Additively Manufactured Engine Lowering Inefficiency at Altitude (AMELIA) - Project Plan

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1 Project Scope

This project aims to design, build and test a ramjet combustor and nozzle capable of producing a net thrust at its design conditions. An extension is to ensure the engine operates well at off-design conditions, for example higher or lower speeds and atmospheric pressures. The supply nozzle and intake will be designed in a separate project, but the two projects will work together closely.

To allow the use of complex shapes in the design and to reduce manufacturing costs in the long term the engine will be constructed primarily through additive manufacturing, also known as 3D-Printing. 3D Printing is also more environmentally conscious than subtractive manufacturing (such as the use of a lathe or chisel), as it substantially reduces waste produced. When a sufficiently capable machine is used, final manufactured items can be far more intricate and complex than items made by hand.

Computational Fluid Dynamics will be used to design and optimise the engine before manufacture, in order to increase the performance achieved without having to iterate on a physical design.

In order to carry out what is a highly ambitious project the design process will be arranged so that a viable solution is produced as soon as possible. This solution will then be matured over time to give increased performance before a decision is made after the interim report whether to go ahead with construction. The project will be structured around the CADMID (Concept, Assessment, Demonstration, Manufacture, In-Service, Disposal) cycle which is standard for UK Ministry of Defence (MoD) projects. A brief overview of the CADMID cycle is contained in Appendix A. The CADMID cycle will be used because it has been demonstrated by the MoD to be effective for the management of projects with a single final manufactured solution.

It is envisaged that time spent maturing the design will focus on the combustion chamber, as this is considered the highest risk component. This is because the majority of work done advancing combustion chamber technology is highly proprietary in nature. Basic combustion chambers are however easy to design, however they are often extremely inefficient.

2 Major Risks

There are several major hurdles to be overcome during the life of this project:

- Personal training:
  - This project will leverage Computational Fluid Dynamics (CFD) a great deal. Accurate and reliable use of CFD requires significant levels of training, alongside a good level of understanding of the underlying theory. Effective use of CFD is as much an art form as it is a science. It must be ensured that personal training is at a sufficient level that major mistakes are not made early in the project which are costly to rectify later on.
  - If this project goes to manufacture it will utilise two pressurised gas systems (pressurised air and a pressurised gas fuel supply). It is vital from a safety perspective that training in the use of these systems has been completed.
  - This project will involve the installation and running of the engine in the engine test cells, this will require training in the engine test cell procedures. Training may also be required in workshop use and possibly welding.

- Safety hazards:
  - This project may use a high-voltage spark for ignition. This is a safety hazard and must be taken into account with regards to risk assessment and training.
  - This project will use combustible materials in an untested system. There is therefore a significant risk of fire, and a slight risk of explosion. This must be taken into account at all stages of the project, particularly so that the system fails safely.
- Design process hazards:
  - If a workable solution cannot be created in the time constraints, or the project sponsor is not sufficiently satisfied with the design, there is the option to extend the demonstration phase past the interim design review, and to push back the manufacturing date. This would have the knock-on effect of curtailing (or removing altogether) testing time. If the design is still not sufficiently mature then the physical construction of the engine may not occur at all. Obviously this is not a preferred option.

3 Project Timeline

The project timeline is synchronised to the milestones detailed by the University, however it is hoped milestones will be delivered early so that the project can be more rapidly progressed towards the manufacturing and testing phase where the greatest time constraints lie - it has been advised that available time in the engine test cells is limited.

A The CADMID Cycle

The CADMID cycle is broken down into six stages:

- Concept
  - In the Concept phase the need for a project is identified.
  - Options for possible solutions to the problem are identified.
  - In this project's context, the literature review is contained here, primarily.
- Assessment
  - In the Assessment phase the requirements are defined.
  - A single solution to the problem is identified.
  - In this project, the final geometry will be defined here, along with a broad description of the control system's architecture.
- Demonstration
  - In the Demonstration phase the solution to the requirements is defined more fully, and is used to demonstrate the compliance of the final solution with the requirements.
  - In this project full CFD simulation will be used here to demonstrate efficiency, and the miscellaneous components of the control system will be defined and included.
- Manufacture
  - In the Manufacturing phase the final solution is built and validated.
- In-service
  - This phase begins when the project's output is accepted into use, and the project is monitored for obsolescence issues.
- Disposal
  - In this phase the obsolete solution is removed from use in such a way as to minimise the impact on the user and the environment.