



## What we offer

### Potential producers of the robot:

- Licence for service robot production,
- Cooperation on starting serial production of the robot,
- Cooperation on the research and development of purpose-made superstructures.

### Potential users:

- A perspective system for glass-façade cleaning (for designers),
- Cooperation on the development of "system superstructures" to make buildings suitable for robotic cleaning,
- A system for the surface integrity inspection of specific devices (e.g. pressure vessels).

### Producers of cleaning devices:

- Cooperation on installing cleaning modules into the superstructure of the service robot (shared know-how).

### Producers of inspection machines:

- A mobile platform for moving inspection machines on vertical façades,
- Cooperation on implementing other inspection systems,
- Cooperation on developing software for detecting physical conditions of various surfaces.

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## Research on the Top

### New Technologies and Special Machine Components

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# ROBOTS TO BE USED FOR MOVEMENT ON VERTICAL WALLS



## Mobile platform applications for inspection and technological tasks

Construction of high-rise buildings with façades made of protective flat glass fixed to supporting grids is a contemporary trend in modern architecture. There has been a long-term increase in the demand for devices and new technologies enabling users to deal effectively with problems concerning cleaning, inspection, installation and other service applications. Inspection of the potential surface disruptions of large pressure vessels is just one of many examples.

A number of service robots or, more precisely, mobile platforms with different movement characteristics as well as various abilities to deal with surface height differences have been developed recently. The design of their holding system is the main difficulty. This system must be able to resist adverse operational conditions. There are two substantial problems: the effect of gravity caused by the vertical position of the device on the wall and the variable nature of the friction ratio of the surface which the device is operating on. Supporting elements mounted on glass façades, interspaces between individual glass façade parts and the state of the particular façade surface given by damp and varying degrees of dirt also have adverse effects. The system must also be endowed with sufficient load capacity for the technology or inspection superstructure.

The ROBOTUL Vertical Climber 02 is a service robot which has been developed by the Technical University of Liberec. It is able to deal with movement on smooth or structured surfaces in a unique way while offering high stability of the path. It is able to rotate without any trouble and is able to surmount surface discontinuities and assembly holes. It is able to move very safely on vertical as well as negative-angled surfaces and has a relatively high effective load capacity.

In combination with technological superstructures, the ROBOTUL Vertical Climber 02 is intended for façade washing and cleaning or for performing inspection tasks, such as supervision of the state of the façade at points where glass is fixed to the surface, or checking for potential surface disruptions of pressure vessels made of rust-resistant steel.

The mobile platform of the service robot has undergone several stages of development, comprising the designs of kinematics, drives and holding system, including control system procedures, communication and determination of its level of autonomy.

The first version of the mobile platform was tested in a laboratory and presented to the public in 2008. Positive test results revealed that the chosen concept of the device's mechanics based on the principle of two parallelograms provides the device with sufficient movement functions and the ability to surmount non-homogenous surfaces with small height inequalities, which are eliminated by flexible mounting of the suckers.

The second generation of the ROBOTUL Vertical Climber 02 consists of

a compact duraluminium frame connected to its rotary undercarriage by a rotating servo-drive. These elements constitute the body of the robot. The rotary undercarriage is mounted with articulated active suckers. It is possible to set the distribution of the suckers according to the character of the particular surface geometry, e.g. a façade system. The frame of the service robot is connected to four legs by means of versatile latches. The legs are also equipped with suckers and an individual electric rotatory servo-drive. The ROBOTUL Vertical Climber 02 is equipped with a number of intelligent sensors used to identify its current position in space. Drive control is conducted by an advanced control system based on a compact industrial computer platform to which input and output modules, a module for temperature measurement and a unit for wireless communication are added.

The presented device falls into the category of semi-automatic systems with partial autonomy. It is intended to be used with other technologies such as low-weight cleaning devices for dry cleaning, cleaning with a minimum cleaning liquid consumption and applications for inspection devices.

### Technical parameters of the design prototype ROBOTUL® Vertical Climber 02:

- Dimensions: 1120 × 1120 × 300 mm,
- Weight of the mobile platform itself: 48 kg,
- Useful load (according to the type of superstructure): 15 – 20 kg,
- Working width of subsequent technology: 800 – 1200 mm,
- Working speed: 0.8 – 1.2 m / min,
- Cleaning surface output: 60 – 80 m<sup>2</sup> / h,
- Inspected surface output: 30 – 90 m<sup>2</sup> / h.



1 2

1 – Superstructure for camera-assisted inspection tasks

2 – Technological superstructure for cleaning façades made of glass

Two types of superstructures are being developed for the ROBOTUL® Vertical Climber 02. One is intended for camera-assisted inspection tasks and the other is a technological superstructure for cleaning building façades made of glass.

The low-weight cleaning superstructure for dry cleaning and the technology for minimum cleaning liquid consumption are both being developed with the intention of ensuring maximum cleaning output and minimum energy consumption.

Inspection is ensured by two HD cameras which enable the monitoring of the state of the observed surface.

In the long term, the Technical University of Liberec has been developing a system of image analysis which, when connected to a computer, is able to analyse images on-line when the device is in operation. It is possible to implement the image analysis system into the ROBOTUL® Vertical Climber 02 inspection system.