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INPUT PROCES ANALYSIS FOR TESTING CAR ENGINES

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Rezumat. *Subiectul abordat în această lucrare este un studiu realizat în departamentul de testare auto al Renault Technologie Roumanie. Acest studiu cuprinde: o analiză a procesului de testare de la primirea unei cereri de testare până la generarea rezultatelor și transmiterea acestora spre interpretare către client, analiza tipurilor de teste mecanice de motoare efectuate la Renault România și analiza economică a implementării unui banc de testare a motoarelor hibride, primul de acest fel din România, cu analiză de proiect și analiză SWOT. Ceea ce se urmărește prin acest proces este delimitarea corectă a etapelor de testare, succesiunea și modalitatea de a deveni competitivă pe o piață cu tradiție și care oferă oportunități de dezvoltare progresivă de-a lungul evoluției vehiculelor către hibrid și full-electric.*

Abstract. *The topic covered in this paper is a study conducted in the automotive testing department of Renault Technologie Roumanie.The contains of this study is: an analysis of the testing process from receiving a test request to the generation of results and sending them for interpretation to the customer, the analysis of the types of mechanical engine tests performed at Renault Romania and the economical analysis of implementing a hybrid engine test bench, the first of its kind in Romania, with project analysis and SWOT analysis. What is being pursued by this process is the correct delimitation of the test stages, the succession and the way to become competitive on a market with tradition and which offers opportunities for progressive development along the evolution of vehicles towards hybrid and full-electric.*

Keywords: Test bench, Engine test, Test facilities, Static test bench

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1. Introduction

The future of developement of the cars it is nonsens without the test of the engines. Testing the engines is a complex process with applicability and utility in the development of new performance, but also in the limitation of the harmful effects that the use of internal combustion engines entails. This is possible as an integral part of the research and development process, either in machine-building enterprises or in research laboratories in universities with a profile in automotive engineering. The engines are designed to be integrated and operational in a

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vehicle, so the test must be performed in an enclosure that meets as closely as possible the conditions under which they will be operated on the cars. As a result, there are currently a searies of specifical systems and control required to perform engine testing in laboratory conditions. Enclosures called test cells and machines called test benches have been created to test the car engines. This configures a virtual environment or platform to test its performance in a real-world scenario, to ensure its accuracy and correctness for future mass applicability. The fact that at present the engines are more and more sophisticated with the highest possible performance, at the lowest possible consumption and with polluting emissions that last year tend more and more to zero is due to the detailed testing, ranging from when testing emissions and fuel economy, durability, noise and vibration optimization in addition to high performance and acceleration / deceleration response capability [1], [2]. Some of these parameters often work against each other, so the tests mean large financial investments and considerable time periods because the overall balance is taken into account. The testing process itself has evolved with the development of new requirements related to performance, consumption, reduction of pollutant emissions, integrated software without losing sight of the QCD triangle (Quality, Cost, Deadline). The test generally follows two tracks: finding defects in an already existing and implemented system and these are called production conformity tests, and the second track seeks to find the best possible solution for the mobility of the future, for this second purpose engines that are in development are tested, and there are called prototype engines tests.

2. The current stage

The history of engine testing overlaps with the history of automobiles. The pioneers in the invention of engines and in their integration into automobiles did tests in various modes of operation, all in order to create cars in the beginning, the definition of the car being at that time "car " = "moving by itself." If in the beginning the tests were aimed at verifying the operation, later the tests had to answer more and more questions related to power, economy, reliability, endurance, and since then with the measurements that showed an increasing degree of pollution, the most important question that engine tests need to answer is how polluting an engine is to know if it can still be produced and operated. The complexity of the test is the key word today, because if in the beginning most of the parts of an engine was mechanical, now the engine is a mixture of a small mechanical part and a large electronic weight. The principles of mechanics mostly have remained the same, but the integration of increasingly sophisticated electrical systems that are driven by complex software has led to the development of the testing process, the variety and multiplication of the number of tests. The

way that it works, the consume, the power, the noise, the pollution that is resulted from using the engines represent parts of the full product, that's why testing targets the interdependence of these parameters, the analyses of a test doesn't mean at the moment just the simple testing a part, but how that part influences the assembly of the engine. The view of the drivers looking at the performance of the vehicle and at the driving it is now less determined by its mechanical proprieties and more by the different software programs which are located in the control systems interpose between the driver and the hardware. The majority of the drivers don't know how their vehicles became "wired" making the driver more a commander than a controller. In this last role, driver uses the commands of the vehicle, including the throttle pedal, to communicate the intentions, but it's the electronic control unit (ECU), calibrated and mapped in the testing cell, that decides how and if the intention is realized. Including the legislation at the moment impose a set of regulations that require testing and mass implementation of system without which cars are no longer approved. So, including euro norms, opened a new chapter in testing, from the launch of the first norm in 1992 until the final one, Euro 7 which is going to be implemented in the year 2025, the role of the testing departments and university laboratories is to succeed bringing the engines to respect those norms, without performance drop and making them less marketable. Another example of legislative implication is the following: both American and European legislation require now installing a system of stability on light vehicles (ESP is the acronym for the Electronic Stability Program) a system which, in a predetermined set of circumstances, it notices if the driver is about losing the control of the car, intervenes, takes control and tries to correct the driving of the car. Similarly, the diagnosis system on the board (OBD is the acronym for ON Board Diagnostics) become world-wide mandatory. Another factor that influenced the testing improving is competition on car market. The producers are looking at solutions that are as efficient as possible to produce and commercialize cars which need to respect the actual legislation, as cheap as possible and with highest possible profit. This encourages testing and implementing engines that are becoming better and better on the market. The competition is tough and producers are constantly investing in research and in improving of the tests [3], [4], [5]. At the moment, the testing requires the existence of an enclosure of testing, a test bench, the required software and qualified human resources, usually calibration engineers, mechanic engineers, IT engineers etc. For better understanding of why the engine testing needs specific testing requirements and methods of testing:

-The design testing of the cell and the functioning of the instruments.

-How the engine works with internal combustion.

-Engine testing.
-Exhaust gas emission, fuel analysis.
-Performance testing and validation.
-Instrumentation, temperature, pressure and flow.
-Fuel loops, ignition and emission which lead to mapping and calibration.
-Test cell procedures and safety issues;

The constituent elements of the process and their role:

1.The testing cell: this part is a civil construction, warehouse type, of production. However, the particularities are given by the construction specificity which must provide a certain ventilation of the enclosure, the possibility of introducing the air with help from a special installation, a so-called "seismic-massif", which takes over vibrations during the tests and a nozzle evacuation line. In the neighborhood of the test cell is the control room, an enclosure where the bench control system is located.

2.The bench itself or the testing stand of the engine is an installation used for development, characterization and engine testing. This allows the engine functioning in different operating modes and provides measurements of several physical variables associated with the functioning of the engine.
In engine testing with internal combustion, three types of tests are being used:
-Static bench
-Dynamic bench
-Roller bench

3. The support of test is the engine on which certain components or software are tested. In engine terminology it is abbreviated as SE (short for the equivalent French term "Support Essai"). In the process it is provided by the customer, the customer representing the entity for which one or more tests are performed and for which results are generated under the form set out in the test application by both parties, the test taker and the customer, respecting the test conditions indicated by the customer.

4. Specialized human resources represent the persons who have the necessary specialization to set and comply with the test conditions. They are usually specialists in the field of engine calibration, car electronics specialists, engine engineers, automotive software engineers, and so far.
Starting from these coordinates described above, a diagram of the testing process can be created as follows (Fig. 1):

Fig. 1. Scheme of testing process.

Another way to express the upstream process is the following (Fig. 2):

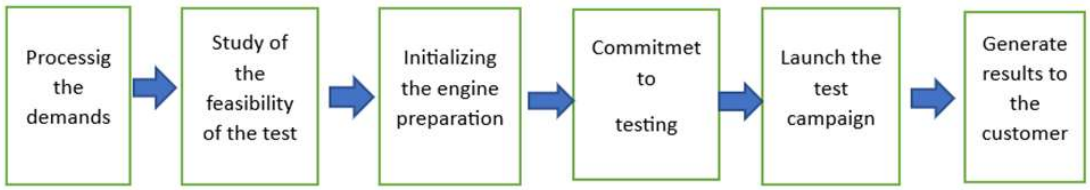

Fig. 2. The step-by-step scheme of the process

The load entry is a test request made by the customer or a customer's representative in written form specifying the type of engine, the type of test, the test conditions, the duration of the test and the period during which the test will be performed. This document is received by the test leader, test specialist and planner and is discussed in the technical meeting to see the feasibility of the ability and availability to be able to treat in terms of quality, time and costs of that test.

Following this meeting, the test leader decides on the acceptance or rejection of the test request, depending on the ability of the banks and the availability during the period requested by the client.

Once a test request has been accepted following the feasibility validation, the overall study and planning of activities is initiated. This means that the logistics and engine preparation must respect the deadlines and respect the conditions according to the specifications of the test demand. The necessary actions for the supply of test parts are listed, intervals are reserved for the preparation of the engine in order to be mounted on the bench. This stage represents a close collaboration between the testing teams, the logistics teams and the engine training teams, collaborations on which depends largely the realization of the test in compliance conditions and with the observance of the quality and the term desired by the client [6].

Launching the test campaign means mounting the engine on the bench in accordance with the specifications in the test data sheet, communicating with a technical representative from the client who approves throughout the test and who finally analyzes and validates the results generated, staged validation and overall.

3. SWOT analysis of the process

As mentioned in Chapter 2 of this paper, the current state of testing, testing is a fairly well-developed process, due to the existence of both relatively good testing capabilities and capabilities related to the market and specialized human resources. which represents the guarantor of quality services, at competitive prices on the profile market. However, as the technologies are changing at a very fast pace, the car testing process will have to keep up with what is expected to be the future in motoring, a future with all that it entails, namely the transition from thermal engines to engines hybrids, in the first phase thermal-LPG, after which evolution to thermal-electric hybrid, following the last evolution from hybrid engines to full-electric motors. This will happen relatively quickly. Pollution rules are defining in this purpose. The last Euro norm, Euro 7, will come into force in 2025 (Fig. 3). It is the last regulation that gives another chance to use thermal engines in Europe. In the table below you can see the limits allowed by this regulation. And if by Euro 7 things were regulated according to the type of fuel, from 2025, petrol and diesel will no longer be different in the amount of agreed pollutant emissions.

			Quantities of emissions admited				
Emission standard	Deadline	Date of implementation	Admitted	THC	VOC	No_x	$HC+No_x$
Euro 7	2025	2025	0,1 to 0,3 g/km			0,03 g/km	

Fig. 3. Emissions agreed in Euro 7 standard for vehicle class M
(M-"multi purpose vehicle" or "vehicles used for various purposes")

The testing process will have to keep up with the changes that are expected in the automotive area and this will be done gradually according to the Figure 4.

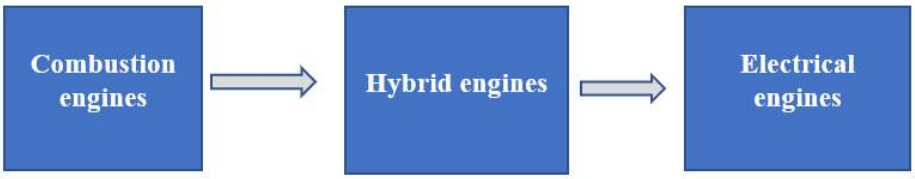

Fig. 4. Evolution of types of tests

In the context of this evolution, the testing technology in Renault Romania must face the challenges of the new technologies. The testing process and technologies will have to keep up with the changes, this being a process of anticipation, forecasting, detailed organization, implementation and operation at the highest level for a top competitiveness. In the future, success in any activity will mean new technologies, prompt applicability, very accurate risk calculation and very well defined and very strictly applied risk avoidance policies of any kind.
To this context of compliance with the norms imposed by polluting emissions, is added the maintenance and even the increase of the engine performance, the resistance and the low price of the production costs.
These cumulative data lead to major engine challenges. Engine manufacturers establish action criteria, establish multi-purpose research and development strategies that meet a variety of requirements, develop globally agreed solutions to limit and reduce pollution, while not regressing in engine performance on reliability, durability, consumption and performance [7], [8].
The challenge is hard, but the levers at hand are many and varied. It will all depend on strategies, calculations, realistic forecasts and pragmatic decisions.
At the Renault site in Romania, engine tests are currently being carried out. But the technology only allows thermal engine tests and hybrid characterization tests for hybrid thermal-LPG engines. What does this thing mean? It means that we need to invest in new technologies that will allow us to evolve in the same time with the evolution of engines. The future will be with those who keep pace with technological changes, this is proven, and investors who understand this will benefit from the advantage of anticipation.
A hybrid test bench should be implemented on the Dacia site. It is a technology that would help the Romanian car manufacturer to save time and money. The installation of hybrid thermal-LPG engines in Dacia is already a reality, testing must keep pace, if not with research and development, at least with industrialization, assembly and approval for series (Fig. 5).
SWOT analysis is a relevant tool to be able to have a real picture of the existing situation (Fig. 6).

3.1 Summary of main strengths

• The management of the Dacia test department uses a combination of managerial techniques, a combination between classic (classic means that technical experience has a say) and evolved (size and pace of evolution are the variables that make the difference).
• The information represents the decision base, the documentation of the information is rigorous, demonstrable, argued in writing, archived, accessible to the targeted persons and transmitted in due time.

• The existence of a state-of-the-art computer system with specific applications that communicate with each other and are based on current computer technology is a guarantee of the quality and speed of information transmission.
• Existence of activities necessary to achieve the objectives, from the design, implementation, capitalization, services, maintenance, quality, customer feedback.
• Existence of the Internal Regulations, the Standard Operating Sheets, the procedures and the quality management system.
• Commercial domain
• The existence of a secure, stable and still expanding market.
• The remuneration rate of human resources is quite advantageous.
• Low utility costs compared to Western European countries.
• Profitability of the department even in the conditions of limitation to do only tests on thermal engines.
• Well-trained human resources through trainings within the Renaut group.
• Collaboration relations with RAR in order to validate and certify the tests
• Licenses for calibration software and recording and validation of engine test data.

3.2 Summary of the main weaknesses

• Decisions of weak quality and in delay
• Lack of elaboration of a complex strategy focused on prognostic studies, diagnosis and even the study of human resources.
• Insufficient sizing of the activities of the attributions and tasks.
• Lack of a complex system of objectives that reaches the level of the position and its occupant.
• Limited to testing only thermal engines

3.3 Opportunities

Existence of a qualified workforce for this type of activity.
• Possibility to attract skilled labor.
• The growing potential of the specialized workforce.
• The obligation to align the management system with the modern management systems within the Renault crane of which Dacia is part.
• Existence of a secure market for this engine testing service.
• Possibility to access cheaper financial resources due to sustainable development programs.
• Strategic location.

No.	SITE	Planning of the tests		
		Year 2022	Year 2023	Year 2024
		Hours/year	Hours/year	Hours/year
1	Dacia-Mioveni	1200	2500	2000
2	Renault-Valladolid	1500	470	1000
3	Renault-Cleon	2200	1700	1700
4	Renault-Douai	500	1200	500
5	Renault-Oyak	1200	700	500
6	Renault-Avtovaz	1400	1000	3000
TOTAL		8000	7570	8700

Fig. 5. Forecast of extra-capacity test hours in Renault Group 2022 ->2024

3.4 Threats

• The possibility of migrating specialized personnel to competing companies.
• The possibility for Ford Romania competitors to implement test benches.
• Bureaucracy in obtaining operating permits.
• Accelerated economic instability and rising inflation.
• The risk of "freezing" advantageous financial programs.
• The risk of the technology evaluating accelerated to the electric motor and the obsolescence of the technology before depreciation.

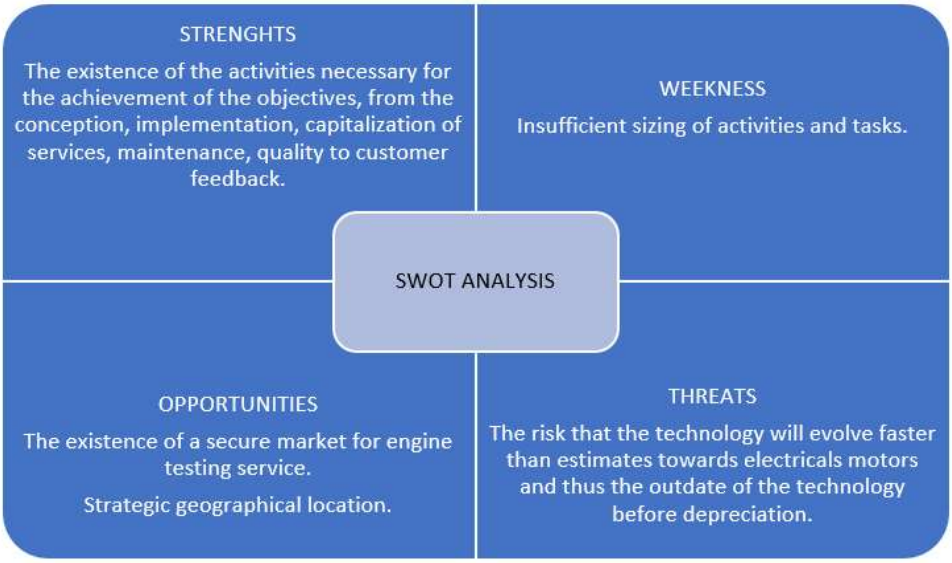

Fig. 6. Synthesis of SWOT analysis

3.5 Strategic proposals to capitalize on the SWOT analysis

Accelerate the updating of the management system especially by applying management through objectives and through rigorously elaborated and effective budgets

Increasing the degree of capitalization of data and information in order to make prompt decisions.

Utilizing the existing IT potential.

Improving real-time anticipation, forecasting and action policies.

Taking advantage of the possibilities to access both the own investment budget in the renewal of technology and non-reimbursable public financing for financing innovation and technology transfer projects.

4. Implementation of a hybrid engine test bench

The implementation of a test bench for hybrid engines is a priority for the evolution of the car testing process in Dacia.

What would be new in engine testing? The fact that hybrid thermal-LPG engines are already being installed in series is a reality to which all the technologies that contribute to the full range of production cycle must be adapted, starting from conception, testing, validation, implementation, industrialization, certification, assurance. quality, maintenance, feedback analysis and troubleshooting. This aspect is paramount in the decision to implement a hybrid bank.

This technical solution is created from scratch, this being the specific objective of this project.

The specific objectives of this project are:

- developing testing capability
- increasing the group's performance
- attracting new customers
- performing tests without wasting time and money for sending abroad
- offering on the external testing market competitive testing services in terms of quality and costs

The problem was identified on the engine testing department in Dacia where the tests on hybrid engines are carried out with difficulty, with exceeding the milestones, with loss of time and money. Following the finding of this problem, it was sought to remedy it by implementing an advantageous solution that would lead to good results in terms of cost, quality and time.

Based on the experience in the field at group level, a feasibility study was started with an estimate of costs, time and resources.
The estimates from this analysis are as follows:

4.1 Project conditions

• the deadline is 10 months
• the test bench must be ISO / TS 16949 certified and approved

4.2 Estimating inputs and outputs

Entries:

- human resources: project manager, civil construction manager, mechanical assembly and assembly manager, maintenance manager, project planner, supplier relations manager, designer, implanter, 2 technicians, 3 mechanics, 2 welders, 2 plumbers, electrician, test specialist, 6 workers
- material resources computers, software, the actual bank, raw materials, tools and accessories, location

Exits:

- Implementing a bench
- Adherence to the international hybrid engine testing network
- Attracting new customers

5. Presentation of the upstream engine testing process

Any testing process is structured in two parts: upstream and downstream.
The downstream test part refers to the pre-test process and is formed and involves the succession of the following steps:
• Introduction of the load input, by load input understanding the need for testing expressed by the customer and the analysis related to the feasibility of the test according to the request expressed by the customer.

• Defining the parts needed to prepare the Test Stand.

• Contracting with the client the date of completion of the test as well as the delivery data by the client of the input data (documents, parts, physical test support) that would allow the implementation of the test.

• Monitoring the program, prioritizing by mutual agreement with the client if necessary, in order to perform the test (Table 1) [9].

Table 1. Stages of the engine testing process

Stage	Activitys • Responsibile • Participant		Project manager logistical tests	Teast leader	Planner	Customer
S1	Express of the need		•	•	•	•
S2	Defining the feasibility of the test			•	o	o
S3	Centralizing the need for test parts		•	o	o	o
S4	Record the commitment to perform the test		o	•	o	o
S5	Launch test campaign	o	o	•	o	o
E6	Establishing the order of entry on the test bench		o	•	o	o

6. Types of engine tests in Renault Technologie Roumanie

The aim of car engine testing applications is either to research the development of very good performance in accordance with very low fuel consumption, or to validate new components for engines and suppliers as affordable as possible in terms of price, quality and delivery deadlines.

Thus, there are tests that are done for project engines and tests that are done for the so-called series life.

There are two categories of tests:

- characterization tests, tests that involve a relatively small number of hours on the test bench

- endurance tests, tests that require a large and very large number of hours of running on the test bench

6.1. Examples of characterization tests
-grip piston
-corrosion test
- turbocharger coking
-bubble test
-grip axle piston
6. 2. Examples of endurance tests
-maximum power test
-maximum torque / maximum power test
- hot / cold cycle
-Nardo test
-slow city test

7. Conclusions

The testing process is a complex process that involves specialized human resources and investments in state-of-the-art technologies in the field of car testing.

The advantage of the Renault subsidiary in Romania and implicitly of our country, is the membership in the Renault-Nissan-Mitsubishi alliance and in this context in Romania, research and development projects are being carried out for engines that comply with European pollution norms.

The existence of a surplus testing market is a context in which Romania can use the human resources specialized in this field, the technologies and knowledges to generate quality results at the lowest prices on the profile market.

This paper is a synthesis from two points of view, an economic approach to engine testing with SWOT process analysis and feasibility study of the implementation of a hybrid thermal-LPG test bench and a technical approach to the types of tests and study case of a " Nardo " test bench.

The originality of the paper is represented by this mixed approach of this subject, economic but also technical.

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