Ship CAD Systems - Past, Present and Possible Future

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Abstract

The evolution of computer technology employed in ship design and building will be traced from pre-graphic to current database-centric data management systems. Four of the currently most employed ship modelling techniques will be presented, and their contribution to design spiral, production, and PLM phases documented. Nature and role of the ship model will be discussed, and the current understanding of its nature analyzed in historical perspective. Contribution to the ship model by each method will be reviewed, and a comparison made with certain technologies, methods and processes in other industries. Possible evolutions using existing software, technology, and modelling methods will be considered, and a near-future vision thereof presented. Finally, one possible vision of the future will be presented.

1. Introduction

Visualization has been used by pretty much all life forms since the very early existence of life. Consider for example the colours of leaves, the flying patterns of insects, smiling, and so on. For early humans, visualization served even more purposes: general communication (ex. the ancient hunter who did not count may have drawn a picture to show all the deer in the herd he had spotted earlier), concretisation of symbols (ex. representation of feelings, spiritual entities), communication of intentions (ex. the bone caver represents what the bone bracelet he is working on will look like, or a hunting plan).

Over the centuries, visualisation became an increasingly structuring agent in the life of human kind, coming to influence, if not dictate, behaviour. For example, consider aesthetics and fashion.

On the more technical side, but only just, visualization techniques have been extended over time to represent conceptual information buried in large data sets, the goal being to communicate it in a generally understandable fashion. Communicating information in a way easily understandable by the receiver is therefore a driving factor in the formatting thereof, which in turn still requires consideration of social, cultural and technical additional factors. Consider for example, the fundamentally different hierarchical structures of groups around the world (ex. companies) and how this affects information management and flow, the resistance against change in methods, and the inability to implement certain techniques if appropriate tooling is not available or mastered.

Drawings are one of many means used to communicate several types of information: shapes, quantities, sizes, procedures, methods, logical data, planning, implementation, desire, intention, etc.

Coming to the world of ships, only drawing of the finished product remain from the early days of ship design and building, which is not to say that plans, however rudimentary, were not actually drawn.

The transition from the raft to the dugout canoe may indicate an intuitive understanding of Archimedes's principle, but there seem to be no records, graphical or otherwise, of this process. So, we can only assume that this knowledge was passed on orally, or by example, which likely constituted quite a communication feat in the days of probably limited technical vocabulary.

Water craft drawings probably started in the early Naval Architects' mind, when he walked the forest to find braches naturally shaped like the hull he intended to build. Later, and this is probably another technological turning point, wood was actually bent to fit a given shape. This is possibly when the explicit documenting of craft building techniques started, hence the formal creative process we call "design", a notable later example being the "Encyclopédie de Diderot et d'Alembert".

Fig.1: Petroglyph of, possibly, a canoe with crew and paddles or oars, ca. 8000 BC.
source: US Forest Service, Tongass National Forest, Alaska

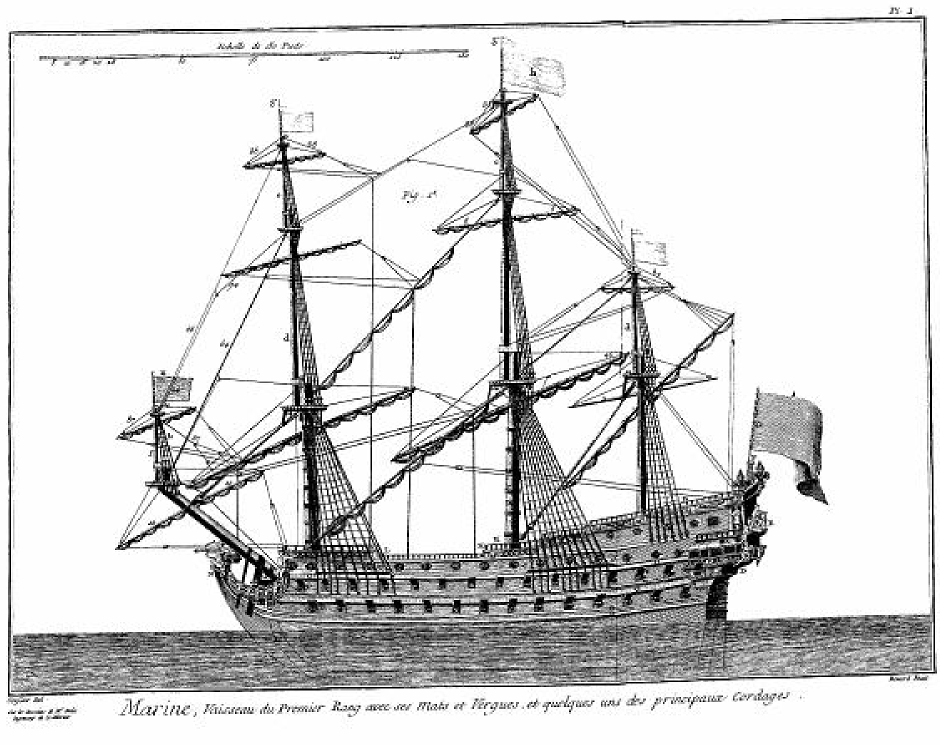

Fig.2: *Planche de Marine*, one of several figures illustrating and detailing a ship's construction from the *Encyclopédie de Diderot et D'Alembert*, 1765, http://diderot.alembert.free.fr/

Drawings had become common place by the Middle Ages, be it to sketch paintings or statues, or to show the paying ruler what his building would look like, or simply to carry out an estimate of cost or required space. In the ship world, while drawings seem to have established themselves as a standard document a little later, they have since remained what is possibly still today the one universal way to communicate pretty much all types of information. Then, at some point in the 1960s, computers technology gained recognition, and started replacing the tools used to draw and calculate, but not the drawings themselves.

The task of combining computers and the fundamental need of a generic human useable graphical representation of information, be it a technical drawing, a photorealistic rendering, text or a bar graph, is, in the author's opinion, an ill understood requirement, and has become one significant obstacle in the effective exploitation of existing technology in communicating information.

2. A brief history of the use of computers in ship design and ship building

This paper is not intended to exhaustively document or catalogue the enormous amount of technological development and ensuing software and hardware products produced over the past decades in the fields of computer aided ship design and ship building, but rather to present a significant glimpse thereof, and thereby provide enough background for the reader to put the conclusion in context.

Despite the existence of television since the mid-1920s, early computers were in general exclusively dedicated to computation, kept well out of the way, and offered no easily available graphical interface or display until the late 1970s. Some may recall the blind punch cards on the DEC-10 terminals, the ca. 1978 IBM advertising "we take the computer out of the back room", and the ca. 1980 arrival of the awe inspiring Textronics green on black, very high resolution display.

Fig.3: Textronics green-on-green 4000 dpi monitor

The lack of a graphical user interface for the computer, of video graphics and of computer generated pictures probably dictated the birth of CAD as a logical modelling tool. Software development work in the field of CAD took place concurrently in several countries around the world, and some of those programs continue to be developed and remain commercially available today.

As a measure of the speed of development in the field of computers, by 1983 touch screens were used to create and edit distributed systems models, and in some countries desktop computers had become almost common place. This is the time when a first fork in the road appeared: one way went the comparatively very much lower cost desktop computer with its small screen and fast growing peripheral accessory list, the other went the far more powerful mainframe (soon to become the still quite large mini computer) and its significantly fewer peripherals. Concurrently, and particularly in the desktop computer world, easy-to-use modem-accessed data banks, early (internet) search engines, spreadsheets, and actual drawing programs became generally available. Crash proof laptops with solid state memory, integrated modem and network capability were only a few months behind. Shoebox size Ink-Jet colour printers appeared in 1987.

Fig.4: The HP110 second generation portable computer set includes ink-jet printer and portable disc drives for a total weight of under 4 kg and several hours battery autonomy,
Source: University of Waterloo, California

By the late 1980s, the choice of how to use the now common place graphical environment created a second fork in the road: one way went the CAD-based modelling systems, the other went those using graphics as the display of logical modelling systems.

Another significant factor driving the development of certain programs was the poor quality and limited size of printed output, which was hard to use with, for example, optical cutting machines. While computer generated drawings could be of lesser graphical quality than hand-made ones without significantly impacting the industry, cutting machines required far better. Hand tracing and cutting, as well as hand-drawn sheets destined to optical cutting machines were replaced by transferring the cutting instructions directly from the computer to the machine, hence the birth of "NC", or numerically controlled, machines. In this case, the drawing was eliminated from the process, probably the only such instance.

3. The four most used methods for creating ship data models

Today, four methods seem to be the most used in creating ship data models: plain drafting, logical modelling, CAD-supported logical modelling, and logic-supported graphical modelling. Some continue to exist since the early days; others have been born of advanced in technology, graphical display technology in particular.

Due to the widespread and heterogeneous use of the terms, before discussing the methods in themselves it may be appropriate to define what the words data model, CAD, logical, etc. stand for in this paper:

- Data model: a collection of data and information defining, describing or otherwise referring to one object, or collection of objects, such as a ship.

- CAD, or Computer Aided Design: software, methods and technology in general providing functions and tools used in the creation or generation of graphically representable, original data model components. CAD modelling is carried out using an interactive CAD environment, such as drawing programs, graphical libraries, etc.

- Logical: definitions or entities related to object, generally non-graphical, such as attributes, properties, relations, associations, etc. Logical modelling is carried out using macros, scripts and other generally non-graphical methods.

3.1. Plain drafting

Plain drafting is just that. This method consists of drawings, essentially in pure 2D, representing and depicting all that can be with such means. The only and completely manual method existing before the inception of computers, today generally implemented via drawing programs. While data and information are rather limited in scope, drawings are in general very portable as CAD files can be shared among different software programs more often than not.

3.2. Logical modelling

Logical modelling involves describing data and information, e.g. objects, their properties and attributes, using text organized in scripts, macros, tables, syntactically coded files, etc. This was the only computer based methods existing before video displays became common. As an example, consider the definition of a line by a name and its end point absolute coordinates, such as :

Line "*name of line*" x_1,y_1,z_1 x_2,y_2,z_2

Which for a line called "edge of beam" and going from 0,0,0 to 1,1,1, would read

Line "edge of beam" 0,0,0 1,1,1

It can easily be seen how a variant of the command would allow the bounding of an object by another object, etc. Logical modelling requires an intimate knowledge of the overall model and sharing of a lot of information with other working on the same model to avoid duplications, misrepresentations and other errors. Logical models tend to be virtually impossible to share among different, but otherwise identical in scope, programs.

3.3. CAD supported logical modelling

In this case, the modelling takes place in a CAD environment, for example drawing, solid modelling, etc. The software program sources data and information directly from the CAD interface and / or model itself, the best programs working interactively and transparently, and integrate the harvested information it with other non-graphical information and data entered otherwise or elsewhere.

Software programs implementing this method may use a database for storage of data and information, and/or use the CAD files themselves for storage. While a database may be somewhat less immediately portable than a CAD file, it is a far more robust and reliable storage means. Moreover, a database can be easily interfaced if not integrated with other data management systems, while CAD files hardly lend themselves to such practices.

3.4. Logic supported graphical modelling

This method involves the use of logical programming, partly or wholly, and a more or less comprehensive display of the defined entities is provided. Modern logic supported graphical modelling sometimes allows the direct use of graphical entities, of course only once they have been defined logically. This way, the software helps somewhat in the writing of macros and scripts.

4. Contribution of the methods to the design spiral, building and PLM work phases,

Of course all methods contribute to every phase of a ship's life but, perhaps surprisingly, the use of computers does not per se translate into a greater contribution.

4.1. Contribution to the design spiral

In this phase, an important contribution is made by the immediate availability of data and information. In this respect, plain drafting and CAD based modellers tend to surpass other, more logical oriented methods for a good portion of the phase. Moreover, in addition to the availability of drawings by definition, drafting and CAD based methods also generally support immediate conversion of drawings, data and information to neutral formats, for broad and easy sharing.

While perhaps more flexible in case of changes at an advanced stage of the design phase, the more logical modelling oriented methods often require a significant amount of setting up and definition work before their models can be so exploited and drawings, data and information can be produced. Drawings area also often produced in very rigid formats, which severely restricts further processing and exploitation thereof.

Some CAD based systems build a relational/associative model via the CAD interface itself, possibly providing the best of all worlds during this phase.

Many advantages offered by certain methods are similar to those pertaining to the production phase, and will be discussed there, a more traditional ground for the exercise.

4.2 Contribution to the production phase

The production phase, often simplistically identified with detailed engineering, culminates with the modelling of each and every component of the ship that will be manufactured from stock, such as plate and pipe parts, or which requires a construction drawing for its fabrication, for example a railing or a ladder, or which is to be sourced as a finished product, such as equipment and machinery.

The methods' features which most contribute to this phase include: propagation of repetitive and relational information, thereby logically linking similar and associated objects, ease of sharing data and information of all types with other programs, ease of integration of data and information coming from external, heterogeneous sources, ease of model creation and drawing production, ease of data and information management, ease of cooperative work, ease of data and information extraction and reporting, etc.

Plain drafting will contribute the least to this phase, as it will require the largest amount of manual, error-prone and repetitive work, while providing neither data nor information management facilities, nor allowing any derivation of data and information whatsoever.

Interfacing or better still integrating CAD systems with other relevant data and information management system, such as ERP, project management, etc., is a also a major, although yet underexploited, advantage offered by some systems. An open architecture, API endowed database is fundamental in this respect.

Another important requirement in this phase is the ability to track the ship's construction, integrate production feed back, data and information into the model's environment, and analyse it for a dynamic critical path review. Again, doable with an open, extensible or interfaceable database.

4.3. Contribution to the PLM phase

This is possibly the phase in the ship's life where most systems do not contribute as much as one would expect or hope. This is due to various factors, such as the inability to provide the model, related data and information in common place or even open file formats, to the modelling software not being portable or requiring significant training to be used, etc.

Possibly yet more than in the production phase, PLM will benefit from the integral ship model, combining CAD, logical and non-CAD information being available via an open architecture, commercial database, which will allow integration with other data and information management systems.

5. File formats, data structure, databases

In great part due to historical reasons, even some present day software development strategic choices remain heavily influenced by past necessities. The risk, or choice, is to remain isolated in a data communication and management sense.

File formats, arbitrary object definitions and hence the inability to share models among ship modelling programs are, still today, a quasi-insurmountable obstacle in the exploitation of the ship model by the end user, the ship owner or manager.

The pure drafting method does not even produce a model to speak of, and its final product, drawings, simply provides reference documentation, with the additional caveat that more often than not drawing sets are not kept up to date during ship construction and later ship modifications.

In the case of ship modelling systems, object definition and file format are historically intimately related, and in many cases the early development environment has remained fundamentally unchanged over years of software development. Save for one or two more recently born software programs, ship modelling systems were developed at a time when CAD and video were either simply not commonly available or felt to be inadequate for the task, hence the perhaps forced choice of logical modelling already discussed. Moreover, until very recently, ship modelling applications were intended to serve the requirements of production only, with limited attention, if any, to design and PLM.

Great importance was placed on modelling and NC producing of structure, and lesser efforts dedicated to software for the modelling and production of distributed systems, which were instead handled by software developed for the process and energy industries. Such industrial programs were often used in the ship industry, but not integrated with the structure modelling system. Distributed systems modelling also suffered, and continue to suffer, from the poor cousin's syndrome, and seem to be unavoidably reserved the back seat when allocating resources, or scheduling, let alone take priority over structure.

The inexistence of "standards" and the rather different cultural and technological environments in which software was developed led to programs performing the same tasks in a variety of, remarkably incompatible, ways. As the goal of ship modelling was reached with completion of the ship, the possibility of model sharing or re-use was probably never even considered.

Over the years, modelling programs grew more capable and more powerful, and the concept of pre-outfitting was born out of the need to lower costs and increasing capacity by shorten building time. Greater sophistication of existing software often also meant reduced flexibility in system adaptation, forcing the bridging of the gap between ship structural modelling and non-ship distributed systems modelling applications. This was achieved mostly by creating dedicated data exchange formats serving only two programs.

Moreover, many programs were being sold commercially, and development continued along existing lines, increasing software isolation and losing any chance there may have been of catering to some sort of object definition standards.

Software using a database to store geometry, topology and other data, as opposed to files, could provide the environment in which to potentially create a model complete in all its components, or least complete to the extents allowed by the available modelling capabilities.

The importance and ensuing benefits of sharing models was recently recognised, and attempts were made to create modern neutral file standards, such as STEP, an exercise which, still today, after several years of work, has not yet produced an industry-wide practical outcome.

Today, model sharing is limited to some programs exporting and/or importing solid or similarly fashioned geometry, using CAD standards such as ACIS or Parasolids. However, no data or information is shared in this way. At least one program goes a few steps farther, by acquiring native geometry and, if exposed, corresponding logical information.

The intention to create the all-encompassing model was the birth of the much abused "product model" punch line, and a true result has yet to materialize.

6. The model

The "model", or to evoke the far more fashionable definition "product model", has been referred to a lot so far in this paper, but different readers will have attributed quite different meanings to this label. One general definition could go something like "a CAD model which includes all the parts making up the ship". However, "CAD" and "all" remain very generic ways of defining anything, let alone something as complex as a ship. A recent, even richer sounding, evolution of this definition is "building information model".

6.1. CAD data

"CAD" could be anything from a simplified sketch to a fully detailed, realistic, 3D model and "all" generally refers to those portions of the ship which the software being considered can model, in whichever way it can. "Information" is also a purpose-suited word, often used to convey the impression that there is more than one will really find, particularly in that the generally limited data set available tends to pertain solely to a sub-set of the "CAD" portion of the model. So, in order to avoid the debatable accuracy of many claims made in the commercial world; the less-specific but potentially more encompassing definition "ship model" was and will continue being used here.

Moreover, commercial promotion of software products and ground-breaking research tends to highlight the contents per-se of the model, be they CAD or logical, and largely omit any consideration of the availability, usability and specific usefulness of such contents aside from the generation of only a part of the finished ship.

6.2. Non-CAD data

Stopping short of proposing to integrate the model with all the even remotely related available data in existence during the design, building and PLM phases, there still is a remarkable amount of non-CAD information which could, and should, be combined with the CAD model, within the model itself or to produce a non-CAD, integrated data set.

ERP is the most evoked such data set, but a lot more is already available and commonly in use, albeit separately from the ship model, such as production feed back, production analysis, critical path forecasting and analysis, cost estimation and analysis, contingency planning, etc. It is only too evident that a lot of this data is very directly related to the design, production and PLM phases, but it is not directly attributable to the contents of the CAD model. On the other hand, non-geometrical relations can easily be established and exploited between CAD and non-CAD objects, data and information.

6.3. The ship model

Combining the ship's CAD model with, still related, non-CAD data would yield what is probably the closest to the ship model. And, in turn, the ship model could be the live, integral part of a more far ranging model. Imagine for example a database of up-to-date ship loading and unloading capabilities, current machinery breakdowns, etc., being used to schedule port activities.

So, let us now use the definition "ship model" to represent a collection of ship-related data including CAD, CAD-related logical, and non-CAD-related data, without restrictions.

7. Relevance and role of ship model components

Throughout the discussion so far, the components of the ship model have been loosely collected into three very broad categories: CAD, logical and non-CAD. This seems to work well, and lends itself as an effective data set classing approach identifying three categories. We could then assign attributes to each category, such as "time critical", "static", "dependent", "independent", and so on.

7.1. CAD components

CAD components can be attributed all the attributes listed above, for example:

- time critical : a drawing, or a computer model used to derive a drawing, must be completed before a certain date in order not to hold up the classification process or even the building of the ship.
- static : once issued, a drawing is considered to be static, one needs not further verify its contents.
- dependent : the contents of a drawing or the objects making up a model are related and will influence / depend on to one another.
- independent : certain CAD quantities, such as the length of the ship, are and will remain independent of other data. For example the breadth of a Suez-max ship will not change even if a greater load carrying capacity were required and catered to.

The role of CAD is to show, symbolically or realistically, what the product being depicted or illustrated is to look like.

7.2. Logical components

Just like CAD components, logical components can also take on all the attributes of which above:

- time critical: the power and torque curves of an engine will influence engine room design and propeller selection. The choice of the engine is therefore a time critical component.
- static: a given object can be mounted only in one way. This orientation will not be changed by anything else in the ship model.
- dependent: a weld detail will depend on the thickness and metal grade of the components being welded. Weld detail is a dependent component.
- independent: for a given ship, the wattage of the ship lights will remain unchanged irrespective of anything else.

Mostly due to the actual implementation scheme in software, the role of logical components is mainly limited to qualify CAD objects, although their role is actually far more varied and far reaching.

7.3. Non-CAD components

Non-CAD components also can take on all the attributes listed above, for example:

- time critical: knowing which surface treatment must be applied to an object must be known in good time for the provisioning of the appropriate supplies and for the timely availability of that object during construction. Supply of the required consumables and ability to apply them is time critical.
- static: suppose an object can be delivered by rail only. The railroad's traffic schedule, sometimes fixed months in advance, is a static component.
- dependent: the material grade of a plate will depend on the thickness it can take at the location where it will be placed, and on the load it will be carrying. For example consider a thin, heavily loaded plate which must therefore be of high tensile strength steel. The ability to actually mount the plate depends on the availability of welders qualified for this type of metal.
- independent: something as simple as production feed-back can, and often does, influence what goes on in the technical office and beyond, during the production phase itself. Consider the case of a fabrication gone wrong due a design mistake, and the ensuing need to re-design it, re-source or re-build its parts, and re-fabricate it.

The role of non-CAD components is to add "external" data and information to the model which will influence anyone of the ship's phases, hence the CAD components as well. Anyway, the purpose of the exercise above is not to subdivide components into intersecting groups or classes, but rather to simply show how any of the above carefully worded definitions could be plausibly changed just slightly and that component become assigned to another, completely different group or no longer qualify for that attribute.

This is to say that, possibly with a minimal umber of exceptions, every component of a ship model, regardless of its nature, is relevant and, potentially, of critical importance due to the deep, cascading interaction between all components, direct or indirect. Therefore, it seems safe to state that a ship model should include the greatest quantity of components from the categories mentioned above, and that they should be accessible to anyone needing that information, in as neutral a format or fashion as possible in order to avoid needing to use the native software application.

8. Other industries

Methods, processes, analyses, etc. are all different ways to describe tools, or means to reach a goal. Tool is a convenient, modern word, and will be used here as the generic definition of choice. Many examples can be brought forward to illustrate technologies and methods being used in other industries that would benefit the ship industry via the creation and management of the ship model, but, in the end, it is easy to condense them all by drawing an exquisite analogy, and in a very stimulating fractal fashion, with the search engine, a tool that permeates our modern world much deeper than most realize..

The very concept of the search engine, an old but ever increasingly important tool, provides the link between the opening discussion on communications, the processing of data and information during (at least) three main stages of all phases in a process, very early planning, under-way and emergency, and the varying nature of the data itself.

This ancient tool, already implemented in Babylon via clay tablets and much later with card indexes, can provide significant help far and beyond its current implementation, and this without requiring revolutionary computers or other inexistent technology.

8.1. Very early planning

During planning, use is made of uncertain or estimated data and information. Provisions are drawn and safety margins applied. The lesser the certainty about what is thought to be known, the greater the spectrum of possible outcomes is, and the greater the potential deviation from the objective goal. At this stage, the ability to identify and quantify information and its quality is crucial: estimated data can be used effectively if a measure is known of its presumed accuracy, inaccuracy, and impact. Ship weight estimation is a glaring example of this.

Drawings, low detail CAD models and macroscopic data analysis are easily identified characteristics of the planning phase. In some circles, this is known as the concept and / or feasibility phase. This is when fundamental mistakes can be made. Let us use as an example the industrial process which cannot yield the product at the forecasted cost, a surprise discovered well after production got under way.

8.2. Under-way

This is when everything is supposed to proceed smoothly, according to plan. Once a process is under way, the main activity is monitoring and checking. Once again, drawings, more detailed CAD models and data analysis at various levels of detail are used to assess progress and the quality thereof.

8.3. Emergency

Many situations qualify as emergencies, but the common denominator is generally the immediate need for all potentially relevant data and information to be available and exploitable. Much can come from the CAD model, much cannot and will not. So, once again, drawings, CAD models, non-CAD data and data analysis tools will be sought after. Qualification of the need to have data and information of all types, have access to it, and be able to exploit it effectively and in a way useful to everyone needing it will be the last factor supporting the assessment and vision to follow.

9. What can be done today

A lot of technology exists today that can be put to use in creating, maintaining and exploiting the ship model: drawing software, 3D modelling software, open architecture databases, etc. And, not least, the search engine analogy used above is easily applied in reverse, when dealing with input to the model.

Input can take many forms, and data can be of disparate nature: drawing entities, logical attributes and properties, non-CAD information, etc. Then, if input were identified, its relations to other objects in the model could be established, regardless of their respective natures. Logical modellers and some CAD modellers work this way, but input of non-CAD or not CAD- related data is often hampered, if not impossible.

So, input facilities are an integral part of the data management process. Graphical input techniques are probably by far the easiest and more intuitive channel, easily used by just about anyone, and allowing for direct, transparent input identification and management.

Now, let us consider the search engine again. The "finds" returned include both exact and approximate matches, as the search engine will purposely use inaccuracies to cater for what could be loosely defined input search criteria (the engine is programmed to operate in a stringent fashion). Nonetheless, it is easy to gather substantial amounts of relevant information from a vast, unformatted amount of source data.

On the other hand, in the case of a ship model, the environment is far more regimented than the contents of the internet. This favours cross-matching and correct connections between objects, or groups of objects. In modelling work, stringent rules must be followed when defining objects, and even more so when defining dependencies and relations. In a given planning model, representative data will use fixed formats: dates, locations, etc. The list of examples of what is achieved already thanks to formal formatting is long: bar codes, report table formats, time sheets, ISO procedures, etc.

So, these being known quantities, the following would constitute a constructive step in assembling data from different sources and exploiting it in innumerable ways:

- having the data
- the data being available and accessible
- the data being readable and interpretable
- having information about data interconnection (this data pertains to that object but only on the day of the week defined in table so and so, . . .).

All the above exist today, but rarely as a useable, complete set. No sustainable reasons exist today to justify the persistence of such a restriction. Of course, as seen above, another factor is that in many cases similar (or even identical) objects will be defined in very different ways, thereby making the connection close to impossible. This places an objective constraint on data sharing and exploitation, but one that can be circumvented and that need not persist either.

Search engines have been used every day since the existence of computers, for example to find a file containing a certain word. Today, there exist sophisticated query tools, file searchers, automated data assembly tools, etc. that can be employed, if the source data is available and can be searched thanks to documented formatting. So, a more effective exploitation of existing data and information, of varying nature, purpose and scope, is technically possible today, and would be more common place if source data were richer, more easily available and easier to access.

10. Conclusion

If the present paper were to be condensed in a couple of statements, these could be:

- while not a means for systematic or automated data and information management, drawings remain a fundamental corner stone in making information available to the real-world, wider ship audience, at all times, information without which not much would happen.
- non-CAD data is a dangerously overlooked, vital component of the ship model that can and should be used throughout the various phases of a ship's life. Combining and connecting this data with the CAD model provides a quasi-universal means of making it known, understood and exploitable.

Achieving the common goal of these two statements, e.g. making relevant information available in a way that is meaningful to the recipient, at all times starting from the earliest stage of concept design and until the latest stage of dismantling, requires software which easily allows:

- input of appropriate and relevant data and information, be it graphical, logical or non-CAD, via standard, non-proprietary interfaces and/or data tools.
- exploitation and generation of model-associated drawings, which must remain available for further formatting using standard, non-proprietary CAD tools.
- extraction of CAD related logical data for analysis, reporting, etc., also combined with non-CAD data, via standard, non-proprietary data management tools.

The software and hardware needed to accomplish the above exist today, off the shelf, and some ship CAD systems already provide the facilities, if not the tools, identified in this paper as being one avenue towards industry-wide exploitation of the existing, rich, ship data set.