Project Management at CERN

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Engineering Department

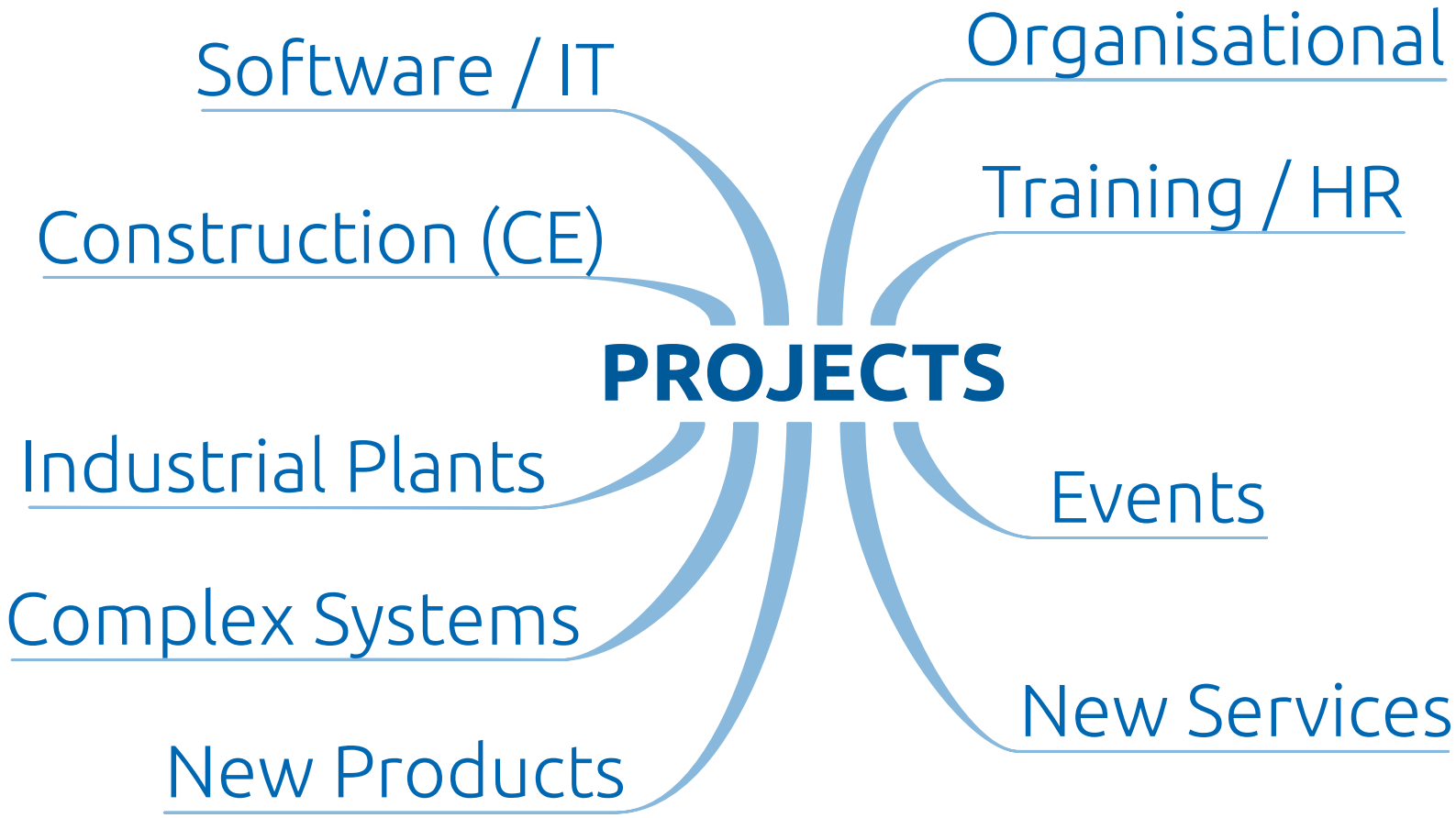
ENGINEERING
DEPARTMENT

RIGI Meeting @ CERN

Contributions from CERN to Project Management

Outline

- **PRAM** in the Sixties
- Web-based tools of the Nineties
- **Project Control 2.0** in the years 2000s
- openSE in the years 2010s
- Will **Project Planning & Scheduling 2.0** be next?


Software / IT
Organisational
Construction (CE)
Training / HR
PROJECTS
Industrial Plants
Events
Complex Systems
New Services
New Products

PRAM in the Sixties

PRAM in the Sixties

CERN PS 56-59

CPM in 1959

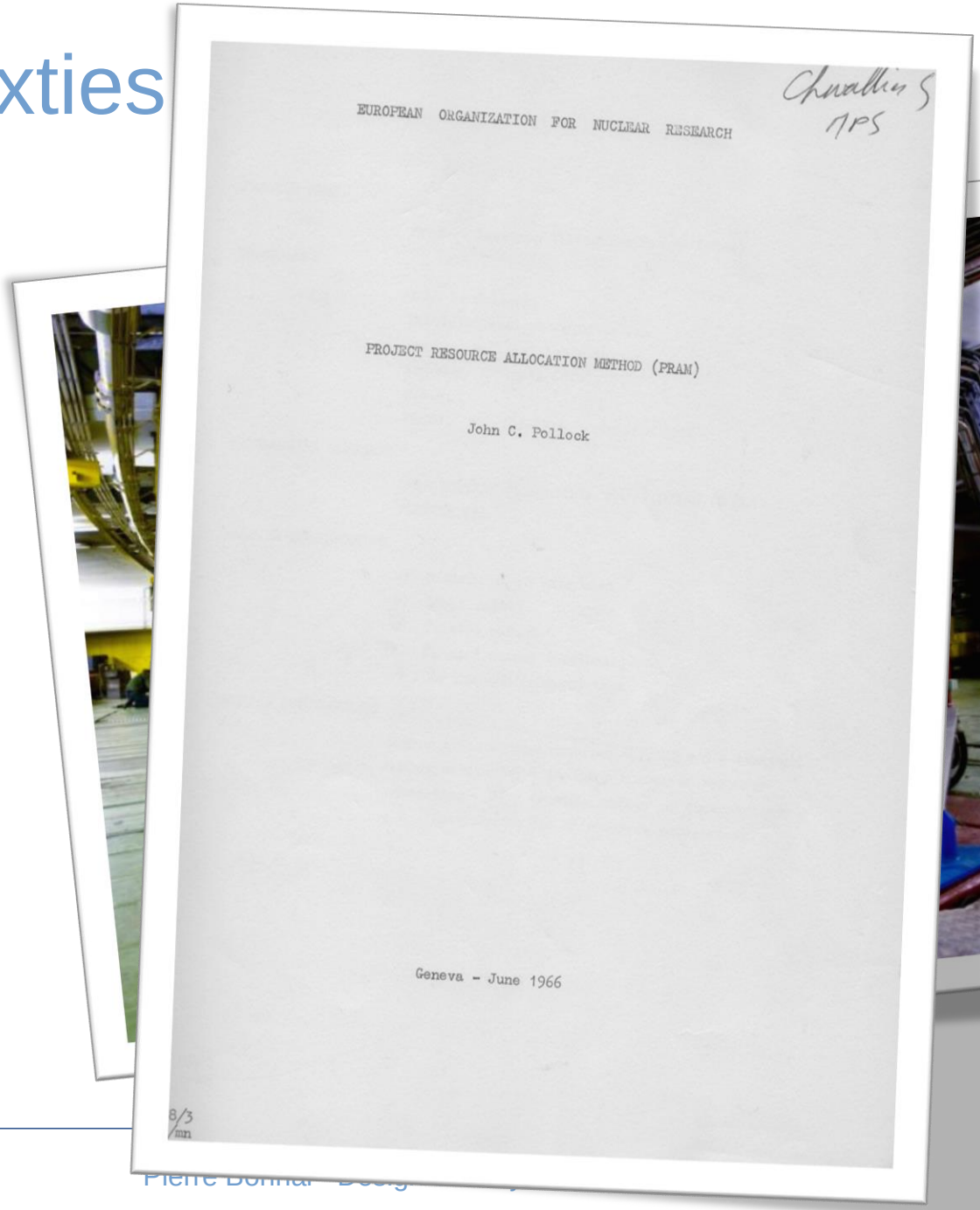
PERT in 1959

PDM in 1960-68

PRAM in 1966

RCPS in mid-60s

CERN ISR 67-71


EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Chevallier S
TPS

PROJECT RESOURCE ALLOCATION METHOD (PRAM)

John C. Pollock

Geneva - June 1966

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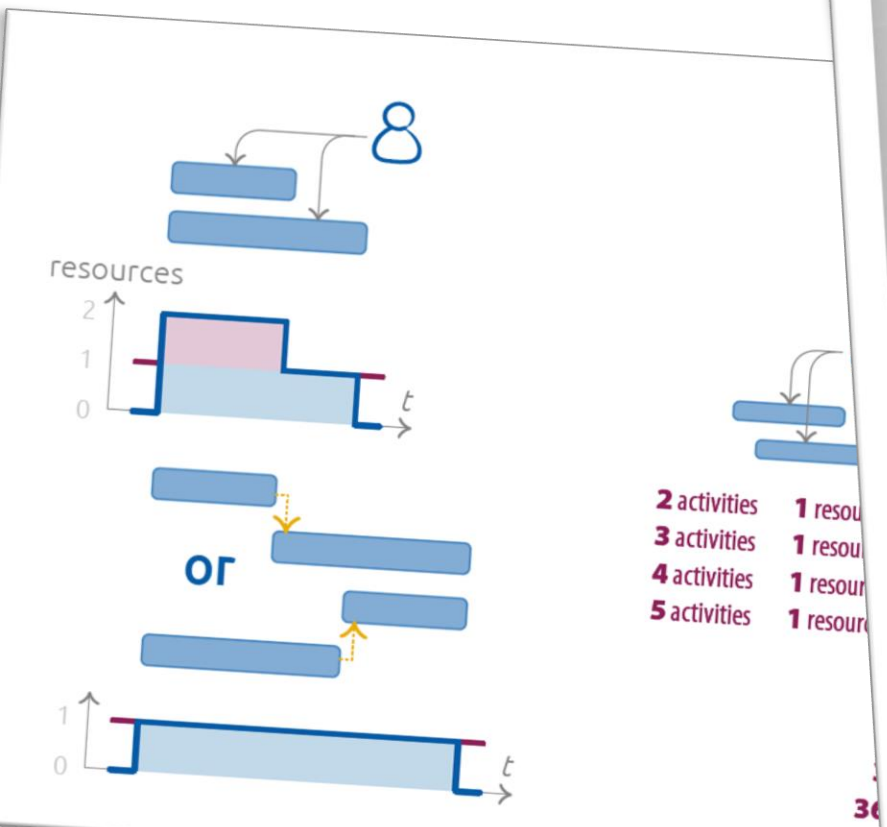
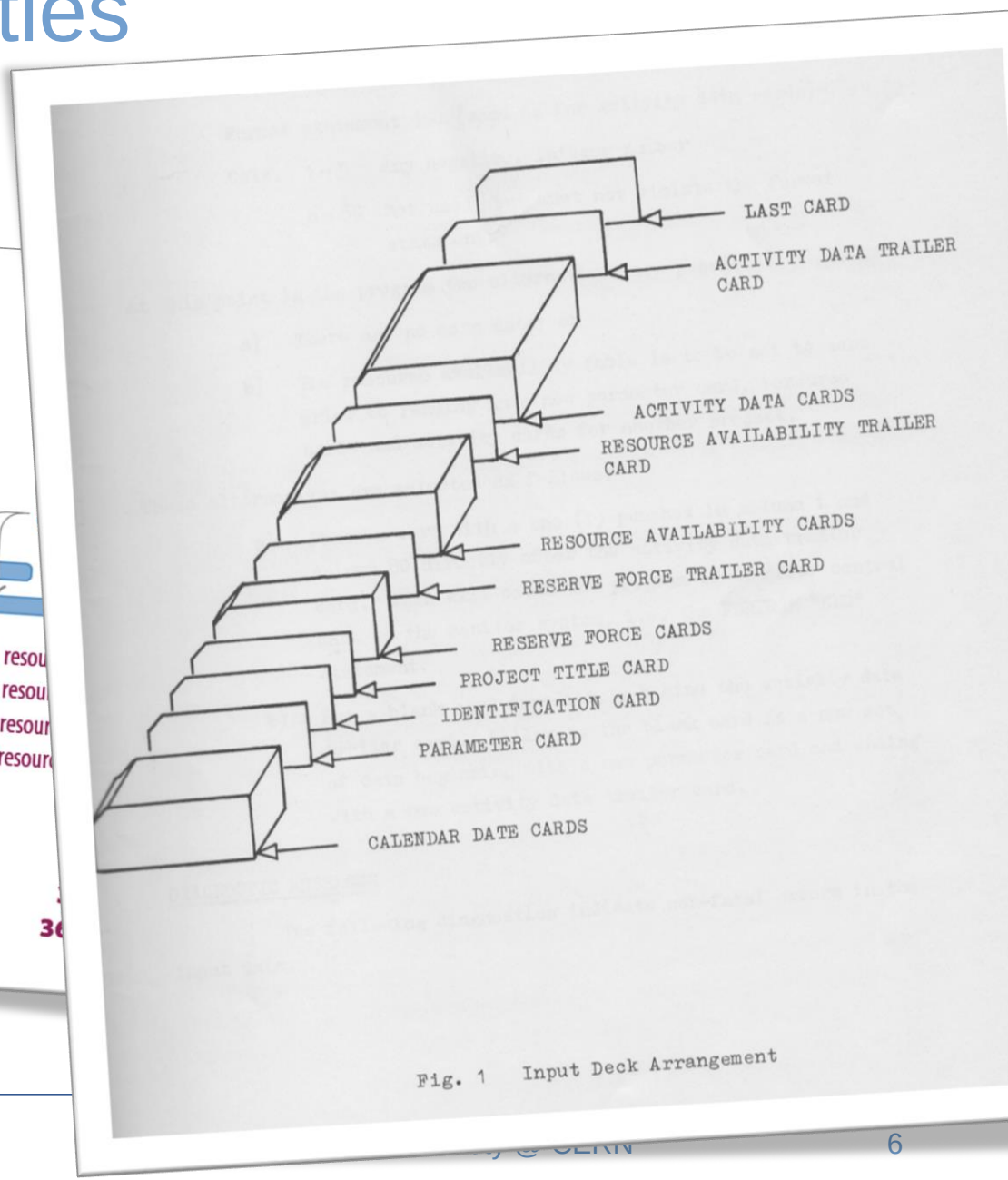
mn

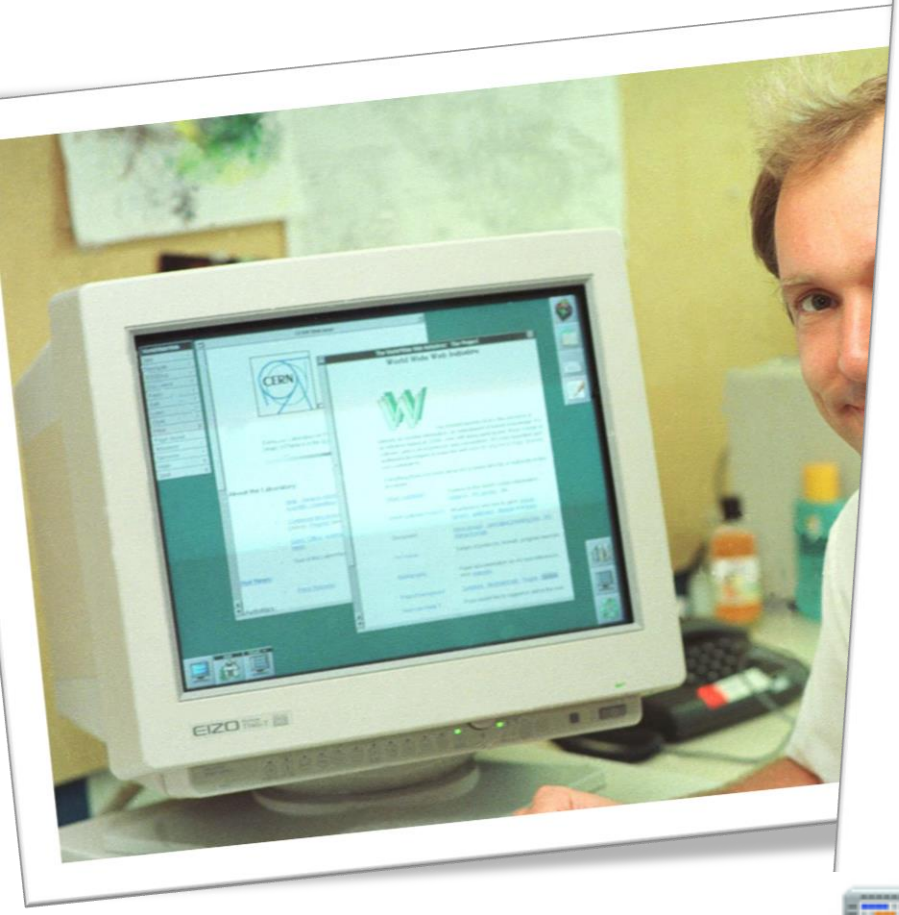
PRAM in the Sixties





Web-based tools in the Nineties

Web-based tools o



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
Laboratory for Particle Physics

ALICE/96-02
Internal Note GEN
ATLAS Internal Note
TECH-No-17
CMS TN/96 016
CN/96/2
ECP 96-03
EST 96-02 (ISS)
LHC/96-03 (VAC)
TN-PPE-TA1/96-05
ST TECHNICAL NOTE

Progress Report of the Engineering Data Management System Task Force

J.-L. Chevalley, G. Faber, W. Flegel, A. Herv , C. Hauviller (Chairman), W. Klempt, J- Kuipers, R. Loos, B. Nicquevert (Secretary), A. Onnela, M. Price, G. Rollinger, W. Witzeling/PPE, A.-P. Hameri, M. Mottier, J. Nikkola, T. Pettersson, J. Schinzel, M. Tarrant, J. Vuoskoski/EST
P. Farthouat, P. Palazzi, B. Rousseau/ECP
M. Ferran, N. Hoimyr/CN
J. De Jonghe/AS
P. Strubin/LHC
S. Oliger/ST

An Engineering Data Management System (EDMS) is a collection of tools and rules, which enables, as a minimum, a body of vetted information to be built up in a safe place and be easily accessible to the users. The Task Force worked through 1995 - to elucidate CERN's needs for an EDMS in the construction and lifetime of LHC and its experiments, - to discover the state of the art of EDMS and find a product on the market which fulfilled CERN's needs. A Call for Tenders was issued in December 1995 and the replies are being evaluated.

The name CEDAR has been chosen for the activity of implenting an EDMS at CERN (CERN EDMS for Detectors and Accelerators) see http://cadd.cern.ch/cedar/

Administrative Secretariat
LHC Division
CERN
CH - 1211 Geneva 23

Geneva
31 Jan

EDMS

CDS

APT

IMPACT

indico

Project Control 2.0 in the years 2000s (EVM LSM RSM)

Project Control 2.0

Large Hadron Collider 1995-2008

Multi-billion-CHF project → very large scale
Many contributors, several sources of funding

Highly technological project → several challenges
Sufficient room for creativity and innovation

Performance-driven project → it must work!
Even if it takes more time and more resources

Highly distributed project → really worldwide!

Public-funded project → public auditors

Project Control 2.0 (cont'd)

In 1994 → "Must Win" project, under-funded and under-resourced!

All CERN's departments involved in some ways

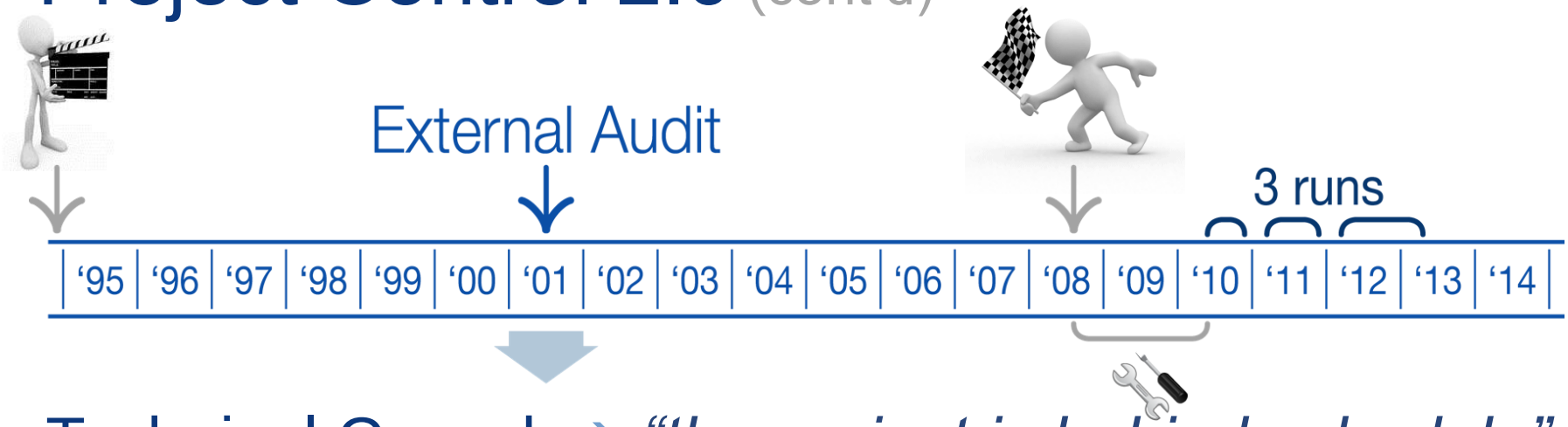
LHC Project Leader appointed as a director

Budgeting and cost control → Project Administrator

Planning and scheduling → Technical Co-ordinator

No link between the cost control system and the scheduling system!

Project Control 2.0 (cont'd)



Technical Co-ord. → *"the project is behind schedule"*

Project Admin. → *"the project is under-running"*

The LHC Project Management Team was not in capacity to demonstrate that EAC < TAB

Member States asked CERN Management to set up an appropriate Project Control System

Project Control 2.0 (cont'd)

Multi-level planning and scheduling
3 levels → master, co-ordination and detailed

Earned Value Management-based

Interfaced to accounting system → Actual Costs

Interfaced to contract management system

Interfaced to human resource management system

In-kind contributions

Collaborative and web-based ← obvious!

Lean → planning + reporting by Project Engineers

Project Control 2.0 (cont'd)

But how to get rid of the 90%-syndrome?

Deliverable-oriented PM System

Project Control 2.0 (cont'd)

Transparency of the physical progress reporting

A "*10 magnets out of 20*" physical progress statement is more informative than a "50% complete" statement!

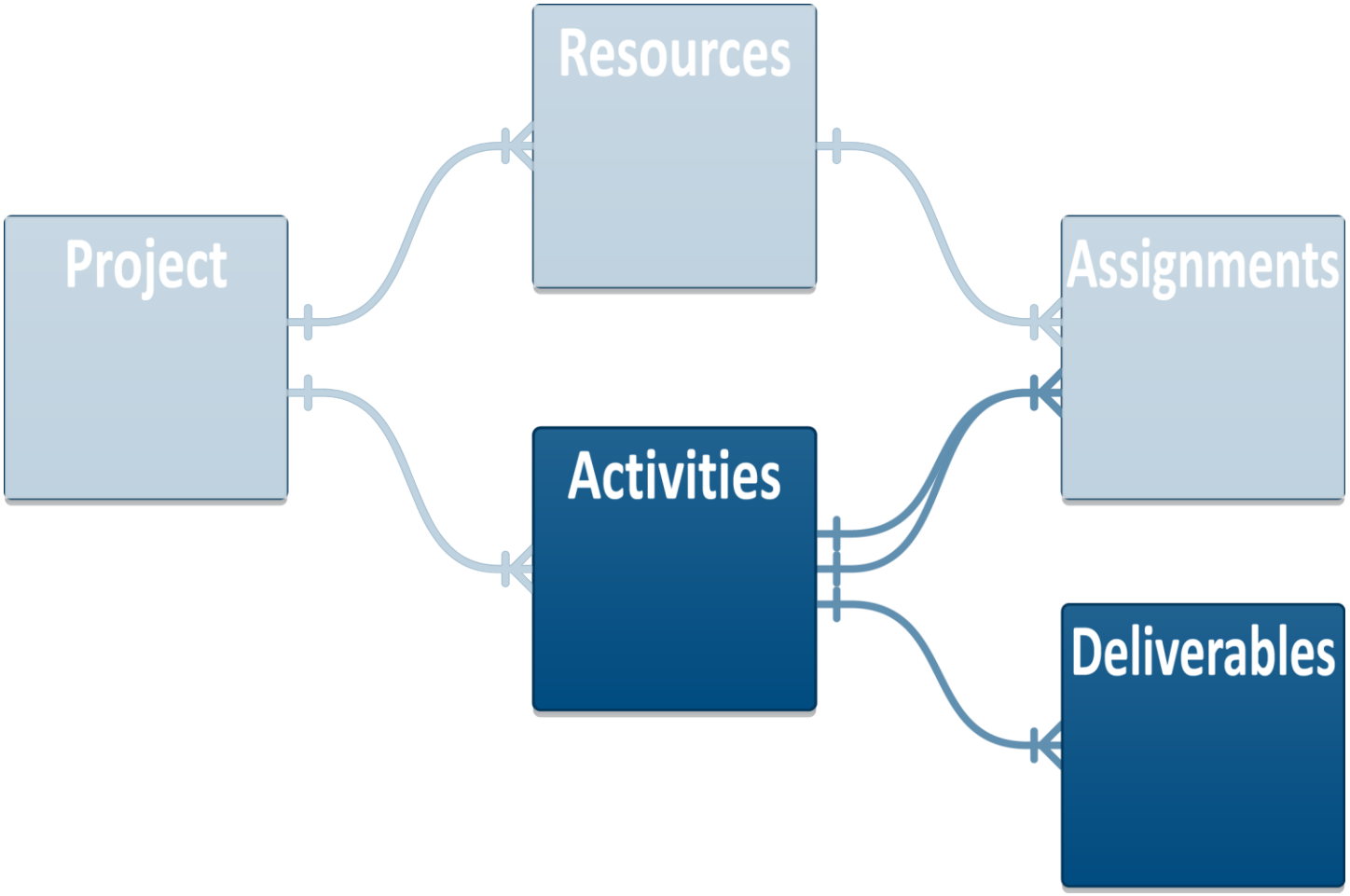
Payment milestones of **result-oriented contracts** refer to effective deliveries

Finish dates of contract activities are always known!

Finally, a trend in project management practices

(ref. Patrick A. Howard. *Deliverable-oriented project management*. ProjectWorld'98 Proceedings, 1998)

Project Control 2.0 (cont'd)



Project Control 2.0 (cont'd)

A start date + a finish date

one of Microsoft Project

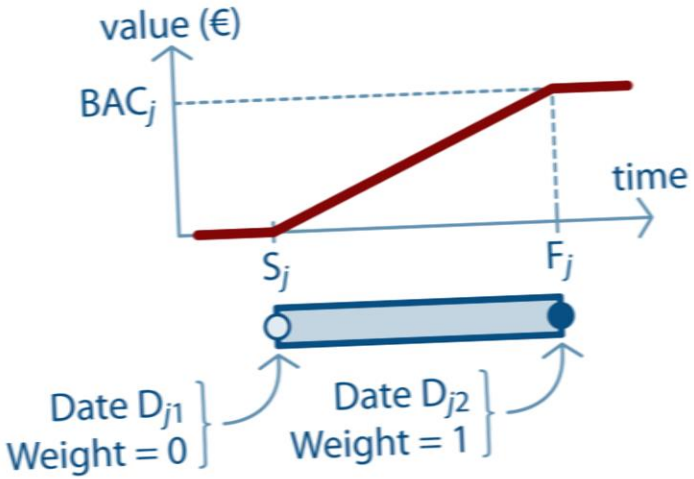
Stand

Outsourced

Complex

Level-of-Effort

E.g.: the activity that consists of managing the project to which the project manager is assigned to`



before D_{j1} : $\varphi_j = 0\%$

d between D_{j1} and D_{j2} : $\varphi_j = \frac{\mathbf{d} - S_j}{F_j - S_j}$

after D_{j2} : $\varphi_j = 100\%$

LHC Project EVMS | *Weak points*

Introduced while AC = CHF 1 billion!!

Granularity between contract breakdown structure, co-ordination schedule, codes of accounts…

Too many activities → 12’000+ activities

Varying granularity of activities:
from a few kCHF to several MCHF
from a few weeks to several months

Project Engineers planned too optimistically

Weak integration with schedule networks

LHC Project EVMS | *Lessons learned*

Number of planned activities < 500
Work Package vs. Planned Package features

Constrain the size of the activities so that:

- 80% of the activities in range 0.2% – 2% BAC
- Duration < 10% project duration and 3 months
- No. of level-of-effort activities in range 1 – 1%
- Unambiguous responsibility → only one per activity

Systematics in breaking down to ease taking over

LHC Project EVMS | *Strong points*

Delive amework

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Micros DBs

Strongl ses

Planned gures

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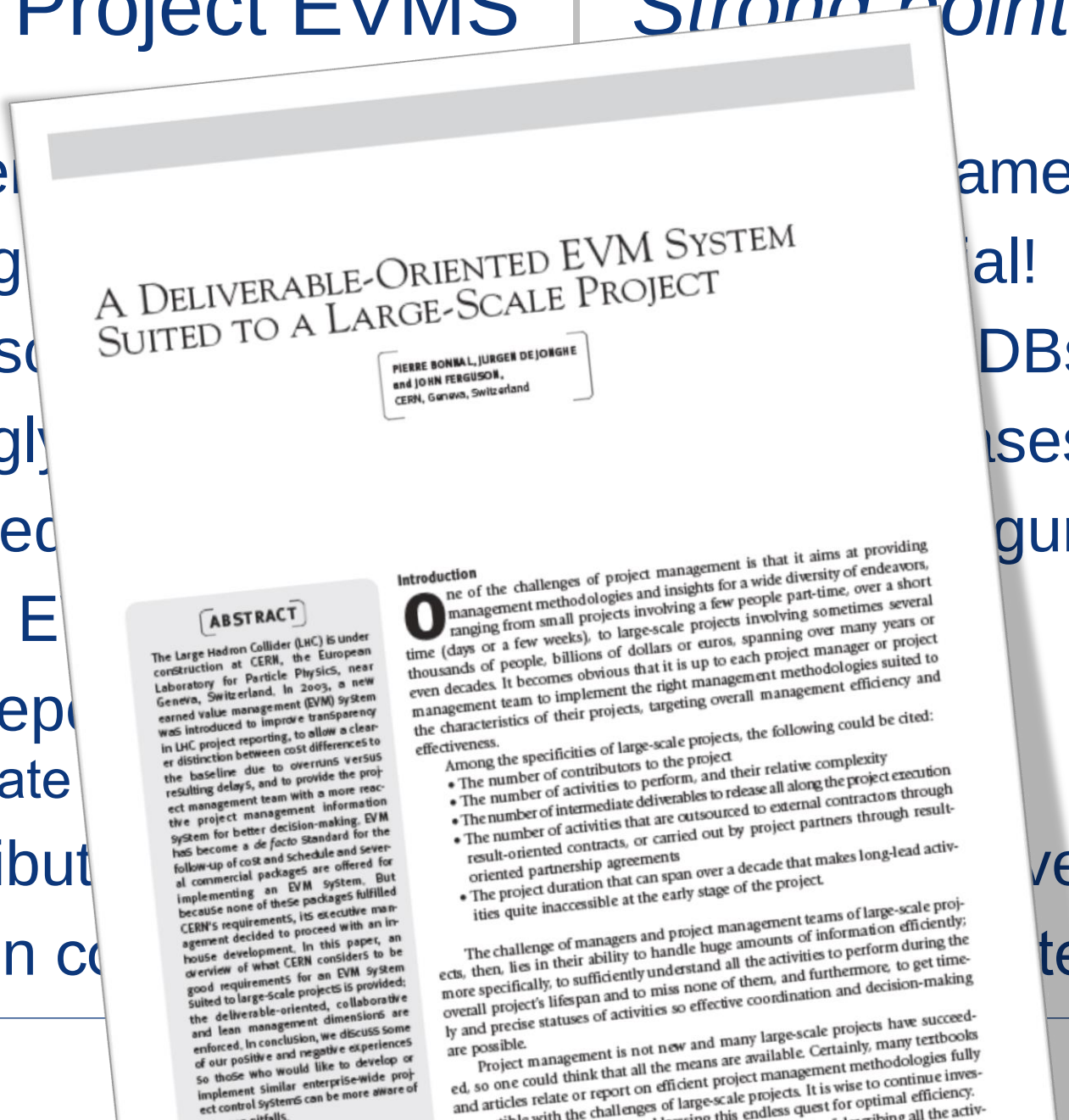
One rep

(eliminate

Contribut vels

Regain c tes



A DELIVERABLE-ORIENTED EVM SYSTEM SUITED TO A LARGE-SCALE PROJECT

PIERRE BONNAL, JURGEN DEJONGHE and JOHN FERGUSON,
CERN, Geneva, Switzerland

ABSTRACT

The Large Hadron Collider (LHC) is under construction at CERN, the European Laboratory for Particle Physics, near Geneva, Switzerland. In 2003, a new earned value management (EVM) system was introduced to improve transparency in LHC project reporting, to allow a clearer distinction between cost differences to the baseline due to overruns versus resulting delays, and to provide the project management team with a more reactive project management information system for better decision-making. EVM has become a *de facto* standard for the follow-up of cost and schedule and several commercial packages are offered for implementing an EVM system. But because none of these packages fulfilled CERN's requirements, its executive management decided to proceed with an in-house development. In this paper, an overview of what CERN considers to be good requirements for an EVM system suited to large-scale projects is provided; the deliverable-oriented, collaborative and lean management dimensions are enforced. In conclusion, we discuss some of our positive and negative experiences so those who would like to develop or implement similar enterprise-wide project control systems can be more aware of

Introduction

One of the challenges of project management is that it aims at providing management methodologies and insights for a wide diversity of endeavors, ranging from small projects involving a few people part-time, over a short time (days or a few weeks), to large-scale projects involving sometimes several thousands of people, billions of dollars or euros, spanning over many years or even decades. It becomes obvious that it is up to each project manager or project management team to implement the right management methodologies suited to the characteristics of their projects, targeting overall management efficiency and effectiveness.

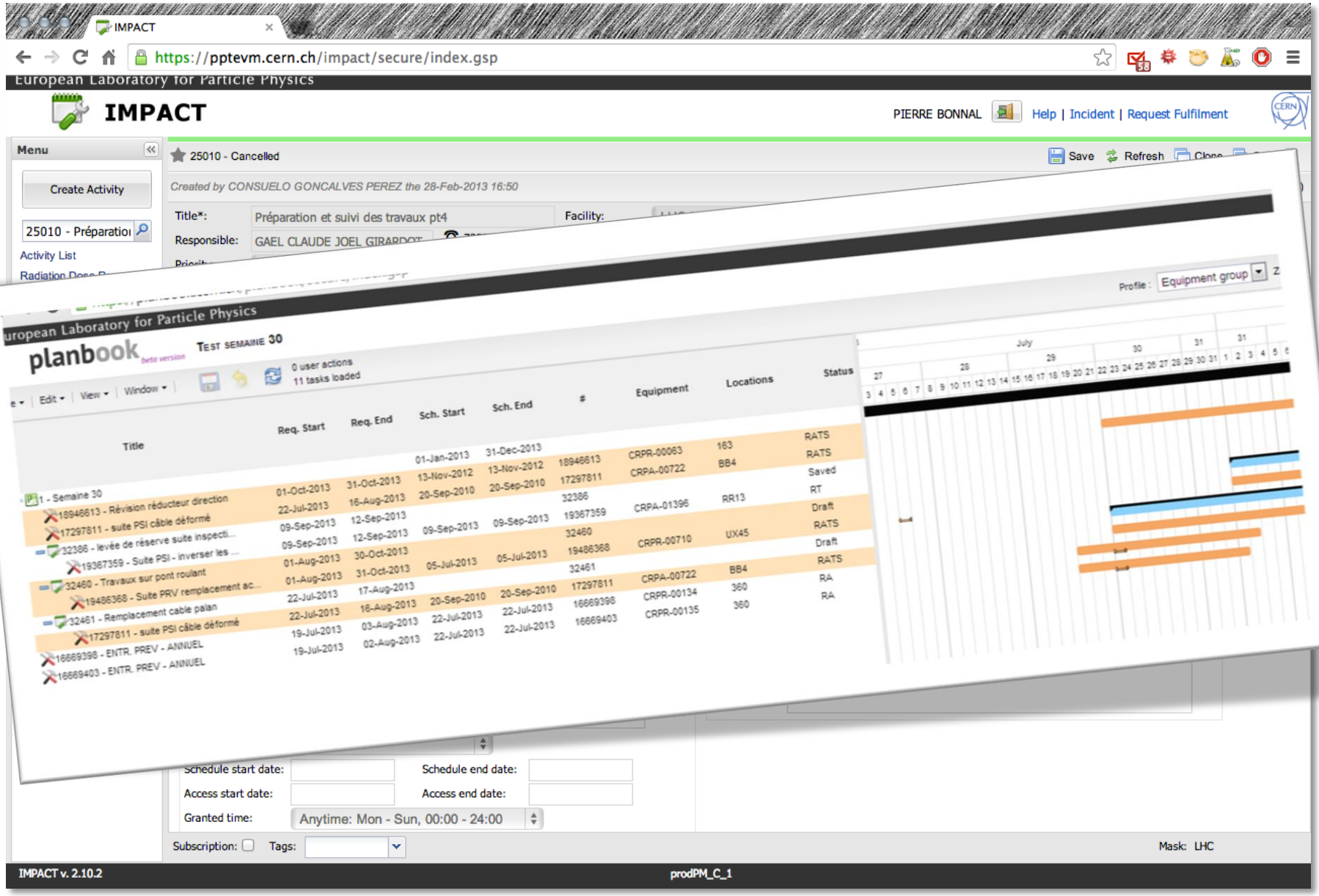
Among the specificities of large-scale projects, the following could be cited:

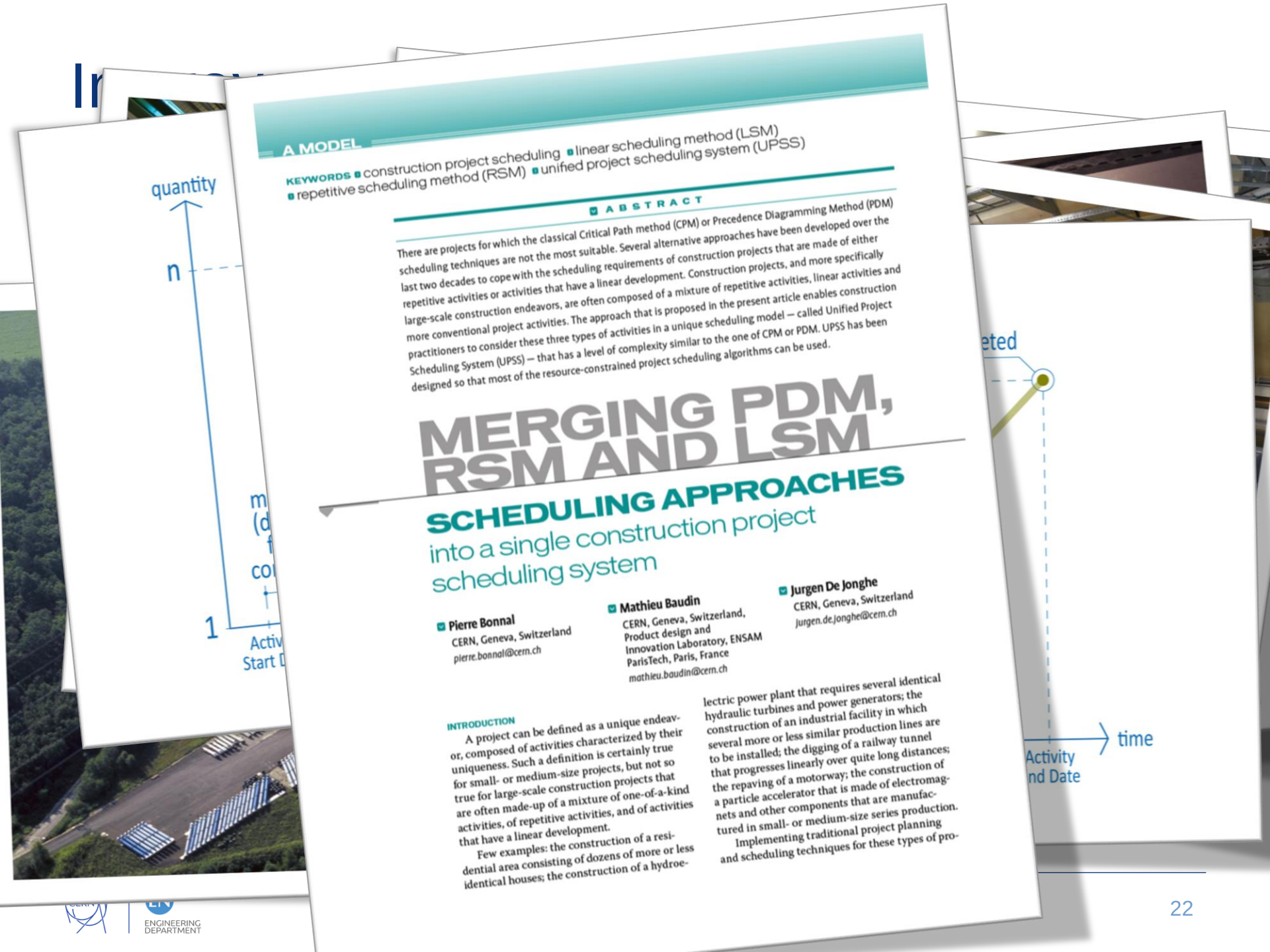
- The number of contributors to the project
- The number of activities to perform, and their relative complexity
- The number of intermediate deliverables to release all along the project execution
- The number of activities that are outsourced to external contractors through result-oriented contracts, or carried out by project partners through result-oriented partnership agreements
- The project duration that can span over a decade that makes long-lead activities quite inaccessible at the early stage of the project.

The challenge of managers and project management teams of large-scale projects, then, lies in their ability to handle huge amounts of information efficiently; more specifically, to sufficiently understand all the activities to perform during the overall project's lifespan and to miss none of them, and furthermore, to get timely and precise statuses of activities so effective coordination and decision-making are possible.

Project management is not new and many large-scale projects have succeeded, so one could think that all the means are available. Certainly, many textbooks and articles relate or report on efficient project management methodologies fully

Improvements





A MODEL

KEYWORDS ▪ construction project scheduling ▪ linear scheduling method (LSM) ▪ repetitive scheduling method (RSM) ▪ unified project scheduling system (UPSS)

ABSTRACT

There are projects for which the classical Critical Path method (CPM) or Precedence Diagramming Method (PDM) scheduling techniques are not the most suitable. Several alternative approaches have been developed over the last two decades to cope with the scheduling requirements of construction projects that are made of either repetitive activities or activities that have a linear development. Construction projects, and more specifically large-scale construction endeavors, are often composed of a mixture of repetitive activities, linear activities and more conventional project activities. The approach that is proposed in the present article enables construction practitioners to consider these three types of activities in a unique scheduling model — called Unified Project Scheduling System (UPSS) — that has a level of complexity similar to the one of CPM or PDM. UPSS has been designed so that most of the resource-constrained project scheduling algorithms can be used.

MERGING PDM, RSM AND LSM SCHEDULING APPROACHES into a single construction project scheduling system

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INTRODUCTION

A project can be defined as a unique endeavor, composed of activities characterized by their uniqueness. Such a definition is certainly true for small- or medium-size projects, but not so true for large-scale construction projects that are often made-up of a mixture of one-of-a-kind activities, of repetitive activities, and of activities that have a linear development.

Few examples: the construction of a residential area consisting of dozens of more or less identical houses; the construction of a hydroelectric power plant that requires several identical hydraulic turbines and power generators; the construction of an industrial facility in which several more or less similar production lines are to be installed; the digging of a railway tunnel that progresses linearly over quite long distances; the repaving of a motorway; the construction of a particle accelerator that is made of electromagnets and other components that are manufactured in small- or medium-size series production.

Implementing traditional project planning and scheduling techniques for these types of pro-

Improvements (cont'd)

Embed a **resource-constrained critical path scheduling** engine

Embed **repetitive & linear scheduling methods** functionalities

Manage better the **Project Management Reserve** in synchronization with **change records**

Consider a **Planning & Scheduling 2.0** approach

in the Years 2010s

PURESAFE
Preventing hUman intervention for IncREased SAfety inFrastructures — Emitting ionizing radiation

= 15 early-stage researchers

GSI FAIR (Germany)

CERN (Switzerland)

TUT (Finland)

UPM (Spain)

KIT (Germany)

Sensetrix (Finland)

bgator (Finland)

Oxford Technology (UK)

A&M ParisTech (France)

U. de Savoie (France)

ESS (Sweden)

ECP (France)

LASS (France)

openSE

an **open**, **lean** and **participative** approach to **systems engineering**

The research leading to this framework has received funding from the **European Commission** under the **FP7** ITN project **PURESAFE**, grant agreement no. **264336.**

SEVENTH FRAMEWORK PROGRAMME

MARIE CURIE ACTIONS

The need:

A systems engineering (SE) framework suited to scientific facilities and systems that are subject to ionizing radiations

The preferred solution:

Participative-based

every project/systems engineer contributes actively to managerial tasks

Lean thinking-based

enhance outcome value while limiting waste

Open source-based

creative common license

Editorial Content

Guidelines, *Standards*, Specifications, SW, etc.

Improvement of the editorial content

cern.ch/openSE

Not yet openSE.org

CERN Accelerating science

Sign in Directory

openSE

an open, lean and participative approach to systems engineering

About | Framework | Guidelines & Specifications | Other Resources | Community | News

The openSE Framework

openSE Charter

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openSE Framework

openSE Framework (80-p. booklet, v.1.0.1)

openSE Framework (80-p. booklet, v.1.0.1)

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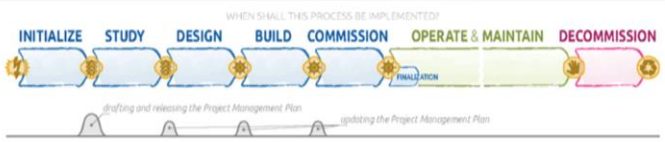
TYPE Process | SERIES PM | DOCUMENT NO. 1000 | VERSION 0.0

Setting up a Project Management System
Drafting and Releasing a Project Management Plan



What it is about

Every project team is an organizational entity that should work efficiently and communicate appropriately with *its outside world*. To do so, as from the beginning of the study phase and based on the **Project Roadmap** (see [1]), the project team should conceive and develop a project management system, task that consists among others to draft and release a **Project Management Plan** (PMP). This document is then expected to be updated at the beginning of every of the remaining phases.

The aim of this key project management document is twofold: ensuring that the members of the project teams agree upon and share a common framework for organizing their project; giving the project board the assurance that the project expectations are well understood and that everything is done to ensure the operational success of the project.

Three approaches to draft and release a PMP are proposed in the present brochure, corresponding to projects of different sizes and project teams of different maturity levels. In sake of effectiveness, the present brochure shall be read in conjunction with the document entitled *openSE Framework* (see [2]).

The typical editorial process is featured on the simplified process diagram of Figure 1. Further revisions of the PMP follow a similar process (see also [3]).

From a quality assurance point of view, this document is:

- authored by the project manager and a few key project team members
- verified (i.e. cross-checked) by some others key project team members, and when available, project management experts
- validated and released by the project manager.

The PMP is not expected to be validated by the project board. However, the project board members should receive all released versions of this document. They are not expected to acknowledge its receipt and no response from them shall be understood as a tacit endorsement of the document. If some members of the project board feel that the PMP does not address the project expectations as they have been communicated to the project team by means of the Project Roadmap, the project manager may be asked to improve the PMP until it provides all guarantees or at least sufficient guarantees to the project board that the project expectations can be achieved.

1 Simple approach

This simple approach is rather suited to projects of a small size or to newcomers to project management.

1.1 Editorial process

Even if the PMP is considered as the outcome of a team exercise, it is likely that its writing is initiated by the project manager, then complemented, commented and corrected by key project team members.

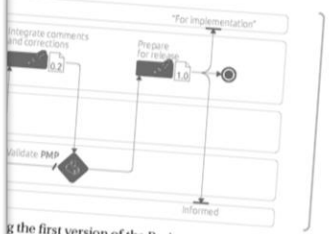
1.2 Typical content

The typical content of a PMP is threefold.

Section 1. Overview. This section is a brief reformulation of the Project Roadmap. The project purpose and objectives are recalled and reformulated, the key milestones and deliverables are listed, so the assumptions, dependencies and constraints that may influence the completion of the project from the three usual perspectives: scope, schedule and

budget. All key documents that are of prime importance to understand

the project, the budget breakdown and the project risk registry, if not stand-alone documents, shall be included in this first section.



g the first version of the Project Management Plan.

which measures are or will be set up to ensure the consistency of documents and more broadly of all deliverables released in the framework of the project. The description of the document management framework as well that for configuration management and change management are typically found in this subsection. Additionally, this subsection may provide insights on the organization of reviews, the naming/coding conventions, etc.

Communication Management. This subsection explains how the project team communicates or will communicate inside the project team, towards the project board and the various stakeholders and, if required, towards the general public.

Risk Management. This subsection explains how risks, whether they are perceived as threats or opportunities, are or will be managed, i.e. identified, assessed, treated and monitored.

Contribution Management. Finally, this subsection explains how procurement and external contributions, if any foreseen, are or will be managed, which activities are to be outsourced and what are the specific policies and processes to follow.

ermediate approach

mediate approach is suited to rather challenjects or to project management teams that are perienced.

knowledge areas of the *PMBoK*
PMBoK.

g a Project Management Plan

drafting and releasing the PMP and its associated subdocuments.

3.2 Typical content

In this context, the PMP is necessarily a head document that refers to several subdocuments. Subdocuments will be groups in several families of PMP subdocuments:

- the subdocuments that define the processes (see section 1.2)
- the subdocuments that define the generic and specific roles of project members
- the subdocuments that define the specific project standards, including definitions and document templates

These subdocuments can be assembled in a so-called **Project Management File.**

Key project management documents such as:

- the Work Breakdown Structure and Work Package and Work Unit Description Datasheets
- the Project Master, Coordination and Detailed Schedule(s)
- the Project Budget Breakdown Document(s)
- the Project RACI Matrix
- the Project Risk Registry, the Risk Analysis Documents, the Contingency and Continuity Plans

shall necessarily be considered as stand-alone versionable documents.

Terminology

The following terms are assumed to be equivalent:

Project Roadmap ≡ Project Mandate; Project Charter; Project Mission Statement

Project Management Plan ≡ Project Quality Plan; Project Quality Manual; Project Quality Assurance Plan (a.k.a. Project QAP)

Project Management File ≡ Project Management Portfolio; Project Management Folder; Project Management Dossier.

References

[1] The openSE editorial community (2014) *Initiating a Complex Systems Project — Drafting and Releasing a Project Proposal/Roadmap*, Geneva, Switzerland. openSE Brochure no. 10XX.

[2] The openSE editorial community (2014) *openSE Framework*, Geneva, Switzerland.

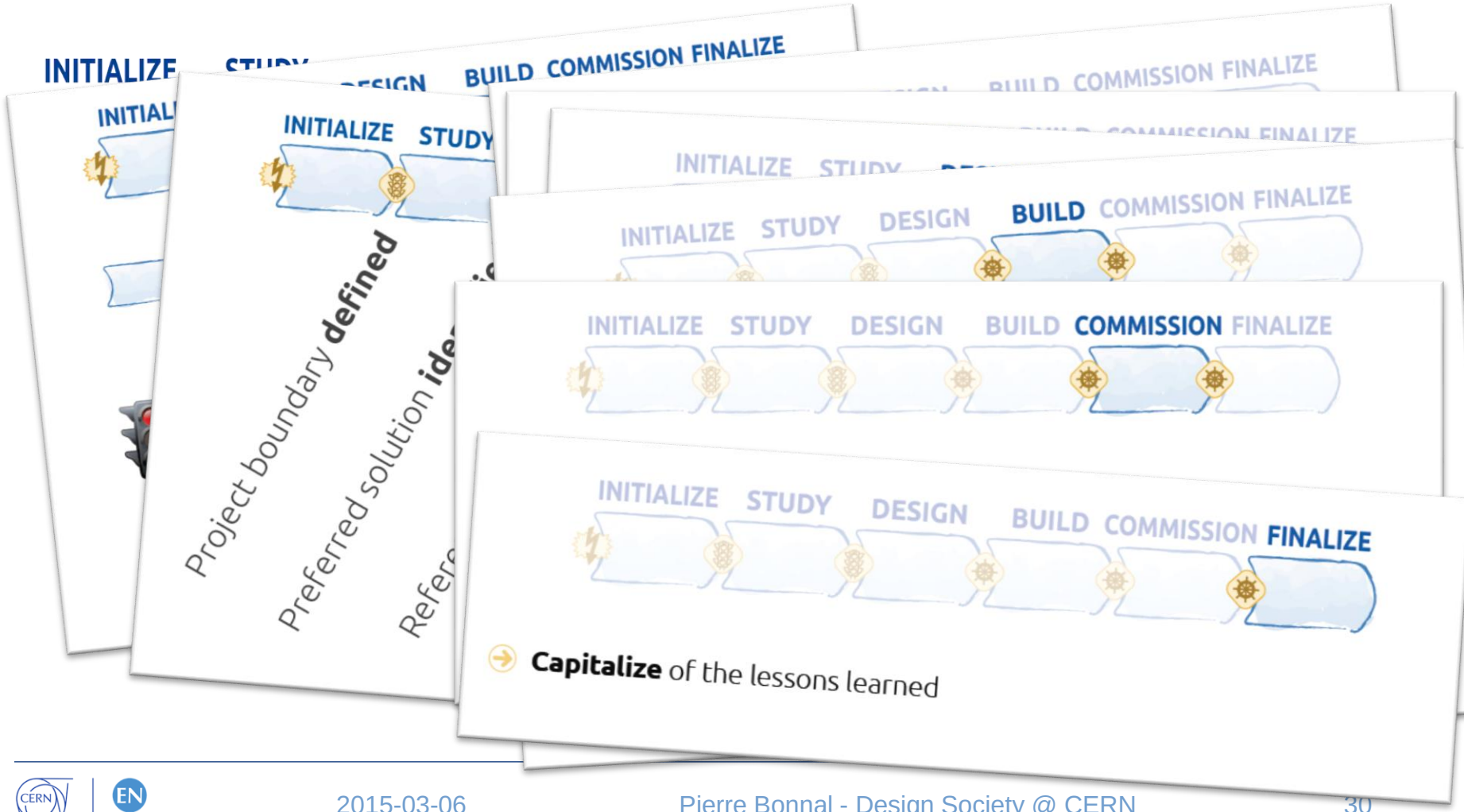
[3] The openSE editorial community (2014) *Coding and Versioning Project Documents*, Geneva, Switzerland. openSE Brochure no. 10XX.

andard Committee (2008) *A guide to the management body of knowledge*, 4th ed. Square, PA: Project Management Insti- 3 p. ISBN 1933890517.

All openSE documents are downloadable from

Lifecycle

A common understanding of a facility or system lifecycle



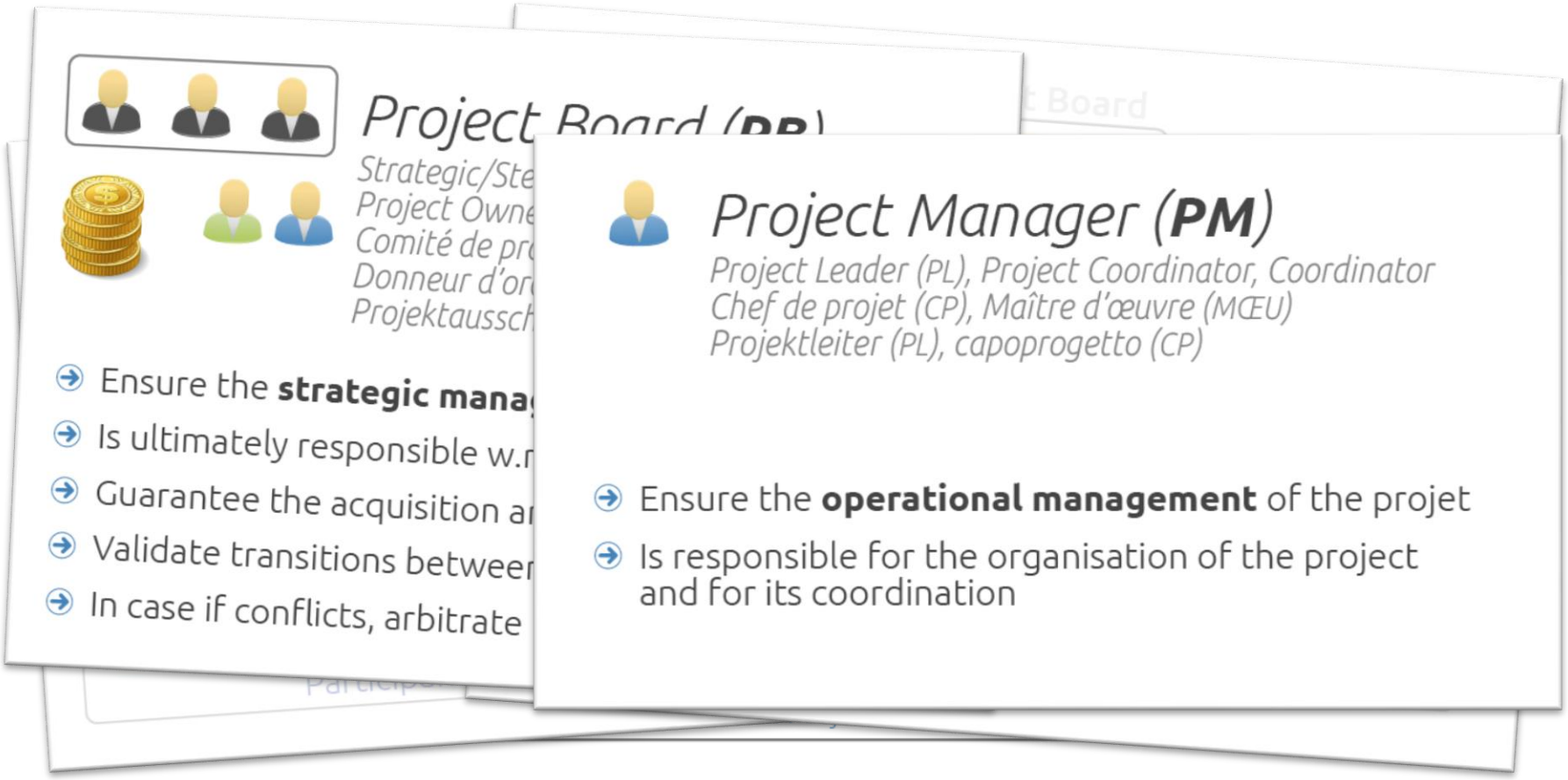
Processes

A common understanding of key processes

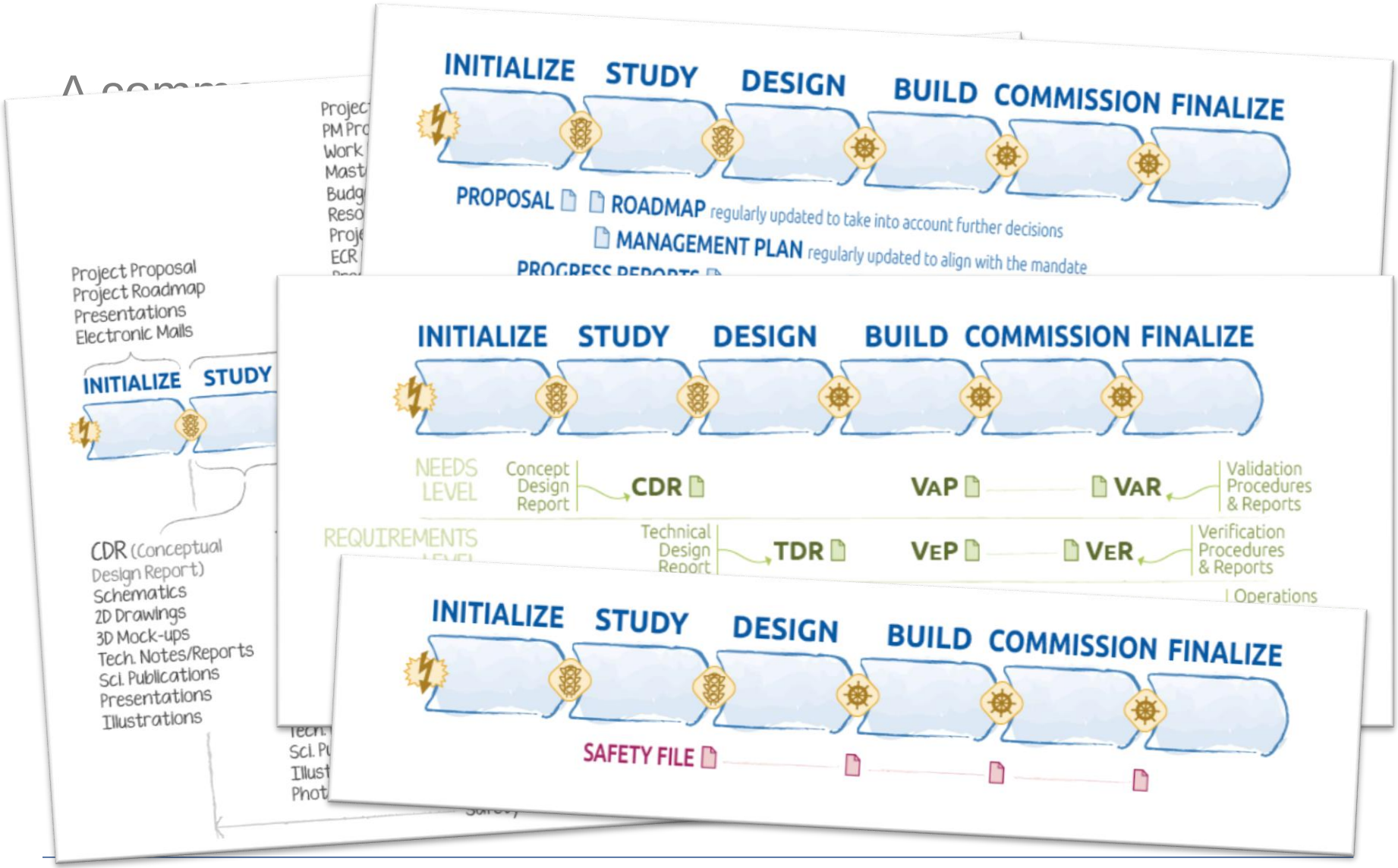
- Systems Engineering processes:
  gathering needs and defining requirements,
  systems architecting and modelling, verifying & validating,
  managing product risks, managing configuration & quality
- Project Management processes:
  scoping, planning and scheduling, costing,
  managing project risks, supplying components
- Design and Engineering processes:
  DfS, DfE, DfMA, DfP, DfC, DfO, DfR, DfA, DfM, **DfT/DfRH***
  * Design for Telerobotics / Design for Remote Handling

Roles

A common understanding of roles and responsibilities



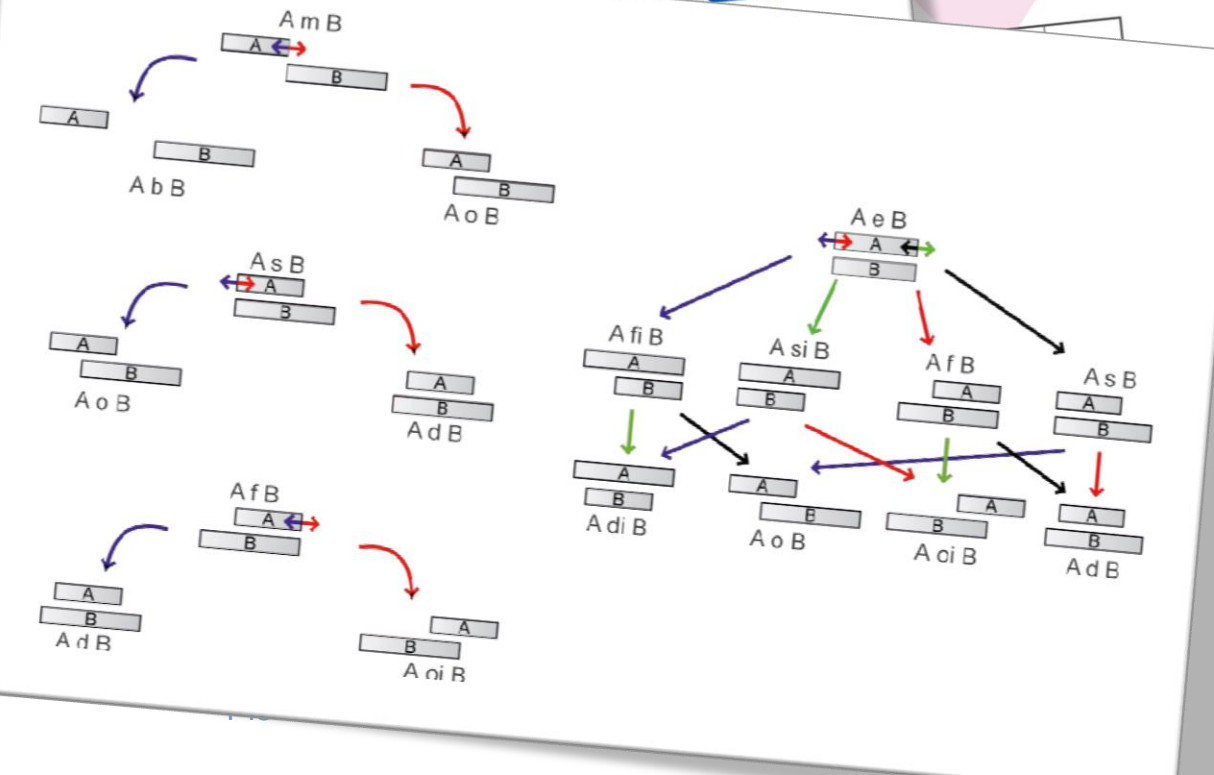
Results


INITIALIZE STUDY DESIGN BUILD COMMISSION FINALIZE
PROPOSAL
ROADMAP regularly updated to take into account further decisions
MANAGEMENT PLAN regularly updated to align with the mandate
INITIALIZE STUDY DESIGN BUILD COMMISSION FINALIZE
NEEDS LEVEL
Concept Design Report
CDR
VaP
VaR
Validation Procedures & Reports
REQUIREMENTS
Technical Design Report
TDR
VeP
VeR
Verification Procedures & Reports
Operations
INITIALIZE STUDY DESIGN BUILD COMMISSION FINALIZE
SAFETY FILE
Project Proposal
Project Roadmap
Presentations
Electronic Mails
INITIALIZE STUDY
CDR (Conceptual Design Report)
Schematics
2D Drawings
3D Mock-ups
Tech. Notes/Reports
Sci. Publications
Presentations
Illustrations

Will **Project Planning & Scheduling 2.0** (PDM 2.0) be next?

Relation	Interpretation	Gantt chart-like illustration
A b B **B bi A**	**A** takes place before **B** **B** takes place after **A**	
A m B **B mi A**	**A** meets **B** **B** is met by **A**	
A o B **B oi A**	**A** overlaps **B** **B** is overlaped by **A**	
A s B **B si A**	**A** starts with **B** **B** is started with **A**	
A d B **B di A**	**A** is during **B** **B** contains **A**	
A f B **B fi A**	**A** finishes with **B** **B** is finished by **A**	
A = B	**A** equals **B**	

	0	2	3	5	1a	1b
0						
2	m b				m b	
3		b				m b
5			m			
1a	m b					
1b	m b					
4a		m b				
4b			m b			



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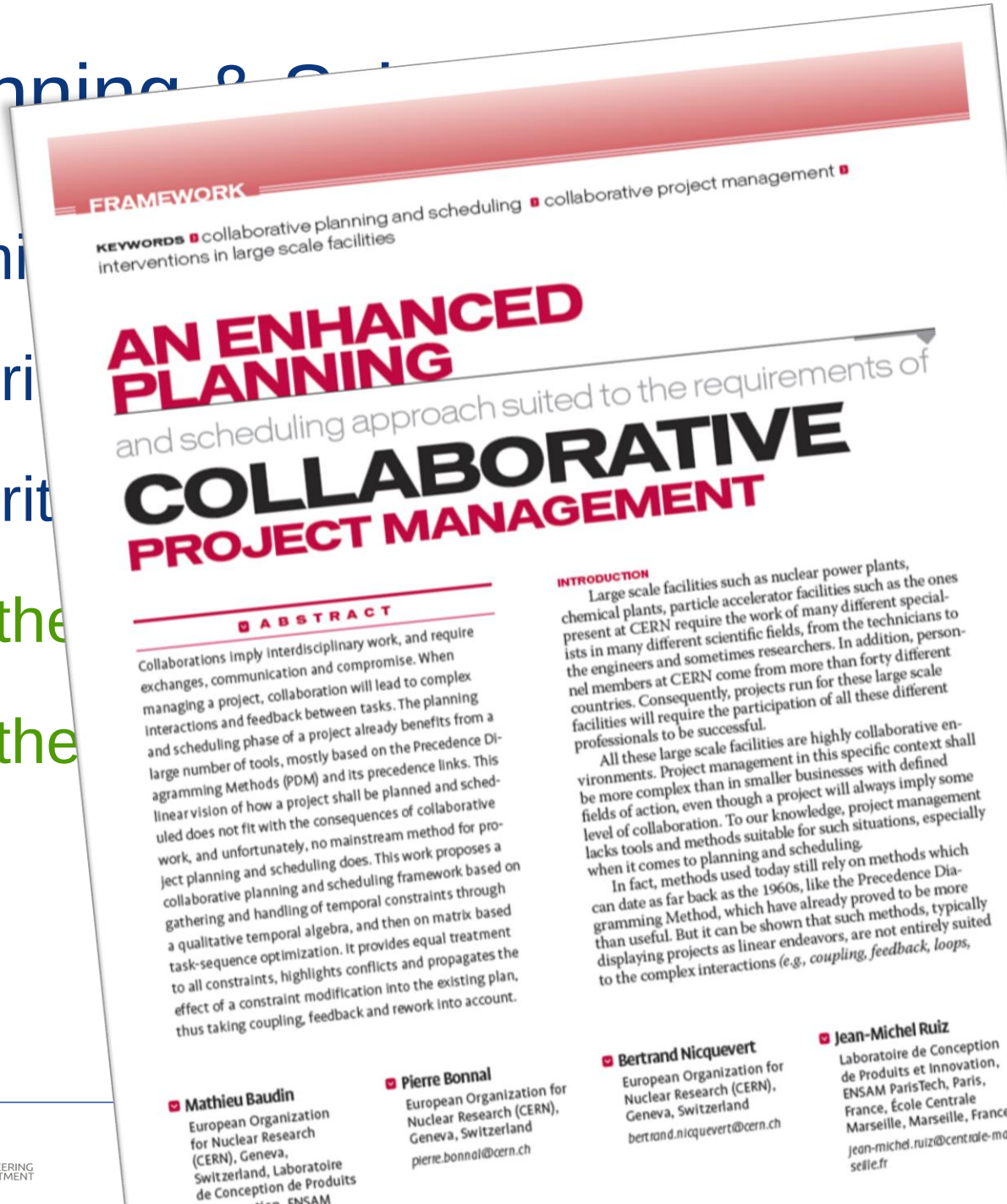

FRAMEWORK

KEYWORDS collaborative planning and scheduling · collaborative project management · interventions in large scale facilities

AN ENHANCED PLANNING and scheduling approach suited to the requirements of COLLABORATIVE PROJECT MANAGEMENT

ABSTRACT

Collaborations imply interdisciplinary work, and require exchanges, communication and compromise. When managing a project, collaboration will lead to complex interactions and feedback between tasks. The planning and scheduling phase of a project already benefits from a large number of tools, mostly based on the Precedence Diagramming Methods (PDM) and its precedence links. This linear vision of how a project shall be planned and scheduled does not fit with the consequences of collaborative work, and unfortunately, no mainstream method for project planning and scheduling does. This work proposes a collaborative planning and scheduling framework based on gathering and handling of temporal constraints through a qualitative temporal algebra, and then on matrix based task-sequence optimization. It provides equal treatment to all constraints, highlights conflicts and propagates the effect of a constraint modification into the existing plan, thus taking coupling, feedback and rework into account.

INTRODUCTION

Large scale facilities such as nuclear power plants, chemical plants, particle accelerator facilities such as the ones present at CERN require the work of many different specialists in many different scientific fields, from the technicians to the engineers and sometimes researchers. In addition, personnel members at CERN come from more than forty different countries. Consequently, projects run for these large scale facilities will require the participation of all these different professionals to be successful.

All these large scale facilities are highly collaborative environments. Project management in this specific context shall be more complex than in smaller businesses with defined fields of action, even though a project will always imply some level of collaboration. To our knowledge, project management lacks tools and methods suitable for such situations, especially when it comes to planning and scheduling.

In fact, methods used today still rely on methods which can date as far back as the 1960s, like the Precedence Diagramming Method, which have already proved to be more than useful. But it can be shown that such methods, typically displaying projects as linear endeavors, are not entirely suited to the complex interactions *(e.g., coupling, feedback, loops,*

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Thanks.