

MOBILE ARTILLERY SYSTEM

Field of the invention

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The present invention relates to a self-propelled mobile system. Although for convenience, the description describes such a system that includes an artillery gun, such as a howitzer, mounted onto a vehicular platform for rapid deployment in the battlefield, it should be appreciated that the invention need not include such an artillery gun. In particular, the system is lightweight and maneuverable.

Background of the invention

15 The emerging trend in today's battlefield is to employ a rapid deployment force, which is lighter, more lethal and less dependent on logistic tails. A highly agile and capable force must be sufficiently versatile to sustain a high operating tempo and defeat the opponent with minimum losses. They must then quickly re-position, re-focus and execute subsequent missions against
20 an opponent by employing asymmetric means.

Currently, artillery support brigades operate large artillery weapons, such as howitzers which are towed. These howitzers are not integrated with the vehicles by which they are towed but may have auxiliary power units that
25 are capable of propelling them to a maximum speed of about 20 km/h on paved roads and half that speed off-road. An example of such a system is the 155mm/52 calibre FH2000 self propelled howitzer, which consists of a howitzer mounted with an auxiliary power unit (APU). These howitzer systems are relatively heavy and may need to be supported by a tow
30 vehicle and ammunition supply train during long-distance operations. The main problem with such equipment is its limited maneuverability, which

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largely depends on the tow vehicle and the ability of the logistics support train to re-equip. Loading onto fixed-wing aircraft is also difficult due to its weight and bulk and/or the need for it to be towed into the aircraft. Other howitzer systems may be tracked, but these are unable to attain high speeds of say, up to 80 km/h and are not capable of being airlifted.

In today's battlefield, the lack of mobility can well mean a lower survival probability, as shoot and scoot capability is important. It is with this motivation that the present invention of a lightweight self-propelled howitzer was conceptualized.

Summary of the invention

It is an object of the present invention to provide a field artillery system that has improved firepower, in terms lethality and accuracy.

It is another object of the invention to provide a field artillery system that is mobile, both strategically and tactically, whether in the air or on the ground.

It is also an object of this invention to provide a field artillery system that has improved survivability in the field of operations and which requires minimal logistics support.

According to one aspect of the present invention, there is provided a self-propelled mobile artillery system characterized by a lightweight space frame chassis on which is mounted a large caliber artillery piece.

An artillery system in accordance with the invention has the advantage that it is lighter, faster and more maneuverable than existing long range artillery systems such as those discussed above.

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Preferably, the weight of the system is less than 8,000kg, and the artillery piece has a caliber of up to 155 mm 52 calibre. Furthermore, it is advantageous for the artillery piece to have a firing system which includes an elevating and traversing mass and gun chassis mounted on the space
5 frame vehicle having a weight which does not exceed 3,800 kg.

In the preferred embodiment, the system includes dual-purpose hydro-pneumatic cylinders which provide suspension damping of the rear wheels and also are operable to move the rear wheels away from the ground for
10 firing of the artillery piece. This has the advantage that stability of the system is improved during firing. The stability may be further improved by provision of retractable outriggers built at the rear of the gun chassis, each of which has a spade on its free end, the outriggers being operable to engage the ground with the spades embedded therein upon firing of the
15 artillery piece. This will result in the transfer of most of the recoil load to the ground.

Front wheels of the system are preferably mounted on the chassis by means of a multi-link independent suspension system. Advantageously,
20 each such suspension system includes a hydro-pneumatic strut, which preferably utilizes nitrogen gas as a spring and hydraulic fluid as a damper, connected to a suspension arm which not only absorbs both shock and vibrations from the front wheels which arise during transit of the system and counter-recoil forces which arise during firing of the artillery piece, but also
25 can have their length adjusted to vary the ride height of the system. This has the advantage that the ground clearance of the chassis can be adjusted to suit the particular terrain over which it is traveling and also to enable it to be loaded more easily onto transport vehicles such as fixed or rotary wing aircraft. A lower gun elevation can also be attained to enable the gun to fire
30 at a lower elevation angle. This will contribute to the direct fire capability of the gun.

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The drive of the system is preferably provided by a turbo-charged inter-cooled diesel engine which is coupled to a hydromechanical transmission. One drive line, preferably the rear wheel drive, may then be effected by use
5 of radial piston in-hub motors in the rear wheels, which have the advantage that they provide good spatial configuration for mounting the weapon platform and allow the weapon recoil force to be fully transferred to the ground. As a result, there is a smaller overall loading on the vehicle structure so that further weight saving is possible.

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Front wheel drive may also be provided by means of a hydromechanical gearbox which drives the front wheels. A microprocessor may also then be provided to enable drive modes to be switched between front wheel drive, rear wheel drive and four wheel drive modes to suit the particular terrain
15 and circumstances.

Other improvements and advantages of the invention will become apparent from the specific embodiment described below.

20 It will be convenient to hereinafter describe an embodiment of the present invention with reference to the accompanying drawings which illustrate one form of a mobile artillery system incorporating the invention. It is to be understood that the particularity of the drawings and the related description is not to be understood as superseding the generality of the broad
25 description of the invention as defined in the claims.

Brief description of the drawings

Figure 1 is a perspective view of a mobile artillery system according to one
30 embodiment of the invention.

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Figure 1a is a perspective view of only the space frame of the mobile artillery system of Figure 1 with all the other parts removed.

5 Figure 2 is a side view of the mobile artillery system looking from position A of Figure 1.

Figure 3 is a side perspective view of the mobile artillery system of Figure 1.

10 Figure 4 is a side view of the mobile artillery system, including shock isolators.

Figures 5a to 5c illustrate the travelling positions of the rear wheels of the mobile artillery system from an extended to a fully retracted position.

15 Figure 6 is a side view of the mobile artillery system illustrating the suspension system.

20 Figure 7 is an enlarged view of the suspension system of the mobile artillery system.

Figure 8 is a schematic diagram illustrating the various components of the drive mechanism of the mobile artillery system.

25 Figure 9 is a diagrammatical representation of the components of a hydromechanical transmission comprising a mechanical transmission and hydrostatic transmission used in one embodiment of the invention.

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Detailed description of the preferred embodiment

Incorporation of a space frame chassis

5 Figure 1 is a perspective view of a mobile artillery system according to one embodiment of the invention. The system includes a light weight vehicle 10 with a chassis 12 that comprises primarily of a space frame structure 14. The space frame structure can be more clearly seen from Figure 1a, wherein all the other parts of the mobile artillery system have been
10 removed. The space frame 14 requires less material to manufacture and makes the whole structure light-weight. The lightweight space frame design makes the complete system both air-portable and heli-portable. The design of the space frame 14 can thus be relatively light but achieve both structural and dynamic rigidity. The space frame 14 not only has to carry the
15 intended payload, but can also withstand the stress and fatigue from prolonged travelling on off-road terrain.

The space frame 14 of the vehicle 10 is reinforced at the points where the load is being transferred. The members of the space frame 14 are
20 positioned to achieve maximum torsional and structural rigidity. The vehicle may be powered by a 125kW turbo-charged intercooled diesel engine. The engine and necessary transmission lines are held on the vehicle chassis 12 via the space frame 14. This is to reduce the weight of the complete system.

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The chassis 12 has front wheels 16 and rear wheels 17 mounted to it, and a driver compartment 18 towards the front of the vehicle 10 for steering the vehicle. A compartment for ammunition storage 20 may be incorporated to
the chassis 12.

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Mounted on top of the vehicle chassis 12 and integrated with the vehicle chassis 12 is a weapons system including a howitzer gun 22, supported by a cradle 24 and saddle 26. The howitzer gun 22 includes a barrel 28 and muzzle brake 30. A barrel clamp 32 clamps the barrel 28 to the space frame 14 when the howitzer gun 22 is not in use.

At the rear of the vehicle, a pair of outriggers 34 are mounted for stabilising the system structure during firing. The outriggers 34 are movable and retractable using hydraulic pistons (not shown) such that they may be raised in the position shown or lowered to engage the ground when in the firing position.

In order to preserve the integrity of the lightweight space frame structure 14, the recoil force is isolated by means of shock isolators 36 positioned between the gun chassis and the vehicle structure. They can also dampen vibration when the vehicle is travelling from point to point. The shock isolators are sized and mounted onto the space frame structure 14 by four mounting brackets. These mounting brackets are preferably welded onto the space frame 14 as shown in Figures 3 and 4. Two shafts (not shown) run the length of the gun chassis through the holes of the shock isolators 36. The vehicle chassis 12 will then be supported by these shock isolators which help to reduce the amount of force that is being transmitted to the space frame structure 14. During firing, the recoil load is transmitted from the trunnion to the gun chassis, shock isolator shafts and finally to the shock isolator 36. The shock isolators 36 serve to isolate the firing load that is being transmitted to the space frame 14, thereby protecting it from damage. Figures 3 and 4 show only one embodiment of the shock isolators 36 and the mounting brackets mounted to the space frame. It should be apparent that other embodiments are possible, wherein the firing load is transmitted to the space frame 14. As such the vehicle structure can be

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optimized to be as light as possible and yet able to handle the tremendous firing load.

5 In addition, roll-over bars 38 are designed to surround the driver compartment 38 to protect the driver and passengers in the event the vehicle rolls over, for example in undulating terrain. Each outrigger 34 has a spade structure 35 at its end. The spade structure 35 is self-embedding once the outrigger 34 is lowered by the hydraulic pistons. The embedding of the spade structure 35 enhances the stability of the howitzer gun 22 once
10 deployed to be fixed to the ground and enables the first shot to be fired at high accuracy.

Figure 2 is a side view of the mobile artillery system looking from position A of Figure 1. Figure 3 is a side perspective view of the mobile artillery
15 system of Figure 1.

The capability of the system to be both lightweight and attain structural rigidity enhances the effectiveness of the rapid deployment force to respond quickly to an emerging crisis in less time from base to a global theatre of
20 operation. The integrated system offers high ground tactical mobility because of its capability to move rapidly about the battlefield. The howitzer 22 can thus be rapidly deployed to critical areas immediately upon landing so as to exert influence on the battlefield. Likewise, the howitzer 22 has the capability to evacuate from critical areas immediately. In the battlefield,
25 high mobility means higher survival probability. The system, including the howitzer gun 22 also functions as the tow vehicle and logistics train, thus eliminating the dependency on a separate tow vehicle and logistics train.

There are two operating modes of the artillery firing system, the travelling
30 mode and the firing mode. In the travelling mode, the elevation of the gun barrel 28 is kept low and passes through the cab of the vehicle (see Figure

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1). The safety roll-over bar 38 is hinged at both sides of the vehicle. It can be opened up from the midline at the top to allow traversing and elevation of the gun barrel 28 (see Figure 2). In the firing mode, the outriggers 34 are lowered so that the spade structure 35 engages the ground to stabilize the howitzer gun 22 during firing, and the rear wheels 17 are lifted off the ground using trailing arms powered by hydro-pneumatic cylinders (72 in Figures 5a-5c) which function also as a rear wheel suspension. This lowers the rear end of the chassis 12 together with the gun platform to touch the ground.

Rear wheel assembly

Figures 5a to 5c illustrate the travelling positions of the rear wheels from a retracted position wherein the wheels are in contact with the ground, to a fully extended position, wherein the wheels are lifted off the ground.

The rear wheels 17 are mounted onto specially designed wheel arms 70. The wheel arms 70 are pivotally attached to the chassis 12. Alternatively, it could be pivotally attached to the structure of the space frame 14. Adjacent to the point of attachment of the wheel arm 70 to the chassis 12, side hydro-pneumatic struts 72 are pivotally connected to the wheel arms 70. As can be observed, extension and contraction of the side hydro-pneumatic struts 72 result in the raising and lowering of the rear wheels 17 in a leveraged arrangement. Between the side hydro-pneumatic struts 72, a centre hydro-pneumatic strut 74 is positioned to provide an additional force to ensure that the rear wheels 17 are fully raised when the side hydro-pneumatic struts 72 are extended. The side hydro-pneumatic struts 72 and centre hydro-pneumatic strut 74 are interconnected by a portion of the space frame 14.

Figure 5a shows the side hydro-pneumatic struts 72 in a retracted position and the rear wheels 17 lowered to be in contact with the ground. Figure 5b shows the side hydro-pneumatic struts 72 in an extended position such that the rear wheels 17 are rotated counter-clockwise and are raised off the ground. In this position, the rear wheels 17 are still not fully retracted. Figure 5c shows the rear wheels 17 in a fully retracted position. The centre hydro-pneumatic strut 74 has been extended to push the axle 76 further so that the wheel arm 70 is almost horizontal and the rear wheels 17 are brought further towards the front of the vehicle.

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Multi-link suspension system

Figure 6 is a side view of the mobile artillery system giving an overview of the suspension system associated with the front wheels 16. A multi-link suspension 80 is incorporated to the front wheels 16.

Figure 7 is an enlarged view of the multi-link suspension system of the mobile artillery system. The suspension system utilizes a multi-link independent suspension comprising a lower link 82 and an upper link 84 with hydro-pneumatic struts 86 for optimum off-road performance. The front wheel 16 is attached to the front wheel hub 90. The suspension system is designed for three functions. The main function is to damp as well as to absorb the shock that is present from the undulating off-road terrain. The hydro-pneumatic struts 86 may use nitrogen gas as their spring and hydraulic fluid as the damper. Some of the advantages of incorporating the multi-link suspension with the hydro-pneumatic suspension are:

- 1) small space requirement;
- 2) a kinematic or elasto-kinematic toe-in change tending towards understeering;

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- 3) easier steerability with existing drive;
- 4) low weight;
- 5) independence by there being no mutual wheel influence;
- 6) ability to counteract the change of wheel camber due to roll pitch of
5 the vehicle body;
- 7) Higher off-road mobility and speed;
- 8) Larger wheel travel;
- 9) Progressive suspension characteristics allow for high driving speeds
while providing improved comfort for driver and crew.

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The secondary function of the suspension system is to serve as a shock absorber for the counter-recoil force during firing. The gun recoil force during firing causes the front of the vehicle to lift off the ground. A counter-recoil force is usually generated after gun recoil due to a whip-lash effect.

- 15 As the counter-recoil force is tremendous, the suspension at the front of the vehicle has to be sized to absorb and damp the shock so as to prevent damage to the vehicle instrumentation and other systems on-board.

- 20 The third function of the suspension system is to provide height adjustment control of the vehicle. This is accomplished by depressurizing the fluid in the cylinders of the hydro-pneumatic struts 86 by means of relief valves (not shown) that are incorporated into the cylinders and thus allow the cylinders to be compressed. The reason for allowing the height adjustment is to enable the howitzer gun 22 to fire at a lower elevation angle. This will
25 contribute to the direct fire capability of the gun. The height adjustment control will also provide more height clearance in situations where lower height is required, eg. when the vehicle is loaded onto a C-130 airplane.

- 30 It should be appreciated that hydro-pneumatic struts using hydro-pneumatic cylinders can also be added to the rear suspension. One advantage of

doing so is that the height of the rear of the vehicle is adjustable. This will be very useful for clearing obstacles or difficult terrain.

Hydraulic drive system

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Figure 8 is a schematic diagram illustrating the various components of the driving mechanism of the mobile artillery system. The system includes a turbo-charged inter-cooled diesel engine 100 which is coupled to a rear pump 102, auxiliary pump 104 and steering/brake pump 106. The rear pump 102 is operatively connected to a manifold 120 and to radial in-hub motors 112 towards the rear of the vehicle via fluid drivelines.

There is a switch on the driver's instrumental panel (not shown) which allows the driver of the vehicle to select between front wheel drive mode (on-road), four-wheel drive mode (off-road) and automatic mode. Front wheel drive mode allows the vehicle to travel on roads at higher speeds. Four-wheel drive mode allows the vehicle to travel off-road up to a maximum speed of about 25 km/h, depending on the hydraulic radial piston in-hub motor. The automatic mode allows the vehicle to travel in a mixed configuration of four wheel drive and two wheel drive depending on the speed of the vehicle. A vehicle speed below 25 km/h will have a four wheel drive configuration while a speed above 25 km/h will have a two wheel drive configuration. The switching of these two modes is controlled automatically by a microprocessor 122. The turbo-charged diesel engine 100 drives a hydromechanical transmission 108 comprising 2 shafts: 1) a hydrostatic transmission and 2) a mechanical transmission. The hydromechanical transmission is connected to a differential 110 which drive propeller shafts 18 to which the front wheels 16 are attached.

The input from the engine is split by using two gears (not shown). The hydrostatic transmission consists of a variable displacement pump which is

closely coupled to a fixed displacement motor or variable displacement motor. The mechanical transmission consists of a set of planetary gears and a clutch. The purpose of the clutch is to engage and disengage the hydrostatic and mechanical modes.

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The hydrostatic transmission and mechanical transmission will now be described with reference to Figure 9. In the hydrostatic transmission, when the engine flywheel rotates a gear G1 in the clockwise direction (as seen from the engine), another gear G2 will rotate in the anti-clockwise direction.

10 The rotation will be transmitted via a shaft S1 to a gear G3. A shaft S2 will drive the input of hydrostatic transmission (pump) and the output will be shaft S3 (from the motor). The torque from the motor will subsequently be transmitted to gear G8 by gear G4. The direction of Gear G8 is the same as the engine rotation. The speed of the hydrostatic transmission can be
15 varied by adjusting the swash plate in the variable displacement pump. As the angle of the swash plate in the pump is increased, more flow results and the motor will turn faster. This will increase the speed of gear G4 and eventually to the output speed N_o .

20 In the mechanical transmission, rotation of gear G5 is effected by gear G3. Gear G5 rotates the shaft S4 in the same direction. Shaft S4 is directly connected to the planetary carrier. The rotation of the planetary carrier will cause all the planetary gears G6 to rotate. Since the sun gear G7 is in direct contact with the planetary gears, the sun gear will also rotate together
25 with the planetary gears, which will in turn cause the shaft S5 to rotate in the same direction. With the clutch engaged (hydromechanical mode), this rotation will be transmitted to gear G8 via shaft S6. Gear G8 will then rotate gear G9 via a shaft. The rotation from the gear G9 will be transmitted to the ring gear, which will eventually cause the output shaft to the differential to
30 rotate at the speed of N_o .

There are three different drive modes: i) the hydrostatic mode whereby the swashplate is varied to cause the motor to rotate with the clutch disengaged; ii) the hydromechanical mode whereby the swashplate is varied and the clutch is disengaged; iii) the swashplate is at zero displacement (no flow to the motor) and the clutch is engaged (fully mechanical).

The front wheels 16 are steerable via a steering system 116 and steering pump 106. The rear pump 102 also transmits power to a pair of in-hub radial piston motors 112, each of which drives a rear wheel 17. A brake pump 106 is operatively connected to brake callipers 112 which control brake discs 114 at the front and rear wheels 16,17. The components of the system are generally controlled by a microprocessor 122.

The use of the radial piston in-hub motors 112 provide good spatial configuration for the mounting of the weapon platform and allow the weapon recoil force to be fully transferred to the ground through an integrated firing platform. Due to this design, there are fewer requirements on the strength of the space frame 14, thus allowing for weight savings.

The vehicle can move at up to speeds of 80 km/h on 4 x 2 drive (front wheel drive) on paved roads and the two rear wheels 17 can be activated for 4 x 4 drive off-road. The vehicle is capable of being deployed and displaced within 30 seconds to 1 minute. It can move 500 meters within 30 seconds and can be ready for firing in less than 30 seconds from the deployed position.

During highway travelling, the hydromechanical transmission is used to drive the front wheels 16 while the rear radial piston motors 112 are allowed to freewheel. During off-road travelling, all the four wheels 16,17 are activated to optimize wheel traction.

The extensive application of lightweight materials such as titanium alloys further helps to reduce the weight of the whole system and enhance its operational mobility.

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While a particular embodiment of the invention has been shown and described, it will be appreciated by those skilled in the art that changes and modifications of the present invention may be made without departing from the invention in broadest aspects. As such, the scope of the invention
10 should not be limited by the particular embodiment and specific construction described herein but should be defined by the appended claims and equivalents thereof. Accordingly, the aim in the appended claims is to cover all such changes and modifications as fall within the spirit and scope of the invention.

Claims

1. A self-propelled mobile system, characterised by a
5 lightweight space frame chassis on which is mounted a large calibre
artillery piece.
2. A self-propelled mobile system as claimed in claim 1,
wherein the weight of the system is less than 8,000 kg.
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3. A self-propelled mobile system as claimed in claim 1 or claim 2,
wherein the artillery piece has a calibre of up to a 155 mm 52 calibre gun.
4. A self-propelled mobile system as claimed in any of the
15 preceding claims, wherein the artillery piece has a firing system which
includes a lightweight elevating and traversing mass and gun chassis
mounted on the space frame vehicle, said vehicle having a weight
which does not exceed 3,800 kg.
- 20 5. A self-propelled mobile system as claimed in any of the
preceding claims, wherein the chassis includes a cradle and saddle
for supporting the artillery piece.
6. A self-propelled mobile system as claimed in any of the
25 preceding claims, wherein the artillery piece is a howitzer gun which
includes a barrel.
7. A self-propelled mobile system as claimed in any of the
preceding claims, further including a barrel clamp for clamping the

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barrel of the artillery piece to the space frame chassis when the artillery piece is not in use.

8. A self-propelled mobile system as claimed in any of the preceding claims, further including at least one retractable outrigger built at the end of the system opposite to the direction of firing of the artillery piece, the or each outrigger in a first extended position engaging the ground to stabilise the system during firing of the artillery piece against the recoil thereof, and in a second retracted position being raised clear of the ground to facilitate transit of the system over rough terrain.

9. A self-propelled mobile system as claimed in claim 8, wherein two outriggers are mounted on the chassis and are each pivotally movable between said extended and retracted positions by means of hydraulic pistons.

10. A self-propelled mobile system as claimed in claim 8 or claim 9, wherein the or each outrigger carries a spade structure on its free end which embeds in the ground in the extended position to enhance the stability of the artillery piece during firing.

11. A self-propelled mobile system as claimed in any of the preceding claims, further including at least one shock isolator for damping out shock and vibration during transit of the vehicle and during firing of the artillery piece.

12. A self-propelled mobile system as claimed in claim 15, wherein the or each shock isolator is mounted on mounting brackets which are mounted to the space frame chassis, further including at least one shaft

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which runs the length of the chassis of the artillery piece and through holes in the shock isolators, whereby, during firing of the artillery piece, a recoil load is transmitted through the or each isolator shaft to the or each shock isolator, which, in turn, isolate the firing load from the space frame.

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13. A self-propelled mobile system as claimed in any of the preceding claims, further including wheel arms pivotally attached to the back of the gun chassis or spaceframe on which are carried rear wheels of the system.

10 14. A self-propelled mobile system as claimed in claim 13, further including hydro-pneumatic struts which are pivotally attached to said wheel arms at a position offset from the point of attachment of each wheel arm to the chassis, wherein extension and retractions of said hydro-pneumatic struts effects rotation of the wheel arms relative
15 to the chassis so as to effect movement of the rear wheels.

15. A self-propelled mobile system as claimed in claim 14, wherein in a retracted position of the hydro-pneumatic struts the wheels arms extends downwards and rearwards from their pivot point
20 with the chassis such that the rear wheels are in contact with the ground for transit of the system, in an intermediate position of the hydro-pneumatic struts the wheel arms are rotated so as to extend substantially vertically upwards from their pivot point with the gun chassis such that the rear wheels are lifted off the ground, and in a
25 fully extended position of the hydro-pneumatic struts the wheel arms extend generally forward from their pivot point with the chassis such that the rear wheels are brought further forwards for firing of the artillery piece.

16. A self-propelled mobile system as claimed in claim 14 or claim 15, wherein a wheel arm is provided on each side of the gun chassis or spaceframe to each of which is connected one hydro-pneumatic strut, and a third centre hydro-pneumatic strut is provided
5 between said wheel arms which is connected a pivot axel of the wheel arms so as to provide additional force for moving said wheel arms.

17. A self-propelled mobile system as claimed in any of claims
10 14 to 16, wherein the hydro-pneumatic struts also operate to dampen vibration from the rear wheels during transit of the system.

18. A self-propelled mobile system characterised by a lightweight space frame chassis, wherein front wheels of the system
15 are connected to the chassis by means of an independent multi-link suspension system.

19. A self-propelled mobile system as claimed in claim 18, wherein the suspension system for each front wheel includes an
20 upper suspension arm, one end of which is pivotally attached to the chassis and the other end of which is pivotally attached to the top of an upright of the front wheel assembly, a lower suspension arm, one end of which is pivotally attached to the chassis below the pivot axis of the upper arm and the other end of which is pivotally attached to
25 the bottom of the upright of the front wheel assembly, thereby forming a multi-linkage suspension system.

20. A self-propelled mobile system as claimed in claim 19, further including a hydro-pneumatic strut connected to at least one of

the upper and lower suspension arms for absorbing vibrations from the front wheels as well as to absorb counter-recoil forces during firing of the artillery piece.

5 21. A self-propelled mobile system as claimed in claim 20, wherein the hydro-pneumatic strut utilises nitrogen gas as a spring and hydraulic fluid as a damper.

22. A self-propelled mobile system as claimed in claim 20 or
10 claim 21, wherein the length of each hydro-pneumatic strut is adjustable to enable height adjustment of the system.

23. A self-propelled mobile system as claimed in claim 22,
15 wherein each hydro-pneumatic strut includes at least one pressure relief valve for depressurising the fluid in the cylinders thereof for adjusting the height of the system.

24. A self-propelled mobile system characterised by a
lightweight space frame chassis, wherein the space frame chassis
20 includes a driver compartment having hinged roll-over bars which are movable between a first position in which they overlie the driver compartment to protect occupants from injury in the event of roll over of the vehicle, and a second position in which they are rotated away from the top of the driver compartment so as to enable elevation of
25 the artillery piece to be increased for firing.

25. A self-propelled mobile system characterised by a
lightweight space frame chassis, further including a hydraulic drive
system comprising radial piston in-hub motors which drive the rear

wheels of the system and a hydromechanical transmission comprising a hydrostatic transmission and a mechanical transmission to drive the front wheels.

5 26. A self-propelled mobile system as claimed in claim 29, wherein the hydromechanical transmission includes a hydrostatic mode whereby a swashplate is varied to cause a motor to rotate with a clutch disengaged, a hydromechanical mode whereby the swashplate is varied and the clutch is disengaged, and a fully
10 mechanical mode whereby the clutch is engaged.

27. A self-propelled mobile system as claimed in claim 26, further including a switch to switch the system between the modes of two or more of: front wheel drive, four-wheel drive and automatic
15 drive.

28. A self-propelled mobile system as claimed in any one of claims 18 to 27, on which is mounted a large calibre artillery piece.