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Emerald Article: Gantt charts revisited: A critical analysis of its roots and implications to the management of projects today

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SPECIAL ISSUE SECTION
Gantt charts revisited
A critical analysis of its roots and implications to the management of projects today

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Abstract

Purpose – The purpose of this paper is to explore a classic tool in project management, which for some has become almost synonymous with project management: the Gantt chart. The Gantt chart was developed in the early twentieth century, at the heart of Scientific Management; yet, the chart is used with very little adaptation across a wide range of types of projects. In this conceptual paper, the authors question its universal and unreflective use.

Design/methodology/approach – The authors analyse the conceptual roots of the Gantt chart, its historical development and use, derive its engrained principles, and analyse its implications to the management of projects.

Findings – While a Gantt chart can be useful to cope with some of the "complicatedness" of projects, and embraces the importance of time and timing, it is based on principles that are not valid to all projects. The consequence is a propagation of a management approach that does not explicitly cope with complexity, ambiguity, uncertainty and change. In that respect, the Gantt chart fails to acknowledge insights from years of organization theory research and project management research with a firm grounding in contingency theory.

Originality/value – While the majority of contemporary project management thinking already accepted that a normative use can be inappropriate, the practice is still pretty much embracing this approach. By showing the conceptual roots of the Gantt chart, the authors hope to make some of its limitations more evident to practitioners and academics, and encourage its use to be more reflective and contextualised.

Keywords Project management, Performance criteria, Uncertainty management, Visualisation, Scientific management, Gantt chart, Project success, Rethinking project management

Paper type Research paper

1. Introduction

This article explores the conceptual roots of a classic tool of project management, the "Gantt chart". The Gantt chart is one of the most used planning and controlling tools in projects today. In a survey with 750 project managers, the Gantt chart was the fourth most used tools out of 70 tools and techniques associated with project management (Besner and Hobbs, 2008). Indeed, we can hardly imagine project management practice or training without it. As project management scholars and practitioners we are all familiar with the Gantt chart, and many have used it to plan and control a project or personal complex tasks. Thus, the Gantt chart is part of the common language amongst the members of project management community.

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Considering that management discipline is replete of fashions and fads (Abrahamson and Fairchild, 1999), the Gantt chart is remarkably resilient; it was developed nearly a 100 years ago (Wilson, 2003), and survives until today despite numerous innovations in the area. In the 1950s, more sophisticated scheduling techniques were introduced (Morris, 1994), such as Program Evaluation and Review Technique (PERT) and critical path method (CPM) methods. Unlike the Gantt chart, these tools enabled the analysis of more complex relationships between the tasks, the needed resources and the uncertainty of each task's duration. With such precision, the critical path could be better calculated and understood. Still, these tools did not supersede the Gantt chart, nor did they substitute its use. Actually, the use of Gantt chart increased at the time (Wilson, 2003); the tools were used in combination, and the outcome was visualised through the Gantt chart. Later, earned value was introduced, and provided a more holistic understanding of project progress by linking cost, time and progress into one tool. In the 1990s, the concept of critical chain was introduced (Goldratt, 1997), which highlighted the influence of behaviour aspects into projects. Still, the Gantt chart remained an important tool both in planning and controlling project schedules; so much so that popular project management software, such as MS Project and Primavera, uses the Gantt chart as the central platform to plan and manage projects integrating all other functions of the software.

All of above suggests that Gantt chart can be and actually is used universally, i.e. in many contexts – across the spectrum from continuous production (low variety, high volume) to projects (high variety, low volume) (Slack *et al.*, 2010). Taken that the literature in project management has already established that project management approaches need to be tailored to its context, i.e. "one size does not fit all" (Shenhar and Dvir, 1996), the question could be raised if the Gantt chart is an exception. Is it indeed a universal tool to every project? Does it "fit" all?

In this conceptual article, we question a universal and unreflective use of Gantt charts. We content that such impression of universal applicability could be challenged through a critical engagement with the roots of the Gantt charts and how they colour its current use. This has not yet been done in the literature. We purport to fill this gap. We analyse the conceptual roots behind the Gantt chart and elucidate its principles. We then analyse the consequences of these principles to the management of project, and propose a more critical and reflected use of Gantt charts.

The article is divided into four parts. The paper begins by exploring the historical development of the Gantt chart and how it has been intended to be used at the time. In the second part of the article, we derive principles underlining the concept of Gantt charts from its historical roots. The third part explores the implications of these principles to how projects are conceptualised and consequently managed. In the last part of the article, we address the "so what" and "what now" for the practitioner, linking the conceptual discussion to practice of using Gantt charts contextually and reflectively.

2. Gantt chart: origin and development

As we started the work in this article, we had hoped that the reason for conflicts between Henry Lawrence Gantt and Frederick Winslow Taylor (Wren, 1976/1987) was Gantt's exposure and interest in projects (unique, uncertain, temporary endeavours), in opposition to repetitive operations as was Taylor's main concern. We had hoped to find in the original work of Gantt some hints as to the uncertainty of projects, some tips or

wisdom on the use and limitations of Gantt chart that have been lost in the development of knowledge over the years.

What we found though was that Gantt developed his methods for repetitive routine operations. Gantt was a prolific writer and had an impressive intellectual productivity, he has published over 150 titles and three major books: "Works, Wages and Profits", "Industrial Leadership" and "Organizing for Work". He also patented over 12 inventions, has made numerous presentations in the American Society of Mechanical Engineers and lectures at Stevens, Columbia, Harvard and Yale. So it could well be that among this large body of work, he had mentioned other contexts apart from repetitive operations; we do know that he has studied project-like activities too such as the production of ships. However, we can assert that repetitive operations were his key concern in all three books. He was, as much as Taylor, concerned with the efficient and effective use of resources and increase of productivity in repetitive, routine operations through rational, Scientific Management of work.

The first Gantt chart-like visual representation was used to "fix the habits of the industry". Gantt developed visualisation tools that allowed foremen and workmen to check the current productivity level of each employee and observe which employees have under- or over-performed. The idea was to monitor and reduce idle time, and increase personal accountability for levels of productivity. The productivity of each employee was recorded across time in a tabulated system, where red meant lost of bonus and black gain of it. It acted as a motivation and control mechanism, where both managers and workers could quickly visualise their achievements.

Gantt also used graphics extensively to monitor the utilisation of resources, e.g. control costs, daily production balance, quantity of work per machine, expense of idle machinery among others (Wren, 1976/1987, p. 136). This adaptation of the first version of the Gantt chart was used to monitor the production progress with permanent record of how the order was fulfilled. Here, the chart contains start and end dates[1].

Until then, the charts were mainly focused on the past (monitoring what had happened) instead of planning for the future. It was when Gantt faced the production network for war supplies in the 1914 in the USA that the Gantt chart as it is known today was developed. The production network lacked appropriate coordination mechanisms. "Plants were scattered all over the nation, shipments were late, warehouses crowded or disorganized, and the Ordnance Department and the Navy used their resources poorly" (Wren, 1976/1987, p. 136). The systems were also overwhelmed as orders increased from hundreds to millions (Clark *et al.*, 1922, p. iii). Gantt realised that it has been wrong to manage schedule based on quantities; the essential element is time (Alford, 1934).

His solution[2] was a second version of the Gantt chart, which is very similar to what we know today as the Gantt chart[3]. The focus of this second version of the chart was not only in the present, but also in the comparison between plan and actual. It also provided a visualisation of the issues hampering higher efficiency, shown by the letters –, e.g. W, waiting for set up, M, lack of material, H, lack of help, as Clark *et al.* (1922, p. 84) explains:

> The Gantt progress chart enables the manager to keep before him all the promises he has made, to concentrate his attention on overcoming obstacles and avoiding delays, and, when it is impossible to live up to a promise, it enables him to give the customer advance notice of the fact.

Thus, the second version of Gantt charts was not limited to coordination of the production, but also helped to recognise patterns of failures instigating double loop learning, e.g. if "M" dominates all issues and reasons for delay, managers can look more in depth at what is happening with material deliveries, and how to improve it.

Although it was originally established as a general production planning tool for repetitive operations by the mid-1920s, Gantt charts have been applied to a variety of contexts including project management. The earliest illustration of a project based Gantt chart was found in Koepke's (1941, p. 391) work. Yet very similar to the second version of the Gantt chart used by Gantt to coordinate the production network. It was in Muther's (1944) work that the Gantt chart as we know today appeared for the first time and was called schedule charts. It is important to note though that the only significant difference between the second version of the Gantt chart and our current version is that the first also records the reasons for deviation.

The application of Gantt charts in project management was greatly increased with the development of modern project management. The advent of the CPM and PERT in the mid-1960s contributed to the wide expansion of interest in Gantt charts in project management (Weaver, 2007; Wilson, 2003). The use of Gantt charts as a complementary tool for project planning and management then became more prominent. Later, the subsequent development of micro computing and its stimulation of personal computer based project management packages have revived Gantt charts (Wilson, 2003).

Today, the Gantt chart is seen as a simple, intuitive, practical and useful tool to connect project activities and durations. Further, the Gantt chart is instrumental to enhance our cognitive ability to cope with structural complexity – coordination of a large number, diverse and interdependent tasks (Geraldi *et al.*, 2011). According to Wilson's (2003) review of the early use of Gantt charts, Moore (1951) and MacNeice (1951, p. 57) are amongst the first researchers to directly comment on the usefulness of Gantt charts for managing projects. MacNeice's (1951) experiment provides a good indication of how powerful Gantt chart can be; 300 management students were faced with complex production planning task, when asked to resolve it intuitively only 1 per cent could solve the problem, when given Gantt chart, all students developed a solution in 15 minutes. The chart is also a useful tool to communicate the project schedule and create a shared understanding of the progress (and lack of progress) of tasks. This aids the management of projects. For example, project managers can use the Gantt chart to point to potential schedule delays and focus the project team's attention on the critical tasks to the delivery of project in time.

In summary, our excurse into the historical development of the Gantt chart allows us to draw two main conclusions. First, the Gantt chart was originally developed at the heart of Scientific Management movement. Its first version was used to monitor past performance of worker and use of resources. Its later version aimed at the coordination of the work of a network of production facilities, focused not only in their past performance but also planning the delivery of future orders. Both versions embedded the Scientific Management ethos – the wish to increase efficiency through rational analysis of work, where the duration of each task was clearly defined and scientifically validated and deviations were seen as errors, that should be corrected and avoided. The reasons for deviations were tracked and studied to improve the system, to avoid variations in the future.

Second, the Gantt chart was developed for repetitive operations. Its use in a project context was first recorded in the 1940s, almost 20 years after the creation of the tool. Interestingly, the chart was applied to project contexts (with higher variety and lower volume) with very little adaptation from its original use in repetitive operations. It became popular in the 1950s with the emergence of project management as we know today. Gantt chart has been universally used across all types of projects since.

Thus, Gantt chart has its roots clearly engrained in the Scientific Management practices, and yet used with very little adaptation to projects across all types of projects. What are the conceptual implications of the use of a Scientific Management tool to projects? In order to investigate this we first extracted principles intrinsic to how the Gantt charts function, i.e. its logic (Section 3) from its conceptual roots; and then explored the conceptual implications of these principles to projects and its management (Section 4).

3. Principles of use ingrained in the Gantt charts

We derived six basic principles of the use of Gantt charts from the historical account of how and why the tool was used in the beginning of the twentieth century, when Scientific Management was the predominant management paradigm. Table I summarises the result of this analysis.

The next paragraphs describe each of the principles, namely: time-focused, objective, deterministic, analytic, accountable and sequential, and elucidate its intrinsic relationship with its historical use in the context marked by a predominant Scientific Management paradigm:

- *Time-focused.* The complexity of the operations increased with the war, and the work needed to be coordinated across a network of production facilities spread all over the USA. Gantt charts enabled coordination through time and deadlines played a crucial role to meet the volume and speed necessary (Wren, 1976/1987).

	Time-focused	Objective	Deterministic	Analytic	Accountable	Sequential
Principles in the context of the Scientific Management	Maximise work that can be done in a given period of time	Systematically define what is the right task performance and the fair day's work	Orders were executed as planned, deviations were seen as errors	Work was broken into tasks, detailed a priori to increase efficiency	Clear accountability and control over the execution of the task	Sequential manufacturing process
Generalised definition	Focus on one dimension over others	There is one truth, one right way, and that can be determined	It is possible to determine everything that will happen	Break a task into pieces. The whole is the sum of the parts	Clear definition of who is responsible for something or some action	Characterised by regular sequence

Table I.
Linking Gantt chart principles with Scientific Management principles

The Gantt chart defines, quantifies and manages interfaces in terms of time and sequence, not content. Actually the control of efficiency through time and timing was the great "insight" in the Gantt chart.

- *Objective*. Objectivity was the ethos of the Scientific Management. Taylor (1911, p. 3) and his proponents wished to reduce the systematic soldiering, i.e. "deliberately working slowly so as to avoid doing a full day's work" by developing a "true science of work" and systematically defining what would be the fair day's work rewarded with a fair pay – Taylor's first principle. Frank and Lillian Gilbreth increased the precision of Taylor's work and introduced the time and motion studies: the work is analysed in detail, so to establish precisely the best way to do the task and the exact time needed to do so[4]. The Gantt chart was used to visualise these tasks, and thus, promoted (and promotes) an objective understanding of reality, i.e. the object (in our case, the project and its tasks) exists independent from the person or mind (IEP, 2011). There is one truth, one right way, and that can be determined.
- *Deterministic*. Gantt charts are based on determinism. It is expected that the world is predictable and we can predict it. Determinism is implied in the first two principles of Scientific Management proposed by Taylor, namely the development of the science of work and the scientific selection and development of the worker. It is assumed that the process to perform a task can be standardized and that people could be trained to perform these tasks. This implies that tasks could be fully pre-defined, described and studied in detail. The first two principles also evoke Taylor's notion of "one best way" of performing a task by separating planning from executing. Perfectionist planning should eliminate any need adaptations, and ensure the optimal execution of the task.
- *Analytic*. In the beginning of last century, industrialists were learning to tame down the production and separate it into parts, so the analytic principle was fundamental in the process of industrialisation. They were also dealing with a cultural revolution with urbanisation and the dramatic change in the nature of work (repetitive, closely supervised and inside factories). Levels of staff turn around were immense, Taylor (1911) also observed a systematic soldiering, i.e. employees "deliberately working slowly so as to avoid doing a full day's work", and there was also a strong social pressure against rate buster (those who would increase productivity). Increasing manager's understanding of the tasks, and durations of the task through its analysis, and establishing clear accountability also were believed to help to cope with this behaviour issues at the time. Gantt chart is based on analysis, i.e. our ability to divide into parts, breaking a complex topic, task, problem into pieces, to gain a better understanding of it.
- *Accountable*. As mentioned in last section, enforcing accountability was actually one of the motivations to use Gantt charts to "fix the habits of the industry" (Clark *et al.*, 1922; Gantt, 1916). Gantt chart enables a clear accountability for each task.
- *Sequential*. The Scientific Management defines, based on the task analysis, a sequential task execution process. And so Gantt charts represent tasks in a specific sequence, in which each task is truly completed, frozen, and one can move to a next task.

4. Implications of the use of Gantt chart principles in managing projects

Our analysis demonstrates that Gantt charts and their underlying principles are intertwined with the basic ideas of Scientific Management. Thus, the application and use of Gantt charts to implement specific tasks has to follow these principles in order to effectively support management in making resource allocation decisions. Thus, these principles shape and so have a significant impact in how projects, project management, project managers and task performance are conceptualised. In this section we discuss the implications of the use of Gantt charts to our conceptualisation and practice of projects and its management. Table II provides a summary of the implications.

4.1 Principle: time-focus

Projects are time bound. The power of time and timing to coordinate work has been identified in project management; meeting schedule deadlines is the heart beat of projects (Lindkvist and Soderlund, 1998), and represents something shared across parties involved in projects and therefore has the potential to integrate them

	Time-focus	Objective	Deterministic	Analytic	Accountable	Sequential
Project	Project is a process with clear start and finish	Project exists and can be defined independent from people enacting it	Project is about turning the plan into reality	Project is the sum of the tasks to be executed	Governance structure could be clearly ascribed	–
Project management	Managing through deadlines to meet pre-defined delivery date	Follow the Gantt chart. Estimates are defined rationally, and progress reports are valid and reliable	Define the scope a priori, and process and execute it; avoid and manage the gap between plan and actual	Break down the scope, and transform it into tasks	Assign clear accountability to the different pieces of the project	Management through a waterfall project process. Projects progress linearly
Project manager's role	Make sure people deliver on time	Plan the best way to do the project and control progress against this baseline	Plan to avoid gaps between plan and actual, or at least identify and put project back on track	Ensure an optimal division of work Define roles and responsibilities, including of the PMer	Emphasise accountability over each task, and "blame" those who fail to deliver	Ensure tasks are executed in the "right" sequence, and each step is completed and freeze, so the project can move to the next
Task performance	Delivery on time	Meet the baseline [. . .]	[. . .] without surprises	Deliver every task [. . .]	[. . .] that one is accountable for	Right first time – no loops

Table II.
Implications of the Gantt chart principles for managing projects

(Dille and Söderlund, 2011). Gantt chart organise activities in time, it makes the time and timing of tasks visible. As Yakura (2002) concluded from his empirical study of Gantt chart as boundary objects, "[Gantt Chart makes] time concrete and negotiable for various groups of participants."

However, projects are not only about time, and the unreflected use of Gantt chart may promote a project management that is overly preoccupied and focused on time over other relevant aspects involved in managing a project, such as the value creation and realisation, development of relationships, exploitation of opportunities. The Gantt chart encourages a project management focused primarily in monitoring the schedule, i.e. whether tasks have been completed on time and the consequences of delays to meet its pre-defined delivery date. Project manager becomes the "keeper of the charts" and computer operator, and project management is quickly reduced to the management of schedules[5] (Maylor, 2001).

This is also problematic as time is not necessarily the key success criterion. The challenger project presents a good illustration. Time was critical; any delays could compromise the mission. However, the pressure to launch on time compromised safety (Vaughan, 1996). While in the beginning of the twentieth century, the focus on time and efficiency was understandable (although not without criticism[6]), such a context is quite unusual in today's turbulent and uncertain business context, with clients and customers expecting customised products and services and with an increasing preoccupation with sustainability and mindful use of natural resources. Moreover, the emphasis on time over other performance criteria is no longer in line with today's understanding of success criteria (Jugdev and Müller, 2005). This leads to the first implication questioning the normative use of Gantt charts: the use of Gantt charts is justified if efficiency is the critical performance indicator for a project but if other performance criteria are more important Gantt charts will not support management to fulfil those criteria. This might be also indicated by the large number of projects that do not meet time criteria and are still seen as very successful.

4.2 Principle: objective

Gantt charts promote an objective understanding of reality, i.e. the object (in our case, the project and its tasks) exists independent from the person or mind (IEP, 2011). There is one truth, one right way, and that can be determined. The normative use of Gantt chart implies that the bars in the Gantt chart represent an objective (and precise) description of what it is to be undertaken; it is assumed that duration of each task can be defined a priori, and so can the dependencies between each of the tasks. As concluded Yakura (2002, p. 968):

> The remarkable aspect of the timeline phenomenon [use of Gantt Charts] is that participants assign permanence to these constructions. In spite of their being distant representations of an uncertain future, these simple charts are treated as concrete realities.

This principle impacts our conceptualisation of "projects". It suggests that projects exist regardless of people involved in it. The Gantt chart becomes the "statement of reality" (Maylor, 2001, p. 146)[7]. Thus, the objectivity of the Gantt chart has ontological implications. It denies that projects are enacted – projects are not a pre-defined "thing" to be managed (Kreiner, 1995); that its vision, goals and management processes are

constructed by its participants based on previous experiences (Packendorff, 1995); and the plan is not questioned nor an object of negotiation as the project starts.

Objectivity of Gantt charts also implies a management of projects by following the plan. If we were to consider project plans objectively, we would also need to accept that neither politics nor interests influence estimates in the Gantt chart, nor the progress reports. For example, Flyvbjerg and colleagues showed that "guesses" of time and cost are consistently overly optimistic. They found it suspicious as estimation tools and experience should have aided decision makers with more reliable information to develop more precise estimations. Moreover, if estimations were wrong due to lack of knowledge, there would be a balance between optimistic and pessimistic estimations. Therefore, they suggest that initial plans are a political act instead of an objective definition (Flyvbjerg *et al.*, 2003, 2002). Thus, the use of Gantt charts is justified if objectivity could be assured by its contextual conditions, e.g. political influences will be marginal and technical solutions are given.

4.3 Principle: deterministic

This implies that tasks could be completely pre-defined, described and studied in detail; and therefore does not accept potential uncertainty in goals or methods, which is widely recognised in projects (Turner and Cochrane, 1993). Yet, the ability to determine what will happen underlines the predominant project management logic: define-execute. We define what is to be executed at the front-end, cement this in the contract, and then manage its execution.

Thus, following this logic, projects are about turning the plan into reality, and project management refers to defining the scope and process and executing it, whereas gaps between the plan and current progress should be avoided or identified and mitigated. Project manager's responsibility then is to plan so precisely considering all different scenarios and potential risks that gaps between plan and actual can be avoided, or at least identified quickly. As they do emerge then project managers should put the project "back on track". Project management success is then not only about meeting the baseline, but being able to meet it without surprises.

It is not our intension to diminish the importance of the front-end to projects and the need for careful planning; there is plenty of evidence suggesting that we do need to plan, and there is undoubtedly the need to dedicate effort to the understanding of the scope and demands and build a relationship with the client and other project stakeholders (Cooper, 1988; Morris, 1994; Morris and Hough, 1987; Pinto and Kharbanda, 1996; Verworn, 2009; Williams and Samset, 2010). Instead, we argue that there is a need to recognise that the principles behind the use of Gantt charts promote a false sense of certainty and stability under uncertainty, and so it is possible that we become trapped by the constraints set at the front-end. Projects are too risky and costly to be left to the front-end alone. It is exactly at this first phases that projects are particularly uncertain, in some cases very political, project team is not well-formed yet, key stakeholders are still negotiating their roles, responsibilities and rewards. It does not appear to be the most adequate context for fixing how projects should be delivered. It makes us overly dependent on our estimations and "ability" (or wish) (Flyvbjerg *et al.*, 2003) to predict the future with high levels of certainty.

This principle has also consequences to the definition of a project manager. Taken all that could happen in projects can be pre-defined (determinism), and one can define

precisely one right way to undertake the work (objectivity), it is possible to determine a priori what project managers need to do in order to manage projects – a work code, train them accordantly, and implement sanctions for not following this code. In other words, project management can be defined as a professional only, i.e. a science and not an art.

Thus, the use of Gantt charts is justified if determinism could be assured by its contextual conditions, e.g. uncertainty and change will be marginal.

4.4 Principle: analytical

In crude terms, as we accept the analytic principle completely and unreflectively, a project becomes the sum of the tasks to be executed. The whole is considered as the sum of the parts, and the best way to execute the project is divide it into tasks. Management is done by division of work and clear accountability – divide and conquer. It is the role of the project manager to ensure a good and clear partitioning of the work. Issues in interface between tasks are due to an "erroneous" or sub-optimal division of the work, and can be improved. If a task is not completed on time, the person/group/organisation accountable for that task is to "blame".

The project fragmentation encourages focus on low-level delivery and not the overall project effectiveness. There is a risk that parts of projects are seen as silos, and optimized independently. As projects are uncertain and likely to change, grey areas between silos often emerge as project scope and context changes and are often source of conflict, especially between suppliers and client. Suppliers will tend to focus on "their task" usually pre-defined by the contract, and will consider the project to be successful if their task is delivered on time and budged, regardless whether this led to the strategic benefits intended by the clients. So, if we are to accept the analytic and accountability principle, project success is reduced to the delivery of each task; taken that project is the sum of the tasks, if every party ensures that their task is delivered, than the project will be a "success".

Finally, the professionalization of each element of projects also enforces the fragmentation not only of scope but also of the function of project managers. For example, we have often observed project managers that delegate risk management to the risk practitioner or consultant and had little ownership about the actions and consequences of risks in projects, and therefore fail to integrate risks into negotiations with client, conversations with team, etc.

Thus, the use of Gantt charts is justified if analysis – breaking it work down into tasks – could be assured by its contextual conditions, e.g. work can be easily broken down into parts, the interfaces and interdependencies can be clearly defined and coordinated, and the project and its performance are the result of the sum of the tasks to be executed.

4.5 Principle: accountable

When a Gantt chart is used, we assume that not only projects can be divided into parts, but also that it is possible to assign a person accountable for each of the parts. Indeed, establishing clear accountability to each task is one of the suggested "best practices" in normative project management (Meredith and Mantel, 2003; PMBoK, 2004). As Yakura (2002, p. 966) concluded from her observations of project management practices in an IT consulting firm, "the timelines [Gantt Chart]

were the *locus* for accountability because they described what was to be done, and when and by whom". Following this principle in using a Gantt chart it gives the impression that it is possible to identify those who fail to deliver. However, complex interactions between different tasks emphasises accountability over each task, and "blame" those who fail to deliver. Moreover, it encourages individualistic thinking instead of teamwork and cooperation to address project issues instead of excellency in each of its parts.

Thus, the use of Gantt charts is justified if accountability could be assured by its contextual conditions, i.e. it is possible to establish clear accountability to each of the tasks and it is possible to trace back who would be responsible for any "mistakes" or issues.

4.6 Principle: sequential

It is part of the normative use of the tool to define the sequence of activities, and this is visualised in Gantt chart as a sequence of tasks, in which each task is truly completed, frozen, and one can move to a next task. Gantt charts are the ultimate representation of the waterfall project process. For example, by the end of the design phase one reaches "design freeze" and moves to the next phase. Following this logic, project manager's role is to ensure that the process follows in the right sequence, and each step is completed and frozen, so the project can move to the next step. Project success then means that one "gets it right the first time", loops are sign for incompetence or "sloppy" work.

The problem occurs for activities that are circular, i.e. they have to be reiterated until they converge to a solution or a specific level of quality is achieved. Software development processes are a good example. They start with the analysis of requirements, followed by program design and coding and finally testing. If a software module shows significant defects during the testing stage the cycle starts again either with the first or second or third process until an acceptable level of software quality is achieved. The progress of this type of process is not linear. Today, there is a strong movement in software projects (as well as projects with high uncertainty and ambiguity in scope) against the waterfall sequential process, and to accept these cycles, ensure continues testing, as proposed by agile manifesto (Beck *et al.*, 2001). These types of processes cannot be adequately represented in Gantt charts as it is simply not known a priori how often the loops have to be repeated. Such process also enables a stronger relationship and influence of the customer/client (Boehm, 1988) and encourages co-creation of value (Vargo and Lusch, 2004).

Further, accepting that tasks as sequential, we assume that the project progress is measured linearly. Project controlling with Gantt charts builds on the logic of linear effort behaviour, e.g. if a bar in the chart representing a project task is 50 per cent elapsed then the status of the task execution is 50 per cent. This is at odds particularly with the front-end of projects in drifting environment where projects converge into the development.

Thus, the use of Gantt charts is justified if sequencing of work could be assured by its contextual conditions, i.e. the activities have a natural linear sequence, and it is possible to get each task right first time without the need to revisit it.

5. Towards a contextualised and reflected use of Gantt charts

Our analysis suggests that the Gantt chart is not divorced from its roots in Scientific Management. Its engrained principles are not valid to every type of project and have

significant implications to project practice. This section addresses what the above conceptual discussion means to the practitioner – what can be done different and how. It is aimed at encouraging and facilitating a contextualised and reflected use of Gantt charts.

It is important to stress that we are not suggesting to completely ban the use of Gantt charts – Gantt charts are useful visual representations and can add value to projects, in, e.g. visualising key deadlines, understanding sequence of activities, negotiating duration of different phases and tasks, etc.

Contextual use of Gantt charts

The appropriate use of Gantt charts occurs if the principles are met by the situational conditions – a contextual use of Gantt charts. The questions indicated in Table III were designed to assist project managers to reflect about the appropriateness of the Gantt chart to their specific project. If many of the questions below are answered with yes, the project management should consider the use of Gantt charts to manage the project's implementation.

As the project develops, the context of the project may change; so it is worth maintaining the eyes open to certain project dynamics, that can be indicative of inappropriate use of Gantt charts, e.g. when people involved in the project are overly focused on time compromising other relevant performance areas of the project or when meeting deadlines at all costs become a self-fulfilling prophecy.

Reflective use of the Gantt chart

Obviously though reality is never as black and white as limned above. Fit between principles and project tasks does not guarantee an appropriate use of Gantt charts either. For example, despite time being the key value of projects, e.g. in Olympic Games, project managers may create an exaggerated time pressure and stress, encouraging unnecessary concurrent work or rework.

Moreover, if project managers understand the implications and typical effects of misfit, a potential negative impact of the use of Gantt chart can be mitigated or compensated. For example, project managers can raise awareness to a multitude of alternative visual representations of the project, such as charts with number of accidents, cash flow charts, design drawings, etc.

If project managers adapt the use of Gantt charts appropriately, the tool can be very useful even in contexts that are not natural fit. For example, uncertain and creative

Principles	Questions
Time-focused	Is the project mainly time driven, e.g. the focus on time precedes other performance areas of a project?
Objective	Can the tasks of the project and its duration be described precisely, unequivocally and incontestably?
Deterministic	Is the project mainly a routine project and uncertainties are not really expected?
Analytical	Can the project be easily broken down into parts and the interfaces and interdependencies can be clearly defined and coordinated? Does the performance of the project equal the sum of the performance of its parts?
Accountable	Can one establish clear accountability to different parts of the system?
Sequential	Do the activities have a natural linear sequence? Is it expected to get each task right first time without the need to revisit it?

Table III.
Questions to encourage a contextual use of Gantt chart

projects go through a very messy process that could go forever; deadlines visualised in Gantt charts can help focusing attention and finalising work; yet the work is not managed and sequenced through the Gantt chart. Similarly, in situations of high ambiguity and low objective Gantt chart can act as an instrument to negotiate consensus and understand different perspectives of time/duration across different groups of stakeholders instead of imposing "a reality" to the project.

Therefore, our suggestion to practitioner is not only a contextual but also reflective use of Gantt charts.

6. Conclusion and outlook

Gantt charts were developed for specific conditions at the heart of Scientific Management, yet have been applied to project contexts with little adaptation. In this article we analysed the conceptual roots of the Gantt chart and identified six principles that are embedded in the use of Gantt charts. We explored their implications to what we conceptualise as project, project management, the role of project managers and performance. As we explored each of the principles, we argued that these were made to a very different context (repetitive routine operations) in a different time (early twentieth century) and have inherent limitations; we show that Gantt charts still are appropriate to certain project contexts and certain project phases, but definitely not all.

While the majority of the contemporary project management thinking already accepted that the assumptions of the Scientific Management are flatted, the practice is, with notable exceptions, still pretty much embedded in this deterministic and mechanistic paradigm. The consequences for managing projects are significant, as discussed in Section 4. However, there are paths to encourage a more reflective and less normative project management, as suggested in Section 5.

The analysis leads also to further research questions and alternative tools to visualise project plans and progress. In line with Whyte *et al.* (2008), we have showed in the article that tools and images and intrinsically related to how we think about projects and manage them. Yet, there have been surprisingly few studies on what visual representations are used, how they are used, why and with what results. There is room for the development of other visualisation tools that are not based on flatted assumptions as the Gantt chart, and to identify relevant managerial skills related to a mindful use of visual representations.

In a more conceptual level, our analysis suggests a "fit" hypothesis between the use of Gantt charts and its logic to manage projects in specific contexts only. Reflecting on the derived conditions it could well be that a misfit between the situation and the use of Gantt charts could be a predictor of project failure. Further research could unravel a relation between project performance issues and the inappropriate use of Gantt charts or its underlying principles to plan and manage the implementation process.

Finally, this article shows that some of the logic embedded in project and project management has been borrowed from other contexts and applied to projects without deep understanding of the implications of this logic to projects. In that respect, the Gantt chart fails to acknowledge insights from years of organisation theory research and project management research with a firm grounding in contingency theory. This calls for a development of a "discipline of project management", which is more deeply engaged with the already existing own theories and thought, and encourages a more careful application of theories and ideas that are not made for projects. Taken the high

adoption of project-organising in standing organisations (Pettigrew, 2003), and that the current (general) management context is, so as projects are, recognised to be uncertain, dynamic and far more temporary than one would care to consider in the times of Scientific Management, project-driven theorising can contribute not only to the management of projects, but also to general management.

It is clear that Gantt charts are representing a specific paradigm that could enhance or limit the implementation process of a project depending on the specific situation. By showing its roots, we hope to portray a caricature of project management and so with help practitioners and academics to understand its limitations, and, in Foucault's terms, "free thought from what it silently thinks, and so enable it to think differently" (Foucault, 1971, p. 9; Gantt, 1919; Geraldi, 2008; Jarvenpaa, 1989; Jarvenpaa and Dickson, 1988; Tufte, 1991; Tufte and Howard, 1983; Vessey, 1991, 1994).

Notes

1. For an early version of the Gantt chart, please see Gantt (1916, p. 276).
2. Gantt himself though did not publish the Gantt chart (as we know today) in his books. It was Wallace Clark, a member of Gantt's consulting firm, and colleagues that popularised the graphic in the first decades of the twentieth century through the book "The Gantt Chart: A Working Tool of Management" and extensive consultancy. For a detailed account on the development of Gantt chart see Clark *et al.* (1922). Later, Wilson claims that the origin of the Gantt chart is still unclear, and may not have been developed by Gantt himself. This view contradicts that of Clark and Wren's (1976/1987) account of the development of Gantt chart.
3. An example of the second version of the Gantt chart can be found in Clark *et al.* (1922, p. 24).
4. This extreme objectivity was not in line with Gantt's (1919) view; he puts emphasis on the habits of the industry over the exact definition of the task. However, the Gantt charts create (i.e. impose) one (i.e. the optimal) view of how the project should progress and at what rate.
5. Interestingly, the current response to the wish to "keep the charts" has been not to revise this principle, but instead to add another layer of management, the project management offices and schedule managers, responsible to keeping the charts, while the project manager has the time to manage the project (Geraldi, 2008).
6. Even in such context, the emphasis on efficiency was heavily criticized at the time. For a comprehensive account see, e.g. Wren (1976/1987).
7. Some could argue that Gantt charts are merely a visual representation and therefore cannot impose an optimal view of the project. We content that this would, first, be a naïve understanding of visual representations. Research suggests the importance of visual representations in how we conceive reality, and how those visuals can and do impact our decisions (Jarvenpaa, 1989; Jarvenpaa and Dickson, 1988; Tufte, 1991; Tufte and Howard, 1983; Vessey, 1991, 1994). Second, it would be a understatement of what the use of Gantt charts involves, namely a method to do scheduling, based on the breaking down of tasks, the clear definition of its duration and sequence, etc.

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