TITLE OF INVENTION

Tiled Terrain System for Games and Simulations

CROSS-REFERENCE

(1) This disclosure further develops an invention first described in provisional application US 62/584,700 “Method for simplifying hexagon and square terrain map pathfinding, adjacency, and presentation algorithms when edge (and vertex) properties are important” filed by Jason William Staiert on 10 NOV 2017. Benefit of that filling date is requested for claim one this application as per 35 U.S.C. 119(e).

(2) This disclosure further develops an invention first described in provisional application US 62/620,675 “Method for generating high resolution two dimensional cartesian coordinate digital topographical maps from lower resolution maps assembled from reusable high resolution tiles with instance specific properties” filed by Jason William Staiert on 23 JAN 2018. Benefit of that filling date is requested for claims two and three of this application, as they pertain to raster graphic based terrain, as per 35 U.S.C. 119(e).

(3) This disclosure further develops an invention first described in provisional application US 62/768,895 “Method for assembling a tile map from reusable tiles with instance specific properties where each tile instance must have edge properties that match those of adjoining tiles along the shared edge.” Filed by Jason William Staiert on 17 NOV 2018. Benefit of that filling date is requested for claims two and three of this application, as they pertain to vector graphic based terrain, per 35 U.S.C. 119(e)

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FEDERAL SPONSORSHIP

Not Applicable

JOINT RESEARCH AGREEMENT

Not Applicable

INCORPORATION-BY-REFERENCE

Not Applicable

PRIOR DISCLOSURES

Not Applicable

BACKGROUND OF INVENTION

[0001] Maps rendered to physical surfaces or computer displays have been used to visually communicate the presence and position of terrain features such as elevation, slope, ground cover, rivers, settlements, coastlines, and national boundaries. These maps have been used for cross-country navigation, civil and military planning, education, simulation, and entertainment [23].

[0002] War-games, which are military simulations and tactical exercises bound by a set of rules to adjudicate mock engagements, have been used to train the human mind in battlefield, strategic, and political critical thinking since ancient times [24]. The first known tabletop war-games were played on tiled surfaces. When terrain features were included they were highly abstracted [49].

[0003] Professional military minds rejected tile-based games because the abstraction inherent in the tile structure created a conceptual dissonance between the skills necessary to win the game and those needed on the battlefield.

[0004] In 1812 a Prussian army officer, Georg Heinrich Rudolf Johann von Reiswitz, invented the first known war-game to use miniature terrain. This war-game, named Kriegsspiel, used sand-table maps and its game pieces were sized so that each occupied an area on the scaled map equal to its real-life counterpart. Later, Reiswitz replaced the sand-table with a map built from square tiles showing segments of natural terrain. These tiles could be assembled to produce almost any hypothetical terrain. Kriegsspiel, unlike it’s tile-based predecessors, preserved many of the tactical, strategic, and political decision driven elements faced by real-life commanders at war [25][49].

[0005] REQUIREMENT 1: The depiction of terrain as in Reiswitz Kriegsspiel, and its British and American Army and Navy derivatives, should be the desired goal for any improvement on the state-of-the-art. The efficacy of these systems as professional training aids is the result of the equivalence between the critical thinking required to win the game and the critical thinking required to win on the battlefield. This equivalence is the result of the accurate modeling of terrain, forces, and choices available to the players [49][50]. Even the amateur historian can benefit from this equivalency since the accurate portrayal of the challenges faced by our past, present, and future armed forces informs on the necessity of military readiness, training, and technology research. The availability of powerful, and portable, computing devices allows the possibility of unprecedented level of war-game accessibility owing to automation for rules and map systems.

[0006] However, the detail and irregularity of real terrain represented by scaled maps makes estimating the effect of that terrain on movement, field of vision, and other game mechanics costly in terms of time, with the total cost being proportional to the number of game pieces involved. Historically, this cost decreased the training and entertainment utility of war-games, and may have driven war-game designers to return to square-tiled maps where each tile was considered to contain only the predominant terrain in the area covered. When game pieces were constrained to occupy only tiles, and move only between tiles, the effect of terrain on movement could be determined quickly simply by adding integer values. Most game mechanics benefit in a likewise manner. Several war-games with square-tiled maps (of questionable utility) were patented between 1906 and 1983 [4][6][7][8][9] and the first successful commercial war-game, which also used a square-tiled map, was published in 1954 by the Avalon Game Company under the name "Tactics" [26][27][28].

[0007] Shortly after the publication of "Tactics" commercial war-game, designers recognized that square-tiled maps were far from ideal. A square tile has eight neighbors; four share an edge and four share only a vertex. The distance from the center of a tile to an adjoining tile sharing an edge is substantially less than the distance to the center of an adjoining tile sharing a vertex (the ratio being approximately 1 to 1.4) [29][30]. As a consequence, war-game designers were faced with an unfortunate choice. They could either outlaw diagonal movement, accept the distortion caused by considering diagonal moves equal to lateral moves, or increase the complexity of the game by assigning a cost multiplier to diagonal moves (typically 1.5 due to relative simplicity of computing multiples of 1/2). This led to the adoption of hexagon-tiled maps where all adjoining tiles share only edges and the distances between centers of adjoining tiles is exactly equal [31][32]. The first successful commercial war-game, "Tactics", was republished in 1958 as "Tactics II" with a hexagon-tiled map [28][33].

[0008] Later it was discovered that terrain features such as hedgerows or escarpments did not fit well within the established hexagon-tile scheme. These features are approximately linear over short distances and can be barriers to movement, field-of-vision, and zone-of-control. However, they cannot be occupied, nor do they provide shelter from enemy attacks in the same way as terrain features with substantial length and width. For example, troops located in a patch of dense vegetation are more difficult to spot and attack due to the all-angle concealment and cover provide by that patch. That same vegetation set in a line, as in a hedgerow, provides concealment and cover only over limited angles and leave troops exposed to enemy observation and attack from most directions. In this disclosure, the term for these approximately linear features is “linear-terrain” and the term for terrain features with substantial width and length is “area-terrain”.

[0009] If linear-terrain is allowed to occupy an entire hex when it normally wouldn’t (because the scale of the map makes its width only a small fraction of the width of a hex) a significant distortion of distance is created between points of interest on opposite sides of that hex. Furthermore, this distortion drives undesirable increases in area effects and zones of control (to compensate for the presence of linear-terrain), or requires special rules for counting distance over linear-terrain tiles.

[0010] War-game designers tackled these problems by moving linear-terrain to the edges and vertices of tiles. However, this didn’t eliminate the complexity associated with allowing game pieces to occupy tile edges and vertices. For example; rivers are barriers to land movement, but are also avenues of supply and attack and can be occupied and controlled by waterborne forces. Moreover, some war-games allow game pieces to move from tile to edge, edge to edge, and edge to tile, allowing twelve possible directions of travel from every playable location [34]. This is the state-of-the-art for table-top and software war-games [22][35][46]. At least one patent has been issued for a game using a hexagon-tiled map [5]. From 1958 to present day, many war-games have been published using this design, some examples include [37][38][39][40].

[0011] REQUIREMENT 2: An improvement on the state-of-the-art should allow linear-terrain to be present without distorting distances between points of interest on opposite sides of those features.

[0012] REQUIREMENT 3: An improvement on the state-of-the-art should preserve the map space location of linear-terrain features relative to area-terrain features.

[0013] REQUIREMENT 4: An improvement on the state-of-the-art should preserve, to some degree, the difference in dimensions between linear-terrain features and area-terrain features as perceived by the player.

[0014] REQUIREMENT 5: An improvement on the state-of-the-art should allow all tile-edges to be playable locations for certain types of playing pieces.

[0015] For software implementations of games using tiled maps, substantial algorithm support exists. References [41][42][43][51] establish the state-of-the-art. Of particular relevance to this invention are these methods:

(A) coordinate systems giving all tiles unique coordinates,

(B) discovery of adjoining tiles using a fixed set of algebraic transforms,

(C) calculation of distances between tiles by algebraic operations on coordinate sets,

(D) enumeration of all tiles within a specific range using algebraic operations on coordinate sets,

(E) enumeration of all tiles in an intersection of two ranges using algebraic operations on coordinate sets,

(F) rotation of a tile coordinate about an arbitrary tile using algebraic operations on coordinate sets,

(G) enumeration of all tiles in a ring about an arbitrary tile using algebraic operations on coordinate sets,

(H) transformation of tile coordinates to model space coordinates using linear algebra matrix operations on a coordinate set,

(I) transformation of model space coordinates to tile coordinates using linear algebra matrix operations on a coordinate set,

(J) transformation of tile coordinates to storage coordinates using algebraic operations with modulus operators on a coordinate set,

(K) calculation of field-of-vision, zone-of-control, and line-of-sight as described in [51] or similar in basic mathematical formulation as patent [21] on tiles represented in a cartesian coordinate system.

[0016] REQUIREMENT 6: An improvement on the state-of-the-art preserves the utility of all state-of-the-art coordinate systems, coordinate transformations, and related algorithms.

[0017] Coordinate systems for state-of-the-art tiled maps with linear-terrain require an additional axis to identify on which tile-edge or tile-vertex the feature lies [41]. This is undesirable for two reasons: (1) Every edge and vertex can be identified by more than one coordinate set, as a consequence, a simple equality comparison of each element of two coordinate sets is not sufficient to determine if those coordinate sets point to the same location. (2) Coordinate sets will have a non-power-of-two number of elements. This leads to unaligned memory access which can decrease algorithm performance on some platforms, or it increases storage requirements for coordinate sets which must be padded to ensure aligned memory access.

[0018] REQUIREMENT 7: An improvement on the state-of-the-art should guarantee all playable locations can be identified by a unique coordinate set.

[0019] REQUIREMENT 8: An improvement on the state-of-the-art should eliminate the extra coordinate needed for linear-terrain identification

[0020] Regardless of the many innovations made with tiled maps they still create an undesirable abstraction of terrain features when the scale necessary to properly represent engagements at the tactical scale is much smaller than the scale needed to represent army movements at operational or strategic scales. Both scales are necessary to completely portray the decisions required in war [48], however, most war-games choose to represent only one of these scales and at most handle the others abstractly. This not only simplifies the rules for the game but also significantly reduces the effort required from the designer and the player; unless the creation of smaller scale maps is automated in some way (as in [52].) However, this abstraction creates a significant distortion of the demands placed on military leadership since throughout most of history leaders made decisions at all levels. Ancient generals directed strategic army movements as well as tactical deployments, they traveled with the army and engagements were fought on a field (usually) completely in their field-of-vision. The advent of the digital battlefield allows modern military leaders to have much greater control over all levels of military operations and the importance of simulating conflict at multiple scales within the same game system was recognized at least as far back as 1983 [48].

[0021] REQUIREMENT 9: An improvement on the state-of-the-art should reduce the effort required by a designer in creating maps for a single game at multiple scales.

[0022] REQUIREMENT 10: An improvement on the state-of-the-art should allow for a decrease in scale which also preserves the nature of linear-terrain and its geometric relationship to area-terrain at all scales.

[0023] Advances in real terrain mapping systems, as described in patents [10][11][12][13][14][15][16][17][18][19][20][22], inform us as to what features should exist in a better-than-state-of-the-art tiled map system. Those features are described in the following paragraphs.

[0024] REQUIREMENT 11: An improvement on the state-of-the-art should present map tiles in a manner that emphasizes the capabilities of any specific playing piece or mode of movement. One method of accomplishing this in real-world maps is described in patent [10]. Patent [19] describes a mechanism using hexagon geometry overlaying a map to convey information. Together they suggest that the rendering of the grid outline of a tiled map can be manipulated for similar effect.

[0025] REQUIREMENT 12: An improvement on the state-of-the-art should allow for the blending of terrain features in a natural manner that preserves the distinction of natural terrain transitions and the stark transitions in human curated terrain. Methods that succeed at this with limited success are described in patents [11][12][13][14][17].

[0026] REQUIREMENT 13: An improvement on the state-of-the-art should allow for the creation of smaller scale maps that take into account the terrain of the larger scale map. While heuristic based methods described in patents [15] and [16] produce usable results for area-terrain they do not integrate linear-terrain without producing the distortions described earlier unless very high-resolution are used. Increasing map resolution (decreasing its scale) increases memory and cpu utilization at a rate equal to the square of the increase (doubling the resolution quadruples the memory and cpu utilization). Spatial sub-division methods can be used to apply higher resolutions only when necessary but they also require more complicated tools and game engines.

[0027] REQUIREMENT 14: An improvement on the state-of-the-art should allow the complexity found in real terrain to exist at a tactical scale in a way that does not burden the user or designer of a game. Patents [18][20][21] hint at the existence of an alternative method for encoding and assembling a map using vector-graphic-like [47] tile descriptions. Patent [22] hints at an alternative method for restricting the adjoining instances of vector-graphic-like tiles in a map that preserves the continuity of contour-lines and other terrain features.

[0028] Taken together, paragraphs [0005], [0011], [0012], [0013], [0014], [0016], [0018], [0019], [0021], [0022], [0023], [0024], [0025], [0026], and [0027] define the requirements for a system that improves on the state-of-the-art.

SUMMARY OF INVENTION

[0029] At all map scales there are terrain features which have negligible surface area however, due to their length, significantly affect the evolution of game state and which may also represent important tactical and strategic objectives. One such feature, the river, appears frequently in games at all scales. Rivers are natural barriers to land movement while also being avenues of attack and supply. Rivers in state-of-the-art games are either unplayable and represent only barriers to movement [35], or they occupy surface area far exceeding their natural dimensions [36]. This distortion affects any game system which depends on distance; such as ranged attacks, zone-of-control, path-finding, field-of-view, line-of-sight, and area-effects (such as artillery sheafs). As a result, game engines such as [36] cannot accurately portray conflicts where river terrain is a significant factor.

[0030] Furthermore, the scale of strategic or operational maps work against the inclusion of tactical decision making. Existing commercial war-games which integrate strategic (or operational) and tactical scales have done so by introducing an (often painstakingly researched) abstraction or have implemented a tactical system that bears no resemblance to the strategic system despite there being no functional difference (units at all scales move, detect and engage opposing forces at range, and must be supplied). Only the Harpoon series commercial war-games [53], and it’s child and grandchild products, integrate all scales in a single consistent system which transitions easily from one to another. This is not surprising given that these war-games are modeled after those employed by the US Navy as far back as the

1920s. The US Navy’s use of simulation can be considered to have had a significant positive effect on the outcomes in the Pacific Theater of World War 2 [49].

[0031] Finally, the most successful professional war-games have done away with the tile structure entirely. The first Kriegsspiel and its British and American derivates work as training tools because the capabilities of troops are modeled accurately and the decisions required by players are the same as those required by commanders at war.

[0032] This invention is the result of a development effort directed at designing a war-game/simulation system that melds the best aspects of scaled miniature terrain and the utility of state-of-the-art tile coordinate systems, coordinate transformations, and algorithms. Such a system will eliminate much of the artificiality and abstractness of tiled maps and thus should more accurately model the decision driven elements of conflict while also benefiting from the smaller state space of tiled maps.

[0033] This invention is composed of three elements:

(1) The AL-FORM map, a novel order of tiled map that integrates both area-terrain and linear-terrain as first class tiles organized according to a strict mathematical function, and the novel methods required for utilizing such a map.

(2) The VECTOR-FORM tile, a novel order of tile that describes terrain features in a partially malleable vector format, and the novel methods required to utilize them in a tiled map.

(3) The AL-VECTOR-ENGINE system, a novel map system that enables game designers to utilize AL-FORM maps and VECTOR-FORM tiles to maximum effect with minimum effort, and the novel methods required to make it work.

[0034] The AL-FORM map integrates linear-terrain features into the structure of a regular tiled map as a special class of tile with strict, and regular, placement restrictions. As a consequence, all linear-terrain and area-terrain features are playable (REQUIREMENT 5) if the war-game requires it, and the utility of all tiled map coordinate systems, coordinate transformations, and related algorithms is preserved (REQUIREMENT 6.) Since any linear-terrain is a regular tile its coordinates are unique (REQUIREMENT 7) and no extra coordinate for linear-terrain features are necessary (REQUIREMENT 8.)

[0035] Furthermore, the strict placement restrictions on linear-terrain tiles in AL-FORM maps guarantees that any two adjacent area-terrain tiles are separated by no more than one linear-terrain tile. This preserves, without distortion, the distances between area-terrain tiles on opposite sides of any linear-terrain (REQUIREMENT 2.) The regular placement restrictions on linear-terrain tiles guarantees that the map space location of any linear-terrain feature, relative to any area-terrain features, is preserved (REQUIREMENT 3.)

[0036] The VECTOR-FORM tile allows the construction of topographical-map-like playing surfaces greatly reducing the artificiality and abstractness of state-of-the-art tiled maps (REQUIREMENT 1.) Furthermore, the scale of the map may be decreased (increasing resolution) with no loss of accuracy (REQUIREMENT 10 and 13.)

[0037] Unlike traditional raster representations the VECTOR-FORM works equally well for all tiles of a icosahedron-hexagon-tiled map (see FIG.5) whose hexagons are not entirely regular and which contain pentagon tiles located at the vertices of the icosahedron.

[0038] The AL-VECTOR-ENGINE allows the dimensions of linear-terrain tile visualization geometry to range from up-to half that of area-terrain tiles to any reasonably smaller value. This preserves the visual distinctiveness of linear- and area-terrain features as perceived by the player (REQUIREMENT 4.)

[0039] The AL-VECTOR-ENGINE only creates outlines about tiles that are playable, either for all game pieces, a single specific game piece, or a class of game piece. This eliminates the natural clutter of an AL-FORM map and provides useful information to the player about the capabilities of a specific troop formations or class of formations (REQUIREMENT 11.)

[0040] The AL-VECTOR-ENGINE defines a set of matching rules that limit the placement of VECTOR-FORM tiles where edge-crossing terrain features don't match those of already placed tiles. This eliminates the burden of using a VECTOR-FORM tile description (REQUIREMENT 9.)

[0041] The AL-VECTOR-ENGINE allows the definition of a smaller scale substitute for any tile. These smaller scale substitutes are themselves AL-FORM maps and together with the structure of the higher scale AL-FORM map and well defined blending rules allows the creation of smaller scale maps that preserves natural and artificial terrain transitions (REQUIREMENT 12.)

DESCRIPTION OF DRAWINGS

FIG.1 – A schematic depiction of a square-tiled map.

FIG.2 – “ offset-square-tiled map. Factional (unusable) tiles are half-shaded.

FIG.3 – “ rectangular-hexagon-tiled map. Factional (unusable) tiles are half-shaded.

FIG.4 – “ hexagonal-hexagon-tiled map. Factional (unusable) tiles are half-shaded.

FIG.5 – " icosahedron-hexagon-tiled map. The line drawing on the left is a two dimensional rendering of the sphere, the line drawing on the right is the surface of that sphere reduced to a two dimensional plane. Fractional edge tiles are contiguous with their counterpart on opposite edges.

FIG.6 – “ coordinate axes (cartesian) for square-tiled maps and an example map with coordinates assigned to each tile.

FIG.7 – “ coordinate axes (60°) for offset-square-tiled maps and an example map with coordinates assigned to each tile. Factional (unusable) tiles are half-shaded.

FIG.8 – “ preferred coordinate axes (120°) for offset-square-tiled maps and an example map with coordinates assigned to each tile. Factional (unusable) tiles are half-shaded.

FIG.9 – “ coordinate axes (60°) for rectangular-hexagon-tiled maps and an example map with coordinates assigned to each tile. Factional (unusable) tiles are half-shaded.

FIG.10 – “ preferred coordinate (120°) axes for rectangular-hexagon-tiled maps and an example map with coordinates assigned to each tile. Factional (unusable) tiles are half-shaded.

FIG.11 – " coordinate axes (cube) for hexagonal-hexagon-tiled maps and an example map with coordinates assigned to each tile. Factional (unusable) tiles are half-shaded.

FIG.12 – " coordinate axes (integer-longitude-latitude) for icosahedron-hexagon-tiled maps and an example map with coordinates assigned to each tile. Fractional edge tiles are contiguous with their counterpart on opposite edges.

FIG.13 – " adjoining-tile-coordinate-transformation-set for a square-tiled map with cartesian coordinate axes. On the left is the axis pair, center the resulting tile coordinates around a chosen point, and right the resulting adjoining-tile-coordinate-transformation-set.

FIG.14 – " adjoining-tile-coordinate-transformation-set for an offset-square-tiled map with 60° axes. On the left is the axis pair, center the resulting tile coordinates around a chosen point, and right the resulting adjoining-tile-coordinate-transformation-set.

FIG.15 – " adjoining-tile-coordinate-transformation-set for an offset-square-tiled map with 120° axes. On the left is the axis pair, center the resulting tile coordinates around a chosen point, and right the resulting adjoining-tile-coordinate-transformation-set.

FIG.16 – " adjoining-tile-coordinate-transformation-set for an rectangular-hexagon-tiled map with 60° axes. On the left is the axis pair, center the resulting tile coordinates around a chosen point, and right the resulting adjoining-tile-coordinate-transformation-set.

FIG.17 – " adjoining-tile-coordinate-transformation-set for an rectangular-hexagon-tiled map with 120° axes. On the left is the axis pair, center the resulting tile coordinates around a chosen

point, and right the resulting adjoining-tile-coordinate-transformation-set.

FIG.18 – " adjoining-tile-coordinate-transformation-set for an hexagonal-hexagon-tiled map with cube axes. On the left is the axis triplet, center the resulting tile coordinates around a chosen point, and right the resulting adjoining-tile-coordinate-transformation-set.

FIG.19 – " icosahedron-hexagon-tiled map showing the various vertex, edge, and face tile regions on its surface used to determine which adjoining-tile-coordinate-transformation-set is applicable. Fractional edge tiles are contiguous with their counterpart on opposite edges.

FIG.20 – " square-tiled AL-FORM-MAP. AREA-TILEs are shaded.

FIG.21 – " offset-square-tiled AL-FORM-MAP with 60° axes. AREA-TILEs are shaded, fractional (unusable) tiles are half-shaded.

FIG.22 – " offset-square-tiled AL-FORM-MAP with 120° axes. AREA-TILEs are shaded, fractional (unusable) tiles are half-shaded.

FIG.23 – " rectangular-hexagon-tiled AL-FORM-MAP with 60° axes. AREA-TILEs are shaded, fractional (unusable) tiles are half-shaded.

FIG.24 – " rectangular-hexagon-tiled AL-FORM-MAP with 120° axes. AREA-TILEs are shaded, fractional (unusable) tiles are half-shaded.

FIG.25 – " hexagonal-hexagon-tiled AL-FORM-MAP. AREA-TILEs are shaded, fractional (unusable) tiles are half-shaded.

FIG.26 – " icosahedron-hexagon-tiled AL-FORM-MAP. AREA-TILEs are shaded, and fractional edge tiles are contiguous with their counterpart on opposite edges.

FIG.27 – " FIG.19 merged with FIG.26.

FIG.28 - “ expansion of a state-of-the-art square-tiled map into an AL-FORM-MAP. On the left is the original map with all tiles shaded, on the right is the AL-FORM-MAP showing the new tiles as unshaded.

FIG.29 - “ expansion of a state-of-the-art offset-square–tiled map into an AL-FORM-MAP. On the left is the original map with all tiles shaded, on the right is the AL-FORM-MAP showing the new tiles as unshaded. Fractional (unusable) tiles are half-shaded.

FIG.30 - “ expansion of a state-of-the-art rectangular-hexagon–tiled map into an AL-FORM-MAP. On the left is the original map with all tiles shaded, on the right is the AL-FORM-MAP showing the new tiles as unshaded. Fractional (unusable) tiles are half-shaded.

FIG.31 - “ expansion of a state-of-the-art hexagonal-hexagon–tiled map into an AL-FORM-MAP. On the left is the original map with all tiles shaded, on the right is the AL-FORM-MAP showing the new tiles as unshaded.

FIG.32 - “ expansion of a state-of-the-art icosahedron-hexagon–tiled map into an AL-FORM-MAP. At the top is the original map with all tiles shaded, at the bottom is the AL-FORM-MAP showing the new tiles as unshaded. Fractional edge tiles are contiguous with their counterpart on opposite edges.

FIG.33 – “ AL-FORM-MAP transformation on a squared-tiled map during the AREA-TILE assignment stage. On the left is the cartesian axis pair, center a localized area of the source map, and on the right the corresponding area in the AL-FORM-MAP.

FIG.34 – “ AL-FORM-MAP transformation on a rectangular-hexagon-tiled map during the AREA-TILE assignment stage. On the left is the 120° axis pair, center a localized area of the source map, and on the right the corresponding area of the AL-FORM-MAP.

FIG.35 – " AL-FORM-MAP transformation on a hexagonal-hexagon-tiled map during the AREA-TILE assignment stage. On the left is the cube axis pair, center a localized area of the source map, and on the right the corresponding area of the AL-FORM-MAP.

FIG.36 – " AL-FORM-MAP transformation on a squared-tiled map during the edge LINEAR-TILE assignment stage. On the left is the cartesian axis pair, center a localized area of the source map, and on the right the corresponding area in the AL-FORM-MAP.

FIG.37 – " AL-FORM-MAP transformation on a rectangular-hexagon-tiled map during the edge LINEAR-TILE assignment stage. On the left is the 120° axis pair, center a localized area of the source map, and on the right the corresponding area of the AL-FORM-MAP.

FIG.38 – " AL-FORM-MAP transformation on a hexagonal-hexagon-tiled map during the edge LINEAR-TILE assignment stage. On the left is the cube axis pair, center a localized area of the source map, and on the right the corresponding area of the AL-FORM-MAP.

FIG.39 – " AL-FORM-MAP transformation on a squared-tiled map during the vertex LINEAR-TILE assignment stage. On the left is the cartesian axis pair, center a localized area of the source map, and on the right the corresponding area in the AL-FORM-MAP.

FIG.40 – " section of an icosahedron-hexagon-tiled map undergoing the transformation to an AL-FORM-MAP. Upper right is the source map section, to the left is the same face with tile identifiers and coordinates superimposed over the tiles and edge identifiers superimposed over the tile-edges, and to the bottom right the resulting AL-FORM-MAP after transformation.

FIG.41 – A map legend for terrain symbols in FIG.42 through FIG.58 and FIG.66 through FIG.81.

FIG.42 – A schematic depiction of a square-tiled source map with terrain symbols.

FIG.43 – " AL-FORM-MAP for FIG.42 after the assignment of area-terrain symbols to AREA-TILES.

FIG.44 – " AL-FORM-MAP for FIG.42 after the assignment of edge linear-terrain symbols to LINEAR-TILES.

FIG.45 – " AL-FORM-MAP for FIG.42 after the assignment of vertex linear-terrain symbols to LINEAR-TILES.

FIG.46 – " AL-FORM-MAP for FIG.42 after the transformation.

FIG.47 – " rectangular-hexagon–tiled map with terrain symbols.

FIG.48 – " AL-FORM-MAP for FIG.46 after the assignment of area-terrain symbols to AREA-TILES.

FIG.49 – " AL-FORM-MAP for FIG.46 after the assignment of edge linear-terrain symbols to LINEAR-TILES.

FIG.50 – " AL-FORM-MAP for FIG.42 after transformation.

FIG.51 – " hexagonal-hexagon–tiled map with terrain symbols.

FIG.52 – " AL-FORM-MAP for FIG.51 after the assignment of area-terrain symbols to AREA-TILES.

FIG.53 – " AL-FORM-MAP for FIG.51 after the assignment of edge linear-terrain symbols to LINEAR-TILES.

FIG.54 – " AL-FORM-MAP for FIG.51 after transformation.

FIG.55 – " section of icosahedron-hexagon–tiled map with terrain symbols.

FIG.56 – " AL-FORM-MAP for FIG.55 after the assignment of area-terrain symbols to AREA-TILES.

FIG.57 – " AL-FORM-MAP for FIG.55 after the assignment of edge linear-terrain symbols to LINEAR-TILES.

FIG.58 – " AL-FORM-MAP for FIG.55 after transformation.

FIG.59 – A map legend for symbols in FIG.60 through FIG.65.

FIG.60 – A schematic depiction of a square-tiled AL-FORM-MAP during AREA-TILE adjacency calculation.

FIG.61 – " hexagon-tiled AL-FORM-MAP during AREA-TILE adjacency calculation.

FIG.62 – " square-tiled AL-FORM-MAP during AREA/LINEAR-TILE adjacency calculation.

FIG.63 – " hexagon-tiled AL-FORM-MAP during AREA/LINEAR-TILE adjacency calculation.

FIG.64 – " square-tiled AL-FORM-MAP during BORDER/LINEAR-TILE adjacency calculation.

FIG.65 – " hexagon-tiled AL-FORM-MAP during BORDER/LINEAR-TILE adjacency calculation.

FIG.66 – " square-tiled AL-FORM-MAP used in visualization examples.

FIG.67 – " AREA-TILE geometry for FIG.66.

FIG.68 – " LINEAR-TILE geometry for FIG.66.

FIG.69 – " AREA-TILE outline geometry for FIG.66.

FIG.70 – " LINEAR-TILE outline geometry for FIG.66.

FIG.71 – " full rendering of visualization for FIG.66.

FIG.72 – " hexagon-tiled AL-FORM-MAP used in visualization examples.

FIG.73 – " AREA-TILE geometry for FIG.72.

FIG.74 – " LINEAR-TILE geometry for FIG.72.

FIG.75 – " AREA-TILE outline geometry for FIG.72.

FIG.76 – " LINEAR-TILE outline geometry for FIG.72.

FIG.77 – " full rendering of visualization for FIG.72.

FIG.78 – " LINEAR-TILE geometry with variable width for FIG.72.

FIG.79 – " AREA-TILE outline geometry for FIG.72 with FIG.78.

FIG.80 – " LINEAR-TILE outline geometry for FIG.72 with FIG.78.

FIG.81 – " full rendering of visualization for FIG.72 with FIG.78.

FIG.82 – A map legend for terrain symbols in FIG.83 and FIG.84.

FIG.83 – A schematic depiction of an AL-FORM-MAP with a road transition from AREA-TILEs to playable LINEAR-TILEs with all tiles shown.

FIG.84 – “ AL-FORM-MAP with a road transition from AREA-TILEs to playable LINEAR-TILEs with only PLAYABLE tiles shown.

FIG.85 – “ allowed orientations of reusable AREA-TILES in a square-tiled AL-FORM-MAP.

FIG.86 – “ allowed orientations of reusable edge LINEAR-TILES in a square-tiled AL-FORM-MAP.

FIG.87 – “ allowed orientations of reusable vertex LINEAR-TILES in a square-tiled AL-FORM-MAP.

FIG.88 – “ section of square-tiled AL-FORM-MAP composed reusable AREA-TILEs and LINEAR-TILEs with various orientations.

FIG.89 – “ allowed orientations of reusable AREA-TILES in an offset-square-tiled AL-FORM-MAP.

FIG.90 – “ allowed orientations of reusable edge LINEAR-TILES in an offset-square-tiled AL-FORM-MAP.

FIG.91 – “ allowed orientations of reusable staggered-edge LINEAR-TILES in an offset-square-tiled AL-FORM-MAP.

FIG.92 – “ section of offset-square-tiled AL-FORM-MAP composed reusable AREA-TILEs and LINEAR-TILEs with various orientations.

FIG.93 – “ allowed orientations of reusable AREA-TILES in an hexagon-tiled AL-FORM-MAP.

FIG.94 – “ allowed orientations of reusable LINEAR-TILES in an hexagon-tiled AL-FORM-MAP.

FIG.95 – “ section of hexagon-tiled AL-FORM-MAP composed reusable AREA-TILEs and LINEAR-TILEs with various orientations.

FIG.96 – “ allowed orientations of reusable pentagon AREA-TILES in an icosahedron-hexagon-tiled AL-FORM-MAP.

FIG.97 – " two dimensional rendering of a three dimensional icosahedron-hexagon-tiled surface showing the location of visible vertex pentagon tiles.

FIG.98 – hexagon-tiled map VECTOR-TERRAIN-TILE.

FIG.99 – A map legend for the symbols in all schematic depictions of vector terrain tiles.

FIG.100 – matching operation applied to the same VECTOR-TERRAIN-TILE with three different orientations.

FIG.101 – square-tile map VECTOR-TERRAIN-TILE.

FIG.102 – offset-square-tile map VECTOR-TERRAIN-TILE.

FIG.103 – mapping operation of edge properties from hexagon VECTOR-TERRAIN-TILEs to pentagon VECTOR-TERRAIN-TILEs.

FIG.104 – parametric line equation used to map hexagon VECTOR-TERRAIN-TILEs edge properties to pentagon VECTOR-TERRAIN-TILEs.

FIG.105 – uphill/inside turning operation for edge crossings.

FIG.106 – anti-uphill/inside turning operation for edge crossings.

FIG.107 – square-tiled AL-FORM-MAP, edge-LINEAR-TILE edge classifications.

FIG.108 – vertex-LINEAR-TILE edge classifications.

FIG.109 –

FIG.110 – VECTOR-TERRAIN edge-LINEAR-TILE …

DETAILED DESCRIPTION OF INVENTION

[XXXX] EMBODIMENTS – Five embodiments of this invention are described in this disclosure, one for each of the most commonly used tiled maps in games and simulations:

(A) square-tile, depicted in FIG.1,
(B) offset-square-tile, depicted in FIG.2,
(C) rectangular-hexagon-tile, depicted FIG.3,
(D) hexagonal-hexagon-tile, depicted in FIG.4,
(E) icosahedron-hexagon-tile, depicted in FIG.5.

[XXXX] IMPLEMENTATION DETAILS – This disclosure avoids language specific to an implementation whenever possible. An expert in graphic design can extrapolate the necessary elements for a physical implementation and an expert in computer graphics and algorithms can extrapolate the necessary elements for a software implementation.

[XXXX] VECTOR MATH – This disclosure avoids mathematical description whenever possible, however some methods can only be properly explained as series of matrix operations on vectors, a method common in computer graphics. Specifically, when the word “transformations” is used it implies a matrix representation that will ultimately be used to transform a set of points (in vector form) and true vectors. In these cases a sequence of operations is implied that mirror, rotate, and translate (in that order exactly) a coordinate system into another coordinate system.

[XXXX] DEFINITION OF TERMS – To facilitate the readers understanding of this invention a taxonomy of terms was created for critical concepts. Each definition includes the part of speech the term belongs to (in parenthesis). These terms are: TILE, MAP, TILE-SPACING, LINEAR-TERRAIN, AREA-TERRAIN, TERRAIN, LINEAR-TILE, AREA-TILE, AL-FORM-MAP, PLAYABLE, UNPLAYABLE, PATH-FINDING, FIELD-OF-VIEW, AREA-EFFECT, MOVEMENT, MOVEMENT-MODE, SCALE, SCALE-RATIO, VISUALIZATION-GEOMETRY, TERRAIN-REPRESENTATION, VECTOR-FORM-TILE, REPRESENTATION, and AL-VECTOR-ENGINE.

[XXXX] TILE (noun) – A TILE is a convex planar shape enclosing a portion of a surface.

[XXXX] MAP (noun) – A MAP is a physical or virtual surface divided into adjoining and maximally packed regular TILEs arranged according to one of these five patterns:

(A) square-tile, depicted in FIG.1,

(B) offset-square-tile, depicted in FIG.2,

(C) rectangular-hexagon-tile, depicted in FIG.3,

(D) hexagonal-hexagon-tile, depicted in FIG.4,

(E) icosahedron-hexagon-tile, depicted in FIG.5.

[XXXX] TILE-SPACING (compound noun) – TILE-SPACING is the distance between the centers of any two adjoining TILEs of a MAP. Since MAPs use only regular [44] tiles, this distance is constant for any one MAP. Different MAPs may have different TILE-SPACINGs. The units of TILE-SPACING may be whatever is most appropriate for the implementation; a physical implementation might use inches or centimeters, while a virtual implementation will likely use pixels or points.

[XXXX] LINEAR-TERRAIN (compound noun) – A LINEAR-TERRAIN is a group of similar terrain features having a length nearly-equal-to or greater-than the TILE-SPACING, but with a much smaller width, which have significant effects on the evolution of game state. In state-of-the-art MAPs these features are usually portrayed on, or near, TILE-edges or TILE-vertices and are rarely playable. Examples of LINEAR-TERRAINs found in various state-of-the-art MAPs are: Interior Walls, Interior Walls with Window, Interior Doors, Slopes of various grade, Tree Line, Hedge Row, Wall, Barricade, Wadi, Reef, Sand Bar, Ridge, Ridge with Pass, Escarpment, Escarpment with Ramp, Mountain Spur, Mountain Spur with Pass, River, River with Ford, River with Cataract, River with Bridge, Canal, Canal with Bridge, Canyon, Canyon with Bridge, Beach at a Water Transition, Cliff at a Water Transition, Land Transition, Berm, and Berm with Road. Some LINEAR-TERRAINs are composites of more fundamental terrains or properties; a river is listed as being bridged or unbridged. This invention makes no assumptions about how LINEAR-TERRAIN is managed in the embodiment, composite types may be assembled from discrete fundamental types or treated as a unique opaque types with specific properties.

[XXXX] AREA-TERRAIN (compound noun) – An AREA-TERRAIN is a category of similar terrain features which covers an area on a MAP nearly-equal-to or greater-than the square of the TILE-SPACING and length and width both nearly-equal-to or greater-than the TILE-SPACING. On a state-of-the-art MAP all TILEs are assigned an AREA-TERRAIN despite sometimes also containing LINEAR-TERRAINs such as rivers. Examples of AREA-TERRAINs found in various state-of-the-art MAPs are: Interior Floor, Deep Ocean, Coastal Ocean, Lake, Clear, Rough, Rocky, Orchard, Swamp, Sand, Plains, Plains and

Forest, Plains and Jungle, Rolling Hills, Foothills, Mountains, Badlands, Forest, and Jungle. Some AREA-TERRAINs are composites of more fundamental terrains or properties; a plain is listed as being bare or forested, or a plain may have a specific elevation above sea-level. This invention makes no assumptions about how AREA-TERRAIN is managed in the embodiment, composite types may be assembled from discrete fundamental types or treated as a unique opaque types with specific properties.

[XXXX] TERRAIN (noun) – The term TERRAIN has one of two meanings depending on the context of its usage:

(A) both AREA-TERRAIN and LINEAR-TERRAIN,

(B) either AREA-TERRAIN or LINEAR-TERRAIN.

[XXXX] LINEAR-TILE (compound noun) – A LINEAR-TILE is a specialized class of TILE which has LINEAR-TERRAIN properties describing the LINEAR-TERRAIN found within its borders.

[XXXX] AREA-TILE (compound noun) – An AREA-TILE is a specialized class of TILE which has AREA-TERRAIN properties describing the predominate AREA-TERRAIN found within its borders.

[XXXX] AL-FORM-MAP (proper noun) – The first of three primary subjects in this disclosure. The term AL-FORM-MAP is the proper name given to the first element of this invention. An AL-FORM-MAP is a MAP composed of two classes of TILE, the AREA-TILE and the LINEAR-TILE, arranged in a pattern distinct to this invention. This term is a contraction of Area-Linear-MAP. AL-FORM-MAPs are also MAPS, and so to increase readability the term MAPs will be substituted for AL-FORM-MAPs when the context is certain.

[XXXX] PLAYABLE (adjective) – A TILE is said to be PLAYABLE if it can be occupied or controlled by a game piece.

[XXXX] UNPLAYABLE (adjective) – A TILE is said to be UNPLAYABLE if it cannot be occupied and/or cannot be controlled by a game piece, however, a game piece may pass through an UNPLAYABLE TILE unless movement through it is prohibited for some other reason (such as the piece having an incompatible MOVEMENT-MODE for the TILE’s assigned TERRAIN).

[XXXX] PATH-FINDING (compound verb) – PATH-FINDING is the act of identifying a path between two TILEs of a MAP.

[XXXX] FIELD-OF-VISION (compound noun) – A FIELD-OF-VISION is the set of TILEs of a MAP that are partially or completely visible from the location of a specific game piece, or pieces. This set may be constrained by the facing of the piece(s) and by other properties modeled by the game.

[XXXX] AREA-EFFECT (compound noun) – An AREA-EFFECT is any effect that modifies game state for all game pieces in a set of TILEs. This set is composed of all TILEs within a certain distance of a target TILE. Which TILE becomes the target and how distance is calculated is a property of a game implementation.

[XXXX] MOVEMENT (verb) – MOVEMENT is the act of moving a game piece from TILE to adjacent TILE.

[XXXX] MOVEMENT-MODE (compound noun) – A MOVEMENT-MODE is a class of mobility modeled by a game. With respect to this invention, its effect is to modify movement costs, or prohibit movement, through specific TERRAINs.

[XXXX] SCALE (noun) – A SCALE is the relationship of MAP units to real-world units expressed as a single unit-less quantity. Specifically, if a MAP is said to have a scale of “1 inch to the mile” then one inch on the MAP surface equals one mile in the real-world which can be expressed as the number 63360. Every distance measured on the MAP, with whatever units are preferred, can be multiplies by that number to achieve the equivalent real-world distance.

[XXXX] SCALE-RATIO (noun) – This invention includes a system for constructing larger-scale MAPs from smaller-scale MAPs, and the term SCALE-RATIO is used to convey the relationship between the dimensions of their TILEs. Both MAPs have a SCALE, and the quotient of their SCALEs is their SCALE-RATIO, however, the context of the usage determines which SCALE is the dividend and which is the denominator. Given a smaller-scale MAP with SCALE equal to N and a larger-scale MAP with SCALE equal to M, when the subject is the smaller-scale MAP their SCALE-RATIO is { N / M }, and when the subject is the larger-scale MAP their SCALE-RATIO is { M / N }. So, if the smaller-scale MAP has a scale of 1000 and the larger-scale MAP has a SCALE of 10000, then, when the subject is the larger-scale MAP the SCALE-RATIO is 10. More specifically, if we know the SCALE-RATIO we know how many TILEs of the subject MAP lie along an axes of the other MAP (that number is equal to the SCALE-RATIO), and consequently we know how many TILEs occupy the same area (that number is equal to the SCALE-RATIO squared). So, from our example above, assuming the two MAPs both use regular square TILEs, then we know the larger-scale MAP has ten TILEs along each axis of the smaller-scale MAP, and that 100 TILEs of the larger-scale MAP occupy the same area as a single TILE in the smaller-scale MAP.

[XXXX] VISUALIZATION-GEOMETRY (noun) – The set of geometric lines, geometric shapes, and art assets assembled to produce an understandable two dimensional representation of a MAP. The construction of a useful VISUALIZATION-GEOMETRY for an AL-FORM-MAP is a key subject in this disclosure. VISUALIZATION-GEOMETRies are always defined in a cartesian coordinate-space regardless of their geometric shape or the coordinate-space of the MAP used to construct them.

[XXXX] TERRAIN-REPRESENTATION (noun) – A TERRAIN-REPRESENTATION is a visual depiction (symbolic, artistic, and/or photographic) of the terrain in a TILE. Due to their significant memory requirements it is assumed TERRAIN-REPRESENTATIONs will texture-mapped to geometry. TERRAIN-REPRESENTATIONs are always defined in a cartesian coordinate-space regardless of the geometric shape used to render them or the coordinate-space of the MAP in which they are used.

[XXXX] VECTOR-FORM-TILE (noun) – The second of three primary subjects in this disclosure. A form of TILE which serves as both a visual representation of the terrain in that TILE and as the mathematical definition of the terrain as required by computer algorithms. Due to their complex structure it is assumed VECTOR-

FORM-TILEs will be instanced rather than reproduced. Each instance includes a reference to the VECTOR-FORM-TILE description (it's geometry and other properties) and a transformation matrix defining mirror, rotation, and translation components to position the instance in the proper location on the MAP surface. VECTOR-FORM-TILEs are always defined in a cartesian coordinate-space regardless of their geometric shape or the coordinate-space of the MAP in which they are used.

[XXXX] REPRESENTATION (noun) – Certain sections of this disclosure pertain to both TERRAIN-REPRESENTATIONs and VECTOR-FORM-TILEs and rather than repeat each paragraph this term is used instead.

[XXXX] AL-VECTOR-ENGINE (noun) – The third of three primary subjects in this disclosure. The body of computer algorithms and data management tools needed to utilize AL-FORM-MAPs and VECTOR-FORM-TILEs.

[XXXX] CLAIM 1 DETAILED DESCRIPTION: The following paragraphs describe the elements of Claim 1 of this invention, in conjunction with the various referenced drawings, with the detail necessary to produce a complete implementation.

[XXXX] An AL-FORM-MAP is composed of adjoining and maximally packed TILEs from two classes, AREA-TILEs and LINEAR-TILEs, arranged in a pattern distinct to this invention.

[XXXX] In an AL-FORM-MAP, AREA-TILEs never adjoin AREA-TILEs and are always separated by one LINEAR-TILE.

[XXXX] In an AL-FORM-MAP, LINEAR-TILEs always adjoin exactly two AREA-TILEs by either a shared edge or vertex.

[XXXX] Every TILE in an AL-FORM-MAP is identified by a unique coordinate set.

(A) Every TILE in a square-tiled AL-FORM-MAP is identified by a unique cartesian coordinate pair, with one of many possible configurations depicted in FIG.6. The position of axes origin is unrestricted. In any alternate configuration, the orientation of an axis relative to the TILE structure must be symmetrical about one axis shown in FIG.6.

(B) Every TILE in a offset-square-tiled AL-FORM-MAP is identified by a unique 60° axial coordinate pair, with one of many possible configurations depicted in FIG.7. Preferentially, each TILE is also identified by a unique 120° axial coordinate pair, with one of many possible configurations depicted in FIG.8. The position of axes origin is unrestricted. In any alternate configuration, the orientation of an axis relative to the TILE structure must be symmetrical about one axis shown in FIG.7 or FIG.8, respectively.

(C) Every TILE in a hexagon-tiled AL-FORM-MAP (either rectangular- or hexagonal-) is identified by a unique 60° axial coordinate pair, with one of many possible configurations depicted in FIG.9. Preferentially, each TILE is also identified by a unique 120° axial coordinate pair, with one of many possible configurations depicted in FIG.10. The position of axes origin is unrestricted. In any alternate configuration, the orientation of an axis relative to the

TILE structure must be symmetrical to one axis shown in FIG.9 or FIG.10, respectively.

(D) Every TILE in a hexagon-tiled AL-FORM-MAP (either rectangular- or hexagonal-) is identified by a unique cube coordinate triplet, with one of many possible configurations depicted in FIG.11. Cube coordinates allow for algorithm optimizations, however, for storage purposes all cube coordinate triplets reduce trivially to either 60° or 120° axial coordinate pairs. The position of axes origin is unrestricted. In any alternate configuration, the orientation of an axis relative to the TILE structure must be symmetrical about one axis shown in FIG.11.

(E) Every TILE in a icosahedron-hexagon-tiled AL-FORM-MAP is identified by a unique integer-latitude-longitude coordinate pair, with one of many possible configurations depicted in FIG.12. The position of axes origin must always reside at a icosahedron vertex. The integer-latitude axis must always be traced, by the shortest route possible, along icosahedron edges between two antipodal (opposite) vertices. The integer-longitude axis counts the distance, in a single direction, from the integer-latitude axis, and all TILEs on the integer-longitude axis must have a zero integer-longitude coordinate.

[XXXX] In an AL-FORM-MAP the set of adjoining TILEs for any given TILE can be determined by applying a fixed-ordered-finite-set of transformations to the coordinates of that TILE. The direction to each adjoining TILE is determined solely by the position of its transformation in that set. In MAPs which wrap one or more axes the resulting coordinate of a transformation is modulo the number of TILEs along that axis (the modulo operation as defined here [45]). For the various tile structures:

(A) The tile-coordinates-to-adjoining-tiles transformation set for a square-tiled AL-FORM-MAP with cartesian coordinate axes { X , Y } starting with the tile directly along the positive Y axis and moving clockwise about the TILE is: { 0 , +1 }, { +1 , +1 }, { +1 , 0 }, { +1 , -1 }, { 0 , -1 }, { -1 , -1 }, { -1 , 0 }, { -1 , +1 }. A schematic depiction of this set is given in FIG.13.

(B) The tile-coordinates-to-adjoining-tiles transformation set for an offset-square-tiled AL-FORM-MAP with 60° axial coordinate axes { X , Y } starting with tile directly along the positive Y axis and moving clockwise about the TILE is: { 0 , +1 }, { +1 , 0 }, { +1 , -1 }, { 0 , -1 }, { -1 , 0 }, { -1 , +1 }. A schematic depiction of this set is given in FIG.14. For an offset-square-tiled AL-FORM-MAP with 120° axial coordinate axes { X , Y } starting with tile directly along the positive Y axis and moving clockwise about the TILE is: { 0 , +1 }, { +1 , +1 }, { +1 , 0 }, { 0 , -1 }, { -1 , -1 }, { -1 , 0 }. A schematic depiction of this set is given in FIG. 15.

(C) The tile-coordinates-to-adjoining-tiles transformation set for a hexagon-tiled AL-FORM-MAP with 60° axial coordinates { X , Y } starting with tile directly along the positive Y axis and moving clockwise about the TILE is: { 0 , +1 }, { +1 , 0 }, { +1 , -1 }, { 0 , -1 }, { -1 , 0 }, { -1 , +1 }. A schematic depiction of this set is given in FIG.16. For a hexagon-tiled AL-FORM-MAP with 120° axial coordinates { X , Y } starting with tile directly along the positive Y axis and moving clockwise about the TILE is: { 0 , +1 }, { +1 , +1 },

{ +1 , 0 }, { 0 , -1 }, { -1 , -1 }, { -1 , 0 }. A schematic depiction of this set is given in FIG.17. NOTE: Both sets are identical to those for an offset-square-tiled AL-FORM-MAP.

(D) The tile-coordinates-to-adjoining-tiles transformation set for a hexagon-tiled AL-FORM-MAP with cube coordinates { X , Y , Z } starting with tile along the positive Y axis and negative Z axis and moving clockwise about the TILE is: { 0 , +1 , -1 }, { +1 , 0 , -1 }, { +1 , -1 , 0 }, { 0 , -1 , +1 }, { -1 , 0 , +1 }, { -1 , +1 , 0 }. A schematic depiction of this set is given in FIG.18.

(E) The tile-coordinates-to-adjoining-tiles transformation set for a icosahedron-hexagon-tiled AL-FORM-MAP with integer-latitude-longitude coordinates is a function of the MAPs side length { L } (L being number of hexagons between the vertex pentagons along any edge of the icosahedron) and the coordinates of the TILE. FIG.19 shows a schematic depiction of the various regions of an icosahedron to be considered. Each TILE of FIG.19 is labeled as follows: TILEs prefixed by V are icosahedron-vertex TILEs (so called because they lie on the vertex of the tessellated icosahedron), TILEs prefixed by E are icosahedron-edge TILEs (they lie on an edge of the tessellated icosahedron), TILEs prefixed by F are icosahedron-face TILEs (the lie entirely on a face of the tessellated icosahedron). All sets have six elements except those for icosahedron-vertex TILEs, which have five elements. The number of unique transformation sets is constant and does not vary with the size of the map except for the smallest MAPs; MAPs with L equal-to zero have no icosahedron-edge or icosahedron-face TILEs, while MAPs with L less-than two have no icosahedron-face TILEs. A MAP with L equal-to three or more has eight transformation sets, they are:

(1) For TILE labeled V0: { +1 , 0 }, { +1 , +1 }, { +1 , +2 }, { +1 , +3 }, { +1 , +4 }.

(2) For TILEs labeled E0 through E4: { 0 , +1 }, { +1 , +1 }, { +1 , 0 }, { +1 , -1 }, { 0 , -1 }, { -1 , 0 }.

(3) For TILEs labeled V1 through V5: { 0 , +1 }, { +1 , +1 }, { +1 , 0 }, { 0 , -1 }, { -1 , 0 }.

(4) For TILEs labeled E5 through E19 or F0 through F13: { 0 , +1 }, { +1 , +1 }, { +1 , 0 }, { 0 , -1 }, { -1 , -1 }, { -1 , 0 }.

(5) For TILEs labeled E20 through E24: { 0 , +1 }, { +1 , 0 }, { +1 , -1 }, { 0 , -1 }, { -1 , -1 }, { -1 , 0 }.

(6) For TILEs labeled F15 through F19: { 0 , +1 }, { +1 , 0 }, { +1 , -1 }, { 0 , -1 }, { -1 , 0 }, { -1 , +1 }.

(7) For TILEs labeled V6 through V10: { 0 , +1 }, { +1 , 0 }, { 0 , -1 }, { -1 , -1 }, { -1 , 0 }.

(8) For TILEs labeled E25 through E29: { 0 , +1 }, { +1 , 0 }, { +1 , -1 }, { 0 , -1 }, { -1 , -1 }, { -1 , 0 }.

(9) For TILE labeled V11: { -1 , 0 }, { -1 , +1 }, { -1 , +2 }, { -1 , +3 }, { -1 , +4 }.

NOTE: The resulting TILE coordinates are always MODULO the number of TILEs along the integer-longitude axis for a given coordinate on the integer-latitude axis.

[XXXX] An AL-FORM-MAP is either AREA-EVEN or AREA-ODD. The preferred class of AL-FORM-MAP is AREA-EVEN due to the overall simplicity of defining which TILEs are AREA-TILEs and the lack of wasted LINEAR-TILEs on the map perimeter. Unless prefixed with

AREA-ODD the term AL-FORM-MAP should be assumed to be an AREA-EVEN AL-FORM-MAP.

[XXXX] If an AL-FORM-MAP is AREA-ODD then AREA-TILEs occupy all TILE locations with coordinates composed entirely of odd numbers, and LINEAR-TILEs occupy all other locations, with the exception of hexagon-tiled AL-FORM-MAPs with cube coordinates which have three possible configurations (each with AREA-TILEs having two coordinates being odd and one even), and icosahedron-hexagon-tiled AL-FORM-MAPs which don't have an AREA-ODD representation using the coordinate system defined in this disclosure. No further information will be provided about AREA-ODD AL-FORM-MAPs.

[XXXX] If an AL-FORM-MAP is AREA-EVEN then AREA-TILEs occupy all TILE locations with coordinates composed entirely of even numbers, and LINEAR-TILEs occupy all other locations.

(A) An AREA-EVEN square-tiled AL-FORM-MAP with cartesian coordinates is depicted in FIG.20.
(B) An AREA-EVEN offset-square-tiled AL-FORM-MAP with 60° axial coordinates is depicted in FIG.21, and with 120° axial coordinates in FIG.22.
(C) An AREA-EVEN rectangular-hexagon-tiled AL-FORM-MAP with 60° axial coordinates is depicted in FIG.23, a with 120° axial coordinates in FIG.24.
(D) An AREA-EVEN hexagonal-hexagon-tiled AL-FORM-MAP with cube coordinates is depicted in FIG.25.
(E) An AREA-EVEN icosahedron-hexagon-tiled AL-FORM-MAP with integer-latitude-longitude coordinates is depicted in FIG.26.

[XXXX] In an AL-FORM-MAP, the class of any TILE can be determined solely by examining its coordinates; if the coordinates of a TILE are all even numbers then it's an AREA-TILE, otherwise it's a LINEAR-TILE.

[XXXX] When an AL-FORM-MAP is derived from an existing state-of-the-art MAP it will have dimensions nearly twice that of the source, and all new TILEs will be LINEAR-TILES.

(A) For a square-tiled MAP with cartesian coordinate axes and { M } TILEs along the X axis and { N } TILEs on the Y axis, the AL-FORM-MAP will have { 2 × M - 1 } TILEs along the X axis and { 2 × N - 1 } TILEs along the Y axis. A schematic depiction of this relationship is given in FIG.28.

(B) For an offset-square-tiled MAP with either 60° or 120° axial coordinates and { M } TILEs along the X axis and { N } TILEs along the Y axis, the AL-FORM-MAP will have { 2 × M - 1 } TILEs along the X axis and { 2 × N - 1 } TILEs along the Y axis. A schematic depiction of this relationship is given in FIG.29.

(C) For a rectangular-hexagon-tiled MAP with either 60° or 120° axial coordinate axes and { M } TILEs along the X axis and { N } TILEs along the Y axis, the AL-FORM-MAP will have { 2 × M - 1 } TILEs along the X axis and { 2 × N - 1 } TILEs along the Y axis. A schematic depiction of this relationship is given in FIG.30.

(D) For a hexagonal-hexagon-tiled MAP with cube coordinate axes and diameter { D }, the diameter being the number of TILEs along any axis, the AL-FORM-MAP will have diameter { 2 × D - 1 }. A schematic depiction of this relationship is given in FIG.31. Some configurations of hexagonal-hexagon-tiled MAPs may have fewer TILEs along two axes than a third (the primary axis) and identical to each other. This configurations is transformed into an AL-FORM-MAP using the same mathematical relationship, so the number of tiles along the axes in the AL-FORM-MAP will be twice the number in the MAP, minus one.

(E) For an icosahedron-hexagon-tiled MAP with integer-latitude-longitude coordinate axes and side length { L } the AL-FORM-MAP will have a side length { 2 × L + 1 }. A schematic depiction of this relationship is given in FIG.32.

[XXXX] AL-FORM-TRANSFORMATION-PROCESSES – The terrain of a state-of-the-art MAP, with axes oriented as shown in FIG.6 through FIG.12, or in any valid alternative as described elsewhere in this disclosure, can be transferred to a properly dimensioned AL-FORM-MAP with axes expanded about a properly selected axes origin, using the following processes:

(A) For each TILE of the source MAP with coordinates { X, Y } the AREA-TERRAIN of that TILE is assigned to the AREA-TILE of the destination AL-FORM-MAP with coordinates { 2 × X , 2 × Y }. A schematic depiction of this process on a segment of a square-tiled MAP with cartesian coordinate axes is given in FIG.33. A schematic depiction of this process on a segment of hexagon-tiled MAP with 120° axial coordinate axes is given in FIG.34. A schematic depiction of this process on a segment of hexagon-tiled MAP with cube coordinate axes is given in FIG. 35, however, in this case the transformation is { 2 × X , 2 × Y , 2 × Z }. In all drawings; TILEs A1, A2, A3, and A4 in the source MAP are mapped to AREA-TILEs in the AL-FORM-MAP.

(B) For each TILE-edge of the source MAP with coordinates { X, Y , E }, where the value of E determines which edge is being referenced and where values of E are an index into the tile-coordinates-to-adjoining-tiles transformation set T of the source MAP TILE, the LINEAR-TERRAIN of that TILE-edge is assigned to the LINEAR-TILE of the destination AL-FORM-MAP with coordinates { 2 × X + T[E].X , 2 × Y + T[E].Y }. A schematic depiction of this process on a segment of a square-tiled MAP with cartesian coordinate axes is given in FIG.36. A schematic depiction of this process on a segment of hexagon-tiled MAP with 120° axial coordinate axes is given in FIG.37. A schematic depiction of this process on a segment of hexagon-tiled MAP with cube coordinate axes is given in FIG. 38, however, in this case the transformation is { 2 × X + T[E].X , 2 × Y + T[E].Y , 2 × Z + T[E].Z }. In all figures; TILE-edge properties E1, E2, E3, and E4 in the source MAP are assigned to LINEAR-TILEs in the AL-FORM-MAP.

(C) (This method is only applicable to square-tiled MAPs.) For each TILE-vertex of the source MAP with coordinates { X, Y , V }, where the value of V determines which vertex is being referenced and where values of V are an index into the tile-coordinates-to-adjoining-tiles transformation set T of the source MAP TILE, the LINEAR-TERRAIN of that TILE-vertex is assigned to the LINEAR-TILE of the destination AL-FORM-MAP with coordinates { 2 × X + T[V].X , 2 × Y + T[V].Y }. A schematic depiction of this process on a segment of a square-tiled MAP with cartesian coordinate axes is given in FIG.39.

A schematic depiction of processes (A) and (B) applied to all TILEs on a single face of an icosahedron-hexagon-tiled MAP is given in FIG.40.

[XXXX] The complete transformation of a square-tiled MAP (depicted in schematic form in FIG.41, with a symbol legend provided in FIG.41) to an AL-FORM-MAP (depicted in schematic form in FIG.46) is given in a series of drawings, each showing the result of one process described in paragraph [XXXX]. The result of process (A) is depicted in FIG.43, the result of process (B) is depicted in in FIG.44, the result of process (C) is depicted in FIG.45.

[XXXX] The complete transformation of a rectangular-hexagon-tiled MAP (depicted in schematic form in FIG.47, with a symbol legend provided in FIG.41) to an AL-FORM-MAP (depicted in schematic form in FIG.50) is given in a series of drawings, each showing the result of one process described under the heading AL-FORM-TRANSFORMATION-PROCESSES. The result of process A is depicted in FIG.48 and the result of process B is depicted in in FIG.49.

[XXXX] The complete transformation of a hexagonal-hexagon-tiled MAP (depicted in schematic form in FIG.51, with a symbol legend provided in FIG.41) to an AL-FORM-MAP (depicted in schematic form in FIG.54) is given in a series of drawings, each showing the result of one process described under the heading AL-FORM-TRANSFORMATION-PROCESSES. The result of process A is depicted in FIG.52 and the result of process B is depicted in in FIG.53.

[XXXX] The complete transformation of one face of an icosahedron-hexagon-tiled MAP (depicted in schematic form in FIG. 55, with a symbol legend provided in FIG.41) to an AL-FORM-MAP (depicted in schematic form in FIG.58) is given in a series of drawings, each showing the result of one process described under the heading AL-FORM-TRANSFORMATION-PROCESSES. The result of process A is depicted in FIG.56 and the result of process B is depicted in in FIG.57. The legend for these MAPs is given in FIG. 41.

[XXXX] In a PATH-FINDING or MOVEMENT context any two TILEs of an AL-FORM-MAP are adjacent if at least one of these terms are true:

(A) Both TILEs are AREA-TILES, both TILEs are PLAYABLE, and both adjoin the same UNPLAYABLE LINEAR-TILE. The absolute distance between the AREA-TILE centers is equal to twice the AL-FORM-MAP's TILE-SPACING, however, this distance may be adjusted to account for the effects of TERRAIN in all three TILEs before being used in cost calculations. A schematic depiction of this term for square-tiled AL-FORM-MAPs is given in FIG.60 (a legend for that MAP is given in FIG.59). In that drawing TILE pairs { A1 , A4 }, { A1 , A5 }, { A2 , A4 }, and { A4 , A5 } are adjacent while TILE pairs { A1 , A2 }, { A1 , A3 }, and { A2 , A4 } are not. Furthermore, TILEs A2 and A5 do not qualify for comparison since they do not adjoin a common LINEAR-TILE. A schematic depiction of this term for hexagon-tiled AL-FORM-MAPs is given in FIG.61 (a legend for that MAP is given in FIG.59). In that drawing TILE pairs { A1 , A2 }, and { A1 , A3 } are adjacent while TILE pair { A1 , A2 } is not.

(B) Both TILEs are adjoining, both TILEs are PLAYABLE, and one TILE is an AREA-TILE and the other is a LINEAR-TILE. The absolute distance between the TILE centers is equal-to the AL-FORM-MAP's TILE-SPACING, however, this distance may be adjusted to account for the effects of TERRAIN in both TILEs before being used in cost calculations. A schematic depiction of this term for square-tiled AL-FORM-MAPs is given in FIG.62 (a legend for that MAP is given in FIG.59). In that drawing TILE pairs { A1 , B3 } and { A1 , B4 } are adjacent while TILE pairs { A1 , B1 } and { A1 , B2 } are not. A schematic depiction of this term for hexagon-tiled AL-FORM-MAPs is given in FIG.63 (a legend for that MAP is given in FIG.59). In that drawing TILE pair { A1 , B2 } is adjacent while TILE pair { A1 , B1 } is not.

(C) Both TILEs are adjoining, both TILEs are PLAYABLE, and both TILEs are LINEAR-TILEs. The absolute distance between the centers of these TILEs is equal to the AL-FORM-MAP's TILE-SPACING, however, this distance may be adjusted to account for the effects of TERRAIN in both TILEs before being used in cost calculations. A schematic depiction of this term for square-tiled AL-FORM-MAPs is given in FIG.64 (a legend for that MAP is given in FIG.59). In that drawing TILE pair { B3 , B4 } is adjacent while TILE pairs { B1 , B2 }, { B1 , B3 }, and { B2 , B3 } are not. Furthermore, TILEs B1 and B4 do not qualify for comparison since they are not adjoining. A schematic depiction of this term for hexagon-tiled AL-FORM-MAPs is given in FIG.65 (a legend for that MAP is given in FIG.59). In that drawing TILE pair { B2 , B3 } is adjacent while TILE pairs { B1 , B2 } and { B1 , B3 } are not.

[XXXX] CLAIM 2 DETAILED DESCRIPTION: The following paragraphs describe the elements of Claim 2 of this invention, in conjunction with the various referenced drawings, with the detail necessary to produce a complete implementation.

[XXXX] A VECTOR-FORM-TILE contains a series of vector-graphic-like terrain-description elements, named VECTOR-TERRAIN in this disclosure, organized into two distinct groups:

(A) INTERIOR-ONLY elements are VECTOR-TERRAINs contained entirely within the TILE. Their vertex-graphic-like representations are closed curves, line segments, or points. Almost any terrain feature may have an INTERIOR-ONLY representation. These VECTOR-TERRAINs are static, their control points and control vectors are constant with respect to their TILE's coordinate axes.

(B) EDGE-CROSSING elements are VECTOR-TERRAINs with an extent only partially defined within the TILE. Their vertex-graphic-like representations are always line-segments, with one or both edge-points lying on an edge of the TILE. Common EDGE-CROSSING terrain features include contour-lines, forests, roads, and rivers. These VECTOR-TERRAINs are mostly static, their control points and control vectors, with the exception of end-points on a TILE edge, are constant with respect to their TILE's coordinate axes.

[XXXX] VECTOR-TERRAIN is organized into three classes: POINT-VECTOR-TERRAIN, LINE-VECTOR-TERRAIN, and AREA-VECTOR-TERRAIN. The properties of each are described here:

(A) POINT-VECTOR-TERRAIN consists of a vector-graphic-like point and a reference to a terrain type. POINT-VECTOR-TERRAIN is always INTERIOR-ONLY. A common example is mountain peak.

(B) LINE-VECTOR-TERRAIN consists of a vector-graphic-like closed curve or line segment, and a reference to a terrain type. LINE-VECTOR-TERRAIN may be EDGE-CROSSING. Common examples are roads, rivers, and walls.

(C) AREA-VECTOR-TERRAIN descriptions consists of a vector-graphic-like closed curve or line segment, an uphill/interior binary indicator (to-the-left or to-the-right of the vector), and a reference to a terrain type. AREA-VECTOR-TERRAIN may be EDGE-CROSSING. Common examples are elevation contours and forests.

A schematic depiction of a hexagon, square, and offset-square VECTOR-TERRAIN-TILEs are given in FIG.98, FIG.101, and FIG.102 respectively (a legend for these drawings is given in FIG.99).

[XXXX] A VECTOR-FORM-TILE contains a unique ordered-set of TERRAIN-POSITION-INDICATORs for each edge, or edge-segment, which may adjoin another TILE. TERRAIN-POSITION-INDICATORs are unique makers associated with one end-point of an EDGE-CROSSING VECTOR-TERRAIN. Any single TERRAIN-POSITION-INDICATOR is found only in the ordered-set associated with the TILE edge on which its associated end-point lies. Each ordered-set is associated with one vertex of its TILE edge, this vertex is used to compute the position of TERRAIN-POSITION-INDICATORs in that set. The position of a TERRAIN-POSITION-INDICATOR in a ordered-set is determined by its distance from the vertex associated with that ordered-sets. The preferred embodiment assumes the sorting function is nearest-first-furthest-last.

[XXXX] A VECTOR-FORM-TILE contains a sorted-set of TERRAIN-PRESENCE-INDICATORs for each edge, or edge-segment, which may adjoin another TILE. A TERRAIN-PRESENCE-INDICATOR is a marker associated with a VECTOR-AREA-TERRAIN contained in the VECTOR-FORM-TILE. It indicates that an entire TILE edge, or edge segment, is within the associated VECTOR-AREA-TERRAIN. The purpose of these sorted-sets will be described in the paragraphs describing the AL-VECTOR-ENGINE.

[XXXX] Hexagon VECTOR-TERRAIN-TILEs can be manipulated to fit a pentagon-shaped boundary such as the icosahedron-vertex TILEs of an icosahedron-hexagon-tiled MAP. The process is best given pictorially, refer to FIG.103. The drawing defines the subdivision of the area of a hexagon and the mapping of the resulting regions to those of a pentagon. For clarity the hexagon and pentagon in FIG.103 have been drawn with significantly different inscribed-circular-diameters, however, in the preferred embodiment of this process the inscribed-circular-diameters are equal. The mapping process involves a two-dimensional parametric equation conversion of the coordinates of all vector-graphic points and lines in the VECTOR-TERRAIN-TILE. A schematic depiction of this process on a single coordinate is given in FIG.104, along with the mathematical vector equation, from which a two-dimensional form can be extrapolated.

[XXXX] CLAIM 3 DETAILED DESCRIPTION: The following paragraphs describe the elements of Claim 3 of this invention, in conjunction with the various referenced drawings, with the detail necessary to produce a complete implementation.

[XXXX] An AL-VECTOR-ENGINE is any system which implements one or more of the processes introduced below:

(A) Data management for AL-FORM-MAPs involving its distinct characteristics, the distinct characteristics of AREA-TILEs and LINEAR-TILEs, or the AL-FORM-MAP tile adjacency rules.

The patentable elements of this process are disclosed by Claim 1 descriptions.

(B) MAP algorithms for AL-FORM-MAPs involving its distinct characteristics, the distinct characteristics of AREA-TILEs and LINEAR-TILEs, or the AL-FORM-MAP tile adjacency rules. The patentable elements of this process are disclosed by Claim 1 descriptions.

(C) Visualization of AL-FORM-MAPs involving its distinct characteristics, the distinct characteristics of AREA-TILEs and LINEAR-TILEs, or the AL-FORM-MAP tile adjacency rules. The patentable elements of this process are disclosed by Claim 1 and Claim 3 descriptions.

(D) WYSIWYG editing of AL-FORM-MAPs involving its distinct characteristics, the distinct characteristics of AREA-TILEs and LINEAR-TILEs, or the AL-FORM-MAP tile adjacency rules. The patentable elements of this process are disclosed by Claim 1 descriptions.

(E) Data management for VECTOR-FORM-TILEs. The patentable elements of this process are disclosed by Claim 2 descriptions.

(F) Visualization of VECTOR-FORM-TILEs. The patentable elements of this process are disclosed by Claim 2 descriptions.

(G) WYSIWYG editing of VECTOR-FORM-TILEs. The patentable elements of this process are disclosed by Claim 2 and Claim 3 descriptions.

(H) Visualization of MAPs composed of VECTOR-FORM-TILEs. The patentable elements of this process are disclosed by Claim 2 and Claim 3 descriptions.

(I) WYSIWYG editing of MAPs composed of VECTOR-FORM-TILEs. The patentable elements of this process are disclosed by Claim 2 and Claim 3 descriptions.

(J) Visualization of AL-FORM-MAPs composed of VECTOR-FORM-TILEs. The patentable elements of this process are disclosed by Claim 1, Claim 2, and Claim 3 descriptions.

(K) WYSIWYG editing of AL-FORM-MAPs composed of VECTOR-FORM-TILEs. The patentable elements of this process are disclosed by Claim 1, Claim 2, and Claim 3 descriptions.

(L) Generation of smaller-scale AL-FORM-MAPs from a set of adjoining TILEs of an AL-FORM-MAP when smaller-scale AL-FORM-MAP substitutes for the includes TILEs are available. The patentable elements of this process are disclosed by Claim 1 and Claim 3 descriptions.

(M) Generation of high-resolution cartesian coordinate terrain maps from MAPs composed of VECTOR-FORM-TILEs. The patentable elements of this process are disclosed by Claim 1 and Claim 2 descriptions.

(N) Generation of high-resolution cartesian coordinate terrain maps from AL-FORM-MAPs composed of VECTOR-FORM-TILEs. The patentable elements of this process are disclosed by Claim 1, Claim 2, and Claim 3 descriptions.

[XXXX] The VISUALIZATION-GEOMETRY of an AL-FORM-MAP is composed of the following elements:

(A) A set of polygons, one polygon for each AREA-TILE, where each polygon is texture-mapped with a TERRAIN-REPRESENTATION of the AREA-TERRAIN assigned to its AREA-TILE.

(B) A set of polygons, one polygon for each LINEAR-TILE, where each polygon is texture-mapped with TERRAIN-REPRESENTATION of the LINEAR-TERRAIN assigned to its LINEAR-TILE.

(C) A set of lines which trace the edges of polygons in element (A) belonging to PLAYABLE AREA-TILEs, minus the edges that are covered by polygons in element (B) belonging to PLAYABLE LINEAR-TILEs.

(D) A set of lines which trace the edges of polygons in element (B) belonging to PLAYABLE LINEAR-TILEs.

[XXXX] All element (A) polygons are regular [44] and of the appropriate shape for the AL-FORM-MAP (regular-squares for square-tiled, regular-hexagons for hexagon-tiled) with an inscribed-circular-diameter equal-to twice the TILE-SPACING. Each polygon is arranged so its edges adjoin those of its nearest-neighbors.

[XXXX] Each element (B) polygon has a shape that is either identical to all other element (B) polygons or is a function of the LINEAR-TERRAIN assigned to its LINEAR-TILE. Each element (B) polygon has an inscribed-circular-diameter less-than-or-equal-to the TILE-SPACING, the actual diameter being identical for all element (B) polygons or a function of the LINEAR-TERRAIN assigned to its LINEAR-TILE. All element (B) polygons are oriented so that as many edges as possible adjoin the edges of its nearest-neighbor element (B) polygons, and oriented so any terrain features depicted in the texture-mapped representations line-up with those of adjoining element (B) polygons. In a trivial realization these polygons will have a shape identical to those in element (A) with an inscribed-circular-diameter equal-to the TILE-SPACING.

[XXXX] The VISUALIZATION-GEOMETRY of an AL-FORM-MAP are rendered parallel to the viewing surface, from first to last in order: (A) first, (B) next, (C) next, and (D) last. The rendering of elements (C) and (D) is optional, but if one is rendered the other must also be rendered. The rendering of a two-dimensional representation of the three-dimensional icosahedron-hexagon-tiled surface is performed such that element (A) is inside element (B), (B) is inside element (C), and (C) is inside element (D).

[XXXX] Elements (C) and (D) together form outlines about all PLAYABLE TILEs.

[XXXX] The TERRAIN-REPRESENTATIONs for AREA-TERRAINs in element (A) consist of images without transparency. The image for any specific AREA-TILE is either unique to that AREA-TILE or is one of a set of images associated with the AREA-TERRAIN assigned to that AREA-TILE. NOTE: This paragraph describes only how TERRAIN-REPRESENTATIONs appear to the viewer, not how they exist in computer memory or are implemented in computer code. For example, if a TERRAIN is a composite of more fundamental terrains these images might be created by blending images for each fundamental type.

[XXXX] The TERRAIN-REPRESENTATIONs for LINEAR-TERRAINs in element (B) consist of images with transparency that are blended with the previously rendered AREA-TERRAIN representations in element (A) according to image specific rules (often embodied in a GPU fragment shader program). The image (and its rules) for any specific LINEAR-TILE is either unique to that LINEAR-TILE or is one of a set of images (and rules) associated with the LINEAR-

TERRAIN assigned to that LINEAR-TILE. NOTE: This paragraph describes only how TERRAIN-REPRESENTATIONs appear to the viewer, not how they exist in computer memory or are implemented in computer code. For example, if a TERRAIN is a composite of more fundamental terrains these images might be created by blending images for each fundamental type.

[XXXX] The lines in element (C) are rendered with colors, widths, and styles that are a function of the AREA-TERRAIN assigned to the AREA-TILE associated with the polygon whose edges are being traced. This function may return results which are specific to all game pieces, or to a single game piece, or to a single MOVEMENT-MODE.

[XXXX] The lines in element (D) are rendered with colors, widths, and styles that are a function of the LINEAR-TERRAIN assigned to the LINEAR-TILE associated with the polygon whose edges are being traced. This function may return results which are specific to all game pieces, or to a single game piece, or to a single MOVEMENT-MODE.

[XXXX] Schematic depictions of each element of a visualization for a square-tiled AL-FORM-MAP with PLAYABLE river terrain are given: the AL-FORM-MAP is depicted in FIG.66 (with terrain symbol legend given in FIG.41), element A is depicted in FIG.67, element B is depicted in FIG.68, element C is depicted in FIG.69, and element D is depicted in FIG.70. The final render of all four elements is shown in FIG.71.

[XXXX] Schematic depictions of each element of a visualization for a hexagonal-hexagon-tiled AL-FORM-MAP with PLAYABLE river terrain are given: the AL-FORM-MAP is depicted in FIG.72 (with terrain symbol legend given in FIG.41), element A is depicted in FIG.73, element B is depicted in FIG.74, element C is depicted in FIG.75, and element D is depicted in FIG.76. The final render of all four elements is shown in FIG.77. Element B for the same AL-FORM-MAP with variable width LINEAR-TILE visualization geometry is depicted in FIG.78. Elements C and D for that same AL-FORM-MAP is depicted in FIG.79 and FIG.80, respectively. The final render of that AL-FORM-MAP is depicted in FIG.81.

[XXXX] A two-dimensional schematic depiction of the three-dimensional surface of a visualization geometry for the AREA-TILEs of an icosahedron-hexagon-tiled AL-FORM-MAP is given in FIG.184.

[XXXX] A two-dimensional schematic depiction of the three-dimensional surface of a visualization geometry for the LINEAR-TILEs of an icosahedron-hexagon-tiled AL-FORM-MAP is given in FIG. 185.

[XXXX] A two-dimensional schematic depiction of the three-dimensional surface of an AREA-TILE visualization geometry rendered inside the variable-width LINEAR-TILE visualization geometry of an icosahedron-hexagon-tiled AL-FORM-MAP is given in FIG.186. Callout (A) points to the visible portion of the AREA-TILE visualization geometry. Callout (B1) points to a narrow visualization geometry for a LINEAR-TILE. Callout (B2) points to a transition (narrow-to-wide) visualization geometry for a LINEAR-TILE. Callout (B3) points to a wide visualization geometry for a

LINEAR-TILE. All shaded regions are the visible portion of AREA-TILE visualization geometry. All unshaded regions are the visualization geometry for LINEAR-TILEs.

[XXXX] Certain types of terrain may be found in both AREA-TILEs and LINEAR-TILEs. An example of this are roads. A raised road is very much a linear-terrain obstacle despite also being navigable by playing pieces with compatible MOVEMENT-MODEs. In such a case, a transition between an AREA-TERRAIN representation and a LINEAR-TERRAIN representation is necessary, however, the visualization of a map with such terrain is fully supported by this invention. An example of such a map is depicted in FIG.83 (with terrain symbol legend given in FIG.82), the final rendering of its visualization geometry is depicted in FIG.84.

[XXXX] The VECTOR-FORM-ENGINE allows the VISUALIZATION-GEOMETRY for any TILE in an AL-FORM-MAP, and any instance of a VECTOR-FORM-TILE, to be transformed by mirroring or rotation before being translated into place. This allows a small set of these objects to be of greater utility than their number might imply by increasing the possible configurations they may have in a MAP. The novel nature of the AL-FORM-MAP requires the disclosure of these configurations. NOTE: Rotations are given in degrees about the center-of-geometry. Mirrors are about an axis perpendicular to a TILE edge in a cartesian coordinate space originating on the center-of-geometry.

[XXXX] LINEAR-TILEs adjoin both AREA-TILEs and other LINEAR-TILEs (AREA-TILEs only adjoin LINEAR-TILEs), and since REPRESENTATIONs are not symmetrical, the allowed placement-sites of a REPRESENTATION and the transformations applicable to it are a function of the coordinates of a specific LINEAR-TILE site.

[XXXX] A square-tiled AL-FORM-MAP has two sub-classes of LINEAR-TILE. One sub-class shares edges with two AREA-TILEs and two LINEAR-TILEs and is named EDGE-LINEAR-TILE. The other sub-class shares edges with four LINEAR-TILEs and is named VERTEX-LINEAR-TILE (since it shares vertices with four AREA-TILEs). These sub-classes are shown in schematic form in FIG.XXX where the EDGE-LINEAR-TILE is callout (A) and the VERTEX-LINEAR-TILE is callout (B).

[XXXX] In an AREA-EVEN square-tiled AL-FORM-MAP the sub-class of any LINEAR-TILE can be determined solely by examining its coordinates.

(A) An EDGE-LINEAR-TILE has one even numbered coordinate. A schematic depiction of an AREA-EVEN square-tiled AL-FORM-MAP with EDGE-LINEAR-TILEs shaded in grey is given in FIG.XXX.
(B) A VERTEX-LINEAR-TILE has all odd coordinates. A schematic depiction of an AREA-EVEN square-tiled AL-FORM-MAP with VERTEX-LINEAR-TILEs shaded in grey is given in FIG.XXX.

[XXXX] Furthermore, EDGE-LINEAR-TILEs are themselves grouped into two sub-classes based on the direction from their TILE center to adjoining AREA-TILEs. EDGE-LINEAR-TILEs which are adjacent to AREA-TILEs along the X axis are named X-EDGE-LINEAR-TILEs, and those that are adjacent to AREA-TILEs along the Y axis are named Y-EDGE-LINEAR-TILEs. These sub-classes are shown in schematic form in FIG.XXX where the X-EDGE-LINEAR-TILE is callout (A) and the Y-EDGE-LINEAR-TILE is callout (B).

[XXXX] In an AREA-EVEN square-tiled AL-FORM-MAP the sub-class of any EDGE-LINEAR-TILE can be determined solely by examining its coordinates.

(A) A X-EDGE-LINEAR-TILE has an even numbered Y axis coordinate. A schematic depiction of an AREA-EVEN square-tiled AL-FORM-MAP with X-EDGE-LINEAR-TILEs shaded in grey is given in FIG.XXX.

(B) A Y-EDGE-LINEAR-TILE has an even numbered X axis coordinate. A schematic depiction of an AREA-EVEN square-tiled AL-FORM-MAP with Y-EDGE-LINEAR-TILEs shaded in grey is given in FIG.XXX.

[XXXX] An offset-square-tiled AL-FORM-MAP has two sub-classes of LINEAR-TILE. Both sub-classes share edges, or edge-segments, with two AREA-TILEs and four LINEAR-TILEs. One sub-class is found only in the same column as AREA-TILEs, shares full edges with two AREA-TILEs, and is named FULL-EDGE-LINEAR-TILE. The other sub-class is found only in columns without AREA-TILEs, shares only edge-segments with two AREA-TILEs, and is thus named HALF-EDGE-LINEAR-TILE. These sub-classes are shown in schematic form in FIG.XXX where the FULL-EDGE-LINEAR-TILE is callout (A) and the HALF-EDGE-LINEAR-TILE is callout (B).

[XXXX] In an AREA-EVEN offset-square-tiled AL-FORM-MAP the sub-class of any LINEAR-TILE can be determined solely by examining its coordinates.

(A) A FULL-EDGE-LINEAR-TILE has an even numbered X axis coordinate. A schematic depiction of an AREA-EVEN offset-square-tiled AL-FORM-MAP with FULL-EDGE-LINEAR-TILEs shaded in grey is given in FIG.XXX.

(B) A HALF-EDGE-LINEAR-TILE has an odd numbered X axis coordinate. A schematic depiction of an AREA-EVEN offset-square-tiled AL-FORM-MAP with HALF-EDGE-LINEAR-TILEs shaded in grey is given in FIG.XXX.

[XXXX] Furthermore, HALF-EDGE-LINEAR-TILEs are themselves grouped into two sub-classes based on the relative position of the adjoining AREA-TILE along the positive X axis. HALF-EDGE-LINEAR-TILEs which are adjacent to, and above, the AREA-TILE along their positive X axis are named UPPER-HALF-EDGE-LINEAR-TILEs, and those that are adjacent to, and below, the AREA-TILE along their positive X axis are named LOWER-HALF-EDGE-LINEAR-TILEs. These sub-classes are shown in schematic form in FIG.XXX where the UPPER-HALF-EDGE-LINEAR-TILE is callout (A) and the LOWER-HALF-EDGE-LINEAR-TILE is callout (B).

[XXXX] In an AREA-EVEN offset-square-tiled AL-FORM-MAP the sub-class of any HALF-EDGE-LINEAR-TILE can be determined solely by examining its coordinates.

(A) A UPPER-HALF-EDGE-LINEAR-TILE has an odd numbered Y axis coordinate in a 120° axial coordinate system. A schematic depiction of an AREA-EVEN square-tiled AL-FORM-MAP with UPPER-HALF-EDGE-LINEAR-TILEs shaded in grey is given in FIG.XXX.

(B) A LOWER-HALF-EDGE-LINEAR-TILE has an even numbered Y axis coordinate in a 120° axial coordinate system. A schematic depiction of an AREA-EVEN square-tiled AL-FORM-MAP with

LOWER-HALF-EDGE-LINEAR-TILEs shaded in grey is given in FIG.XXX.

[XXXX] A hexagon-tiled AL-FORM-MAP has three sub-classes of LINEAR-TILE, but unlike previous tile structures these sub-classes are differentiated only by their transformation configurations. All LINEAR-TILEs in a hexagon-tiled AL-FORM-MAP adjoin two AREA-TILEs and four LINEAR-TILEs arrayed about the perimeter of the TILE in exactly the same order for all instances, a schematic depiction is given in FIG.XXX. Callout (A) indicates the axis about which a LINEAR-TILE may be mirrored.

[XXXX] The LINEAR-TILEs of a hexagon-tiled AL-FORM-MAP are grouped into three sub-classes based on the direction from their TILE center to adjoining AREA-TILEs. The naming scheme used here assumes directions are relative to cube coordinate axes described previously for hexagon-tiled MAPs. The direction from TILE center to adjoining AREA-TILE is perpendicular to the X axis for X-AXIS-LINEAR-TILEs, the direction from TILE center to adjoining AREA-TILE is perpendicular to the Y axis for Y-AXIS-LINEAR-TILEs, and the direction from TILE center to adjoining AREA-TILE is perpendicular to the Z axis for Z-AXIS-LINEAR-TILEs. These sub-classes are shown in schematic form in FIG.XXX where the X-AXIS-LINEAR-TILE is callout (A), the Y-AXIS-LINEAR-TILE is callout (B), and the Z-AXIS-LINEAR-TILE is callout (C).

[XXXX] In an AREA-EVEN hexagon-tiled AL-FORM-MAP the sub-class of any LINEAR-TILE can be determined solely by examining its coordinates.

(A) A X-AXIS-LINEAR-TILE has an even numbered X axis coordinate. A schematic depiction of an AREA-EVEN hexagon-tiled AL-FORM-MAP with X-AXIS-LINEAR-TILEs shaded in grey is given in FIG.XXX.

(B) A Y-AXIS-LINEAR-TILE has an even numbered Y axis coordinate. A schematic depiction of an AREA-EVEN hexagon-tiled AL-FORM-MAP with Y-AXIS-LINEAR-TILEs shaded in grey is given in FIG.XXX.

(C) A Z-AXIS-LINEAR-TILE has an even numbered Z axis coordinate. A schematic depiction of an AREA-EVEN hexagon-tiled AL-FORM-MAP with Z-AXIS-LINEAR-TILEs shaded in grey is given in FIG.XXX.

[XXXX] REPRESENTATIONs for the various sub-classes of LINEAR-TILE are not always compatible with each other. When this is true the level of compatibility is indicated by the addition of a prefix on REPRESENTATION formed from the prefix used for the names of the various LINEAR-TILEs. For example, the REPRESENTATIONS for all EDGE-LINEAR-TILEs are compatible with both X-EDGE-LINEAR-TILEs and Y-EDGE-LINEAR-TILEs, and as a consequence they are named EDGE-REPRESENTATIONs.

[XXXX] TRANSFORMATIONS IN SQUARE-TILED MAPS: The transformations applicable to REPRESENTATIONs for TERRAINs assigned to TILEs in a square-tiled MAP, or to AREA-TILEs in a square-tiled AL-FORM-MAP, are: Rotation 0°, Rotation 90°, Rotation 180°, Rotation 270°, Mirror X, Mirror Y. A schematic depiction of a single mirror transformation and all rotation transformations is given in FIG.XXX.

[XXXX] The transformations applicable to EDGE-REPRESENTATIONs for TERRAINs assigned to X-EDGE-LINEAR-TILEs are: Rotation 0°, Rotation 180°, and Mirror X. A schematic depiction the mirror transformation and all rotation transformations is given in FIG.XXX.

[XXXX] The transformations applicable to EDGE-REPRESENTATIONs for TERRAINs assigned to Y-EDGE-LINEAR-TILEs are: Rotation 90°, Rotation 270°, and Mirror Y. A schematic depiction of the mirror transformation and all rotation transformations is given in FIG.XXX.

[XXXX] The transformations applicable to VERTEX-REPRESENTATIONs for TERRAINs assigned to VERTEX-LINEAR-TILEs are: Rotation 0°, Rotation 90°, Rotation 180°, Rotation 270°, Mirror X, Mirror Y. A schematic depiction of a single mirror transformation and all rotation transformations is given in FIG.XXX.

[XXXX] TRANSFORMATIONS IN OFFSET-SQUARE-TILED MAPS: The transformations applicable to REPRESENTATIONs for TERRAINs assigned to TILEs in a offset-square-tiled MAP, or to AREA-TILEs in a square-tiled AL-FORM-MAP, are: Mirror X and Mirror Y. A schematic depiction of a single mirror and all rotations is given in FIG.XXX.

[XXXX] The transformations applicable to FULL-EDGE-REPRESENTATIONs for TERRAINs assigned to FULL-EDGE-LINEAR-TILEs are: Mirror X and Mirror Y. A schematic depiction of a single mirror transformation and all rotation transformations is given in FIG.XXX.

[XXXX] The transformations applicable to HALF-EDGE-REPRESENTATIONs for TERRAINs assigned to UPPER-HALF-EDGE-LINEAR-TILEs are: Mirror X with Mirror Y = 0. A schematic depiction of these transformations are given in FIG.XXX.

[XXXX] The transformations applicable to HALF-EDGE-REPRESENTATIONs for TERRAINs assigned to LOWER-HALF-EDGE-LINEAR-TILEs are: Mirror X with Mirror Y = 1. A schematic depiction of these transformations are given in FIG.XXX.

[XXXX] TRANSFORMATIONS IN HEXAGON-TILED MAPS: The transformations applicable to REPRESENTATIONs for TERRAINs assigned to TILEs in a hexagon-tiled MAP, or to AREA-TILEs in a square-tiled AL-FORM-MAP, are: Rotation 0°, Rotation 60°, Rotation 120°, Rotation 180°, Rotation 240°, Rotation 300°, Mirror X, Mirror Y, Mirror Z. A schematic depiction of a single mirror and all rotations is given in FIG.XXX.

[XXXX] The transformations applicable to REPRESENTATIONs for TERRAINs assigned to X-AXIS-LINEAR-TILEs are: Rotation 0°, Rotation 180°, and Mirror X. A schematic depiction for the mirror transformation and both rotation transformations is given in FIG.XXX.

[XXXX] The transformations applicable to REPRESENTATIONs for TERRAINs assigned to Y-AXIS-LINEAR-TILEs are: Rotation 60°, Rotation 240°, and Mirror X. A schematic depiction for the mirror transformation and both rotation transformations is given in FIG.XXX.

[XXXX] The transformations applicable to REPRESENTATIONs for TERRAINs assigned to Z-AXIS-LINEAR-TILEs are: Rotation 120°, Rotation 300°, and Mirror X. A schematic depiction for the mirror transformation and both rotation transformations is given in FIG.XXX.

continue from here

[XXXX] TILE TRANSFORMATIONS IN ICOSAHEDRON-HEXAGON-TILED MAPS: The transformations applicable to TILEs in icosahedron-hexagon-tiled MAPs, or AREA-TILEs in icosahedron-hexagon-tiled AL-FORM-MAP, are identical to those in a hexagon-tiled MAP.

[XXXX] The transformations applicable to LINEAR-TILES in a icosahedron-hexagon-tiled AL-FORM-MAP are are identical to those in a hexagon-tiled MAP.

[XXXX] The transformations applicable to pentagon AREA-TILES in a icosahedron-hexagon-tiled AL-FORM-MAP are: Rotation 0°, Rotation 72°, Rotation 144°, Rotation 216°, Rotation 288°, Mirror X, Mirror Y. A schematic depiction of a single mirror transformation and all rotation transformations is given in FIG.96. A schematic depiction of an icosahedron-hexagon-tiled MAP with shaded pentagon TILEs is given in FIG.XXX.

[XXXX] MAP ASSEMBLY: Automatic and manual assembly of a MAP using VECTOR-FORM-TILEs requires an terrain matching operation to filter out VECTOR-FORM-TILEs with incompatible EDGE-CROSSING

VECTOR-TERRAIN. The process for matching two VECTOR-FORM-TILEs is as follows:

(1) The instance of the VECTOR-FORM-TILE to be placed, and those of the TILEs that are already placed and will be adjoined to the new instance, have their instance rotation and mirroring transformations applied in a manner that allows determination of which edges will be adjoined. The matching process advances to step (2).

(2) For each pair of edges that will be adjoined, the TERRAIN-PRESENCE-INDICATOR sorted-sets for those edges are compared. If they are not identical then the new instance may not be placed in that position with those transformations and the matching process is aborted, otherwise the matching process advances to step (3).

(3) For each pair of edges that will be adjoined, the TERRAIN-POSITION-INDICATOR ordered-sets for the those edges are compared. If the anchoring vertices of the ordered-sets are not adjoining then one of the ordered-sets is reversed. If the ordered sets are not identical then the order of one or both sets is adjusted according to TERRAIN specific rules in an attempt to make them identical. If ordered-sets cannot be made identical then the new instance may not be placed in that position with those transformations and the matching process is aborted, otherwise the matching process advances to step (4).

(4) The end-points associated with each matched pair of TERRAIN-POSITION-INDICATORs are adjusted so that they have identical positions and first derivatives (their control vectors are identical for certain specific line equation forms).

[XXXX] A schematic depiction of the assembly process described above is given in FIG.XXX. Shown are three instances of the same VECTOR-TERRAIN-TILE, indicated by callouts (A)(B) and (C), each with different TILE TRANSFORMATIONs as noted in the drawing. The result of the matching operation is shown, indicated by callouts (B)(F) and (D). Match (B) fails because tile (C) has a TERRAIN-PRESENCE-INDICATOR and tile (A) does not. Match (F) and (D) succeed because the ordered-sets of TERRAIN-POSITION-INDICATORs for the edges that will be adjoined are identical.

[XXXX] AL-FORM-MAP ASSEMBLY: Automatic and manual assembly of a AL-FORM-MAP using VECTOR-FORM-TILEs requires the same VECTOR-TERRAIN matching process described previously for MAPs using VECTOR-FORM-TILEs. The matching process is performed when placing AREA-TILEs separated by only one LINEAR-TILE. In addition to the mirroring and rotation transformations applied to an instance of a VECTOR-FORM-TILE, a scale transformation is applied so that the edges of the instance adjoin the edges of other AREA-TILE instances (which are also scaled). The VECTOR-TERRAIN matching process is also performed on LINEAR-TILEs which adjoin other LINEAR-TILEs. This will be explained in the following paragraphs.

[XXXX] LINEAR-TILEs in an AL-FORM-MAP require a specialized VECTOR-FORM-TILE which has three classes:

(A) PASS-THRU is the default class of VECTOR-FORM-TILE assigned to the LINEAR-TILEs of a newly created AL-FORM-MAP. This class is unique, it has no specializations. VECTOR-TERRAIN of adjoining AREA-TILEs pass through these instances without modification. No VECTOR-TERRAIN matching is performed. A schematic depiction of this class is given in FIG.XXX.

(B) PASS-THRU-WITH-TERRAIN is a class of VECTOR-FORM-TILE that contains INTERIOR-ONLY VECTOR-TERRAIN and EDGE-CROSSING VECTOR-TERRAIN which may only cross edges that adjoin other LINEAR-TILEs. These VECTOR-TERRAINs are superimposed on the VECTOR-TERRAIN of adjoining AREA-TILEs, which pass-thru these instances without modification. VECTOR-TERRAIN matching is performed only on those edges which adjoin other LINEAR-TILEs. A schematic depiction of this class is given in FIG.XXX.

(C) BLOCKING is a class of VECTOR-FORM-TILE that contains EDGE-CROSSING VECTOR-TERRAIN which may only have end-points on edges that adjoin other LINEAR-TILEs. These VECTOR-TERRAINs, named BLOCKING VECTOR-TERRAINS, cause the rerouting of VECTOR-TERRAIN in adjoining AREA-TILEs, a process that will be explained in the next paragraph. VECTOR-TERRAIN matching is performed only on those edges which adjoin other LINEAR-TILEs. A schematic depiction of this class is given in FIG.XXX.

[XXXX] VECTOR-REROUTING is the process of inserting additional control points and vectors for the VECTOR-TERRAIN … of instances of VECTOR-FORM-TILEs assigned to AREA-TILEs adjoining a LINEAR-TILE which has been assigned an instance of a BLOCKING VECTOR-FORM-TILE. This process is only run after all BLOCKING VECTOR-FORM-TILEs of a single continuous terrain feature have been placed (for example, placement of all connected river terrains). The steps of this process are as follows:

(1) All vector-terrains which can be rerouted to the same AREA-TILE are done. When rerouting VECTOR-TERRAIN it will sometimes be the case that the nearest compatible VECTOR-

TERRAIN is in the same AREA-TILE (along an edge). An example of this is given in FIG.XXX.

(2) Each remaining is rerouted in the direction of positive turning. Vector-terrain that are closer have priority over others … ie. The closest pairs match.'

(3) If necessary, remaining vector-terrains are routed off-map. When necessary, rerouted VECTOR-TERRAINs may terminate on LINEAR-TILE edges that would adjoin TILEs outside the playing area of the MAP (if the MAP were extended to include those TILEs), as depicted in schematic form in FIG.XXX.

(4) If necessary, empty blocking vector tiles are inserted to create additional matchings. When necessary, empty BLOCKING VECTOR-TERRAIN-TILEs are assigned to adjoining LINEAR-TILEs with so that rerouting may occur through those TILEs. The VECTOR-REROUTING process treats these tiles as if they contain BLOCKING VECTOR-TERRAIN. The preferred embodiment performs a breadth first search of adjoining LINEAR-TILEs for compatible VECTOR-TERRAIN. A schematic depiction of this sub-process is given in FIG.XXX.

[XXXX] POSITIVE-TURNING is the process of redirecting an EDGE-CROSSING VECTOR-TERRAIN in the direction of its uphill/inside attribute, as shown in FIG.XXX, to connect with the nearest VECTOR-TERRAIN of the same type with compatible uphill/inside attribute. A compatible uphill/inside attribute is one that has the same handedness

[XXXX] It may be necessary for a rerouted VECTOR-TERRAIN to pass through multiple BLOCKING VECTOR-FORM-TILE instances before being connected to a compatible VECTOR-TERRAIN.

[XXXX] VECTOR-TERRAINs of similar type will never cross as a result of the VECTOR-REROUTING process.

[XXXX] The most ascetically pleasing and realistic rerouting will follow a path parallel to the BLOCKING VECTOR-TERRAINs, with small variations introduced by a random number generator.

[XXXX] REROUTING CONFIGURATIONS: There are a finite set of possible rerouting configurations for each of the various map forms. These configurations are best conveyed by schematic depictions. The elements of those depictions are shown in FIG.XXX and are identified by the following callouts:

(A) The boundary of the LINEAR-TILE which defines the space through which VECTOR-TERRAIN may be rerouted is represented by a solid narrow black line.
(B) The edge(s) of VECTOR-TERRAIN-TILEs which have been assigned, and scaled, to adjoining AREA-TILEs are represented by dashed narrow black lines.
(C) The BLOCKING VECTOR-TERRAIN is represented by a solid wide black line.
(D) The VECTOR-TERRAIN-ENDPOINTS of the BLOCKING-LINEAR-VECTOr-TERRAIN represented by a bold rounded square.
(E) The allowed VECTOR-TERRAIN rerouting paths are represented by solid narrow shaded omni-directional arrows.
(F) The allowed uphill/inside attribute directions are represented by solid narrow shaded unidirectional arrows.

[XXXX] All rerouting configurations described below are subject to applicable mirror and rotation transformations, however, some configurations are symmetric about one or both axes so those configurations are not shown.

[XXXX] There are two sub-classes of LINEAR-TILE in a square-tiled AL-FORM-MAP. One class is adjoined by edge to two AREA-TILEs and two LINEAR-TILEs. That class is named SQUARE-EDGE LINEAR-TILE, and one is depicted in FIG.107 (edge A1 and A2 are adjoined to an AREA-TILE, edges B1 and B2 are adjoined to LINEAR-TILEs). The other class is adorned by a vertex to four AREA-TILEs. These are identified as SQUARE-VERTEX LINEAR-TILEs and is depicted in FIG. 108. … explain

[XXXX] The routing configurations for EDGE LINEAR-TILEs are:

(A) A single-edge BLOCKING-LINEAR-VECTOr-TERRAIN is given in FIG. 110A.
(B) The routing configuration for an edge-to-opposite-edge BLOCKING-LINEAR-VECTOr-TERRAIN is given in FIG.110B.

[XXXX] The routing configurations for VERTEX LINEAR-TILEs are given in:

(A) The routing configuration for a single-edge BLOCKING-LINEAR-VECTOR-TERRAIN is given in FIG.111A.
(B) The routing configuration for an edge-to-opposite-edge BLOCKING-LINEAR-VECTOr-TERRAIN is given in FIG.111B.
(C) The routing configuration for an edge-to-a-nearest-edge BLOCKING-LINEAR-VECTOR-TERRAIN is given in FIG.112.The routing configuration for an edge-to-opposite-edge-and-nearest-edge BLOCKING-LINEAR-VECTOR-TERRAIN is given in FIG. 113.

(D) The routing configuration for an edge-to-all-edges BLOCKING-LINEAR-VECTOR-TERRAIN is given in FIG.114.

[XXXX] A schematic depiction of the VECTOR-REROUTING process operating on a square-tiled AB-FORM-MAP composed of VECTOR-FORM-TILEs is give in this sequence of drawings: FIG.115, FIG.116, FIG. 117, and FIG.118.

[XXXX] FIG.115 shows a segment of square-tiled AL-FORM-MAP containing contour and forest AREA-VECTOR-TERRAIN and a road LINE-VECTOR-TERRAIN. All LINEAR-TILEs have been assigned the PASS-THRU VECTOR-TERRAIN TILE.

[XXXX] FIG.116 shows the same segment of square-tiled AL-FORM-MAP after the assignment of BLOCKING VECTOR-FORM-TILEs, containing a river LINE-VECTOR-TERRAIN, to several LINEAR-TILEs. The forest AREA-VECTOR-TERRAIN has been rerouted. A bridge structure, represented by a closed AREA-VECTOR-TERRAIN has been placed at the intersection of the road and the river. The contour AREA-VECTOR-TERRAIN has been hidden from view to improve clarity.

[XXXX] FIG.117 shows the same segment of square-tiled AL-FORM-MAP after the assignment of BLOCKING VECTOR-FORM-TILEs, containing a river LINE-VECTOR-TERRAIN, to several LINEAR-TILEs. However, in this drawing the forest and road terrain have been hidden to improve clarity. The contour AREA-VECTOR-TERRAIN has been rerouted.

[XXXX] FIG.118 shows the same segment of square-tiled AL-FORM-MAP after rerouting has been completed. All VECTOR-TERRAIN is shown.

[XXXX] There are two sub-classes of LINEAR-TILE in an offset-square-tiled AL-FORM-MAP. One sub-class adjoins two AREA-TILES, each by a full edge, and to four LINEAR-TILEs, each by a split edge. This sub-class is given the name FULL-AREA-EDGE LINEAR-TILE and an example is depicted in schematic form in FIG.120 (full edges A1 and A2 adjoin AREA-TILEs, split edges B1, B2, B3, and B4 adjoin LINEAR-TILEs). The other sub-class of LINEAR-TILE adjoins two AREA-TILEs, each by a split edge, two LINEAR-TILES, also each by a split edge, two additional LINEAR-TILES, each by a full edge. This sub-class is given the name SPLIT-AREA-EDGE LINEAR-TILE and an example is depicted in schematic form in FIG.119 (split edges A1 and A2 adjoin AREA-TILEs, split edges B1 and B2 adjoin LINEAR-TILEs, and full edges B3 and B4 adjoin LINEAR-TILEs).

[XXXX] The valid routing configurations for FULL-AREA-EDGE LINEAR-TILEs are:

(A) For a BLOCKING VECTOR-TERRAIN-TILE with single EDGE-CROSSING BLOCKING VECTOR-TERRAIN is given in schematic form in FIG.XXX.

(B) For a BLOCKING VECTOR-TERRAIN-TILE with two EDGE-CROSSING BLOCKING VECTOR-TERRAIN is given in schematic form in FIG.XXX.

[XXXX] The valid routing configurations for SPLIT-AREA-EDGE LINEAR-TILEs are:

(A) The routing configuration for an single-edge BLOCKING-LINEAR-VECTOR-TERRAIN is given in FIG.122A.

(B) The routing configurations for an edge-to-opposite-edge BLOCKING-LINEAR-VECTOR-TERRAIN is given in FIG.122B, FIG.123, and FIG.124.

(C) The routing configuration for an edge-to-a-nearest-edge BLOCKING-LINEAR-VECTOR-TERRAIN is given in FIG.124B and FIG. 124C.

(D) The routing configuration for an edge-to-opposite-edge-and-nearest-edge BLOCKING-LINEAR-VECTOR-TERRAIN is given in FIG. 125 and FIG.126.

(E) The routing configuration for an edge-to-all-edges BLOCKING-LINEAR-VECTOR-TERRAIN is given in FIG.127.

[XXXX] A schematic depiction of the VECTOR-REROUTING process operating on a offset-square-tiled AB-FORM-MAP composed of VECTOR-FORM-TILEs is give in this sequence of drawings: FIG.XXX, FIG.XXX, FIG.XXX, and FIG.XXX.

[XXXX] FIG.XXX shows a segment of offset-square-tiled AL-FORM-MAP containing contour and forest AREA-VECTOR-TERRAIN and a road LINE-VECTOR-TERRAIN. All LINEAR-TILEs have been assigned the PASS-THRU VECTOR-TERRAIN TILE.

[XXXX] FIG.XXX shows the same segment of offset-square-tiled AL-FORM-MAP after the assignment of BLOCKING VECTOR-FORM-TILEs, containing a river LINE-VECTOR-TERRAIN, to several LINEAR-TILEs. The forest AREA-VECTOR-TERRAIN has been rerouted. A bridge structure, represented by a closed AREA-VECTOR-TERRAIN has been placed at the intersection of the road and the river. The contour AREA-VECTOR-TERRAIN has been hidden from view to improve clarity.

[XXXX] FIG.XXX shows the same segment of offset-square-tiled AL-FORM-MAP after the assignment of BLOCKING VECTOR-FORM-TILEs, containing a river LINE-VECTOR-TERRAIN, to several LINEAR-TILEs. However, in this drawing the forest and road terrain have been hidden to improve clarity. The contour AREA-VECTOR-TERRAIN has been rerouted.

[XXXX] FIG.XXX shows the same segment of offset-square-tiled AL-FORM-MAP after rerouting has been completed. All VECTOR-TERRAIN is shown.

[XXXX] There is a single class of LINEAR-TILE in a hexagon-tiled AL-FORM-MAP, this is true of the icosahedron-hexagon-tiled AL-FORM-MAPs (the pentagons on the icosahedron vertices are always AREA-TILEs). This class is adjoined by an edge to two AREA-TILEs and four LINEAR-TILEs, as shown in FIG.132 (edge A1, A2 are adjoined to an AREA-TILE, edge B1, B2, B3, and B4 are adjoined to LINEAR-TILEs).

[XXXX] The routing configurations for hexagon-tiled LINEAR-TILEs are simple compared to the previous map forms. As a consequence, hexagon-tiling is the preferred map form for all maps except in certain building-interior cases where a square-tiled or offset-square-tiled map may have advantages. The two configurations are:

(A) The routing configuration for a single-edge BLOCKING-LINEAR-VECTOr-TERRAIN is given in FIG.133A. The BLOCKING terrain can pass to either or both edges, the effect on routing is identical.

(B) The routing configuration for an edge-to-opposite-edge BLOCKING-LINEAR-VECTOr-TERRAIN is given in FIG.133A. The BLOCKING terrain can pass through two, three, or four edges, the effect on routing is identical.

[XXXX] A schematic depiction of the VECTOR-REROUTING process operating on a hexagon-tiled AB-FORM-MAP composed of VECTOR-FORM-TILEs is give in this sequence of drawings: FIG.XXX, FIG.XXX, FIG.XXX, and FIG.XXX.

[XXXX] FIG.XXX shows a segment of hexagon-tiled AL-FORM-MAP containing contour and forest AREA-VECTOR-TERRAIN and a road LINE-VECTOR-TERRAIN. All LINEAR-TILEs have been assigned the PASS-THRU VECTOR-TERRAIN TILE.

[XXXX] FIG.XXX shows the same segment of hexagon-tiled AL-FORM-MAP after the assignment of BLOCKING VECTOR-FORM-TILEs, containing a river LINE-VECTOR-TERRAIN, to several LINEAR-TILEs. The forest AREA-VECTOR-TERRAIN has been rerouted. A bridge structure, represented by a closed AREA-VECTOR-TERRAIN has been placed at the intersection of the road and the river. The contour AREA-VECTOR-TERRAIN has been hidden from view to improve clarity.

[XXXX] FIG.XXX shows the same segment of hexagon-tiled AL-FORM-MAP after the assignment of BLOCKING VECTOR-FORM-TILEs, containing a river LINE-VECTOR-TERRAIN, to several LINEAR-TILEs. However, in this drawing the forest and road terrain have been hidden to improve clarity. The contour AREA-VECTOR-TERRAIN has been rerouted.

[XXXX] FIG.XXX shows the same segment of hexagon-tiled AL-FORM-MAP after rerouting has been completed. All terrain VECTOR-TERRAIN is shown.

[XXXX] A schematic depiction of the VECTOR-REROUTING process operating on a icosahedron-hexagon-tiled AB-FORM-MAP composed of VECTOR-FORM-TILEs is give in this sequence of drawings: FIG.XXX, FIG.XXX, FIG.XXX, and FIG.XXX.

[XXXX] FIG.XXX shows a segment of icosahedron-hexagon-tiled AL-FORM-MAP containing contour and forest AREA-VECTOR-TERRAIN and a road LINE-VECTOR-TERRAIN. All LINEAR-TILEs have been assigned the PASS-THRU VECTOR-TERRAIN TILE.

[XXXX] FIG.XXX shows the same segment of icosahedron-hexagon-tiled AL-FORM-MAP after the assignment of BLOCKING VECTOR-FORM-TILEs, containing a river LINE-VECTOR-TERRAIN, to several LINEAR-TILEs. The forest AREA-VECTOR-TERRAIN has been rerouted. A bridge structure, represented by a closed AREA-VECTOR-TERRAIN has been placed at the intersection of the road and the river. The contour AREA-VECTOR-TERRAIN has been hidden from view to improve clarity.

[XXXX] FIG.XXX shows the same segment of icosahedron-hexagon-tiled AL-FORM-MAP after the assignment of BLOCKING VECTOR-FORM-TILEs, containing a river LINE-VECTOR-TERRAIN, to several LINEAR-

TILEs. However, in this drawing the forest and road terrain have been hidden to improve clarity. The contour AREA-VECTOR-TERRAIN has been rerouted.

[XXXX] FIG.XXX shows the same segment of icosahedron-hexagon-tiled AL-FORM-MAP after rerouting has been completed. All VECTOR-TERRAIN is shown.

[XXXX] The AL-VECTOR-ENGINE allows TERRAIN representations to define multiple substitute AL-FORM-MAPs at various scales. This enables the AL-VECTOR-ENGINE to construct smaller-scale AL-FORM-MAPs from a set of adjacent AREA-TILEs of a large-scale AL-FORM-MAP. How this set is constructed depends on the tile structure:

(A) For a square-tiled AL-FORM-MAP with cartesian coordinate axes the preferred set of AREA-TILEs is constructed about a reference AREA-TILE as shown in schematic form in FIG.XXX.

(B) For an offset-square-tiled AL-FORM-MAP with 120° axial coordinate axes the preferred set of AREA-TILEs is constructed about a reference AREA-TILE as shown in schematic form in FIG.XXX.

(C) For an rectangular-hexagon-tiled AL-FORM-MAP with 120° axial coordinate axes the preferred set of AREA-TILEs is constructed about a reference AREA-TILE as shown in schematic form in FIG.XXX.

(D) For an hexagonal-hexagon-tiled AL-FORM-MAP with integer-latitude-longitude the preferred set of AREA-TILEs is constructed about a reference AREA-TILE as shown in schematic form in FIG.XXX. Note: the pentagon TILEs on the icosahedron vertices may never be a reference AREA-TILE.

[XXXX] The AL-VECTOR-ENGINE provides two blending function, one for AREA-TILEs and another for LINEAR-TILES, which are applied to TILEs which are assigned multiple TERRAINs during the construction of a smaller-scale AL-FORM-MAP.

[XXXX] The AREA-TILE blending function …

[XXXX] The LINEAR-TILE blending function …

more than one TILE during the to be applied to TILEs A first blending function is defined which operates on an unordered set of terrains. This set is composed of all of the terrains from a single tile from all overlapping smaller-scale maps. This set will usually consist of two TERRAINs, however in some cases the number may be more.

A second blending function is defined which operates on an ordered set of terrains.

A third blending function is defined which operates on the output of the first and second blending function. It produces the final TERRAIN for the TILE.

[XXXX] The preferred embodiment of an AL-VECTOR-ENGINE produces smaller-scale AL-FORM-MAPs with scale ratios (to the large-scale AL-FORM-MAPs) of even integer numbers. The dimensions of the smaller-scale substitutes are then defined as the scale ratio plus one, which guarantees the smaller-scale substitutes defined by TERRAIN representations always have an AREA-TILE at each corner of the larger TILE. The substitute is assumed to be placed relative to the center of the larger scale tile such that the vertices of the larger scale tile are position at the center of AREA-TILEs in the smaller scale substitute. Examples are given below.

(A) Square-tiled area-tile, scale ratio 1:10, FIG.XXX.
(B) Square-tiled edge linear-tile with regular visualization geometry, scale ratio 1:10, FIG.XXX.
(C) Square-tiled vertex linear-tile with regular visualization geometry, scale ratio 1:10, FIG.XXX.
(D) Offset-square-tiled area-tile, scale ratio 1:10, FIG.XXX.
(E) Offset-square-tiled full-edge linear-tile with regular visualization geometry, scale ratio 1:10, FIG.XXX.
(F) Offset-square-tiled split-edge linear-tile with regular visualization geometry, scale ratio 1:10, FIG.XXX.
(G) hexagon-tiled area-tile, scale ratio 1:10, FIG.XXX.
(H) hexagon-tiled linear-tile with regular visualization geometry, scale ratio 1:10, FIG.XXX.
(I) hexagon-tiled linear-tile with variable visualization geometry (wide), scale ratio 1:10, FIG.XXX.
(J) hexagon-tiled linear-tile with variable visualization geometry (wide-to-narrow), scale ratio 1:10, FIG.XXX.
(K) hexagon-tiled linear-tile with variable visualization geometry (narrow), scale ratio 1:10, FIG.XXX.

[XXXX] The substitute maps are mirrored and rotated according to the transformation instance properties of a TILE.

[XXXX] The process for constructing a smaller-scale AL-FORM-MAP with scale M from a larger-scale AL-FORM-MAP with scale N once the set of AREA-TILEs is know is as follows:

(1) The smaller-scale AL-FORM-MAP substitute for the TERRAIN representation assigned to the reference AREA-TILE is mirrored and rotated according to the transformation properties of that instance, and is placed at the center of the new AL-FORM-MAP (in the preferred embodiment is at the origin of the coordinate axes).

(2) The smaller-scale AL-FORM-MAP substitute for the TERRAIN representation assigned to each neighboring AREA-TILE is mirrored and rotated according to the transformation properties of that instance with a translation component equal to { SCALE-RATIO x T[V]] }.

(3)

(4) the center of the new AL-FORM-MAP (in the preferred embodiment is at the origin of the coordinate axes).

(5) An AL-FORM-MAP of scale M is constructed with dimensions N:M * X N:M * Y can contain all of the smaller-scale TILEs of the AREA-TILEs selected in step 1.

(6) The TILEs of the smaller-scale AL-FORM-MAP are assigned the TERRAIN types from the smaller-scale substitute AL-FORM-MAPs of the TERRAIN types referenced by the large-scale AREA-TILEs. The TILEs on the permitter of those tiles are blended where they overlap.

(7) The TILEs of the smaller-scale AL-FORM-MAP are assigned the TERRAIN types from the smaller-scale substitute AL-FORM-MAPs of the TERRAIN types referenced by the large-scale LINEAR-TILEs. The TILEs on the permitter of those tiles are blended

where they overlap before ALL of them are blended with the TERRAINs assigned in the previous step. The composite map is complete.

[XXXX] The boundaries of the smaller-scale map conform to the boundaries of the larger-scale TILE such that the edges of the larger-scale TILE must cross AREA-TILEs in the smaller scale map and the vertices of the larger scale TILE must also be centered on AREA-TILEs in the smaller-scale map.

Examples follow

square tiled

[XXXX] The result of the first four steps of the smaller-scale map generation process is shown in FIG.144. Four neighboring AREA-TILEs sharing two-edges and vertex were selected.

[XXXX] The result of the last step of the map generation process is shown in FIG.145.

Offset square tiled

[XXXX] The result of the first four steps of the smaller-scale map generation process is shown in FIG.152. Six neighboring AREA-TILEs were selected.

[XXXX] The result of the last step of the map generation process is shown in FIG.153.

Hexagon tiled

[XXXX] The result of the first four steps of the smaller-scale map generation process is shown in FIG.158. Four neighboring AREA-TILEs were selected.

[XXXX] The result of the last step of the map generation process is shown in FIG.159. The LINEAR-TERRAINs include regular, variable, and narrow geometry LINEAR-TILEs (shown in FIG.157A, FIG.157B, and FIG.157C).

[XXXX] High resolution cartesian axes terrain maps can be generated AL-FORM-MAPs with TERRAIN representations consisting of terrain data images, such as elevation and ground cover, using the processes described previously for creating a visualization of an AL-FORM-MAP. These terrain maps can then be used in ray-casting based implementations of fields-of-view and line-of-sight algorithms.

[XXXX] High resolution cartesian axes terrain maps can be generated from MAPs with VECTOR-FORM-TILEs, and AL-FORM-MAPs with VECTOR-FORM-TILEs, using prior art methods of rendering vector-graphics. Elevation changes between contour lines can be interpolated using prior art contour algorithms. These terrain maps can then be used in ray-casting based implementations of fields-of-view and line-of-sight algorithms.

CLAIMS

The invention claimed is a novel order of tiled terrain map, the AL-FORM-MAP, which integrates linear terrain features as a specialized class of tile with strict placement rules. This allows linear terrain features to be playable when called for, to be dimensioned and to occupy surface area more appropriate to their natural dimensions, while preserving the accuracy of distance based game systems and the utility of various coordinate-system dependent tile algorithms. The elements of this invention include:

A. In a game rule, game algorithm, and data storage context: A definition of area terrain as it pertains to this invention.
B. In a game rule, game algorithm, and data storage context: A definition of linear terrain as it pertains to this invention.
C. In a game rule, game algorithm, and data storage context: A definition of playable tile as it pertains to this invention.
D. In a game rule, game algorithm, and data storage context: A definition of unplayable tile as it pertains to this invention.
E. In a game rule, game algorithm, and data storage context: A map structure composed of two classes of tiles such that one class may only be assigned area terrain (the AREA-TILE class) and the other class may only be assigned linear terrain (the LINEAR-TILE class), where the class of any tile within an AL-FORM-MAP is determined by a mathematical function.
F. In a game rule, game algorithm, and data storage context: A method for determining the terrain class (AREA-TILE or LINEAR-TILE) of any tile from its coordinates in an AL-FORM-MAP.

G. In a game rule, game algorithm, and data storage context: A method for calculating the dimensions of an AL-FORM-MAP that is to be derived from an existing state-of-the-art tiled terrain map.

H. In a game rule, game algorithm, and data storage context: A method for assigning the terrain in a tile of an existing state-of-the-art tiled terrain map to an AREA-TILE in a properly dimensioned AL-FORM-MAP using a precise mathematical formula to determine the coordinates of the AREA-TILE.

I. In a game rule, game algorithm, and data storage context: A method for assigning the terrain on a tile-edge of an existing state-of-the-art tiled terrain map to a LINEAR-TILE in a properly dimensioned AL-FORM-MAP using a precise mathematical formula to determine the coordinates of the LINEAR-TILE.

J. In a game rule, game algorithm, and data storage context: A method for assigning the terrain on a tile-vertex of an existing state-of-the-art tiled terrain map to a LINEAR-TILE in a properly dimensioned AL-FORM-MAP using a precise mathematical formula to determine the coordinates of the LINEAR-TILE.

K. In a path-finding context: A method for determining if two AREA-TILEs should be considered adjacent and which tiles contribute to the cost of a move between them.

L. In a path-finding context: A method for determining if an AREA-TILE and LINEAR-TILE should be considered adjacent and which tiles contribute to the cost of a move between them.

M. In a path-finding context: A method for determining if two adjoining LINEAR-TILEs should be considered adjacent and which tiles contribute to the cost of a move between them.

N. In a path-finding context: A set of polygons with geometric properties dictated by this invention and textured to depict the terrain of all AREA-TILEs of an AL-FORM-MAP.

O. In a visualization context: A set of polygons with geometric properties dictated by this invention and textured to depict the terrain of all AREA-TILEs of an AL-FORM-MAP.

P. In a visualization context: A set of line elements with geometric properties dictated by this invention and rendered to produce an outline about the playable AREA-TILEs of an AL-FORM-MAP.

Q. In a visualization context: A set of line elements with geometric properties dictated by this invention and rendered to produce an outline about the playable LINEAR-TILEs of an AL-FORM-MAP.

R. In a visualization context: A method for ordering elements A, B, C, and D during rendering that will produce the preferred embodiment.

NOTE: last 4, note symmetry is broken, border tiles can take on irregular shapes.

Claim 1 as given above.

Claim 2 is a library of digital terrain tiles

Claim 3 is a rendering mechanism that produces high resolution cartesian coordinate grids suitable for close order battle resolution, which uses a ray casting technique. The the technique is modified for hexagonal maps, skew left and right.

ABSTRACT OF THE DISCLOSURE

This invention advances the state-of-the-art of game and simulation tiled maps by introducing novel order tile structures that integrate linear terrain features as a specialized tile class with strict placement restrictions. This order allows those features to be playable when called for, to be dimensioned and to occupy surface area appropriate to the natural dimensions of those features, all while preserving the accuracy of distance based game systems and the utility of various coordinate system dependent tile algorithms. Also introduced are a set of necessary modifications for path-finding, line-of-sight, and area-effect methods; and methods for constructing the geometry of two-dimensional visualizations of such maps.