WHAT IS CLAIMED IS:

1. A method for assigning an attribute to x-ray attenuation comprising:

acquiring first and second reference material equivalent path length information associated with a first range of dual-energy x-ray attenuation information;

acquiring second and third reference material equivalent path length information associated with a second range of dual-energy x-ray attenuation information; and,

joining ~~the first~~ the first dual-energy x-ray attenuation information range with the second dual-energy x-ray attenuation information range using coefficients representing dual-energy x-ray attenuation information of the second reference material to define a third dual-energy x-ray attenuation information range upon which may be imposed dual-energy x-ray attenuation values within the third dual-energy x-ray attenuation information range to determine corresponding first reference material equivalent path lengths and third reference material equivalent path lengths.

2. The method as in claim 1, wherein the step of acquiring first and second reference material equivalent path length information associated with a first range of dual-energy x-ray attenuation information further comprises the steps of:

scanning in an x-ray scanning device first and second reference materials each having known atomic composition, known dimensions and known orientation in the x-ray scanning device, the x-ray scanning device emitting x-rays which pass through the first reference material with first reference material path lengths and through the second reference material with second reference material path lengths, the x-rays being detected by an array of detectors to provide first dual-energy x-ray attenuation information for each of the first and second reference materials;

associating the first dual-energy x-ray attenuation information with each of the first reference material path lengths and the second reference material path lengths; and,

expressing collectively each of the first reference material path lengths and the second reference material path lengths as a function of the associated first dual-energy x-ray attenuation information to define first dual-energy attenuation surfaces.

3. The method as in claim 1, wherein the step of acquiring first and second reference material equivalent path length information associated with a first range of dual-energy x-ray attenuation information further comprises the steps of:

retrieving from lookup tables saved first and second reference material equivalent path lengths associated with the dual-energy x-ray attenuation information corresponding with the first dual-energy attenuation information range.

4. The method as in claim 1, wherein the step of acquiring second and third reference material equivalent path length information associated with a first range of dual-energy x-ray attenuation information further comprises the steps of:

scanning in the x-ray scanning device the second reference material and a reference third material having known atomic composition, known dimensions and known orientation in the x-ray scanning device to provide second low-energy x-ray attenuation information and high-energy x-ray attenuation information for each of the second and third reference materials;

associating each of the second low-energy x-ray attenuation information and the second high-energy x-ray attenuation information with each of the second reference material path lengths and third reference material path lengths; and,

expressing collectively each of the second reference material path lengths and the third reference material path lengths as a function of the associated low-energy x-ray attenuation information and high-energy x-ray

attenuation information to define second high-energy attenuation surfaces and second low-energy attenuation surfaces.

5. The method as in claim 1, wherein the step of acquiring second and third reference material equivalent path length information associated with a second range of dual-energy x-ray attenuation information further comprises the steps of:

retrieving from lookup tables saved second and third reference material equivalent path lengths associated with the dual-energy x-ray attenuation information corresponding with the second dual-energy attenuation information range.

6. The method according to claim 2, wherein the step of expressing collectively each of the first reference material path lengths and the second reference material path lengths further comprises the step of:

selecting a model for expressing collectively each of the first reference material path lengths and the second reference material path lengths as a function of the associated first dual-energy x-ray attenuation information to define the dual-energy attenuation surfaces.

7. The method according to claim 2, wherein the step of expressing collectively each of the first reference material path lengths and the second reference material path lengths further comprises the step of:

determining numerically pointwise inverted first dual-energy attenuation surfaces using an optimization algorithm inverting the first dual-energy attenuation surfaces.

8. The method according to claim 4, wherein the step of expressing collectively each of the second reference material path lengths and the third reference material path lengths further comprises the step of:

selecting a model for expressing collectively each of the second reference material path lengths and the third reference material path lengths as a function of the associated second dual-energy x-ray attenuation information to define the second dual-energy attenuation surfaces.

9. The method according to claim 4, wherein the step of expressing collectively each of the second reference material path lengths and the third reference material path lengths further comprises the step of:

determining numerically pointwise inverted second dual-energy attenuation surfaces using an optimization algorithm inverting the second dual-energy attenuation surfaces.

10. The method according to claim 6, wherein the model is a second model, the first dual-energy attenuation surfaces are first dual-energy inverse attenuation surfaces, respectively, and prior to the associating step, the method further comprising the steps of:

associating each of the first dual-energy x-ray attenuation information with corresponding ones of each of the first material path lengths and the second material path lengths; and,

selecting a first model for expressing collectively the first dual-energy x-ray attenuation information as a function of the first reference material path lengths and the second reference material path lengths to define first direct attenuation surfaces.

11. The method according to claim 6, wherein the step of selecting the model further includes the steps of:

selecting a set of coefficients to be applied to the model for fitting the first dual-energy x-ray attenuation information with the model; and,

fitting the first dual-energy x-ray attenuation information with the model optimizing the coefficients.

12. The method according to claim 11, wherein the step of selecting the model further includes the steps of:

selecting the set of fitting constraints to be applied to the model for selecting the coefficients; and,

selecting the set of coefficients by applying the set of fitting constraints to the model.

13. The method according to claim 10, wherein the step of selecting the first model further includes the steps of:

selecting a first set of coefficients to be applied to the first model for fitting the first dual-energy x-ray attenuation information with the first model; and,

fitting the first dual-energy x-ray attenuation information with the first model optimizing the first coefficients; and,

the step of selecting the second model further includes the steps of:

selecting a second set of coefficients to be applied to the second model for fitting the first dual-energy x-ray attenuation information with the second model; and,

fitting the first dual-energy x-ray attenuation information with the second model optimizing the second set of coefficients.

14. The method according to claim 13, wherein the step of selecting the first model further includes the steps of:

selecting a first set of fitting constraints to be applied to the first model for selecting the first set of coefficients; and,

selecting the set of first coefficients by applying the first set of fitting constraints to the first model; and,

the step of selecting second the model further includes the steps of:

selecting a second set of fitting constraints to be applied to the second model for selecting the second set of coefficients; and,

selecting the second set of coefficients by applying the second set of fitting constraints to the second model.

15. The method according to claim 6, wherein the model is a second model, the second dual-energy attenuation surfaces are second dual-energy inverse attenuation surfaces, respectively, and prior to the associating step, the method further comprising the steps of:

associating each of the second dual-energy x-ray attenuation information with corresponding ones of each of the second material path lengths and the third material path lengths; and,

selecting a first model for expressing collectively the second dual-energy x-ray attenuation information as a function of the second reference material path lengths and the third reference material path lengths to define second direct attenuation surfaces.

16. The method according to claim 8, wherein the step of selecting the model further includes the steps of:

selecting a set of coefficients to be applied to the model for fitting the second dual-energy x-ray attenuation information with the model; and,

fitting the second dual-energy x-ray attenuation information with the model optimizing the coefficients.

17. The method according to claim 16, wherein the step of selecting the model further includes the steps of:

selecting the set of fitting constraints to be applied to the model for selecting the coefficients; and,

selecting the set of coefficients by applying the set of fitting constraints to the model.

18. The method according to claim 15, wherein the step of selecting the first model further includes the steps of:

selecting a first set of coefficients to be applied to the first model for fitting the second dual-energy x-ray attenuation information with the first model; and,

fitting the second dual-energy x-ray attenuation information with the first model optimizing the first coefficients; and,

the step of selecting the second model further includes the steps of:

selecting a second set of coefficients to be applied to the second model for fitting the second dual-energy x-ray attenuation information with the second model; and,

fitting the second dual-energy x-ray attenuation information with the second model optimizing the second set of coefficients.

19. The method according to claim 18, wherein the step of selecting the first model further includes the steps of:

selecting a first set of fitting constraints to be applied to the first model for selecting the first set of coefficients; and,

selecting the set of first coefficients by applying the first set of fitting constraints to the first model; and,

the step of selecting second the model further includes the steps of:

selecting a second set of fitting constraints to be applied to the second model for selecting the second set of coefficients; and,

selecting the second set of coefficients by applying the second set of fitting constraints to the second model.

20. The method according to claim 6, wherein the dual-energy x-ray attenuation information includes high-energy x-ray attenuation information and low-energy x-ray attenuation information and wherein the step of associating each of the first low-energy x-ray attenuation information and the first high-energy x-ray attenuation information with each of the first reference material path lengths and the second reference material path lengths further comprises:

defining a first space wherein the first low-energy x-ray attenuation information of the first reference material and the second reference material defines a first plane and first reference material path lengths and second reference material path lengths each define a first height over the first plane;

defining a second space wherein the first high-energy x-ray attenuation information of the first reference material and the second reference material defines a second plane and first reference material path lengths and second reference material path lengths each define a second height over second the plane; and,

representing collectively the first reference material path lengths and the second reference material path lengths using the model to define the first high-energy direct attenuation surface and first low energy direct attenuation surface.

21. The method according to claim 10, wherein the dual-energy x-ray attenuation information includes high-energy x-ray attenuation information and low-energy x-ray attenuation information and wherein the associating step further comprises:

defining a space wherein the first reference material path lengths and the second reference material path lengths define a first plane and the first high-energy x-ray attenuation information and the first low-energy x-ray attenuation information each define a respective first and second height over the first plane and representing collectively the first high-energy x-ray attenuation information and the first low-energy x-ray attenuation information using the first model to define the first high-energy direct attenuation surface and first low energy direct attenuation surface; and,

defining an inverse space wherein the first low-energy x-ray attenuation information and the first high-energy x-ray attenuation information define a second plane and first reference material path lengths and second reference material path lengths each define a respective third and fourth height over the second plane; and,

representing collectively the first reference material path lengths and the second reference material path lengths using the second model to define first high-energy and first low-energy inverse attenuation surfaces.

22. The method according to claim 8, wherein the dual-energy x-ray attenuation information includes high-energy x-ray attenuation information and low-energy x-ray attenuation information and wherein the step of associating each of the second low-energy x-ray attenuation information and the second high-energy x-ray attenuation information with each of the second reference material path lengths and third reference material path lengths further comprises:

defining a first space wherein the second low-energy x-ray attenuation information of the second reference material and the third reference material defines a first plane and second reference material path lengths and third reference material path lengths each define a first height over the first plane;

defining a second space wherein the second high-energy x-ray attenuation information of the second reference material and the third reference material defines a second plane and second reference material path lengths and third reference material path lengths each define a second height over second the plane; and,

representing collectively the second reference material path lengths and the third reference material path lengths using the model to define the second high-energy direct attenuation surface and second low energy direct attenuation surface.

23. The method according to claim 22, wherein the associating step further comprises:

defining a space wherein the second reference material path lengths and the third reference material path lengths define a first plane and the second high-energy x-ray attenuation information and the second low-energy x-ray attenuation information each define a respective first and second height over the first plane and representing collectively the second high-energy x-ray attenuation information and the second low-energy x-ray attenuation information using the first model to define the second high-energy direct attenuation surface and second low energy direct attenuation surface; and,

defining an inverse space wherein the second low-energy x-ray attenuation information and the second high-energy x-ray attenuation information define a second plane and second reference material path lengths and third reference material path lengths each define a respective third and fourth height over the second plane; and,

representing collectively the second reference material path lengths and the third reference material path lengths using the second model to define second high-energy and second low-energy inverse attenuation surfaces.

24. The method according to claim 1, wherein the step of joining the first the first dual-energy x-ray attenuation information range with the second dual-energy x-ray attenuation information range further comprises the steps of:

selecting a first model for expressing collectively each of the first reference material path lengths and the second reference material path lengths as a function of the associated first dual-energy x-ray attenuation information range;

selecting a first set of coefficients to be applied to the first model for fitting the first dual-energy x-ray attenuation information range with the first model;

selecting a second model for expressing collectively each of the second reference material path lengths and the third reference material path lengths as a function of the associated second dual-energy x-ray attenuation information range;

selecting a second set of coefficients to be applied to the second model for fitting the second dual-energy x-ray attenuation information range with the second model;

weighting to a zero value the coefficients for fitting the dual-energy x-ray attenuation information of the first reference material to the first model to obtain a subset of coefficients for fitting respective dual-energy x-ray attenuation information of only the second reference material to either of the first model and the second model; and,

fitting the first set of coefficients with the second set of coefficients using the subset of coefficients to join the first model and the second model to provide the third dual-energy x-ray attenuation information range.

25. A method for assigning an attribute to x-ray attenuation comprising:

acquiring first and second reference material equivalent path length information associated with a first range of dual-energy x-ray attenuation information by a first model for expressing collectively each of the first reference material path lengths and the second reference material path lengths as a function of the associated first range of dual-energy x-ray attenuation information, the first range of dual-energy attenuation information being fitted with the first model by a first set of coefficients;

acquiring third reference material equivalent path length information associated with a second range of dual-energy x-ray attenuation information by a second model for expressing collectively each of the third reference material equivalent path lengths as a function of the associated second range of dual-energy attenuation information, the second range of dual-energy being fitted with the second model by a second set of coefficients, the third reference material having an effective atomic number greater than that of the second reference material;

combining the first set of coefficients and the second set of coefficients to provide a third set of coefficients for fitting the first and second range of dual-energy x-ray attenuation information with a third model for expressing collectively the first and third reference material path lengths as a function of the fitted first and second range of dual-energy x-ray attenuation information; and,

for all points in the third model determine a volume fraction of one of the first and the third reference material which represents the second reference material path lengths to identify where in the third model path lengths representing the second reference material are represented.

26. The method as in claim 25, wherein the step of acquiring first and second reference material equivalent path length information associated with a first range of dual-energy x-ray attenuation information further comprises the steps of:

scanning in an x-ray scanning device first and second reference materials each having known atomic composition, known dimensions and known orientation in the x-ray scanning device, the x-ray scanning device emitting x-rays which pass through the first reference material with first reference material path lengths and through the second reference material with second reference material path lengths, the x-rays being detected by an array of detectors to provide first dual-energy x-ray attenuation information for each of the first and second reference materials;

associating each of the first dual-energy x-ray attenuation information with each of the first reference material path lengths and the second reference material path lengths; and,

expressing collectively each of the first reference material path lengths and the second reference material path lengths as a function of the associated first dual-energy x-ray attenuation information to define first dual-energy attenuation surfaces.

27. The method as in claim 25, wherein the step of acquiring first and second reference material equivalent path length information associated with a first range of dual-energy x-ray attenuation information further comprises the steps of:

retrieving from lookup tables saved first and second reference material equivalent path lengths associated with the dual-energy x-ray attenuation information corresponding with the first dual-energy attenuation information range.

28. The method as in claim 25, wherein the step of acquiring third reference material equivalent path length information associated with a second range of dual-energy x-ray attenuation information further comprises the steps of:

scanning in the x-ray scanning device the third reference material having known atomic composition, known dimensions and known orientation in the x-ray scanning device to provide second dual-energy x-ray attenuation information for the third reference material;

associating each of the second dual-energy x-ray attenuation information with the third reference material path lengths; and,

expressing collectively the third reference material path lengths as a function of the associated dual-energy x-ray attenuation information to define second dual-energy attenuation surfaces.

29. The method as in claim 25, wherein the step of acquiring third reference material equivalent path length information associated with a second

range of dual-energy x-ray attenuation information further comprises the steps of:

retrieving from lookup tables saved third reference material equivalent path lengths associated with the dual-energy x-ray attenuation information corresponding with the second dual-energy attenuation information range.

30. The method according to claim 25, wherein the step of fitting the first model by a first set of coefficients further includes the steps of:

fitting the first range of dual-energy x-ray attenuation information with the first model to optimize the first set of coefficients.

31. The method according to claim 25, wherein fitting the first range of dual-energy attenuation information with the first model by a first set of coefficients further includes the steps of:

selecting a set of fitting constraints to be applied to the first model for selecting the first set of coefficients; and,

selecting the first set of coefficients by applying the set of fitting constraints to the first model.

32. The method according to claim 25, wherein the step of fitting the second range of dual-energy attenuation information with the second model by a second set of coefficients further includes the steps of:

fitting the second range of dual-energy x-ray attenuation information with the second model to optimize the second set of coefficients.

33. The method according to claim 25, wherein fitting the second range of dual-energy attenuation information with the second model by a second set of coefficients further includes the steps of:

selecting a set of fitting constraints to be applied to the second model for selecting the second set of coefficients; and,

selecting the second set of coefficients by applying the set of fitting constraints to the second model.

34. The method according to claim 25, wherein the dual-energy x-ray attenuation information includes high-energy x-ray attenuation information and low-energy x-ray attenuation information and wherein associating the first range of dual-energy x-ray attenuation with each of the first reference material path lengths and the second reference material path lengths further comprises:

defining a first space wherein the first low-energy x-ray attenuation information of the first reference material and the second reference material defines a first plane and first reference material path lengths and second reference material path lengths each define a first height over the first plane;

defining a second space wherein the first high-energy x-ray attenuation information of the first reference material and the second reference material defines a second plane and first reference material path lengths and second reference material path lengths each define a second height over second the plane; and,

representing collectively the first reference material path lengths and the second reference material path lengths using the first model to define first dual-energy direct attenuation surfaces.

35. The method according to claim 25, wherein the dual-energy x-ray attenuation information includes high-energy x-ray attenuation information and low-energy x-ray attenuation information and wherein associating the second range of dual-energy x-ray attenuation information with the third reference material path lengths further comprises:

defining a first space wherein the second low-energy x-ray attenuation information of the third reference material defines a first plane and the third reference material path lengths define a first height over the first plane;

defining a second space wherein the second high-energy x-ray attenuation information of the third reference material defines a second plane and the third reference material path lengths define a second height over second the plane; and,

representing collectively the third reference material path lengths using the second model to define second dual-energy direct attenuation surfaces.

36. The method according to claim 25, wherein the dual-energy x-ray attenuation information includes high-energy x-ray attenuation information and low-energy x-ray attenuation information and further comprising the steps of:

defining a space wherein the first reference material path lengths and the third reference material path lengths define a first plane and the first and second high-energy x-ray attenuation information and the first and second low-energy x-ray attenuation information each define a respective first and second height over the first plane and the third model expresses collectively the first and third reference material path lengths as a function of the first and second low-energy x-ray attenuation and the first and second high-energy x-ray attenuation to define a third dual-energy direct attenuation surface; and,

defining an inverse space wherein the first and second low-energy x-ray attenuation information and the first and second high-energy x-ray attenuation information define a second plane and first reference material path lengths and third reference material path lengths each define a respective third and fourth height over the second plane; and,

representing collectively the first reference material path lengths and the third reference material path lengths using the third model to define dual-energy inverse attenuation surfaces.

37. A method for assigning an attribute to x-ray attenuation comprising:

acquiring first and second reference material equivalent path length information associated with a first range of dual-energy x-ray attenuation information by a model for expressing collectively each of the first reference material path lengths and the second reference material path lengths as a function of the associated first range of dual-energy x-ray attenuation information;

selecting an extrapolation range of dual-energy x-ray attenuation information over which first and second reference material path lengths are to be associated with dual-energy x-ray attenuation information of a first imposed material having a predetermined minimum effective atomic number less than an effective atomic number of the first reference material and a second imposed material having a predetermined maximum effective atomic number greater than an effective atomic number of the second reference material, wherein the first range is within the extrapolation range;

selecting a set of fitting constraints for associating each of the first reference material path lengths and the second reference material path lengths over the extrapolation range of dual-energy attenuation information to define extrapolated first and second reference material equivalent path lengths over the extrapolation range; and,

applying the set of fitting constraints to the model.

38. The method as in claim 37, wherein the step of acquiring first and second reference material equivalent path length information associated with a first range of dual-energy x-ray attenuation information further comprises the steps of:

scanning in an x-ray scanning device first and second reference materials each having known atomic composition, known dimensions and known orientation in the x-ray scanning device, the x-ray scanning device emitting x-rays which pass through the first reference material with first reference material path lengths and through the second reference material with second reference material path lengths, the x-rays being detected by an array of detectors to provide first dual-energy x-ray attenuation information for each of the first and second reference materials;

associating the first dual-energy x-ray attenuation information with each of the first reference material path lengths and the second reference material path lengths; and,

using the model to express collectively each of the first reference material path lengths and the second reference material path lengths as a

function of the associated first dual-energy x-ray attenuation information to define first dual-energy attenuation surfaces.

39. The method as in claim 37, wherein the step of acquiring first and second reference material equivalent path length information associated with a first range of dual-energy x-ray attenuation information further comprises the steps of:

retrieving from lookup tables saved first and second reference material equivalent path lengths associated with the dual-energy x-ray attenuation information corresponding with the first range of dual-energy x-ray attenuation information.

40. The method according to claim 37, wherein the applying the set of fitting constraints to the model further includes the step of:

selecting a set of coefficients to be applied to the model for fitting the dual-energy x-ray attenuation information of the first range with the model; and,

fitting, using the set of fitting constraints, the dual-energy x-ray attenuation information of the extrapolation range with the model.

41. The method according to claim 37, wherein the dual-energy x-ray attenuation information includes high-energy x-ray attenuation information and low-energy x-ray attenuation information and wherein associating each of the first and second reference material path lengths with the first range of dual-energy x-ray attenuation information further comprises:

defining a first space wherein the low-energy x-ray attenuation information of the first reference material and the second reference material defines a first plane and first reference material path lengths and second reference material path lengths each define a first height over the first plane;

defining a second space wherein the high-energy x-ray attenuation information of the first reference material and the second reference material defines a second plane and first reference material path lengths and second reference material path lengths each define a second height over second the plane; and,

representing collectively the first reference material path lengths and the second reference material path lengths using the first model to define the dual-energy direct attenuation surfaces.

42. The method according to claim 37, wherein the dual-energy x-ray attenuation information includes high-energy x-ray attenuation information and low-energy x-ray attenuation information and wherein the step of selecting a second model further comprises:

defining a first space wherein the low-energy x-ray attenuation information of the first imposed material and the second imposed material defines a first plane and first imposed material path lengths and second imposed material path lengths each define a first height over the first plane;

defining a second space wherein the high-energy x-ray attenuation information of the first imposed material and the second imposed material defines a second plane and first imposed material path lengths and second imposed material path lengths each define a second height over second the plane; and,

representing collectively the first imposed material path lengths and the second imposed material path lengths using the second model to define the extrapolated dual-energy direct attenuation surfaces.