# HI MOBILITY LOCOMOTION SYSTEMS AND BOARD MANIPULATORS FOR NUCLEAR ROBOTS APPLICATION

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ABSTRACT

The authors examine the experience in the design, manufacture and testing of mobility systems and manipulators for special robots. This is a known six-wheeled robot Special Transport Robot with a mass of about 1000 kg, developed on the basis of progress on the chassis of Lunokhod-1,-2. STR have been used successfully on the roof of the station during the liquidation of consequences of accident on Chernobyl Nuclear Station in 1986. Presented modifications of this robot, developed in 2000-2010.

It also covers the new generation robots weighing up to 200 kg designed by RCL for 2013-2016: crawler robot with variable geometry chassis that can move inside and on a flight of stairs and wheeled-walking robot, which can be applied after the fire at the station.

The authors make a detailed review of the project completed in 2013-2014 in the framework of international cooperation with China. One of such robots (mobile system of 100 kg and six-hinge-on-board-manipulator of 20 kg) was designed and manufactured jointly in collaboration with China North Vehicle Research Institute (Beijing, China).

## 1. INTRODUCTION

In 1986 the accident at the Chernobyl Nuclear Station there was an urgent need in creation of technological machinery, capable of either remote control to work on rubble removal in conditions of high radioactivity. The specialists of "VNII Transmash" within two months was made the robot STR-1 (figure 1), which was used to clear the roof of the emergency power unit of nuclear station.

STR-1 created on the basis of backlog in the development and production of "Moonwalker-1, 2" [1, 2] and other layouts planetokhods. STR-1 has a mass of 1000 kg, six motor wheels attached to the frame with torsion bar suspension. Roll is rotation on the spot due to the opposite rotation of the wheels on the sides.Special equipment installed TV cameras, radiation-measuring equipment, dozer blade [2,3]. Key features STR-1 is given in e.g. the book [2]. In addition to the STR-1 in the robotic system consisted of a device for delivery on the roof; stationary observation TV cameras on masts; remote control radio; wall charger; equipment for decontamination of the robot.

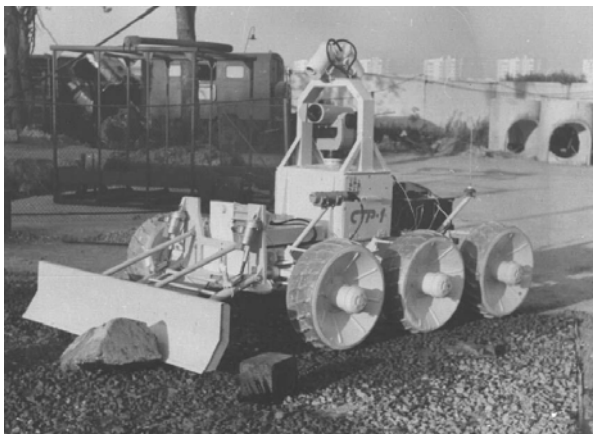

Figure 1. Robot STR-1 on a wheeled chassis 1986

STR-1 achieved its objectives. Based on it was made the robot STR-1 and STR-2M adapted to other types of work. Operation the STR-1 has not only

revealed weaknesses in control systems and communication systems. Itself to use as a basis the chassis of the lunar Rover from the point of view of sustainable performance of the machine is not optimal. The path of further modernization of the STR-1 allowed to only resolve operational problems. For a robot, designed to work in extreme conditions, the consequences of accidents at nuclear station required the construction of special chassis. Actual directions of development the chassis of the robotic systems designed to work on a nuclear station are:

- increasing the duration of autonomous work;
- the creation of structures that facilitate decontamination machine;
- increased mobility of the chassis in terms of the built environment, including after the fires, in the presence of blockages, etc.;
- the creation of specialized transport-technological chassis, to perform a narrow range of tasks.

The aim of this work is to highlight the achievements of the RCL in these directions.

## 2. PROPOSED SYSTEM

One of directions of modernization of the STR-1 was the development of a special manipulator. The presence of the manipulator allowed the machine to work on debris clearing, if necessary, to perform the transport function. The installation of the manipulator did chassis STR-1 is more versatile, such a solution remained and was used in subsequent developments of "VNII Transmash" and RCL [3].

A large mass of STR-1 was justified by the need to ensure the hitch weight to operate the dozer blade. However, the coupling weight can be obtained if necessary with the help of bolasterone, and the car is running on the roofs of buildings and inside the premises should be more lightweight, compact and mobile. The design principles of these machines to some extent scheduled in the fundamental works [4,5], but the specific technical solutions are original developments specialists of "VNII Transmash" and RCL.

An example of this construction is that the machine depicted in figure 2.

Higher compared to STR-1 mobility (including this element as accessibility) provides a wheeled-walking propulsion. The use of modern compact electric motor allowed us to reduce the weight of the motor-wheels. A satisfactory control is achieved through the application of the principle of Board rotation. The speed reaches 3 km/h Manipulator provides the versatility of the robot in relation to the performed technological operations. On the machine hosting the video camera, scientific equipment (equipment to customer specification), batteries and/or drum with a wound cable. The robot can move by steps (overcoming of the escarp height up to 0.4 m), to overcome the trench width up to 0.6 m, slopes up to 30°; overcome brody and loose snow cover to a depth of 0.5 m.

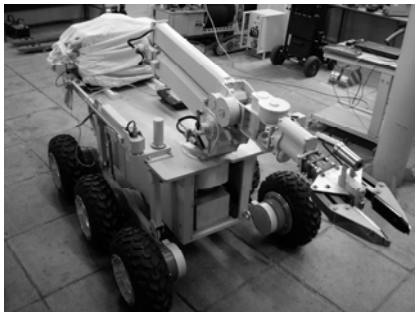

Figure 2. The robot wheeled-walked chassis

The chassis is equipped with an arm designed in the course of joint work on the project cooperation with China North Vehicle Research Institute (Beijing, China). The manipulator has six steppes of freedom and a payload of 20 kg. the Actuator sections of the

manipulator is Electromechanical. The control is performed remotely.

Figure 3 shows a robot developed by RCL and is also equipped with a manipulator. The robot is designed to work in extreme conditions, the consequences of manmade catastrophes, and to perform regular operations, if the presence of the person is dangerous or undesirable. A unique feature of this machine is a tracked chassis transformer with the ability to variable geometry.

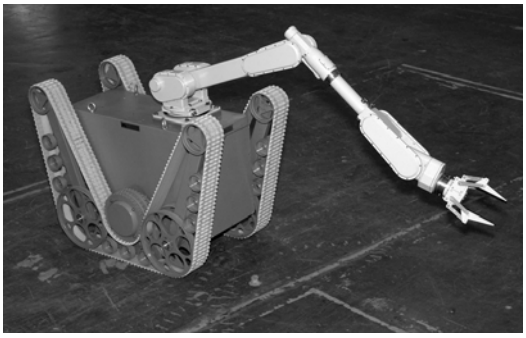

Figure 3. Robot crawler chassis with variable geometry

Tracked mobile robots with a traditional two-track circuit of the engine of a series produced by some foreign companies. In Russia wide range of tracked robots for various purposes have been developed in Moscow state technical University. Caterpillar mover with variable geometry (can have 4 or even 6 tracks) more promising. Such designs allow you to overcome stairs (if the size allows it to maneuver in the stairwells). Some firms, such as Cybernetix (France), Remotec (USA) use this type of propulsion in their designs.

Designed by experts RCL two-track the robot in a more simple construction allows in particular to move along a flight of stairs (the angle of inclination up to 30°). When mass up to 150 kg robot passes through the doorway with a width of 0.7 m. the Height overcoming of the escarp – up to 0.25 m. the Width of the overcome trenches up to 0.5 m. the Permissible fording depth up to 0.1 m.

Разработанное гусеничное шасси имеет конфигурации, позволяющие получить:

• the minimum longitudinal dimension of the robot (for maneuvering in confined spaces and for transporting the robot to the place of work);

• the maximum longitudinal dimension of the robot (for movement over the ground, a floor and ladder marches);

• an intermediate position.

Steering is performed by changing the tractive forces on the tracks of the boards. It possible to turn the robot in place.

A significant drawback of this robot in comparison with the above version of wheel-walking chassis, are large losses in the tracked contour. Advantage – the ability to more evenly distribute the load along the length of the support surface, with the exception of jamming of the propeller on the steps and other obstacles.

Regardless of the particular construction of the chassis both versions of the robot can be used at work as part of a homogeneous or heterogeneous groups as a group member or base chassis, which can accommodate robots for operational local monitoring [6,7]. In turn, this group may be part of a one - or two-component multi-agent system [8]. This approach does not preclude the operation of the landing gear outside the group, for example in remote control mode.

## 3. RESEARCH RESULTS

The parameters of chassis, developed designs, developed and tested to determine basic performance characteristics of prototypes of remotely-controlled chassis: wheeled and tracked walking with variable geometry chassis.

Constructed chassis can be integrated into one - and two-component multi-agent system.

## 4. CONCLUSION

To date, RCL experience of designing robotic systems capable of remote control mode to perform various technological operations with dangerous objects (the movement of goods, rubble, radiation monitoring, etc.). If this worked out technology of creating unique compact machines, capable to navigate inside of buildings and to overcome artificial obstacles (including stairs).

For this class of cars is mastered the design and manufacture of manipulators with a wide range of specifications, designed control systems and information transmission, is efficient in conditions of high radiation background.

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