Project SHARP — Power Generation and Delivery System

Project Plan

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Change record

Issue	Date	Total pages	Page(s) affected	Description of change
1.0	2/2/2026	5	0–5	Adapt Initial Template
2.0	3/2/2026	14	0–14	Create chapters and fill in rough required elements
2.1	6/2/2026	15	4–14	Refine outline for all sections and work out chapters 1–4
2.2	9/2/2026	23	5–8, 10, 13, 14, 17-22	Created data driven Research Questions and Work Packages

Table of Contents:

1 Background

Stellar Space Industries

Stellar Space Industries (SSI) is a Dutch aerospace company located in Noordwijk near ESA's ESTEC facility. SSI specialises in high precision manufacturing capabilities and covers the entire product development cycle including design, machining, assembly, integration and testing. Their production facility is equipped with high-precision machining and testing equipment.

In collaboration with ESA, SSI is developing a novel electrodeless electric propulsion system for small satellites. This propulsion system aims to increase efficiency, lifespan and reliability compared to current state-of-the-art electric propulsion systems. SSI is currently in their second phase of development where they aim to design build and test the entire system in-house.

Presently, several subsystems of the propulsion system are being developed and tested concurrently. During the development of these subsystems, SSI is also looking for opportunities to apply the technology of each component in other applications. One of the subsystems that is currently ready for testing and application is SSI's flow control unit (FCU) which is a high-precision valve that can control the mass flow of gaseous propellants.

Project SHARP

In order to find a relevant application for their FCU, SSI has initiated the Solid Hydrogen Aircraft Regulated Propulsion (SHARP) project. SHARP is a joint investigation between SSI and Solid Flow, a Dutch company specialising in the development of solid hydrogen storage systems. The goal of SHARP is to investigate the feasibility of hydrogen-fuelled drones that utilise solid-state hydrogen storage. In this collaboration, Solid Flow B.V. provides the cool gas generator (CGG), a system capable of producing gaseous hydrogen on demand from solid hydrogen storage. Stellar Space Industries B.V. contributes its expertise in flow control systems for electric propulsion, which may be adapted for hydrogen-based applications.

SHARP is conducted under the Luchtvaart in Transitie (LIT) program of the RVO of the Dutch government, which aims to advance sustainable aviation technologies. SHARP aims to contribute to the aviation energy transition by providing a scalable, weight and volume efficient energy source that is CO_2 and NO_x neutral. SHARP first aims to demonstrate the feasibility of the technology in drone applications, allowing future projects to scale the technology to larger aircraft and replace traditional jet fuel-based propulsion systems.

SHARP — Power Generation and Delivery System

This document considers the project plan for a subsystem of the SHARP project, specifically the development of the power generation and delivery system. This part of the SHARP project is conducted as a graduation internship. Throughout this document the part of SHARP that falls under the graduation internship will be referenced as SHARP — Power System (SHARP-PS).

2 Project Results

For Stellar Space Industries, the primary goal for SHARP is to test and apply their FCU in a real world scenario and thus advance the FCU's technology readiness level (TRL) from 4 to 6. In addition to this, they aim to find a secondary market for their FCU in hydrogen based aviation compared to electric propulsion for satellites. Solid Flow has the same goals for their hydrogen CGG. The goal of SHARP-PS is to integrate the FCU and CGG and demonstrate the technologies and their compatibility in a relevant environment.

The relevant environment for the SHARP-PS project will be a fuel cell that delivers power to a motor and propeller system. Results of tests performed in this environment will be directly applicable to hydrogen based aviation projects. The result of the SHARP-PS project will be a test bench setup that includes this fuel cell and motor-propeller system and the integrated FCU and CGG hydrogen supply. This test bench setup shall be easily adaptable to be integrated into an unmanned areal vehicle (UAV). The project result of SHARP-PS shall meet the following requirements:

- Stellar Space Industries' FCU shall be included in the system.
- Solid Flow's hydrogen CGG shall be included in the system.
- A fuel cell shall be used to generate electricity from hydrogen.
- The system shall function without external power supply.
- The power density (power output over system weight) of the system must be the same or higher than that of state-off-the-art UAV power systems.
- Test results will be recorded and presented in a research report that is in accordance with 'Report writing for readers with little time' (Elling & Andeweg, 2012)
- The research report shall answer the following research question: 'To what extent is a hydrogen fuel cell based power generation and delivery system that integrates a Solid Flow's cool gas generator and Stellar Space Industries' flow control unit feasible for extending the mission time for UAV's'

The afformentioned research question will be subdivided into the following sub research questions:

1. What functional, performance, and safety requirements must the power generation and feed system meet to be integrated into the selected COTS drone?
2. What are the relevant performance characteristics of Solid Flow's cool gas generator and Stellar Space Industries' flow control system?
3. What flight-time improvement is theoretically achievable with hydrogen storage and fuel cells compared to the drone's current battery system?
4. Which system architecture best balances safety, efficiency, weight, system complexity, and manufacturability for the power generation and feed system?
5. Which components (fuel cell, intermediate electrical storage, power electronics) are most suitable based on the system requirements and design constraints?
6. What mechanical modifications are required to integrate the hydrogen storage, generator, fuel cell, and power electronics into the drone airframe without compromising payload capacity?
7. What electrical architecture ensures stable power delivery from the fuel cell system to the drone's propulsion and onboard electronics?
8. How does the integrated hydrogen-based power system perform during ground testing in terms of power output, stability, efficiency, and safety?
9. What technical risks, failure modes, or limitations affect the overall feasibility of implementing the system in operational drone flights?

These research questions have been arranged into a research matrix where they have been assigned a research method and is specified what instruments or tools are used and what the output is of each research question. This research matrix is shown in Appendix A.

3 Project Activities

The project is divided into multiple activities. The activities are organized into categories, so that each category is of a similar level of complexity. Note that some activities are dependent on other activities. This, along with the time constraints of each activity, is discussed in section 8 Planning. Each category also resembles the activities for a work package. A list of all work packages can be found in Appendix B.

1. Project Definition and Requirements
   - 1.1 Literature study on hydrogen storage, fuel cells, and UAV power systems
   - 1.2 Analysis of mission scenario and system constraints
   - 1.3 Definition of functional, performance, and safety requirements
   - 1.4 Writing and finalising the project plan
2. Conceptual Design of Test Bench
   - 2.1 Development of multiple conceptual test bench architectures
   - 2.2 Definition of system boundaries and interfaces
   - 2.3 Trade-off analysis of concepts based on requirements
   - 2.4 Selection of the preferred test bench concept
3. Detailed Design of Test Bench
   - 3.1 Detailed mechanical design of the test bench
   - 3.2 Electrical system design and schematic development
   - 3.3 Component selection for fuel cell, storage, and power electronics
   - 3.4 Verification of the design against system requirements
4. Procurement and Preparation
   - 4.1 Selection of suppliers and components
   - 4.2 Ordering and procurement of parts
   - 4.3 Incoming inspection and preparation of components
5. Manufacturing, Assembly, and Integration
   - 5.1 Manufacturing of mechanical parts where required
   - 5.2 Assembly of mechanical and electrical subsystems
   - 5.3 Integration of FCU, CGG, fuel cell, electronics and fluidics
6. Test Planning
   - 6.1 Definition of test objectives and success criteria
   - 6.2 Development of test procedures and protocols
   - 6.3 Safety and risk assessment for test execution
7. Testing and Data Collection
   - 7.1 Execution of planned ground tests
   - 7.2 Measurement of power output, efficiency and stability
   - 7.3 Data logging and test documentation

8. Data Analysis and Feasibility Assessment
   8.1 Analysis of measured test data
   8.2 Comparison of results with requirements and theoretical expectations
   8.3 Identification of system limitations and technical risks
9. Documentation and Reporting
   9.1 Writing of the research and project report
   9.2 Preparation of presentations and supporting materials
   9.3 Final review and submission of all deliverables

If time allows, the scope of the SHARP-PS project can be extended, this will be discussed in more detail in section 4 Scope. Should this scope extension indeed be the case, this will lead to the following additional activities.

4 Scope

As SHARP-PS is conducted as an internship, the start and end dates are fixed. The internship runs from 2 February 2026 to 14 June 2026, and as such SHARP-PS will follow those dates strictly. At this time, the exact time requirement for the SHARP-PS project can not yet be accurately determined, only estimated. Therefore, the scope of the project is made slightly flexible to satisfy the exact time requirement of the internship.

This chapter defines a minimum scope which concerns the development and testing of an independent power generation and feed system that is not yet integrated in a UAV, this setup is also referred to as a test bench setup. If time allows, integrating this power system into a commercial off-the-shelf (COTS) or custom built UAV may be included in the scope of SHARP-PS as well.

The following lists describe the scope of the SHARP-PS project and exactly which activities are part of it. This is done by listing certain activities that fall particularly at the border of the project, and clarifying whether or not they are part of SHARP-PS, the SHARP-PS extended scope, SHARP as a whole or not part of SHARP at all.

Activities that **are** included in SHARP-PS:

- Designing a system overview of the complete power generation and feed system.
- Selecting components for the hydrogen fuel cell and intermediate electrical storage
- Developing the electrical design of the power generation and feed system.
- Performing assembly and integration of the power generation and feed system.
- Conducting ground testing of the power generation and feed system using a gaseous hydrogen source.
- Compiling a comprehensive report of all findings and results.

Activities that initially **are not** included in SHARP-PS, but **may** be included in SHARP-PS if allowed by time:

- Selecting a suitable COTS or custom built UAV.
- Selecting components for the UAV interfaces.
- Implementing mechanical modifications to the UAV to ensure system compatibility.
- Integrating the power system developed as part of the test bench setup with the selected UAV.
- Conducting flight testing of the integrated power system and UAV using a CGG hydrogen source.

Activities that have already been completed by SSI (**not** part of SHARP-PS):

- Developing the flow control unit.
- Testing the FCU in lab conditions.
- Adapting the FCU for hydrogen purposes.

Activities that **are not** included in SHARP-PS but are part of the larger SHARP project:

- Designing a mission scenario for solid hydrogen based UAV's.
- Setting requirements for the hydrogen CGG.
- Producing a hydrogen CGG.

5 Deliverables

When completed, each activity stated in section 3 produces a result in the form of a deliverable. Each deliverable is a tangible result and can be seen as a milestone within the project. When all the deliverables have been delivered, the project will be complete. The activities are grouped into work packages and as such the deliverables can also be grouped to the same work packages. The complete list of the work packages is shown in Appendix B.

1. Project Definition and Requirements
   - 1.1 Literature review summary
   - 1.2 System requirements specification
   - 1.3 Approved project plan
2. Conceptual Design of Test Bench
   - 2.1 Overview of conceptual design alternatives
   - 2.2 Trade-off analysis and decision matrix
   - 2.3 Selected test bench concept
3. Detailed Design of Test Bench
   - 3.1 CAD models and mechanical drawings
   - 3.2 Electrical schematics
   - 3.3 Bill of materials (BOM)
4. Procurement and Preparation
   - 4.1 Procured and inspected components
   - 4.2 Updated bill of materials and cost overview
5. Manufacturing, Assembly, and Integration
   - 5.1 Fully assembled and integrated test bench
   - 5.2 Integration and assembly documentation
6. Test Planning
   - 6.1 Test plan
   - 6.2 Safety and risk assessment documentation
7. Testing and Data Collection
   - 7.1 Raw test data
   - 7.2 Test logs and measurement records
8. Data Analysis and Feasibility Assessment
   - 8.1 Performance analysis results
   - 8.2 Feasibility assessment and conclusions
9. Documentation and Reporting
   - 9.1 Final project report
   - 9.2 Presentation materials

6 Quality Control

To assure the quality of the project, each deliverable has been assigned at least one review method. For deliverables of the same type, the review methods are the same. Table 1 lists the review methods that are assigned to each type of deliverable.

In addition to reviewing the quality of each deliverable, both quality and time are kept track of by weekly progress meetings with the company supervisor. This allows the company supervisor to provide feedback and advice and review the quality of the project as a whole on a weekly basis.

Deliverable Type	Review Methods	Software used
Documents	Company Supervisor review, University Supervisor review	LaTeX, Word
Designs	Company Supervisor review	Autodesk Inventor
Hardware	Company Supervisor review, Performance testing	—
Test results	Company Supervisor review, Comparison to expected results	??

Table 1: Quality control of deliverable types

7 Project Organisation

This chapter should contain a description of the project organisation. Who are the team members and what are their roles and responsibilities. Contact details of team members and other stakeholders can also be given here. The meeting frequency and dates can also be mentioned as well as the digital workspace that will be used.

- email, phone of me and Imre (and others?)
- Contact details of Solidflow? (outside of scope maybe)
- Weekly progress meetings on Thursdays
- The onedrive space for files
- Decide on a place for CAD files?

Name	**Role**	**Email Address**
Imre Bakker	Project Manager, Company Supervisor	imre.bakker@stellarspaceindustries.com
Philip Weersma	University Supervisor?	philip.weersma@inholland.nl
Emil Boot	Project Intern	661522@student.inholland.nl
	...	

8 Planning

Put the activities in an activity table (basically gantt chart but in table form). Assign required time of each activity. Describe dependencies between activities.
Is the gantt chart in onedrive applicable and/or up to date?

1. Project Definition and Requirements
   1.1 Literature study on hydrogen storage, fuel cells, and UAV power systems
   1.2 Analysis of mission scenario and system constraints
   1.3 Definition of functional, performance, and safety requirements
   1.4 Writing and finalising the project plan
2. Conceptual Design of Test Bench
   2.1 Development of multiple conceptual test bench architectures
   2.2 Definition of system boundaries and interfaces
   2.3 Trade-off analysis of concepts based on requirements
   2.4 Selection of the preferred test bench concept
3. Detailed Design of Test Bench
   3.1 Detailed mechanical design of the test bench
   3.2 Electrical system design and schematic development
   3.3 Component selection for fuel cell, storage, and power electronics
   3.4 Verification of the design against system requirements
4. Procurement and Preparation
   4.1 Selection of suppliers and components
   4.2 Ordering and procurement of parts
   4.3 Incoming inspection and preparation of components
5. Manufacturing, Assembly, and Integration
   5.1 Manufacturing of mechanical parts where required
   5.2 Assembly of mechanical and electrical subsystems
   5.3 Integration of FCU, CGG, fuel cell, electronics and fluidics
6. Test Planning
   6.1 Definition of test objectives and success criteria
   6.2 Development of test procedures and protocols
   6.3 Safety and risk assessment for test execution
7. Testing and Data Collection
   7.1 Execution of planned ground tests
   7.2 Measurement of power output, efficiency and stability
   7.3 Data logging and test documentation

8. Data Analysis and Feasibility Assessment
    8.1 Analysis of measured test data
    8.2 Comparison of results with requirements and theoretical expectations
    8.3 Identification of system limitations and technical risks
9. Documentation and Reporting
    9.1 Writing of the research and project report
    9.2 Preparation of presentations and supporting materials
    9.3 Final review and submission of all deliverables

9 Costs and Benefits

Costs

- Labour hours
- Test bench materials
- Fuel cell system
- Hydrogen fuel
- Safety equipment/education
- Drone prototype manufacturing and testing (if applicable)

Benefits

- Practical testing environment for SSI valve
- Sellable research results
- Practical approach to electric flight using hydrogen CGG

—	**Small**	**Medium**	**Large**
Model	DJI air	DJI Inspire	DJI Matrice 400
Power	100 W	230 W	1.2 kW
Drone Weight	0.7 kg	4 kg	15 kg
Fuel Cell Weight	0.6 kg	1 kg	2–6 kg
Drone Cost	€1,000	€15,000	quote
Fuel Cell Cost	€1,500	€3,000	€12,000
Total Cost	€2,500	€18,000	> €30,000

10 Risks

Points of failure for the project should be identified here. Internal and external risks should be separated. Grit has a whole system on doing this, assigning a value for likelihood and impact to each risk.

Internal Risks

- Running out of time
- Running out of budget
- Underestimation of technical complexity
- Safety issues related to hydrogen handling

Risk	**Likelihood**	**Impact**	**Mitigation Strategy**
Running out of time	Low	High	Regular progress reviews, buffer time in schedule
Running out of budget	Low	High	Cost monitoring
Underestimation of technical complexity	Medium	High	Early prototyping, expert consultation
Safety issues related to hydrogen handling	Low	High	Safety training, proper equipment, adherence to regulations

External Risks

- Solid Flow backing out of collaboration
- Delays in hardware acquisition/manufacturing
- Dependence on external parties for critical components?

Risk	**Likelihood**	**Impact**	**Mitigation Strategy**
Solid Flow backing out of collaboration	Low	High	Early agreement on deliverables, regular communication
Delays in hardware acquisition/manufacturing	Medium	Medium	Early ordering, multiple suppliers

A Research Matrix

RQ-1	**Requirements**
Description	What functional, performance, and safety requirements must the power generation and feed system meet to be integrated into the selected COTS drone?
Research Method	Literature review and stakeholder analysis
Instruments Tools	Scientific literature, hydrogen and UAV standards, requirement templates
Output Data	System requirements specification

RQ-2	**Characteristics**
Description	What are the relevant performance characteristics of Solid Flow's cool gas generator and Stellar Space Industries' flow control system?
Research Method	Technical analysis and literature study
Instruments Tools	Supplier datasheets, technical documentation, prior test data
Output Data	Performance characteristics overview

RQ-3	**Flight-Time Improvement**
Description	What flight-time improvement is theoretically achievable with hydrogen storage and fuel cells compared to the drone's current battery system?
Research Method	Analytical modelling and comparison
Instruments Tools	Energy density calculations, MATLAB/Excel models
Output Data	Theoretical flight-time estimation

RQ-4	**System Architecture**
Description	Which system architecture best balances safety, efficiency, weight, system complexity, and manufacturability for the power generation and feed system?
Research Method	Conceptual design and trade-off analysis
Instruments Tools	Morphological chart, decision matrix
Output Data	Selected system architecture

RQ-5	**Component Selection**
Description	Which components (fuel cell, intermediate electrical storage, power electronics) are most suitable based on the system requirements and design constraints?
Research Method	Component selection study
Instruments Tools	Supplier datasheets, selection criteria tables
Output Data	Selected component list with justification

RQ-6	**Mechanical Integration**
Description	What mechanical modifications are required to integrate the hydrogen storage, generator, fuel cell, and power electronics into the drone airframe without compromising payload capacity?
Research Method	Mechanical design
Instruments Tools	CAD software, mass and tolerance analysis
Output Data	Mechanical design drawings and mass breakdown

RQ-7	**Electrical Architecture**
Description	What electrical architecture ensures stable power delivery from the fuel cell system to the drone's propulsion and onboard electronics?
Research Method	Electrical system design
Instruments Tools	Electrical schematics, simulation tools
Output Data	Electrical architecture and schematics

RQ-8	**System Performance**
Description	How does the integrated hydrogen-based power system perform during ground testing in terms of power output, stability, efficiency, and safety?
Research Method	Experimental testing
Instruments Tools	Hydrogen supply, sensors, data acquisition system
Output Data	Measured performance and test results

RQ-9	**Feasibility and Risk**
Description	What technical risks, failure modes, or limitations affect the overall feasibility of implementing the system in operational drone flights?
Research Method	Risk analysis and evaluation
Instruments Tools	FMEA, test observations, design review
Output Data	Feasibility assessment and risk overview

B Work Packages

WP-1: Project Definition and Requirements
Define the problem, scope, and requirements for the hydrogen-based power system test bench.
Included Activities: 1. Literature study on hydrogen storage, fuel cells, and UAV power systems 2. Analysis of mission scenario and system constraints 3. Definition of functional, performance, and safety requirements 4. Writing and finalising the project plan
Deliverables: 1. Literature review summary 2. System requirements specification 3. Approved project plan

WP-2: Conceptual Design of Test Bench
Develop and select a suitable concept for the hydrogen-based power system test bench.
Included Activities: 1. Development of multiple conceptual test bench architectures 2. Definition of system boundaries and interfaces 3. Trade-off analysis of concepts based on requirements 4. Selection of the preferred test bench concept
Deliverables: 1. Overview of conceptual design alternatives 2. Trade-off analysis and decision matrix 3. Selected test bench concept

WP-3: **Detailed Design of Test Bench**
Translate the selected test bench concept into a detailed and buildable design.
Included Activities: 1. Detailed mechanical design of the test bench 2. Electrical system design and schematic development 3. Component selection for fuel cell, storage, and power electronics 4. Verification of the design against system requirements
Deliverables: 1. CAD models and mechanical drawings 2. Electrical schematics 3. Bill of materials (BOM)

WP-4: **Procurement and Preparation**
Ensure availability and readiness of all components required for the test bench.
Included Activities: 1. Selection of suppliers and components 2. Ordering and procurement of parts 3. Incoming inspection and preparation of components
Deliverables: 1. Procured and inspected components 2. Updated bill of materials and cost overview

WP-5: **Manufacturing, Assembly, and Integration**
Build and integrate the hydrogen-based power system test bench.
Included Activities: 1. Manufacturing of mechanical parts where required 2. Assembly of mechanical and electrical subsystems 3. Integration of FCU, CGG, fuel cell, electronics and fluidics
Deliverables: 1. Fully assembled and integrated test bench 2. Integration and assembly documentation

WP-6: **Test Planning**
Define procedures and criteria for verifying system performance and safety.
Included Activities: 1. Definition of test objectives and success criteria 2. Development of test procedures and protocols 3. Safety and risk assessment for test execution
Deliverables: 1. Test plan 2. Safety and risk assessment documentation

WP-7: **Testing and Data Collection**
Evaluate the performance of the test bench under controlled conditions.
Included Activities: 1. Execution of planned ground tests 2. Measurement of power output, efficiency and stability 3. Data logging and test documentation
Deliverables: 1. Raw test data 2. Test logs and measurement records

WP-8: **Data Analysis and Feasibility Assessment**
Assess the technical feasibility of the power system based on test results.
Included Activities: 1. Analysis of measured test data 2. Comparison of results with requirements and theoretical expectations 3. Identification of system limitations and technical risks
Deliverables: 1. Performance analysis results 2. Feasibility assessment and conclusions

WP-9: **Documentation and Reporting**
Document the project process, results, and conclusions in a professional manner.
Included Activities: 1. Writing of the research and project report 2. Preparation of presentations and supporting materials 3. Final review and submission of all deliverables
Deliverables: 1. Final project report 2. Presentation materials

References

Elling, S., & Andeweg, B. (2012). *Report writing for readers with little time*. Wolters-Noordhoff bv.