ARGOS PROJECT

AUTONOMOUS ROBOTS FOR GAS AND OIL SITES

GROUND ROBOTICS

Towards Next-Generation Facilities

2023

TotalEnergies

GROUND

ROBOTICS

FOREWORD

One of the missions at TotalEnergies R&D is to pave the way for tomorrow's simpler, streamlined and more cost-effective facilities. Before the end of the decade, new oil and gas platforms could be operated by fleets of autonomous robots.

Their development and integration on our facilities are handled by the ARGOS* Project.

This booklet illustrates TotalEnergies' journey through ground robotics started in 2014.

ARGONAUTS
ARGOS Challenge Winner

TRACKER
Emergency Response Robot

INSPECTION ROBOT

OPERATION ROBOT

**ARGOS (Autonomous Robots for Gas & Oil Sites)*

EXPLORING THE FEASIBILITY & POTENTIAL OF GROUND ROBOTICS FOR OIL AND GAS APPLICATIONS *2014 - 2018*

ARGOS Challenge: an international open innovation competition

From the official launch in September 2014 in Paris, five international teams had three years to create the first autonomous surface robot designed especially for oil and gas production sites. Three competitions were organized in Lacq (France).

The team ARGONAUTS won the ARGOS Challenge in 2017, outperforming the other challengers with their robot during the third and final competition.

Competition 3
March 2017

World First: The first autonomous, ATEX* compliant, ground robot

Award Ceremony
May 2017

ARGONAUTS: Taurob (Austria) & Technische Universität Darmstadt (Germany)

**ATEX: ATmosphere EXplosive. This standard comes from the directive 1999/92 / EC set up by the European Union*

First trials on sites in 2018 with a teleoperated ATEX robot

GAS DETECTION CAMPAIGN LACQ - FRANCE
October 2018

Among the technologies tested during the gas detection campaign, the Tracker, a teleoperated ATEX robot, was able to approach and confirm a gas leak, while personnel stayed in a safe location.

TEMPA ROSSA ITALY
December 2018

On the occasion of the Tempa Rossa 4.0 Days in Southern Italy, the Tracker was presented to the local school and officials from the local and national authorities.

Children, who were very much in touch with new technologies, were excited to discover and operate the robot.

GREEN LIGHT FOR INDUSTRIALIZATION!

An anomaly detection, surveillance / emergency response robot

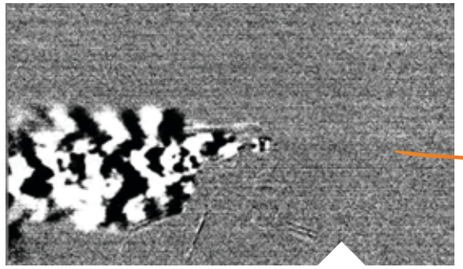
The inspection robot project started in 2018. The robot is ATEX certified and autonomous. It uses its sensors to perform many tasks such as anomaly detection (leaks, fire), collect images and audio data, monitor process parameters and 3D scans, etc.

This robot is now called the Taurob Inspector.

Tested using enhanced safety devices

Gas detection for safety and the reduction of greenhouse gas emissions are TotalEnergies' top priorities. Two extra gas detection systems based on visual and acoustic technologies were successfully tested and will be used in addition to the conventional gas detector already installed on the robot.

Acoustic gas leak detection at the top of a wellhead



Optical imaging of gas leak detection on top of a vent using a camera

FIRST EXTENSIVE TESTS ON AN INDUSTRIAL SITE

Shetland Gas Plant long-term test

Two inspection robots were deployed late 2020 for one year in one process module to perform operator rounds and to monitor process parameters autonomously.

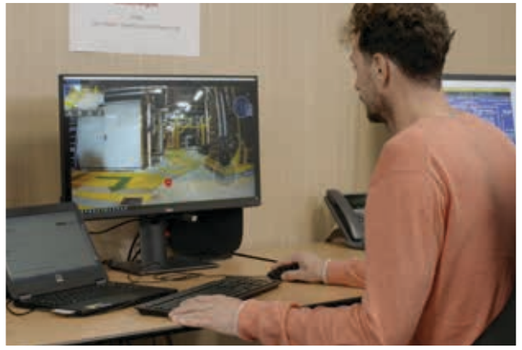
After one year of intensive testing and more than 1,000 autonomous missions, 100 km covered and hundreds of operating hours, the reliability rate reached 97%.

K5 COMPLEX, OFFSHORE NETHERLANDS

2020-2022: Three deployments already and many firsts

World's First: autonomous missions of an ATEX robot on an offshore Oil & Gas platform

In parallel of the Shetland Gas Plant endurance test, the inspection robot was tested in 2020 in a very challenging environment offshore North Sea.



A year later, another test campaign successfully demonstrated the possibility to guide two robots from the onshore control room to complete operator rounds in autonomous and teleoperated modes. The system architecture deployed enabled us to optimize remote operation techniques using TotalEnergies' private wireless connectivity (4G).

In 2022, a 6-month campaign was again started with the addition of a non-ATEX docking station on the site to allow continuous autonomous missions.

During this 2-year period, three versions of the inspection robots were tested on K5 Complex

2021 -2022 FIRST PILOTS IN THE MIDDLE EAST

ADNOC Offshore NASR field, Abu Dhabi

Having proved its reliability in the North Sea region, the inspection robot pursued its qualification program with a new series of tests outside Europe, starting with the Middle East Offshore Abu Dhabi.

Halul Island in Qatar

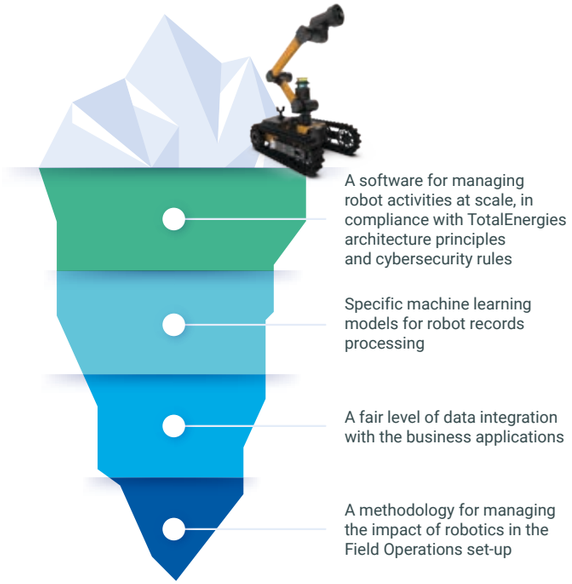
And a few months later Onshore in Qatar. The robot was confronted to a new type of environment with extreme heat and dust.

FIRST TIME IN OFFSHORE WEST AFRICA

PAZFLOR FPSO* – The most ambitious test campaign to date

A test campaign involving two inspector robots, considered as multiskilled resources was started in June 2023. Hence, they are assigned with a work program agreed with operations staff and supervised by a full-time robot operator. This ambition is supported by the first deployment of a new software, the Robot Supervision System, capable of managing the robot activities from end to end, at scale in the context of TotalEnergies business and Information Technology operations.

Even if the robot is the most apparent element of the robotics solution, it would be not possible to fully integrate it in the existing Field Operations organization and IT ecosystem without all the other components that were developed these past years.



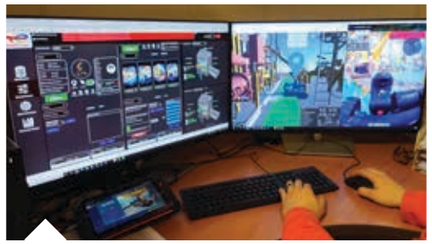
First inspections on Pazflor, July 2023

The Pazflor pilot with an expected duration of six months is our most challenging pilot so far. It includes many firsts with the deployment of two robots and two ATEX docking stations operated by site personnel. Nearly 1,700 checkpoints will be inspected regularly in two process modules with 5 decks each. The Robot Work Instructions will be coming directly from our maintenance planning tool that was modified for this purpose. The robots will also be out of their comfort zone with a first time offshore in West Africa.

Prior to the deployment, the whole solution was tested for months in our robotics lab in France.

Pazflor Robots and docking stations tested in our lab in France, winter/spring 2023

Arrival of the equipment on Pazflor, June 2023

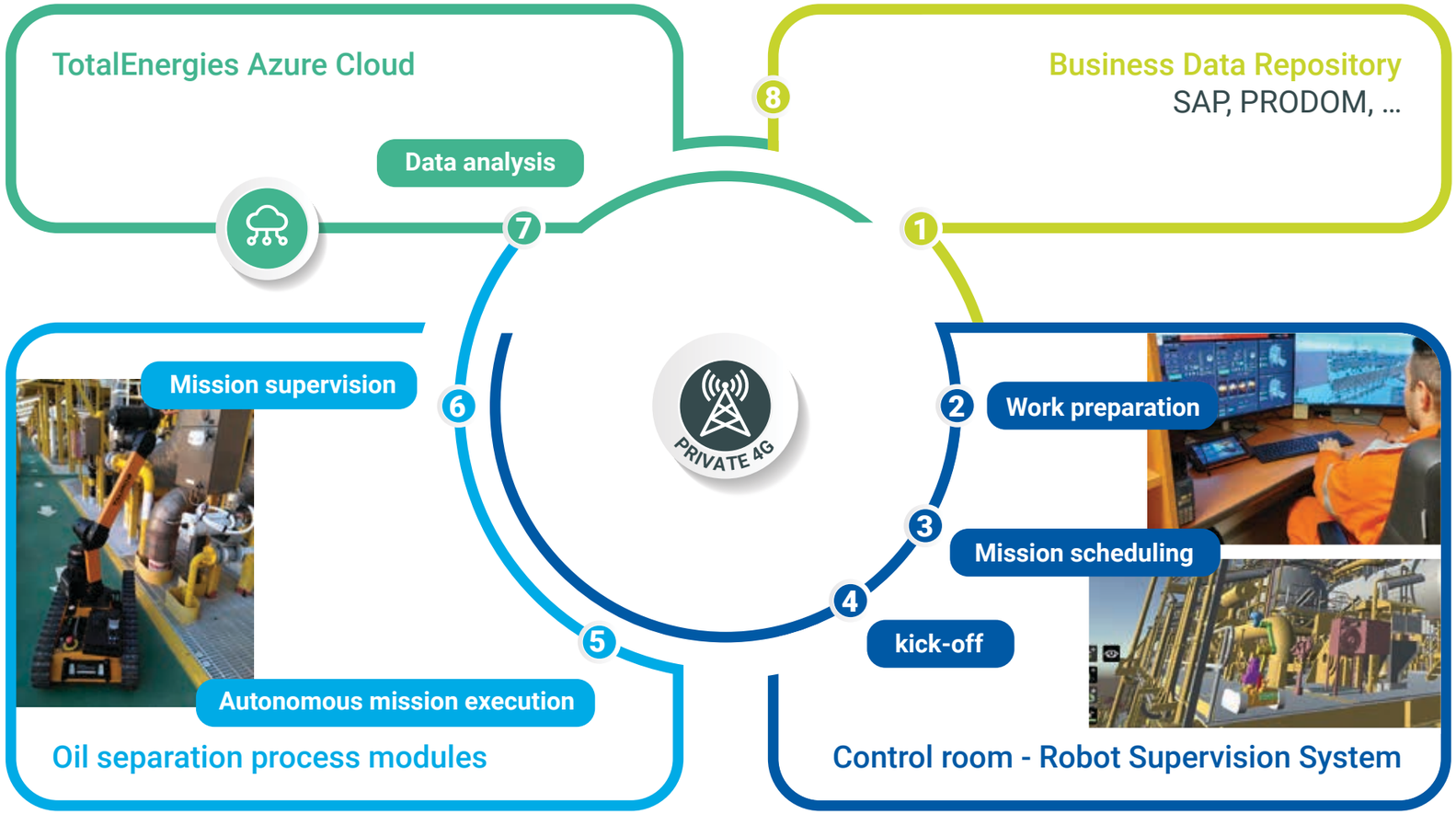


Robot Supervision System in Pazflor Control Room

** FPSO: Floating Production Storage and Offloading vessel*

PAZFLOR FPSO PILOT 2023
ROBOT OPERATOR EXPERIENCE

Robotics Solution Fully integrated in the existing Field Operations & Information Technology ecosystems



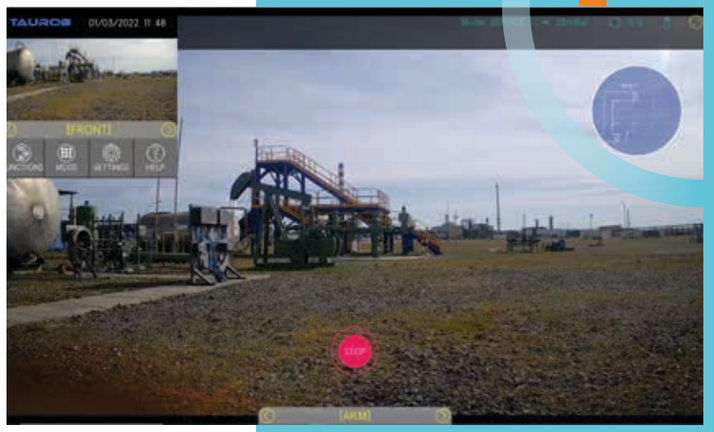
1. Asset breakdown and planned maintenance data are converted into Robot Work Instructions
2. Robot operator defines the robot parameters pertaining to the RWI
3. RWI are split and grouped into missions
4. Mission is launched
5. The robot passes nearby measurement points and records the parameters as per the work program
6. Robot live video stream and self diagnosis are key components of the remote supervision
7. Robot made records are processed by dedicated algorithms
8. Processed data are made available to the business thru the ad-hoc applications

ROBOTICS DEVELOPMENT PLATFORM LACQ, FRANCE

This open-air lab inaugurated in 2019, and part of TADI®*, is a key element for the integration of the robots in our future operating philosophy.

This specifically designed obstacle course site can be used for training, commissioning, testing robots, and experimenting with new facility designs.

** TADI: TotalEnergies Anomaly Detection Initiative*

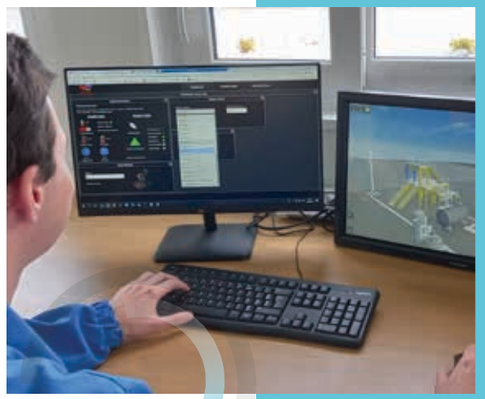


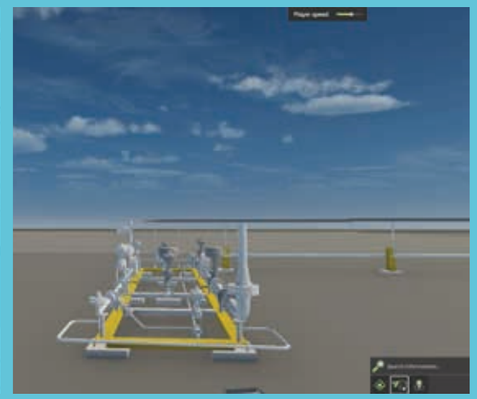
TADI 2021-2023, LACQ FRANCE

Focus on integrating the robots into the TotalEnergies system architecture

TADI is used as a sandbox environment for the development of a specific Robot Supervision System (also considered as a fleet management system) to improve access to data, and manage several different robots with specific Human-Machine Interfaces, all requiring connections to TotalEnergies' system architecture.

After extensive preliminary tests, the solution was later pilot-tested in the Netherlands and deployed in Angola.





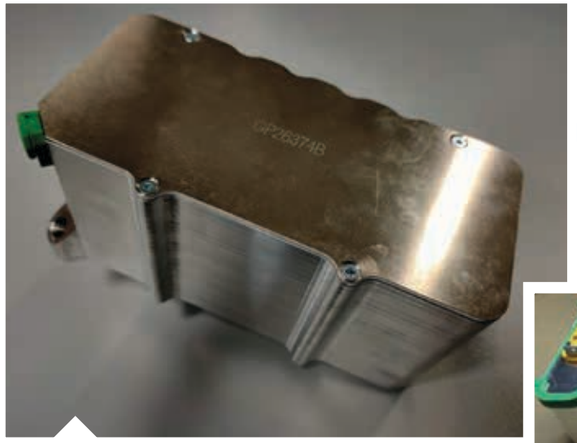
ARGOS JOINT INDUSTRY PROJECT

A robot for simple operations

Thanks to its heavy-duty arm, the Operator Robot will be able to handle simple operations such as turning large manual valves.

More generally, the objective for the Operator Robot is to operate a low complexity production site like a wellhead platform or a well pad.

The Operator Robot will do its first steps in TADI during fall 2023.



One of the battery's power strings

Lithium-ion power cells

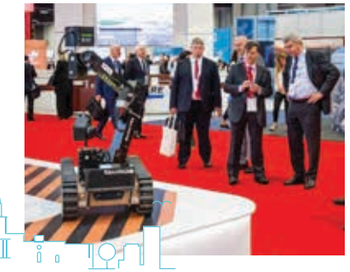
ATEX Certified Lithium-ion Battery

This battery developed by Saft Space & Defense is the first of its kind. As well as complying with the highest safety standards, its outstanding technical performance will expand the range of possibilities for robotic operations.

Battery Management System circuit board

INTERNATIONAL EXHIBITIONS

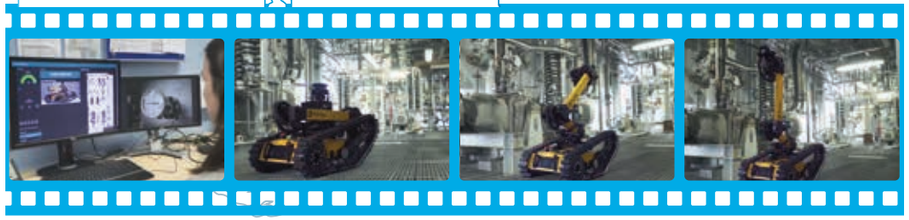
Ever since the end of the ARGOS Challenge, robots developed by TotalEnergies have been presented at many exhibitions around the world, attracting a lot of interest as part of operations of the future.



World Gas Conference in Washington
June 2018

SPE Offshore Europe Conference & Exhibition in Aberdeen
September 2019

TotalEnergies Investors' Day in Aberdeen
February 2020



Live robot operations from Shetland Gas Plant watched by TotalEnergies Investors located in Aberdeen.

Abu Dhabi International Petroleum Exhibition & Conference
November 2017

His Highness Sheikh Hazza bin Zayed Al Nahyan, Deputy Chairman of Abu Dhabi Executive Council with Patrick Pouyanné, Chairman & CEO TotalEnergies.

European Association of Geoscientists & Engineers Amsterdam
October 2021

Angola Oil & Gas
September 2023

Abu Dhabi International Petroleum Exhibition & Conference
November 2019

His Excellency Mohammad Sanusi Barkindo OPEC Secretary General.

Abu Dhabi International Petroleum Exhibition & Conference
November 2021

SHETLAND GAS PLANT
United Kingdom

EQUINOR

NZTC

K5 - COMPLEX PLATFORM
Netherlands

TotalEnergies

SAFT

TAUROB

ROBOTICS DEVELOPMENT PLATFORM
Lacq, France

TEMPA ROSSA
Italy

HALUL ISLAND
Qatar

ADNOC OFFSHORE
Abu Dhabi

ADNOC

PAZFLOR
Angola

PETROBRAS

TEST SITES

JIP PARTNERS

WHAT'S NEXT?

Many more world firsts to come!

Based on the success of the past years, TotalEnergies is involved in the development of different types of robots.

The first one is the inspection robot for anomaly detection. Since 2020, an ambitious testing program has been initiated to industrialize and qualify the robot on numerous sites with different environment conditions, onshore and offshore, starting from the North Sea, to the Middle East and now West Africa.

The adventure also continues with the development of the operator robot as part of the ARGOS JIP.

This project is borne by a partnership with ADNOC, Equinor, Petrobras, Taurob, Saft. Space & Defense for the batteries and NZTC (Net Zero Technology Center) in Aberdeen, who have provided constant support since the development of the inspection robot project.

This second robot is dedicated to simple operations. The prototype is being finalized, and first tests will start during Autumn 2023 in France.

ARGOS Challenge — 2014 ... 2017

Inspection Robot Project — 2018 2019

ARGOS JIP — 2020 2021 2022 2023 2024 2025

World First ATEX Autonomous ground robot

Surveillance / Emergency Response industrial grade robot

Simple manipulation capabilities for operational purpose

Autonomous - ATEX - Water Resistant - Mobile - Multipurpose - Remotely Monitored - 24/7 Service

CREDITS

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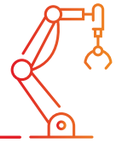
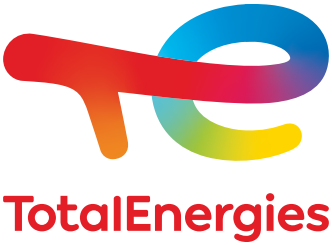


ROBOTICS



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