# PLM Processes and CAD/CAE Tools with Application to Vehicle Component Design

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## Background

### Digital Twins (DT)

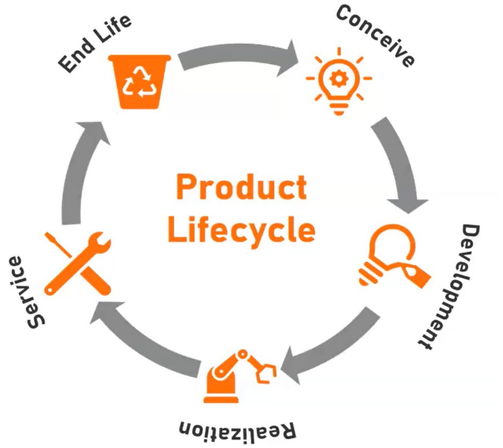
**Definition:**

- A DT is a **computerized representation of a physical object**.
- Simple like a CAD (computer aided design) model or complex and include sensor and data integration.
- Easily modified, scaled, simulated, and more.
- Gather real time data from sensors, analyzing real-world performance.

### Product Lifecycle Management

Product Lifecycle Management, also referred to as digital engineering, can be described by the processes and tools used to manage a products information throughout its lifecycle. Lifecycle is specifically the flow of information from concept to concept through product's evolution and growth.

- PLM starts with **conception** ex. preliminary technology research.
- Next, **design**, including digital models and prototypes.
- Next **realization**, characterized by component manufacturing, assembly, marketing, etc.
- Lastly the **end of the product**, but like said, not the end of the information use.




## Research

### Research Objectives

These objectives aim to showcase the creation process of the digital twin, evaluate the tools utilized, and contribute to establishing effective practices in digital twin development.

- **Develop** a custom digital twin (DT) for a tracked robotic vehicle by integrating dynamic models and real-time data streams using engineering platforms like Siemens.
- **Assess** the effectiveness of various engineering tools in building DTs, demonstrating their suitability for creating and refining vehicular digital twins at different levels of detail.
- **Document** the integration techniques used to synchronize software platforms and data streams, highlighting the process of aligning models with real-world data for a comprehensive digital representation of the robotic vehicle.

## Research Projects

### Geometric Model Integration

**What it is:**

- A crucial part of our DT is a 3D model using Siemens NX and Teamcenter.

**Our Objective for this Model:**

- Create a thorough assembly with all components.
- Run simulations to obtain new data.

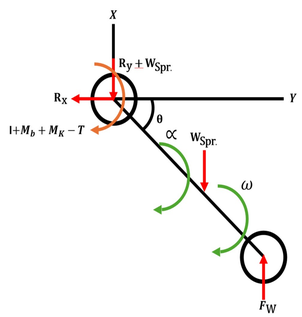
**Why it is Important:**

- Allows us to gain data that is difficult to obtain experimentally for other projects.

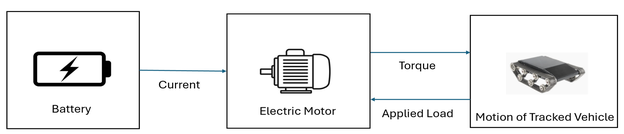
### Model Development

Mathematical models of the tracked vehicle can help with understanding how it will behave in the real world. The development for these models has involved:

- The creation of a free-body diagram for both the two models being observed (electrical motor and suspension).
- Equations derived from the free-body diagram to represent the motion of the tracked vehicle in relation to the motor and suspension and the effects of the tracked vehicle on the motor and suspension.
- Evaluating the equations to determine how the tracked vehicle will be affected by the suspension and motor and vice-versa to establish a relationship between the individual component and the system.



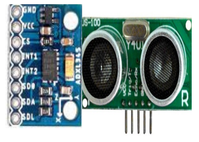

*Free-body diagram of a suspension linkage within the tracked vehicle*



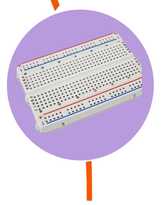

*Flow diagram of the relationship between the battery, electric motor and motion of the tracked vehicle*

### Sensor Integration

#### Accelerometer and Ultrasonic Rangefinder



- Accelerometer; to measure inert acceleration due to gravity using six pins. VCC, GND, X, Y, Z and ST. Accelerometer works by determining changes to force; a mass' movement generates a voltage proportional to applied force.
- HC-SR04; ultrasonic sensor used for measuring distance with four pins. VCC, GND, Trig and Echo pin. Emits ultrasonic waves and calculates the time it takes for waves to bounce back after deflecting off object.



#### Circuit Design

Connecting Ultrasonic Rangefinder/Accelerometer and Arduino Uno on breadboard.

- Taking into account that using more than one of each sensor means connecting these sensors in parallel.

#### C++ Arduino Code

Crafted code to interface with the ultrasonic sensor/accelerometer and Arduino, implementing necessary functionalities.

#### Integration

Mounting the sensor onto tracked vehicle, based on optimal locations and dynamics of tracked vehicle.

### Sensor Data Synchronization

Purpose:
Once data is collected it must be stored properly so it can be analyzed. Data is logged by multiple sensors. The goal of synchronization is to keep all of this data organized in one place.
Implementation:

- Data is currently being logged by an Arduino.
- Arduino can connect to the internet.
- Goal is to use Arduino code to organize the data and move it into Teamcenter (software for data organization).

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