Intellectual Property Office

BL O/138/18
5th March 2018

PATENTS ACT 1977

APPLICANT	Landmark Graphics Corporation
ISSUE	Whether patent applications GB1600697.5, GB1600691.8, GB1600693.4 and GB1600698.3 comply with section 1(2)
HEARING OFFICER	H Jones

DECISION

Introduction

1 This decision relates to a second group of four applications out of a total of sixteen from the same applicant. The sixteen applications have been examined by different examiners and all have concluded that the subject-matter of each of the applications is excluded from patentability under section 1(2) of the Patents Act 1977 ("the Act"), as a computer program in all cases and also as a mathematical method for some. I have already issued a decision relating to a first group of seven applications (BL O/112/18). The four applications with which this decision is concerned relate in general to computer-implemented methods of working with models of subterranean geology and for determining characteristics of that geology. The four applications were examined by the same examiner. Despite several rounds of correspondence, in each case the applicant and the examiner have been unable to resolve matters and the issues came before me on 8 and 9 January 2018.

2 As I explained in my earlier decision, at the hearing the applicant was represented by Mr Alistair Russell and Dr Mark Jones of Hoffmann Eitle who argued that the Office approach in dealing with methods relating to geophysical modelling in these sixteen applications and similar applications refused previously is inconsistent with guidance from the Courts. It remains the case that I am extremely grateful to Mr Russell and Dr Jones for the skeleton arguments provided before the hearing and for their structured presentations on all sixteen of the applications over the course of the two days.

The Law

3 In my earlier decision I dealt with the general approach to assessing patentability under section 1(2) before turning to the seven individual applications. I need not repeat myself here on this general approach and I attach the relevant part of BL O/112/18 at Annex 1.

4 It is sufficient to say here that I will employ the four step test from *Aerotel*[1], the steps from which are as follows:

[1] Aerotel Ltd v Telco Holdings Ltd and Macrossan's Application [2006] EWCA Civ 1371

(1) properly construe the claim;
(2) identify the actual contribution;
(3) ask whether it falls solely within the excluded subject matter;
(4) check whether the actual or alleged contribution is actually technical in nature.

The applications in suit

5 This group of applications were all filed as PCT applications on 15 August 2014 and share a single priority application dated 16 August 2013. The disclosure in each application is essentially the same, since each relates to an overall method, as shown in figure 1 of the specification and reproduced at Annex 2. Consequently I have arranged them in what seems to me to be a sensible order based upon where they lie within the larger method. I will deal with the applications in turn.

i) GB1600697.5

6 GB1600697.5, published as GB2531459 and corresponding to PCT publication WO 2015/23973, relates to the overall method shown in figure 1 and described in paragraphs [0025] to [0035] of the description, reproduced at Annex 2.

7 Claim 1 as currently amended reads as follows:

> 1. A method for determining reserve estimates for a reservoir, which comprises:
> loading a sealed triangulated mesh, which includes a volume, the sealed triangulated mesh being based on received data;
> creating a thickness grid using the sealed triangulated mesh and a computer processor;
> determining reserve estimates in a reservoir model using one of the volume of the sealed triangulated mesh and the thickness grid;
> converting the reserve estimates, the sealed triangulated mesh and the thickness grid into a printable string;
> storing the printable string in Processing History fields with a link to a 3D modeling engine and predefined identification properties describing the reserve estimates; and
> generating at least one of a table, a report and a graph for the reserve estimates and the predefined identification properties using the printable string.

8 Independent claim 9 is directed to program carrier device, but relates to the same inventive concept as claim 1 and so I will consider only claim 1. I note that claims 18 and 19 are omnibus claims, which are no longer allowed following an amendment to the Patent Rules 2007.

9 Turning to the four steps in the *Aerotel* test I must first properly construe the claim. It seems to me that the claim is clear. The method claimed is explicitly implemented using a computer processor and takes as its input a mesh that is based on data that is described as received. At the hearing Mr Russell and Dr Jones were careful to point out that this data is data concerned with geology, so by implication not arbitrary data. Although it is not discussed in the application to any great extent it is clear to

me from the application as a whole that reservoir in this context must relate to a reservoir of fluid within a geological structure.

10 Next I must identify the actual contribution. According to the examiner the contribution is apparently “a means for processing then outputting the processed data without any physical process or external process being affected”. Mr Russell and Dr Jones tell me that the contribution is “a better computer-implemented process for gaining an accurate three-dimensional visual representation of calculated reserve volumes”. The table, report and graph options at the end of claim 1 are not obviously three-dimensional visual representations. However, as paragraph [0024] in the description explains, “At all stages of the analysis, the actual sealed space being analyzed is visible”. Nevertheless the method of claim 1 does not provide a three-dimensional visual representation and hence I cannot agree with the contribution proposed by Mr Russell and Dr Jones. By contrast claim 2 requires “displaying the sealed triangulated mesh and the thickness grid with the at least one of the table, the report and the graph” which seems to provide a three-dimensional visual representation. It seems to me that the contribution must lie in determining reserve estimates using either the volume of a sealed triangulated mesh or a thickness grid, the thickness grid being created using the sealed triangulated mesh. The second half of the claim is concerned with the creation, storage and use of a printable string, but this does not seem to me to be key to a method for determining reserve estimates, to which claim 1 is directed. The description seems to suggest that the use of a sealed triangulated mesh lies at the heart of the invention, see paragraph [0022]:

> “This disclosure complements a new direction in 3D modeling where sealed triangulated mesh spaces, also referred to as called compartments, are modeled instead of just the geological objects (e.g. surfaces, faults, geoshells, fluid contacts). These compartments are auto- grouped into different geologic categories such as stratigraphic layers, fault blocks, fluid layers and geoshells, or they may be grouped manually into custom reservoirs, to help identify the exact GRV and/or reserve calculations. The modeled volumes may be visualized in all views by color and/or lithology fills.”

11 To my mind the contribution I have identified is not a computer program as such, although undoubtedly the invention is implemented using a computer processor. The method takes in a model based on real data representing a geological formation and modifies that model by determining properties of the modelled formation and associating them with the model. In my view, this is similar to "*obtaining and/or reproducing an image of a physical object or even an image of a simulated object*” as referred to in *Vicom*. Arguably in this invention the image or model in the form of the mesh has already been obtained and the model is only changed insofar as a thickness grid and reserve estimates are formed and associated with the mesh.

12 As a final check, this contribution seems to me to be technical in nature and, in the terms of *Halliburton*[2], is “*a highly technical process, capable of being applied industrially……The detailed problems to be solved … are technical problems with technical solutions”*.

[2] Halliburton Energy Services Inc., [2011] EWHC 2508 (Pat)

ii) GB1600691.8

13 The next application is GB1600691.8, which was published as GB2531458 and corresponds to PCT publication WO 2015/023962. This application relates to the fast sweep thickness extraction of step 106 in figure 1, described in more detail in paragraphs [0036] to [0044] on pages 7 to 9 of the description and figure 2 of the drawings, reproduced at Annex 3.

14 There are independent claims to a method and to a program carrier which share an inventive concept. There are also several omnibus claims. Amended claim 1 reads as follows:

> 1. A method for determining reserve estimates for a reservoir, which comprises:
>
> creating a plurality of polylines by intersecting a vertical plane with a sealed triangulated mesh at a predefined slice interval along an x-dimension in spatial extents for the sealed triangulated mesh, each polyline including a first point and a last point;
>
> creating a plurality of polygons by connecting the first point and the last point on each polyline in a respective vertical plane;
> aligning each polygon perpendicular to the respective vertical plane;
> creating a grid wherein each grid node on the grid is initiated with a value of zero;
>
> computing a plurality of thickness values using each aligned polygon at a predefined thickness interval;
> creating the thickness grid using a computer processor by assigning each thickness value to a respective grid node on the grid; and
>
> determining reserve estimates in a reservoir model using the thickness grid and storing the reserve estimates with the sealed triangulated mesh and the thickness grid.

15 As originally filed, claim 1 was directed to a method for creating a thickness grid and lacked the final step above of determining and storing the reserve estimates. In effect the method now claimed concerns the fast sweep thickness extraction of figure 2 and the next relevant steps from the overall process in figure 1, namely steps 112 and 114, but not the details of those steps.

16 In construing claim 1 as the *Aerotel* test requires, I am bound to point out that the use of a sealed triangulated mesh and the estimation of a reserve value for the reservoir both mean that once again this is not an abstract method in that it derives a reserve estimate based on real data.

17 According to Mr Russell and Dr Jones the contribution here is a better computer-implemented process for determining reserve estimates for a reservoir, which has some commonality with the assessment of the contribution by examiner, for whom the contribution is a mathematical means implemented by computer program for calculating reserve estimates. The examiner goes on to say that this provides no technical contribution and is excluded as a mathematical method and/or a computer

program. I agree with Mr Russell and Dr Jones that the contribution is a computer-implemented process for determining reserve estimates for a reservoir, but I would go further and say that the estimate is determined using a thickness grid created from a sealed triangulated mesh.

18 I do not believe that this contribution can be said to fall exclusively within excluded subject matter as either a mathematical method or a computer program, despite the computer implementation. I would go on to say that, in my view, estimating the reserve in a reservoir is necessarily technical in nature.

iii) GB1600693.4

19 Turning now to GB1600693.4, this application was published as GB2530952 and corresponds to PCT publication WO 2015/023964. This application is concerned with determining reserve estimates for a reservoir incorporating the computation of spatially aware reserve estimates of step 112 in figure 1, described in more detail in paragraphs [0050] to [0063] on pages 10 to 13 of the description and figure 4 of the drawings, reproduced at Annex 4.

20 Yet again there are method and program carrier claims which share an inventive concept, and claim 1 as amended reads as follows:

> 1. A method for determining reserve estimates for a reservoir, which comprises:
>
> resampling an attribute grid by matching the attribute grid and a thickness grid so that the attribute grid includes an attribute grid node at each location of a thickness grid node;
>
> creating a unified grid with a plurality of cells and a unified grid node at each location of an attribute grid node; wherein each unified grid node includes a value that is the product of a thickness value of a thickness grid node at a location of the respective unified grid node and an attribute value of a respective resampled attribute grid node at the location of the respective unified grid node;
>
> replacing each invalid value for a respective unified grid node with one of a constant value and an average value;
>
> dividing each cell of the unified grid into four triangles, wherein each of the four triangles includes a vertex at a center of the respective cell and two vertices that form one of four sides of the respective cell;
>
> creating a truncated prism with a volume for each set of four triangles using a computer processor;
>
> adding the volume of each truncated prism together, which represents an Original Oil in Place;
>
> dividing the Original Oil in Place by a Formation Volume Factor, which represents a Stock Tank Original Oil in Place;

multiplying the Stock Tank Original Oil in Place and a recovery factor, which represents Recoverable Hydrocarbon Reserves; and outputting the thickness grid and Recoverable Hydrocarbon Reserves to a resource.

21 The method is concerned with resampling an attribute grid so that it coincides with a thickness grid and then creating a unified grid from the two. The thickness grid in claim 1 is generated by the fast sweep thickness extraction step 106 in figure 1 and shown in more detail in figure 2, this grid being a representation of a geological formation. I am less clear how the attribute grid might be derived, but I am told in paragraph [0051] that the grid "may represent attributes such as porosity, permeability, fluid saturation and NTG, for example", NTG being the Net to Gross Ratio. Therefore, it seems that the attribute grid is necessarily a form of representation of a geological formation and so, once again, the method relies on real data.

22 Turning to the actual contribution, the examiner believes this to be a computer program for processing data to implement the mathematical method of processing data grids and performing calculations on them to derive oil reserve estimates. For Mr Russell and Dr Jones the contribution is simply a better computer-implemented process for determining reserve estimates for a reservoir. It is undeniable that the method delivers reserve estimates for a reservoir, but for me the contribution includes the use of an attribute grid and a thickness grid to derive this estimate.

23 Whilst the method is explicitly implemented with a computer processor and certainly includes very clear mathematical steps of adding, dividing and multiplying, I do not feel that I can characterise the contribution as falling solely within the excluded subject matter of a mathematical method or a computer program as such. As I have said, it seems to me that determining reserve estimates is a highly technical endeavour.

iv) GB1600698.3

24 The last application of this group is GB1600698.3, which was published as GB2531195 and corresponds to PCT publication WO 2015/023970. This application is concerned with the conversion and storage of reserve estimates of step 114 in figure 1, described in more detail on pages 12 and 13 of the description and figures 5 and 7 of the drawings, reproduced at Annex 5. As claimed, the method does more than just the steps in figure 5 and includes creating a thickness grid and making use of the converted reserve estimates as shown in figure 7.

25 As with the other applications in this group, there are independent claims to a method and a program carrier and these claims share an inventive concept. Claim 1 as amended reads as follows:

> 1. A method for converting reserve estimates in a reservoir model to a standard format, which comprises:
>
> loading a sealed triangulated mesh of a geological object;
>
> performing a fast sweep thickness extraction on the sealed triangulated mesh to create a thickness grid;

serializing the reserve estimates, the sealed triangulated mesh and the thickness grid, which each represents a reservoir model, into a byte array using a computer processor;

compressing the byte array;

converting the compressed byte array into a printable string using UTF-8/ASCII characters;

storing the printable string in Processing History fields with a link to a 3D modeling engine and predefined identification properties describing the reserve estimates; and

gaining a three-dimensional visual representation of a geological volume suitable for dynamically comparing a printable string representing the reservoir model at a predetermined time and another printable string representing the reservoir model at another predetermined time to improve the reserve estimates in the reservoir model.

26 As originally claimed, the method did not include the initial loading and performing steps and ended with the converting step. While the term “standard format” is not discussed in the application, it seems that the format in question must be the printable string produced by the converting step since that seems to be the only conversion disclosed. Since the serializing step requires a mesh and a thickness grid, it seems reasonable that loading the mesh and creating the thickness grid could be included in the method for converting the reserve estimates. However, storing the printable string and then gaining the representation at the end of the claim seem to describe what might be done with the reserve estimates once they have been converted to a standard format. It seems to me that in construing the claim I could conclude that either the method for converting should stop at the converting step before the steps of storing and gaining a representation or that the invention claimed should be directed to something along the lines of gaining a visual representation of a geological volume.

27 It seems that what the applicant has attempted to achieve by amendment is to include technical features into the claim in order to shift the invention away from the excluded categories. There is degree of artificiality about this, which I believe would allow form to triumph over substance. The way that claim 1 is currently drafted, I do not believe the steps incorporated into the claim are sufficiently tied or indeed are necessary for the conversion of reserve estimates to a standard format. If the method ended with the step of creating a printable string, I struggle to see that the contribution made by such a method could be much more than a computer program as such, irrespective of the inclusion of the steps of loading the mesh and performing a fast sweep thickness extraction. Shifting the format does not seem to have added to human knowledge a better model for example. There may be an argument that the model has been made more portable or more easily stored, but even then I doubt that such a contribution would be technical.

28 At the hearing, Mr Russell and Dr Jones characterised the contribution as a better computer-implemented process for gaining an accurate three-dimensional visual representation of calculated reserve volumes. However, the invention is not claimed in such terms and therefore I have some difficulty agreeing with their version of the

contribution. I could see that a claim to a method for gaining three-dimensional representation of a geological volume which included the steps of storing reserve estimates in a particular format over time could provide a contribution that fell outside excluded subject matter and was technical in nature, e.g. because the ability to compare the reservoir model at different times allowed improved estimates in the reservoir model, but the invention is not claimed in such a way.

29 As it stands, I find that the invention as claimed falls solely within the excluded subject-matter of a computer program as such. I have found that it would be possible to amend the claim such that the actual contribution made by the invention was clearly outside the excluded categories, so I will invite the applicant to file suitable amendments and refer the application back to the examiner to reconsider the question of exclusion from patentability in the light of my findings above.

Conclusion

30 I find that the inventions in GB1600697.5, GB1600691.8 and GB1600693.4 are not excluded by section 1(2) either as a program for a computer as such or a mathematical method as such.

31 I will refer all of the applications back to the examiner for a number of reasons. I believe that the searches in some or all of the applications need to be updated and the omnibus claims found in some of the applications will need to be deleted in line with current practice. In the case of GB1600698.3, the applicant is invited to file amended claims and the examiner should consider them in the light of my comments above. I will give the applicant a period of 1 month from the date of this decision to file amended claims. If no amendments are filed then the application will be refused in accordance with section 18(3).

Appeal

32 Any appeal must be lodged within 28 days after the date of this decision.

H JONES
Deputy Director, acting for the Comptroller

Annex 1 - Discussion of the law taken from BL O/112/18

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The Law

4 Section 1(2) of the Act lists certain categories of subject-matter which are not considered to be inventions. These categories of subject-matter are conventionally known as excluded subject-matter:

> *1(2). It is hereby declared that the following (among other things) are not inventions for the purposes of this Act, that is to say, anything which consists of –*
>
> *(a) a discovery, scientific theory or mathematical method;*
> *(b) a literary, dramatic, musical or artistic work or any other aesthetic creation whatsoever;*
> *(c) a scheme, rule or method for performing a mental act, playing a game or doing business, or a program for a computer;*
> *(d) the presentation of information;*
>
> *but the foregoing provision shall prevent anything from being treated as an invention for the purposes of this Act only to the extent that a patent or application for a patent relates to that thing as such.*

5 The Court of Appeal in *Symbian*[3] stated that the question of whether a computer-implemented invention is patentable has to be resolved by answering the question whether it reveals a technical contribution to the state of the art. It proceeded to answer the question with the aid of the four-step test set out in its earlier judgment in *Aerotel*[4], the fourth step of this test being to check whether the contribution is technical in nature. In paragraph 46 of *Aerotel* it is stated that applying this fourth step may not be necessary because the third step should have covered the question. This is because a contribution which consists solely of excluded matter will not count as being a "technical contribution" and thus will not, as the fourth step puts it, be "technical in nature".

6 Mr Russell and Dr Jones sought to persuade me how each of the seven applications before me provide the necessary technical contribution. In discussing the general approach to assessing patentability, Mr Russell and Dr Jones in essence had two points to make. The first concerned the appropriate standard of proof that an applicant should meet and the second point concerned the proper application of tests for patentability and especially the consideration of technical contribution. I shall deal with each point in turn.

Standard of proof

7 According to Mr Russell and Dr Jones, once an examiner has raised an objection to an application and the applicant has responded with argument and/or amendment then the examiner should give the applicant the benefit of the doubt and consider the objection overcome, unless there can be no doubt on the matter. While this is offered as a general proposition, in this decision I am particularly considering objections raised under section 1(2). In this regard Mr Russell and Dr Jones took me to a

[3] Symbian Ltd. v Comptroller-General of Patents [2008] EWCA Civ 1066
[4] Aerotel Ltd v Telco Holdings Ltd and Macrossan's Application [2006] EWCA Civ 1371

passage in *Macrossan v Comptroller-General of Patents ("Macrossan")*[5] (at paragraphs 7 and 8) in which *Fujitsu Ltd's Application*[6] is quoted by the Appellant before Mann J; the passage from *Fujitsu* is as follows (paragraph 533):

> *"In coming to that conclusion [*viz a conclusion against validity*] I have borne in mind that, prima facie, a novel technical development should be patentable and that section 1(2) contains a list of exceptions to such patentability. Therefore, the onus lies on the person contesting patentability to prove that the invention falls foul of the statutory exclusions. Furthermore, at the patent office stage, benefit of the doubt should be given to the applicant. Refusal of the grant on the basis of a faulty appreciation of what is involved cannot thereafter be remedied."*

8 Mann J goes on to say at paragraph 9 of *Macrossan*:

> *"Mr Birss, in his written submissions for the Comptroller, points out that Whitford J was not addressing a question of principle in what he said. I agree with that, but his statement nonetheless seems to reflect a principle or principles which are consistent with what Laddie J said in Fujitsu. That principle seems to involve the onus being on the person alleging that the alleged invention is within the exclusion. The reference to the benefit of the doubt is probably intended to signify that if there is substantial doubt then the burden has not been fulfilled. I do not consider that it means that if there is any doubt (legal or factual) then the application should succeed. It is not intended to import something like the criminal burden of proof into the proceedings. The tribunal still has to consider whether the exception applies, and it can come to the conclusion that it does without having to find that there is no doubt at all about it."*

9 The current practice of the Office in this regard is set out in paragraph 1.10 of the Manual of Patent Practice, as follows:

> *"The Court of Appeal, in paragraph 5 of Aerotel Ltd v Telco Holdings Ltd & Ors Rev 1 [2007] RPC 7 (Aerotel/Macrossan), made it clear that assessing excluded matter involves a question of law which should be decided during prosecution of the patent application. The position is therefore assessed fully by patent examiners before grant, and objections are not to be dropped simply because the applicant asserts that the invention relates to non-excluded subject matter. The question of excluded matter is decided on the balance of probabilities, taking into account all of the evidence available. However, as it is a question of law, it is not something on which applicants are entitled to the benefit of the doubt, in the way they would be in relation to questions of pure fact (such as the date of a particular disclosure, or the scope of the common general knowledge)."*

10 The original passage in question from the Court of Appeal is this:

> *"In that connection we should record also that we accept Mr Birss' submission that any pure question of law involved should be decided during prosecution. It is not enough to get a patent past the application stage to show that as a matter of law it merely arguably covers patentable subject-matter. The position is different from that under the old law. Then the rule was that patents should be refused only where on no reasonable view could the subject-matter be patentable, see Swift's & Co Application [1962] R.P.C. 37 at 46. Despite that being the rule, in the years that followed Swift, in practice a decision of the Office or on appeal to the Appeal Tribunal was taken to decide the matter once-and-for all. That itself shows there is no point doing other than deciding the question. Moreover that is what the European Patent Office (EPO) does and there is no warrant in the EPC for the "arguable" approach. Of course if a debatable question of pure fact is or may be involved at the application stage, things are different-one cannot then say that the*

[5] Macrossan v Comptroller-General of Patents [2006] EWHC 705 (Ch)
[6] Fujitsu Ltd's Application [1996] RPC 511

decision at that point must be the last word on the subject. Then the applicant must be given the benefit of any reasonable doubt."

11 From the references to prosecution and application stage I take it that the quote from the Court of Appeal is relevant to the practice of the Office.

12 It seems therefore that there is a burden upon an examiner to demonstrate that an invention falls foul of the exclusions and that to overcome such an objection an applicant must do more than "show that … it merely arguably covers patentable subject-matter". In other words, both the examiner and the applicant must do much more than simply assert that their view is correct.

13 Mr Russell and Dr Jones say in their skeleton arguments that they are not seeking to create false or spurious doubt about whether the inventions in each of the applications are excluded, since it is clear from the case law cited above that this would not be enough to cause an application to succeed. However, they say that the arguments advanced in respect of each of the applications are sufficient to create real and substantial doubt as to whether the inventions are excluded, and they suggest that the Office should only maintain an objection when it is clear that the applicant cannot be right.

14 Crucial to the test set out in *Aerotel* is the step of identifying the contribution, and it is the position of Mr Russell and Dr Jones that examiners have assessed the contribution in the present applications (and others before them) far too narrowly and have been unprepared to question their initial assessment or to consider whether it is possible that the applicant's assessment of the contribution may indeed be right. By way of illustration they asked me to consider the general case of a method that:

> i) uses a computer to read in geological data,
> ii) carries out a sequence of mathematical operations with the computer to create a model of the geological formation, and
> iii) carries out a sequence of mathematical operations with the computer on the model of the geological formation.

15 They argue that such a method is not a mathematical method in the sense of section 1(2) because the claim is to the application of mathematical steps to geological modelling. If there is any doubt about this then they say that the benefit of such doubt has to go with the applicant. It is similarly argued that the use of real data takes the method outside the computer program exclusion and that the steps of creating and manipulating a model create and then change a tangible technical entity which also take the method outside the computer program exclusion. Again, any doubt about this should be resolved in favour of the applicant.

16 I do not think that the arguments advanced in relation to this hypothetical example help clarify the standard of proof required of examiners in objecting to inventions relating to excluded subject-matter. However, I will return to these general arguments when considering the technical contribution in each of the applications before me.

17 Mr Russell and Dr Jones suggest that an applicant should be given the benefit of the doubt unless there is no reasonable doubt to be had. Insofar as this reasonable doubt is the same as the substantial doubt to which Mann J refers, I can agree with this principle. I consider that the question for me is whether or not there is such substantial doubt regarding each of these seven applications, such that where an

applicant makes a reasonable case that their invention is patentable then I am bound to find in their favour. I shall proceed on this basis.

Assessment of the contribution

18 The four steps in the *Aerotel* test which I referred to earlier are as follows:

> (1) properly construe the claim;
> (2) identify the actual contribution;
> (3) ask whether it falls solely within the excluded subject matter;
> (4) check whether the actual or alleged contribution is actually technical in nature.

19 Mr Russell and Dr Jones say that the question of how to identify the contribution in the second step of this test is critical and referred me to the following paragraphs in *Aerotel* for guidance:

> *"43.The second step – identify the contribution - is said to be more problematical. How do you assess the contribution? Mr Birss submits the test is workable – it is an exercise in judgment probably involving the problem said to be solved, how the invention works, what its advantages are. What has the inventor really added to human knowledge perhaps best sums up the exercise. The formulation involves looking at substance not form – which is surely what the legislator intended.*
>
> *44. Mr Birss added the words "or alleged contribution" in his formulation of the second step. That will do at the application stage – where the Office must generally perforce accept what the inventor says is his contribution. It cannot actually be conclusive, however. If an inventor claims a computer when programmed with his new program, it will not assist him if he alleges wrongly that he has invented the computer itself, even if he specifies all the detailed elements of a computer in his claim. In the end the test must be what contribution has actually been made, not what the inventor says he has made."*

20 They referred me to paragraphs 37 and 53-54 of S*ymbian* as evidence of how the Office's approach to identifying the contribution made by inventions of the kind set out in the present applications is too narrow and is resulting in decisions by the Office to refuse applications that would otherwise be allowed by the Courts. Paragraphs 50-52 are also worth referencing as context to the subsequent paragraphs:

> *"37. The right starting point is the decision of the Board in Vicom/Computer-related invention T0208/84, [1987] 2 EPOR 74. At [3], the Board said that:*
>
> *"a method for obtaining and/or reproducing an image of a physical object or even an image of a simulated object (as in computer-aided design/computer-aided manufacturing … systems) may be used e.g. in investigating properties of the object or designing an industrial article and is therefore susceptible of industrial application. Similarly a method for enhancing or restoring such an image, without adding to its informational content, has to be considered as susceptible of industrial application" and hence would not be excluded from patentability.*
>
> *At [12]:*
>
> *"a claim directed to a technical process which process is carried out under the control of a program (… in hardware or in software) cannot be regarded as relating to a computer program as such …, as it is the application of the program for determining the sequence of steps in the process for which in effect protection is sought".*
>
> *At [15]:*

"Generally claims which can be considered as being directed to a computer set up to operate in accordance with a specified program (whether by means of hardware or software) for controlling a technical process cannot be regarded as relating to a computer program as such … ."

Finally at [16] the Board described "making a distinction between embodiments of the same invention carried out in hardware or in software" as "inappropriate", as what is "decisive" is the "technical contribution which the invention described in the claim when considered as a whole makes to the known art".

50. The fact that "the boundary line between what is and what is not a technical [contribution]" is imprecise (as Nicholls LJ said in Gale, and as was echoed by Aldous LJ in Fujitsu) may be attributable to three causes, which are not mutually exclusive. First, national tribunals and the Board may still be at an intermediate stage of working out and identifying the precise location of that line; secondly, the problem may be inherent and never wholly satisfactorily soluble; thirdly, there are competing views based on different philosophies (the "open source movement represents one extreme, that of companies such as the present applicant, the other). The uncertainty is well demonstrated by the elusiveness of the meaning of "technical", the change of attitude manifested in the more recent decisions of the Board, the contrasting outcomes in Vicom and Fujitsu, and indeed the possible reconsideration of the correct view of computer program patents in the United States (see Professor John Duffy: Death of Google's Patents? Patently-O Patent Law Blog, July 21st, 2008).

51. These considerations reinforce our view that, at least in this court at this stage, we should try to follow previous authority, we should seek to steer a relatively unadventurous and uncontroversial course, and we should be particularly concerned to minimise complexity and uncertainty. These aims are not necessarily mutually consistent, but, on this occasion, we believe they are achievable, namely by following the analysis adopted by the Board in Vicom and the two IBM Corp. cases, and of the Court of Appeal in Merrill Lynch and Gale.

52. These considerations also manifest the difficulty of formulating a precise test for deciding whether a computer program is excluded from patentability, and suggest that it could be inappropriate to accept either of the rival simple propositions (summarised at [17] above) advanced by the parties here. Bearing in mind the multifarious features of computer programs and the unpredictable developments which will no doubt occur in the IT field, we believe that it would also be dangerous to suggest that there is a clear rule available to determine whether or not a program is excluded by art 52(2)(c). Each case must be determined by reference to its particular facts and features, bearing in mind the guidance given in the decisions mentioned in the previous paragraph.

53. Based on these principles, we consider that Patten J was right and that the claimed invention does make a technical contribution, and is not therefore precluded from registration by art 52(2)(c). To start with a defensive point, the program in this case does not embody any of the items specifically excluded by the other categories in art 52; thus, it is not a method of doing business (as in Merrill Lynch), or a mathematical method (as in Gale), or a method for performing mental acts (as was probably the case in Fujitsu).

54. More positively, not only will a computer containing the instructions in question "be a better computer", as in Gale, but, unlike in that case, it can also be said that the instructions "solve a 'technical' problem lying with the computer itself". Indeed, the effect of the instant alleged invention is not merely within the computer programmed with the relevant instructions. The beneficial consequences of those instructions will feed into the cameras and other devices and products, which, as mentioned at [3] above, include such computer systems. Further, the fact that the improvement may be to software programmed into the computer rather than hardware forming part of the computer cannot make a difference – see Vicom; indeed the point was also made by Fox LJ in Merrill Lynch.

21 Mr Russell and Dr Jones note that the European Patent Office Technical Board of Appeal's decision in *Vicom*[7] was approved by the Court of Appeal in *Aerotel* and *Symbian.* They suggest that it is hard to conceive of a case that could be closer to the issues under consideration in the present application and say that *Vicom* points to the fact that the inventions in the seven applications before me are technical and do not lie in excluded subject-matter as such. They say that for the Office to find differently suggests that its approach to assessing contribution must be wrong.

22 So what then is the correct approach to assessing the contribution? In his second sentence in paragraph 44 of *Aerotel* (quoted above), Jacob LJ refers to the Office accepting the word of the inventor with regard to the contribution made, however it is not clear whether the qualification that follows, i.e. "It cannot actually be conclusive", is also intended to apply to the Office. Paragraph 1.20 of the Manual of Patent Practice appears at first glance to be helpful in this respect in that it takes me to paragraphs 23-24 in *IGT/Acres Gaming Inc*[8]*,* where Mr Peter Prescott QC (sitting as Deputy Judge) addresses this general issue:

> *"23. After hearing argument in this case I wondered what is meant by the second paragraph I have quoted, namely paragraph 44. Does it mean that the Patent Office is bound to accept the applicant's assertion (save in blatant cases)? Or can the Patent Office do a prior art search to find out what has the inventor really added to human knowledge? I therefore invited further submissions in writing.*
>
> *24. Although there was some disagreement, both parties accepted that the Patent Office is entitled to do a prior art search and that if it turns out that the alleged contribution was already known, or was obvious, there can hardly be a contribution to human knowledge. In my judgment that is correct. And there will be no patentable contribution to human knowledge if what is new and not obvious relates solely to a business method as such."*

23 What Mr Prescott appears to be saying here is that if the alleged contribution is either known or obvious such that the claimed invention adds nothing to human knowledge (per *Aerotel*), then the application can be refused under section 1(2). Although Mr Russell and Dr Jones did not address me directly on this case, they did address the general point that the correct basis for refusing an application in this situation would be for lack of novelty or inventive step and not under section 1(2), which is the approach, they say, that the European Patent Office takes.

24 Mr Russell and Dr Jones suggested that I need only look at how the Courts have approached the assessment of "actual contribution" to see how the Office approach is inconsistent. In the Patents Court judgment in *Halliburton Energy Services Inc. ("Halliburton")*[9]*,* in which HHJ Birss QC (as he then was, and sitting as a judge of the High Court) heard an appeal of an Office decision[10] to refuse various applications relating to the use of a computer simulation to improve the design of roller cone drill bits for drilling oil wells, the actual contribution made by the invention was addressed as follows (paragraphs 66 and 67 of *Halliburton*):

> *"66.Mr Thorpe identified the contribution made by this invention in paragraph 29. He said:*
>
> *29. I will leave for a moment the issue of whether outputting the results to a resource*

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[7] Vicom T 0208/84
[8] IGT/Acres Gaming Inc, Re [2008] EWHC 568 (Pat)
[9] Halliburton Energy Services Inc., [2011] EWHC 2508 (Pat)
[10] BL O/080/11

adds to the contribution. For the moment I am happy to proceed on the basis of a slightly broader interpretation of what Mr Davis has proposed. The contribution of the claimed invention is in my view, as a matter of substance:

A method of designing drill bits that includes simulation of the performance of the drill bit based on calculating a three dimensional mesh for each cutting element and for the earth formation and using that to determine the forces acting on each mesh segment of the cutting element and then the forces and stresses acting on each cutting element.

67. I agree with that statement save that it seems to me to be important to state that the contribution is a computer implemented method of designing drill bits. Normally that emphasis would not be very important, for example if the case was concerned with the business method exclusion it would be irrelevant, but in this case, given the debate about the mental act exclusion, it is critical."

25 At paragraph 67, HHJ Birss agrees with the Hearing Officer's assessment of the actual contribution but considered it important to emphasise that the method of designing drill bits was limited to implementation on a computer, i.e. the contribution was a "computer-implemented method of designing drill bits". Having identified the actual contribution, the Hearing Officer went on to consider whether the contribution fell within excluded subject-matter and felt bound to follow the conclusion reached previously by Pumfrey J in *Halliburton v Smith ("Smith")*[11] given the similarity of the inventions. The Hearing Officer refused the applications on the basis that the "untethered" inventions were mental acts. However, HHJ Birss said that the Hearing Officer had taken too broad a view of the mental act exclusion and had misinterpreted the way in which Pumfrey J had applied the exclusion in *Smith* - the claims in *Smith* encompassed acts that could be performed mentally whereas the claims in *Halliburton*, which included steps of simulation and outputting, tied the method to implementation on a computer and therefore could not be performed mentally. He says at paragraph 77 of *Halliburton* that *"His concern [i.e. Pumfrey J] was not with the technical contribution as a matter of substance – which he did not doubt – but with the form of the claims."* The Hearing Officer had understood from *Smith* that a "tethering step", i.e. the subsequent manufacture of the drill bit, was needed to avoid the mental act exclusion and for a technical contribution to be made, but HHJ Birss said that this was incorrect.

26 When it came to the step of assessing whether the contribution fell solely within excluded subject matter, i.e. the third step of the *Aerotel* test, HHJ Birss says at paragraph 71 that the contribution is a method of designing a drill bit and therefore more than a computer program as such. Here he relied upon a more general description of the contribution than the narrower version formulated by the Hearing Officer. When checking whether the contribution is actually technical in nature, i.e. the fourth step of the *Aerotel* test, HHJ Birss says at paragraph 74 that *"designing drill bits is obviously a highly technical process, capable of being applied industrially……The detailed problems to be solved with wear and ability to cut rock and so on are technical problems with technical solutions"*, concluding that the applications did satisfy the requirements of section 1(2). Here again he relies upon a more general description of the contribution, his conclusion on whether the more general description of the contribution is actually technical in nature echoing his comments earlier in the judgment (at paragraphs 29-38) after reviewing the

[11] Halliburton Energy Services, Inc. v Smith International (North Sea) Ltd & Ors [2005] EWHC 1623 (Pat) (21 July 2005)

judgments in *Merrill Lynch*[12], *Gale*[13], *Macrossan*, *Aerotel*, S*ymbian*, etc.. Paragraph 38 says:

> *"38. What if the task performed by the program represents something specific and external to the computer and does not fall within one of the excluded areas? Although it is clear that that is not the end of the enquiry, in my judgment that circumstance is likely to indicate that the invention is patentable. Put in other language, when the task carried out by the computer program is not itself something within the excluded categories then it is likely that the technical contribution has been revealed and thus the invention is patentable. I emphasise the word "likely" rather than "necessarily" because there are no doubt cases in which the task carried out is not within the excluded areas but nevertheless there is no technical contribution at all."*

27 Even though it seems that the applicant, Halliburton, may not have been the first to invent a computer-implemented method for designing drill bits *per se*, it seems from this judgment that one can take a step back from the actual advance over the state of the art when assessing the contribution for the purpose of section 1(2) and simply identify the field of endeavour in which the method is applied. In other words, it might not be necessary to conduct a forensic analysis of the difference between the invention and the prior art in order to assess what the inventor has really added to human knowledge when it is clear that the invention is limited to a very specific task or application that is not itself excluded. The fact that one can specify precisely the difference between the invention and the state of the art within a description of the actual contribution does not alter the fact that a contribution is also made within a general field of endeavour if the invention is claimed and limited in such a way. If that field of endeavour is a technical one then, according to *Halliburton,* there is a reasonable chance of it being a patentable invention under section 1(2). For computer-implemented inventions such as the ones in *Halliburton* and *Vicom*, it can be sufficient to determine whether the general task performed by the computer program is external to the computer and does not fall within one of the excluded areas in order to conclude that a technical contribution has been revealed. For other computer-implemented inventions, where the task performed by the program is limited entirely to what is going on inside the computer, an invention can be patentable if it solves a technical problem relating to the running of computers generally.

28 This poses an interesting question in respect of the assessment of contribution as determined in *Halliburton.* Given that HHJ Birss agreed with the narrow description of the contribution identified by the Hearing Officer but then relied upon a more general description of it when assessing steps 3 and 4, would HHJ Birss have come to a different conclusion on the question of patentability had he proceeded on the same narrow basis as the Hearing Officer? In other words, was the reason that a different conclusion was reached by the Hearing Officer a direct consequence of having taken a narrower view of the contribution, which Mr Russell and Dr Jones suggest is the practice of the Office, or simply because he came to a different view of what is technical.

29 On reading the Hearing Officer's decision it seems clear that the latter was the case, However, I shall first set our Mr Russell and Dr Jones' argument as to how a narrow view of the contribution can lead to inconsistencies in deciding what is and isn't a

[12] Merrill Lynch's Application, [1989] RPC 561
[13] Gale's Application [1991] RPC 305

patentable invention before I explain my reasons why. They sought to illustrate their argument by way of example. In an invention where the only difference between a known method of processing particular data sets, e.g. a method for enhancing/modelling image or geophysical data, is the use of a Fast Fourier Transform (FFT) instead of a Fourier Transform (FT), the benefits of doing so being to reduce the processing load of the computer, a narrow assessment of the contribution could lead to a conclusion that what has been added to human knowledge is the mere replacement of a FT with an FFT, and a mistaken assessment that this is nothing more than a mathematical or computational advance. They say that such a narrow approach would be wrong, because the invention remains a method for enhancing/modelling image or geophysical data, which is inherently patentable (per *Vicom*). Once past the hurdle of section 1(2), they say that the act of replacing the FT with an FFT should then be assessed against the requirement for inventive step, this being the proper place for doing so and not confused with any consideration of whether the invention is within the list of exclusions set out in section 1(2)

30 I accept Mr Russell's and Dr Jones' point that there is a risk of reaching the wrong conclusion on section 1(2) if the contribution is not properly framed. However, as I have said, I do not believe that the reason the Hearing Officer came to a different conclusion to that of the Court in *Halliburton* was a consequence of having relied upon a much narrower description of the contribution in assessing steps 3 and 4 – the Hearing Officer had simply applied the mental act exclusion on too broad a basis.

31 So where does this leave me with regard to the correct approach to assessing the contribution? It seems to me from *Halliburton* that it is quite possible to arrive at either a narrow or a broad view of the actual contribution made by the invention and still be able to come to the same conclusion as to whether the contribution falls solely within excluded subject-matter. I have already noted that HHJ Birss agreed with the narrow form of the contribution set out by the Hearing Officer in *Halliburton* while also relying on a broader description when assessing whether the contribution was technical. The reason for doing so seems clear, in that it allowed him to quickly highlight the nature of the task performed by the computer program as representing something specific and external to the computer, i.e. designing drill bits. This task was included in both the narrow and broad descriptions of the contribution, and illustrated how the computer program was tied to a specific field of endeavour. He then goes on to consider whether the contribution is technical, saying that when the task is not something within the excluded categories then it is likely that that the technical contribution has been revealed and that the invention is patentable. He emphasises the word "likely" rather than "necessarily" because there would no doubt be cases in which the task carried out is not within the excluded areas but nevertheless there is no technical contribution at all.

32 It is precisely this approach I intend taking in this decision: when assessing the actual contribution in a computer-implemented invention, I shall take proper account of the task performed by the computer and determine whether the task falls outside the excluded categories. I shall also take account of Mr Russell and Dr Jones' argument that such cases, i.e. the cases in which the task carried out is outside the excluded areas but nevertheless there is no technical contribution at all, would be the exception rather than the norm. If the task carried out is within an excluded area, e.g. a computer program, then HHJ Birss explains at paragraph 37 of *Halliburton* that this is not necessarily the end of the matter because a program that solves a technical

problem relating to the running of computers generally is not excluded by section 1(2). The oft-quoted signposts in *AT&T/CVON*[14] provide a useful summary of where the Courts have identified a technical contribution in computer-implemented inventions when the task carried out falls within an excluded category, but there are likely to be other areas where a technical contribution is found that have not yet been considered by the Courts.

The applications in suit

33 Before addressing each application in turn, Mr Russell and Dr Jones made some general comments regarding the set of applications I am to consider and the field of endeavour in which they lie.

34 A parallel is drawn between the geological models in these applications and an image that is manipulated as in *Vicom,* and a quote is taken from the Reasons for the Decision in *Vicom*:

> *5. There can be little doubt that any processing operation on an electric signal can be described in mathematical terms. The characteristic of a filter, for example, can be expressed in terms of a mathematical formula. A basic difference between a mathematical method and a technical process can be seen, however, in the fact that a mathematical method or a mathematical algorithm is carried out on numbers (whatever these numbers may represent) and provides a result also in numerical form, the mathematical method or algorithm being only an abstract concept prescribing how to operate on the numbers. No direct technical result is produced by the method as such. In contrast thereto, if a mathematical method is used in a technical process, that process is carried out on a physical entity (which may be a material object but equally an image stored as an electric signal) by some technical means implementing the method and provides as its result a certain change in that entity. The technical means might include a computer comprising suitable hardware or an appropriately programmed general purpose computer.*

35 Mr Russell and Dr Jones reminded me that a similar point was put to me in a previous hearing concerning a method of processing seismic or other geophysical data, namely *WesternGeco Ltd's Application*[15]*.* In that case I agreed "*that Vicom was particularly relevant to the present application because of the similarity in the subject matter of the two inventions*" and I agree that the same is true with the present applications. In *WesternGeco* my decision was that some, but not all, of the claims related to subject matter excluded from patentability under section 1(2), namely the "untethered" claims that did not include a step of determining one or more parameters relating to physical properties of the earth's interior from the processed geophysical data. I came to the same conclusion as the Hearing Officer in *Halliburton* that a tethering step was necessary to make a method of processing seismic data patentable, i.e. technical, which the Court has since found to be incorrect. To the extent that Mr Russell and Dr Jones wish me to draw general conclusions regarding patent applications relating to methods involving geological models, all that I can say is that such methods are not inherently excluded from patentability and that such an invention must be considered upon its own merits.

……..

[14] AT&T Knowledge Ventures LP, Re [2009] EWHC 343 (Pat)
[15] BL O/135/07

Annex 2 - flow diagram and description illustrating an embodiment of the invention

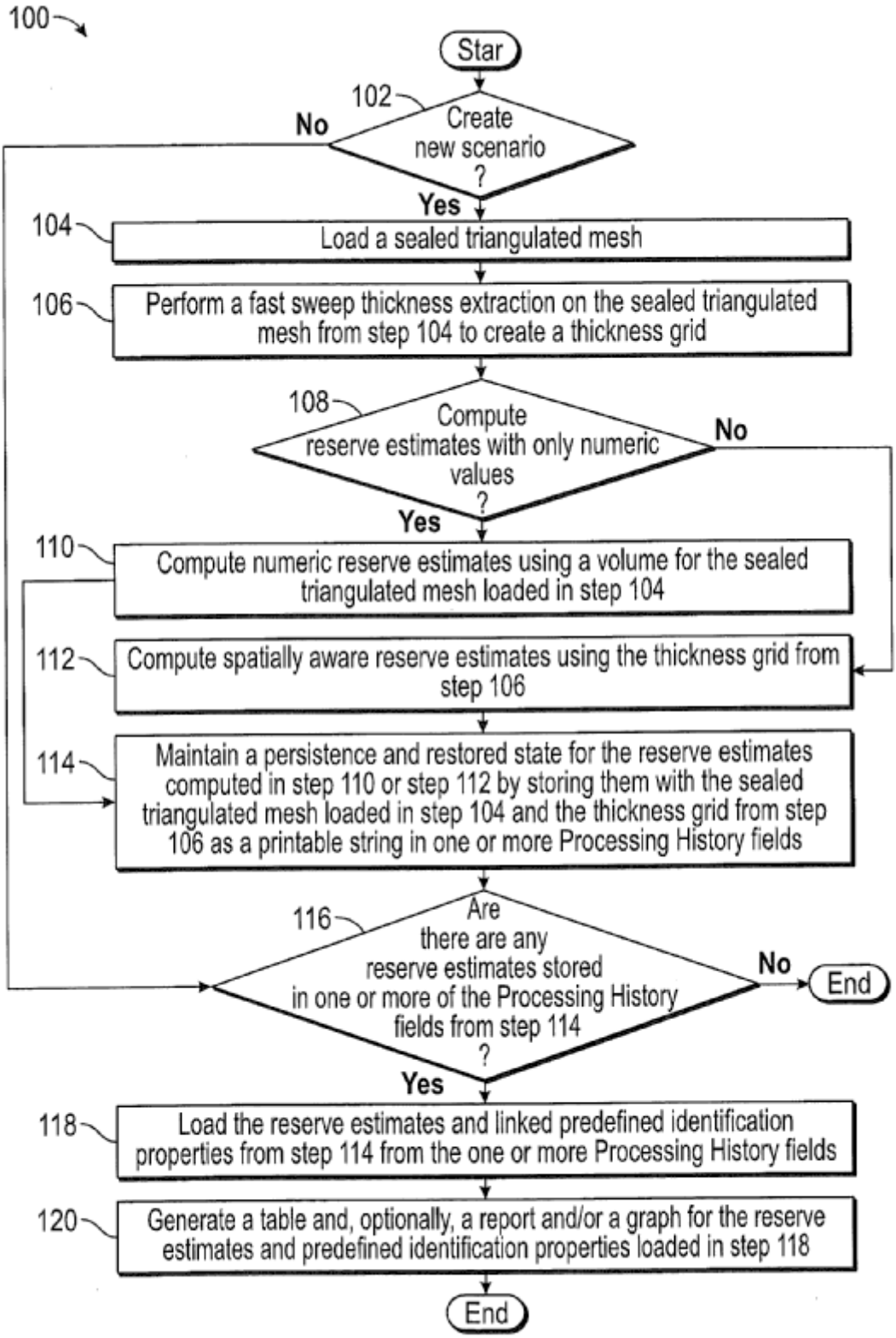

FIG. 1

[0025] Referring now to FIG. 1, a flow diagram of one embodiment of a method 100 for implementing the present disclosure is illustrated.

[0026] In step 102, the method 100 determines if a new scenario should be created using the client interface and/or the video interface described in reference to FIG. 10. If a new scenario should not be created, then the method 100 proceeds to step 116. Otherwise, the method 100 proceeds to step 104.

[0027] In step 104, a sealed triangulated mesh is loaded. The sealed triangulated mesh includes a volume that is computed in the unit system of any well-known 3D modeling engine using techniques well known in the art such as Stoke's Theorem.

[0028] In step 106, fast sweep thickness extraction is performed on the sealed triangulated mesh from step 104 to create a thickness grid. One embodiment of a method for performing this step is described further in reference to FIG. 2,

[0029] In step 108, the method 100 determines if reserve estimates should be computed with only numeric values using the client interface and/or the video interface described in reference to FIG. 10. If reserve calculations should not be computed with only numeric values, then the method 100 proceeds to step 112. Otherwise, the method 100 proceeds to step 110.

[0030] In step 110, numeric reserve estimates are computed using the volume for the sealed triangulated mesh loaded in step 104 and the method 100 proceeds to step 114. One embodiment of a method for performing this step is described further in reference to FIG. 3.

[0031] In step 112, spatially aware reserve estimates are computed using the thickness grid from step 106. One embodiment of a method for performing this step is described further in reference to FIG. 4.

[0032] In step 114, a persistence and restored state are maintained for the reserve estimates computed in step 110 or step 112 by storing them with the sealed triangulated mesh loaded in step 104 and the thickness grid from step 106 as a printable string in one or more Processing History fields. One embodiment of a method for performing this step is described further in reference to FIG. 5.

[0033] In step 116, the method 100 determines if there are any reserve estimates stored in one or more of the Processing History fields from step 114. If there are no reserve estimates stored in the one or more Processing History fields, then the method 100 ends. Otherwise, the method 100 proceeds to step 118.

[0034] In step 118, the reserve estimates and linked predefined identification properties from step 114 are loaded from the one or more Processing History fields.

[0035] In step 120, a table and, optionally, a report and/or a graph are generated for the reserve estimates and predefined identification properties loaded in step 118. One embodiment of a method for performing this step is described further in reference to FIG. 6.

Annex 3 - Detail of the fast sweep thickness extraction of step 106 and GB1600691.8

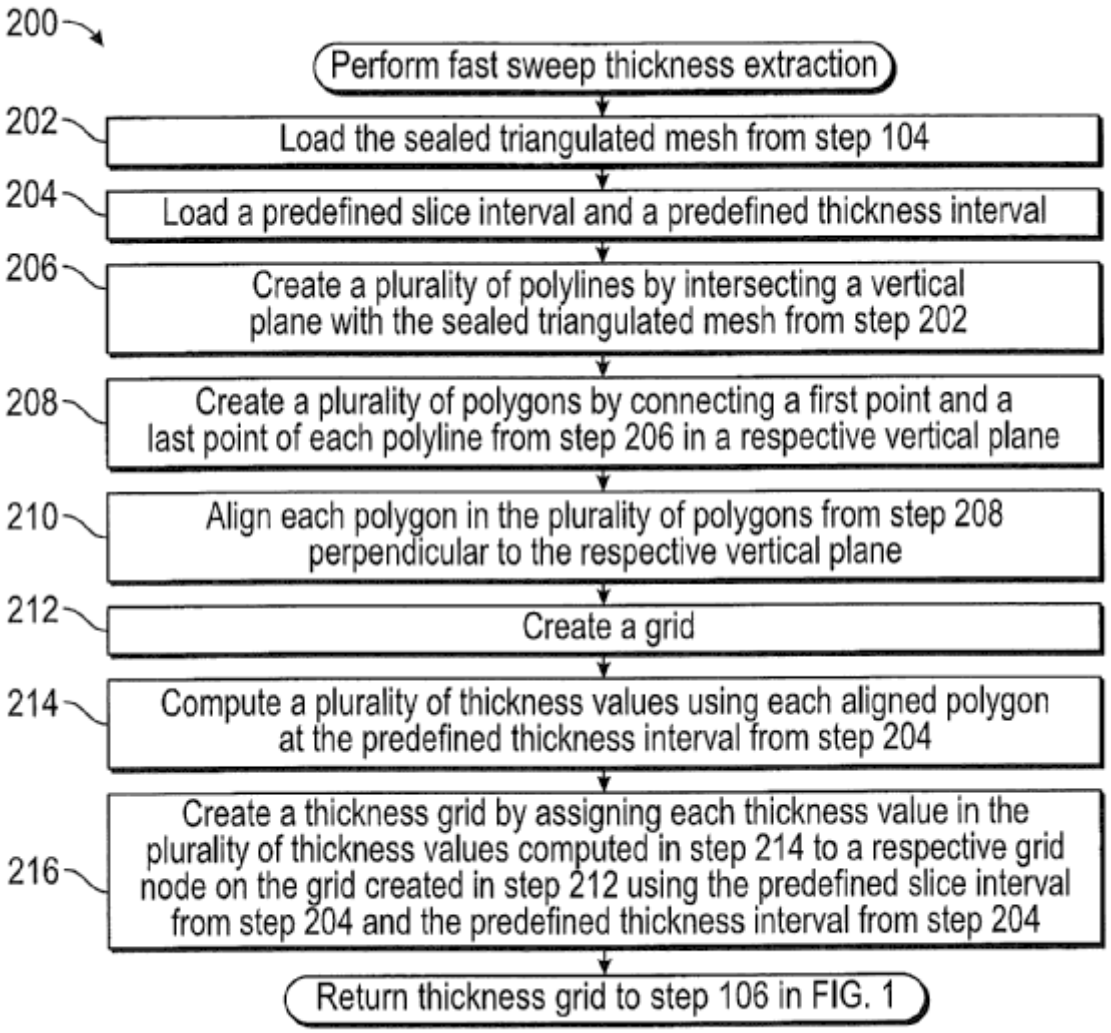

FIG. 2

[0036] Referring now to FIG. 2, a flow diagram illustrating one embodiment of a method 200 for implementing step 106 in FIG. 1 is illustrated. The method 200 performs a fast sweep thickness extraction on the sealed triangulated mesh from step 104 to create a thickness grid. The thickness grid may be multiplied by a constant value or by one or more other grids with laterally- varying attributes to produce reserve estimates.

[0037] In step 202, the sealed triangulated mesh from step 104 is loaded.

[0038] In step 204, a predefined slice interval and a predefined thickness interval are loaded.

[0039] In step 206, a plurality of polylines is created by intersecting a vertical plane with the sealed triangulated mesh from step 202 at the predefined slice interval from step 204 along an x-dimension in spatial extents for the sealed triangulated mesh

using contouring techniques that are well known in the art. Each polyline includes a first point and a last point.

[0040] In step 208, a plurality of polygons is created by connecting the first point and the last point of each polyline in a respective vertical plane. Each polygon in the plurality of polygons lies in a respective vertical plane defined by the intersection of the vertical plane with the sealed triangulated mesh at the predefined slice interval.

[0041] In step 210, each polygon in the plurality of polygons from step 208 is aligned perpendicular to the respective vertical plane.

[0042] In step 212, a grid is created having an equal number of rows and columns, spatial extents that match the spatial extents of the sealed triangulated mesh from step 202, a grid x- dimension cell size equal to the predefined slice interval from step 204 and a grid y-dimension cell size equal to the predefined thickness interval from step 204. Each grid node is initialized with a value of zero. The grid, for example, may have 1000 rows and 1000 columns for computing efficiency and broad application coverage. The grid is preferably positioned above the sealed triangulate mesh from step 202,

[0043] In step 214, a plurality of thickness values are computed using techniques well- known in the art and each aligned polygon at the predefined thickness interval from step 204.

[0044] In step 216, a thickness grid is created by assigning each thickness value in the plurality of thickness values computed in step 214 to a respective grid node on the grid created in step 212 using the predefined slice interval from step 204 and the predefined thickness interval from step 204. The predefined slice interval and the predefined thickness interval are used to assign each thickness value to a respective grid node by assigning each thickness value corresponding to a respective vertical plane at the predefined slice interval and predefined thickness interval to a respective grid node on the grid at an x-dimension corresponding to the respective vertical plane at the predefined slice interval and at a y-dimension corresponding to the predefined thickness interval. The thickness grid is returned to step 106 in FIG. 1.

Annex 4 - Detail of the spatially aware reserve estimates of step 112 and GB1600693.4

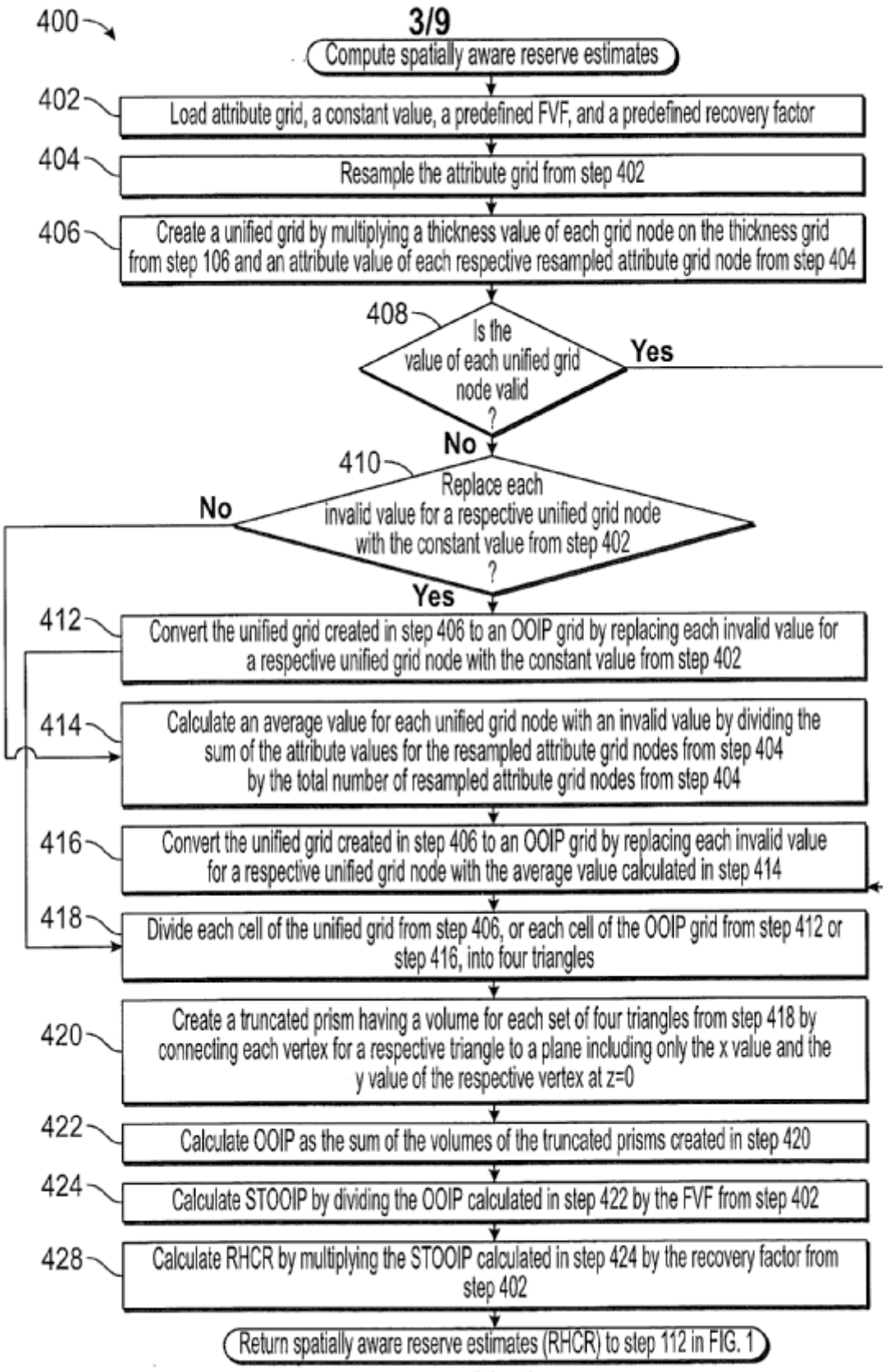

FIG. 4

[0050] Referring now to FIG. 4, a flow diagram of one embodiment of a method 400 for implementing step 112 in FIG. 1 is illustrated. The method 400 computes spatially aware reserve estimates using the thickness grid from step 106. A defining feature of the method 400 is the ability to match the thickness grid and an attribute grid. The thickness grid represents the aggregate vertical thickness of a compartment at each grid node. The method 400 enables the thickness grid to be multiplied by one or more grids of laterally- varying attributes to produce a unified grid, Gross volumes may then be derived from gross thickness grids and net volumes may be acquired from the unified grids.

[0051] In step 402, an attribute grid, a constant value, a predefined FVF, and a predefined recovery factor are loaded. The attribute grid includes an attribute grid node at each intersection of the attribute grid representing a plurality of attribute grid nodes, wherein each attribute grid node has an attribute value. The attribute grid thus, may represent attributes such as porosity, permeability, fluid saturation and NTG, for example.

[0052] In step 404, the attribute grid from step 402 is resampled using resampling techniques well known in the art such as bicubic interpolation to match the attribute grid and the thickness grid from step 106 so that the attribute grid includes an attribute grid node at each location of a thickness grid node. As a result, some of the attribute grid nodes may have an attribute value that is null when the attribute grid and the thickness grid are not the same size.

[0053] In step 406, a unified grid is created by multiplying the thickness value of each grid node on the thickness grid from step 106 and the attribute value of each respective resampled attribute grid node from step 404. The unified grid thus, includes a unified grid node at each location of an attribute grid node representing a plurality of unified grid nodes, wherein each unified grid node has a value that is the product of the thickness value of a thickness grid node at the same location and the attribute value of a respective resampled attribute grid node at the same location. The value of a unified grid node is invalid if the thickness value of a thickness grid node is at the same location is multiplied by a null attribute value of a respective resampled attribute grid node at the same location. The unified grid also defines a plurality of cells, wherein each cell includes four sides and a center.

[0054] In step 408, the method 400 determines if the value of each unified grid node is valid. If the value of each unified grid node is valid, then the method proceeds to step 418. Otherwise, the method proceeds to step 410.

[0055] In step 410, the method 400 determines whether to replace each invalid value for a respective unified grid node with the constant value from step 402 using the client interface and/or the video interface described in reference to FIG. 10. If each invalid value for a respective unified grid node should not be replaced with the constant value, then the method 400 proceeds to step 414. Otherwise, then the method 400 proceeds to step 412.

[0056] In step 412, the unified grid created in step 406 is converted to an OOIP grid by replacing each invalid value for a respective unified grid node with the constant value from step 402. The OOIP grid thus, includes an OOIP grid node at each location of a respective unified grid node representing a plurality of OOIP grid nodes,

wherein each OOIP grid node has a value that is the same value as the valid value of the respective unified grid node or the constant value. The OOIP grid defines a plurality of cells, wherein each cell includes four sides and a center. The method 400 then proceeds to step 418.

[0057] In step 414, an average value for each unified grid node with an invalid value is calculated by dividing the sum of the attribute values for the resampled attribute grid nodes from step 404 by the total number of resampled attribute grid nodes from step 404.

[0058] In step 416, the unified grid created in step 406 is converted to an OOIP grid by replacing each invalid value for a respective unified grid node with the average value calculated in step 414. The OOIP grid thus, includes an OOIP grid node at each location of a respective unified grid node representing a plurality of OOIP grid nodes, wherein each OOIP grid node has a value that is the same value as the valid value of the respective unified grid node or the average value. The OOIP grid defines a plurality of cells, wherein each cell includes four sides and a center.

[0059] In step 418, each cell of the unified grid from step 406, or each cell of the OOIP grid from step 412 or step 416, is divided into four triangles. Each of the four triangles for each cell includes a vertex at the center of the respective cell and two vertices that form one of the four sides of the respective cell. Each vertex includes an x, y, z value.

[0060] In step 420, a truncated prism having a volume is created for each set of four triangles from step 418 by connecting each vertex for a respective triangle to a plane including only the x value and the y value of the respective vertex at z=0.

[0061] In step 422, OOIP is calculated as the sum of the volumes of the truncated prisms created in step 420.

[0062] In step 424, STOOIP is calculated by dividing the OOIP calculated in step 422 by the FVF from step 402.

[0063] In step 428, RHCR is calculated by multiplying the STOOIP calculated in step 424 by the recovery factor from step 402. The spatially aware reserve estimates (RHCR) are returned to step 112 in FIG. 1.

Annex 5 - Detail of the conversion and storage of reserve estimates of step 114 and GB1600698.3

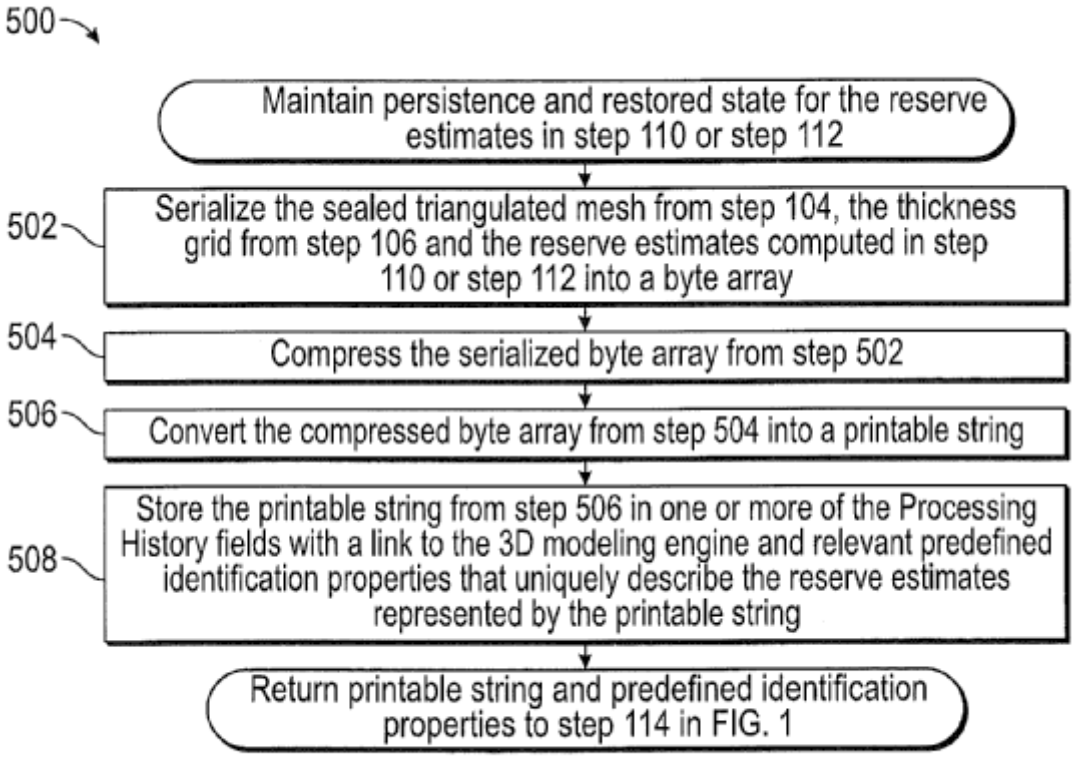

FIG. 5

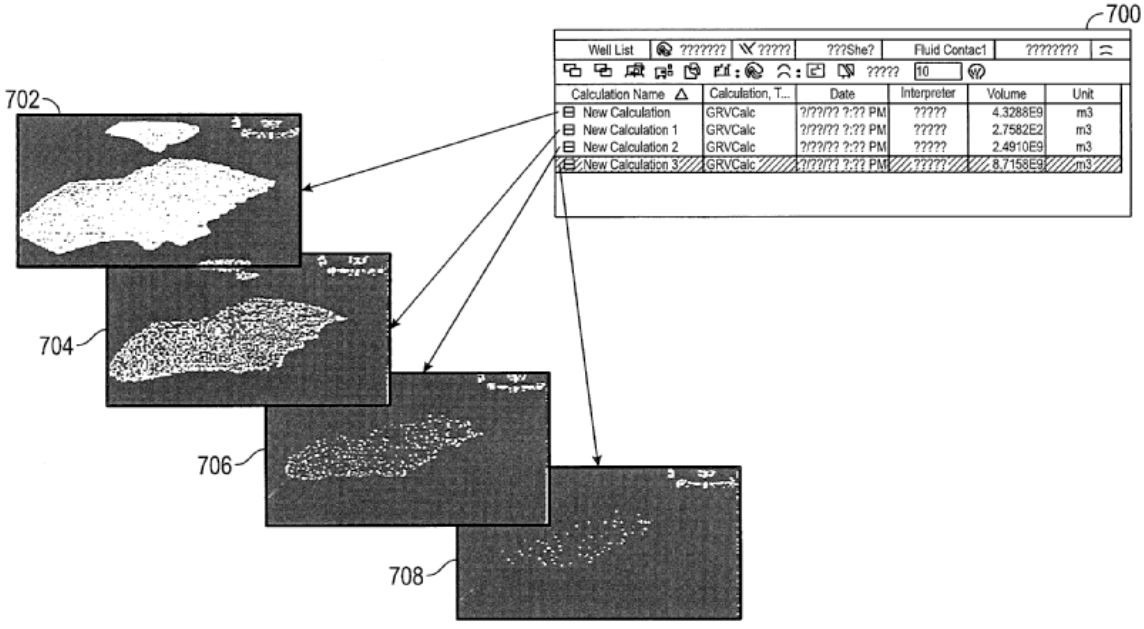

FIG. 7

[0064] Referring now to FIG. 5, a flow diagram, according to an embodiment of the invention, of a method 500 for implementing step 114 in FIG. 1 is illustrated. The method 500 maintains persistence and restored state for the reserve estimates computed in step 110 or step 112 by storing them with the sealed triangulated mesh loaded in step 104 and the thickness grid from step 106 as a printable string in one or more Processing History fields. In this manner, the reserve estimates are permanently saved with identification, interpreter, date and parameters used. Each saved result of any reserve estimate is linked to relevant predefined identification properties By saving the sealed triangulated mesh, thickness grid and reserve estimates in the Processing History fields, the structure can be recovered, visualized again, and used as a basis for additional analysis even as the structure changes over time.

[0065] In step 502, the sealed triangulated mesh from step 104, the thickness grid from step 106 and the reserve estimates computed in step 110 or step 112 are serialized into a byte array using techniques well known in the art.

[0066] In step 504, the serialized byte array from step 502 is compressed using techniques well known in the art.

[0067] In step 506, the compressed byte array from step 504 is converted into a printable string using UTF-8/ ASCII characters to make it compatible with standard Processing History fields.

[0068] In step 508, the printable string from step 506 is stored in one or more of the Processing History fields with a link to the 3D modeling engine and relevant predefined identification properties that uniquely describe the reserve estimates represented by the printable string. The printable string and predefined identification properties are returned to step 114 in FIG. 1. In FIG. 7, a display 700 illustrates exemplary predefined identification properties linked to a sealed triangulated mesh 702, 704, 706, 708 that is displayed at four different time intervals using the 3D modeling engine. In this manner, the reservoir model at a predetermined time may be dynamically compared to the reservoir model at another predetermined time to improve the reserve estimates in the reservoir model.