Chapter 1 Establishing Vehicle Concepts and a Benchmark

1. 1 Preparations for Establishing a Benchmark

1. 1. 1 Introduction

Fundamental to establishing a vehicle benchmark with no errors is to marshal the efforts of all members of the team to collect the necessary and sufficient information for its construction. A failure in this regard can result in reduced operational efficiency and wasteful expenditure of energy. Of critical importance in the development and fabrication of a product is how to eliminate superfluous work and direct the limited amounts of time, man-hours, and money to the work to be accomplished. This is the basic tenet of rationalizing work.

While a benchmark is the direct object of the fabrication of a product (in this case, a vehicle), it must be something that can be broken down into individual units and design goals. Specifically, in establishing a benchmark, the following tasks must be accomplished:

① The finding of means to accomplish goals such as the functionality, weights, and costs of the units and components that are necessary to achieve the overall objective for the vehicle.

② Fundamental to finding such means is to clearly assess any gaps between the intended objective and the capabilities of the team.

③ Unless it is sufficiently broken down, a benchmark cannot be established. Setting an objective is only one half of the journey, and the benchmark is not yet complete.

1. 1. 2 Types of information to be collected [1] [2] [3] [4]

(1) FSAE rules (the latest edition) Check to see, without missing anything, whether there has been any change of rules; what changes, if any, have been made; and the reasons (purposes) for those changes. Without up-to-date information on the rules, the car that has been developed after so much hard work may fail to comply with the requirements and be disqualified, wasting untold toil and effort.

(2) Collecting information on past competition results From among the cars that competed in past Student Formula programs (global programs if possible) and that are to be ear-marked, research all the score items in as much detail as possible, including vehicle specifications, structure, mass, various capabilities, and competition results (design, inspection, acceleration, skid-pad, autocross, durability and fuel efficiency, cost, presentation contents, braking, noise, and so forth). Gather information on successes and failures. If there are negative factors, it is important to pinpoint, through interviews, not only the phenomena (what happened), but also the reasons (what caused that problem).

It is also important to assess the overall scoring trend in terms of how scores on the various events have changed from year to year. Discerning whether the points scored by participants at the same ranking in previous years have increased or decreased, whether in either case the change means that the underlying technology for the car submitted has improved or the scoring criteria have become more stringent, and other trends constitutes an important piece of information in establishing a benchmark.

(3) Organizing information on the cars submitted by your own school in the past Sort out information on the cars submitted by your school in the past, including their specifications, structures, weights, capabilities and overall ratings, scores on the various events, the degree of goal attainment, and the reasons for success and failure (not only the phenomena, but also the causes).

(4) Collecting information on sponsors Although not directly relevant during the creation

Chapter 2 Creating a Vehicle Plan and Vehicle Layout

2. 1 Objective of Creating Vehicle Plan and Vehicle Layout (L/O)

The vehicle plan and L/O are the ultimate compilation of a vehicle expressed in words and drawings, following the process of establishing vehicle concepts by designing concrete structures of individual units and parts.

During the process of compiling such information, units and parts must be re-designed and newly developed so that dichotomy-ridden issues between units and parts are resolved, and problems among the parts are adjusted and controlled. The vehicle design L/O constitutes a template and a standard during this process.

In order to materialize the vehicle concepts, the person responsible for creating the vehicle plan must ensure the feasibility of each unit and part and compatibility with other parts; at the same time, he must review the overall vehicle from the perspective of ensuring that there is nothing wasteful or superfluous in vehicle functionality, weight, and cost, and that they are all necessary and sufficient.

Another critical perspective is scheduling. If parts are not procured or developed in time or if they are obtained in an incorrect sequence, the project can fall behind schedule. If such a problem arises, one must determine what event benchmark (or more than one benchmark) will be impacted, and what methods can be employed to recoup the lost ground. If the lost time cannot be recovered, it is necessary to make a quick and judicious judgment as to what specific event benchmarks can be discarded, whether the overall benchmark for the vehicle should be lowered, or whether other factors can be used to compensate for the loss. Any hesitation only compounds the problem of shortage of time. The Major Schedule table in Chapter 3 provides a tool for dealing with such eventualities.

The person ultimately responsible for the vehicle plan and L/O is the project leader. The leader must constantly face the Major Schedule and make the types of decisions described above.

2. 2 Vehicle Plan Decision Process

2. 2. 1 Role of vehicle plan and L/O

The vehicle plan and L/O represent the kingpin (foundation) of the basic policy and goals for vehicle development; they document a set of rules for all team members. Therefore, the vehicle plan and L/O are like the two sides of a coin, and cannot be considered separate entities. In the following, we describe the process of creating a vehicle plan and L/O.

2. 2. 2 For first-time teams

The vehicle L/Os of the team that won the first place and that of the team that received the best design award are published in the All Japan Formula SAE Review. First, adopt the three-view drawings (front, side, and plan) of the vehicle L/Os of those cars as benchmarks.

Basically, a quick way to develop a targeted car is to duplicate it. Therefore, analyze all event scores and the strengths and weaknesses of the targeted vehicle. To this end, visit the school that featured the car, interview the people involved in the development, and learn the ways in which the development effort went well, and where it failed. This is the first step in your developmental process. Don't forget to acquire information on the characteristics of units and components, and on sponsors. Since not all information can be gathered, any information that is missing must be filled in by yourself. Information from other teams beyond the targeted car can also be valuable.

The process from this point on will be the same as

the process employed by previously competing teams (2. 2. 3).

2. 2. 3 Previously competing teams

The basic requirement is to build on a previous vehicle plan and L/O.

(1) First, review your past performance.

(2) Relative to your school's past goals, in what events did you fall short, and by how many points? Also, clearly identify the cause of the non-attainment. For each event category, sort out the items to be improved, not in terms of who is to blame, but for such items as technology and management.

(3) Compare the points scored on each event by five teams above and below your next target team. Especially, study the scores of losing teams and what caused the difference between them and the stronger teams. This way, you can discern pointers on what needs to be improved upon in order to attain the next goal value (benchmark).

(4) For each event category, sort out improvement items on relevant capabilities, weight, cost, operations methods, and other items.

For example, in the case of acceleration capability,

① Compared with the past performance on dynamic performance, to what extent must the torque be improved? By how many rpm?

② What gear ratio should be selected, including the final ratio?

③ What vehicle weight should be chosen?

④ What tire coefficient of friction and size should be adopted? Did the road surface match what it was assumed to be?

⑤ What torque converter and clutch characteristics should be adopted?

⑥ Were transmission switching operations performed smoothly?

⑦ Other

Sort out the types of evaluations listed above; quantitatively where possible. Beyond the acceleration capability, similarly sort out all other event categories and vehicle inspection test items (including dynamic tests such as noise and braking, as well as all static tests).

(5) Re-organize capabilities common to all events, by unit and part.

For example, establish goals on engine torque characteristics (rpm and torque characteristics). Using similar procedures, sort out the functional target capabilities, weights, dimensions (size and position), and cost for all parts, thus developing targets (benchmarks) for each part.

(6) Incorporate the dimensions onto the vehicle L/O for the previous vehicles. The new drawing incorporating this information will be the L/O drawing for the next vehicle.

(7) The evaluations performed according to Steps (2) to (6) may be unable to achieve the benchmark for each event in a single try; repeat the process as many times as necessary until the benchmark is cleared. By repeating the steps, benchmarks for the units and parts can be fixed. In other words, the design of units and parts and the vehicle plan and L/O must be carried out simultaneously and in parallel; it is only after that process that a vehicle plan and benchmarks for individual units and parts are established. It is this process that constitutes the developmental process for a vehicle design. Subsequently, design development must be conducted in order to clear benchmarks for units and parts.

It should be noted that the above is the fundamental process for manufacturing and development. Particularly critical are Steps (2) and (3), which correspond to the C and A in the PDCA (Plan, Do, Check, Action) cycle. It is not uncommon for valuable pointers on development to be buried in these steps.

After determining the above items, establish the following assumed values that were developed in Section 1. 2. 4. Establishing Benchmarks for Events and Designing the Parts:

① Mass

② Position of the center of gravity

③ Tread

④ Wheel base

⑤ Engine type, position, and mass

⑥ Transmission type, position, and mass

⑦ Tire size

⑧ Steering gear ratio and steering wheel diameter

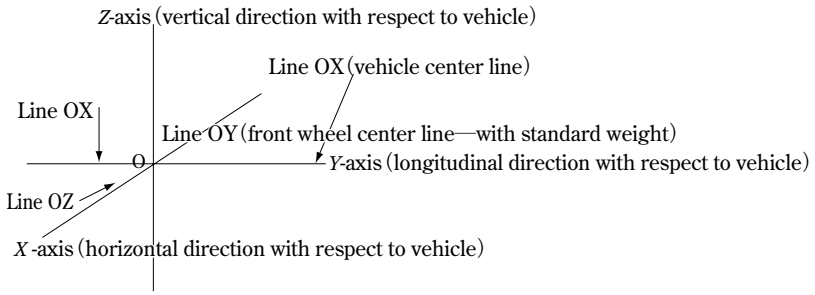


Fig. 2-1 Defining Vehicle Coordinates

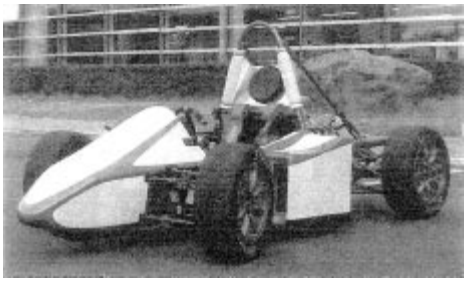
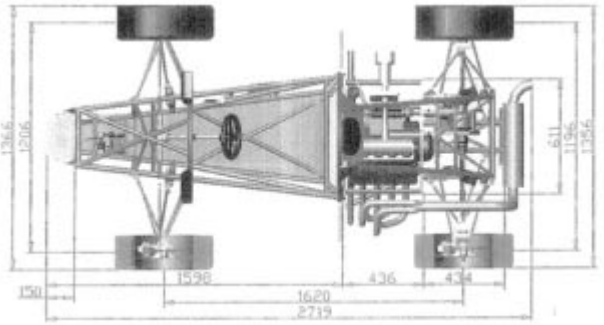
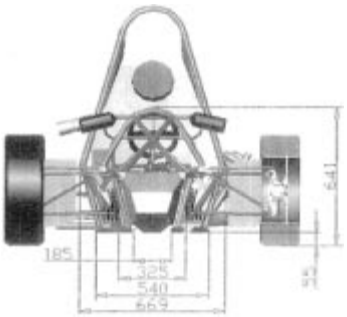


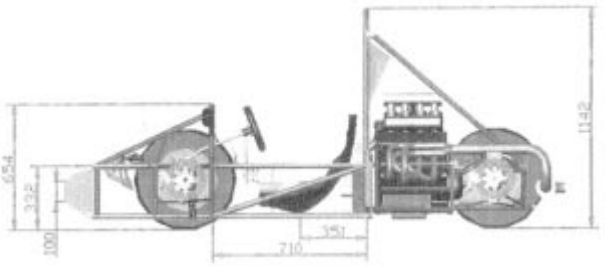
Fig. 2-2 2005 Formula-JSAE Vehicle K-005[1]



Plan view



Front view



Side view

Fig. 2-3 Vehicle L/O Drawings (Three-View Drawings)[1]

⑨ Positions in which occupants ride in the vehicle, and the locations of the gas, brake, and clutch pedals
⑩ Gasoline tank capacity and position
⑪ Position of the exhaust system
⑫ Schematic structure of the frame
⑬ Other

The foregoing establishes the vehicle plan and L/O drawing. **Fig. 2-1** shows an example of defining coordinates to clearly indicate the locations of parts and units that are mounted on the vehicle.

For reference, **Figs. 2-2** and **2-3** show a bird's-eye view diagram and vehicle L/O three-view drawing of the vehicle submitted by the team that earned an overall score of the second place and won the best design award in the Third All Japan Formula SEA competition.

References

(1) Documentation provided by Kanagawa Institute of Technology (in Japanese)