# Preparation of the Design Event

## Objectives

The main objective of the design event is to **evaluate the design** of the vehicle and the step of conception that lead the team to design and produce the vehicle bring to the competition from the FSG rules which is, for us, the specification requirements for the system.

The main question judges will ask is : **Why ?**

You must be able to **justify any choices you have made** since the first reading of the rules until the competition using precis arguments, simulations and testing.

In order to best prepare for this test, everyone should think about the various elements of answers regarding the systems they have worked on. To do this, the following questions require a reasoned answer, comparing the different options available, if necessary with figures (mass, price...), and illustrated with diagrams or simulation results... Make a **matrix decision** for each design choice you have made to make the criteria taken into account as clear as possible.

The aim is to have the **most accurate information** possible during the event, and to allow those who will interact with the judges to have the best chance of reporting on the team's work. Some may not participate in the event and others will have to explain the process. The information will also be used by future members of the team.

The first part presents the **general line** followed during the design, the others are intended for **questions for the different members of the team**. The answers will of course have to be as close as possible to the general line of conduct to ensure a good cohesion of the answers. I am open to any discussion on this course of action.

The questions are the ones I thought of, I would really appreciate it if you would add some questions, for you or for others (I hope I'm not the only one trying to take a step back...). The order of the questions is not well thought out and can be changed without any problem.

Given the amount of work, let me know right away if you don't have time to answer before May 6. Maybe I can answer some questions for you if necessary and we can find a solution together.

Feel free to ask me if you want us to look for possible answers together.

Good luck !

NGO, Team Leader & Design Leader

NB : No Centralien pipo here, we must be as clear as possible

## Global guideline of the design

Example Dynamix Guideline (context : First FS vehicle for EPSA) they decided to oversize the entire system :

1. **Ease :** intended for amateurs, the car should not be too sharp and difficult to handle
2. **Reliability :** the solutions chosen are proven solutions, and the safety margins are high
3. **Safety :** the car must be safe for its driver
4. **Price :** All these qualities contained in a reasonable price )

Optimus is the name of the 2019 car of our FS team called Ecurie Piston Sport Auto (EPSA) from Ecole Centrale de Lyon (France). We are composed of 4 departments: Vehicle dynamic, Powertrain, Frame & Electrical. After a study of the rules, the team decided to design and build a reliable, high-performance car with a reasonable budget that would satisfy an amateur driver and obtain a good ranking in the Formula Student competitions.

Our design guideline is the following:

* **Vehicle Dynamic :** The cornering behaviour have been privileged during design
* **Ergonomics :** the car must adapt to the different drivers
* **More settings available:** many settings are possible to allow the car to be adapted to the different tests as well as possible and adding data acquisition to find the optimal setting for each dynamic event.
* **Reliability :** Reuse of efficient design and optimization of parts weight
* **Maintenance :** the ease of servicing and maintenance of the vehicle has been taken into account in the design

The objective weight was 200kg. The resultant vehicle weight is 204 kg. The car is based on a tubular steel space-frame chassis, powered by a four-cylinder internal combustion engine combined with 13” tyres.

We structured the whole conception of our vehicle using the V-model. Starting from general specification, according to FSG rules and time expectation for dynamic events, each team member developed his own specification for his subsystem. An iteration process has been done, in order to have viable designs that reach the specification. After, the mechanical design of each part was made using Catia. Then, following that phase of conception, the production of the parts started in compliance with the feature we set. Unit validation of each part has been done, to proceed to the integration and validation of the subsystems and finally the car was realised in order to confront its performances to the objectives announced.

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## Frame & body

### Frame (Robin)

Why did you choose a tubular structure in acier 25CD4S ?

Why the bottom of the frame is not flat ?

Why did you choose this crash box ?

What have been the load cases used to size/make the detailed deisgn of the frame ? How have its been determined?

What is the safety factor of your frame ?

What is your our stiffness objective ? Why ?

What have been your guideline for the chose of tube diameter and position ?

What simulations have been made (boundary conditions, hypothesis) ? What are the resultats ?

How have you chose the driver position in the frame ?

Why have you chosen a karting seat ?

What tools have you used during the design ?

### Body (Josselin)

Why did you chose a body for the vehicle ?

Protection, aérodynamique, esthétique

Why did you not put plat between tubes but a body ?

Why did you put a body only at the front of the vehicle ?

What are the material used for the body and why ?

Comparaison des différentes solutions, choix de l’épaisseur

Which processes were used?

How many body parts are there? Why? Why?

What studies have been conducted in aerodynamics?

What were the design steps of the bodywork?

What were the steps in the manufacture of the bodywork?

### Ergonomic (Calixthe)

How were the harness attachment points chosen?

What are the load cases used for harness attachments?

What are the possible adjustments on the harness?

What materials are used for the air box? Why? Why?

What are the constraints related to the sizing of the air box?

What are the possible adjustments at the seat?

Size, positioning, forces

What studies and simulations have been conducted on admission?

What material is used for the headrest? Why? Why?

What are the load cases used for the headrest and its attachments?

## Suspension

### Steering (Guillaume Touzé)

What have been the target caracteristics chosen during the steering kinematic design ?

Ackermann, dérive des pneumatiques, bump steer, angle au volant

What are the load cases used for sizing? How were they determined?

Why a rack-and-pinion steering?

Comparison of the different solutions

Why a cardan shaft column? Why two gimbals?

Comparison of the different solutions

Why such a guidance of the column?

Comparison of the different solutions

What are the possible settings?

What materials are used for the different parts? Why?

Why a rack cover? Why PVC (plastique) ?

What software was used during the design?

### Tyre choice (Michele + PA + Guillaume Touzé)

Why did you choose 13-inch wheels? Why this model?

13' rim: place for the LAS, more margin for the packaging so the suspensions go into the triangles where the direction/cardanic joints pass -> drop of the cdg

Aesthetics, we didn't want the car to be too "small

Rim model: aesthetic concerns (see black colour in harmony with the red of the stirrups), good quality; offset that we wanted

Why did you choose Hoosier R25B 20.5 x 7.0 tyres?

Used by many teams, reference in the competition, not able to analyze the tires on the other hand

Why does the car have suspensions?

Comfort, impact on roadholding because otherwise rigid car,

Why double triangulation?

Comparison of the different solutions

Epsa knew about this system, but before we only had parallel triangles. First time we try triangles not // of different lengths. Allows to discover concepts (CIR, roll center...)

Easy adjustment

Lightweight because tubes only

What are the characteristics targeted when choosing the kinematics of double triangulation?

Choice of the location of the suspension CIR (see VSAL aimed for the camber grip), control the dynamic movement of the roll centre even if we have not succeeded completely on this point. The roll centre moves a little too far to the side to encourage rolling.

What elements have been set aside in the design? Why?

Anti-plunge / anti-abrasion, order 2 effect

anti-roll system -> instead we play on stiffness and damping. Pb no decoupling between the roll grip and the stiffness of the springs.

Coupling of gripper grips and coolant depending on the travel. Each of the angles was studied separately. Moreover, some angles are fixed and not adjustable. This allows you to focus and understand how certain angles work (body/clamp)

Because lack of time

What assumptions were made for the modelling?

Not taking into account the deformation effects of the tire. Contact point of the tire in its center. Choice of a mass of 250kg, choice of the cdg at 35cm (see other stables), decoupling of the angles in the study, no deformation of the elements (chassis...)

What simulations have been done? What are the results?

2D study of the LAS. Gives the geometry of the triangles (length and inclination) for targeted characteristics (camber grip)

Study of the suspensions in 2D. to have the link between tyre/spring displacement coupled with excellence to find the associated stiffness for a chosen roll value

Study of tyre forces during load transfers with Matlb.

Why a hub and hub carrier solution?

Comparison of the different solutions

How were the hub and hub carrier materials chosen?

Why angular contact bearings? Why this assembly?

Why hinges and not pivots at the ends of the triangles?

Montability, misalignment is corrected

Which load cases were used for the sizing of the different elements? How were they determined?

Load cases : braking (1,5g), cornering (1.3g), Acceleration (1g) & mixed load cases (cornering + braking)

Hand calculations using pfd and torsor and solving the equations under matlab. Consideration of load transfers,

Why are the triangles made of steel?

We didn't want to innovate on this point, we privileged the known and wanted to innovate more on kinematics than on the dimensioning of parts for point gain. -> results something reliable but oversized.

Why did you choose Ohlins TTX25 mkII shock absorbers?

Possibility of adjustments to compensate for design errors (stiffness...), it was useful (see stiffness error), compact and light (see bike),

Why use tie-rod and tilting suspensions? How was the kinematics chosen?

Tension rod (increased strength)

Kinematics: we have inquired about the MRs, we have tried to find a kinematics (through the MR) that allows us to have a compromise on the frequencies at the wheels (linked to stiffness) and the roll taking knowing that we cannot decouple them because of the absence of anti-roll bar

Comparison of different solutions, motion ratio

What train and suspension settings are possible? How were they chosen?

See tyre angles/pressure, by pilot tests, several configurations according to the tests

### Braking (Benji)

Which braking power was chosen? Why?

A 1.5g depending on tyre grip (see matlab)

Why did you choose 4 disc brakes?

Comparison of the different solutions

Ease of use, manufacturer's advice

Why these Beringer brakes? What factors dictated the choice?

Disc size, caliper size, master cylinder size, materials, floating discs

Beringer in Lyon, easy to have a partnership

Weight of the elements and their size (e. g. very small mc) light and efficient stirrup

Why two separate front / rear circuits?

Safety related to the regulations (I think we really need to insist on this point wherever we can because it's the first thing an engineer has to think about.)

If leakage -> safety

Why use a brake distribution system?

Idea to easily adjust the mass distribution, but creates too high a pressure drop compared to the calipers and mc (the rear does not lock). So we deleted it.

Adjustment on the lifting beam is more than enough

Why braided hoses (= durites tressées) ?

Comparison of the different solutions

Quality, resistance-> Safety = priority

Are the brake hoses the same length?

Yes, to have the same left/right pressure drop. Facilitate wheel braking at the same time

What software was used during the design?

CATIA, geogébra (geometric drawing), matlab

Why a two pedal crankset?

Comparison of the different solutions

Why the left brake?

What are the possible settings?

Why this solution for the action on the accelerator cable?

Comparison of the different solutions

Why this solution for action on master cylinders?

Inclined master cylinders, comparison of different solutions

Why such a law of pedal angle / cable pull?

What are the load cases used for sizing? How were they determined?

What materials are used? Why? Why?

### Flond plat & cooling system (Maros)

Why a flat bottom? Why in carbon fiber?

What is the coolant? Why?

Why an aluminium radiator?

How much power is dissipated by the radiator? How was it chosen?

How was the position of the radiator chosen?

Why silicone hoses?

Why use the mechanical water pump?

Is the engine temperature controlled? If so, how?

Why is the radiator mounting bar twisted?

Why is the radiator mounted on a silentblock?

## Engine & powertrain

### Engine choice (Clement)

What are the characteristics targeted when choosing the drive components?

Why choose an existing engine?

How was the engine chosen?

Why keep a wet housing?

How is the electronic management of the engine done? Why? Why?

Which sensors are used?

Why use two injection bars?

Why mount the motor on silentblocks?

How was the capacity of the fuel tank chosen?

What material is used for the tank? Why? Why?

Why use braided fuel hoses?

Why use an external fuel pump?

What is the regulating pressure of the fuel system? Why? Why?

What simulations have been conducted?

Which agreement regime was being sought? Why? Why?

Why did you choose a 4-2-1 exhaust?

What is the exhaust material? Why? Why?

What tests were performed on the engine?

What vehicle tests have been performed? What test plan was followed? Why? Why?

What changes were made as a result of these tests?

Why a firewall?

Which material was chosen? Why? Why?

How is the sealing of the firewall ensured?

Which solution is used for the clutch? Why? Why?

Comparison of the different solutions, ergonomics, left or right placement

Why did you install an anti-dribble clutch?

Why did you choose to use paddles when driving?

Comparison of the different solutions

Why only turn off the ignition when changing to a higher gear?

Why did you provide several adjustment notches on the gearshift linkage?

How was the control of the drawings before manufacture organised?

### Exhaust & air intake systems

### Fuel system

### Secondary drivetrain (Mathieu)

Why a limited slip differential?

Comparison of the different solutions

Why chain transmission?

Comparison of the different solutions

Why tripod seals?

Comparison of the different solutions

What are the load cases used for sizing? How were they determined?

How was the final transmission ratio determined?

What are the possible settings on the secondary transmission?

What materials are used, why?

Case of transmission shafts!

How is the chain tension made? Why this solution?

What maintenance is required? Why?

## Electrical

### DashBoard

What are the indications available on the dashboard? How were they chosen?

Circuit breakers, clutch switch, fuses

### Electronic

What are the safety features of the wiring harness? Why?

### Data acquisition

What sensors have you added ? Why ?

What sensors haven’t you added ? Why ?