VIKING XII DESIGN PHILOSOPHY

REVISION 1.0

AN OUTLINE TO GUIDE THE DECISION MAKING PROCESS OF THE PROJECTS AND CHOICES MADE FOR THE VIKING XII

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1 Purpose of the Design Philosophy

The design of anything purposeful is contingent on comparing the differences between choices and weighing which is better. Getting to this state of "better" is not possible without knowing what the overarching project is striving for. Without a design philosophy there is no "better", only personal preference. This is not how a collaborative project is developed. Instead, this document will serve as the foundation for all decisions that are made with respect to the Viking XII. The intention is thus to harmonise the development of different parts of the car and achieve a car that is coherent in its goals.

For every single design decision made on V-XII it should be possible to ground the final choice in this document.

2 Objectives & Directions

The goals which will be set for V-XII are divided into directional and objective goals. Objective goals have a number as a goal for a specific simulation, test, event, etc. The directional goals include improvements which are not based on a definitive number.

2.1 Competition Requirements

As the team wishes to participate in competitions held by Formula Student, it is self evident that the organiser's rule set must be abided by. The car will not be allowed to run at the competition if it does not adhere to these rules. A failure to run at the given competition is expected to impact present and future sponsorships and member participation. This will in turn hinder the completion of the goals for the car, and these rules are therefore of the utmost priority.

2.2 Objective Goals

The objective goals that have been set for V-XII may be seen in the lists below. These mostly concern times for dynamic events present at FSG. Further details of these events may be seen elsewhere.

Vehicle performance goals:

- Skid pad: $5{,}0\,\mathrm{s}$
- Acceleration: $3{,}75\,\mathrm{s}$
- Sprint: $1\,\mathrm{min}\ 15\,\mathrm{s}$
- Endurance: $30\,\mathrm{min}$
- DV Acceleration: $5\,\mathrm{s}$
- Weight: $200\,\mathrm{kg}$

Static event goals:

- Cost event: Top 15
- Business plan: Top 20
- Design event: Top 30

It is the intention of the team to achieve all of these goals. Failure to do so means the team has failed to complete its intended task. Goals that have not been stated will not be regarded with any importance.

2.3 Directional Goals

Current simulations of the V-XI has indicated that it cannot achieve the previously mentioned goals. As such, improvements must be made to the design from the V-XI when developing the V-XII. V-XI provides inspiration, knowledge, materials, and testing possibilities for systems and projects to be used in the V-XII. The intended directional goals include making a light and efficient car. Directional goals may never be achieved! The car can always be lighter and more efficient. One should instead strive for these at every turn and in every decision.

The reasoning for making V-XII as light as possible is found in eq. (2) which shows the distance travelled for a given acceleration and duration.

$$d = \frac{1}{2} \cdot at^2 \tag{1}$$

$$d = \frac{1}{2} \cdot \frac{F}{m} \cdot t^2 \tag{2}$$

For a given distance d, the time t to cross this distance is dependent on the force F propelling the car and mass m. The force is a function of the power supplied to the wheels. A maximum of $80\,\mathrm{kW}$ leaving the energy storage is given by the ruleset of FSG and thus serves as the upper limit of power output for the team. This power output is already possible with V-XII and so for a situation of maximum power output the time may only be decreased by decreasing the mass of the car.

Efficiency affects the performance of the car in two ways. The first has to do with the capacity of the energy storage and the second has to do with the amount of power going to the wheels. Inefficiencies in the powertrain means power losses occur between the mode of energy storage, such as cells, and the wheels. The more inefficient the powertrain, the more energy must be stored for the car to perform at a given distance. Taking a

conventional energy storage system as an example, this would mean an increased number of cells which adds to the weight. Decreased efficiency also means less power gets to the wheels. An example of this is shown in eq. (3) wherein each component of the powertrain has an efficiency of $95\,\%$.

$$\eta_{powertrain} = \eta_{accumulator} \cdot \eta_{inverter} \cdot \eta_{motor} \cdot \eta_{wheels} = 81{,}45\,\% \tag{3}$$

The resulting power being used to propel the car is only $81\,\%$ of that which has been stored. This results in a slower car than what is possible within the constraints of the ruleset.

Complementary to the earlier mentioned objectives, there exists an additional set of goals whose attainment ensures the realisation of the primary goals.The first among these is that of reliability. Having a reliable car means the team feels assured that it is capable of running as intended during the season's Formula Student competition. Reliability is defined as the car always running free of issues in a standard setup. The time frame being considered is only the four months before competition. The reliability will only be considered for the season that the car is intended to run. Any issues that are predicted to occur after this point is of no importance.

3 Design Evaluation

To know whether the desired goals have been achieved when a project is being worked out, it is important to have a method of evaluation. This evaluation will be done by performing simulations and/or tests of the new part and comparing its performance to that of the previous part. The new part should have performance requirements in accordance to the goals set in this document and which improves upon the previous part where relevant. When worthwhile improvements have been made to the part it should be implemented on the V-XII.