

Determination of a Fire control solution of an Artillery Weapon

The present invention relates to methods for determining a fire control solution of an artillery weapon in indirect ballistic fire to hit a target. Further objects of the invention are a fire control system for determining a fire control solution of an artillery weapon in indirect ballistic fire to hit a target and an artillery weapon system with an artillery weapon for combating a target in indirect ballistic fire.

In order to hit a target with a ballistic projectile of a weapon reliably and precisely over long distances, as is common in the use of weapon systems with large-caliber weapons, and thus to be able to fight successfully, it is necessary to describe the movement of the projectile depending on the orientation of the weapon. For this purpose, a fire control equation is used, which, following its solution, provides a fire control solution according to which the weapon can be aimed in order to be able to combat the target. To solve the fire control equation, a fire control system is usually used, which enables an automated determination of the fire control solution.

Among weapon systems with large-caliber weapons, which are aimed using fire control solutions, artillery weapon systems have one of the most important support functions in modern military conflicts. As flexibly deployable systems, these can be used both offensively and defensively. The precision of the artillery weapons of such artillery weapon systems has increased significantly in the past. Modern weapon systems enable the use of state-of-the-art ammunition and improved fire control technology to achieve high accuracy due to their high manufacturing quality. Above all, this makes it possible to minimize collateral damage and avoid endangering one's own or allied forces.

In contrast to direct-firing weapons, combating a target with artillery weapons takes place in indirect ballistic fire. In this case, the ballistic projectile is fired by the artillery weapon in the lower or upper angle group, i.e. with an elevation angle of up to 65° , which is also referred to as steep fire. While in direct-firing weapons there is a direct line of sight between the weapon and the target, so that the target can be seen from the weapon and detected directly relative to it in the coordinate system of the direct-firing weapon, such a direct line of sight is not present with artillery weapons.

Looking from the artillery weapon, the target is rather obscured by visual obstacles or due to the great distance by the curvature of the earth. In connection with artillery weapons, therefore, the term "non-line-of-sight" is also used .

- 5 With the current artillery weapons, in a stationary firing position, i.e. from a non-changing weapon position, it is only possible to determine a fire control solution to fire at an equally static target at its target position. Assuming the stationary firing position requires a considerable amount of time for the transition from moving to stationary, unlash and aiming the weapon, firing, resuming the transport position, 10 lashing down and finally resuming the journey. Throughout this process, the weapon itself forms a simple static target. The artillery weapon and its crew are therefore exposed to the threat of return enemy fire, significantly reducing its survivability.

The o b j e c t of the present invention is therefore to increase the survivability of 15 the artillery weapon and its operating crew, in particular during a fire fight in which the weapon shoots at a target and is itself exposed to return fire.

This object is a c h i e v e d with a method of the type mentioned above by taking into account a changing weapon position of the weapon and a target position of the 20 target as geographical position data.

By taking into account the changing weapon position of the weapon and the target position as geographic position data, it is possible to hit the target as the weapon moves in the terrain, thus changing the weapon position. This can also maximize the 25 mobility of the weapon during a firefight and increase survivability, as a moving weapon is harder to reconnoiter and hit. The risk of a hit by enemy return fire is reduced because the protective moment of the weapon's own movement can be maintained even during firing. Such a possibility of indirect ballistic fire with an artillery weapon while moving has so far been classified in expert circles as technically un- 30 feasible. By taking into account the changing weapon position as well as the target position as geographical position data, which are not affected by the positions and locations of the weapon and the target relative to each other, it is possible to determine a fire control solution despite the movement of the weapon and the lack of a direct line of sight connecting the weapon and the target.

The fire control solution is determined while taking into account the changing weapon position and the target position of the target as geographic position data.

- 5 The geographical position data can be detected in the form of geographical coordinates, for example in the form of latitude and longitude.

The fire control solution can be determined during movement of the weapon. The preparation of indirect firing while moving can also be done in this way while moving. The ability of indirect firing while moving can lead to a reduction in the reaction time between the receipt of a firing task via a command system and implementation of the firing task in the context of an adapted firing command after the determination of the fire control solution in combination with a minimized vulnerability of the weapon.

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Preferably, at least one absolute parameter independent of the relative position and/or relative location of the weapon and the target is taken into account. By taking into account an absolute parameter, it is possible to take into account parameters which influence the fire control solution and which are independent of the relative position and/or relative location of the weapon and the target to each other when determining the fire control solution. The at least one absolute parameter can be determined in an absolute coordinate system which is not dependent on the position of the weapon and/or the target or can be determined as a value on an absolute scale. Such an absolute parameter can thus be independent of the relative position of the weapon and the target to each other and/or of the relative location of the weapon and the target to each other, i.e. a change in the position and/or location of the weapon in relation to the target just as little effect on it as a change in the position and/or location of the target in relation to the weapon.

30 In this context, it is particularly advantageous if an absolute terrain height of the weapon position, an absolute terrain height of the target position, an absolute time and/or an absolute system parameter of the weapon is taken into account as absolute parameter. The absolute terrain height of the weapon position and/or the target position can be determined as the height difference of the weapon position or the target

position compared to a zero level. To determine the absolute terrain height, for example, topographic map material and/or topographical measuring instruments can be used. In particular, the same zero level may be used when taking into account the absolute terrain height of the weapon and the absolute terrain height of the target position. By taking into account an absolute time, a calculation of parameters flowing into the fire control equation, which are determined at different times, at different locations and/or by different system components, can be carried out in a consistent time relationship. The absolute time can serve as a time standard, which is referred to in the determination of the other parameters included in the fire control equation. In contrast to direct-firing weapons, where transmission and detection times are negligible due to the direct line of sight and the detection at the speed of light, the long distances in indirect ballistic fire of artillery weapons can cause considerable transmission and detection times. The influence of detection times and/or transmission times can be taken into account by means of the absolute time. Parameters existing at the same time, but present at different times due to the detection and/or transmission times, can be synchronized with each other by means of the absolute time and can be used as synchronous parameters for determining the fire control solution. The absolute time can be taken into account as a time stamp for determining the parameters, especially in decentralized system components. The absolute temperature of the propellant, the shape of the projectile, the weight of the projectile, the caliber of the weapon, the rifling profile of the weapon and/or the spin of the weapon can be taken into account as absolute system parameters of the weapon, for example.

In a development of the invention, the motion dynamics of the weapon and the motion dynamics of the target, in particular in absolute coordinates, are taken into account. By taking into account the motion dynamics of the weapon and of the target, a fire control solution for hitting a moving target with a moving artillery weapon with indirect ballistic fire can be determined. The consideration of the motion dynamics makes it possible, in addition to constant, rectilinear movements of the weapon and/or the target, to take into account changes in the speed and direction of movement of the weapon and/or of the target. As limiting cases in which the speed of movement drops to zero, the method can also determine a fire control solution for a moving artillery weapon to hit a stationary target, for a stationary artillery weapon to hit a moving target, and for a stationary artillery weapon to hit a stationary target.

With this method, the functionality of the known determination methods of a fire control solution can be covered, so that this method can not only supplement known determination methods but can completely replace them. By taking into account the motion dynamics of the weapon, the future weapon position that the weapon occupies at the time when a fired projectile leaves the weapon can be determined. By taking into account the motion dynamics of the target, a future target position, which the target is likely to occupy when the projectile hits, can be anticipated. To anticipate the future target position, the movement of the target can be extrapolated from the previously recorded motion dynamics of the target. By taking into account the motion dynamics in absolute coordinates, they can be taken into account independently of the relative position and/or location of the weapon and the target in relation to each other. With the absolute coordinates, the motion dynamics of the weapon and the motion dynamics of the target can be taken into account without being influenced by a change in the target position or the weapon position. The motion dynamics of the weapon and the motion dynamics of the target can each be the movement behavior, in particular the totality of the previously detected movements of the weapon or the target.

In this context, it is particularly advantageous if the motion dynamics are detected in indirectly referenced coordinate systems. The motion dynamics recorded in indirectly referenced coordinate systems can be related to each other without the coordinate system in which a motion dynamics is detected being directly referenced to the coordinate system in which the other motion dynamics is detected. Since there is no line of sight between the weapon and the target in the case of indirect ballistic fire, the coordinate systems of the weapon and the target cannot be directly referenced to each other. By indirectly referencing the coordinate systems via one or more other coordinate systems, the motion dynamics recorded in different coordinate systems can also be related to each other without a direct line of sight, in particular in absolute coordinates.

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When referencing each other, two coordinate systems can be set in relation to each other. Indirect referencing allows two, especially moving, coordinate systems to be related to each other without there being a direct line of sight between them.

A further embodiment provides that a detection system is used to detect the target. The detection system can also allow detection of the target without a direct line of sight between the weapon and the target. The detection system may be a separate system from the weapon and in particular independent of the weapon, such as a satellite, a drone, a UAV, an unmanned ground vehicle, an observation post, a vehicle-based target detection system and/or an infantry target detection system. With the detection system, the target and in particular the target position relative to the detection system can be acquired from a coordinate system bound to the detection system. To detect the target, the detection system may use one or more detection signals. The detection signal can be, for example, radar radiation reflected by the target, infrared radiation emitted by the target or light reflected by the target, with which the detection system can detect the target.

Preferably, the motion dynamics of the detection system are taken into account when determining the fire control solution.

Furthermore, it is advantageous if an absolute detection system position of the detection system is used in indirect referencing of the coordinate systems. Because the detection system position is different from the weapon position, the target's coordinate system can be referenced directly to the coordinate system of the detection system located at the detection system position. The coordinate system of the detection system located at the detection system position can in turn be referenced directly or indirectly via further coordinate systems to the coordinate system of the weapon. In this way, the coordinate system of the target can be indirectly referenced to the coordinate system of the weapon via the coordinate system of the detection system. Similarly, the coordinate system of the weapon can be indirectly referenced to the coordinate system of the target or the coordinate systems of the weapon and the target can be indirectly referenced to another coordinate system.

When referencing the coordinate systems, they can be related to each other in such a way that the positions and directions detected in a first coordinate system can be transformed into the other coordinate system without loss of information. For this purpose, several matching positions, in particular at least three, can be detected from both coordinate systems.

In an advantageous embodiment, the properties of the detection system are taken into account. Properties of the detection system to be taken into account may include, for example, the processing time from reception to forwarding of a detection signal by the detection system to the weapon, the transit time of the detection signal from the target to the detection system, the transit time of a forwarded signal from the detection system to the weapon, the movement of the detection system and/or the motion dynamics of the detection system. By also taking into account the properties of the detection system when determining the fire control solution, the accuracy in determining the fire control solution can be further improved.

In a further embodiment of the invention, at least one artillery-relevant influencing parameter is taken into account, in particular vibration influences of the weapon, vibration influences of a weapon carrier and/or a firing time development. Artillery-relevant influencing parameters can have an influence on the internal ballistics and/or the external ballistics during indirect ballistic fire. The artillery-relevant influencing parameters can be described statistically, in particular the vibration influences of the weapon and/or the vibration influences of the weapon carrier. The weapon carrier can accommodate the weapon as such and can enable its movement in the terrain, wherein the weapon carrier may be a chassis or an armored hull, for example. Together with the weapon, the weapon carrier forms part of a weapon system. During the change of the weapon position, both vibrations of the weapon carrier relative to the surrounding terrain and vibrations of the weapon relative to the weapon carrier can occur. Vibrations of the weapon as well as those of the weapon carrier can affect the fire control solution, wherein it can lead to both constructive and destructive interference of the respective vibrations. By taking into account the vibration influences of the weapon and the vibration influences of the weapon carrier, these interferences can also be taken into account. The consideration of the firing time development, which is the time offset between the ignition of a propellant charge and the muzzle exit of a projectile driven by this propellant charge from the muzzle of the weapon, the acceleration time of the projectile can be taken into account. In addition to the pure acceleration time, the acceleration behavior of the projectile can also be taken into account as another artillery-related influencing parameter.

In this context, it is particularly advantageous if the artillery-relevant influencing parameter, in particular its effect on the fire control solution, is extrapolated. By extrapolating, an indication of the magnitude of this influencing parameter in the future time relevant to determining the fire control solution and in the immediate future can be gained from the previous development of the at least one artillery-relevant influencing parameter.

In an advantageous embodiment, at least one geographical interference parameter is taken into account for determining an interference-contour-free projectile trajectory.

10 In addition to the topography of the terrain, i.e. the height profile of the earth's surface without vegetation and buildings, the geographical interference parameters may also include other natural or artificially constructed geographical structures, such as vegetation or buildings. By determining an interference-contour-free projectile trajectory when determining the fire control solution, it can be ensured that the projectile

15 does not encounter any obstacles, in particular static obstacles, influencing the projectile trajectory during its projectile trajectory from the weapon to the target.

In an advantageous embodiment, geographic interference parameters in the area of the weapon position and in the area of the target position are, in particular exclusively,

20 ly, taken into account for determination of the interference-contour-free projectile trajectory. In this way, an interference-free launch angle of the projectile from the weapon and an interference-free approach angle of the projectile to the target position can be ensured.

25 Furthermore, when determining the interference-contour-free projectile trajectory, the distance between the weapon position and the target position, the projectile flight time and/or the motion dynamics of the target can be additionally taken into account.

Advantageously, terrain modeling between the weapon position and the target position is carried out, in particular continuously. Due to the terrain modeling, which in

30 addition to the topology can also include geographical interference parameters present in the terrain, a model of the terrain that reflects the real conditions can be accessed at any time and for each weapon position. Preferably, the terrain modeling is performed highly dynamically, so that a reliable terrain model can be provided even

with changes in the direction of movement and the speed of movement of the weapon and/or the target. For terrain modelling, map material of one or more maps stored in a database can be used. The terrain modelling can be carried out between the weapon position assumed at the time of modelling as a quasi-static firing position
5 during the movement of the weapon and the current and/or extrapolated target position. By including the extrapolated target position in the terrain modeling, the interference contour freedom of the projectile trajectory can be easily determined, since the end point of the projectile trajectory is the extrapolated target position at which the target is expected to be when the projectile hits. By superimposing the calculated
10 projectile trajectory with the terrain model, it can be easily determined whether there are geographical interference parameters in the projectile trajectory. For this purpose, it can be checked whether the calculated projectile trajectory and the surface of the terrain model intersect at one or more points between the weapon position and the target position.

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In an advantageous embodiment, at least one blocking parameter, in particular a definable restricted area, is taken into account. By taking into account at least one blocking parameter, a firing of the weapon, by which the projectile would pose an inadmissible security threat, can be prevented. In a particularly simple way, a restricted area into which a projectile may not enter and/or in which a projectile may
20 not strike can be defined as a blocking parameter. A restricted area can be defined, for example, as an area around a civil protection facility, a hospital, a separate field camp or one's own units. If the consideration of at least one blocking parameter shows that firing would lead to a violation of the blocking parameter, for example, a
25 fire signal of the weapon can be interrupted. A definable restricted area can be variable over time and can move, for example, together with own units that are moving.

In this context, it has proved advantageous if no fire control solution is output depending on the blocking parameter, in particular depending on the situation and/or
30 time. Without the output of a fire control solution, there can be no inadmissible firing of the weapon based on consideration of at least one blocking parameter. The prevention of the output of a fire control solution can be carried out depending on the blocking parameter and or depending on the situation and/or time, so that, for exam-

ple, a blocking parameter is only valid with regard to a type of munition used, in a defined time window, from a defined point in time or up to a defined point in time.

In the case of a fire control system of the type mentioned above, it is proposed for achieving the above object that it is set up to carry out the method described above, resulting in the advantages described in connection with the method.

The features described in connection with the method may also be used individually or in combination in the fire control system. This results in the same advantages that have already been described.

In an artillery weapon system of the type mentioned above, it is proposed for achieving the above object that this has a fire control system of the type described above, resulting in the advantages described in connection with the method and the fire control system.

According to an exemplary embodiment of the invention, the artillery weapon system comprises a damped weapon carrier for reducing vibrations during motion dynamics, in particular for filtering high-frequency vibrations. Vibration influences on the fire control solution can be reduced by the damped weapon carrier, whereby the accuracy of the artillery weapon system can be increased during indirect ballistic firing while driving.

It is further advantageous if the weapon system has a hydraulic and/or electrical compensation system for compensating for vibrations of the weapon while driving.

In a further embodiment of the invention, the weapon is supported relative to the weapon carrier with an imbalance-compensated weapon support. Due to the imbalance-compensated weapon support, the dynamics of the directional movement of the weapon can be increased and faster combatting of the target can be enabled.

Preferably, the weapon is supported about 360° relative to the weapon carrier, in particular in a turret system. The weapon carrier may advantageously provide a large contact area to reduce tilting movements resulting from unevenness in the terrain

and/or to enable firing of the weapon in different directions relative to the weapon carrier with no supporting system, in particular in a horizontal angular range of 360° around the weapon carrier.

5 Further details and advantages of a method according to the invention, a fire control system according to the invention and an artillery weapon system according to the invention will be explained below by way of example on the basis of the exemplary embodiments of the invention schematically represented in the figures. In the figures:

10 Fig. 1 shows schematically a direct firing weapon in a top view,

Fig. 2 shows schematically an indirect ballistic firing of an artillery weapon in a top view,

15 Fig. 3 shows schematically taking into account interference parameters when determining a fire control solution and

Fig. 4 shows schematically taking into account a blocking parameter when determining a fire control solution.

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In order to hit a target 5 with a ballistic projectile of the weapon 2 of a weapon system 1, it is necessary to solve the so-called fire control equation in order to obtain a fire control solution. With direct firing weapons 1, this is no particular challenge even for a weapon 2 on a moving weapon carrier 3, so that the fire control solution
25 can also be determined for a moving weapon 2. As a result, the direct firing weapon 2 achieves good survivability, since the protective moment of the weapon's 2 own movement can be maintained even during shooting. In the case of indirectly firing ballistic weapons 2, however, such firing while moving is not yet possible, which is reflected in the survivability of such indirectly firing artillery weapons 2.

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As shown in fig. 1, there is a direct line of sight 7 between a direct firing weapon 2 and the target 5 to be hit. Without any particular difficulties, the direct-firing weapon 2 can already be roughly aimed at the target 5 along a direct line of sight 7. To determine the fire control solution, the movement of the target 5 in the target coordinate

system K5 can be easily detected from the weapon 2 with a direct line of sight 7 to the target 5 directly in the coordinate system K2 of the weapon 2 and used to determine the fire control solution. In such a direct firing weapon 2, the position and movement of the target 5 relative to the weapon 2 are determined directly and as such relative positions and movements are also taken into account in determining the fire control solution.

Due to the comparatively small distances and the direct line of sight 7 between the weapon 2 and the target 5 during direct firing, which is characterized by a flat projectile trajectory, an error between the position of the target 5 detected by the weapon 2 and the actual position of the target 5 results solely from the time that the light needs to travel the distance between the target 5 and the weapon 2. Due to the comparatively short distance and the very high speed of light, this time lag is negligibly small in direct firing.

During the indirect ballistic firing shown in fig. 2, however, the fire control solution cannot be determined as easily as for direct firing. During indirect ballistic firing, the distance between the artillery weapon 2 and the target 5 to be hit is significantly greater than in the case of a direct firing weapon, so that there is no direct line of sight between the weapon 2 and the target 5. As indicated in fig. 2, which is not to scale, the line of sight 7 of the artillery weapon 2 is rather interrupted by an interference parameter 12. This interference parameter 12 is indicated in fig. 2 as a terrain height, but due to the very long distances can also be caused by the curvature of the earth as such. Due to the lack of a direct line of sight between the weapon 2 and the target 5, the coordinate systems K2, K5 can no longer be related to each other, so that there are two independent coordinate systems for the weapon 2 and for the target 5.

In order to be able to determine a fire control solution under these conditions in order to be able to hit the target 5 with the artillery weapon 2, the changing weapon position P2 of the weapon 2 and the target position P5 of the target 5 are taken into account as geographic position data with the method according to the invention. Both the position of the target 5 and the constantly changing weapon position P2 during the movement of the weapon system 1 — indicated by the black arrow arranged on the weapon carrier 3 — are indicated as geographical positions on the earth's surface.

This indication can be made, for example, according to the respective longitude and latitude, so that these are considered for a weapon position P2 and the target position P5 as geographic position data in an absolute coordinate system KA, which is not affected by the respective position of the weapon 2 and the target 5 relative to each other.

In addition to the weapon position P2 and the target position P5, the respective motion dynamics of the weapon 2 and target 5 can also be taken into account when determining the fire control solution. These motion dynamics can also be taken into account when determining the fire control solution in an absolute coordinate system KA, which can be, for example, the same coordinate system as has already been used for determining the geographic position data.

However, in order to be able to take the motion dynamics into account when determining the fire control solution, they must first be detected. The movement of the target 5 takes place in the coordinate system K5, while the motion dynamics of the weapon 2 take place in the weapon's own coordinate system K2. However, in order to be able to detect the motion dynamics of the weapon 2 and the target 5 in relation to each other, in order to then transfer them to an absolute coordinate system KA and take them into account when determining the fire control solution, the coordinate systems K2 and K5 must be referenced to each other, i.e. related to each other. This can be carried out by means of a detection system 6 independent of the weapon 2, with which the target 5 can be detected. By means of this detection system 6, indirect referencing of the coordinate systems K2, K5 to each other can take place, even without an existing direct line of sight between the weapon 2 and the target 5. This indirect referencing relates the two moving coordinate systems K2, K5 to each other. In this way, it is possible to transform the motion dynamics of the target 5 detected in the coordinate system K5 with the indirect reference to the coordinate system K2 of the weapon 2 and the geographical position of the weapon 2, for example more easily detectable by means of a weapon's own GPS system, into an absolute coordinate system KA. This motion dynamics of the target 5 transformed into the absolute coordinate system KA can then be taken into account when determining the fire control solution.

Since vibrations of both the weapon carrier 3 and the weapon 2 relative to the weapon carrier 3 can occur while the weapon system 1 is moving in the terrain, the influences of these vibrations as artillery-relevant influencing parameters in addition to the classic parameters for firing while moving, such as the target distance, the wind and the air pressure, can be considered as additional statistical parameters when determining the fire control solution of the weapon 2. In this case, these vibration influences of the weapon 2 and/or the weapon carrier 3 as well as other artillery-relevant influencing parameters, such as firing time development, can be calculated for the time of firing the weapon 2 by extrapolation. A terrain model, from which unevenness in the terrain and resulting vibration influences can also be predicted, can also be incorporated in the prediction of these artillery-relevant influencing parameters and in particular of the vibration influences, in addition to the past values of these influencing parameters.

In fig. 3, the indirect ballistic firing of an artillery weapon 2 of a weapon system 1 is shown schematically from a side view. This shows how the topography of the terrain as an interference parameter 12 prevents a direct line of sight between the weapon system 1 and the target 5. As can also be seen, the terrain at the weapon position P2 has a different terrain height than at the target position P5. To solve the fire control equation, these different absolute terrain heights of the weapon position P2 and the target position P5 are taken into account as absolute parameters. The absolute terrain heights at the weapon position P2 and the target position P5 can be specified against an absolutely defined zero level, such as sea level, and as such, for example, are taken from map information stored in a memory of the weapon system 1, based on the geographical position data of the weapon position P2 and the target position P5.

A detection system 6 in the form of a satellite is shown above the weapon system 1 and the target 5 in fig. 3. From the detection system position P6, this detection system 6 can directly detect both the target 5 at the target position P5 and the weapon system 1 at the weapon position P2, i.e. there is a direct line of sight between the detection system 6 and the target 5 or the weapon system 1.

From the detection system position P6, the detection system 6 can thus detect the target 5 and its motion dynamics in the coordinate system K5 in this way. This detec-

tion can be carried out, for example, using radar radiation reflected by the target 5, infrared radiation emitted by the target 5 or optically using light reflected by the target 5. The reflected radar radiation, the emitted infrared radiation or the reflected light thus forms a detection signal which, despite propagation at the speed of light, requires a time t_1 to travel the distance between the target 5 and the detection system 6 and to be detected at the detection system position P6.

In the detection system 6, this detection signal is processed before the processed signal is forwarded from the detection system 6 to the weapon system 1 at a time t_2 after detection. The transmission of this processed signal from the detection system 6 to the weapon system 1 in turn requires a certain time t_3 .

Since both the weapon 2 with the coordinate system K2 located at the weapon position P2 and the target 5 with the coordinate system K5 located at the target position P5 can be detected from the detection system 6, the detection system 6, with its detection system position P6 determinable in the absolute coordinate system KA and the coordinate system K6 of the detection system 6 at this position, is suitable for indirect referencing of the coordinate systems K2 and K5. During this indirect referencing by means of the detection system position P6, for example, the coordinate system K5 with its origin at the target position P5 can first be referenced from the detection system position P6 with the original coordinate system K6 there. Subsequently, referencing of this detection system position P6 in the coordinate system K2 can be carried out from the weapon position P2. By means of the coordinate system K6 located at the detection system position P6, referencing of the coordinate system K2 and the coordinate system K5 at the vehicle position P2 or the target position P5 can be carried out in this way, even without there having to be a direct line of sight between the target position P5 and the weapon position P2.

In order to further improve the accuracy in determining the fire control solution, properties of the detection system 6 are also taken into account when determining the fire control solution. These properties may be in particular the time t_1 for acquiring the target 5 detection signals by the detection system 6, the time t_3 for transmitting the detection signals or the time t_2 for processing the detection signal by the detection system 6.

Although in fig. 3 the detection system 6 is shown as a satellite, it may also be other movable detection systems 6, such as a drone, a UAV or a reconnaissance aircraft. Such mobile detection systems 6 could have a changing detection system position
5 P6. For such movable detection systems 6, the motion dynamics of the detection system 6 itself may also be included in the properties to be taken into account during determination of the fire control solution.

A special challenge for land-based weapon systems 1 in the context of indirect fire
10 while moving is the solution of geographical challenges, which are reflected in particular in the form of geographic interference parameters 12-14. These geographic interference parameters 12-14 may be, for example, the topography 12 of the terrain or geographical structures, for example bridges or buildings as structures or the trees
13, 14 shown as vegetation in fig. 3 in the area of the weapon 2 and in the area of the
15 target 5. In order to avoid influencing the projectile during its ballistic movement from the weapon 2 to the target 5, a projectile trajectory 11 must be selected which is free of interference contours of these geographical interference parameters 12-14. Technically, the firing weapon system 1 must calculate the interference contour freedom of the projectile trajectory 11 to the target 5 on the basis of geographical map
20 material. This requires continuous, highly dynamic terrain modeling between the weapon system 1 at the weapon position P2 and the target 5 at the target position P5, extrapolated into the future, especially taking into account the duration of the projectile flight. As a result, on the one hand, an interference-free launch angle A relative to the horizontal at the weapon position P2, which is to be regarded as a quasi-static
25 firing position at the moment of firing the projectile, and on the other hand, an interference-free approach angle B to the extrapolated target position P5, calculated in particular taking into account the projectile flight time, can be ensured.

In fig. 3, only the projectile trajectory 11 is free of an interference contour. The projectile trajectory 8 having a smaller launch angle A, on the other hand, would already
30 intersect the interfering contour 13 shown as a tree in the area of the weapon 2, so that a projectile on this projectile trajectory 8 would be disturbed by the interfering contour 13. The projectile trajectory 9 intersects the profile of the terrain as an interference parameter 12, so that the projectile on this projectile trajectory 9 would not

reach the target 5 but would previously strike at the height of the terrain. The projectile trajectory 10 also intersects an interference parameter 14 in the form of a tree, whereby the approach angle B of the projectile would be disturbed. Of the projectile trajectories 8 to 11 calculated for different fire control solutions and shown in fig. 3, taking into account the geographical interference parameters 12 to 14, only the projectile trajectory 11 would be free of interference and would thus be suitable for hitting the target 5 by indirect ballistic fire.

With the modification shown in fig. 4, in addition to the detection system 6 in the form of a satellite, a further detection system 6 is provided at the detection position P6, which may be, for example, a fixed observation post from which the target 5 can be detected at the target position P5. The motion dynamics of the target 5, which is moving on a road 17, can be detected from this terrestrial observation post as a detection system 6.

The motion dynamics of the target 5 detected relative to the detection system position P6 can be transmitted to a fire control system 4 of the weapon system 1 together with the absolute position of the detection system 6, for example in the form of GPS positions in the absolute coordinate system KA. Together with the map data stored in the fire control system 4, the motion dynamics of the target 5 in the absolute coordinate system KA can be determined from the relative motion dynamics of the target 5 together with the absolute detection system position P6 for being taken into account when determining the fire control solution. During determination of the fire control solution by the fire control system 4, the absolute motion dynamics of the weapon system 1 are then also incorporated in the absolute coordinate system KA, being detected in the coordinate system K2 and transformed if necessary.

As well as the information from the ground-based detection system 6 at the detection system position P6, the detection signals processed by the detection system 6 in the form of a satellite can be forwarded to the fire control system 4 of the weapon system 1 for determining the fire control solution.

A defined restricted area 15 extends as a blocking parameter around an object 16 to be protected, which is a hospital, for example. A projectile may not enter this re-

- stricted area 15 for safety reasons and may not strike there, otherwise it would represent an inadmissible safety-related threat to the object 16. In order to comply with this restricted area 15, this is taken into account as a blocking parameter when determining the fire control solution. Should the target 5 continue to move along the road
- 5 17 towards the object 16 to be protected, so that it enters the restricted area 15, no fire control solution would be output when determining the fire control solution as long as the target 5 is in the restricted area 15, even if hitting the target 5 would be possible without taking the blocking parameter into account.
- 10 With the help of the method, the fire control system 4 and the artillery weapon system 1 described above, it is possible to increase the survivability of the artillery weapon 2 and its operating crew, in particular even during a firefight in which the weapon 2 is firing at a target 5 and is itself exposed to return fire.

Reference signs:

	1	Weapon system
5	2	Weapon
	3	Weapon carrier
	4	Fire control system
	5	Target
	6	Detection system
10	7	Line of sight
	8-11	Projectile trajectory
	12-14	Interference parameter
	15	Restricted area
	16	Object
15	17	Road
	A	Launch angle
	B	Approach angle
	KA	Absolute coordinate system
20	K2	Coordinate System
	K5	Coordinate System
	K6	Coordinate System
	P2	Weapon position
	P5	Target position
25	P6	Detection system position
	t1	Time
	t2	Time
	t3	Time

Claims:

1. A method for determining a fire control solution of an artillery weapon (2) in
5 indirect ballistic fire for hitting a target (5),
characterized in that
a changing weapon position (P2) of the weapon (2) and a target position (P5)
of the target (5) are taken into account as geographical position data.
2. The method as claimed in any one of the preceding claims, characterized in
10 that at least one absolute parameter independent of the relative position and/or
the relative location of the weapon (2) and the target (5) is taken into account.
3. The method as claimed in claim 2, characterized in that an absolute terrain
height of the weapon position (P2), an absolute terrain height of the target po-
sition (P5), an absolute time and/or an absolute system parameter of the
15 weapon (2) is taken into account as absolute parameter.
4. The method as claimed in any one of the preceding claims, characterized in
that a motion dynamics of the weapon (2) and a motion dynamics of the tar-
get (5), in particular in absolute coordinates (KA), are taken into account.
5. The method as claimed in claim 4, characterized in that the motion dynamics
20 are detected in indirectly referenced coordinate systems (K2, K5).
6. The method as claimed in any one of the preceding claims, characterized in
that a detection system (6) is used to detect the target (5).
7. The method as claimed in claim 6, characterized in that an absolute detection
system position (P6) of the detection system (6) is used in the indirect refer-
25 encing of the coordinate systems (K2, K5).
8. The method as claimed in any one of claims 6 or 7, characterized in that the
properties of the detection system (6) are taken into account.

9. The method as claimed in any one of the preceding claims, characterized in that at least one artillery-relevant influencing parameter, in particular vibration influences of the weapon (2), vibration influences of a weapon carrier (3) and/or a firing time development, is taken into account.
- 5 10. The method as claimed in claim 9, characterized in that the artillery-relevant influencing parameter, in particular its effect on the fire control solution, is extrapolated.
11. The method as claimed in any one of the preceding claims, characterized in that at least one geographical interference parameter (12, 13, 14) is taken into
10 account for determining an interference-contour-free projectile trajectory (11).
12. The method as claimed in any one of the preceding claims, characterized in that a, in particular continuous, terrain modeling between the weapon position (P2) and the target position (P5) is carried out.
- 15 13. The method as claimed in any one of the preceding claims, characterized in that at least one blocking parameter, in particular a definable restricted area (15), is taken into account.
14. The method as claimed in claim 13, characterized in that depending on the blocking parameter, in particular depending on the situation and/or time, no
20 fire control solution is output.
15. A fire control system for determining a fire control solution of an artillery weapon (2) in indirect ballistic fire for hitting a target (5), characterized in that it is set up for carrying out the method as claimed in any one of the preceding claims.
- 25 16. An artillery weapon system with an artillery weapon (2) for combating a target (5) in indirect ballistic fire, characterized by a fire control system (4) as claimed in claim 15.

17. The artillery weapon system as claimed in claim 16, characterized by a damped weapon carrier (3) for reducing vibrations during motion dynamics, in particular for filtering high-frequency vibrations.