Design of Floating Medical Transport Vehicle for Emergency Patients in Thailand Countryside Using Beaglebone Black Controller

Kittinan Noimanee[1], **Suranan Noimanee**[2], and **Wongwit Senavongse**[3],

ABSTRACT

This paper we present a design of floating medical transport vehicle for emergency patients in Thailand countryside before a feed to an ambulance transport which it can float from the non-smooth ground up to the air 80 cm with an automatic position sensitive detector (PSD). Motion control using the embedded BeagleBone Black for floating up from the ground and maximum mobile speeds up to 1-5 km./hr. (adjusted as appropriate). This is a prototype designed for the medical device developed by Thai Biomedical Engineering Association for the movement of emergency patients in places without access roads. Designed to support a patient's weight up to 150 kg. The floating size of 300 cm. with it can accommodate many ambulances. Including a system to prevent the patients from falling and holding the bed to those who are moving to prevent accidents that may occur and may harm patients in this floating medical transport vehicle for emergency patients in Thailand countryside. If we design and completed the prototype tested, it can be fed into the production line. The design of the floating medical transport vehicle for emergency patients in Thailand countryside for emergency patients will make it easier for the staff to the roadless areas to access.

Keywords: Medical Transport, BeagleBone Black, Thai Biomedical Engineering Association, Roadless area.

1. INTRODUCTION

1.1 Patients Transporting

Before taking up floating medical transport vehicle for emergency patients in Thailand countryside for an emergency, the helper must have to know about the patient's mobility. Because of moving the right way is very important for patients. If he/she has experience, knowledge, principles and know how to move the right way. He/she can help the injured survivor. Safe to reduce disabilities or hazards that will occur later. Also, tools and equipment to help with transportation are very important. In this study, my team designed a floating medical transport vehicle for emergency patients in Thailand countryside for patients able to support up to 150 kg of weight that could move in all areas. There is also space for emergency equipment, such as electrocardiogram monitoring, breathing air tanks, saline bags, etc. The patient's transportation before go to the floating medical transport vehicle for emergency patients in Thailand countryside can use one or more helpers to help, but it must be helped properly. If that does not help move was necessary to make his patients have been dangerous. So we introduce the right way such as:

1.1.1 Moving of patients with two helpers.

The first way, to carry and lift is suitable for patients who are not conscious. However, it should not be used in cases of a trunk or broken bones. The second way, sitting on four interlocking catch a stretcher. It is suitable for patients with leg pain, but feels good and can use both arms. The final way, walking support is used in cases where there are no severe injuries or broken bones, and the injured person is still feeling well. How to move: The two helpers use their right hand to hold their left wrist, while the left-hand holds the right hand to one another, allowing the patients to use both arms, leaning on four hands holding the ligaments [1].

Both arms of the patients hugged the helper's neck, then placed the patients on the knee at a stroke, and take a second stand and walk at the same time and patient with three helpers are shown in Figure 1 and Figure 2.

1.1.2 Moving of patients with three helpers.

The first way, hold three helpers together, it is ideal for the patient who is unaware and wants to be carried up in bed or carried narrowly. How to move: The three helpers knee in a kneeling position, all under one's hands and hold the body parts step by step as follows: - First step, the first helper insert both hands under the patient's neck and upper back. The second step, the second helper inserts both hands to the area in the lower back and buttocks of patients. The final step, the third helper put both hands under the legs. The weakest helper should be

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Fig.1:: Patient with two helpers by the right way. (Picture from http://www.wikihow.com/images)

Fig.2:: Patient with three helpers by the right way.

the third person because of the least weight. When lifting patients, all three helpers have to work simultaneously and let one of them order. First step: Raise the patient simultaneously and put it on the knee, from this posture it is suitable for lifting the patient up on an emergency cradle or in bed. But if they were to move, the three helpers would have to support the patient on his side and stand up. The second way, the use of three helpers this way in the case of a patient lying supine. Or lying face down by giving the patient's chin elevated to open the respiratory tract. As follow:-

a. Helper knees side by side one patient, on the other side of helper's knees beside the patient.

b. The first helper must support head and shoulders of a patient, the other hand vice upper back of the patient.

c. The second helper is opposite the first person, with one arm behind the casualty, with one hand in hand, holding the helper's hand, the other on the hip of the patient.

d. The third helper, under the second thigh, under the hips, hands with the second assistant under the hip, and the other hand in the lower leg.

e. The 1st and 2nd hand should be held between the midpoint of the upper body of a patient, and the helper has to give rise to the signal simultaneously.

Fig.3:: Moterlance transport of Bangkok Hospital (Picture from Bangkok Hospital)

1.2 Medical Transport Vehicle in Thailand.

1.2.1 Private Hospital.

Medical transportation of private hospital in Thailand serving existing patients is Bangkok Hospital. They include the following services:

a. Motorlance, use in heavy traffic or location that cannot be reached by ambulance or not a floating medical transport vehicle for emergency patients in Thailand countryside by itself is shown in Figure 3.

b. Regular ambulance, if it is clinically needed is shown in Figure 4.

c. The helicopter, at headquarter (BHQ) certified by European Air Medical Institute (EURAMI) is shown in Figure 5.

1.2.2 Public Hospital.

The emergency medical system in Thailand has been started by Hua Poh Teck Tung which has initiated transportation of bodies without relatives in 1937 and began to transfer patients and emergency casualties in the following year. The Raum Katanyu Foundation has served as the same activities in 1970.

Both Foundation has initiated the emergency medical system that people can access services without discrimination nor specific services. The emergency medical services in Thailand has been developed since then together with the development of the tool and life-saving appliances in the emergency rooms of each hospital, both public and private hospital [2], [3]. Medical transportation of public hospital in Thailand serving existing patients is the National Institute for Emergency Medicine (NIEM). They include the following services: Supported the public hospital around Thailand about medical transportation for the emergency patient. Such as Office of the Permanent Secretary, Ministry of Public Health. Normally, the transport for emergency patients in the countryside areas is difficult, for example, is shown in Figure 6.

This picture is shown elderly patients with diabetic retinopathy and severe physical deficiency of sugar must promptly help in time. So the transportation must be careful. In 10 years later Department of En-

Fig.4:: Ambulance transport to Bangkok Hospital (Picture from Bangkok Hospital)

Fig.5:: Helicopter transport of Bangkok Hospital (Picture from Bangkok Hospital)

gineering, Ministry of Public Health has developed an off-road floating medical transport vehicle for emergency patients in Thailand countryside to replace patient transportation in the countryside is shown in Figure 7. The call name is Off-Road floating medical transport vehicle for emergency patients in Thailand countryside for medical transport.

That floating medical transport vehicle for emergency patients in Thailand countryside includes a safety belt to lay down protected and cushioned bed and a bottle of saline solution. However, it is not possible to solve the problem of transport the patient to a non-smooth location in the countryside of Thailand [3].

Fig.6:: Emergency patient transportation in Thailand countryside present. (Picture from Surin Hospital)

Fig.7:: Floating medical transport vehicle for emergency patients in Thailand countryside off-road model. (Picture from NIEM)

2. STRUCTURE OF FLOATING MEDICAL TRANSPORT VEHICLE FOR EMERGENCY PATIENTS IN THAILAND COUNTRYSIDE CONCEPTION

2.1 General structure of floating medical transport vehicle for emergency patients around Thailand.

Thailand hospital medical transport vehicle for emergency patients in Thailand countryside for emergency patients in present consists of the following: An emergency ambulance bed, whose structure is mostly made of aluminium or stainless steel, can be adjusted in sitting position and adjustable for height adjustment. The standard size of the floating medical transport vehicle for emergency patients in Thailand countryside is 56 cm in width, 190 cm in length and 82 cm in height, and 21.50 cm in floating medical transport vehicle for emergency patients in Thailand countryside. Most are made of aluminium to lighten the floating medical transport vehicle for emergency patients

Fig.8:: Medical transport vehicle for emergency patients in Nakorn Nayok province, Thailand.

Fig.9:: Medical transport vehicle for emergency patients in Thailand countryside.

in Thailand countryside. The case of the mattress of the patient is about 2 inches thick, it is made with a well used best grade waterproof leather upholstery. Floating medical transport vehicle for emergency patients in Thailand countryside are wheelchair 2-wheel rotating and non-rotating 2-wheel size 5-inch, which can be folded legs for ambulance conveniently with bed rails and two straps for a patient. To prevent the patient from falling down to the ground, as shown in Figure 8 and Figure 9. They show the structure of the floating medical transport vehicle for emergency patients in Thailand countryside can not take for the transportation of emergency patients in places without access road, just only can take for the transport in place with a smooth road. This makes it very difficult to transport emergency patients. Also, if the helper does not volunteer, the patient may lose access to medical treatment if the patient's mobility is not properly assisted, thus disrupting the patient's mobility. The emergency is very much. Also, if the helper does not volunteer, the patient's access to treatment may be fatal if the patient's transportation is not properly assisted.

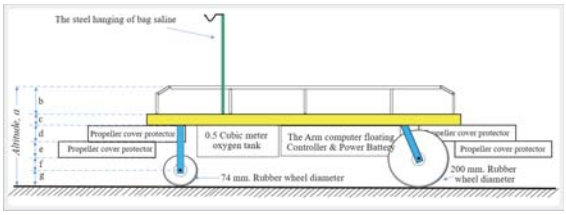


Fig.10:: The altitude of floating medical transport vehicle for emergency patients in Thailand countryside at the ground status

2.2 The design of floating medical transport vehicle for emergency patients in Thailand countryside.

2.2.1 The principle of the floating medical transport vehicle for emergency patients in Thailand countryside:

The principle of the floating medical transport vehicle for emergency patients in Thailand countryside float from the earth up from 50 to 80 cm. the mechanism is a key part of this design. According to the principle of combination type floating mechanism, the height floating adjustment of the floating medical transport vehicle for emergency patients in Thailand countryside is that four high-speed fans and controlled by BeagleBone computer. There is also a pair of handles to control the floating medical transport vehicle for emergency patients in Thailand countryside in the desired direction. There is a space for an oxygen tank of size E or 0.5 cubic meters made of sturdy materials mounted under the floating medical transport vehicle for emergency patients in Thailand countryside. The central brake system is mounted on the headboard and the bed end. It can be braked from a single position and remote to lock the movement of the floating medical transport vehicle for emergency patients in Thailand countryside. It can lock both rotating and be shifting directional floating medical transport vehicle for emergency patients in Thailand countryside. When the back of the bed is raised, the hip support can collapse automatically to prevent the patient from moving to the bottom of the bed. The hip support is flush with the backrest adjustable [4], [5].

Consideration of the altitude of a floating medical transport vehicle for emergency patients in Thailand countryside at the ground status. The relationship between floating altitude component of the floating medical transport vehicle for emergency patients in Thailand countryside consists of the value of b + c + d + e + f + g. Therefore,

$$Altitude = b + c + d + e + f + g \qquad (1)$$

Where

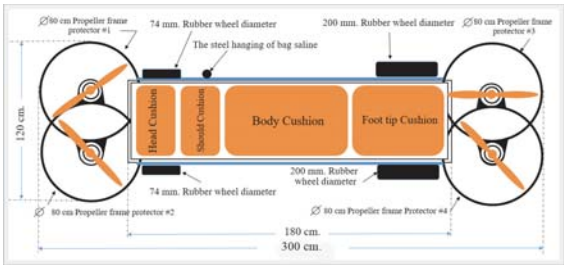


Fig.11:: Top view of floating medical transport vehicle for emergency patients in Thailand countryside designed

b = Rail's height
c = Thickness of the floating medical transport vehicle for emergency patients in Thailand countryside surface and upholstery
d = Thickness of propeller cover protector
e = Thickness of propeller cover protector
f = The height between propeller cover protectors and rubber radius wheel
g = Radius of rubber wheel

The schematic diagram of altitude total mechanisms structural parameters with side view is shown in Figure 10. The values of b are the structural design of the floating medical transport vehicle for emergency patients in Thailand countryside surface and g is determined by the radius of the wheel. We can not change the floating adjustment process, while the parameter g will change with the change of the floating medical transport vehicle for emergency patients in Thailand countryside's altitude, as follows:

$$f' = f + g \tag{2}$$

Figure 11 is a shows the top view of the floating medical transport vehicle for emergency patients in Thailand countryside for an emergency patient which is my designed consists details the following:

a. Four high-speed motors and wood propellers with 80 cm. diameters of four propeller frames protector.

b. The radius of all single propellers is 72 cm/each.

c. The length of the floating medical transport vehicle for emergency patients in Thailand countryside for lay down patients is 180 cm.

d. The total length of the floating medical transport vehicle for emergency patients in Thailand countryside is 300 cm.

e. One pair of 74 mm. and one pair of 200 mm. diameter rubber wheels.

Consider the height of the floating medical transport vehicle for emergency patients in Thailand countryside. If move the both rubber wheel to the top of the vehicle, from equation (2), we have f' equal minimum the altitude of floating medical transport vehicle for emergency patients in Thailand countryside

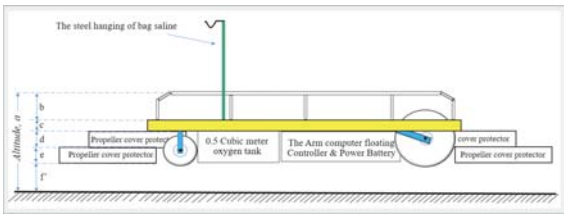


Fig.12:: The altitude of floating medical transport vehicle for emergency patients in Thailand countryside at the ground status.

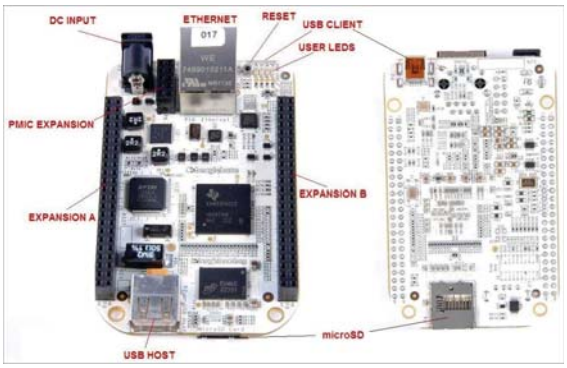


Fig.13:: The BeagleBone Black computer board.

from the ground is shown in Figure 12. We set the height of the floating medical transport vehicle for emergency patients in Thailand countryside floating from the ground (from the top of the floating medical transport vehicle for emergency patients in Thailand countryside) approximately 80 cm, which is equal to the standard height of the patient transport bed.

Therefore, an altitude sensor must be installed underneath the electronics storage box to detect and send the value to the BeagleBone Black computer input port. It will calculate the height of floating medical transport vehicle for emergency patients in Thailand countryside from the ground and send the motor speed control to a reasonable speed in floating. BeagleBone Black computer is a low-cost arm computer that connects to the Internet and runs Android software. With plenty of I/O and processing power for real-time analysis, BeagleBone Black computer can be complemented with hardware plug-in boards which augment BeagleBone Black functionality. We have considered that it is suitable to be used in the motor control of this floating medical transport vehicle for emergency patients in Thailand countryside because it is cheap and stable in operation and the circuit board is shown in Figure 13 [6].

2.2.2 The parameter for given to floating medical transport vehicle for emergency patients in Thailand countryside:

They are consists of, firstly, speed motor and central brake control, secondly, altitude sensors, thirdly, an automatic floating stability control, fourthly, non-smooth ground surface detection with four sonar sen-

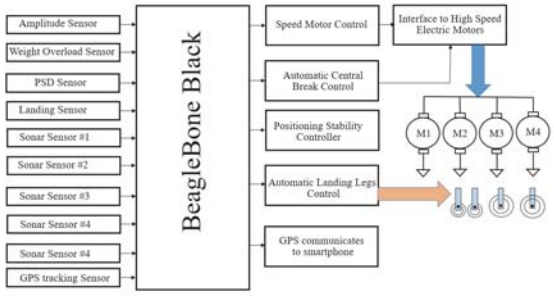


Fig.14: The flowchart of the control system for the automatic floating of floating medical transport vehicle for emergency patients in Thailand countryside.

sors, then position sensitive detector sensor (PSD) and then GPS sensor for tracking the patient's position. Therefore, we can write the block diagram of this work in is shown in Figure 14. it is my design of floating medical transport vehicle for emergency patients in Thailand countryside for emergency patients in Thailand countryside controller which using BeagleBone Black is the hardware and Android are the operating systems for control the following:

a. Automatic altitude of the floating medical transport vehicle for emergency patients in Thailand countryside sensor.

b. Weight overload of floating medical transport vehicle for emergency patients in Thailand countryside sensor.

c. Position Sensitive Detector sensor (PSD).

d. Automatic landing sensor.

e. Four sonar sensors for non-smooth ground detection.

f. GPS tracking sensor.

We can set the parameter of program command for controlling the floating medical transport vehicle for emergency patients in Thailand countryside consists of 25 variables is shown in command table in Figure 15.

2.2.3 Characteristic of BeagleBone Black which uses in this design:

We consider the use of it as if it is a version of the BeagleBone White is suitable for general control or the Blue version is suitable for robot control and the Black version is suitable for controlling Hover drone etc. The features required for this floating medical transport vehicle for emergency patients in Thailand countryside design includes:

a. 1GHz ARM A8 CPU
b. 2 x 200 MHz 32-bits PRUs
c. 512 MB RAM
d. 4 GB eMMC w/Debian
e. Micro SD card slot.
f. USB host and client
g. IEEE802.11 bgn & Bluetooth
h. Four DC motor drivers
i. 8 x Servo/ESC motor output
j. 9 axis 1MU+Barometer

No.	Command	Code	Parameter
1	Enable input sensors	0x00	<id>
2	Disable input sensors	0x01	<id>
3	Get input voltage	0x02	N/A
4	Get Active/deactive status	0x03	N/A
5	Get altitude max in used	0x04	N/A
6	Get altitude min in used	0x05	N/A
7	Get temperature	0x06	N/A
8	Get IP address	0x07	N/A
9	IP address setting	0x08	<ip>
10	Factory reset	0x09	N/A
11	Get MAC address	0x0A	N/A
12	Get GPS positioning status	0x0B	<id>
13	Get patient name	0x0C	N/A
14	Vehicle name setting	0x0D	<name_utf-8_char_code>
15	Firmware version setting	0x0E	N/A
16	Firmware download	0x0F	N/A
17	Firmware upload	0x10	<data>
18	Get max motor speed	0x11	N/A
19	Get min motor speed	0x12	N/A
20	Get Location	0x13	<name_utf-8_char_code>
21	Set Location	0x14	<data>
22	Set Weight load max in use	0x15	N/A
23	Set Weight load min in use	0x16	N/A
24	Set Auto Landing	0x17	<data>
25	Set Central Break Control	0x18	<data>

Fig.15: The parameter of BeagleBone Black.

k. Board size 3.4 inch x 2.1 inch

2.2.4 Determine the load of floating medical transport vehicle for emergency patients in Thailand countryside using Finite Element Analysis (FEA):

This design requires that the floating medical transport vehicle for emergency patients in Thailand countryside can float more than the weight of 150Kg that is 1,410N. To improve security and reliability of floating, this work assumes that a patient emergency lies in one place and all his/her weight distributes in 10 nodes of the floating medical transport vehicle for emergency patients in Thailand countryside frame in the middle of the floating medical transport vehicle for emergency patients in Thailand countryside, each node can stand the force Fi =1410/10=141N. Thus, it establishes a complete finite element model are two states, as is shown in Figure 16(a) and (b)

Force equals mass time acceleration. Weight is a force and it can replace force in the equation. The acceleration would be gravity, which is an acceleration.

$$F(force) = \quad m \times a.....Newton \tag{3}$$

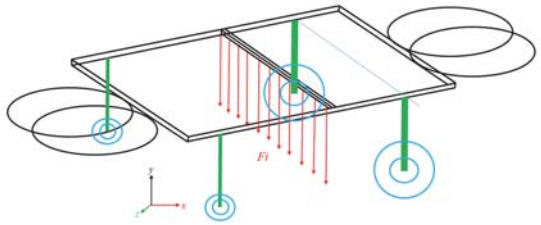
$$Fw(weight) \quad = \quad m \times gravity(9.8m/s^2) \tag{4}$$

$$\begin{aligned} \therefore Fw \quad &= \quad m \times g \\ &= \quad m \times 9.8m/s^2 \end{aligned} \tag{5}$$

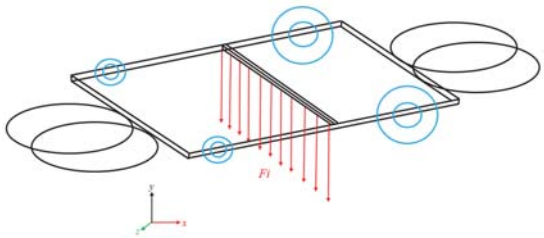
Therefore change 150 kg.(Mass) to Newton (weight).

$$Fw \quad = \quad 150 \times 9.8 \quad = \quad 1,410N$$

We use FEA for analysis this work because the majority of design components are made of metal, so most FEA calculations involve metallic components.



(a)



(b)

Fig.16:: The finite element node of the ground-adjustable floating medical transport vehicle at the floating state.

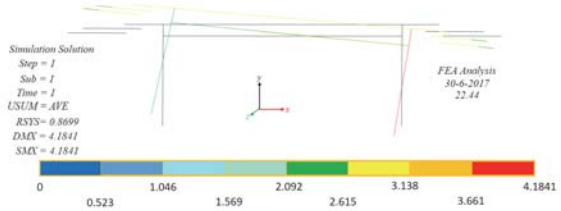


Fig.17:: The solution of displacement deformation figure of the floating-adjustable medical transport vehicle at the 80 cm. float from the ground.

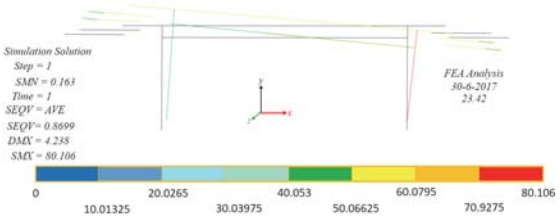


Fig.18:: The equivalent of floating.

The analysis of metal components can be carried out by either linear or nonlinear stress analysis. Which analysis approach you use depends on how far you want to push the design. If we want to ensure the geometry of floating medical transport vehicle for emergency patients in Thailand countryside remains in the linear elastic range (that is, once the load is removed, the component returns to its original shape). If we want to an analysis of plastic or rubber which is nonmetallic, we have to carry out using nonlinear stress analysis methods. When the simulation is used by FEA methods to analysis the force and stresses displacement in our a workpiece due to operational loads such as force, weight overload, an altitude of floating medical transport vehicle for emergency patients in Thailand countryside floating, temperature, accelerations, and mass etc.

3. RESULT

The results were that a prototype of floating medical transport vehicle for emergency patients in Thailand countryside design by my researcher teams using special software which is the standard size to feed to an ambulance in Thailand countryside that can use every location. In this simulation, we take from the simple equation and use Finite Element Analysis (FEA) for calculated the structure of them. Our design according to the finite element model at the two states in figure 17, this work is running to solve using the FEA and obtains the result through the post-processing: the altitude deformation figure of the height from the ground-adjustable medical transport vehicle at the highest and lowest state is shown in Figure 18.

The displacement deformation figure of altitude-adjustable medical transport vehicle at 80 cm. from the ground is stable around 80%. The displacement deformation figure of altitude-adjustable medical transport vehicle at 80 cm. from the ground is deformed about 20% the reason of the number of DMX and SMX from FEA is 4.1841.

At the floating state, the maximum displacement deformation occurs in the left frame, the value of deformation $y_{max} = 4.1841$ mm is very small, which meets maximum displacement deformation when the floating requirement. The maximum equivalent floating $\sum_{eq\max} = 80.106$ cm. occurs at the weld node near the middle of the vehicle frame.

4. CONCLUSION

This paper has designed a new floating medical transport vehicle for emergency patients in Thailand countryside for emergency patients in Thailand countryside and then a comprehensive Finite Element Analysis (FEA) has been conducted using special software on this transport vehicle for emergency patients in Thailand countryside. The results of the simulation analysis have shown that this design found that the reliability and stability of floating medical transport vehicle for emergency patients in Thailand countryside requirements, verifying the rationality of this structured design. The way of using special software to conduct a floating medical transport vehicle for emergency patients in Thailand countryside analysis and check for designing work is simple, practical, high efficient, highly shorting the production cycle and reducing the research and development costs. This method is worthy of the further extension.

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