**Discorso presentazione discussione tesi**

**Slide 1: Introduction**

Good [morning/afternoon], everyone. My name is Mattia Oliva, and I am here to present my thesis, which focuses on defining a library for an automotive ECU API layer using a Model-Based approach.

[???Lo tengo? ???I would like to thank my advisor, Prof. Massimo Violante, and my internship tutor, Ing. Emilio Bertrand, for their guidance throughout this journey.]

**Slide 2: Collaboration with Metatron**

This thesis was made possible through collaboration with Metatron S.p.A., a company within the Landi Renzo Group that specializes in developing electronic and mechanical components for alternative fuels. My work was conducted at the Metatron Research Centre in Volvera, Turin, where I gained valuable insights into the automotive industry.

**Slide 3: Current Situation**

Over the years, Metatron has developed a complex and layered code base in response to evolving standards and customer demands. [???Aggiungi elenco fattori che richiedono uno standardised and flexible API layer???]

However, this complexity has led to challenges in managing the code effectively.

Our goal was to create a standardized and flexible API layer that would simplify development, enhance portability, and ensure compliance with diagnostic standards across various markets.

**Slide 4: Thesis Goals**

[???Lo tengo? Forse l’ho già riscritto???To address these challenges, my thesis had several key goals. First, I analysed the current ECU API layer and existing Model-Based Software Libraries (MBSL). I then defined and implemented Model-Based libraries, focusing on memory management functions and diagnostic protocols. Additionally, I developed a Demo Application Layer to validate these libraries.]

[???Riscrivi/riassumi??? The thesis continues the path of standardisation and revision of the interface level of the Metatron platforms.

Consequently, the first goal was the analysis of current ECU API layer/MBSL libraries and the documentation about the main functions for a generic ECU and about the customisation process identified to maximise the configurability.

This thesis goal was twofold, and the process was split into smaller steps:

* Analysis of current ECU API layer / MBSL libraries and of the state-of-the-art for diagnostic protocols for heavy duty systems
* Definition of Model-Based (SIMULINK) Libraries according to an automatic/user-friendly process
* Memory **Management (NVRAM):** *management of units to give the user the possibility to store/retrieve data from permanent memory with a safe approach.*
* **Diagnostic modules:** *analysis of the state-of-the-art for diagnostic protocols for heavy duty systems (OBD2, WWH-OBD, J1939), predisposition of a general finite state machine (FSM) for the management of the status of diagnostic lines, keeping into account main diagnostic protocols and relative interfaces between the basic software layer and application software layer.*
* Implementation of a Demo Application Layer for the validation of the libraries.]

**Slide 5: Architecture**

I’ll explain this graph more in details later, but as you can see as the foundation of this work there is a solid and general-purpose memory management strategy.

We needed it to be general purpose both as a good principle per se, but mainly because at this moment we still had no idea of how the OBD system would be implemented.

We designed it to be general-purpose, ensuring flexibility as we navigated the complexities of the On-Board Diagnostic (OBD) system. By utilizing the NVRAM modules of the HDS9 board in combination with the designed strategy, we ensured data redundancy and reliability.

**Slide 6: NVRAM Management - HIL Testing**

To validate our memory management system under continuous working conditions (powering on, reading, writing, and powering off) and to ensure the correct functioning of the strategy, we conducted Hardware-in-the-Loop (HIL) testing.

Two automated tests were implemented using LabVIEW, focussing on the system's resilience under stress and the flexibility of our memorisation strategy.

Communication between the board and the test program was established via the CAN protocol.

**Slide 7: NVRAM Management - Results**

The data collected were then compared to the expected results (the values calculated by the board were all defined by mathematical formulas that can be found in the thesis).

The results of our tests were promising. The second test ran for over four days, simulating 6000 ignition cycles and collecting more than 30,000 samples. We observed the expected behaviour, confirming the integrity of the data stored in memory. The first test also demonstrated correct data retrieval and module selection.

**Slide 8: Diagnostic Requirements**

We’ll now move on to the main goal of the thesis, a **multi-step redesign** of the On-Board Diagnostic system to align with the most recent **standards** aiming at **reducing** the **complexity** of the system and interfaces for better maintainability and ease-of-use for future customers. It could also be a possible starting point **for future implementations**.

The work started with the analysis of the top standards for the On-Board Diagnostic, like Euro-VI and WWH-OBD, drawing the system requirements to then design the architecture you see here.

**Slide 9: Diagnostic Flow**

The different components of the architecture correspond to the various phases of the diagnostic flow…

[???Espandi???For each fault defined in the system, the diagnosis flow has been meticulously updated.] This modular approach enhances maintainability and ease of use for future customers.

**Slide 10: FSM**

[???Moving on to the diagnostic system, we updated the diagnosis flow to adopt a modular approach. The automaton, named ADIA, plays a crucial role in validating error conditions and managing the error memory. We simplified the original code, condensing multiple types of ADIA into a standard-compliant Finite State Machine (FSM). The ADIA automaton cycles through its states to validate error conditions, ensuring efficient management of the error memory and recovery strategies.???]

**Slide 11: Error Memory & Freeze Frame**

The Error Memory and Freeze Frame (a snapshot of the engine state at the moment of the fault) are vital components for the OBD, and their behaviours are widely described in the standards.

Their contents are essential for the correct functioning of the MIL and other components.

For their implementation, we focused on minimising the data stored in non-volatile memory while ensuring that essential information is retained for effective diagnostics.

Here you can see the direct correlation between the structure for the faults in memory and the associated freeze frames.

The fields of the latter were obtained by combining and pruning the requests of both Euro-VI and China-VI.

**Slide 12: Interfaces**

To facilitate model-based design, we created APIs that are now available as SIMULINK blocks in the company’s library. Additionally, we developed user-friendly SIMULINK masks to simplify the setup process for the OBD strategy.

**Slide 13: Video**

[???]

**Slide 14: Work Recap**

Before concluding, here is a short summary of the work done for this thesis.

First, we analysed pre-existing code and implemented a new strategy, using HIL testing to tune the designed solution.

In the second part, we started with the analysis of the current standards to design and implement each component of a new OBD strategy, performing both integration and system testing, and producing useful interfaces for the users to interact with the system.

**Slide 15: Conclusion & Next Steps**

In conclusion, we have successfully simplified the system architecture, thus increasing maintainability and reducing the error points. We also increased modularity and ensured compliance with OBD standards.

Moving forward, we aim to integrate protocols with the Basic Software Level and identify a pilot project to fully test the system in a real-world environment.

**Slide 14: Thank You**

That’s all, folks. Thank you for your attention. I am happy to answer any questions you may have.