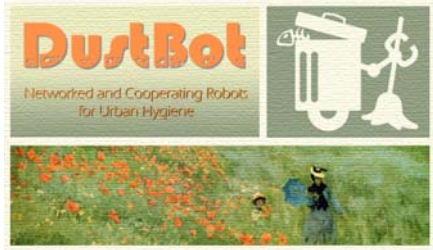
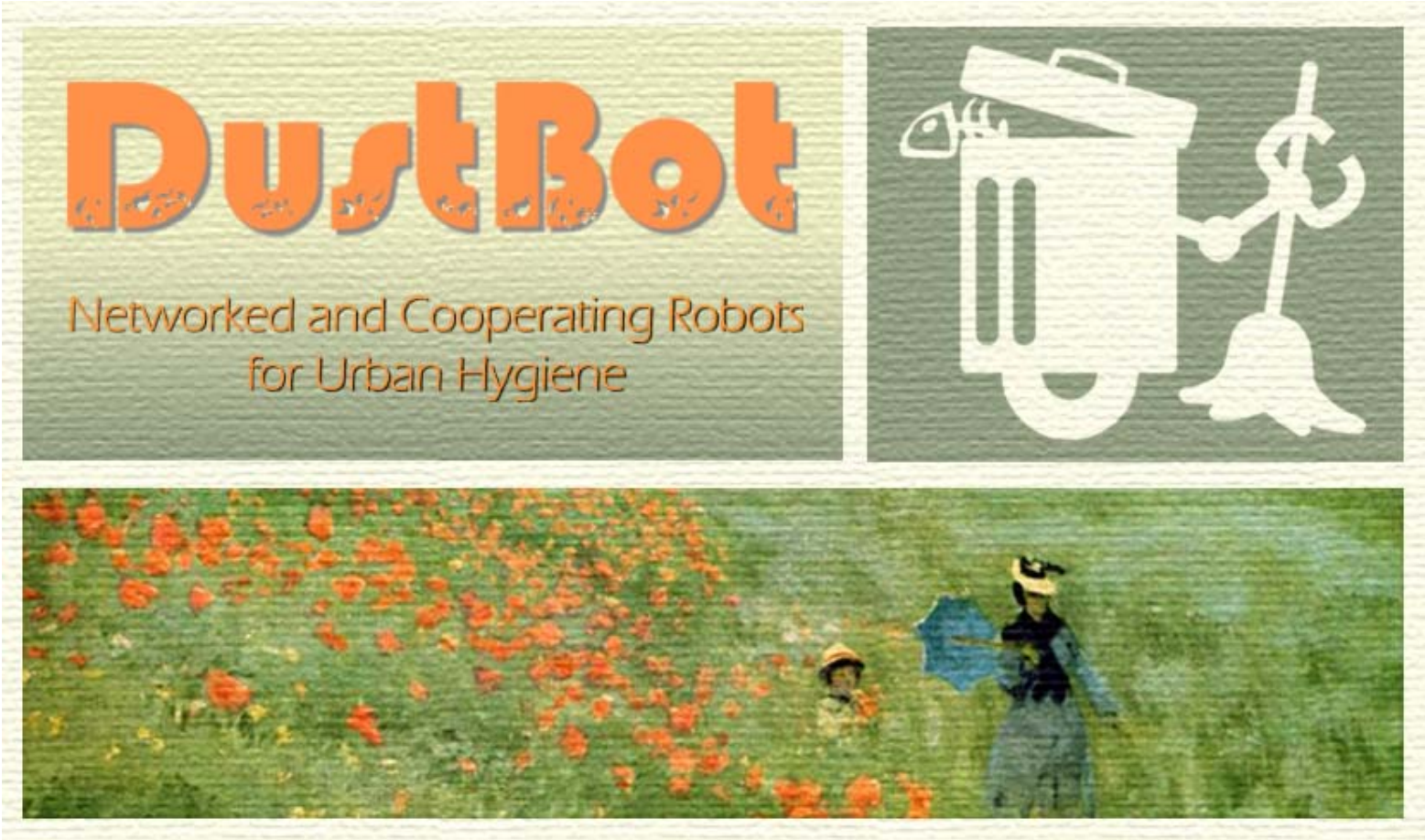
Specific Targeted Research Project
IST call 6
FP6-2005-IST-6





Project Reference Number: FP6 - 045299

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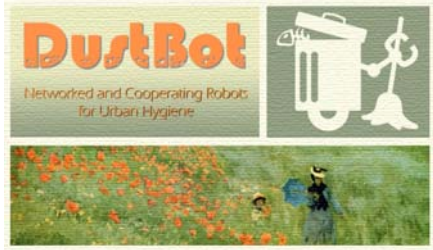
Project Information



Project acronym: *Dustbot*

Project title: *Networked and Cooperating Robots for Urban Hygiene*

Start date: *December 1, 2006*

Project duration: *36 months*

Activities codes: *IST call 6 - FP6-2005-IST-6*

Project cost: *2.822.600 €*

EC contribution: *1.898.000 €*

Coordinator organization: *Scuola Superiore Sant'Anna*

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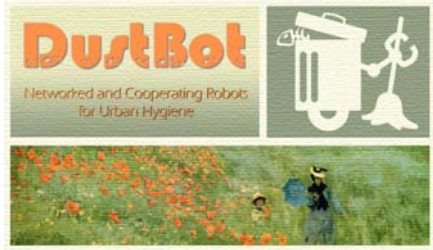
DustBot Consortium

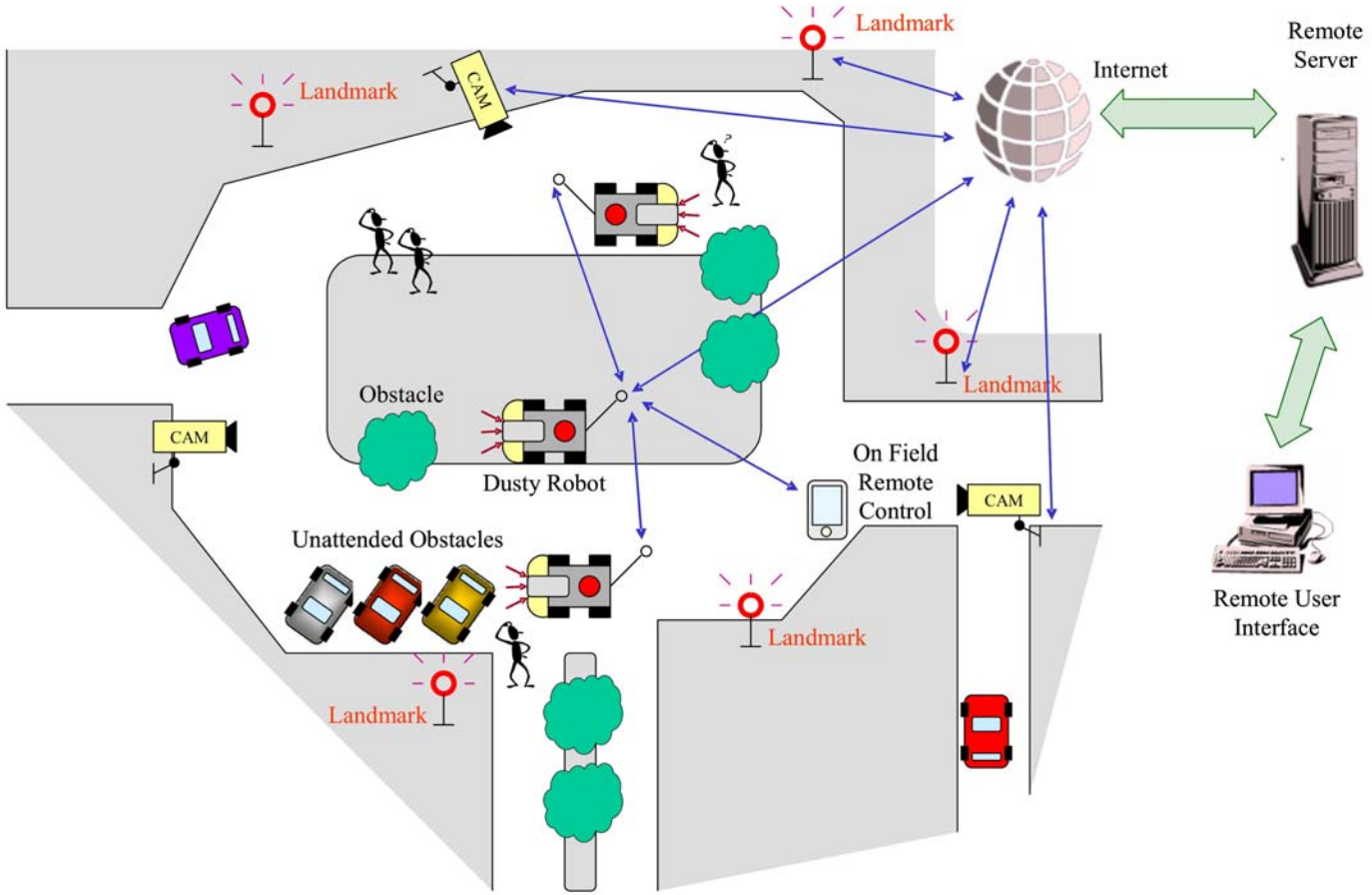


*The DustBot project involves **nine** partners from **five** European countries:*
***Italy, Germany, Spain, Sweden, Switzerland and United Kingdom**.*

Partner organisation name and principal investigator (P.I.)	Acronym	Country
Scuola Superiore Sant'Anna – Pisa *Prof. Paolo Dario*	SSSA	
RoboTech s.r.l. – La Spezia *Dr. Nicola Canelli*	RT	
Multidisciplinary Institute for Developments Researches and Applications – Firenze *Prof. Romano Fantacci*	MIDRA	
Synapsis s.r.l.– Livorno *Dr. Riccardo Fontanelli*	SYNAP	
Örebro University – Örebro *Dr. Achim Lilienthal*	AASS	
HW Communication Ltd – Lancaster *Dr. David Lund*	HWC	
Robotiker Inmotion – Bizkaia *Dr. Arantxa Renteria*	Robotiker	
Lucerne School of Engineering and Architecture – Lucerne *Prof. Dr. René Hüsler*	HTA	
Haute Ecole d'Ingénieur et de Gestion - Yverdon-les-Bains *Prof. Stephan Robert*	HEIG-VD	

DustBot Objectives

The DustBot project is aimed at designing, developing and testing a system for improving the management of urban hygiene, based on a network of autonomous and cooperating robots, embedded in an Ambient Intelligence infrastructure.

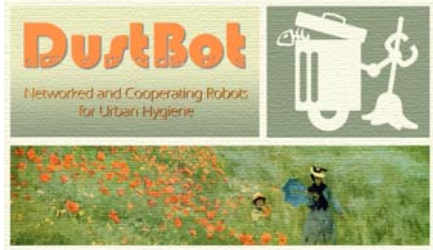


Faced Problems

1. Garbage collection in historical urban centers with small streets (not easy to reach by traditional public vehicles for waste removal).
2. Garbage collection house-to-house in historical urban centers
3. Air quality monitoring in pedestrial areas.




The DustBot System



The DustBot system is composed by:

→ **2 typologies of Robot** with different functionalities

→ A **Wireless Sensor Network** and fixed **cameras** for robot management and security monitoring

→ **Environmental sensors** for the air quality monitoring

DustBot System Architecture

High Level User Interface

High Level Functionalities:
- Tasks management
- Work scheduler
- Data presentation
- System configuration
- All level diagnostic
- Alerting and Assistance services

AmI Core

Bin liner collection and transport service software (for Dust-Cart Robot):
- Web based Registration
- User call management
- Bin liner transport scheduler

AmI Bus - XML Based Protocol

Protocol Handler (**PH**)

Task Planning / Robot Allocation (Path Pre-Planning)

External Cam Image processing

AmI Software Infrastructure

Unlimited (UMTS, GPRS,GSM, EDGE, WiFi)

XML Based Protocol

Unlimited (UMTS, GPRS,GSM, EDGE, WiFi)

XML Based Protocol

ZigBee

Blue-tooth

Robot

Unlimited GW

ZigBee Module: Robot-WSN Interaction

Cam

Blue-tooth (RS232)

PMCIA

RS232

USB

RS232

SUPERVISOR (PC):
- Path Planning
- Path following
- Sub Module Management

User Interface

Magnetic Compass

Inertial Platform

GPS

Odometry

ZigBee Module: Localization Support

Landmark System

Localization Sensor Module

Proximity sensors

Laser Scanner

Obstacle Avoidance Module

Air Monitoring Module

PnP Air Quality Sensors

CAN BUS

Actuators: Tools

Low level Locomtion controller

Low Level Obstacle Avoidance Module

Proximity sensors

Actuator: Locomotion

Stand-Alone Remote Control

Basic Functionalities:
Low level control (locomotion, tools)
- Debugging
- Diagnostic

Localization system based on ultrasonic beacons integrated on WSN

ZigBee Module

Beacon

ZigBee Module

Sensor

ZigBee Module

Actuator

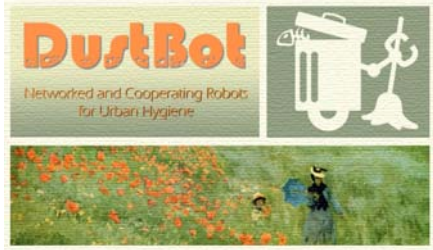
ZigBee Module

Unlimited GW)

Cam

In Filed WSN (Sensors, Actuators and Beacons)

DustClean and DustCart Robots

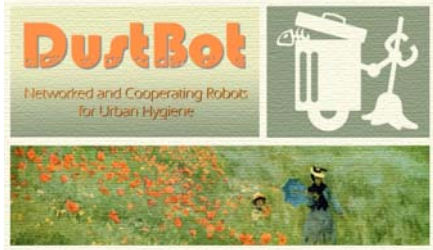


Two different kind of robots will be developed and tested on the basis of functions that they will accomplish: ***the cleaning robot and the citizen-friendly / dust-cart robot****. The robot structure will be designed as a highly modular system (robots will have several common subsystems).*

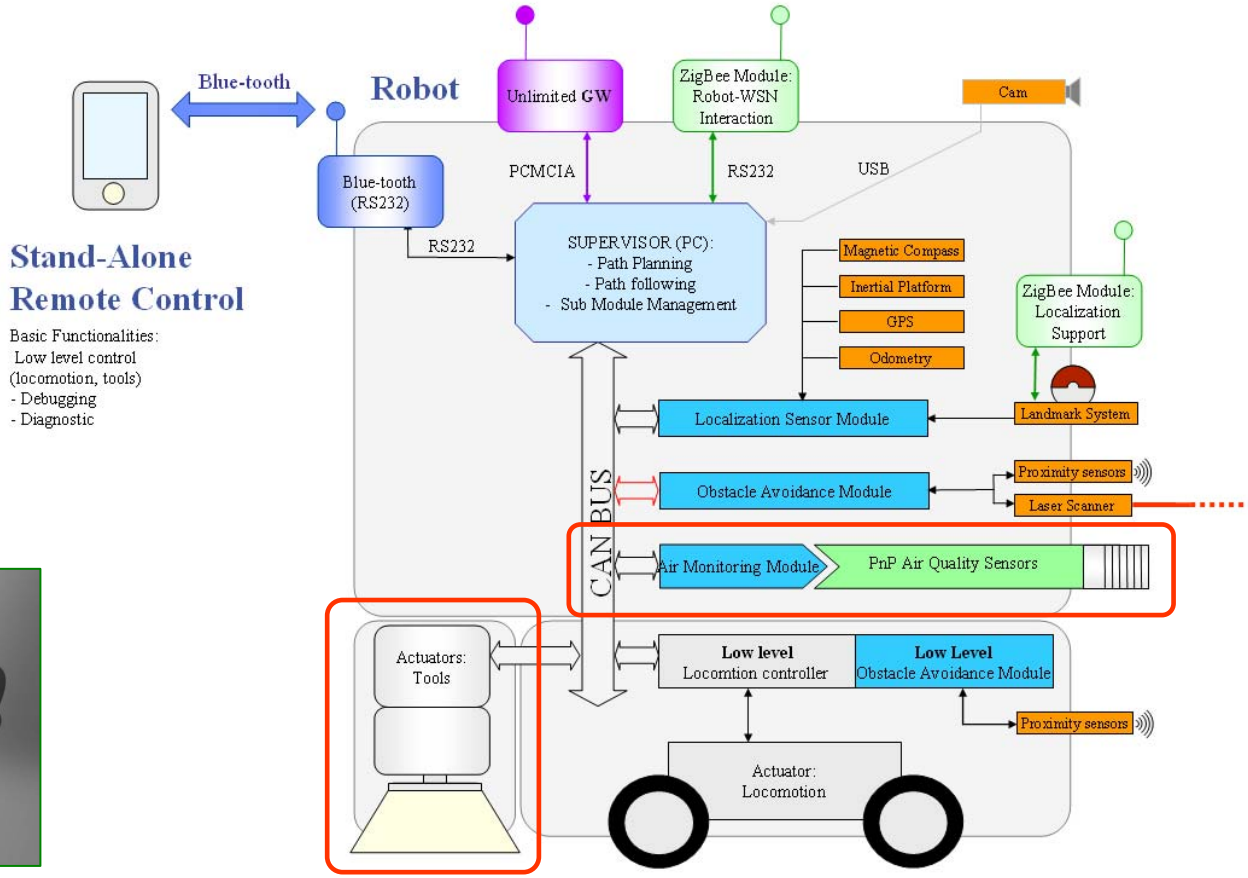
DustClean Robot

DustCart Robot

DustClean Robot

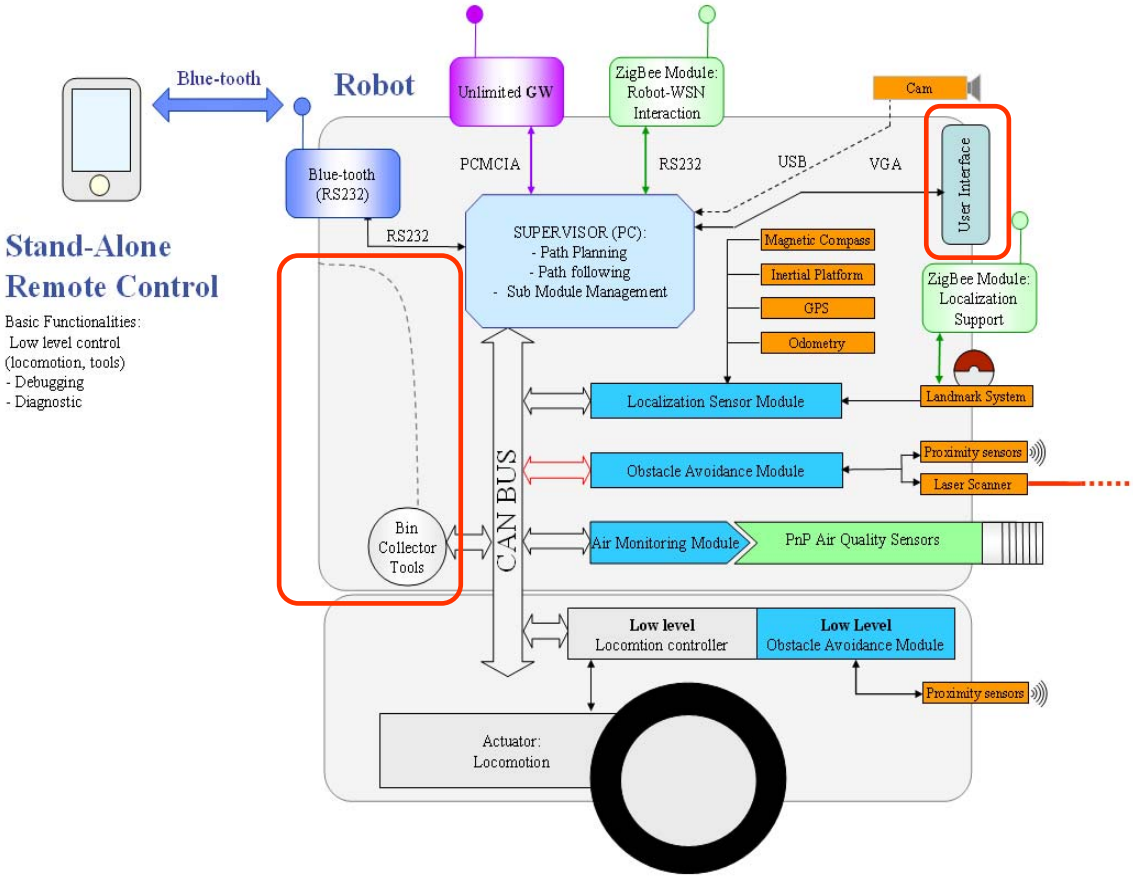


This robot will be mainly devoted to the cleaning of pedestrian streets, squares, parks and pedestrian areas. It will be equipped with ***brushes and a vacuum-cleaning tool*** *for the collection of waste and ground cleaning. In addition to the cleaning functions, this kind of robot will be also equipped with* ***environmental sensors*** *for monitoring pollutant levels.*



DustCart robot

This type of robot will provide feedback to human actors (pedestrians, decision makers, e.g. municipality managers, etc.) and/or robotic operators, in order to perform actions. These robots will be characterised by a ***friendly aspect****, and will be equipped with a suitable* ***human machine interface*** *(like touch-screen displays/speech recognition and synthesis). This robot will serve also for the* ***rubbish collection of citizen bin liners*** *and it will be equipped with a dust-cart for bin liner transport and automatic discharge.*



DustCart robot

Approach:

Customization of the Segway Robot Mobility Platform (RMP) for implementing the DustCart robot.

Speed	0 – 10 mph / 1 – 16 kph	**Stabilization**	Dynamic
Range	12 – 15 miles / 19 – 24 km	**Weight**	140 lbs / 64 kg
Dimensions	25" x 29.5" x 24" / 64 x 75 x 61 cm		

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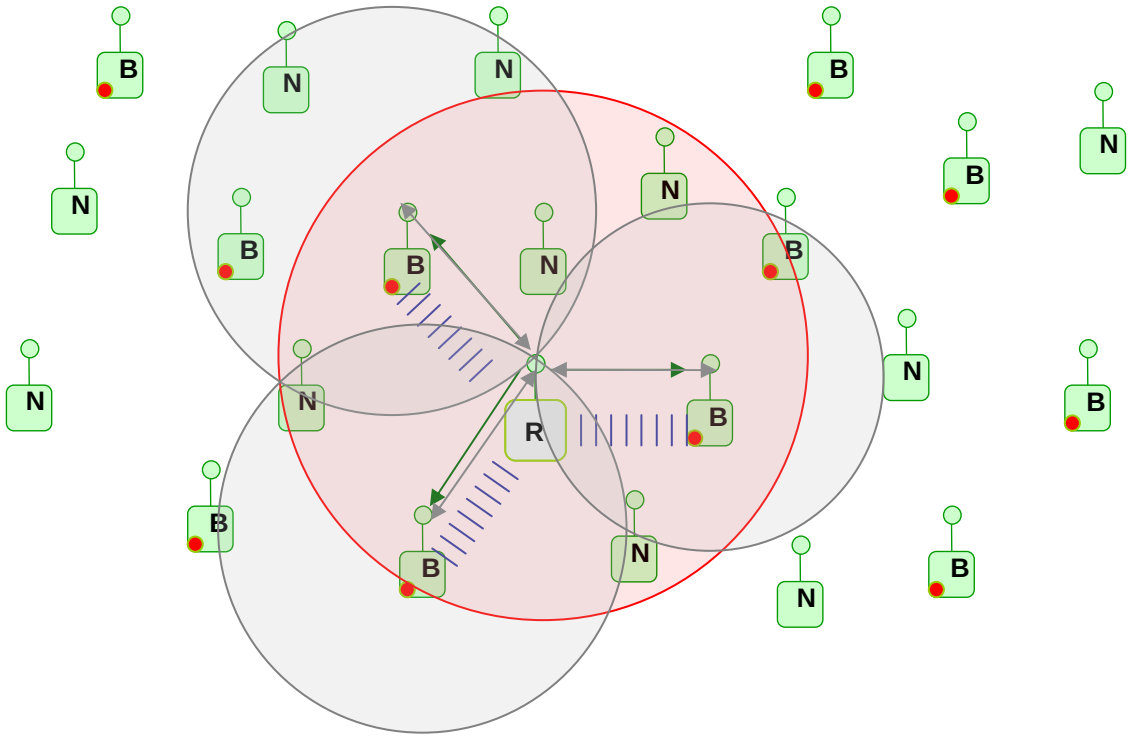
Localization strategy

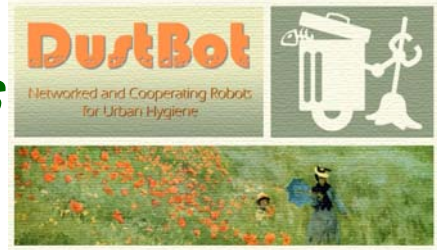
The robots will interact with the WSN as a "special" node. The interaction should be used by the robot (and by the WSN) to evaluate the rough position of the robot itself (i.e. by using transmitting power). This evaluation is made with every type of node. After rough estimation of position the Robot interact directly with the nearest Beacons node to evaluate more precisely its own position. Beacons will be based on ultrasound time-of-flight ranging.

R = Robot B = Beacon N = Other Wireless Node



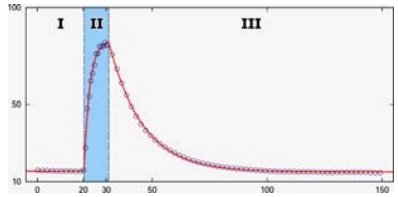
- Rough evaluation of position by using RF signal strength
- Selection of nearest ultrasonic beacons
- Use of RF communication for ultrasound triggering – Time of
- Measurement of ultrasound Time of Flight
- Evaluation of Robot-Beacons distances
- Triangulation: Robot Self-Localization

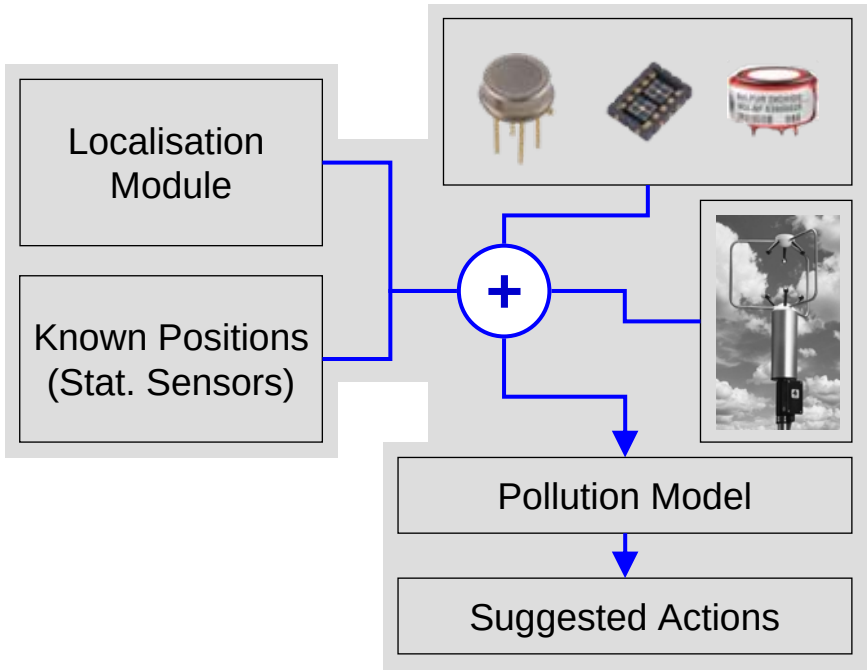
Environmental Monitoring Sensors



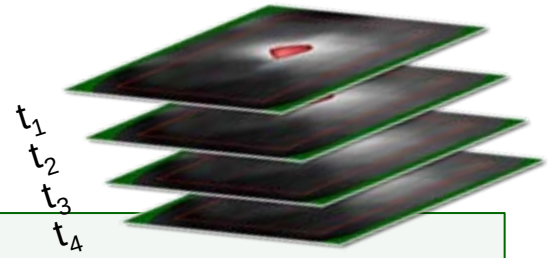
Objectives: *To make the robots like mobile stations for the environmental monitoring of the road or square that are under the robots control. Large use in different places of these robots will permit the mapping of pollution distribution.*

Atmospheric pollutants affecting cities
NOx, CO, O_3, SO_2, Micro Particulate



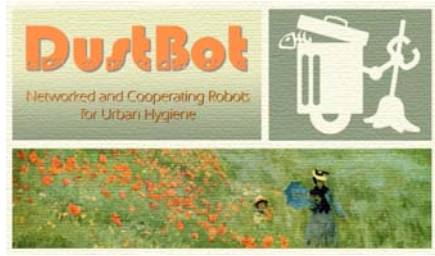


Environmental sensors integration (PnP sensor interface modules)



Pollution distribution modeling module

Designing the acceptability of the DustBot robots



Acceptability is a key factor for the DustBot robots, as we want them applied in real-world scenarios

Acceptability of robots is not easy…

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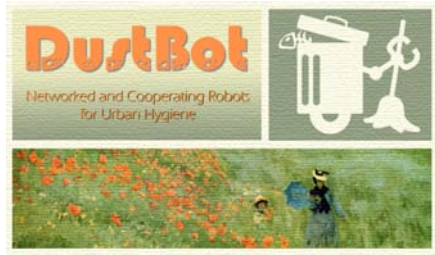
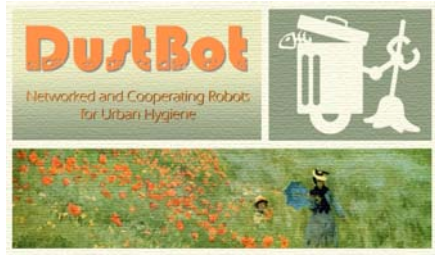
Designing the acceptability of the DustBot robots



Main factors for acceptability:

- Usefulness → **DustBot User Group**
- Effectiveness → **DustBot specifications**
- Appearance → **Industrial design**
- Human-robot interaction → **Design of the metaphor and user interface(s)**

Final integration and testing of the DustBot Robots



- Tasks to be performed and evaluated:
  - *remove waste from the ground*
  - *vacuum clean the ground*
  - *wash and disinfect the ground*
  - *patrol an area and acquire information on air quality*
  - *collect and transport bin liners to the garbage station*

Operative Scenario
DustClean

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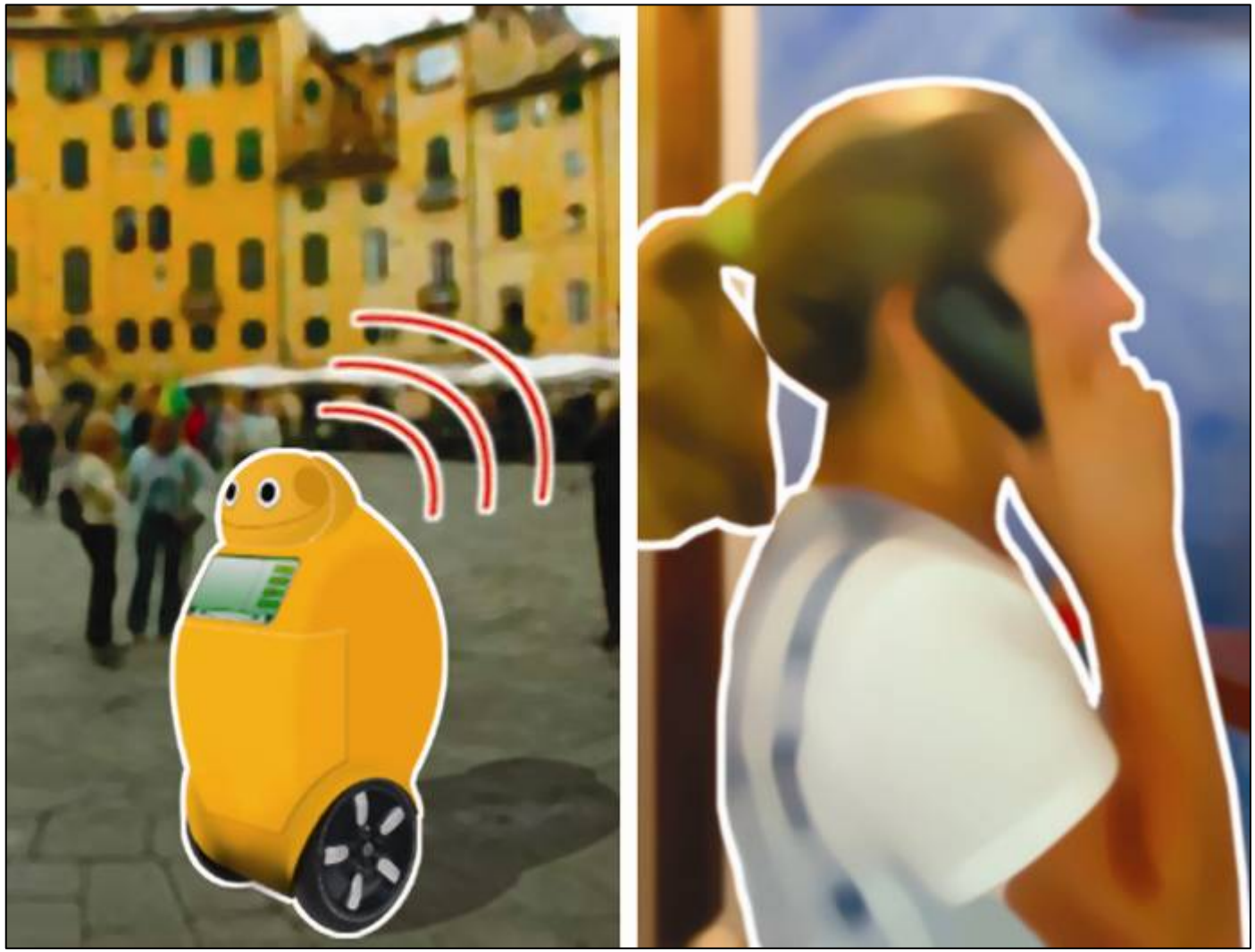
Operative Scenario
DustCart (1)

Operative Scenario
DustCart (2)



Operative Scenario
DustCart (3)

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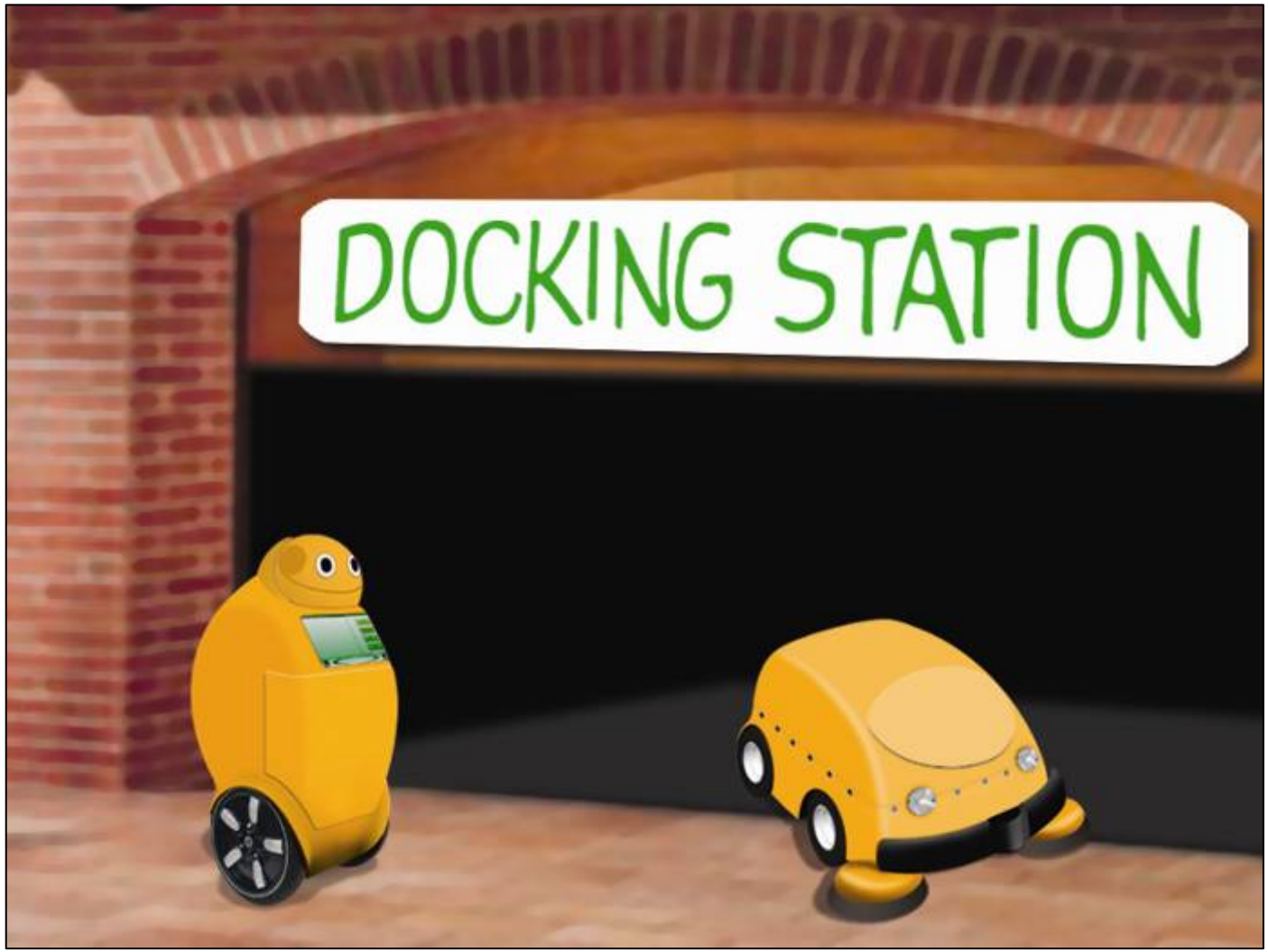
Operative Scenario
DustCart (4)

Operative Scenario
DustCart (5)

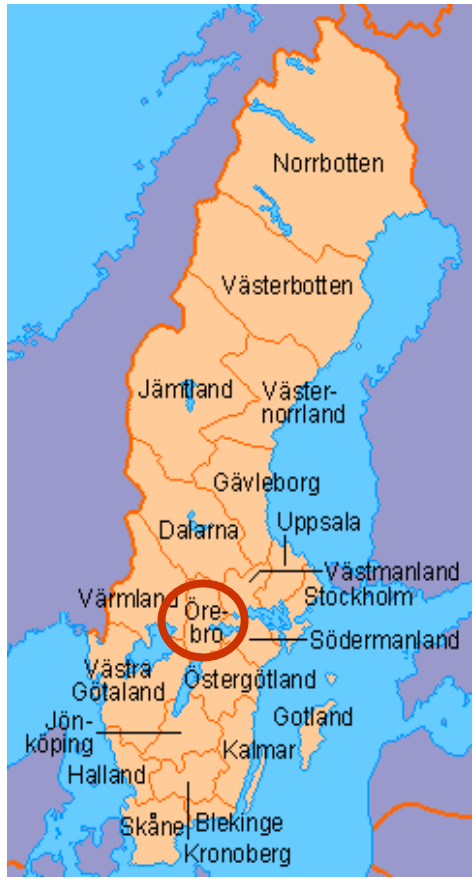
Operative Scenario
Docking Station



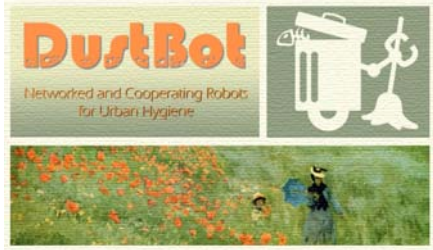
The DustBot Demonstrators

Five demonstrators will be set up in real operational scenarios during the last eight months in order to demonstrate the functionality of the DustBot platform:

- Demonstration in **Massa**, Italy (March 2009, SSSA)
- Demonstration in **Bilbao**, Spain (June 2009, Robotiker)
- Demonstration in **Örebro**, Sweden (July 2009, ORU)
- Demonstration in **Peccioli**, Italy (August 2009, RT)
- Demonstration in **Pontedera**, Italy (September 2009, SSSA)



DustBot Potential Impact



Urban environment preservation and monitoring:

- removing of waste from urban areas, increasing hygiene;
- monitoring of the air quality by using embedded sensors.

Risk prevention:

- improvement of worker security, avoiding their contact with hazardous wastes.

Social services:

- collection of home garbage on demand, particularly useful for elderly people.

Safeguard of citizens' health:

- reduction of thin dusts (PM10, or less in Ø), removing often waste from the streets;
- cleaning and disinfection of the streets.

Economic impact for the community:

- reduction of the personnel cost, economic benefit for municipal authorities;
- professional re-qualification of the human capital.

Economic Impact for the ICT and Robotics Industry:

- SMEs are involved in the project for improving competitiveness in the ICT and Robotics sectors.