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Spherical Accounting

using geometry to embody developmental integrity

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Introduction

It is universally accepted that the most basic form of accounting lies in the single answer to the question "what does it cost?" A more elaborate approach, leading to that figure, is to itemize in a list the costs which total to that single budget figure. The great historical innovation in ensuring control over financial accounts was the shift to double entry bookkeeping, subsequently taking the form of the spreadsheets that are basic to the project and program management of any modern institution. Spreadsheets facilities have of course been embodied into spreadsheet software.

The following text is concerned with how the third dimension is reflected in an actual geometrical representation of accounting -- moving beyond one-dimensional "budgets", and two-dimensional budget lines and spreadsheets. It is correct that standard spreadsheets offer 3-D graphics in addition to 2-D displays -- as a means of obtaining an overview of sets of datapoints. The focus here however is on the potential significance of the actual geometry in integrating disparate (or potentially incommensurable) preoccupations of an organization in such a manner as to heighten the coherence and integrity of the operation.

The only resources relating tangentially to this possibility seem to be materials referenced by Robert Grace (*The Over-all Picture*, 2000). The exercise here is intended to be suggestive of possibilities -- as a stimulus to imagination and creativity -- rather than implying closure on a well-defined new method.

Case for multi-dimensional accounting

Chris Lucas (*Multidimensional Economics*, 1999) outlines a complexity-based economics in the light of the following assessment.

Current economic theory reduces all things to one dimension, that of monetary value, in fact that seems to be the whole basis of the science. Yet value is not in itself a one dimensional concept, we value many things that are impossible to classify in such linear monetary terms, air or sunlight for example. Complex notions of value require a type of economics that is itself complex and multi-dimensional, a value system that goes beyond the trade based concept of material exchange and takes into account the wider needs of people and planet.

Vahe Poladian, et al (*Time is Not Money: The case for multi-dimensional accounting in value-based software engineering*, 2003) argue that:

Indeed, in theoretical economics all costs can, in principle, be expressed in dollars. Software engineering problems, however, often present situations in which converting all costs to a common currency is problematical. In this paper we pinpoint some of these situations and the underlying causes of the problems, and we argue that it is often better to treat costs as a multidimensional value, with dimensions corresponding to distinct types of resources. We go on to highlight the differences among cost dimensions that need to be considered when developing cost-benefit analyses, and we suggest mechanisms for mediating among heterogeneous cost dimensions.

Richard B. Dull and David P. Tegarden (*A Comparison of Three Visual Representations of Complex Multidimensional Accounting Information*, 1998) have investigated the relationship between three visual representations (two-dimensional, three-dimensional fixed, and three-dimensional rotatable) of multidimensional data, and the subjects' ability to make predictions based on the data (namely "cognitive fit"). Output of a momentum accounting system was simulated and graphics were rendered based on that information. They concluded:

The results of this study indicate that the form of the representation of data affects the accuracy of the predictions novices make based on that data. Additionally, one can conclude that multidimensional visual representation of complex multidimensional data results in greater decision making accuracy because it facilitates the direct examination of the complex relationships in the data. This conclusion has implications within the realm of accounting with respect to decision-making when multiple variables are involved. As variables increase in complexity (defined as dimensionality), there should be representations that show the interaction among the variables to help enhance decision-making accuracy. Furthermore, with the trend towards supporting decision-making with multidimensional data using on-line analytical processing (OLAP), knowledge discovery, and data mining tools, this conclusion implies that in the future, designers of advanced accounting information systems should be cognizant of the need to "fit" the dimensionality of the data to the dimensionality of the visual representation. Otherwise, the effectiveness of the decision maker may be compromised.

David Ellerman (*Double-Entry Bookkeeping: The Mathematical Formulation and Generalization*, 1986) explores the lack of any mathematical exploration of standard double entry bookkeeping which might enable its generalization:

With [one] exception, the author has not been able to find a single mathematics book, elementary or advanced, popular or esoteric, which notes that the ordered pairs of the group of differences construction are the T-accounts used in the business world for about five centuries. And this mathematical basis for DEB is totally unknown in the "parallel universe" of accounting. This almost complete lack of cross-fertilization between mathematics and accounting is a topic of some interest for intellectual history and the sociology of knowledge. The story is probably rather simple from the mathematics side. Double-entry bookkeeping is apparently too mundane to hold the sustained attention of mathematicians. The real question lies on the accounting side. Over the last century, how could professional accountants and accounting professors have failed to find the mathematical basis for DEB even though it was part of undergraduate algebra? [see also [below](#)]

In arguing for "a more flexible approach to logic chains", Réal Lavergne (*Results-Based Management and Accountability for Enhanced Aid Effectiveness*, 2002) states:

One of the dangers of the textbook logical framework analysis (LFA) is that it seems to imply a degree of orderliness and certainty about managing for development that often belies reality. At least superficially, the logic model assumes that there is consensus about the goals and objectives of the project and about the choice of strategies to achieve those goals and objectives. It also implies a linear chain of causality from inputs and activities to outputs and successive levels of outcomes, of the sort that one can observe in the HIV/AIDS example cited above. It suggests a degree of predictability that makes it possible to plan in advance and a capacity to measure outcomes that may be unrealistic in many cases.

Xavier Bry and Jean-François Casta (*Synergy Modelling and Financial Valuation: Contribution of Fuzzy Integrals*, 2003) point out that financial assessments are characterized by: the importance of the role assigned to human judgement in decision making, the use of qualitative information and the dominant role of subjective evaluation. They examine the specific problems raised by the modelling of synergy between the assets of a firm:

As a process which aggregates information and subjective opinions, the financial evaluation of the company raises very many problems relating to issues such as measurement, imprecision and uncertainty. The methods used in the process of financial evaluation are classically based on additivity. By construction, these methods abandon the idea of expressing phenomena of synergy (or redundancy, nay mutual inhibition) linked to over-additivity (or under-additivity) that may be observed between the elements of an organised set such as a firm's assets. This synergy (respectively redundancy) effect may lead to a value of the set of assets greater (resp. lower) than the sum of the values of all assets. This is particularly the case in the presence of intangible assets as good will.

Multiple-entry bookkeeping

"Triple-entry bookkeeping": Henning Kirkegaard (*The Logic of Double-Entry Bookkeeping*) proposes a new understanding of the inherent uncertainties of double-entry bookkeeping system in the light of the study on triple-entry bookkeeping by Yuji Ijiri (*Momentum Accounting and Triple-Entry Bookkeeping: Exploring the Dynamic Structure of Accounting Measurements*. American Accounting Association, 1989). He stresses that for five centuries the questions about the causes of claims and agreements have been left unanswered in accounting since double-entry bookkeeping has only two logical measurement points.

As a result, double-entry bookkeeping can only be called an "absolutely perfect system" in a world where there are no time intervals worth mentioning between the expectation, the agreement, and the claim. This may have been the case in our world 500 years ago, where merchants brought their commodities to the market and transactions were completed within a single day. Unlike then, in our modern society there is often a considerable span of time between the measurement points expected and agreed, and also between agreed and realized. These time intervals can be seen in both income and expense accounts.

He concluded that:

... despite its overwhelming formal strength, double-entry bookkeeping still has extreme serious weaknesses as far as its description range is concerned. The very method once considered to be a step forward and the stroke of genius, must now be seen as a logical straitjacket preventing complete and timely descriptions of the financial position.

Therefore, I am of the opinion that the epistemological problem of accounting could be on the brink of a solution, if the reader accepts the following two conclusions involving a rejection of the teleological explanation and basing it on the causal explanation:

1. In its original form, the double-entry bookkeeping system is a model for describing, explaining, and predicting the financial consequences of the operations of an organization.
2. The double-entry bookkeeping system is a logically incomplete model since the time intervals of expected/agreed and agreed/realized are absent in a model that only describes the time interval of realized/paid.

The term triple-entry bookkeeping has not been extensively used although various approaches are taken to resolving the time-based uncertainties in accounting.

"Quadruple entry bookkeeping": On behalf of the International Monetary Fund, Cornelis N Gorter and Manik L Shrestha (*Bookkeeping Conventions and the Micro-Macro Link. Review of Income and Wealth*, Vol. 50, No. 2, pp. 181-201, June 2004) point out that the formal accounting logic of the national accounts and other macroeconomic statistics is not always well understood. In addition, the relation between macro statistics and micro accounting data often is not clear. They summarize the main bookkeeping conventions at the macro level:

A distinction is made between vertical and horizontal double-entry bookkeeping, which, if applied simultaneously, result in quadruple-entry bookkeeping. Vertical bookkeeping refers to the double-entry bookkeeping used in business practice. Horizontal bookkeeping requires that the transactions and other economic relationships between agents answer strict consistency rules regarding valuation, timing, and classification. At the micro level, this consistency is not guaranteed. The article reviews three options to reinforce the micro-macro link... and concludes with a few suggestions that could be used in the upcoming revisions of the international statistical manuals.

Harry Postner (*Winter of Our Discontents: A Personal View of the National Economic Accounts*, 2001) discusses the relationship between economic accounting and commercial accounting:

First, it should be noted that national accounts are an aggregation of the economy's sectoral accounts. Each sectoral group of economic transactors, for example, households or corporate enterprises, practises double-entry bookkeeping for its transactions over the sector's own sequence of accounts... The accounting entries are also inter-related through cross-sectoral transaction articulation, for example, employee compensation received by households equals employee compensation paid by (corporate) enterprises. This implies the system as a whole practises quadruple-entry bookkeeping that is a unique feature of a complete set of national economic accounts. The idea of sectoral interdependence is the centre of attention.

Multidimensional or matrix accounting: A multidimensional accounting system uses existing company data to look at the organization in multiple ways. Different users require diverse perspectives or dimensions of information, which are not possible to furnish under the sole concept of double-entry accounting. But designers of computer-based accounting systems in the past thirty years have tended to focus on producing existing information cheaper, or faster. Few questions have been asked about whether better accounting information could be produced by using a computer -- whether cost-effective, computer-based accounting systems can be used to generate better accounting information than existing transaction processing accounting systems. There have been few studies of these issues beyond:

- the work of Ijiri [1966, 1975] on multidimensional accounting,
- the work by McCarthy [1978, 1979, 1982] on the REA model and his suggestion that conventional accounting reports should be defined as views of an underlying set of facts about the enterprise, and his willingness to abandon double-entry accounting that shaped the Resource and Exchange Events (REE) model
- the work of Weber [1977, 1986] on packaged software as a source of evidence about how computer-based accounting is currently practiced. [\[more\]](#)

Examples of multidimensional accounting include:

- **Multicurrency General Ledger:** Its operation and control are fully automated. All trades forming part of the accounting process are identified by their monetary origin and, through a given exchange rate, the value of the transaction is calculated at its monetary equivalency.
- **Multiple Structures:** The accounting of an institution is organized from a basic structure so as to be able to draw out information by specific criteria in a way that is both automatic and on line, without having to manipulate it outside the books or incur costly manual processes.
- **Parameter model:** The double-entry accounting system is supplemented by matrix accounting, so that each account (according to the needs or criteria of each user) stores through parameters, balances and movements, without having to establish additional accounts. In the based on a matrix, lines represent accounts and columns represent parameters (criteria) associated with each of them. So, with just one record, each account stores the required criteria that can then be consulted according to need.

Vector accounting: David Ellerman (*Double Entry Multidimensional Accounting*, 1986) proposes a model of double entry multidimensional accounting using vectors of property rights. He notes that:

There is, in modern algebra, a standard construction called the *group of differences* [or '**Pacioli group**' named after the "Father of Accounting", Luca Pacioli (*Summa de arithmetica, geometrica, proportioni et proportionalita*, 1494)]... the intuitive algebra of T-accounts used in double entry bookkeeping is precisely equivalent to that group of differences construction... The T-accounts of double entry bookkeeping are the ordered pairs of the group of differences construction... Double entry bookkeeping lives in group theory, not in matrix algebra.

Such vector accounting (or property accounting) provides a valuation-free description of the property transactions underlying the value transactions of ordinary accounting, thus avoiding their valuation controversies. According to Ellerman, it is called property accounting because it keeps accounts directly in terms of the stocks and flows of the underlying property rights. It attempts to stake out the objective territory that involves no valuation in order to delineate the real issues of valuation. Property is understood to change by: *transactions* between parties and *appropriations* ("or, metaphorically, with Nature"). He states:

...vector accounting shows that an accounting equation can still be used in the presence of incomparability between dimensions by using vector equations. This is a mathematical fact independent of the content. the content of the vector accounting formalism could be property accounting, social accounting, accounting for physical inventories at different locations, and so forth.

Ellerman criticizes the model of Ijiri (above) because of the lack of balance sheet equation, the lack of any equity accounts, nonclosure and unworkability of temporary accounts, nonbalancing trial balance, and the use of scalar accounts rather than vectors. These are maintained and generalized in the vector accounting model.

Subsequently Ellerman (*Introduction to Property Theory: The Fundamental Theorems*, 2002) develops his approach using directed graph theory.

"Bottom lines"

The metaphor of the "bottom line" has become fundamental to many aspects of new discourse and reporting regarding sustainable development and corporate social responsibility. The following "**bottom lines**" are to be understood as **cumulative or nested**, namely "triple bottom line" reporting includes both double and single bottom line reporting:

Double bottom line: Sustainable development and concerns about corporate social responsibility have over the past decades forced attention on the double (or dual) bottom line. This tends to signify the need to reconcile the financial bottom line with the social bottom line -- possibly with the aid of a "social audit". It could be argued that the double bottom line was first articulated internationally through the call for "structural adjustment with a human face" -- in response to the strictures of traditional IMF and World Bank practices. There is however some confusion in the terminology in that a more sophisticated approach to social responsibility tends to be acknowledged in triple or quadruple bottom line reporting -- and the environmental dimension may even be acknowledged as double bottom line reporting [more]. These distinctions are tentatively made in [Table 1](#) where the interpretations of Scheme A tend to be more conservative than Scheme B.

Table 1: Accounting bottom lines		
	Scheme A?	Scheme B?
Single bottom line	Accounting isolated from non-local, non-economic, financial factors	Accounting isolated from non-economic, financial factors -- although subject to legal constraints (health and safety legislation)
Double bottom line	Accounting partially conditioned by legal constraints (health and safety legislation) on the enterprise	Accounting partially conditioned by social constraints beyond those envisaged by legislation. Structural adjustment "with a human face"
Triple bottom line	Accounting conditioned by impact on the immediate natural and social environment (localized corporate social responsibility)	Accounting conditioned by impact on the wider natural environment and social environment (global corporate social responsibility)
Quadruple bottom line	Accounting recognizing a relationship with the transcendent, providing for that relation in decision-making (as in faith-based governance) and exhibiting a degree of	Accounting reflecting involvement of stakeholders (including employees) in ethics of strategic decision-making, management practices and

line	openness to wider community	governance
Quintuple bottom line		Accounting recognizing a relationship with the transcendent, providing for that relation in decision-making and exhibiting a degree of openness to wider community

Triple bottom line: More recently, the Global Reporting Initiative guidelines for "triple-bottom-line reporting" broaden financial reporting into a three-dimensional model for economic, social and environmental reporting [more]. This focuses corporations on the environmental value added (or destroyed) -- in addition to the economic and social values of the double bottom line. Narrowly conceived, the term "triple bottom line" is then used as a framework for measuring and reporting corporate performance against economic, social and environmental parameters. More broadly understood, the term is used to capture the whole set of values, issues and processes that companies must address in order to minimize any harm resulting from their activities and to create economic, social and environmental value [more]. The "triple bottom line" of sustainability reporting can be disaggregated into a "five capitals model" in the following way: economic (manufacturing, financial), social (human, social), environmental (natural). As noted in the *Sustainability Accounting Guide* (2003):

Almost inevitably, sustainability accounting currently deals with economic, environmental and social issues in relative isolation from each other. Attempts are being made to explore the inter-relationships between these three central pillars of sustainability...but, with the possibility of some experimentation with integrated performance indicators (socio/economic or eco-financial), corporate progress towards sustainability is mainly measured in discrete chunks rather than as an integrated whole.

It has been estimated that 45% of the world's top companies publish triple bottom line reports. The triple bottom line may be understood as "social responsibility", taking into account issues such as globalization and the impact of multi-national companies, in terms of their responsibilities to the communities in which they work.

Quadruple bottom line: This form of reporting embraces a further component - governance. It represents the emergence of sustainability reporting through which reporting is aligned more closely with underlying management practices and measures of corporate performance. The trend to quadruple bottom line reporting has been accelerated by major company collapses that have focused attention on governance and social responsibility. Corporate social reputation is increasingly recognized as having less to do with earnings and more to do with reputation across a broad array of stakeholders. However, in the "bottom line indicators race", technology has also been proposed instead of governance (*Sustainable Energy Watch Global Report for RIO+10*). But quadruple bottom line reporting may be better understood in terms of "ethical responsibility" (as distinct from social responsibility") as the focus on employees, on stewardship and on leadership fostering and nurturing employees. This takes account of the challenge to ethics indicated by in boardroom disclosures. As noted by Nasir Butrous and Ellen McBarron (*A Call for an Ethical Focus in Business*, 2004), many organizations judged to be socially responsible for their philanthropic and community work have been found to have made unethical decisions; support unethical values and in fact have acted unethically. The quadruple bottom line adds a new dimension to the running of the company quite separately from the bottom, dual and triple bottom lines. The ideas of ethical leadership foster the internal democracy of open management.

Quintuple bottom line: As noted above, there is an emerging consensus recognizing "governance" as the key factor in quadruple bottom line reporting. However another candidate is spirituality -- as reflected in the "spirit in business" movement, or as articulated by Sohail Inayatullah (*Spirituality as the Fourth Bottom Line*, 2003). Spirituality may indeed be understood as fundamental to a more enlightened form of governance -- as exemplified in "faith-based governance". If however spirituality is considered distinct from governance, then it would need to be allocated to a fifth bottom line. For Inayatullah, spirituality means four interrelated factors.

1. A relationship with the transcendent, generally seen as both immanent and transcendental. This relationship is focused on trust, surrender and for Sufis, submission.
2. A practice, either regular meditation or some type of prayer (but not prayer where the goal is to ask for particular products or for the train to come quicker).
3. A physical practice to transform or harmonize the body - yoga, tai chi, chi kung, and other similar practices.
4. Social - a relationship with the community, global, or local, a caring for others. This differs from a debate on whose God, or who is true and who is false, to an epistemology of depth and shallow with openness and inclusion toward others.

In what follows, the question is whether such "bottom line" notions can be integrated with greater precision into a new geometry suggestive of a system of accounting -- spherical accounting.

"Three sets of books": shadow of the "bottom line" approach?

Before exploring how spherical accounting might work, it is useful to note how parallel accounting systems tend to exist in practice -- independently of any implementation of triple or quadruple reporting as advocated above. In fact the following examples in many ways constitute a shadow form of what is recommended with respect to corporate social responsibility. They represent a marked tendency to maintain parallel sets of books as illustrated by the following:

- A decade ago, the Italian government revised the gross domestic product upward by about 17% to account for the black market, although it is generally acknowledged that this percentage is still too low. Italians like to joke about taxes: "We have three sets of books: one for the government, one for the bank, and one for ourselves." [more]
- "Organized crime controls retail... Hotel managers know how much they have to provide for the mob cut. Most Russians keep three sets of books: the books for the mob, the ones for the tax collector and the real books." [more]
- How much money does the business really make? I have heard it said that some shopkeepers keep three sets of books - one for

the tax man showing they made no money; one for the buyer showing they made lots of money; and one for themselves telling the truth. [\[more\]](#)

- And because factories in developing countries often supply a variety of buyers, they are faced with many different, and sometimes conflicting, codes of conduct. Some factories "have two or three sets of books" to deceive tax collectors and multinational purchasers about working conditions and the real costs of production. [\[more\]](#)
- Another ... company told us how they keep three sets of books: one for the overseas investor, one for tax man and another showing what was actually happening. This kind of sometimes necessary "triple-think" encourages those involved to be deceptive and makes others think that all business is simply a racket. [\[more\]](#)
- In Indonesia, before the revival of the capital market and the introduction of accounting reforms in the 1980s and early 1990s, it had been common for private companies to maintain three sets of books -- one which showed the "true" state of the business and was used for management decision-making; one which showed a positive result and which was used for raising loans from foreign and local banks; and one which showed a loss or small profit and was used for taxation purposes.

In such circumstances it is not surprising that software is advertised as: "Maintains five independent sets of financial information on each asset and allows analysis by displaying three sets of books side by side" [\[more\]](#).

In relation to the emergence of governance as the focus for quadruple line reporting, it is interesting to note the following comment, and controversy, on the potential for abuse of electronic voting during the 2004 presidential elections in the USA:

By entering a 2-digit code in a hidden location, a second set of votes is created. This set of votes can be changed, so that it no longer matches the correct votes. The voting system will then read the totals from the bogus vote set. It takes only seconds to change the votes, and to date not a single location in the U.S. has implemented security measures to fully mitigate the risks....The GEMS program ... typically receives incoming votes by modem, though some counties follow better security by disconnecting modems and bringing votes in physically. GEMS stores the votes in a vote ledger...Any properly designed accounting program will allow only one set of books.... But in the files we examined, we found that the GEMS system contained three sets of "books." (Bev Harris, *Diebold GEMS central tabulator contains a stunning security hole* 30 August 2004) [\[more\]](#) [\[more\]](#) [\[more\]](#) [\[more\]](#)

Whilst steps may indeed be taken to implement triple and "higher" forms of bottom line reporting -- with their own "sets of books" and audits -- it would be naive to imagine that these "white books" would not be obliged to continue to coexist with their shadowy analogues ("black books") to which reference is made above. For example, although (as noted above) "45% of the world's top companies publish triple bottom line reports", there is little debate concerning the relationship between such a response to "corporate social responsibility" and the tax avoidance practices of such corporations -- many are alleged to pay very little tax in practice. It might even be asked whether such reports are used as a "good citizen" disguise for tax avoidance.

The following table may therefore prove to be a useful reminder that public debate and reporting may be ignoring an unstated reality (whose scope [Transparency International](#) continues to document):

Table 2: Accounting sets of books			
	"Sets of books"		
	Overt	Covert / "Unsaid"	
	"White books?"	"Grey books?"	"Black books?"
		"Everybody knows"	"Secret"
	Public relations (regulatory authority, fiscal authorities)	Fiduciary relations (bank, lawyers, etc)	"for owners" ("strictest confidence")
Single bottom line	declared profit/loss in standard financial accounts	"undeclared" income; tax avoidance; use of tax havens; stock options (as a means of tax avoidance); bribes and kickbacks; "commissions"; overbilling; overselling	"dirty tricks"
Double bottom line	social audit; compliance with labour conventions; worker representation; gender equality	outsourcing to less constrained regimes, externalizing losses; non-compliance with labour legislation	concealed exploitation of employees and suppliers
Triple bottom line	environmental audit (energy, water); minimize adverse environmental impacts; compliance with standards	lobbying for favourable legislation and loopholes; undue influence on regulatory bodies and inspectors; exporting toxic waste; non-compliance	concealed discharge of wastes
Quadruple bottom line	ethical decision-making & governance	irregular voting practices; gerrymandering; cronyism; nepotism; price-fixing cartels	"under the table" deals with employees
Quintuple bottom line	faith-based decision-making, appeals for divine blessing by decision-makers	manipulation of gullible believers; reporting on sins in confession only	spiritual double-standards; guilty conscience

This table benefitted from the insights of Nadia McLaren

Conditioning metaphors

There is now an extensive literature on the relevance of metaphor to strategic thinking -- and hence the need for empowering metaphors to enable more effective strategies. The question to be asked in relation to the challenge of the times is: what kind of metaphoric trap is strategic thinking entrapped in?

The suggestion here is that in relation to accounting, as a fundamental tool of management, the world's initiatives are trapped in a disempowering, impoverished metaphor. This might be described in terms of the oversimplistic "geometry" that leads to expressions like "budget lines" and "bottom lines". This is an extension of the kind of thinking dependent on "bullet points" in strategic presentations. Such thinking tends to avoid more contextual articulations of any value to strategic understanding. In fact there is a dramatic split between:

- the kind of thinking that is articulated in detailed project analysis, replete with systems diagrams respectful of the complexity held to lie within the boundaries of the system with which the project is concerned -- but totally lacking in any coherent overview comprehensible to wider audiences called upon to assess the merits of the initiative
- the kind of imaginative presentation, using the best aesthetic input, to convey a "concept" to a wider audience -- but totally lacking the pattern of connectedness on which the viability of the initiative depends.

From this perspective, it might be argued that the economic preoccupations of business and development are well-served by "closed-system" thinking that is articulated through spreadsheets. Such thinking reinforces tendencies to grid systems, notably in urban planning. Distinct from this mode of thinking is that associated with more "open systems" of less predictable behaviour. Typically these include the ecosystems of the natural environment -- the "pattern that connects". They also include the kind of thinking pioneered by Christopher Alexander (*A Pattern Language: Towns, Buildings, Construction*, 1977) in relation to urban environments.

It might be argued that the developmental mode is essentially two-dimensional and is an excellent tool for appropriately limited purposes. The second is in some ways three-dimensional -- as presented imaginatively through photographs and representations of a spherical Earth. The argument here is that sustainable development is the challenge of the interaction between two geometries -- the plane and the sphere -- and the nature of the transitions and transformations required to shift from one to the other.

This theme has of course been explored in several works of fiction well-known to mathematicians (Edwin A. Abbott. *Flatland: A Romance of Many Dimensions*, 1884; Dionys Burge, *A Fantasy About Curved Spaces and an Expanding Universe*, 1965; Ian Stewart, *Flatterland: Like Flatland, Only More So*, 2002) [[more](#)].

Boundedness

It is of course clear in geometrical terms that the two-dimensional may be very well suited to local perspectives and issues -- laying out a garden or a town, a small business. But it would appear to be extremely problematical in dealing with global issues -- environmental degradation, depletion of natural resources, the clash of civilizations -- where the three-dimensionality of some form of spherical approach is more isomorphic with the shape of the world and how it may need to be understood. This consideration relates to work on "cognitive fit" (cf Ritu Agarwal, et al. *Cognitive Fit in Requirements Modeling: A Study of Object and Process Methodologies*, *Journal of Management Information Systems*, 1996). "Cognitive Fit" is defined as the degree to which a particular diagramming technique is representative of a problem space, notably in accounting systems (cf Roberta Ann Jones, et al. *An Empirical Investigation of the Cognitive Fit of Selected Process Model Diagramming Techniques*; Cheryl Dunn, et al. *An Investigation of Localization as an Element of Cognitive Fit in Accounting Model Representations*, *Decision Sciences Journal*, 2001).

Will the future see present approaches to global accounting as somewhat akin to the "flat earth" mindset of centuries past? Why was it so difficult to demonstrate the sphericity of the globe and to enable its circumnavigation? The challenge for mapmakers of the past was to ensure a relationship between surface measurements and the shape of the world -- using appropriate approximations. To what extent is the nature of this challenge recognized in the case of any accounting system that claims to be global, whether geographically or in terms of an inclusive attitude to all sectors of human activity?

A particular property of a two dimensional representation of reality is the nature of its boundaries. A spreadsheet is apparently well bounded -- with a limited number of columns and rows. But more columns or rows can be easily added. Similarly an urban grid plan is bounded -- but further streets can be added whenever required. This is in fact the essence of development as widely conceived. Green belt zones can always be "cleared" as a basis for further development. No inherent limits are integrated into strategies based on a two-dimensional approaches to accounting. Such strategies are essentially unconstrained by any higher dimensionality.

Even the discussions of multidimensional accounting, as a generalization of double entry bookkeeping, imply an unbounded grid -- even though the array is multidimensional. In an urban context, the contrast is especially evident between a gridwork of streets and a neighbourhood focused on a square -- where the focus is meaningful to all in the area as a "centre of gravity". This is a form of constraint on the unboundedness of the grid.

By contrast with a grid, the three-dimensionality of a sphere is inherently constrained -- although the surface is described as "finite but unbounded". The constraining features of a sphere reflect the additional constraints on two-dimensional thinking imposed of necessity by triple, quadruple and possibly quintuple bottom line thinking in response to the challenge of living on a sphere rather than on an infinite plane -- as developers tend to continue to assume.

Completeness

The shift towards quadruple and higher forms of accounting can be understood as an effort towards completeness. Elsewhere (*Needs Communication: Viable need patterns and their identification*, 1980) it was argued that:

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Clearly the most favored representations of a total set of human needs are the list and the table-matrix. However, both conceal the question of completeness, as noted below.

A list does not order the relationships between its elements except in relation to nested sublists or in the case of a list in series form. This does not imply that such relationships are lacking, merely that they cannot be reflected in the list form. Note that a list is in fact a series of "points," but it is not necessary to conceive of it as such. The points could be represented as areas on a surface. It is only in the matrix that the manner in which the total area is cut up becomes explicit.

The cells of a matrix may be thought of as subareas of the area representing the totality that the matrix attempts to reflect. The subareas are, of course, positioned with respect to column and row commonalities. It is now interesting to ask why the area is bounded in such a limiting manner, for the rectangular or square form is one of the simplest. It provides a (paned) "window" through which the totality may be perceived. But it raises questions about the "wall" in which the window is set and the position of the observer in relation to the observed on the other side of the window.

Now to the extent that the matrix is complete in its coverage, there really should not be any "wall." The matrix should in such cases in effect "wrap around" the observer; all is window and nothing is implicit, unexplicated, or excluded. If this is not so, then the wall should be conceived as wrapping around the observer, possibly with other windows corresponding to other partial views of the external totality to which the observer may turn his attention.

From this point of view the conventional two-dimensional matrix raises the question of the conceptual significance of crossing the encompassing boundary. It seems irrational and unmeaningful because the wall is unrecognized. There is almost a flavor of danger of "falling over the edge," as sailors feared with the early "flat earth" models.

If it is assumed that the matrix is complete, then it should be possible to represent it without such an arbitrary external boundary. If the external boundary is eliminated, then the matrix takes the form of a closed surface (wrapped around the observer). By what procedure can a two-dimensional matrix be so modified, and to what does it give rise?

The "wrapping" called for must necessarily be understood as the introduction of curvature. **Can sustainable accounting be designed without the forms of curvature that will take account of all the feedback loops essential to sustainability?** In contrast to the feedback loops that figure on systems diagrams, the requirement in the case of sustainability is surely for **mutually constraining loops associated with distinct value flows** -- to which the double, triple and quadruple bottom lines point.

Spreadsheet to torus

A simple exercise in geometry can be used to transform the spreadsheet -- as a sheet -- into a torus (namely a doughnut shape):

- the top and bottom of the spreadsheet are joined to create a tube, with the spreadsheet columns constituting circular bands at different points on its length -- along which the columns run
- the ends of the tube are connected -- linking the left and right ends of the rows of the spreadsheet

What purpose might this shape serve in understanding the financial viability of an organization? Clearly, when displayed graphically, any strictures in the torus might provide a way of sensing the health of the organization -- perhaps to be expressed as "constipation" or "bloat" at certain points.

If the spreadsheet of an organization were to be displayed in this way, it would raise the interesting question of the stability of a torus under dynamic environmental conditions. Most striking is the comparison with the viability of a smoke ring. The integrity of a smoke ring is sustained by movement around the circular bands around the doughnut shape.

Toroidal dynamics are of fundamental interest in nuclear fusion research -- in the search for new sources of energy. Spheromaks are easily formed, self-organized magnetized plasma configurations -- sometimes called magnetic vortices, magnetic smoke rings, or plasmoids (Paul M Bellan. *Spheromaks: A Practical Application of Magnetohydrodynamic Dynamos and Plasma Self-Organization*, 2000)

In terms of the challenge of relating disparate elements, significant to double or triple bottom line insights, the advantages of this kind of approach would appear to be modest.

Imaginative reframing

In the light of the arguments for multidimensional accounting, the existence of "sets of books", and the promotion of multiple "bottom line" reporting, it is worth considering alternative ways of framing possible future approaches -- especially now that there is both a need, and a willingness, to make extensive use of computer visualization facilities.

For example, it could be assumed that:

Lines:

- Each "bottom line" should be understood as the carrier of a distinct kind of "value" or "currency". This would be consistent with some of the arguments for multidimensional accounting.
- Different "bottom lines" could, for example, be represented by straight geometric lines.
- Lines might be variously oriented to one another as an indication of such difference in value type. In this sense the "currency", whether monetary or otherwise, would be distinguished from other value types by orientation.

Circles:

- Rather than being lines over a flat surface, the lines could be on the surface of a sphere, curving to follow the curvature of that sphere (for a justification for curvature in this context see Jonathan Tennenbaum. [Incommensurability and Analysis Situs](#), 1997).
- Lines could even be understood as circling around the sphere, so that each line was in effect a circle. "Budget lines" are reframed as "budget circles".
- As a circle, the lines might then hold insights into systemic feedback loops, given that lines do not then have a starting place and an ending place. Each circle is understood (and experienced) as a complete (sub) system, possibly with some degree of interdependence, if not integrity.
- In a sustainable undertaking, such circles are then necessarily conduits for value flows, whether monetary or otherwise.
- Circles might not all circle the sphere they together define. Some might indeed do so (as the "great circles" of geometry and navigation), to be understood as in some way reflecting "global" flows. Others might circle regions of the sphere -- reflecting "regional" flows (perhaps parallel to a "global" flow as indicative of similar value orientation). The smallest might reflect "local" flows.

Intersections:

- Lines might intersect. Three such lines might, for example, intersect to form a triangle.
- Intersection points of lines would then be understood as nodes at which value was transformed between different "currencies".
- When three distinct "great circle" lines intersect, they effectively interlock and give form to a larger system with a degree of integrity and sustainability. This might be understood as the minimum criteria for the emergence of a distinct and sustainable psycho-social system.
- More lines, carrying a greater variety of values, might circle the sphere

Zones:

- In the simplest case, the intersection of three such lines generates triangles. But in more complex cases, four circular lines generate squares, five would generate pentagons, etc.
- Such zones reflect the intersection of an extensive selection of explicit values -- relating disparate value factors. In practice they correspond to the functioning of a "multi-stakeholder" panel where different values have to be held and adjusted in relation to one another (eg economic issues, social issues, environmental issues, cultural issues, political issues, security issues, etc).
- There are constraints on the variety of flows that can characterize such zones -- as with the variety of stakeholders in a panel. Zones defined by more than six flows would tend to be rare or less stable. This suggests that an "octuple bottom line" may, for example, be less likely to be called for or recognized.

Flows:

- As value conduits, the "flow" in the lines may increase or decrease. It might be understood to reverse. In financial terms this clearly reflects positive (income) or negative (costs) flows.
- At intersection points, the relative level and direction of flows give rise to tensions and pressures that affect the degree of transformation between flows lines of different types.
- The spherical system of circular flows is then in a dynamic condition adjusting flows in relation to one another -- between values of different types. This process may be understood as a dynamic set of checks and balances vital to the integrity of the system.

Although such a system adjusts relatively rapidly through the redistribution of tensions and pressures along various value streams, this takes time. There are lags typical of those recognized in "momentum accounting". In the sense the sphere may hold the temporal dimension, in a manner reminiscent of longitude.

Synergetics and tensegrity

The extensive work of [R Buckminster Fuller](#) (*Synergetics: the Geometry of Thinking*, 1975) on synergetics provides a formalization and integration of many of the elements noted above. Fuller has described it in the following terms:

Synergetics promulgates a system of mensuration employing 60-degree vectorial coordination comprehensive to both physics and chemistry, and to both arithmetic and geometry, in rational whole numbers. Synergetics originates in the assumption that dimension must be physical; that conceptuality is metaphysical and independent of size; and that a triangle is a triangle independent of size. Since physical Universe is entirely energetic, all dimension must be energetic. Synergetics is energetic geometry since it identifies energy with number. Energetic geometry employs 60-degree coordination because that is nature's way to closest-pack spheres. Synergetics provides geometrical conceptuality in respect to energy quanta. In synergetics, the energy as mass is constant, and nonlimit frequency is variable. Vectors and tensors constitute all elementary definition. Synergetics shows how we may measure our experiences geometrically and topologically and how we may employ geometry and topology to coordinate all information regarding our experiences, both metaphysical and physical. [[more](#)]

Fuller has described synergetics as a form of universal accounting system (cf Amy C. Edmondson. [A Fuller Explanation: A Quick Comparison: "Synergetics Accounting"](#)).

But although Fuller has articulated this extensive, and much-cited formalization, this does **not** focus specifically on **semantic** content -- of the type required by the **distinct value flows** discussed earlier. In arguments analogous to the economic reduction to financial flows (noted earlier), he stresses their reduction to energy flows. However in the 1970s, Fuller promoted a [World Game](#) approach (still

promoted through the [World Game Institute](#)) that emphasized "total energy accounting" based on a 25-year "economic accounting" [[more](#)]. It is essentially a programme for the [Design Science Revolution](#). It is conceived as an Integrative Resource Utilization Planning Tool. This called for:

"graphical, functional and mathematical orderings and simplifications of the omni-complicated and inter-related processes of the World. The conceptual simplifications of "reality" into the vectors of an interacting process which can be dealt with on a scientific basis. [[more](#)]

The formalization does however stress the value of exploring such system representations through polyhedra having various properties and interrelationships -- and capable of transformation from one to another. This is most evident in his work on the vector equilibrium ([cuboctahedron](#)) and tensegrity [[more](#) | [more](#) | [more](#)].

"Sustainability" through "golden mean accounting"?

Bonnie Goldstein DeVarco (*Energetic Architecture - Buckminster Fuller's Geometry of the Sphere*, 1997) notes the anticipation of some of Fuller's geometric insights by the so-called "Father of Accounting", [Luca Pacioli](#) (*De Divina Proportione*, 1509, illustrated by Leonardo da Vinci). A glass [rhombicuboctahedron](#) half-filled with water is the focus of a widely analyzed contemporary [painting](#) of Pacioli -- held to epitomize the deep Renaissance connection between art and mathematics. Pacioli is a key figure in the recognition of centro-symmetrical polyhedra [[more](#)]. Pacioli's own mathematical work had been preceded by that of Leonardo of Pisa, (1170-1250), also known as [Fibonacci](#), to whom the Republic of Pisa awarded a yearly salary for his advice on accounting and related matters -- following his vital role in collating the Arab and Indian insights into mathematics for Europeans (*Liber abaci*, 1202).

Although the relevance of [Fibonacci series](#) in relation to financial markets has been widely explored [[more](#)], there do not appear to be any direct references in current financial accounting to the shared concern of Fibonacci and Pacioli with the Golden Mean. This "golden ratio" of any two consecutive numbers in the Fibonacci sequence is a proportion that is an important phenomenon in music, art, architecture and biology. The question is whether this ratio, as expressed in polyhedra, can be in any way understood as vital to new insights into [sustainability accounting](#) -- especially given the ease with which virtual polyhedra can now be constructed (cf George Hart, *Virtual Polyhedra*) [[more](#)], and linked to data of significance to policy-making and management (as has been done with the databases of the online *Encyclopedia of World Problems and Human Potential*).

The possibility is perhaps usefully emphasized by the current restriction of representation of "multi-dimensional accounting" to one of the simplest polyhedra, the cube -- as in the *Sustainability Accounting Guide* (2003).

Perhaps ironically, the only reference to "golden mean accounting" is in an early Western poem concerning Japan [[more](#)]. However the group associated with the '[San Francisco](#)' [Model of Economic Adjustment](#), in discussing their study of *Multi-Dimensional Hyperbolae and the General Utility Problem* (by Kurt Roemer, *Newtonian Economics*, 1985, Chapter 4), do explain the function of the Golden Mean in order to conclude that:

Hyperbolic descriptions of indifference tradeoffs are inseparable from the SFEcon initiative. So far as we know, these descriptors are unique in providing the references by which capitalistic systems might navigate among their chaotic states toward stasis governed by a unified expression of value...

In searching for a meta-pattern behind the natural dynamism of economic order, we might well consult ancient wisdom in beginning with a generator of elementary forms that can grow in time and space by replication of their simple rules. Perhaps the economist's notion of a general optimum might then be discovered as a pattern around which economic dynamics are stabilized. [[more](#)]

The importance of a "golden mean" is recognized **metaphorically**, as stressed in 2004 with regard to doing business in China by a leader of the China Society of Economic Reform [[more](#)]. Similarly David Hiley (*Striking a Balance between Budget Extremes*, 1999) in discussing Responsibility Centered Management (RCM) argues:

Aristotle also understood that there was not an absolute mean. The "golden mean" will be relative to individual character and circumstances. The "golden mean" is not a bad reminder for thinking about the challenges of developing and implementing a decentralized budget model at the university. There is no single best model. Our challenge has been finding the model that makes sense for our circumstances. And finding that model has been governed by the need for hitting the mean between too little and too much control, or the same thing from the other side, between excesses and deficiencies of decentralization.

Similar metaphoric recognition is given in the case of the well-known alternative community, [The Farm](#):

The Second Foundation is an attempt to explore more harmonious and equitable social and economic systems. It starts by establishing a golden mean between those things which are best handled collectively - through group agreement or social contract - and those things which are best handled individually - at a family level. [[more](#)]

Severyn T. Bruyn (*Civil Republic: Beyond Capitalism and Nationalism*) also focuses on the metaphorical insight, arguing optimistically:

Aristotle might ask: Could extreme principles (e.g. freedom vs. order) be resolved in a Golden Mean? Could great philosophical differences join in some higher order of thought and practice? Could there be a middle-path, perhaps a synthesis? Could the market develop a civil order of freedom with a civil order of justice?

The answer is yes, but there are **a lot of details**. It is a fact that the corporation operates in a culture of contradictions in which the principles of freedom and order are at play. It follows that good citizenship in "justice-oriented free markets" can be a goal. The goal can be set forth through civil associations. [\[more\]](#) (*emphasis added*)

The challenge in moving beyond metaphor does indeed lie in "a lot of details". Given David Ellerman's approach to "vector accounting" [\[above\]](#) -- using directed graph theory to handle distinct forms of property ("property accounting") -- it is tempting to foresee a link to Fuller's formalization of polyhedral energy systems in terms of vectors (*Synergetics: Explorations in the Geometry of Thinking*, 1975: 420.00, 513.00, 521.00). However any such approach needs to be set in the context of other formal approaches to polyhedra (cf Branko Grünbaum. *Are Your Polyhedra the Same as My Polyhedra?*).

Also of great potential interest is the approach of [Stafford Beer](#) (*Beyond Dispute: The Invention of Team Syntegrity*, 1994) from the perspective of [management cybernetics](#) (as mentioned [below](#)). The geometric representation of dynamic systems, integrating the insights of Fuller and Beer has been usefully summarized by Curt McNamara (*Systems Coupling and Precession*, 2001; *Geometrical Systems Mapping*, 2002). Beer was also responsible for the development of a [Viable Systems Model](#) [\[more\]](#) that has colour-coded systemic features similar to those identified by Edwad de Bono (*Six Thinking Hats*, 1987; *Six Action Shoes*, 1991).

Collectively these approaches address the real-world challenge of ambiguity and uncertainty as noted by J G March (*Ambiguity and accounting: the elusive link between information and decision making*, 1987). **The point to be stressed is the generalization from accounting in purely financial terms, through accounting for "flows" based on incommensurable "value currencies", to "accounting" for flows of information (essentially meaning) that are fundamental to system viability or sustainability.**

Towards a "semantic dome"

Fuller's insights into the redistribution of energy in systems enabled him to invent an architectural structure, for which he is best known - namely the [geodesic dome](#). But in this exploration of the possibility of spherical accounting, which is consistent with many of these insights, the question is raised as to whether it is possible to develop what amounts to a "semantic dome", or perhaps a "memetic dome". This would not be constructed from physical materials. Rather it would be a virtual dome, integrated with and reflecting the contents of an information system of which it represented the "accounting".

This semantic dimension is already evident, coincidentally and ironically, in the "DOME" approach articulated by Zhan Cui and Paul O'Brien (*Domain Ontology Management Environment*, 2000):

Business-to-business e-commerce requires dynamic and open-interoperable information systems. Although, XML/DTD allow large organisational databases to publish information over the Internet, the automatic sharing of information among these systems has been prevented by semantic heterogeneity. True electronic commerce will not come until the semantics of the terms used to model these information systems could be captured and processed by computers. To develop a machine process-able ontology (vocabulary) is intrinsically hard. The semantics of a term varies from one context to another. We believe ontology engineering will be a major effort of any future application development process. In this paper we describe our work on building a Domain Ontology Management Environment (DOME). [\[more\]](#)

However, despite this use of "dome" and the focus on semantic integration, this metaphor is not explicitly related to the geodesic and systemic insights of Fuller. Other distinct tools inspired to some degree by the same metaphor include:

- DOME [of Honeywell] is an extensible system for graphically developing, analyzing and transforming models of systems and software...DOME is used to build models and to build notations. For quickly building models, DOME comes with a set of notations, which can also easily be extended. But DOME is designed for developing new notations, and then modeling systems based on them. For instance, if a project needs a special interface description, a DOME notation could be developed for it, complete with custom visual elements, required interface properties and analysis reports. [\[more\]](#)
- Dome [Document Object Model Editor] is a visual programming language for manipulation of XML documents. It is being used in the [AKT project](#) to trawl through large websites, extracting information from them by transforming the source HTML into RDF. [\[more\]](#)
- The DOME (Distributed Object-based Modeling Environment) environment developed at CAD Lab of MIT that may provide basic support for web-based collaborative problem solving, especially through integrated modeling. [\[more\]](#)

These various approaches are significant in relation to the emergence of the [semantic web](#) -- specifically to the challenge of ontologies as a key enabling technology for the semantic web. Ontologies are formal and consensual specifications of conceptualizations that provide a shared understanding of a domain. (cf Haoxiang Xia, Yanzhong Dang. *Toward a Semantic- Web- Services- enabled Knowledge Ecosystem Some Research Issues*, 2003). Such work is seen as the underpinning of the emergent global brain (cf *Simulating a Global Brain: using networks of international organizations, world problems, strategies, and values*, 2000).

Specifically missing from these insights into a "semantic dome" are the systemic relationships between distinct semantic content as value flows -- fundamental to dynamic accounting in a functioning system, in contrast with the static descriptive analysis characteristic of knowledge ontologies. The former is vital to the operacy of sustaining the viability of a functioning psycho-social

system -- whereas the latter is more concerned with learning about it and understanding it as an observer.

The contrasting semantic "flows" capable of holding the requisite variety to govern a complex system may perhaps be usefully described in terms of "languages" (*12 Complementary Languages for Sustainable Governance*, 2003). This recognition of distinct epistemological frameworks has been explored by Edward de Bono (*Six Thinking Hats*, 1987; *Six Action Shoes*, 1991).

Strategic dilemmas

Within the community of those developing knowledge tools for the emerging semantic web of the 21st century there is a marked belief in the possibility of uniformity and compatibility, however it is to be achieved. On the one hand, in addition to technological standardization, the challenge of interoperability addressed by computer-based ontology tools does indeed deal with terminological incompatibilities -- but on the questionable assumption that key terms do have similar referents, whether within or across cultures (but see *Systems of Categories Distinguishing Cultural Biases*, 1993).

On the other hand, the accounting systems concerned with interrelating different value flows do indeed recognize that the flows are distinct (and even incommensurable) and that it is less beneficial (even when possible) to reduce them to a common currency. But such accounting systems (whatever the number of "bottom lines") do not address the strategic challenge of the fundamental dilemmas engendered by these value flows -- with their different appeals and calls on quite distinct resources. And yet it is dealing with these dilemmas that is fundamental to the way in which the psycho-social system adapts to the future.

The possibility and role of incommensurable semantic content is neither recognized nor addressed. Whilst the web can indeed enable users to locate disparate information and to navigate between unconnected zones of semantic space, the designs for a semantic web do not acknowledge those challenges of epistemologically disparate content for which imposition of uniform semantic rules and processes would be rejected. A small indication of the challenge is recent steps to abandon the multilingual web domain names promoted since 2000 by the Multilingual Internet Names Consortium (MINC).

There would appear to be an assumption of an emergent degree of universal order and seamlessness -- a semantic continuum -- when there is every possibility that knowledge space may be troubled by increasingly chaotic dynamics and cleavages disruptive of the normalization favoured by those who feel empowered to "encourage" it. The conflicts, only too evident in the geopolitical and social spheres, may simply be replicated or echoed in knowledge space -- where they have already long been active, as is evident in the challenges of faculty politics, interdisciplinarity and transdisciplinarity. These challenges persist despite efforts at universal classification of knowledge, notably as pioneered by Paul Otlet, founder of the [Union of International Associations](#), and reflected in his final vision (*Monde: Essai d'universalisme*, 1935) -- now seen by historians as an early visionary of the internet (cf *Union of International Associations -- Virtual Organization Paul Otlet's 100-year Hypertext Comundrum?*, 2001).

Traditionally "ontology" has been the most fundamental branch of metaphysics -- the study of being or existence as well as the basic categories thereof [[more](#)]. As such it has strong implications for the conceptions of reality notably where this is determined by theology. "Ontology" has been borrowed by computer science for the purpose of formulating an exhaustive and rigorous conceptual schema **within a given domain**, a typically hierarchical data structure containing all the relevant entities and their relationships and rules (theorems, regulations) within that domain [[more](#)]. The very fact of such borrowing may be considered as a metaphoric illustration of the challenge.

These issues are given dramatic current significance in the light of the strategic impact of the semantic challenges inherent in:

- emerging trends towards "faith-based" governance and its possible consequences for high levels of censorship of the web and the emergence of isolated knowledge communities (cf *Dynamically Gated Conceptual Communities: emergent patterns of isolation within knowledge society*, 2004);
- the increasingly recognized "clash of civilizations" and its potential impact on the organization of knowledge space, if only in terms of language preferences, but necessarily with their semantic consequences -- and despite continuing hopes for a kind of "semantic Esperanto";
- the clash of cultures between those giving priority to "serious" semantic content and those increasingly favouring an "edutainment" emphasis on imaginative content, possibly minimizing the "reality-based" dimensions -- and often poorly distinguished from the wishful thinking embodied in strategic planning (whether for fund-raising, political, public relations, or propaganda purposes);
- systematic misuse of the semantic web (as characterized in the "three sets of books" of [Table 2](#));
- the predicted increasing constraints on non-renewable resources [[more](#)], may give rise to emergence of extreme pressures to use the semantic web as a "Potemkin" device to minimize or focus public panic and to sustain the belief system of world leadership (cf *Globalization within a Global Potemkin Society*, 2000; *Promoting a Singular Global Threat -- Terrorism: Strategy of choice for world governance*, 2002; *Spontaneous Initiation of Armageddon -- a heartfelt response to systemic negligence*, 2004);
- dynamics arising from inherent discontinuities characteristic of the different knowledge bases of communities with very different disciplines, experiences or strategic objectives -- as formally described by Ron Atkin (cf *Social organization determined by incommunicability of insights*, 1995).

The nature of the challenge of "semantic discontinuity" was explored on the occasion of the United Nations Earth Summit (Rio de Janeiro, 1992) in *Configuring Globally and Contending Locally: shaping the global network of local bargains by decoding and mapping Earth Summit inter-sectoral issues* (1992). This specifically focused on the challenge of configuring meaningfully the "inter-sectoral strategic dilemmas of sustainable development", whether as a [matrix](#) or as a [3D icosidodecahedral structure](#). The latter representation was used in order to take advantage of the systemic insights developed by Fuller as synergetics. Of relevance are more recent hypotheses regarding the role of tensegrity (Jim Nystrom. *Tensegrity as the agent of phase transitions*, 1998; Donald E. Ingber, *The Architecture of Life*, *Scientific American*, Vol. 278, 1998, 1).

As was stated then (*Summary of analysis on the occasion of Earth Summit*, 1992):

The difficulty is that bargains are typically discussed in the verbal and textual mode. In this mode, notions of "giving up" in order to "get something else" are understood in the simplest terms and therefore readily evoke opposition. This opposition is indeed legitimate in terms of the "two-dimensional" images (of "sides") through which they are currently discussed....

As in architecture, it is through balancing the stresses and tensions between a set of complementary construction elements that the integrity of a building is ensured. Richer structured imagery is required to facilitate understanding of how the larger and more encompassing bargains can be achieved. It is through such images of integrity, emerging from more complex structures, that the logic of that integrity gives justification to issue-specific bargains with greater effectiveness. It shows how they "fit". Structured images are required to give precision to the vague notions of "checks and balances" conventionally articulated in textual terms. Such images give precision to the notions of "giving up", and tensional "trade offs", which readily lend themselves to description in architectural terms, for example.;;;

... [The [3D icosidodecaahedral structure](#)] is one attempt to respond to this situation by showing how different social functions, understood as strategic opportunities, interfere with each other to engender a pattern of strategic dilemmas. In that pattern each strategy may take a privileged role or may in turn be constrained by other strategies. For example, when "environment" is a privileged function, "well-being (+jobs)" may be sacrificed, whereas, when "well-being (+jobs)" is the privileged function, sacrificing "environment" is the alternative option. Neither option is satisfactory, but both appear to have their place. Any such dilemma may of course be "resolved" by short-term measures, but the nature of the dilemma renders such solutions unsustainable in the longer-term. Sustainable development is a function of the pattern as a whole rather than of its components....

This approach points to new policy possibilities in which the degree of global consensus required is reduced to a minimum (in a design sense) by localizing the patterns of disagreement. In this way disagreement no longer acts globally -- tearing apart the global community. Rather it is locally confined and understood as a long-term strategic dilemma on which "consensus" can only be achieved in the short-term. Sustainability thus lies at the global level not at the local level....

Spherical accounting thus points to ways of using unavoidable fundamental disagreement as an essential feature of the design of organizations adapted to the turbulent conditions of the 21st century (cf *Using disagreements for superordinate frame configuration*, 1994). The challenge of strategic balancing under such conditions, using Fuller's insights into tensegrity, has been articulated elsewhere (cf *Implementing Principles by Balancing Configurations of Functions: a tensegrity organization approach*, 1979). The point to be stressed is that "incommensurables" and "disagreements" are then distributed into a polyhedral configuration of polarities rather than fused into a single polarity -- thus opening up a large spectrum of possibilities for negotiation and the "management of disagreement".

Tensegrity structures clarify ways in which individual bargains need to be interlocked using local elements of disagreement ("compression elements") within the global network of agreement ("tension elements"). Tensegrity structures are effectively patterns of sustainability. The challenge is to find useful ways to encode such patterns to offer insights into the strategies of sustainable development. [\[more\]](#)

Management cybernetics, notably as developed by [Stafford Beer](#) [\[more\]](#), resulted in a particular application of Fuller's tensegrity insights to integration of diverse perspectives (*Beyond Dispute: The Invention of Team Syntegrity*, 1994), a [syntegration](#) process, and a World Syntegration Action Plan (*Origins of Team Syntegrity*, 1992; *World in Torment: a time whose idea must come*, 1992). As further developed by the [Syntegrity Group](#) for the syntegration process, syntegrity combines the notions of synthesis and tensegrity -- itself a combination of tension and integrity (cf Allenna D Leonard. *Team Syntegrity Background*, 2002). Team syntegrity is a suite of structured group processes based on cybernetic principles for decision-making and consensus building. It optimizes the effectiveness and efficiency of information exchange while integrating various points of view. As used by the [Systems and the Information Society Network](#) (2001-2), to explore frameworks considered useful "to account for the complexity of social and organisational activities in the new information society", the "syntegration protocol" was described as:

The protocol is usually applied for groups ranging from 6 to 40 persons and has been successfully used in more than one hundred of meetings in different countries. Each member of the group plays three different roles: the role of a participant, the role of a critic and the role of an observer. For a group of 30 people the protocol is better explained by using an [icosahedron](#) as a metaphor. Here, each person is represented by an edge whereas each vertex corresponds to a topic, therefore in this case we have 12 topics. Usually each vertex (i.e., a topic) is associated with a colour so each member of the group is represented by two colours, the two colours that connect its edge in the icosahedron. This structure implies that in order to discuss a topic five participants meet in a place (i.e., five edges lead to a vertex). In fact, according to the protocol, in order to keep a good tension on each meeting, five other members join the discussion assuming the role of critics during the meeting. Another five members can also attend a meeting, assuming the role of observers. So, in each meeting of a particular topic we may have 15 persons at the same time (5 participants, 5 critics and 5 observers). This means that with 30 people it is possible to run two meetings on two different topics simultaneously. [\[more\]](#)

Shann Turnbull (*The competitive advantages of stakeholder mutuals*, 2000) introduces the related concept of "social tensegrity" as a method for efficiently managing the problems created by the limited, inconsistent and contrary operating characteristics of people. It uses the contrary characteristics of humans to improve self-governance and it is an emergent property of organisations established with holonic architecture:

For social tensegrity to exist in organisations a division of control is required to establish a basis for competition and cooperation

between control centres and competition and cooperation for obtaining tenure as a member of a control centre. Likewise, a compound board is required to provide a basis for a watchdog board to be suspicious about the self-interest of managers and to confirm their trust in them to be selfless stewards. A compound board provides a forum for customers to check up on any suspicions on the integrity of the goods and services of suppliers and provides a basis for establishing trust to overcome the problems...

Construction of "semantic shelters" or "memetic vehicles"?

On the larger scale a "semantic dome" (or perhaps a "memetic dome") may be envisaged in a manner analogous to that of Buckminster Fuller's ambitions for protective physical domes for cities and regions. Such semantic shelters ("memetic shelters") may be seen in the pressure to adapt "star wars" information systems (sustaining "nuclear shields" or "umbrellas") to include protection from semantic content associated with information and memetic warfare (*Missiles, Missives, Missions and Memetic Warfare: Navigation of strategic interfaces in multidimensional knowledge space*, 2001).

Of much greater interest is the development of semantic shelters for (virtual) communities, neighbourhoods, households or individuals (cf *Dynamically Gated Conceptual Communities: emergent patterns of isolation within knowledge society*, 2004), notably as illustrated by emergence of "renaissance zones" during the forseen periods of social breakdown (cf *Renaissance Zones: experimenting with the intentional significance of the Damanhur community*, 2003). The development of "memetic vehicles" as a further possibility may depend on a generalization of understanding of the function of a "wheel" -- integrating the flows characteristic of "spherical accounting" for project management -- to provide a form of "traction" through semantic space (cf *Metaphors as Transdisciplinary Vehicles of the Future*, 1991).

Conclusion

In struggling to comprehend what the future may consider as self-evident as the wheel, it is particularly interesting to recognize the variety of different insights into the challenge (cf Darrell Mann and Simon Dewulf. *Evolving The World's Systematic Creativity Methods*, 2001). These are often mutually "hostile" and heavily patented (cf *Future Coping Strategies: Beyond the constraints of proprietary metaphors*, 1992). More interesting however is the possibility that they each represent a valid perspective lacking a common framework of requisite complexity to integrate them -- or that they are each slightly "out of focus" with respect to a more generic understanding for which current language is inadequate.

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