

## Development of Medium-Sized Multipurpose Agriculture Vehicle

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**Abstract**— In this decade, the farmers in Thailand suffered from a labour shortage, loss during harvest, improved productivity and increased cost of the farming part. The rice crop plots of the northeast province have been set to the case study. This research aimed to develop the Medium-Sized Multipurpose Agriculture Vehicle (MSMAv) innovative from the conventional agriculture tractor for two purposes. The firstly is to present the novel modified technique of automatic gear for the MSMAv to serve the development of automatic control that expect to reduce the number of labour while controlling machine. Secondly, extending the implementation for several peripheral via a drawbar or hitch system means minimizing the cost of the machine investment. Therefore, the research team has collaborated to develop the conventional farm tractor by changing from a manual to an automatic gear system, including supplementing equipment such as a remote-control system, GPS, car camera, sensors, voice command, for instance, based on existing technologies. The research team expects the development prototype of the vehicle for rice production will be the novelty approach, which provides both opportunities and knowledge to farmers at the same time.

**Index Terms**— Medium-Sized Multipurpose, Harvesting, Organic rice.

### I. INTRODUCTION

Most of Isaan (the north-eastern part of Thailand) population live in agricultural activities [1]. The Northeast region (NE) (Figure 1) also has an area of around 41,724,732 acres or 33.17%, which is comparable to one-third of Thailand's total area, making it the largest in the country. This region currently has approximately 5,378.95 acres of farmland, of which 5,259.57 acres on rice production, and trend to expand in the future, which the farmers aim to expand the production area, including managing everything from ranching, sowing, planting, weeding, watering, and humus. Therefore, farmers were established on behalf of Social Enterprise Company Limited to help farmers and sell rice, causing the economy's circulation. They have a marketing plan to distribute various rice varieties to known all over the country in the future.



Fig.1. The map of the Northeast region of Thailand.

Figure 2 is an example of a paddy field in the NE region conducted to meet consumer demand. However, most farmers in the group faced problems in rice production, such

as labour shortage in the agriculture sector and the requirement careful of chemical contamination problems following market demands and government policies. Therefore, the existing conventional agricultural tools

[2-4] do not respond to these problems. In addition, there is a problem of harvesting time for some varieties that desire to improve the quality to get the best rice taste and aroma, it is necessary to harvest in a limited time. Moreover, an important problem of a general harvester is an obstacle to small plots and uneven terrain of paddy production. It made the farmers working in small and narrow spaces unable to use the combined harvester as it is a significant obstacle in using large and heavy agricultural machinery [7-8].



Fig.2. A croft area of the province with the cultivation of rice.

Finally, farmers will have to face the problem of access to capital, as they require significant investments in new technology, equipment and agricultural machinery. This problem is complex for farmers who wish to purchase farming machinery to make them more convenient and efficient; therefore, we can develop agricultural machinery with modern technology, such as the development of powerful engines [9]. Including interfacing with a semi-automatic control system for rice growing needs by developing from this medium-sized multi-purpose vehicle called that E-Tak truck can solve the shortage of labour factors in production. The issues mentioned earlier will lay the foundation and spark the development of modern technology for the new generation of farmers in Thailand.

In the first sample area, the research team explored the problem and attended a meeting to listen to opinions and ask questions about farmers' needs in Nong Bua Lamphu province, therefore the most extensive rice production area in the NE. The village community leaders supervised the research team to meet and discuss the initial problems and present the solution to this research problem.

## II. MATERIAL

The problem with farmers in many provinces is that they have not had tractors/trucks for farming for a long time. Due to many factors such as economic problems, personal problems, and many other technical problems, this province is still an emerging province. Agricultural scholars or agricultural mechanical engineers are still not enough to help each other bring modern technology to aid in agriculture [12]. Therefore, the research team has tried to push government agencies to help the farmers, assisted by The Thailand Research Fund Thailand Science Research. Innovation, which will start in Nong Bua Lamphu province as beginning with the development of a medium-sized vehicle from "E-Tak vehicle" as a small agricultural truck, has a low horsepower. Save solar fuel in driving to have the ability to work by improving and developing the limitations of E-Tak vehicles in general in three areas as follows: Firstly, we can reduce the number of vehicle operator workers from two to only one person. Then, we will modify the structure of the E-Tak vehicle, which was initially thick steel material, to be lighter material to reduce the burden of carrying a lot of weight, resulting in unnecessarily high fuel consumption and production costs. Finally, we are present to biodiesel (palm diesel) as diesel fuel produced from agricultural products in the area. The final research was to develop the control of this medium-sized multipurpose with a semi-automatic remote-control system.

### A. Study on the medium-sized-vehicle prototype



Fig.3. The operation of the prototype vehicle in the farm [18].

We studied the information of the actual vehicle in use present-day—the performance characteristics of vehicles and peripherals required for farmers. Figure 3 shows the researcher team visit to the existing site to study the operation of a full-size car and survey the materials used and related technologies to design a medium-sized multipurpose agriculture vehicle prototype, particularly the hydraulic system structure.

#### *B. Researcher designing of hydraulic system*

The researcher team has designed the hydraulic structure system by visiting the area to study and develop the medium-sized-purpose vehicle structure suitable for the actual operation. The researcher team has investigated the model of a full-size vehicle prototype agricultural with farmers who use it in this region.

#### *C. The system of the medium-sized-multipurpose vehicle*

The entire system of the MSMAv in this research is divided into three distinctive design sections to the most relevant results based on existing technology. 1) the mechanical structure design, then 2) the electronics hardware plans and sketch followed by 3) a system of the invention is software application designing.

#### *D. The Mechanism Design*

The mechanism design consists of complete designing such as hydraulic system design, power transmission design, steering mechanism design, and brake system design.

### III. METHODOLOGY

#### *A. Hydraulic System Design*

We design considerations to meet function requirements, including performance specification, life expectancy, facilitate good maintenance practice and efficient operation. We developed a system for power transfer controlled by hydraulic oil compressing. Since adding a pressure for the device to change the stress of hydraulic oil to mechanical energy (Actuator) or (Hydraulic Cylinder), the system relies on the leading equipment as follows: Figure 4 showed the prototype of this research for the development of a medium-sized multipurpose agriculture vehicle.

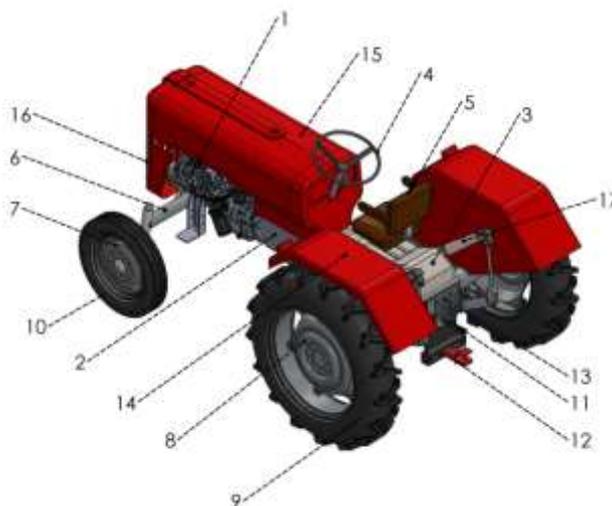


Fig.4. The main driveline units of the medium-sized-purpose vehicle.

Table 1 shows the number of objects of the prototype Medium-sized multipurpose agriculture vehicle.

TABLE I  
NUMBER OF THE OBJECTS

No.	Object
1	Diesel engine
2	Gear box
3	Differential gear
4	Steering wheel
5	Seat
6	Front axle
7	Front brake set
8	Rear brake set
9	Back tire
10	Front tire
11	PTO Shaft
12	Towing set 1
13	Towing set 2
14	Rear fender set
15	Mid hood
16	Front grill
17	Lifting set

**B. Power Transmission Design**

The design of the tractor transmission system has two functions: First, to free the engine from the tractor wheels when changed gear. Second, to transmit the smooth torque without shocks and jerks to the engine to change the engine torque and engine speed into the torque and speed required by the road wheel for the different tasks required of a tractor. The transmission system is our design; the driveline of a medium-sized-purpose tractor in our case consists of components that transmit the torque developed by the engine to the driving on wet/dry field wheels and to vary the torque and direction of rotation of the ground wheels [16-17].

The power transmission system design consists of the following parts: Firstly, the clutch – the device that connects or disconnects two torque-transmitting devices. Then an apparatus for transmitting power at a multiplicity of speed and torque. Then, power take-off drive – the parts that transmit torque from the engine to the PTO spline on the tractor's rear. Then, the differential part– the device, usually in the axle housing, allows the two wheels on an axle to rotate at different speeds. Then, the brake system, usually in the axle housing, stops the tractor's motion. Then axle – the shaft and connecting parts that transmit torque from the differential or final gear reduction to the wheels. Finally, engine – crankshaft system – flywheel system – clutch system– transmission box system – differential system – final drives system – axle – drive wheels. In this research, a medium-sized-purpose vehicle transmission system has two functions: isolate the engine from the medium-sized vehicle wheel when desired. Then, provide for an auxiliary power outlet in the form of power take-off for powering the implements and stationary machinery.

**C. Steering Mechanism Design**

An alternative steering mechanism's preliminary design and calculations are present, which dedicate to lightweight medium-sized-purpose vehicles. This mechanism aims to keep both steered wheels at ideal turning angles in the rice field dry or wet. Therefore, a tool has been designed based on our optimal spiral path method. The advantage of this steering, besides eliminating error that the machine can self-locking. This mechanism is ideal for autonomous application, as the system does not require energy to hold the turning angle consumes energy when the angle is changed. This research covers the main theoretical concept, design fundamentals, and calculations.

TABLE II  
EXPERIMENTAL PARAMETERS

Parameters	Description	Range
$\beta_{La}$	The steering angle of the outer wheel	0-45
$\beta_{Li}$	The steering angle of the inner wheel	0-75
$\beta_{LaA}$	The idea of turning angle	0-65
$\beta_F$	The deviation between the ideal steering angles	0-50
$S_{RH}$	The center of gravity (Vertical)	N/A
$L_F$	Center of the front to the rear axle	3.80
$L_y$	Center of the half between front axle to the rear axle	1.90

Typically, a vehicle steering mechanism requires to give the steerable wheels a correlated steering angle of the wheel such that the intersection of the wheel axes should meet at the centre of the bend [20].

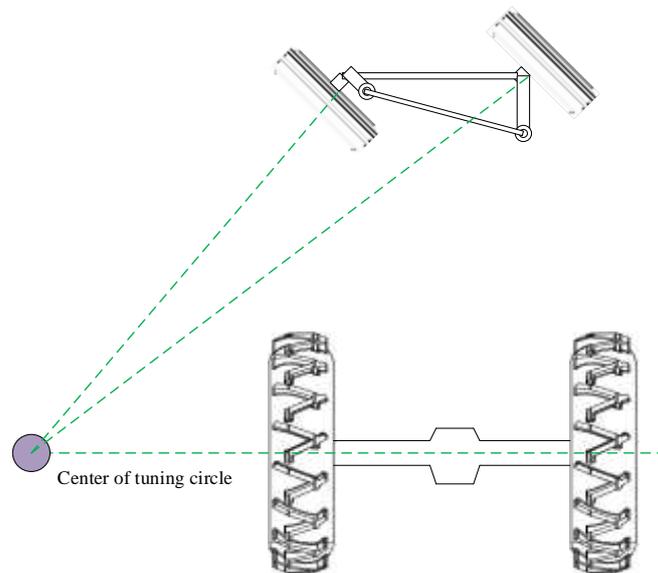


Fig.5. Steering Mechanism Design.

This rule can also see for a two-axle vehicle in figure 6 has known as the “Ackermann Theory”, in equation (1). Mathematically, Ackermann Principle as:

$$\beta_{LaA}(\beta_{Li}) = \tan^{-1} \frac{1}{\cot \beta_{Li} + \frac{j}{L_F}} \quad (1)$$

Where  $\beta_{La}$  is steering angle of the outer wheel,  $\beta_{LaA}$  is the idea of turning angle, which is obtain from equation (1) for a given steering angle  $\beta_{Li}$  of the inner wheel. The deviation  $\beta_F$  between the ideal steering angles of the wheel, which is cause by the steering mechanism geometry, is called “the steering error” or “Ackermann Error.”

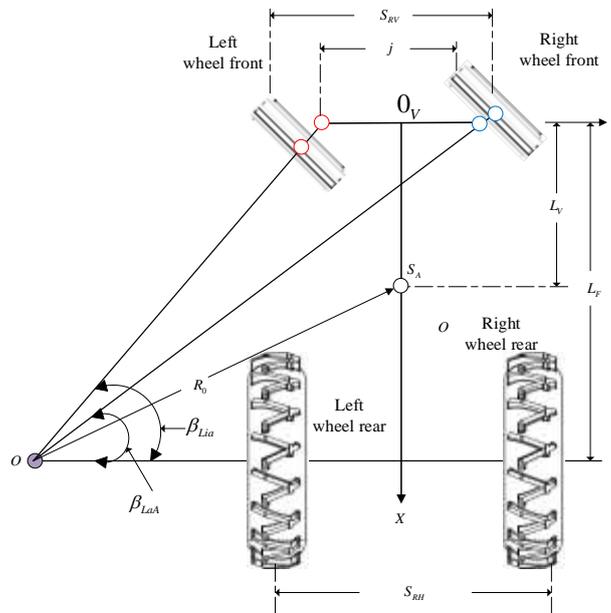


Fig.6. Geometry left wheel front angle by Ackermann steering theory.

Generally, the mechanism of steering of a full-size vehicle should satisfy with the Ackermann principle theory of forgiven steering error tolerances.  $\beta_F$  can be written the following:

$$\beta_F(\beta_{Li}) = \beta_{La}(\beta_{Li}) - \beta_{LaA}(\beta_{Li}) \quad (2)$$

The position of the tie rod of a multi-link steering system also affects the vehicle tracking ( $\beta_v$ ) deviation of the wheel (Fig.7.) as well as the maximum steering error. Therefore, the multi-link steering mechanism during the kinematic design process, the deviation of ( $\beta_v$ ) caused by the wheel travel have to take into calculation

#### D. Brake System Design

The tractor vehicle brakes system is designed and balanced for the fully working loaded condition and makes excessive braking on some axles when the vehicle is not fully loaded [26]. This problem is compound because the rice field actual practice, a structured brake system design in a medium-sized vehicle, an engine-driven compressor provides liquid oil. It collects in a disk brake controller.

In this research, we design a brake system as a disk brake because the brake pads grip the side of a metal disc to delay the rotation of wheels down of a metal disc to delay the rotation of wheels down.

#### E. The Electronics Design for medium-sized multi-purpose vehicle

The overall electronics design for taking the medium-sized-purpose vehicle to operate consists of six parts such as the radio transmission part, receiver part, antenna part, digital control part, encryption part, GPS receiver path and screen interfacing such as the follows.

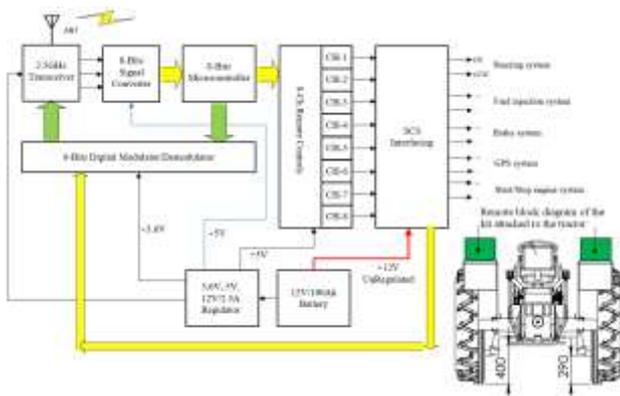


Fig.7. Overall, block diagram of transmission control for medium-sized-purpose vehicle.

1) Radio Transmission Part Design

The radio transmission of the box diagram and PCB Module. It consists of 2.4 GHz. (2.40–2.48 GHz.) transmission/transceiver with an output transmission power of 5 watts, and our design is suitable for all types of multi-purpose vehicles. The operation type selects according to the purposed vehicle used and various hybrid functions. It is ideal for all types of fixed-wing, glider and multi-rotor. The model type can choose according to the tractor used. Illustrate Figure starts the first box is 2.4-2.48 GHz.—transceiver or two-way communication for receiving the GPS signal, which installs at rice filed. If the GPS1 signal is coming through this box, it feeds to an 8-bits signal converter for compared the valid location with the GPS2 signal. If they are balanced, the medium-sized-purpose vehicle will be stopped and turn right or left next. Then 8-bits microcontroller will process all signals is coming and feed to the 8-out-of-1 multiplexer and receive activity from an 8-Ch remote control such as steering wheel, fuel injector, brake system, GPS control, and the engine starts/stop controls.

2) Antenna Part Design

The radio transmission has an omi-direction antenna, a pattern around the transmitter with 6-dBi antenna gain and 5 watts power output. Therefore, it can send the electromagnetic wave of the radio wave from 1 to 5,000 meters in space. It is ideally suited to control the car in broad fields.

3) Digital Control Part Design

The digital control part with our design consists of 5 sections. Firstly, 8-bits signal converter. Then we have an 8-bits microcontroller for any input process. Then, 8 out of 1 multiplexer circuit. Then we have an 8-bits digital modulator. Finally, this research has 8-channels of remote control, as the block diagram.

4) The GPS Receiver Module

We cannot design the GPS part because we take import from china country are both modules. Therefore, we just designed the direction of the tracker from the GPS 1 and GPS 2 receivers.

5) The Screen Interfacing Module

The design of the screen interface using the Android operating system and create by PCB with consists of semiconductor components. This part is an interfacing board between digital control and video camera installed at the medium-sized-purpose vehicle for watching the front view of the vehicle moving. Thai farmers can watch the environment of his/her field while the medium-sized-purpose vehicle tracking time.

6) The Application Software Design

Figure 8 is a functional flowchart of a remote-control system that can control the medium-sized-purpose to move through the fields with a start/stop engine. The fuel injection control rate allows the accelerator pedal to inject or reduce the accelerator as the car approaches the GPS 1 installed on the edge of the field, and steering controls, etc., while the work platform will place on the cloud (Crown Management Platform), which the farmer can use from a smartphone to real-time control.

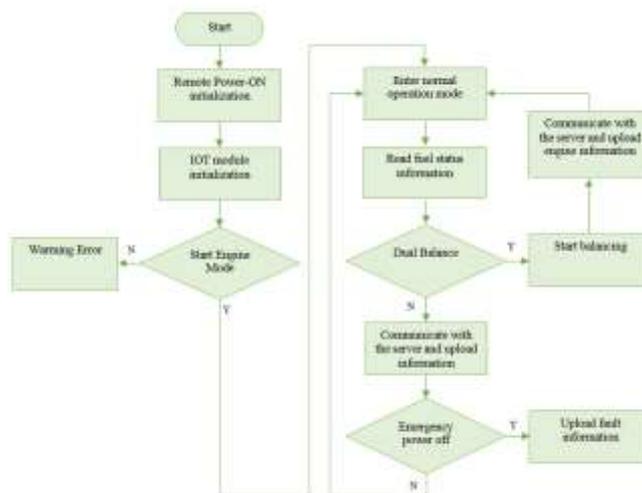


Fig.8. Flowchart of medium-size multipurpose agriculture vehicle remote control.

The researcher team also develops the transmitter support software is used for other project tasks like loading transmitter/receiver firmware to the remote, backing up model settings, editing settings and running radio-remote simulators. That is available for Windows, Apple OSX and APK for smartphones.

#### IV. RESULT AND DISCUSSION

The results of prototype medium-sized-multipurpose vehicle performance testing for rice harvesting will be an experiment of phase I. The research team designed this vehicle for harvesting rice in an actual paddy field and prepared to test its performance in Non-Sang district areas. In the case study, we have an experimental plot at the farmer plot in Non-Sang District, Nong Bua Lamphu province.

Non-Sang District is a significant rice-growing area. This research focuses on and aims to use as the area for testing vehicle performance and collecting the numbers of quality around 198 Acres. Therefore, the villagers allow the researcher to set and test this innovation in paddy fields have to cooperate on data collecting concerning management problems, yield, cost, and economic impacts. This research presents a prototype of medium-sized-multipurpose vehicle innovation for supporting farmers to harvest rice production.

The research team sincerely hopes that this prototype will be a small utility vehicle that might help the farmers under 55°C sunshine with the electronics operating and cover varieties of function.

It can be derived from high, low, uneven areas; uneven terrain allows farmers to work more efficiently in the northeast region as Nong Bua Lamphu province topography. Moreover, it has the ability to serve the purpose of rice farmer groups directly. Therefore, they have to understand how to learn the machine and technology applied in the medium-sized-multipurpose vehicle. In the future, the researcher expects that they will provide excellent cooperation and also attempt to improve or extend this innovation to the non-profit organization in their area.

Table 2 shows the specification of the prototype Medium-sized Multipurpose Agriculture Vehicle innovation for rice harvesting prototype vehicle.

TABLE III  
SPECIFICATION OF TOYOTA HILUX ENGINE AND BASICALLY OF MEDIUM-SIZED MULTIPURPOSE VEHICLE INNOVATION CAR

Specification	Description	Testing
<i>Engine</i>		
Model	Diesel 2L	working
Type	4 strokes, water-cooled	working
Combustion	IDI, naturally aspirated	working
Number of cylinders	4	working
Bore x Stroke	92 x 92 mm	working
Displacement	2.4L (2446 cc)	working
Compression ratio	22.3 :1	working
Combustion chamber	Swirl chamber	N/A
Nozzle type	Throttle	working
Cooling system	Pressurized circulation	working
Continuous power output	53.6 kW at 4000 rpm	N/A
Torque	155.9 Nm at 2200 rpm	N/A
Gear system	Automotive transmission	working

#### V. CONCLUSION

Since the system allows users for remote control, installing various types of equipment at the drawbar or hitches. The medium-sized-multipurpose vehicle will assist farmers from the conventional practice to the new technology of intelligent farming with a powerful engine and practical. These advantages are for both rice farmers and those who are operating agriculture in Thailand.

Nevertheless, the radio link implemented does provide a reliable and communications protocol coupling to the transfer of control data. This research demonstrates that the final solution is achievable where a completely wireless remote system would solve the inconvenience of medium-sized-multipurpose vehicle automatic tracking.

The research team plans to finish the prototype vehicle testing in the actual paddy field concerning future work. Then evaluate its performance associated with the car's running mate, the fuel consumption, the controlling through the application, including the harvest efficiency of the rice harvesting part compared with

the manual labour. The expansion of the experiment results, improving, testing the performance, and promoting this vehicle to be one of machinery in agricultural machines cooperative of local rice organization the Non-Sang district of Nong Bua Lamphu province for instance.

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