Pergamon

International Journal of Project Management Vol. 16, No. 4, pp. 201–208, 1998

Printed in Great Britain
0263-7863/98 $19.00 + 0.00

PII: S0263-7863(97)00031-8

From Plan-Do-Check-Action to PIDCAM: the further evolution of the Deming-wheel

Adri Platje*
Rietbeek 3, 5501 CA Veldhoven, The Netherlands

Sipke Wadman
Gildestraat 15, 5581 HP Waalre, The Netherlands

The currently published Plan-Do-Check-Action (PDCA) models for cyclic control of projects or processes have some major drawbacks on aspects like showing timing and sequence of events. The Plan-Implement-Do-Check-Action (or Assess)-Management (PIDCAM) cycle newly developed in this paper is time dependent and does not suggest a sequential winding up of the PDCA cycle.

The PIDCAM cycle is well suited to support the Goals–Means hierarchy of an organisation. This Goals–Means hierarchy can be constructed from elementary planning cells according to Hartmann's five laws of stratification. The PIDCAM cycle and the Goals–Means hierarchy are tools for diagnosis of organisations as well as for organisational development. Delegation of tasks with accessory responsibilities and competences to the lowest possible organizational gremia is a key issue in this matterabsaabsbs.

Keywords: planning and progress control, project planning, multi-project planning, elementary planning and progress control cells, goals–means hierarchy, laws of stratification, diagnostics and design of organisations, conduct of management

Elementary planning and progress control cells ('planning dipoles')

Platje, Seidel and Wadman[1] have indicated that communication between two organisational levels (e.g. a Project leader and his Project Team) should follow the principle of *double interaction*. It means that a message can be exchanged between subsequent organisational levels without deformation caused by aggregation problems, because there is no misunderstanding about the meaning of a message. The translation code for the aggregation and deaggregation of information has been fixed in a plan, authorised by the two parties concerned. Often the problem is that this code is non-deterministic, which makes it impossible to handle for computer assisted Project Management Information Systems.[2]

For a better understanding of the principle of double interaction we define an elementary planning and progress control cell (we call this a 'planning dipole') as a system where two subsequent organisational entities communicate with each other by means of *a Project Realisation Plan* (PRP). This PRP contains the Project Management (PM) aspects scope, organisation, time, resources, costs, information, risk, quality and public relations. See *Figure 1*.

Format and contents of the PRP is the result of a trade-off process between the two parties involved (within given constraints) dealing with the nine PM aspects. Because each planning diplole requires its own information system, the Information Breakdown Structure (IBS), the Planning Breakdown Structure (PBS) and the Organisational Breakdown Structure (OBS) within such an elementary planning cell are coupled.[1] Therefore, the Work Breakdown Structure (WBS) can also be described in terms of planning dipoles.

Goals–means hierarchy

By default every organisational stratum (except the highest and the lowest) is part of two planning dipoles. The hierarchy built on this principle is called a goals–means hierarchy. The higher level management regards the goals of a subordinate level as their means to reach their own goals. In this way a hierarchical order

*Author for correspondence.

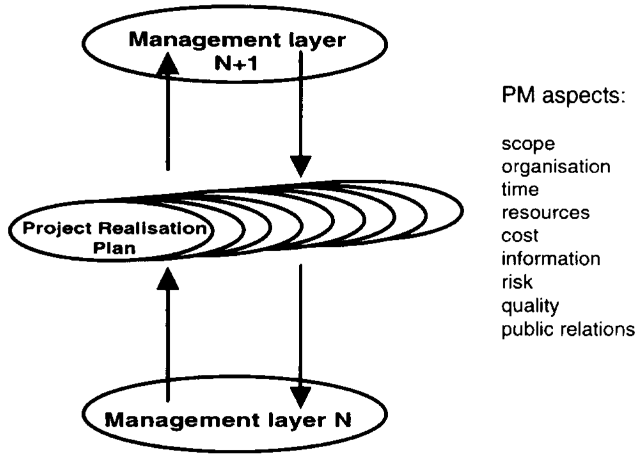

Figure 1 Elementary planning and progress control cell (planning dipole)

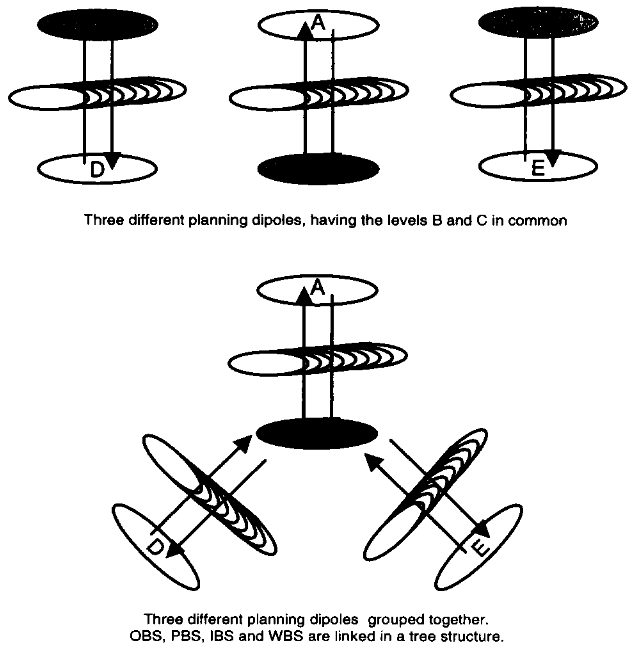

Figure 2 Linked planning dipoles

of goals of one level that are means of the next level is formed. This allows optimal planning and progress control.

In practice it appears to be difficult to design consistent organisational structures especially for matrix organisations running multiple projects (of different sizes and complexity) sharing the same resources at the same time. An example of this is the hesitation of Management to install the required Portfolio Management Team as a new organisational level[3] in multi-project matrix organisations.

Using Hartmann's category analysis[4] one will be able to see through these problems and become able to design consistent organisational structures (a goals–means hierarchy) with planning dipoles as the building blocks.

In the view of Hartmann, a category is a philosophical *a priori* (in advance) conception of a characteristic property of a stratum that can be sensed or measured by performance indicators. Defining IBS, PBS, OBS and WBS as categories being part of a planning dipole the deterministic dissection of this cell should meet Hartmann's five laws of stratification. These laws are:

1. There are always categories of a deeper layer that return in a higher layer, but the reverse is never true. Linking of categories only exists in upward direction.
2. The return of categories is always limited: It does not occur for all categories of the deeper layer and does not automatically extend to all higher layers. The validity of a category is stopped at a certain layer.
3. Categories of lower layers that are also valid in higher layers are deformed to the character of the higher layer.
4. Categories of lower layers extending in higher layers never determine the typical character of the higher layer. This character is determined by categorical novae first formed in this layer.
5. The ascending sequence of existential levels is discontinuous. Levels become sharply separated because categorical nova occur simultaneously in different categories.

Application

These five laws of stratification enable an *a posteriori* (afterwards) diagnostic process to define unique planning dipoles. Because these laws determine the natural structure of a successful stratified organisation *a priori*, their effects must be clearly recognisable *a posteriori*. If properties are found that do not comply with these laws (e.g. the two hats problem, level skipping, use of planning information aggregated to the wrong level, etc.) they are inconsistent with the required unambiguous goals–means hierarchy. These laws of stratification beautifully explain the fundamental reasons for the vicious circles found by Crozier.[5] Planning dipoles are therefore the building blocks of an organisation and parts of its goals–means hierarchy. They form a step in the direction of describing hierarchies in terms of processes rather than structures. This allows a revitalisation from a functional organisation towards a process-driven self-learning organisation.

Much literature has been published about planning and progress control techniques. All these approaches have a dominantly mechanistic approach in common. Despite this, things like level-skipping on aspects of IBS, PBS, OBS and WBS continue to exist. Level-skipping is a human tendency of (often informally) jumping over an organisational stratum and over its PRP if it seems to lead to a local or personal advantage. To avoid these problems the chain of planning and progress control processes in organisations (goals–means hierarchy with all its IBS, PBS, OBS and WBS structures) should therefore:

- comply with the five rules of stratification.
- be based on (linked) planning dipoles (see *Figure 2*).

Some examples:The planning dipole of a *single project* consists of:

- the Project leader.
- the Project Realisation Plan.

- all other members of the Project Team.

The planning dipole of a *functional department* consists of:

- the Head of a Department.
- the Department Schedule.
- all group leaders in that department.

The planning dipole of a *Portfolio Management Team* in a multi-project organisation consists of:

- the Masterplanner or Director of Projects.
- the Portfolio of Projects Plan.
- the project leaders and heads of departments concerned.

Planning dipoles and the theory of the goals–means hierarchy can be used for:

- the design of organisational structures.
- diagnosing organisations.
- describing hierarchies in terms of processes rather than structures.
- planning and progress control.

In the following section we discuss the impact of linked planning dipoles on the currently used planning and progress control processes.

Planning and progress control in classical models

The *Planning and Progress Control cycle* can be described with the Deming wheel[6] of quality improvement. The Deming wheel is widely known as *the Plan-Do-Check-Action cycle*, the PDCA cycle for short. De Jonge[7] added the component *Management* to the cycle and later Platje, Seidel and Wadman[1] further developed this cycle into the fully closed Project Planning Cycle with Management (PDCAM cycle for short) with the corrective *Action* block as a function of management. Thus, in a single project situation, *Management* and *Action* are both functions of the Project leader, placed on the same physical location but separated in time. The PDCAM cycle is given in *Figure 3*. The PDCAM cycle is fully applicable on planning dipoles. The managerial setpoint defines boundaries, priorities, resource constraints and goals of the single project. This managerial setpoint is the link to the next higher planning dipole.

The functional blocks of the PDCAM cycle for a single project are:

1. Managerial setpoint (boundaries, priorities, resource constraints and goals as set by the Management Team of the Portfolio of Projects.
2. Project with its actual performance of tasks (*DO*).
3. Reports about the proceedings of the project (*CHECK*).
4. A project planning or replanning (*PLAN*).
5. A Project leader who controls (*Project Leader*).
6. Reset a goal for corrective reasons (*ACTION or ASSESS*).
7. A reset authorised plan (*PLAN*) on the single project level.
8. Authorisation of the reset Managerial setpoint.

Remark: ACTION block 6 serves to correct for small internally caused deviations from the planned track. They are part of the project planning and progress control process. Handling of externally imposed large changes that change the track itself (e.g. a fundamental change of the requirement specification of the

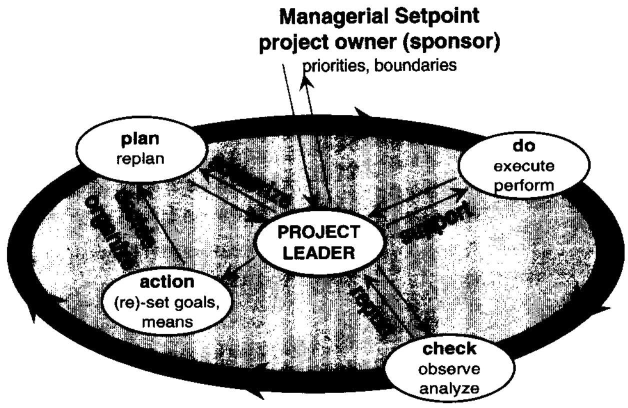

Figure 3 The Project Planning Cycle with Management (PDCAM) for a single project

project due to external influences) runs via the Management link of blocks 1 and 8.

The external directive for the single project planning dipole is the managerial setpoint, set by the project owner e.g. the Management Team of a Portfolio of Projects. On the multi-project level (or concurrence of phases in a single project) the boundaries, priorities, resource constraints and all project goals of every single project in the Portfolio of Projects are defined. The linking pins in this structure are of course the Project leaders and heads of Departments, who are both members of the Portfolio Management Team (the multi-project level) and of their own Project Teams (the single project level) and Departments.

On the other hand, all members of a Project Team have to plan their own activities to meet their personal commitments, because the responsibilities and competences of activities have been delegated to their level.

In this matter the PDCAM concept has functional connections to the surrounding organisational levels (upwards and downwards), making it a link in a chain with fractal structure.

Shortcomings of the PDCAM concept

It is a shortcoming of the usual PDCAM diagram that it does not indicate that item 7 (the reset authorised plan) does not lie in the same plane as (does not coincide with) item 4 (a project planning) of *Figure 3*.

The PDCA cycle is rather a PDCA spiral out of the plane of the paper with the project progress (time) on a vertical axis. There is of course no other causal connection between successive spiral windings than along the spiral itself. The flat PDCAM figure is only a flat projection along the time-axis.

Using this flat projection has three major drawbacks:

1. The PDCAM cycle has no time-dependent element,
2. The PDCAM cycle suggests a purely sequential winding up of *Plan*, *Do*, *Check* and *Action*.
3. There is no activity that implements a new plan after authorisation and yet implementation takes time.

Point 3 justifies the introduction of an *Implement* block, that is part of both the ongoing activity stream and the corrective action stream and carries a newly reset plan into effect. This implementation phase is generally regarded as a part of the classical 'DO' block. The authors find that in some situations this may indeed be the case, but only if implementation requires very little effort and time. In many cases where larger efforts are needed, such as processes with learning curves, the introduction of a quality assurance system or the training of a new employee, implementation takes a notable time before it takes effect.

In real life, planning and progress control situations have continuous and discontinuous activities:

- Continuous activities are the *project deployment* itself (*DO*) and *Project Management* by the project leader.
- Discontinuous activities are corrective *Action* by the Project leader and *Check*, *Plan* and *Implement* by the Project Team.

For these reasons we find that the original PDCA cycle and the PDCAM cycle do not fully describe the whole planning and progress control situation or its development in time. For many discussions, the flat PDCAM projection is quite adequate, though, and we will continue to use flat figures where appropriate.

The PDCAM cycle in terms of delays

In the PDCAM cycle, several activities are grouped and chained. All these activities take their time and cause inevitable delays. Many of these delays can be identified in the PDCAM cycle. See *Figure 4*. Time proceeds in a clockwise direction.

The PDCAM diagram has mainly four major loops:

1. The first loop is the main *primary process loop*, with its delay *T line*. A correction in a plan takes a time *T line* to reach the *DO* output to come in effect. It is blind time, so to speak.
2. The second loop is the *check loop*. It takes a total time of *T check* after a call for report before the project leader knows the actual situation. This is the time needed to generate a progress report.
3. The third loop is the *steering loop* where the project leader and his team actually co-operate. It takes a summed-up time *T steer* = the time it takes the project leader to compare actual and wanted situation, to reset goals *T regoal* and to authorise the new plan *T auth* before a deviation of the project can be corrected. It is often necessary to pass this loop more than once. This is an authorisation on the single project level. This loop is only active within the 'local' authority delegated to the project leader by Managerial setpoint.
4. The fourth loop is the *external authorisation* loop where the higher management authorises the new plan as a part of new Portfolio of Projects. This external authorisation process takes a time *T setpnt* before a deviation of the project can be corrected. In this loop the new boundaries and priorities on the single project level are authorised by the management on the multi-project level. We will discuss the effects of this external authorisation loop later.

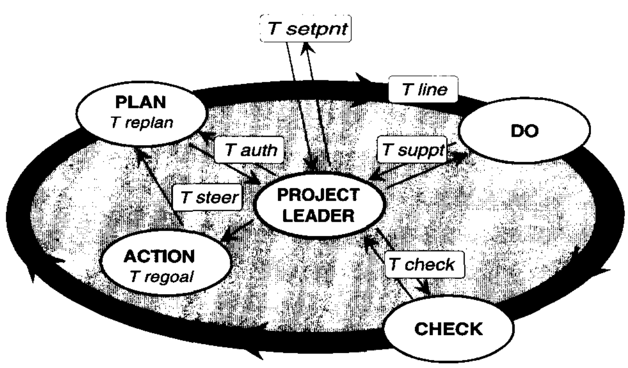

Figure 4 The locations of important delays in the PDCAM cycle

The PDCAM loop revisited: the birth of the PIDCAM loop

The PDCAM diagram suggests that all blocks containing *Plan*, *Do*, *Check* and *Action* are passed in succession in that order, with the project leader having connections with each via the *Management* block. This is not necessarily so. As mentioned, *Do* and *Management* are continuous and *Plan, Check, Action* are discontinuous. The logical step is to skip the *Do* block and integrate it in the cycle itself. It is now clear that the Project leader can give support to the *Do* activity at any time required, i.e. in any sector of the cycle. A support interaction is simply represented by a dual arrow lying on any radius of the cycle. The *Check* and *Action* block remain unaltered. At the end of the latter, however, we do not return to the primary cycle yet. The reason is that if the Project Team has replanned, there has to be authorisation first. Only if the new plan is authorised on the single project level (after a passage of the steer loop) and if not conflicting with the Managerial setpoint as set by the management on the multi-project level, it will be implemented in the running project.

Implementation is therefore a separate activity and we give it a separate block on the cycle. After implementation, there can be a finite free running time (*FRT*) without management interventions (apart from calls for support from the Project Team), before a new *Check* block is started. Thus the sequence can be best described as *Plan*, *Implement*, *Do*, *Check*, *Action* with *Management*. For recognition, we use the acronym 'PIDCAM' for this loop. See *Figure 5*.

This PIDCAM diagram now has interesting properties. The *Do* cycle and the *Management* centre are continuous in time, which runs clockwise around the centre. This makes this figure a functional diagram and a phase diagram in one presentation. As indicated in the diagram, the whole control cycle takes its time, and there is a free running time (*FRT*).

The actual control period is represented by one full 360° turn. The cycle starts at *Cycle start* and after *T check* a progress report is ready. Then during a period *T steer* an authorised plan is made, and finally the plan is implemented, taking *T line* to take effect. Here is the end of the control cycle; the rest of the time is *FRT*. The times taken in *T check*, *T steer*, *T line* and *FRT* are presented as sectors of the whole cycle, with the angle they span proportional to the time they take. Using this presentation, it is very easy to see that if it takes too long to complete the control cycle, for instance by having to pass the steer loop two

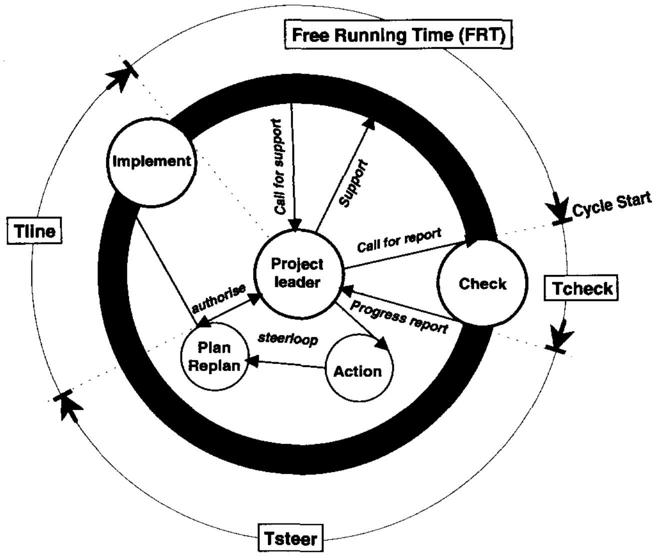

Figure 5 The PIDCAM cycle of Planning and Progress Control

(*Figure* 6b) or three times (*Figure* 6c), the cycle is choked if the spare time contained in *FRT* does not allow. The same is true if the managerial setpoint (containing the requirement specifications of the whole project) is altered too often. *FRT* decreases if the number of passes of the *replan* loop increases and may even become negative. This means disaster, because in that case the project leader is forced to steer on outdated information if a new control loop starts without him necessarily knowing. This is often the case if political issues are involved.

At this point it is totally obvious that the decision-making policy is very important. Making the wrong decision (maybe due to incomplete information) is often much better than making no decision at all. The former leads to a temporary deviation that is corrected afterwards, but the sometimes lengthy hesitations of the latter completely upset the control system. Here we define this decision making and steering policy as the *Conduct of Management*. The *Conduct of Management* is the functional approach management choose for their control parameters; it *is what they do to correct and by which means they choose to decide*. In cybernetic terms: it is the control algorithm.

This terminology is distinguished from the Management Style of McKinsey's 7S-model and from personal mastership as discribed by Peter Senge[8] which rather describes the manner in which management corrects; *or how they do it* in their organisations. This conduct of management is not always determined by aligned personal visions and project progress motives as it should be, but also by project-wise totally irrelevant matters like personal careers and/or political motives more often than not. Despite many differences it is very well possible to compare the PIDCAM cycle to a cybernetic control loop as explained in the next paragraph, although the control algorithm contains many human, non-deterministic factors. These human factors in terms of team motivation, the ability to direct human energy, confidence and trust, empathy, charisma, creativity and intuition. The quality of these human factors depends on the *personal* development of the projectleader rather than on his professional development. Training peoples' personal qualities is very often forgotten in industrial organisations because it is the culture to regard them as 'soft'. These personal capabilities of a projectleader are a measure of so-called personal empowerment and they can potentially make explicit why some PL's simply do better than others. The Conduct of Management contains the key to successful Project Management in a given environment.

Project Management has developed from a systems oriented methodology, through 'goal orientation' to Project-Based Management. It developed from a topic in which computers were pre-eminent, to one in which people, interpersonal and intergroup relationships predominate.[9] Therefore Project Management is not equal to cybernetic control. Nevertheless, there are a few very strong cybernetic control loop truths that apply to Project Management very well. These truths are:

- A clear, unambiguous and authorised plan is needed and it must be known to everybody dealing with it.
- Project leaders should be sensitive to weak signals of potential disturbances coming from the project team. Constant interaction is necessary.
- A communication protocol between organisational levels is a must.
- Management by exception is not enough; a project leader must be active all the time but also have an open eye to stochastic variations.
- Delegate work and responsibilities and competences to the lowest possible level.
- A project needs performance indicators at all levels.

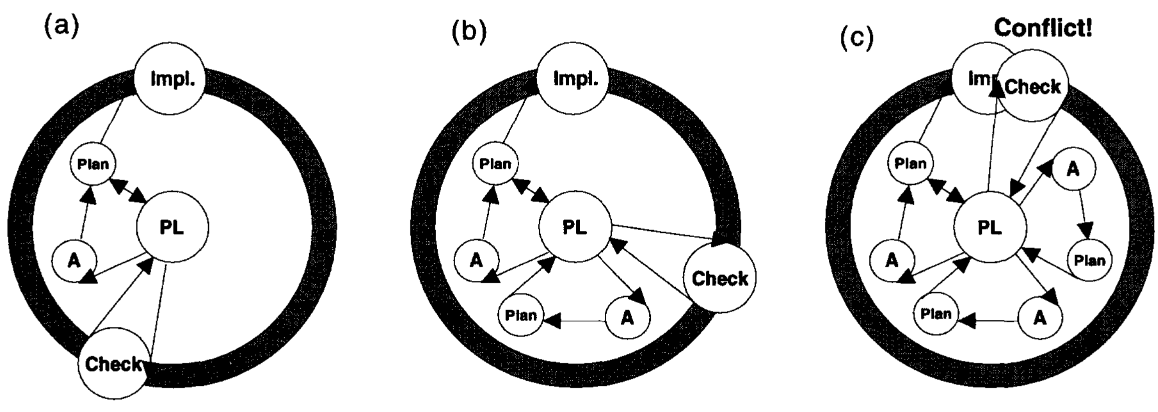

Figure 6 Choking of the control cycle in case of too many delays

- Corrective actions must get time to take effect before being reassessed (don't panic).
- Cumulating delays are killing and destabilise the control loop.
- During stable periods of a project, different conduct of management is needed than during dynamic periods.
- In different stages of a large project, different conduct of management is needed, maybe coming from different project leaders.
- Project planning, progress report timing and meeting agendas have causal links and are not necessarily coupled to the calendar. Meeting as needed is better than periodically.
- Level skipping is very disturbing and deregulating.
- Different types of organisations need different styles of conduct of management.[10–12]
- The conduct of management should react and adapt flexibly to the current situation of the complex set of influences. In cybernetic controls, this situational flexibility is known as fuzzy logic.

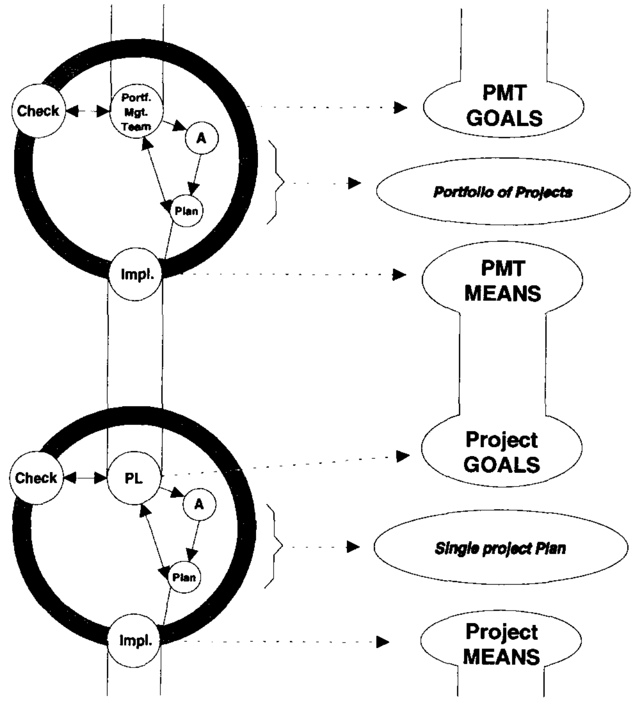

Figure 7 The Goals–Means hierarchy in a multi-project situation described in PIDCAM loops (part of a fractal chain)

The multi-project situation

The PIDCAM planning and progress control cycles of a Portfolio of Projects (the multi-project situation) are hierarchically coupled from the *Management* function block to the *Implement* block of the next higher organisational level, because the Project leader of a single project should be member (linking pin) of the Portfolio Management Team as stated before. The situation where several activities in a project are carried out concurrently in order to speed up the project deployment (usually at the cost of certainty and predictability) is very much the same as the multiproject situation, but one fractal level deeper. As we have already pointed out, we consider the whole range of projects as a fractal structure in all organisational levels. Therefore the 'Portfolio-' and 'Project' levels are only two subsequent levels in a longer hierarchical chain, all whose links have similar structures at their aggregate levels.

After a deterministic process in which all planning dipoles have been defined according to the five laws of stratification it is possible to construct a goals–means-hierarchy. For a Portfolio of Projects-plan the Project-plans and the Department Schedules are the means to reach a certain goal. In this way, a Project-plan sets a goal for the single project, but at the same time the project result (goal) is a means to reach a higher goal for the Portfolio of Projects. Thus a whole goals–means hierarchy can be constructed, running as a parallel link-chain to the planning chain. See *Figures 2 and 7*.

The PIDCAM loop takes a form that is particularly well suited to illustrate this structure. In *Figure 7*, two links of a chain (the Portfolio of Projects and a linked Project) are given in the left part. The links couple as explained above. This chain is the Project Breakdown Structure (PBS). The goals–means hierarchy is indicated in the right half of the diagram and arrows indicate the functional loci of the communication processes. This chain contains the Information Breakdown Structure (IBS).

In this sense, the multi-project situation can be characterised as a construction of multiple coupled PIDCAM cycles in series and parallel in a fractal tree-structure. It is pointed out that there is a phase-dependence between all projects. This means that undue delays in one project may have repercussions in other

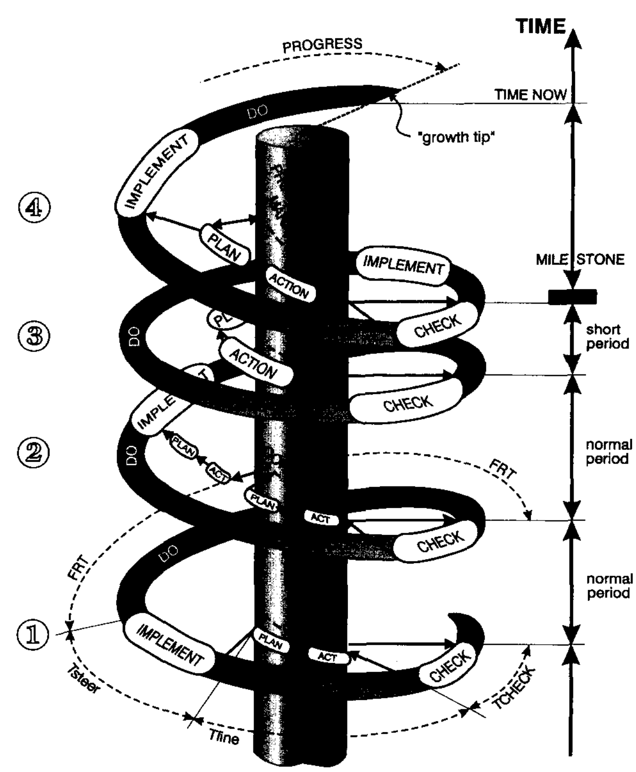

Figure 8 The planned PIDCAM spiral of a single project (ideal situation)

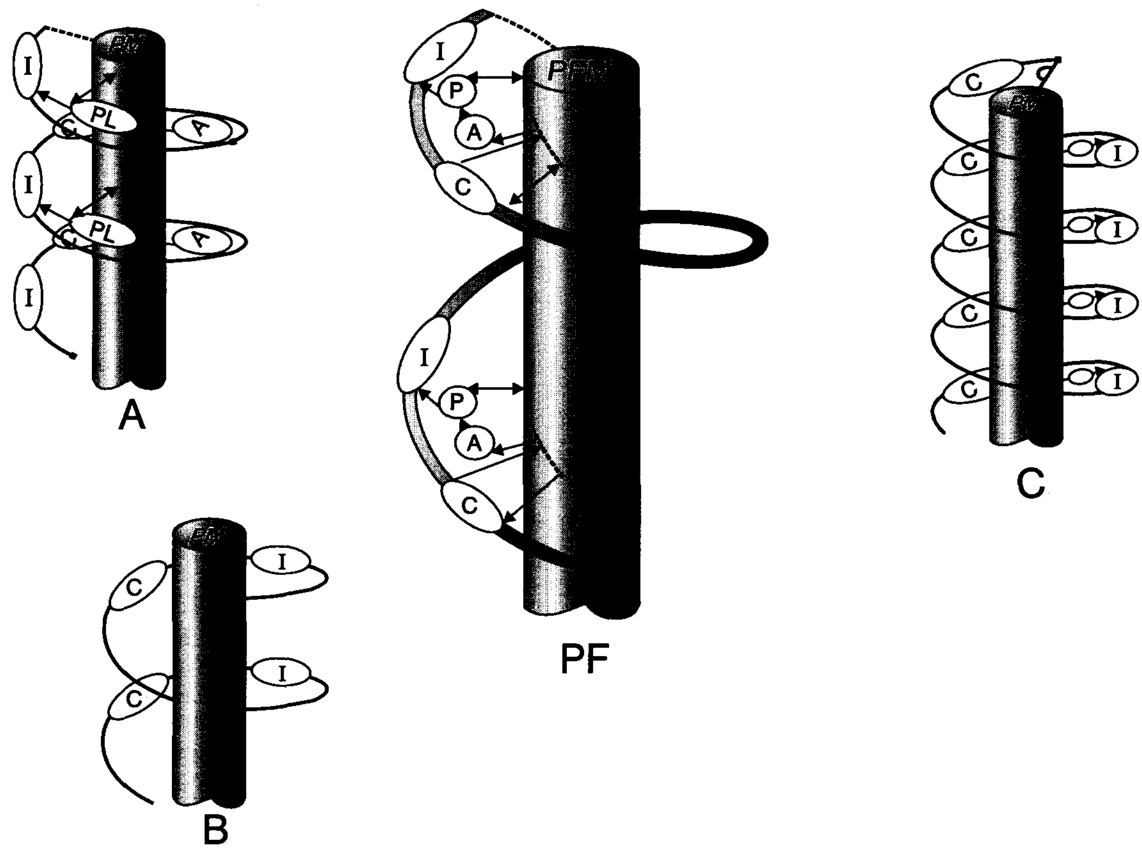

Figure 9 PIDCAM spirals in a Portfolio of Projects or concurrent activities in a monoproject

projects and the whole Portfolio of Projects.

Development into the time-resolved PIDCAM spiral

Like the PDCA loop, the PIDCAM loop is actually spiralling up in the time domain. *Figure 8* gives a preliminary impression of the concept. The cycle is now projected on a spiral ribbon surface. This surface carries all activities that have to follow the planning. While the rotation along the spiral rim can be considered as the project-axis, the vertical progression can be regarded as the time-axis. It is unnecessary to say that there will always be deviations from the strictly regular spiral pitch (number of calls for report per unit of time) or the tightness of winding of the spiral and deviations from its diameter (claim of capacity). To cope with these continuous changes, flexibility is provided by management-as-needed rather than management-as-planned. It is a living system coloured by the personal conduct of the individual managers involved on all levels.

The situation of the project at any given moment is a horizontal section through the spiral. The connection at *TimeNow* is the *growth tip* of the figure. The angular phase of the developing spiral indicates the present situation in the project. In terms of *Figure 7* the project is now half-way a free running period.

The cycles 1 to 4 in *Figure 8* illustrate different situations of project control.

Cycle 1 is an *everything allright*-cycle with only small deviations to correct in the ACTION block. *Tline* is rather short here and there is a lot of time FRT with little to manage.

Cycle 2 implies a larger correction that is only authorised after a second round through the steering loop. It takes longer before the correction is implemented at the cost of FRT.

Cycle 3 faces an oncoming milestone and is characterised by frenzy activity. The whole cycle is shorter in time and FRT is reduced to almost nothing but as the next CHECK arrives the milestone is passed. Ready just in time!

Cycle 4 is again normal and allows the team to relax a little, but usually only to make sure that they have to hurry again for the next milestone!

Even more interesting is the picture when drawn for a whole Portfolio of Projects. *Figure 9* gives a simplified image of the situation for a Portfolio of three parallel projects.

The middle spiral is a representation of the activity of the Portfolio Management Team (PMT) and the other three (A,B,C) are connected projects. The figure is also valid for concurrent, separately managed activities in one project. The PMT spiral revolves at a slow speed. The project spirals A,B,C are wound tighter, indicating a faster control cycle, but not necessarily harmonic (single Project control cycles in a Portfolio of Projects can be restarted at any given phase due to a redefinition of Managerial setpoints).

In *Figure 9* we can see the importance of phase coupling between the PMT cycle and the mono-projects. At TimeNow, the PMT cycle has just passed the block *Implement*. This means that the Project leaders have just agreed upon a new planning in their projects, and now they have to implement it.

Project A has also just passed its *Implement* block and is therefore inaccessible to any readjustment before the end of next cycle ("hear no evil, see no evil"), unless the existing cycle is broken off (unharmonically) and a newly synchronised cycle is started. This is of course what should be done in practice.

Project B is at the beginning of its *Check* block, which is a favourable moment to initiate a new planning cycle.

Project C on the other hand was in phase with the PMT cycle, so that it had completed its progress report cycle just-in-time. Here the project is in a receptive phase and the Project leader starts a new corrective action block, so that the PMT instructions (managerial setpoint) can be incorporated in the revised planning seamlessly.

Vertical projection of the last figure produces of course the planning sectors loops for the whole Portfolio of Projects.

Conclusions

- Planning dipoles are the building blocks of organisational structures.
- Planning dipoles and Hartmanns laws of stratification can be used as diagnostic as well as design tools for organisations.
- The progress of single projects as well as the Portfolio of Projects can be projected on a PIDCAM spiral to visualise their interdependencies in a quantifiable way.
- The application of PIDCAM-cycles in a well designed goals–means hierarchy enables better planning and progress control processes based on double interaction.
- Conduct of management determines the quality of planning and progress control on all organisational strata.
- Conduct of Management is governed by personal empowerment and makes the quality aspects of projectleadership explicit.

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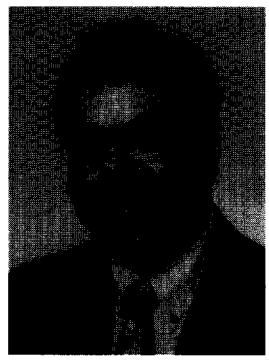
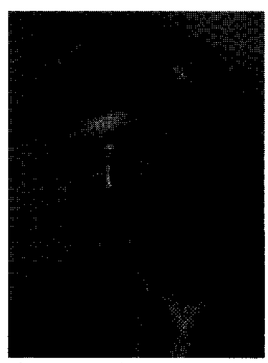


Adri Platje is a consultant in Project Management at Applicon Project Management, Veldhoven, The Netherlands. His professional experience covers management, consultancy and support in a broad range op projects in professional, industrial and international R&D environments. Since 1978, he has been involved in the operational development and application of industrial models and multiproject management concepts. He is a consultant in quick-scan studies on the architecture and on the project-management profile of project organisations. He uses the techniques of coupled planning dipoles to assess the quality of planning processes. In 1995 he started a special working group within the Dutch Project Management Institute to investigate the application of creativity and intuition in the field of Project Management. Topics here are: teambuilding, Project Start Up workshops and Future State Visioning processes.



Sipke Wadman has engaged in many project activities in applications within Philips, Eindhoven, the Netherlands since 1973. He has been active in the whole range of environments from fundamental reseach laboratories to factory floors across the whole span of industrial activities of Philips. He is now project leader of multinational European R&D and manufacturing process projects. He is also a consultant on energy consumption reduction programmes in manufacturing plants. He is an active member of a professional network interested in the theoretical and applied development of models, tools and techniques for the enhancement of project management. He is also interested in the project-management aspects of novel techniques for the mobilisation of creativity in members of project teams.