EVALUATION OF THE TECHNICAL CONDITION OF THE POWERPACK FOR AMV ROSOMAK ON THE DYNAMOMETER TEST STAND

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Abstract

The paper describes standard methods of diagnosing of the AMV (the Rosomak) drive unit technical condition used in daily operation in military missions in Afghanistan. Main rule of the method of diagnosing of the vehicle technical condition is using an external diagnosing system. This system is connected to the vehicle at the time of checking of operation of the powertrain control system configuration of the drive unit to permit the diagnosis, including examination of the engine and gearbox. Enhanced diagnostic system is connected to the OBD system with using standard PC computer with appropriate software. Stored examples of the results of the operation of such system are included in the paper. Measuring was led on a dynamometer stand to perform research of a propulsion unit in work condition. Measurements of the engine parameters were led in steady state and transient engine operating conditions. Unsteady-state condition studies were carried out using the method of free-range acceleration of the engine. Pointed out the merits of the development of this type of study due to the perceived potential and usefulness of the results obtained. The results of studies carried out by various methods and assess the current condition of the engine and the entire powertrain were compared.

Keywords*: combustion engine, diagnostics, powerpack*

1. Introduction

Military vehicles can be used in extremely difficult weather and terrain conditions. They are also exposed to the effects of different types of enemy missiles and mines. The main threats to the integrated power unit ("PowerPack") operated during military mission include:

- intensive operation with short time for the maintenance of the vehicle,
- high variability of weather conditions,
- poor fuel quality,
- improvised explosive devices (IEDs) and cumulative projectiles.

A very important issue is maintaining a steady high performance of military vehicles used in such conditions. This is done by constantly monitoring their condition and the quick response to any change or damage. Military vehicles have their own on-board diagnostics system that indicate the current state and technical changes. However, not all defects can be detected by these systems. After the explosions impact on vehicles are possible internal sets damage, which are difficult to detect during idle engine run. They require the verification of the entire operating load range. Similar checking must be done after repair of vehicles.

One of the most important groups at risk of damaging the vehicle's powertrain. Comprehensive verification of the technical condition of the integrated power unit must be carried out in the whole range of engine speed and engine load, as well as in steady and transient states of work. Such tests require a special dynamometer stand. This stand has been built at the Laboratory of Combustion Engines of Military University of Technology. It is equipped with a hydraulic dynamometer Zöllner type PS1-3812/AE with water control system providing high dynamics of load changes. It also provides a load test object high torque at low speed, which allows testing the powertrain including a transmission. The stand is equipped with instruments for measuring fuel consumption, exhaust smoke, and exhaust gas analysis.

2. Powerpack and its diagnostics system

Integrated propulsion system (powerpack) includes three main units (Fig. 1):
- SCANIA DI 12 engine controlled by the EMS system,
- ZF AG 7 HP 902 S Ecomat automatic transmission with hydraulic pumps,
- cooling unit with two fans driven by hydraulic motors.

Engine and gearbox have their own control panel located in the driver console. The drivers for these devices are combined in master controller knows as the coordinator.

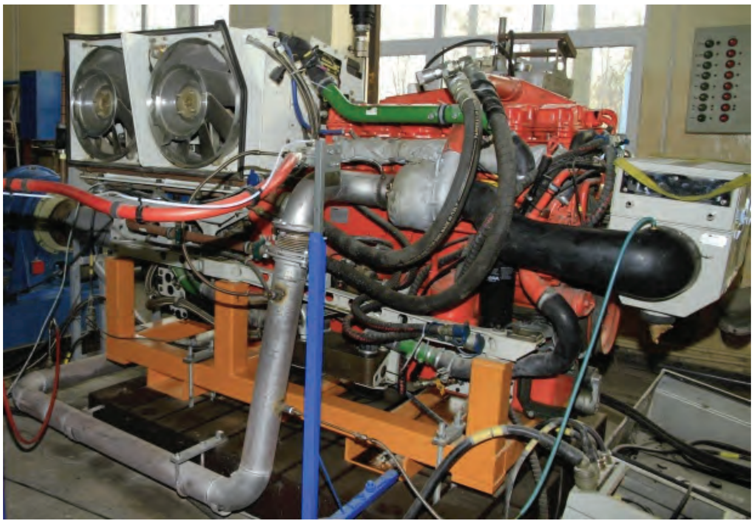

Fig. 1. Powerpack for AMV Rosomak (Source: by authors)

The task of the engine management system (EMS) is to measure the flow of fuel supplied the engine, monitoring its work and the response to the position of accelerator pedal and other settings changed by the driver. The effect of the system is to obtain optimum engine efficiency, high power and high purity of the exhaust gas. The engine control system is connected to the gearbox via CAN bus.

The main elements of the control system are different types of sensors inside the engine, electric injectors PDE, instruments console, coordinator of command and control system that controls the EMS system. Coordinator transmits information from the sensors to EMS system, which directly controls the unit injectors PDE, their fitting open and close in such way that the beginning of the injection and the amount of fuel injected to the combustion chamber are optimal.

If the engine control system detects a fault, then depending on the type of failure, the control system reacts EMS according to one or more procedures:
- the light of the control system EMS is turn on - usually extinguishes itself when the fault disappears, but there are defects that require stop the engine,
- engine torque is decreasing,
- idle speed is increasing,
- the engine is stopped or reduced to a idling speed.

The goal of these procedures is reducing the effects of engine failure.

Automatic transmission is also a motor unit, which can be easy, damaged. Transmission with seven gears consists of hydrokinetic gear, planetary gear, retarder, emergency gear, two shafts and auxiliary pump. It uses electrohydraulic control of the gear ratio. A lever in the driver cab changes gear ratios. The driver also has an impact on the operation of the transmission gear by forcing through the accelerator and retarder lever. The powertrain also includes the transmission oil cooler.

Electronic transmission control system EST 146 S is located inside the instrument panel and works with other control units via CAN bus. The electronic system controls the pressure and switch gears in order to maintain uniform performance throughout the lifecycle of the gearbox. If the specified time of gear switching cannot be achieved (e.g. due to failure or low oil pressure), control devices inform the driver of a chance to minimize the adverse effects of failure. The control system is able to perform self-monitoring of the operation.

Basic diagnostics of the transmission is largely based on the reading of fault codes stored in the memory of transmission control system, which allows assessing the state of the transmission and emergencies that occurred during the operation. Diagnosing of the transmission is also possible on the basis of pressure measurement systems in each box: PH - nominal pressure, PD1 - the pressure on the throttle, PD2 - pressure before convector, PD6 - the pressure in front of the heat exchanger, PR3 - the pressure on the brake mountain PRR3 - brake control pressure.

Powerpack also contains a cooling unit with two fans powered by hydrostatic motors pumps. Oil hydrostatic pumps are to be fitted to the gearbox flange and powered by an internal combustion engine.

The test stand is equipped with all the necessary measurement systems, the mains system fuel and exhaust system.

3. Dynamometer test stand

Hydraulic dynamometer is connected to the drive unit. Unit consists of the diesel engine ScaniaDI12 56A 03PE, along with a seven-speed automatic gearbox ZF Friedrichshafen AG7HP902S Ecomat with a shorts haft with two joints. Motor control is done with a driver’s desktop disassembled from the vehicle and placed in the cab of the dynamometer.

The test stand was made in Internal Combustion Engines Laboratory of WAT. In the control cab is mounted original desktop from armoured vehicle driver, which allows to simulation of real driving conditions (Fig. 2b). The desktop is connected to Texa Navigator TXT scan tool and PC with the installed software Texa IDC4 Truck Plus).This allows performing a wide range of adjustments in addition to reading the current operating parameters and errors.

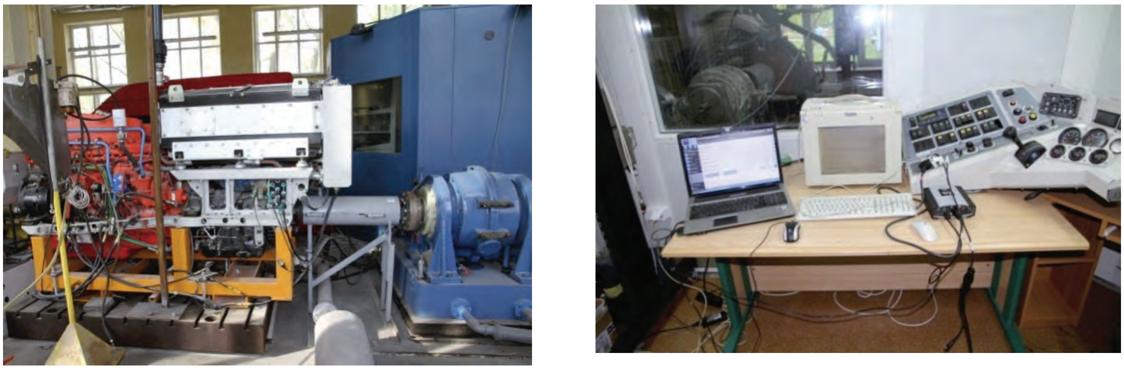

Fig. 2. Test stand for test drive units AMV Rosomak: a) the engine with the gearbox, in the back can see the control cabin, b) diagnostics device TEXA with computer and driver’s console (Source: by authors)

Verification of the powerpack were divided into four stages, which should be carried out sequentially. It is necessary for proper verification powertrain units. Successively should be carried out:

a) diagnostic of the engine electronic system,
b) diagnosis of the electronic control system for gearbox,

c) measurement of hydraulic oil pressure at selected points of the gearbox,
d) determination of the engine characteristics at different operating conditions.

Powertrain diagnostics cannot be performed with a single-purpose device. Therefore, it was divided into three areas (Fig. 3). Most activities require engine researches. In addition to the elementary reading fault codes perform pump-tests (volumetric and spray), as well as measurements on the dynamometer with a scan tool TEXAIDC4. The cooler unit has sensors for measure of air flow and for oil pressure in the propulsion system of the fans.

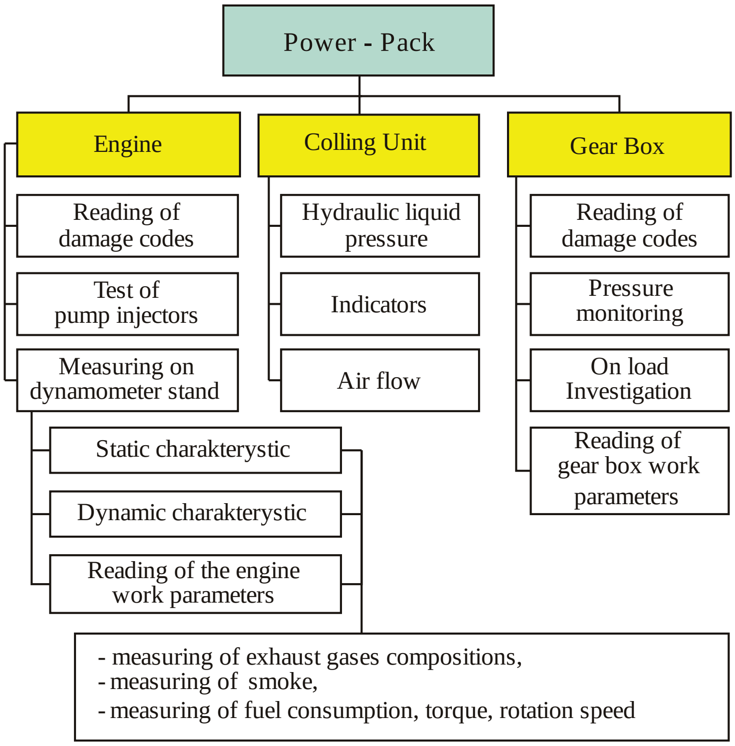

Fig. 3. Diagnostics areas of the powertrain AFV Rosomak (Source: by autors)

4. Diagnostics of combustion engine and gear box

Choosing a diagnostic system for the vehicle was analyzed description of the following diagnostic systems:
- KTS with software ESITronic made by BOSCH,
- TEXA with software IDC4 made by Texa,
- Diagnostic Tester Logic made by Magneti Marelli.

Finally decided to use TEXA diagnostic system. This device does not require a cable for connection to the visualization device or power supply. Through a series of devices NAVIGATOR can perform, all tests on electronic systems working anywhere near the vehicle. All TEXA interfaces are equipped with IDC4 operating software, which provides direct access to the entire range of the additional data: data sheets, technical data sheets, cards, components, wiring diagrams, etc. The software also includes special features.

TGS2 system (TEXA Global Scan 2), built-in operating systemIDC4, is the second generation of the automatic scanning of vehicle ECUs. This innovation developed by TEXA offers in-depth analysis of many makes and models of drive systems, which always TEXA's strength.

After plugging in the TEXA interface to the diagnostics socketIDC4softwarescans all the known systems in a fully automatic way (Fig.4). If errors are detected during scanning, you can directly go to the appropriate diagnostic control unit. If the systems operates correctly, there are also simplified the entrance to the ECU to the testing or adjustment.

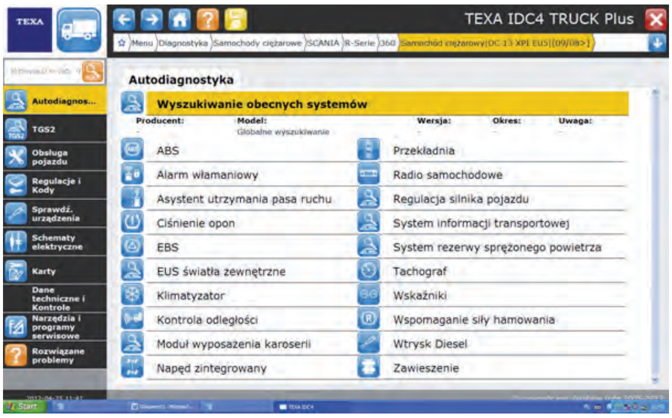

Fig. 4. Window of the TEXA program presented range of possible diagnostic range for trucks (Source: by authors)

Connection to the motor and gearbox is progressed by the engine diagnostic connector OBD2 and special connectors for ZF gearbox. EMS control unit stores the errors in the permanent memory. This allows checking whether the problem is intermittent or continuous. With the appropriate tables error can be identify, and then determine content of a repair required (Fig. 5). Tool to detect this type of fault is the systemTGS2.

During engine runs, its parameters are read-to-date the control unit measures the value of physical quantities detected by the sensors and sends them to the actuators as a digital signal. Minimum and maximum values are updated. Trend of changes of parameters can be presented as a graph.

a) b)

Fig. 5. TEXA Windows presented powertrain work parameters: a) SCANIA engine, b) ZF gear box (Source: by autors)

During engine diagnostics' works in the laboratory, it is possible to perform the verification tests of its performance under varying load, wide range of speed, different shutter solenoid or off state of the cylinder (Fig. 6).

a) b)

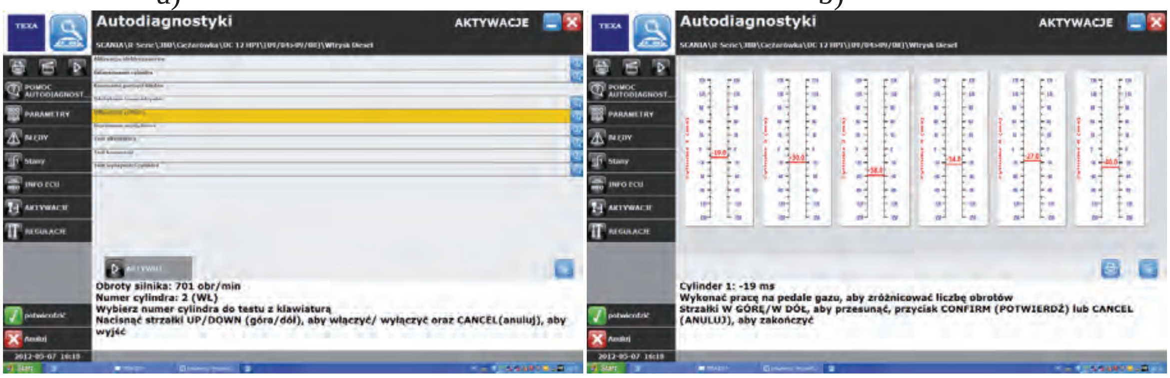

Fig. 6. The results of measurements: a) balance of cylinders, b) the deviation of fuel dose (Source: by autors)

For example, during the investigation of the technical condition reconditioned engine and gearbox were three errors in the control system due to defective speed sensors and very low voltage at the battery terminals. In the box were found 10 errors during the set clutches and brakes. Taken reset faults. Over next test of the engine at all times was observed state of the lights that inform the driver of the errors in the control system, gearbox and engine. There were no system faults listed vehicle Powertrain Control that proves its efficiency.

Pressure measurement in the gearbox runs under load for quick evaluation of operation of the transmission. Transmission tests were performed using the original software developed and connected to the box corresponding pressure sensors. The use of universal diagnostic connectors on the drive unit side panel allow for fast connection the sensors to the pre-prepared data points(Fig. 7a). Industrial transducers A-10 were used for pressure measurements (Fig. 7.b)

For registration pressure wave forms, WaveView for Windows measurement software was used. (Fig. 8).This software is supplied with the measurement chart. It has two modes that are supported: scope and record chart. The measurement results are compiled in an Excel spreadsheet.

a) b)

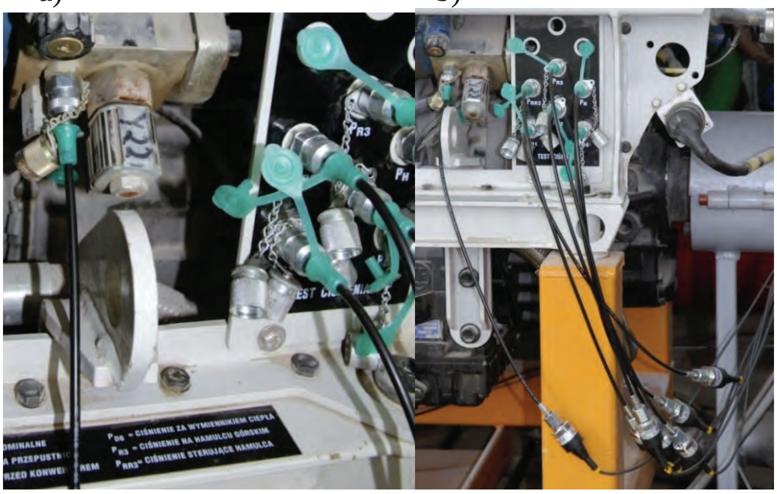

Fig. 7. Pressure measurement in the gearbox a) terminals of sensor connectors, b) view of the pressure sensor (Source: by authors)

The tests repaired transmission powertrain is made in two stages by measuring the pressure in transmission systems under steady state and transient engine operating conditions. When powertrain was tested in transient states, speed was varied between 700-2300 rev/min. There was observed a process of acceleration and deceleration (about 100 times), proper gear, the occurrence of jams in the gearbox and the presence of faults in the control box.

a) b)

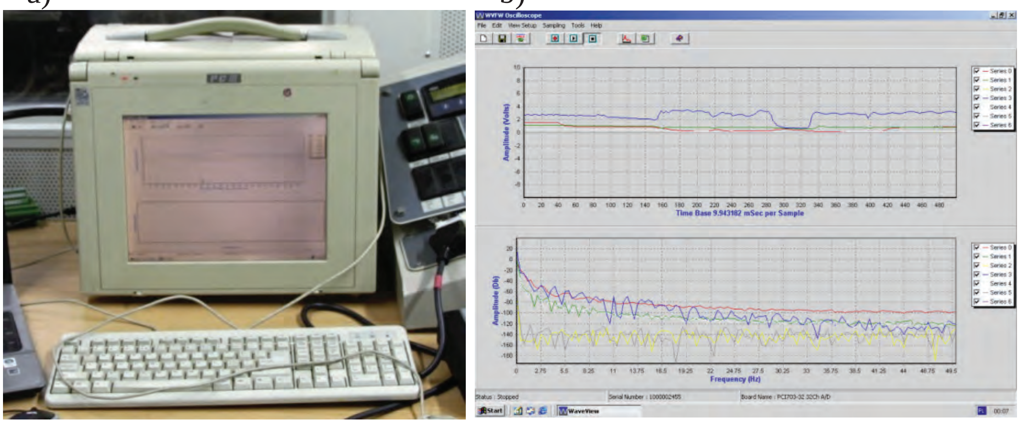

Fig. 8. Acquisition computer set: a) computer, b) Window of parameters collected (Source: by authors)

Based on the results of measurements it was found that the resulting switching times of individual gears were repetitive, and when working under load transmission control box signal any faults. Then the pressure wave forms recorded by sensors mounted to the measurement transmission. It was a regular change of pressure in accordance with the instructions of the engine (Fig. 9).

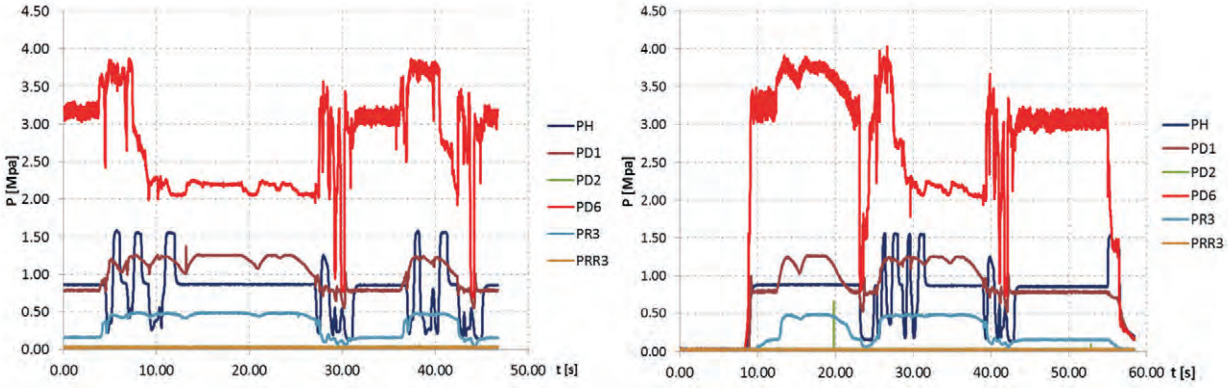

Fig. 9. Pressurecourses in the gearbox during a) acceleration engine speed, b) start-up and shutdown engine (Source: by authors)

Conclusions

1. The dynamometer test stand presented in this paper and the set of devices enables very accurate diagnosis of a single powertrain AMV Rosomak. It is possible to determine the parameters of the motor and the electronic parameters of the control systems, as well as the parameters of the electronic control transmission.
2. Engine tests can be carried out on the dynamometer stand in the steady state and transient conditions. Used Hydraulic dynamometer allows high torque even at low speed. This allows measurements to be carried out at a high gear ratio and high torque.
3. Development and application adapters with pressure sensors enables diagnosis of automatic gearbox conveyor runs from the oil pressure in the chest. Regular pressure waveforms were obtained in accordance with the manufacturer's instructions.
4. Currently, the position of is designed to analyse the composition of exhaust gases and examination of propulsion of the cooling fans, which allows for an even more detailed examination of the technical condition of the integrated power unit.

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References

[1] Sitek, K, Syta, S., *Badania stanowiskowe i diagnostyka*, WKiŁ, Warszawa 2011.
[2] Dąbrowski, M., Kowalczyk, S., Trawiński, G., *Pracownia diagnostyki pojazdów samochodowych*, WSIP, Warszawa 2011.
[3] Kołowy Transporter Opancerzony 8x8 Rosomak, *Instrukcja Napraw*, WZM Siemianowice Śląskie, 2004.
[4] TEXA: *Maksymalny potencjał diagnostyczny*, AutoElektro, Nr 128, Czerwiec 2011.
[5] Poradnik serwisowy *Pokładowe systemy diagnostyczne OBD I EOBD oraz sieci transmisji danych, Wybrane zagadnienia*, Nr 4 i 5, 2010.
[6] Karczewski, M., Koliński, K., Szczęch, L., Walentynowicz, J., *Stanowisko dynamometryczne do oceny stanu technicznego KTO Rosomak*, w monografii Technologie podwójnego zastosowania, Wybrane technologie Wojskowej Akademii Technicznej, Wydawnictwo WAT, Warszawa 2012.

[7] Łagoda, T., Macha, E., *A critical plane approach based on energy concepts: application to biaxial random tension-compression high-cycle fatigue regime*, [in:] Int. J.Fatigue 21, 1999.
[8] Karczewski, M, Szczęch, L, Walentynowicz, J., *Diagnozowanie zintegrowanego zespołu napędowego KTO Rosomak*, Zeszyty naukowe WSOWL, 2013.
[9] Scientific work funded to study for the years 2009-2011 as a development project.