Efficient and effective maintenance is crucial for all kind of industries. In the case of capital intensive investment industries such as petrochemicals, steel industry or power generation plants it is even more relevant and has an important impact in the operation costs during the long life cycle of their production means.

Besides the traditional maintenance problems of any industrial installation, this kind of facilities presents other additional challenging characteristics:

- **Huge number of elements to inspect**. Pipes, valves, switches, pumps, vessels, motors, vibrating machinery, chillers, ovens, etc.
- **Multiple inspection technologies to be used:** visual inspection (leaks, corrosion, paint condition, insulation condition, misalignments,...), thickness measurement (corrosion) mainly using Ultrasonic tests, vibration measurement, ultrasonic test, radiography, thermography, eddy current, noise analysis, gas sensors, etc.
- **Extensive production facilities**. This kind of plants spreads out for thousands of square meters, conducting pipes account for several tenths of kilometres and it is not infrequent to find several chimneys of high height.
- **Risky working conditions** for maintenance personnel due to the presence of hazardous materials (in case of inhalation or contact), high voltage elements and wires, need to work at height, etc.

Currently, the most common way to maintain equipments working properly is the implementation of a preventive maintenance plan. Many times maintenance tasks are supported by a previous inspection task of the equipment. But preventive maintenance or inspections have the same disadvantages: they are usually scheduled at fixed intervals and require a large number of material and human resources. The maintenance problem is addressed according to different criteria (not necessarily mutually exclusive):

- By **intensive human force employment** in inspection tasks. Due to the multiple technologies involved and the skills need to operate the measuring equipment, the above mentioned huge dimension of plants and the number of inspection points, Maintenance and Inspection services require employing a great amount of operators travelling along the plant.

- **Optimizing the frequency of inspection** based on previous experience. The intervals are usually set up by the manufacturers during the design phase, generally based on their intuition or on subjective estimations for the life expectancy of the different components. Due to the huge number of control points in the extensive production facilities it is necessary to optimize the maintenance/inspection frequencies looking for the balance between the failure

probability and the consequences of the failure. There are several methodologies to obtain an efficient and quality maintenance for all the equipments, but the most common one is to use the RCM (Reliability Centered Maintenance) process. This starts with an identification of the critical components by a product FMEA (Failure Modes and Effects Analysis) or by a Risk Assessment. As a rule, 20% of the components use to cause the 80% of the problems (Pareto). Therefore, once the critical components are identified, all the available historical data referring to their failures or events (not failures, but request for an intervention) is collected. With this information, the next step is to perform a statistical analysis to obtain the product life cycle curve. Maintenance/inspection intervals are optimized by adjusting the failure probability vs. the incurred cost of each task. In a more complex way, intervals can be optimized by modelling system behaviour and simulating different strategies of inspection/maintenance.

- **Deploying a huge number of sensors** (high cost) that allow continuous monitoring of some parameters. Those sensors have to be powered to operate (by wiring them or using batteries that have to be replaced from time to time) and different communication mechanisms can be used: logging the information and downloading periodically, wiring the sensors, deploying Wireless Sensor Networks (WSN) or incorporating other wireless communication means. In a large and complex plant, any stationary network of sensors will not provide a precise and effective detection and, in particular, localization of weak points such as hot or cold spots or leaks. Preventively installing sensors for pressure or leaking gas or a stationary camera at every place might eventually become impractical.

- Employing uncomfortable and sometimes expensive **Individual Protection Equipment** (gloves, safety helmets, gloves, suits, boots, masks, harnesses) and other transport and access devices (vehicles, cranes).

MAINBOT proposes using service robots **to autonomously execute inspection tasks in extensive industrial plants** in order to measure in-field parameters and detect degradation problems (faulty elements, corrosion and leakages, etc.) in equipment that are arranged **horizontally (using ground robots) or vertically (climbing robots).**

Disturbance handling is by nature unpredictable. Therefore, in general, this maintenance task is much more likely to require human-in-the-loop control. In order to define achievable goals in the timeframe of the project, we will **leave them out** of the scope of the project.

The operation of semi-autonomous or fully autonomous mobile robots will **increase the efficiency of the plant, reduce the operation and maintenance costs and improve safety**

and working conditions of workers

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Our approach is not to develop robots from scratch but to take available **wheeled mobile platforms and climbing robots**
that have already been tested in other related scenarios as starting point. However, due to the nature of the problems to be solved, it is necessary to adapt them, deploying innovative solutions in order to fulfill the industrial objectives.