**Project Development Plan**

**Modernized Steam Engine**

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# 1.0 Product Description, Operational Concept, and Operational Requirements

## 1.1 Product Description, Operational Concept and Environments

The OSE Steam Engine Project Plan is a follow-on energy producing mechanism to be backwards-compatible, or replace entirely, the Global Village Construction Set (GVCS) Power Cube.

### Since the Steam Engine is meant to replace the Power Cube, the product must Form, Fit, and Function (F3) the Power Cube interfaces. Modification to interfaces shall be included in feasibility analyses. In addition, the Modern Steam Engine shall be designed to incorporate GVCS Specifications/Core Values. Specifically, the Modern Steam Engine shall be designed to include: Modularity, Flexible Integration and Maintainability.

### 1.1.1 Steam Engine Hardware Description

The Modern Steam Engine shall have a modular design. All functional elements shall have connectors that permit easy removal and replacement during maintenance operations. The design shall implement an Open Systems Architecture (OSA) construction.

The typical components of the Modern Steam Engine include the following: Water pump, expander, condenser, tank reservoir, and control mechanism.

Human interfaces: The Modern Steam Engine requires human interfaces to monitor elements such as temperature and pressure. These may be manual gauges or digital gauges, but shall be evaluated for human factors elements, maintainability, and safety.

The Modern Steam Engine shall operate utilizing bio-mass pellets as its heat source.

## 1.2 Operational Concept and Operational Environment

The Modern Steam Engine shall be designed for use in both stationary and mobile applications as part of the GVCS.

### 1.3. System Support Key Performance Parameters and Key System Attributes

The following are key design parameters for the Modern Steam Engine:

1.3.1 Open Architecture (OSA). Produced with non-unique, locally manufactured/sourced parts for development, application flexibility and maintainability. A modular crankshift design shall allow for the addition of more than one unit.

1.3.2 Backward Compatibility. The Modern Steam Engine shall be backward compatible to the GVCS Power Cube and meet or improve upon Size, Weight and Power (SWAP) requirements and integration specifications, unless efficiencies are gained through platform integration modifications.

1.3.3 Reliability. The Modern Steam Engine should have a Mean Time Between Failure (MTBF) of (insert) hours.

1.3.4 Size, Power, and Weight. Size and weight requirements should meet or exceed (be less than) those of the Power Cube. Power requirements: 5-100 hp (scalable).

1.3.5 Digital Feedback. Requires digital electronic feedback control for functions such as speed governing, fuel flow regulation, and valve cutoff timing.

# 2.0 Program Costs

## 2.1 System Development Costs, Per Unit Costs and Other Production Costs

The Modern Steam Engine’s targeted total Research, Development, Test, and Evaluation (RDT&E), integration testing and initial rate production is budgeted at $50,000.

# 3.0 Notional Program Schedule

1. Pre-planning – Assess project opportunities and risk with product manager. Identify constraints, obstacles, non-human resources, scope, and success criteria. (Task duration 5 days).

2. Key Personnel Requirement/Integrated Product Team Development (IPT) – Identify not more than seven (7) Team Members: Product Lead, Mechanical Engineer, Logistician/Tech Data Manager, and 2-3 Subject Matter Experts. Develop team based upon requisite skills/experience, availability, teaming ability. Identify Matrix Support such as a CAD Drawing Specialist and a Reliability Engineer. (Start concurrently with previous, task duration 14 days).

3. Establish Project Goals – 1) Review project goals and plans with team members; 2) Develop project plan with resources identified; 3) Affirm test plan/strategy. (Start: week 2; Task duration 5 days).

4. Communication Plan – Publish communications plan to include: program schedule and status update plan, problem and issue tracking, change control procedures, and position/functional responsibilities. (Start: Upon Completion of #2 Key Personnel Requirement; Task duration 1 day).

5. Research & Development – 1) Define current best product; 2) Evaluate weaknesses, inefficiencies, safety problems, production issues, and maintainability of current product; 4) Develop an analysis of alternatives for each area of improvement; 5) Identify risks and perform a cost-benefit analysis for each potential course of action; 6) Update plans for new prototype. (Start Week 3; Task duration 3-4 weeks).

6. Prototype Testing – 1) Build and document prototype; 2) Test in accordance with the Product Test Plan; 3) Evaluate protype build and testing with logistics objectives; 4) Evaluate test results with metrics established for success; 5) Determine if further R&D is required (repeat step 5). (Start upon completion of #5 R&D; Task Completion 5-10 (full days).

7) Logistics Planning –1) Permanently update all supporting documentation and archive previous version; 2) Perform a Reliability Analysis and update FMECA; 3) Develop potential supply sources for more unique hardware; 4) Refine training/maintenance manuals and update maintenance task list; 5) Develop benchstock parts list, if required. (Start upon completion of #6 Prototype Testing; Task Completion 3-5 days).

Notional Project Schedules would be built in Microsoft Project that break down major tasks, sub-tasks, etc. and allows the Product Manager to resource-load the schedule. This schedule can be distributed to team members. This schedule will also define the Critical Path.

# 4.0 Technical Assessment

**4.1 Analysis of Current Configuration**

The current version of the Modern Steam Engine presents the following problems:

* Water might condense in the cylinder chamber resulting in a blow-out condition
* Power output will be low unless operated at high speed and high steam pressures
* Bump valves are subject to wear and breakage
* Air is compressed on the return stroke, losing valuable work
* Horizontal layout leads to excessive wear on parts (piston rings, etc)

**4.2 Alternatives**

Current COTS steam engines that meet system requirements are cost prohibitive ($7K+ range) and may prove to have integration problems and other logistics and support issues for the GVCS.

However, Cyclone Power Technologies (<http://www.cyclonepower.com/index.html>) has produced two engines that may be viable candidates, though cost/unit will likely be higher than the targeted cost per unit. Cyclone Power Technologies has developed two steam engines, the Mark II (20 hp) and the Mark V (100 hp). Click [here](http://www.cyclonepower.com/technical_information.html) for technical information on the Mark II and Mark V engines. A white paper describing Cyclone Power Technologies is available [here](http://cyclonepower.com/PDF/Cyclone%20Engine%20White%20Paper.pdf). Though these products are patented and may not meet all specifications for OSE’s Modern Steam Engine, these designs may be able to assist OSE’s Modern Steam Engine IPT with resolving the problems identified in section 4.1.

Other research found numerous plans for creating steam engines or converting diesel engines to steam engines, however, these engines operated at a low horsepower and were not designed for reliability and maintainability.

**5.0 Recommendations**

The following are recommendations for the Modern Steam Engine:

1. Talent Acquisition: There are many steam hobbyists, however, outreach for IPT inclusion should focus on verifiable experts who have worked to produce steam engine products. Outreach should include a core team, and a collection of matrixed support to assist in problem solving. The matrixed support can be functional (i.e. Reliability Engineering), but also for engineering solutions to specific problems the IPT may encounter. The [white paper](http://cyclonepower.com/PDF/Cyclone%20Engine%20White%20Paper.pdf) referenced in section 4.2 addresses optimization issues that may prevent condensation as well as thermal optimization to produce greater horsepower using heat exchangers. In addition, the Mark II/V engines are designed so that no oil is needed, but is water lubricated—which may prove more efficient if the OSE IPT can obtain or create similar technology. Ideally, some of the experts may be obtained from private industry (for instance, major auto manufacturers have personnel who have developed steam engine technology) as well as academia, private green energy enthusiasts and hobbyists.
2. Schedule: This particular Modern Steam Engine Project would have a schedule developed and incorporated into a Product Life Cycle Schedule that includes evaluation for continued improvement, design feedback, and improved efficiency/safety/maintainability analysis. etc. This schedule would feed into OSE’s Enterprise Master Schedule. As schedules are developed, processes established, etc, the proposed notional schedule will be shortened as the IPT matures.
3. .Operational Environment: Further definition of the operational environment should be established, especially definitions for environmental temperature tolerances, weather conditions, etc.
4. Technically Challenges: Besides the items already identified in section 4.1, other issues may include maintaining a constant heat source to maximize efficiency, corrosion prevention and safety concerns. To reach 100 hp, the engine must operate at high pressure. Certain safety components should be identified with replaceable substitutions and warnings to the user if other substitutions are used.
5. Goals: Product definition should include a MTBF, Mean Time To Repair, and a Reliability Analysis/goals to ensure the product creation is successful. Other goals (adjudication of feedback, risk analysis/mitigation, schedule completion, etc) should be included.
6. On-boarding: An on-boarding plan should be developed to bring aboard new members. Current project information is varied and overwhelming. A streamlined on-boarding approach will enable the IPT to more quickly spin up new members , establish goals/expectations, and encourage participation of experts who would like to assist, but have limited time available.