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APPLYING THE CHRONOGRAPHICAL APPROACH FOR MODELLING TO DIFFERENT TYPES OF PROJECTS

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Abstract: Graphical modeling is considered to be a suitable approach for displaying project data because of its ability to effectively communicate information. To meet this objective, the Chronographic Approach analyses the layout of the user interface in the spatial dimension and discusses the suitable visual parameters and their associated values. The main goal is to communicate information clearly and effectively through a visual graphical representation of the schedule. This paper discusses the application of the Chronographical Approach to modeling different types of projects, such as buildings and infrastructure. The graphical approach describes how the schedule information can be communicated using tabular and graphical interfaces, in order to manage specialties, locations, means, processes and constraints on different strata and show them either separately or combined using layering, sheeting, juxtaposition, alterations and permutations while allowing for groupings, hierarchies and the classification of project information. The result is the presentation of the same project schedule through different compatible approaches. The planner has the ability to switch from one approach to another by changing the graphical parameters. In this way, graphic representation becomes a living, transformable image, thus assisting planners in solving problems of a variable nature, and simplifying site management while simultaneously utilizing the visual space as efficiently as possible.

1 BACKROUND

1.1 Graphical modeling of projects' schedules

Over time, graphic modeling has become an essential tool for project managers. Project schedules represent the graphical modeling of project performance that serves as decision support tool. In order to construct a model, we isolate a class of phenomena and try to report on them using a number of assumptions and rules. As a simplification of the world, every model has its limitations and its range of validity (Legay, 1997). Facing increasingly complex processes and procedures, and multidisciplinary infrastructures, a model with a clear visualization can facilitate the demonstration of the necessary information, and becomes a useful tool for decision making. Shen-Hsieh et al (2002) support the fact that each decision is a step based on the experience and intuition of the manager, and remains subjective. Graphical tools can easily summarize the information in order to improve response time and facilitate decision making for managers, designers, and other stakeholders to a project. What cannot be modelled-cannot be properly managed. Any model must allow proper identification of a problem’s source, or even anticipate them upstream. The aim is to improve the level of coordination and the ability to identify problems. Karavakis et al (2010) mention that the extraction of the desired data is facilitated from simple graphical interfaces.

Visual representation usually allows for faster data exploration and often provides better results, especially in cases where automatic algorithms fail (Keim, 2002). According to Friedman (2008) the main goal of data visualization is to communicate information clearly and effectively through graphical means. Bertin (2005) notes that visual perception has three sensitive variables: the two planar dimensions and the variation of the mark on the plane. For comparison, sound perception and its representations (such as scriptural or mathematical)~~,~~ possess only two variables. Graphs are understood differently than text, i.e. the former is understood globally, whereas the latter is understood sequentially. In addition, graphs can act as both a type of artificial memory and as a research tool in that they allow for the simultaneous display of the general structure, as well as the details and exceptions: they can show the leaves, the branches and the whole tree at the same time (Bertin, 2005).

1.2 Actual Limitation for Graphical modeling of Project schedules

Kuo et al (2010) states that the development of methods of presenting information in building a multi-mode system will improve access to and understanding of the project information required for each. They also state that although technological developments today enable the development of high performance tools, the fact remains that the current planning software only partially meets the demand of managers. Francis and Miresco (2006b) remark that many weaknesses are associated with the existing scheduling software. None of this software is intended for the planning of all types of projects. In addition, they are only directed by activities and cannot graphically use the other constraints, such as resources or work area, to present a production schedule. We can also remark that the proposed graphical schedule is global. These systems do not use multiple sheets, like spreadsheets, in order to manage lots separately. They also do not use multiple layers, as CAD does, in order to lay out data and constraints on different layers, thus allowing managers to improve the graphical visualizations of the schedule. Consequently, we can note the complexity encountered in the following the project schedule on screen (Fisk 2010; Francis 2004).

Francis and Miresco (2006b) states that the actual situation of project scheduling demonstrates that traditional methods seem to be unable, individually, to answer all planners' needs, to solve multiple kinds of problems or to represents all types of projects. The managers have to deal with various project types and they are confronted with problems of different natures. Modeling information using several strategies and displaying them on numerous angles of points of view seems to be appropriate as a decision-making tool. It is thus relevant to model simultaneously more than one scenario and to perform analyses in order to improve the works coordination, optimize the performance execution, reduce risks and minimize uncertainties. In addition, the quality of needed information to be displayed on the project schedule model, and the required level of detail depends on the role and position of an entity in the project and the hierarchical reporting of the manager. As an example for a building project, the primary role of the general contractor's project manager is to manage the project site. This manager is responsible for coordinating the deliverables of the subcontractors, monitoring the progress of work, quality control and insurance and health security, managing workspaces, storage areas, the vertical and horizontal circulation of materials on site and the reverse cycle for recycling and scrap. Schedules and progress monitoring are preferably arranged according to the price schedule. The sub-contractor's manager is responsible for the planning, coordinating and monitoring of the daily or weekly progress of work teams. He also manages the supply according to the site progress.

Francis and Miresco (2014) state that subcontractors and general contractors do not share the same goals. Figure 1 shows the intersection between two schedules, the vertical for the general contractor and the horizontal for the subcontractor. The general contractor organizes project planning and monitoring vertically in which he coordinates the work and deliverables of the various subcontractors. He is interested in completing the project within time and budget. The sub-contractor promotes the optimal use, the leveling and the improvement of the productivity of his teams between the different projects in which he is involved to the detriment of the overall health of these projects. Francis and Miresco (2013) state that a schedule capable of providing a user-friendly tabular and graphical interface, able to easily structure project information, able to adapt to work in an interactive, changing environment, and accept productivity variation, is necessary for everyone on the site, especially the foremen and superintendents.

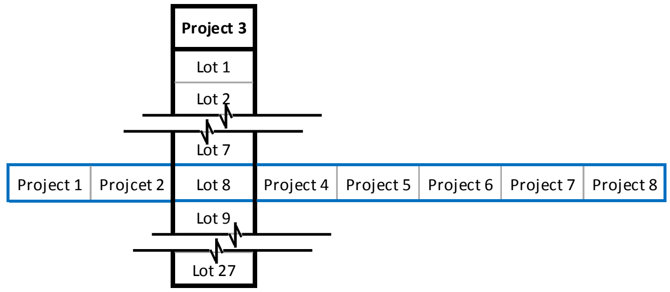

Figure 1: Intersection between vertical and horizontal schedules

This paper discusses the application of the Chronographical Approach to modeling different types of projects, such as buildings and infrastructure. The graphical approach describes how the schedule information can be communicated using tabular and graphical interfaces, in order to manage specialties, locations, means, processes and constraints on different strata and show them either separately or combined using layering, sheeting, juxtaposition, alterations and permutations while allowing for groupings, hierarchies and the classification of project information. In this way, graphic representation becomes a living, transformable image (Francis 2013).

1.3 The Chronographical Modelling Approach

As designed by Francis (2013), the Chronographic Approach analyses the graphical representation of the schedule and discusses the suitable visual parameters and approaches. The main goal is to communicate information clearly and effectively using tabular and graphical means. The Chronographic Approach defines five categories, called Entities (Table I) as modelling parameters:

- The Physical Entities represent all the elements required to perform the construction operations (e.g. activities, labor, permanent materials, operators or haulers, construction site locations).
- The Associative Entities indicate the dependencies among the Physical Entities. They can represent: Relationships and Constraints; Hierarchy; Grouping; c) Layering and Sheeting; and Attributes.
- The Functional Entities characterize the Physical or Associative Entities. These entities may denote deterministic relations, decisional or probabilistic functions or Temporary Functions.
- The Scale Entities designate the external measuring units (e.g. Time, Cost, Quantity, % Progress, Risk, Performance, or Resources) or internal measurement.
- The Direction Entities present the coordinates on up to three Cartesian axis systems. Each axis allows for no scale, single scale with cumulative data, or grouping.

Table 1: Entity Types (Francis, 2013)

Physical (PE)	Associative (AE)	Functional (FE)	Scale (SE)	Direction (DE)
Activities / Deliverables	Relationships & Constraints	Deterministic ; Probabilistics &	Time	No axis (Cyclic scales)
Direct & Indirect Labours	Hierarchical	Heuristic	Cost	Single axis Scaled, Grouped or none
Operators / Haulers	Grouping	Fixed and variables	Quantity	
Permanent materials	Layering	Optimization	% Progress	Two axis Scaled, Grouped or none
Emplacements	Sheeting (Sub)	Decision	Performance	Three axis Scaled, Grouped or none
Type of contract	Attributes	Generalized	Risk	

2 APPLYING THE CHRONOGRAPHICAL APPROACH FOR MODELLING DIFFERENT TYPES OF PROJECTS

Managers have to deal with various project types and they are confronted with problems of different natures. To answer these various needs, managers must currently handle information within several incomplete methods, which are incompatible between each other. Although the existence of several scheduling methods is criticized because of the lack of compatibility, the existence of a complete model, which can present information within different and compatible facets, is considered as an optimal solution (Francis and Miresco 2006b). To meet this objective, the Chronographic Approach analyses the layout of the user interface in the spatial dimension and discusses the suitable visual parameters and their associated values. The main goal is to communicate information clearly and effectively through a visual graphical representation of the schedule.

Francis (2013) describes the preparation steps for the project schedule using the Chronographical Model. First, we should define the necessary Physical and Associative Entities that simulate the construction operation: a) the work breakdown structure (WBS) for deliverables, activities and tasks; the work location breakdown structure (WLBS), by dividing the site locations; c) the Organization Breakdown Structure (OBS) for the composition of project teams and specialities. Then we define the attributes' entities and we define the Cartesian axis and their measurements. We can use zero to three Cartesian axes; external and internal measurement scales; hierarchy, grouping, layering, sheeting and attributes; relationships and constraints to model construction operations through the Physical Entities (e.g. activities, labour, permanent materials, operators or haulers, construction site locations).

The result is the presentation of the same project schedule through different compatible approaches. The planner has the ability to switch from one approach to another by changing the graphical parameters. In this way, graphic representation thus assists planners in solving problems of a variable nature, and simplifying site management while simultaneously utilizing the visual space as efficiently as possible.

2.1 Linear Projects

Developed by the US Navy Department in the early fifties, linear methods are designed to ensure continuity of resource use and support a stable and optimized production. Trimble (1984) mentions that schedules oriented by resources are more realistic than those dominated by activities. These methods show graphically any imbalance due to uneven progress of activities and quickly allow the manager to quantify the deviation (Khisty 1970).

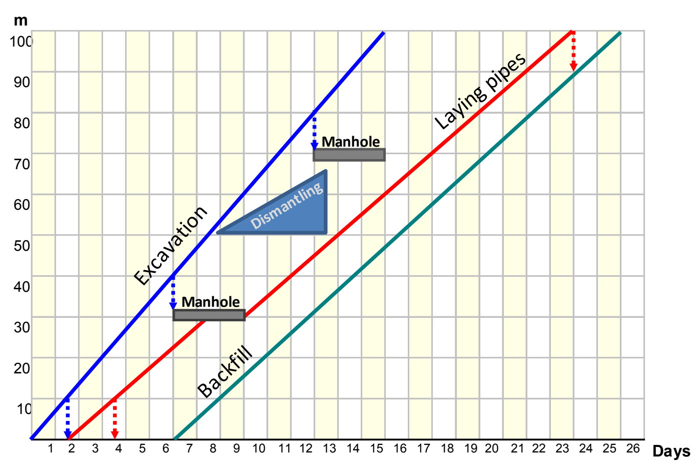

Figure 2: Example of scheduling a linear project

These methods have been the subject of countless improvements either through their graphical models and their methods of calculation. These methods are therefore well-suited to road, highway, railway and pipeline projects. We note that within these projects the machinery and the work teams operate continuously in a linear way. The difference with the simulation methods based on CYCLONE is that simulation are used to optimize the production, versus a target of linearity and operating in parallel way between the successor activities for the linear methods.

Figure 2 shows a linear project for installing a drainage system. In these types of projects, mainly the activities are linear. However, the schedule could combine simultaneously linear activities (such as excavation and backfill) and repetitive activities (such as manholes). The approach uses two axes. Time is shown as the scale of the horizontal axis and the units (meter) scale the vertical axis.

2.2 Repetitive Projects

Repetitive projects are projects where assigning tasks are usually repeated from unit to unit or from floor to floor. This differentiates them from the linear projects where machinery is operating continuously. We can distinguish two types of repetitive projects: a) Vertical projects such as multi-storey building; and b) Horizontal projects such as the construction of several similar units.

2.2.1 Repetitive Vertical Projects

In repetitive vertical projects, such as a multi-storey building, some activities are non-repetitive activities, such as the foundation and the roof, while others are repeated from one floor to another, such as structure, architectural finishing and services.

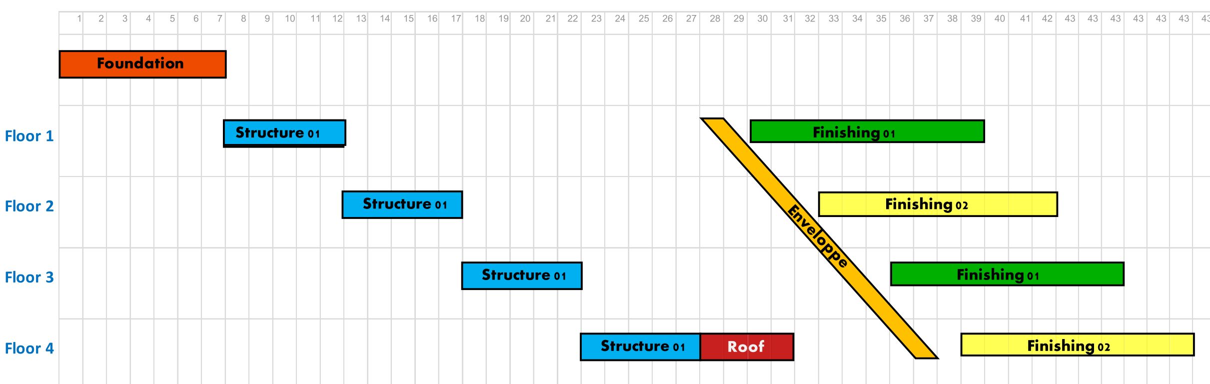

Figure 3: Example of scheduling Repetitive Vertical Projects

Figure 3 proposes an approach that uses two axes. Time is shown as the scale of the principal direction. The second direction shows the different levels: Foundation (non-repetitive) and repetitive floors (1 to 4). Thus, these projects combine mainly repetitive activities (structure and finishing), and occasionally non-repetitive activities (Foundation and Roof) or linear operations (Envelope). Team work describes the detailed operation of these buildings symbolizing the Physical Entity. In this figure we can track the sequence of work of each team on the different floors.

2.2.2 Repetitive Horizontal Projects

In repetitive horizontal projects, such as the construction of several similar units, most activities are repetitive. In these horizontal projects the work of several units can be planned simultaneously to accelerate the project schedule. The number of specialty teams can be calculated by the quotient of the duration required to complete a single unit by the total time available to complete the work of this specialty for all units.

Figure 4 proposes an approach that uses two axes. Time is shown as the scale of the principal direction. The second direction shows the repetitive horizontal buildings. Team work describes the detailed operation of these buildings symbolizing the Physical Entity. In this figure we can track the sequence of work of each team on the different buildings. For example, the buildings' foundations are executed by two teams: "Found 01" and "Found 02". The team "Found 01" consecutively executes the buildings 1, 3, 5 and 7 (see also Figure 5). The time required for building is 4 days and the total duration of the work of this team is 16 days.

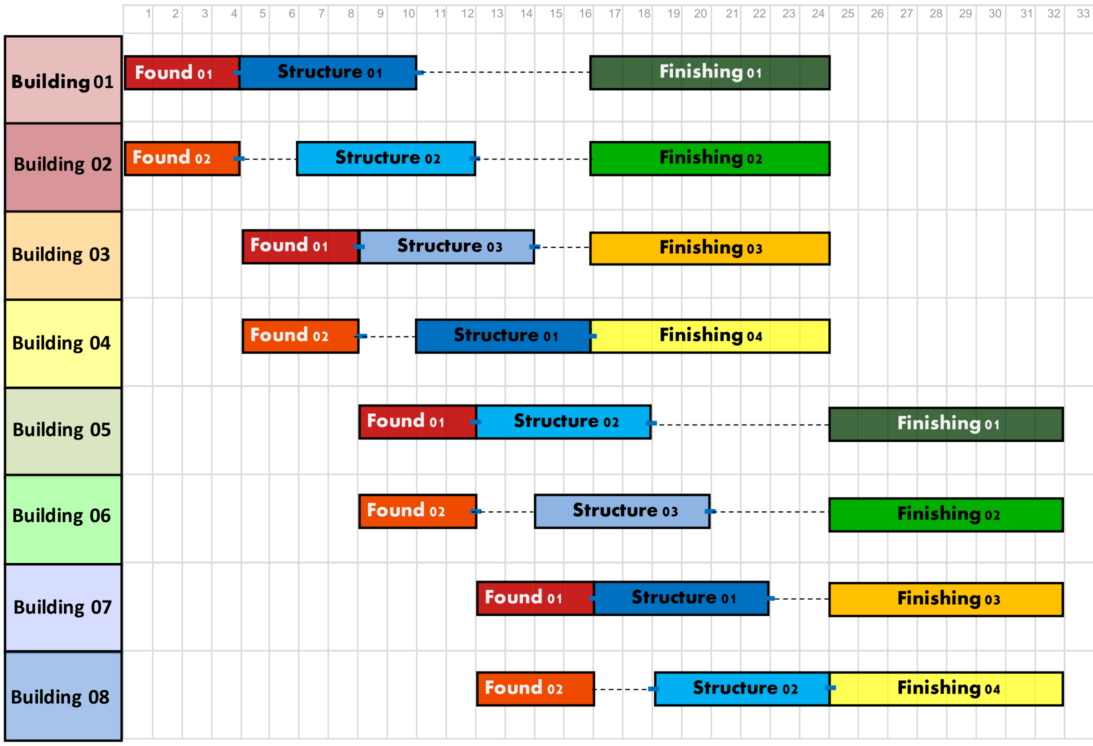

Figure 4: Example of scheduling Repetitive Horizontal Projects

The utilization of resources as a second direction represents an effective solution for showing resource allocation and levelling. Manpower occupations are easily optimized and work over-load or under-load are avoided. Francis (2013) classifies this approach as “Chrono-Allocation Modelling: Using Resources as a second direction”. Figure 5, shows an approach with two directions. Time shows the scale of the principal direction. The second direction shows teams. This example uses: two (2) teams for foundation works, three (3) teams for structure; four (4) teams for finishing. It should be noted that teams use a scale of dark colours and building uses a scale of light colours.

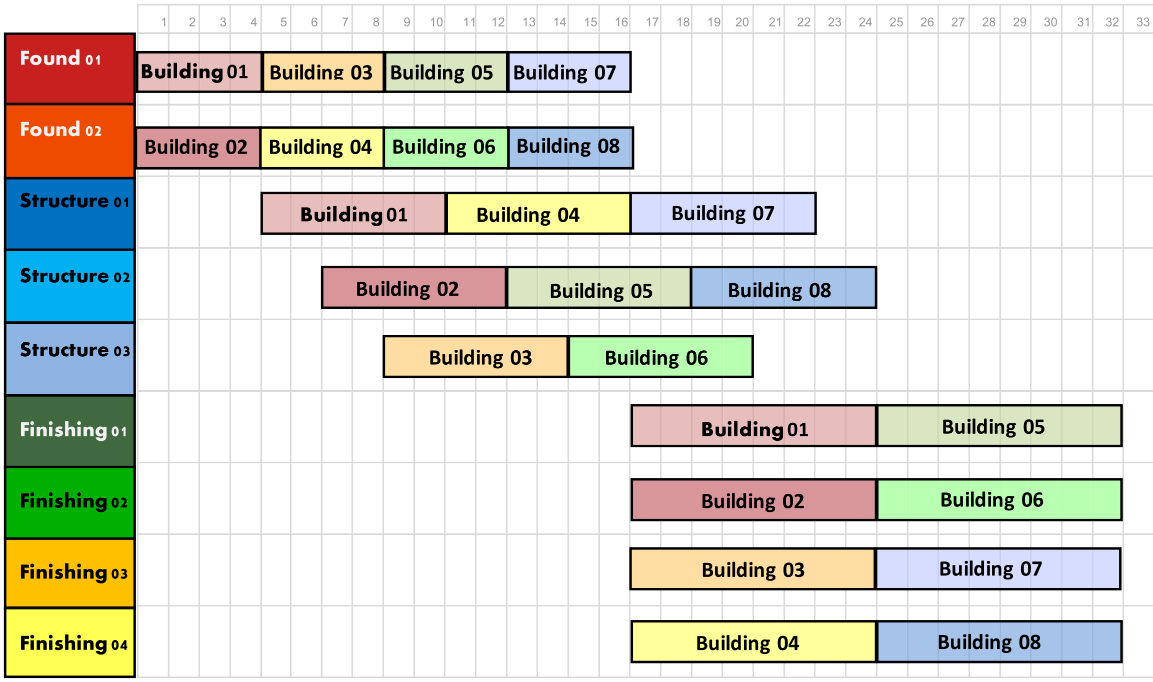

Figure 5: Example of Chrono-Allocation Modelling for Repetitive Horizontal Projects

2.3 Non-Repetitive Projects

Non-repetitive projects are projects where the intervening work teams are specific. Generally, there are only a few repetitive activities. This type of project is well-planned through a time-scaled Precedence network (unfortunately not modeled by commercial scheduling software) or a Gantt/Precedence Diagram, modeled by commercial scheduling software such as MS-Project or Primavera. The difference is that time-scaled Precedence networks plot activities in parallel and in series while in a Gantt/Precedence Diagram each activity is drawn on a separate line resulting in the non-optimal use of the modeling area.

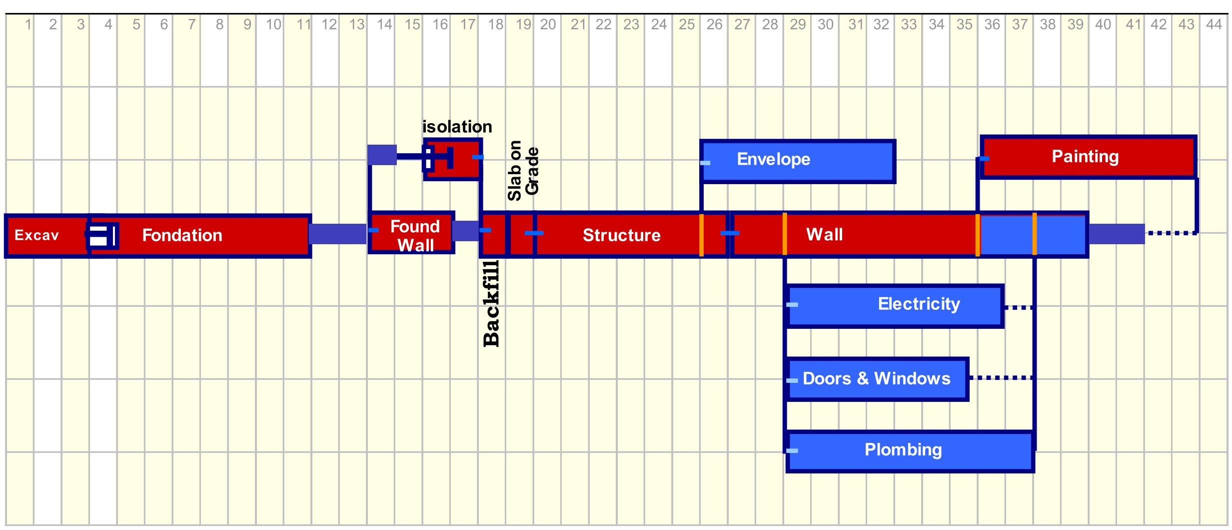

Figure 6: Example of scheduling Non-Repetitive Projects

Figure 6 shows a non-repetitive project modeled with the Chronographic Method. The difference between this method and the time-scaled Precedence network is the use of internal divisions and internal relationships as function of quantities or productions (Francis and Miresco 2006a). In this figure, the activities that represent the implementation of walls are divided into four internal divisions as a function of quantities or work steps. The two first divisions are critical while the two other divisions possess margins. The three activities Electricity, Doors & Windows and Plumbing are related to the end of the first internal division with Finish-to-Start relations. Their end dates should be completed before the start of the last division of the implementation of walls.

2.4 Scheduling Projects by Working Areas

Most building project activities are carried out by subcontractors. As a result, the majority of project resources are assigned to subcontractors who are responsible for the planning and management of their work programs. Thus, project planning complexity is generally related to the coordination of the subcontractors' work. The planners of multi-storey building projects also face many other difficulties such as avoiding conflicts of use within limited workspace, the organization of on-site traffic to avoid congestion, the supplying, handling, and storage of project materials, and waste management and recycling (Francis and Miresco 2013). Kuo et al (2010) quote that assembly sequences require an interface of spatial and temporal information. Therefore, a schedule oriented by work areas is considered to be an appropriate approach for planning building projects.

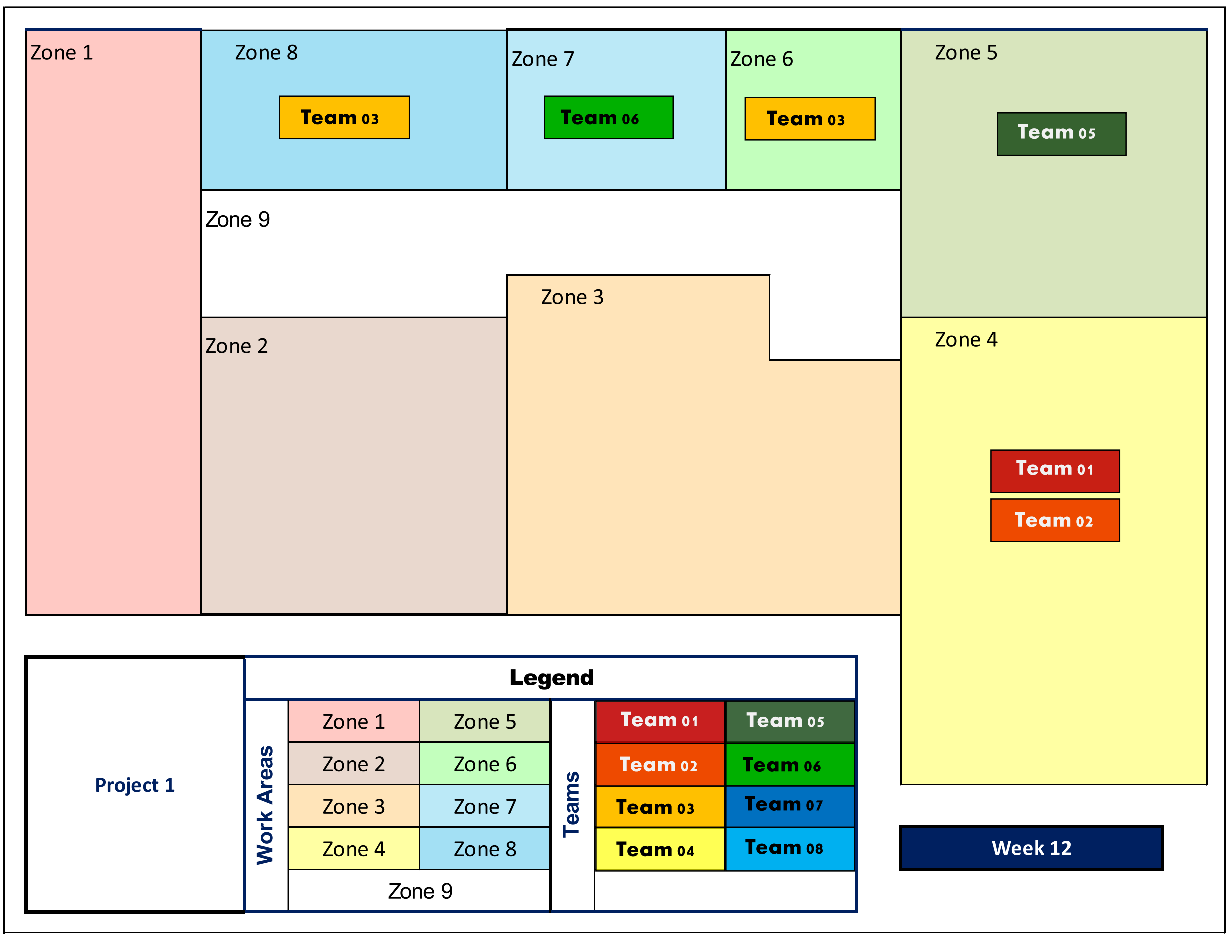

Figure 7: Example scheduling Projects by Working Areas

Figure 7 shows the construction work during week 12. In this plan, we can see : a) Areas 1, 2, 3 and 9 are vacant demonstrating underutilization of the work area; b) the conflict between teams 1 and 2 in Zone 4; and c) team 3 is used at the same time in both zones 6 and 8. Using this type of planning we can easily manage conflicts and adjust the plan manually during weekly site meetings without complex calculations.

3 CONCLUSION

The present paper discusses the application of the Chronographical Approach to modeling different types of projects, such as~~,~~ buildings and infrastructure. The main concern is studying the modalities of information representation. The graphical approach describes how the schedule information can be communicated using tabular and graphical interfaces, in order to manage specialties, locations, means, processes and constraints on different strata and show them either separately or combined using layering, sheeting, juxtaposition, alterations and permutations while allowing for groupings, hierarchies and the classification of project information. The Chronographical Approach defines the graphical parameters that model the construction operation, establishes constraints, and determines directions and scales. Using these parameters, the planner can schedule the construction operation by laying out project information under diverse approaches. The result is the presentation of the same project schedule through different compatible approaches. The planner has the ability to switch from one approach to another by changing the graphical parameters. In this way, graphic representation becomes a living, transformable image, thus assisting planners in solving problems of a variable nature, and simplifying site management while simultaneously utilizing the visual space as efficiently as possible. The use of understandable visual communication methods facilitates the sharing of information while aiding in planning and controlling project activity, including the improvement of productivity, performance and effectiveness.

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