Examination**	10.05.2023	
Y	1_MIS_10_11	**Orbit Decay**	**Constraints**	The platform's orbit shall decay such that it reenters into the atmosphere before the 25-year limit imposed by the IADC Space Debris Mitigation Guidelines for LEO satellites	The satellite has reentered before the 25-year limit fixed by the IADC Space Debris Mitigation Guidelines	**Examination**	10.05.2023	
Y	1_MIS_10_12	**Orbit Design**	**Constraints**	The platform's orbit shall pass over Lausanne, i.e the orbit's inclination shall be greater than 46°	The satellite's ground track crosses Switzerland	**Examination**	10.05.2023	
Y	1_MIS_10_13	**Development Management**	**Constraints**	A design-to-cost and risk minimization approach shall be followed for the Space System and associated components	From a specific budget and set of constraints, find the most feasible mission design solution by evaluating trade-offs of different mission components	**Demonstration**	10.05.2023	
	CHESS Mission Objectives							
Y	1_MIS_20_01	**Mission Lifetime**	**Performance**	The CHESS platform shall be designed to survive a nominal mission duration of **[2 years]**, allowing for the gathering of scientific data by the onboard payloads as described by 1_MIS_10_05 and 1_MIS_10_06	The platform is healthy and working after [2 years] of in-orbit operations	**Demonstration**	10.05.2023	Mission should last as long as possible ideally more than 12 years to also measure at lower orbits, however 2 years can be used as a
Y	1_MIS_20_02	**X-Band Ground Station**	**Performance**	Perform demonstration of the, at EPFL designed, X-band Ground Station	The X-Band Ground Station is capable of receiving data from the satellite and is operational	**Demonstration**	10.05.2023	
Y	1_MIS_20_03	**X-Band Module**	**Performance**	Perform demonstration of the, at EPFL designed, X-band module mounted on the fully integrated platform	The X-Band module is capable of transmitting data to the Ground Station and is operational	**Demonstration**	10.05.2023	
Y	1_MIS_20_04	**UHF Ground Station**	**Performance**	Perform demonstration of the, at EPFL designed, UHF Ground Station	The UHF Ground Station is capable of receiving data from the satellite and is operational	**Demonstration**	10.05.2023	
Y	1_MIS_20_05	**UHF-Band Module**	**Performance**	Perform demonstration of the COTS UHF module mounted on the fully integrated platform	The UHF module is capable of transmitting data to the Ground Station and is operational	**Demonstration**	10.05.2023	
Y	1_MIS_20_06	**OBC**	**Performance**	Perform demonstration of the, at EPFL designed, OBC on the fully integrated platform	Bunny successfully handles the whole platform	**Demonstration**	10.05.2023	
Y	1_MIS_20_07	**EPS**	**Performance**	Perform demonstration of the, at EPFL designed, EPS on the fully integrated platform	The EPS is successfully distributing power to the whole platform	**Demonstration**	10.05.2023	

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Y	1_MIS_20_08	**ADCS**	**Performance**	Perform demonstration of the COTS ADCS on the fully integrated platform	The ADCS is successfully stabilizing and pointing the platform	**Demonstration**	10.05.2023	
Y	1_MIS_20_09	**CubeSatTOF**	**Performance**	The CubeSatTOF, designed at the University of Bern, is collecting data	The CubeSatTOF is functional in orbit	**Demonstration**	10.05.2023	
Y	1_MIS_20_10	**GNSS**	**Performance**	The GNSS module, designed at ETH, is collecting data	The GNSS is functional in orbit	**Demonstration**	10.05.2023	
	New suggestions:							

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	Spacecraft Requirements							
Y	2_SC_11_01	Type of Satellite	Constraints	The CHESS pathfinder 1 CubeSat shall be of a 3U standard	The satellite fits inside a 3U dispenser unit	Examination	10.05.2023	
Y	2_SC_11_02	Total Bus Volume	Constraints	The Service Bus shall take no more than a 2U volume	All subsystems fits inside a 2U	Examination	10.05.2023	
Y	2_SC_11_03	Structural Integrity	Interface	All the subsystems shall be attached to the CubeSat frame	All subsystems have been integrated structurally with the rest of the platfrom	Demonstration	10.05.2023	
Y	2_SC_11_04	Total Mass	Constraints	The CubeSat mass shall not exceed 6 kg with contingencies	The weight is below [6 kg] before integration with Launcher	Examination	10.05.2023	
Y	2_SC_11_05	Launch Static Loads	Constraints	The CubeSat shall withstand the static loads of the launch defined by the Launcher User Manual	Successful Vibration Test	Test	10.05.2023	
Y	2_SC_11_06	Launch Dynamics Loads	Constraints	The CubeSat shall withstand the dynamic loads of the launch defined by the Launcher User Manual	Successful Vibration Test	Test	10.05.2023	
Y	2_SC_11_07	CHESS Pathfinder 1 Orbit	Constraints	The launch vehicle shall place the CubeSat CHESS pathfinder 1 in a elliptical orbit with an apogee of 1000km, a perigee of 400km, a semi-major axis of 7078136m, an eccentricity of 0.0424, an inclination of 97.5926deg, a RAAN of 95.9063deg, an argument of perigee of 0 deg and a true anomaly of 0 deg	Succesfull launch in correct orbit	Analysis	10.05.2023	
Y	2_SC_12_01	Power Management	Functional	The CubeSat shall generate, store and distribute power	All subsystems are powered during the whole mission duration	Demonstration	10.05.2023	
Y	2_SC_12_02	Power in Eclipse	Functional	During eclipse, the CubeSat shall be energy independent	All subsystems are powered during eclipses	Demonstration	10.05.2023	
Y	2_SC_13_01	Data Downlink Flow	Functional	The CubeSat shall downlink science and house keeping data to the Ground Segment	The telecom modules are transmitting data	Demonstration	10.05.2023	
Y	2_SC_13_02	Data Uplink Flow	Functional	The CubeSat shall receive commands from the Ground Segment	The telecom modules are receiving data	Demonstration	10.05.2023	
Y	2_SC_15_01	Space Environment	Environmental	The CubeSat shall withstand the environmental conditions present in its orbit	The CubeSat handles the Vacuum, chemical, thermal, riadiative and electrical environment	Test	10.05.2023	
Y	2_SC_15_02	Radiation Dose	Environmental	The CubeSat shall be designed to withstand the radiation dose [8.7*10^12MeV/cm^2] accumulated during the nominal mission duration	No failures due to radiation	Test	10.05.2023	Reference Silvan Wegenast Radiation Report 2023
Y	2_SC_15_03	Total Ionizing Dose	Environmental	The CubeSat shall resist a total ionizing dose of [2.25*10^6 rad]	No failures due to ionization	Test	10.05.2023	Reference Silvan Wegenast Radiation Report 2023
Y	2_SC_15_04	Thermal Environment	Environmental	The CubeSat shall withstand solar irradiation intensity ranging from 0 [Wm-2] to 1371 [Wm-2] and the thermal variations induced	The CubeSat has passed the thermal and radiation test	Test	10.05.2023	Reference Silvan Wegenast Radiation Report 2023
Y	2_SC_15_05	Thermal Variations	Environmental	The CubeSat shall regulate its internal temperature (passively or actively) based on the defined Thermal Budget	All subsystems operate in their temperature range definded in the termal budget [DOC]	Demonstration	10.05.2023	
Y	2_SC_15_06	Thermal Range	Environmental	Each subsystem shall remain inside its operating temperature range	The subsystems have passed the Thermal Test and the functional test later on	Demonstration	10.05.2023	
Y	2_SC_16_01	Autonomy	Functional	The CubeSat shall operate autonomously when not in contact with the Ground Segment	Operations are carried out at all times	Demonstration	10.05.2023	
Y	2_SC_16_02	Life Beacon Identification	Functional	After deployment of the Launch Vehicle, the CubeSat shall continuously emit a beacon signal until contact with the Ground Segment is established	The Spacecraft was identified and communications have been established	Demonstration	10.05.2023	

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Y	2_SC_16_03	**Initial Detumbling**	**Functional**	Upon deployment from the Launch Vehicle, the CubeSat shall perform a detumbling sequence	The Spacecraft attitude's rates have been successfully regulated	**Demonstration**	10.05.2023	
Y	2_SC_16_04	**Attitude Control**	**Functional**	The CubeSat shall determine and control its attitude	The Spacecraft's attitude are controlled	**Demonstration**	10.05.2023	
Y	2_SC_16_05	**Vehicle checkout Procedure**	**Functional**	During vehicle checkout, the CubeSat shall remain operational	The Spacecraft was successfully commissioned	**Demonstration**	10.05.2023	
Y	2_SC_16_06	**Science Phase Commissioning**	**Functional**	The CubeSat's scientific operations shall begin after vehicle checkout, following instructions of the Ground Segment	Science Phase has started	**Demonstration**	10.05.2023	
Y	2_SC_17_01	**Risk mitigation**	**Functional**	All subsystems shall impliment risk mitigation strategies for critical components	Design Reviews	**Examination**	10.05.2023	
Y	2_SC_17_02	**EPS**	**Constraints**	The CubeSat shall have an electrical power system	Design Reviews	**Examination**	10.05.2023	
Y	2_SC_17_03	**OBC**	**Constraints**	The CubeSat shall have an OBC subsystem	Design Reviews	**Examination**	10.05.2023	
Y	2_SC_17_04	**ADCS**	**Constraints**	The CubeSat shall have an ADCS subsystem	Design Reviews	**Examination**	10.05.2023	
Y	2_SC_17_05	**Flight Software**	**Constraints**	The CubeSat shall have a flight software implemented	Design Reviews	**Examination**	10.05.2023	
Y	2_SC_17_06	**Telecom UHF**	**Constraints**	The CubeSat shall have a UHF antenna and transceiver	Design Reviews	**Examination**	10.05.2023	
Y	2_SC_17_07	**Telecom X-Band**	**Constraints**	The CubeSat shall have a X-Band antenna and transmitter	Design Reviews	**Examination**	10.05.2023	
Y	2_SC_17_08	**CubeSatTOF Payload**	**Constraints**	The CubeSat shall include the CubeSatTOF as scientific payload	Design Reviews	**Examination**	10.05.2023	
Y	2_SC_17_09	**GNSS Payload**	**Constraints**	The CubeSat shall include the GNSS as scientific payload	Design Reviews	**Examination**	10.05.2023	
				Payloads Requirements				
Y	2_PL_25_01	**PRODEX Funding**	**Constraints**	The project shall be compliant with PRODEX sponsoring conditions	The project is accepted in the PRODEX program	**Examination**	10.05.2023	
Y	2_PL_25_02	**Science Data Generation**	**Functional**	The Cubeast's scientific payloads shall collect scientific data	Science Data was generated thanks to the mission	**Demonstration**	10.05.2023	
				Ground Segment Requirements				
Y	2_GS_36_01	**Space System Identification**	**Functional**	After deployment, the Ground Segment shall identify the CubeSat through an authorisation protocol	The Ground Team has succesufully identified the satellite	**Examination**	10.05.2023	
Y	2_GS_36_02	**Vehicle Checkout**	**Functional**	The Ground Segment shall perform a checkout on each subsystem first thing upon first aquisition of signal	Successful vehicle checkout procedure	**Demonstration**	10.05.2023	
Y	2_GS_36_03	**UHF Uplink**	**Functional**	The Ground Segment shall uplink commands to the CubeSat through the UHF band	The Spacecraft has successfully recieved commands from the ground through the UHF frequencies	**Examination**	10.05.2023	
Y	2_GS_36_04	**X-Band Downlink**	**Functional**	The Ground Segment shall recieve data from the CubeSat through the X-Band frequencies	The Ground Segment has successfully recieved data from the CubeSat through the X-band frequencies	**Examination**	10.05.2023	
Y	2_GS_36_05	**Data Flow**	**Constraints**	The Ground Segment shall distribute the downlinked science and housekeeping data to their respective owners	The data was distributed to stakeholders according to signed contracts	**Examination**	10.05.2023	

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				Launch Provider Requirements				
Y	2_LP_44_01	**Launch Provider Requirements**	**Constraints**	The CubeSat shall be compliant with the launch vehicle provider requirements	The Launch Provider has accepted to fly our platform	**Examination**	10.05.2023	
Y	2_LP_44_02	**Pre-Launch Storage**	**Constraints**	The CubeSat shall be stored for a duration of max **[4 months]** in the launch vehicle before additional maintenance is required, depending on prior agreement with the launch provider	The satellite is still in good shape after [4 months] in the dispenser	**Examination**	10.05.2023	
Y	2_LP_44_03	**Interface with Launcher**	**Constraints**	The CubeSat shall be compliant with the launch adapter provider requirements	The platform is compatible with the dispenser	**Demonstration**	10.05.2023	
				Mission Operations Requirements				
	2_MO_56_01	**Operational Modes**	**Functional**	The CubeSat shall have the following operational modes : Communication, Charging, Measurement, Safe and End of Life	Successfull switch between operational modes	**Examination**	10.05.2023	
	2_MO_56_02	**Communication Mode**	**Functional**	In Communication mode, the CubeSat shall communicate with the Ground Segment	A connection is established with the Ground Segment	**Demonstration**	10.05.2023	
	2_MO_56_03	**Charging Mode**	**Functional**	In Charging mode, the CubeSat shall collect and store power	The CubeSat charges and stores power	**Demonstration**	10.05.2023	
	2_MO_56_04	**Measurement Mode**	**Functional**	In Measurement mode, the CubeSat shall gather scientific data from the CubesatTOF and/or from GNSS	Scientific data from the payloads is gathered	**Demonstration**	10.05.2023	
	2_MO_56_05	**Safe Mode**	**Functional**	In Safe mode, the CubeSat shall attempt to identify and resolve critical failures	Failures are identified and resolved	**Demonstration**	10.05.2023	
	2_MO_56_06	**Mode Switch**	**Functional**	The CubeSat shall switch between its operational modes when required	Successfull switch between operational modes when required	**Demonstration**	10.05.2023	
				Assembly, Integration & Tests Requirements				
Y	2_SYS_66_01	**Payloads Testing**	**Reliability**	The payloads on-board the CubeSat shall be tested prior to Integration individually by their manufacturers	The payloads have passed qualification tests on EM before sending the FM to EST	**Test**	10.05.2023	
Y	2_SYS_66_02	**Payloads Test levels**	**Reliability**	The partners shall specifiy any constraints they have concerning the AIT of the Space System	The partners agree with the AIT Strategy of the EST	**Examination**	10.05.2023	
Y	2_SYS_66_03	**Platform Testing and Assembly**	**Reliability**	The assembly and testing of the Engineering Model, Engineering Qualification Model and Flight Model shall be the responsibility of the EST	EST has a clear AIT strategy for the platform	**Examination**	10.05.2023	
Y	2_SYS_66_04	**FM Schedule**	**Constraints**	The CubeSat shall be ready for integration in the Launch Vehicle at least **[6 months]** prior to the integration into the launch vehicle	The Flight Model is ready to be shipped to the Launch Provider on time	**Examination**	10.05.2023	
Y	2_SYS_66_05	**AIT Test Levels**	**Constraints**	The CubeSat shall be designed to withstand launch conditions from **[Launch provider]**	The Platform has passed the tests level set by the launch provider	**Test**	10.05.2023	
	New suggestions:							

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