Project Management Case Study

Pierre.Bonnal@cern.ch

Purpose

Presenting you CERN's approach to project management
i.e. the approach developed for the **LHC project**
used on the **CNGS project**
in use on the **Linac4 and LIU projects**
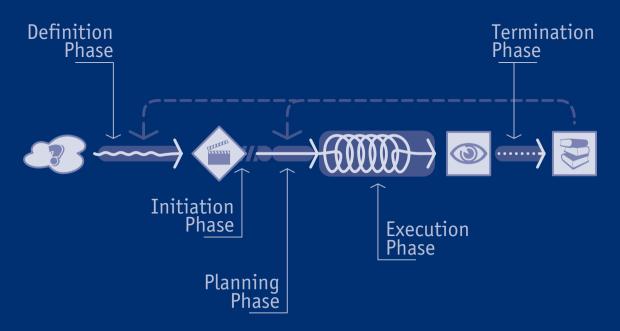implemented on the **NICA project** at Dubna

A project control approach that fully complies
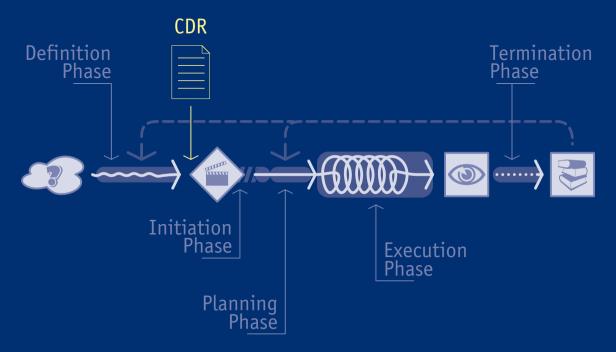with state-of-the-art practice (even better)
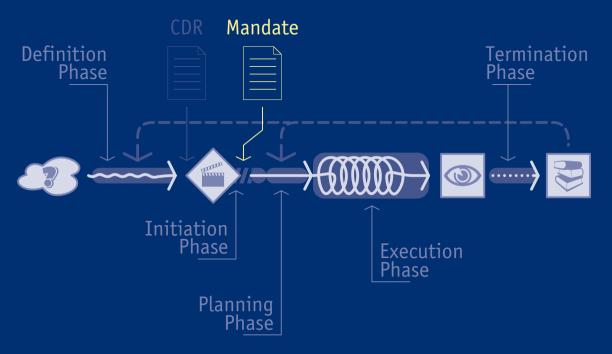**Benoit Daudin** ····⫶ more on the tools used at CERN
Luisela Lari ····⫶ more on installation planning

But before starting ...
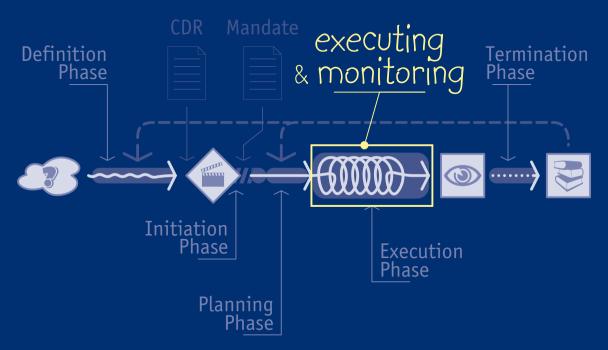
... let's say a few words
    about Project Life Cycles.

Project Life Cycle.

Definition
Phase

Termination
Phase

Initiation
Phase

Planning
Phase

Execution
Phase

Project Life Cycle.

Project Life Cycle.

CDR

Mandate

Definition
Phase

Termination
Phase

Initiation
Phase

Execution
Phase

Planning
Phase

Project Life Cycle.

CDR   Mandate

planning & costing

Definition Phase

Termination Phase

Initiation Phase

Execution Phase

Planning Phase

Project Life Cycle.

CDR Mandate

Definition Phase

executing & monitoring

Termination Phase

Initiation Phase

Execution Phase

Planning Phase

The L🔆MPE Project

Deliverable → Undulator Radiation Facility for Photon Chemistry.

profile monitors

experimental area

undulator

dipole magnet
quadrupole magnet
sextupole magnet
dipole corrector magnet
position monitor

injection   RF

electron beam (200 MeV)

intensity monitor

2001-11-23

- The Definition Phase is completed.
- The feasibility of the project is demonstrated.
- The Conceptual Design Report is released.

CONCEPTUAL
DESIGN
REPORT

2001-11-28
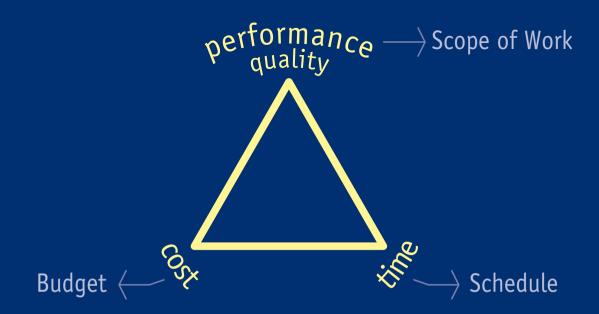
The Board of the Lab has decided to approve the project.

2001-12-06

- The Project Mandate is released by Dizzy, CEO of the Lab.
- Bill was asked and has accepted to become the Project Manager of the LAMPE Project.

LAMPE

Memorandum

PROJECT

MANDATE

Project Mandate.

performance
quality
→ Scope of Work

cost
time

Budget ←
Schedule →

Project Mandate | Scope of Work.

- Infrastructures.
- Electrical services.
- Water cooling.
- Compressed air.
- Magnets & undulator.
- Acceleration (RF cavities).
- Beam instrumentation.

- Vacuum systems.
- Powering.
- Controls.
- Survey.
- Ancillary equipment.
- Installation works.

Project Mandate | Budget & Resources.

Outsourced resources	Insourced resources
Material	Personnel

↓

↓

3'100'000.– CHF

880 person·weeks

(1.– CHF = .65 EUR)

(17.5 person·years)

(5.8 FTEs → 3 years)

Swiss Franc (CHF) → currency of the project.

Project Mandate | Budget & Resources.

Outsourcing through existing contracts (blanket orders...).

Some existing contracts can be used by the project team:

- S01   engineering studies

- S03   vacuum technicians

- S04   RF technicians

- S09   installation team

- F16   logistics support.

Project Mandate | Budget & Resources.

Two in-kind contributions are expected:

- P01   BINP (Russia) → Dipole magnets (except cables).
         100 % Russian funding.

- P02   CAT (India) → Undulator.
         50 % Indian funding.
         50 % Lab funding.

Project Mandate | Budget & Resources.

Purchasing policy:

> 75'000.– CHF

$\downarrow$

Full procedure
i.e. market survey
call for tender
bidder conference
$\rightarrow$ contract.

*Stakeholders want to be
involved in decision making!*

< 75'000.– CHF

$\downarrow$

Light procedure
i.e. price inquiry
$\rightarrow$ order.

Project Mandate | Budget & Resources.

Key resources:

- Oscar .... Integration / installation studies
- Ben .... Magnet systems
- Sweet .... Beam instrumentation
- Max .... Acceleration
- Billie .... Vacuum systems
- Ella .... Power converters
- Cassandra ..... Ring and access control systems
- Gil .... Mechanical equipment; installation coord.
- Ray .... Survey
- Pat .... Electricity and cabling
- Art .... Cooling and ventilation.

Project Mandate | Budget & Resources.

Key resources:
- Bill .... Project manager
- Oscar .... Head design office & deputy PM
- Melba .... PM assistant
- Duke .... Purchasing officer.
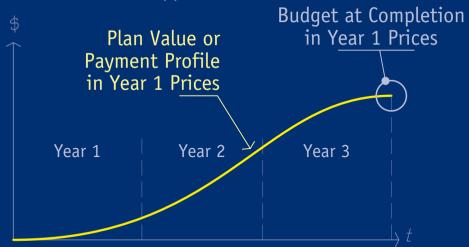
✋ Dealing with Price Escalation...

Three approches:

① The US Government approach:

Yearly price escalation indices are estimated

for the whole duration of the project
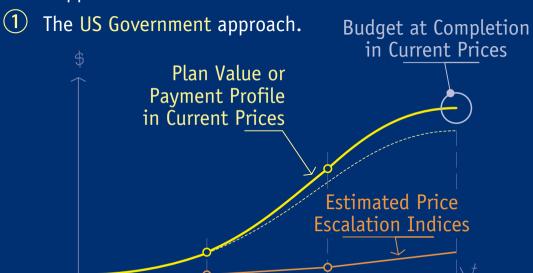
and considered in budgets.

Dealing with Price Escalation...

Three approches:

① The US Government approach.

✋ Dealing with Price Escalation...

Three approches:

① The US Government approach.

Budget at Completion in Current Prices

Plan Value or Payment Profile in Current Prices

Estimated Price Escalation Indices
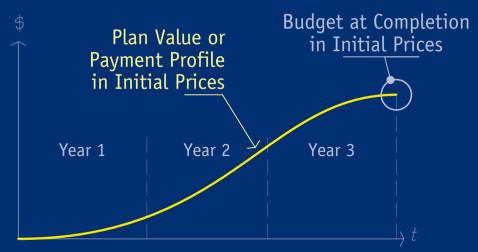
$

t

✋ Dealing with Price Escalation...

Three approches:

② The Major Engineering Companies approach:
The whole project is estimated and budgeted
in Initial Prices (i.e. Year 1 Prices for instance).
Commitments and Actuals are converted in Initial Prices
before being compared to corresponding budgets.

✋ Dealing with Price Escalation...

Three approches:

② The Major Engineering Companies approach.

Plan Value or Payment Profile in Initial Prices

Budget at Completion in Initial Prices

$

Year 1   Year 2   Year 3

t

✋ Dealing with Price Escalation...

Three approches:

② The Major Engineering Companies approach.

✋ Dealing with Price Escalation...
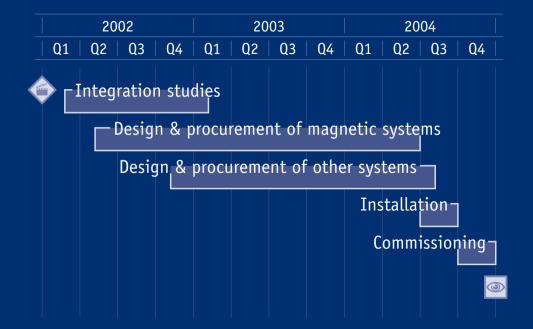
Three approches:

③ The hybrid approach to project cost engineering:
Budgets associated to non-committed resources
are yearly or quarterly recalculated.
As a consequence, budget figures are not constant
in time.

Project Mandate | Budget & Resources.

Cost control policy:

- The hybrid approach to project cost engineering is prefered.

- Yearly (estimated) economical index will be applied from 1st January onwards.

Economical and commercial risks are included in the lump sum budget (3.1 MCHF) of the project.

Project Mandate | Master Schedule.

	2002				2003				2004		
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

Integration studies

Design & procurement of magnetic systems

Design & procurement of other systems

Installation

Commissioning

Before continuing ...

... let's say a few words about
our prefered PM approach.

Prefered project management approach.

① A **Deliverable-oriented** approach.

- Historically, project have been managed with a focus on the tasks to carry out ('process-drives-deliverable' approach).

- History has also shown that focusing on managing the processes has failed over and over.

- A more pragmatic approach consists at looking at the (final + intermediate) deliverables ('deliverables-drive-process' approach).

Prefered project management approach.

② A Risk-oriented approach.

- A project is by definition a risky endeavor!

- Possible risks have to be considered all along the Project Life Cycle. It's up to the project team to protect the project from undesirable events.

- These indesirable events can be of several types:
  - technical risks
  - programmatic risks.

Prefered project management approach.

③ An EVM-oriented approach.

- Project stakeholders hates bad surprises!
  They require means to appraise objectively
  the progress of the project.

- The EVM (Earned Value Management) methodology
  has been promoted to address this requirement.

- This methodology is a model ; i.e. a simplification
  of the reality. As a consequence, it is required to have
  the reality 'adapted', so it complies to the model.

Prefered project management approach.

④ A Corporate management-integrated approach.

- Project management is not a stand alone process!
It must be integrated in the corporate management
systems: financial & personnel planning, accounting,
purchasing, reporting...

- There are organizations that are 'project-oriented':
most of their activities are managed as projects.
They must adapt their corporate management systems
so projects can be managed easily and efficiently.

| 2002 | 2003 | 2004 |

N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J

early days of January

— Let's start! —

Planning & Costing the LAMPE Project

The US approach to project planning...

Refer to:

Project Management Institute. *Practice Standard for Work Breakdown Structures.* PMI, Newtown Square, PA., 2001. ISBN 1-880410-818. www.pmi.org

Gary Sanders. *Planning for Performance Measurement.* Project Science Workshop, Aspen, CO., October 1-5 2003. www.projectscience.org

The European approach...

① Project / Product Breakdown Structure

② Work Breakdown Structure

③ Organization Breakdown Structure

④ Resource Breakdown Structure

⑤ Resource Responsibility Matrix

⑥ Work Unit Dictionary

⑦ Project Gantt Chart :-)

PBS · WBS · OBS · RBS · RRM · WUD · PGC

① Project / Product Breakdown Structure.

PBS

Aim : breaking down the final deliverable into systems...

Final deliverable
→ Systems
→ Sub-systems
→ Components
→ Basic Items

PBS ① Project / Product Breakdown Structure.

Beam instrumentation

Ancillary equipment

Magnet systems

LAMPE

Acceleration

Vacuum systems

Control systems

Undulator

Septum

Kickers

Corrector magnets

Quadrupoles

Dipoles

Magnet systems

Beam instrumentation

Ancillary equipment

LAMPE
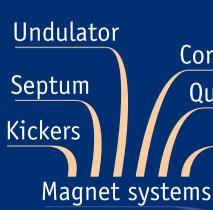
Acceleration

Control systems

Vacuum systems

Undulator

Septum

Kickers

Corrector magnets

Quadrupoles

Dipoles

Magnet systems

BCTU

BTVUs

BPUs

Beam instrumentation

Ancillary equipment

Klystrons

Cavities

Guides

LAMPE

Pumps

Gauges

Chambers

Acceleration

Hardware Software

Control systems

Vacuum systems
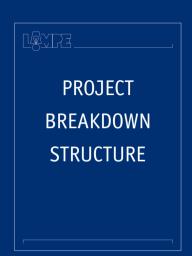
	A	B	C	D
1	level	code	PBS label	qty
2	1		Magnet systems	
3	2	MBU	Dipole magnets	12
4	3		Insulated copper wire	
5	3		Other components	
6	2	QTU	Quadrupole magnets	22
7	3		Insulated copper wire	
8	3		Other components	
9	2	LSU	Sextupole magnets	4
10	2	MDU	Corrector magnets	18
11	2	MUN	Undulator	1
12	2	MSU	Septum	1
13	2	MKU	Kickers	4
14	1		Beam instrumentation	
15	1		Acceleration	
16	1		Vacuum systems	

	A	B	C	D
1	level	code	PBS label	qty
2	1		Magnet systems	
3	2	MBU	Dipole magnets	12
4	2	QTU	Quadrupole magnets	22
5	2	LSU	Sextupole magnets	4
6	2	MDU	Corrector magnets	18
7	2	MUN	Undulator	1
8	2	MSU	Septum	1
9	2	MKU	Kickers	4
10	1		Beam instrumentation	
11	1		Acceleration	
12	1		Vacuum systems	
13	1		Ancillary equipment	
14	1		Ring & access control systems	
15	1		Power converters	
16	1		Fluids	

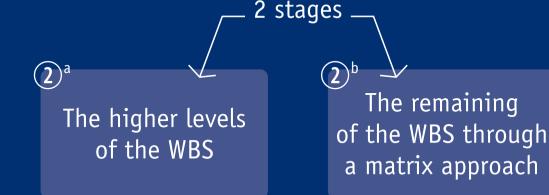|	A	B	C	D
1	level	code	PBS label	qty
2	1		Magnet systems	
14	1		Beam instrumentation	
15	2	BPU	Beam position monitors	12
16	2	BTVU	Profile monitors	2
17	2	BCTU	Intensity monitor	1
18	1		Acceleration	
19	1		Vacuum systems	
20	1		Ancillary equipment	
21	1		Ring & access control systems	
22	1		Power converters	
23	1		Fluids	
24	1		Electricity	
25				
26				
27				

- The Project (Product) Breakdown Structure is released.
- The Project Equipment Coding Convention is also released.
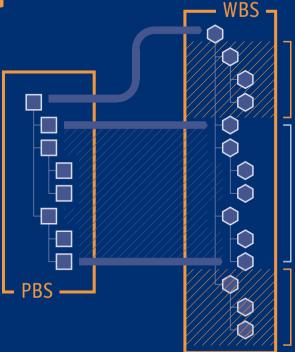
LAMPE

PROJECT
BREAKDOWN
STRUCTURE

② Work Breakdown Structure.

Aim : identifying the activities, i.e. the Work Units (WU), to be carried out, so all the intermediate deliverables and then the final deliverable are delivered.

2 stages

②[a] The higher levels of the WBS

②[b] The remaining of the WBS through a matrix approach

WBS

② Work Breakdown Structure | higher levels.

WBS

Project
Management
Activities

PBS

PBS

Installation &
Commissioning
Activities
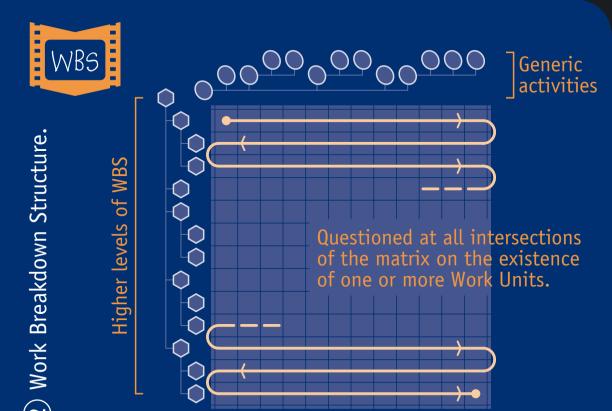
	A	B	C
1	level	code	WBS label
2	1	LAMPE.1	Project management and integration
3	1	LAMPE.2	Magnet systems
4	1	LAMPE.3	Beam instrumentation
5	1	LAMPE.4	Acceleration
6	1	LAMPE.5	Vacuum systems
7	1	LAMPE.6	Ancillary equipment
8	1	LAMPE.7	Ring & access control systems
9	1	LAMPE.8	Power converters
10	1	LAMPE.9	Cooling and ventilation
11	1	LAMPE.10	Electricity and cabling
12	1	LAMPE.11	Installation and commissioning
13			
14			
15			
16			

	A	B	C
1	level	code	WBS label
2	1	LAMPE.1	Project management and integration
3	2	LAMPE.1.1	Project management
4	2	LAMPE.1.2	Integration studies
5	1	LAMPE.2	Magnet systems
6	1	LAMPE.3	Beam instrumentation
7	1	LAMPE.4	Acceleration
8	1	LAMPE.5	Vacuum systems
9	1	LAMPE.6	Ancillary equipment
10	1	LAMPE.7	Ring & access control systems
11	1	LAMPE.8	Power converters
12	1	LAMPE.9	Cooling and ventilation
13	1	LAMPE.10	Electricity and cabling
14	1	LAMPE.11	Installation and commissioning
15	2	LAMPE.11.1	Infrastructures
16	2	LAMPE.11.2	Ring equipment and commissioning

	A	B	C
1	level	code	WBS label
2	1	LAMPE.1	Project management and integration
3	2	LAMPE.1.1	Project management
4	2	LAMPE.1.2	Integration studies
5	1	LAMPE.2	Magnet systems
6	2	LAMPE.2.1	Dipole magnets
7	2	LAMPE.2.2	Quadrupole magnets
8	2	LAMPE.2.3	Sextupole magnets
9	2	LAMPE.2.4	Corrector magnets
10	2	LAMPE.2.5	Undulator
11	2	LAMPE.2.6	Septum and kickers
12	2	LAMPE.2.7	Insulated copper wire
13	1	LAMPE.3	Beam instrumentation
14	1	LAMPE.4	Acceleration
15	1	LAMPE.5	Vacuum systems
16	1	LAMPE.6	Ancillary equipment

	A	B	C
1	level	code	WBS label
2	1	LAMPE.1	Project
3	2	LAMPE.1.1	Proje
4	2	LAMPE.1.2	Integ
5	1	LAMPE.2	Magnet
6	2	LAMPE.2.1	Dipo
7	2	LAMPE.2.2	Quad
8	2	LAMPE.2.3	Sextu
9	2	LAMPE.2.4	Corrector magnets
10	2	LAMPE.2.5	Undulator
11	2	LAMPE.2.6	Septum and kickers
12	2	LAMPE.2.7	Insulated copper wire
13	1	LAMPE.3	Beam instrumentation
14	1	LAMPE.4	Acceleration
15	1	LAMPE.5	Vacuum systems
16	1	LAMPE.6	Ancillary equipment

Septum and kickers PBS nodes have been merged into a single WBS node, because these two items will be under the responsibility of the same engineer, and supplied in a single contract.

	A	B	C
1	level	code	WBS label
2	1	LAMPE.1	Project management and integration
3	2	LAMPE.1.1	Projec...
4	2	LAMPE.1.2	Integr...
5	1	LAMPE.2	Magnet s...
6	2	LAMPE.2.1	Dipole...
7	2	LAMPE.2.2	Quadr...
8	2	LAMPE.2.3	Sextup...
9	2	LAMPE.2.4	Correc...
10	2	LAMPE.2.5	Undulator
11	2	LAMPE.2.6	Septum and kickers
12	2	LAMPE.2.7	Insulated copper wire
13	1	LAMPE.3	Beam instrumentation
14	1	LAMPE.4	RF systems
15	1	LAMPE.5	Vacuum systems
16	1	LAMPE.6	Ancillary equipment
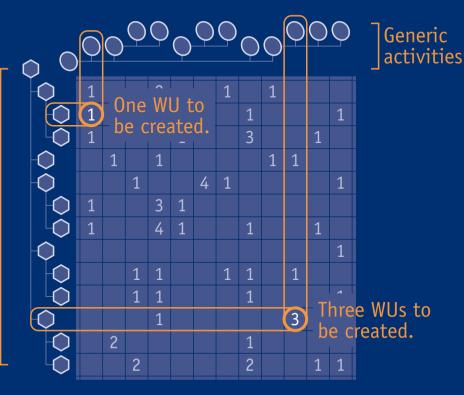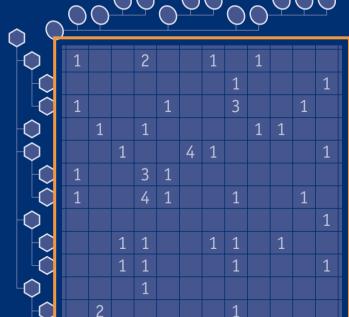
Even if it is used in dipole and quadrupole magnets, the supply of insulated copper wire will be done through a single contract, under the responsibility of a different project engineer.

Generic activities

Higher levels of WBS

Questioned at all intersections of the matrix on the existence of one or more Work Units.

② Work Breakdown Structure.

WBS

② Work Breakdown Structure.

Higher levels of WBS

Generic activities

One WU to be created. ①

Three WUs to be created. ③

② Work Breakdown Structure.

Generic activities

Higher levels of WBS

no. of WUs

$\sum a_{ij} = 53$

1			2			1		1				
							1				1	
1				1			3		1			
	1		1					1	1			
		1			4	1					1	
1		3	1									
1		4	1				1		1			
											1	
	1	1			1	1		1				
	1	1				1				1		
		1										
2						1						
	2					2			1	1		

✋ What's a Deliverable ?

A Deliverable is not a Product:

The LAMPE Facility
$\rightarrow$ Product.

✋ What's a Deliverable ?

A Deliverable is not a Product:

The LAMPE Facility
└→ Product.

The LAMPE Facility commissioned
└→ Deliverable.

✋ What's a Deliverable ?

A Deliverable is not a Product:

Undulator
└→ Product.

✋ What's a Deliverable ?

A Deliverable is not a Product:

Undulator
└→ Product.

Undulator designed
Undulator specified
Undulator manufactured
Undulator installed & prov. accepted
Undulator fully tested
    └→ Deliverables.

✋ What's a Work Unit ?

A Work Unit is an elementary activity that:

> consumes time

> consumes resources

> has a start date and a finish date

> is assignable to a single person

> produces deliverable(s)

> is measurable (to assess its progress).

Work Unit ~ Work Package ~ Activity.

✋ What's a Work Unit ?

A Work Unit is not a Deliverable:

To avoid confusion, several textbooks suggest
to label Work Units as follow:

Verb (infinitive tense) + **Substantive**

└─ i.e. an action.

✋ What's a Work Unit ?

Examples of WU labels:
- Manage the project
- Prepare documents
- Perform magnet design
- Refurbish old RF cavities
- Test, validate power converters
- Fabricate intensity monitors
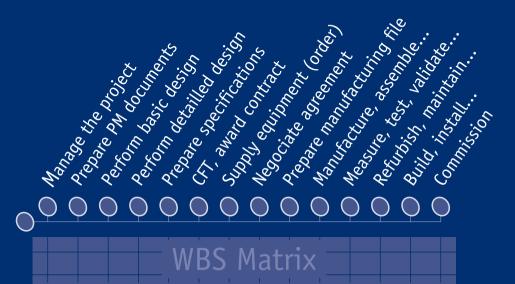- Install vacuum chambers...

✋ What's a Work Unit ?

A Work Unit is an elementary activity that:
> consumes time, within some limits!
> ...

> No definitive answer!
> No more than 5% – 10% of the project duration.
> No more than 13 weeks (long lead projects).
> Some 'Level of Effort' Work Units allowed:

[1 ; 1% of no. of WUs]

What's a Generic Activity ?

Manage the project
Prepare PM documents
Perform basic design
Perform detailed design
Prepare specifications
CFT, award contract
Supply equipment (order)
Negociate agreement
Prepare manufacturing file
Manufacture, assemble...
Measure, test, validate...
Refurbish, maintain...
Build, install...
Commission

WBS Matrix

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
		Manage the project	Prepare PM documents	Perform basic design	Perform detailed design	Prepare specifications	CFT, award contract	Supply equipment (order)	Negotiate agreement	Prepare manufacturing file	Manufacture, assemble	Measure, test, validate	Refurbish, maintain	Build, install	Commission
2	Project management...														
3	Project management	1	1												
4	Integration studies			2											
5	Magnet systems														
6	Dipole magnets														
7	Quadrupole magnets														
8	Sextupole magnets														
9	Corrector magnets														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Manage the project	Prepare PM documents	Perform basic design	Perform detailed design	Prepare specifications	CFT, award contract	Supply equipment (order)	Negotiate agreement	Prepare manufacturing file	Manufacture, assemble	Measure, test, validate	Refurbish, maintain	Build, install	Commission
5	Magnet systems														
6	Dipole magnets	▨	▨	▨		1			1	1	4	1		▨	▨ (8)
7	Quadrupole magnets														
8	Sextupole magnets														
9	Corrector magnets														
10	Undulator														
11	Septum and kickers														
12	Insulated copper wire														

Typical Life Cycle of a component that is supplied in the framework of a collaboration (in-kind contribution).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Manage the project	Prepare PM documents	Perform basic design	Perform detailed design	Prepare specifications	CFT, award contract	Supply equipment (order)	Negotiate agreement	Prepare manufacturing file	Manufacture, assemble	Measure, test, validate	Refurbish, maintain	Build, install	Commission
5	Magnet systems														
6	Dipole magnets					1				1	1	1			
7	Quadrupole magnets				1	1	1			1	6	1			(11)
8	Sextupole magnets														
9	Corrector magnets														
10	Undulator														
11	Septum and kickers														
12	Insulated copper wire														

Typical Life Cycle of a component that is supplied in the framework of a contract with a industrial firm.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Manage the project	Prepare PM documents	Perform basic design	Perform detailed design	Prepare specifications	CFT, award contract	Supply equipment (order)	Negotiate agreement	Prepare manufacturing file	Manufacture, assemble	Measure, test, validate	Refurbish, maintain	Build, install	Commission
5	Magnet systems														
6	Dipole magnets					1			1	1	4	1			
7	Quadrupole magnets				1	1	1			1	6	1			
8	Sextupole magnets				1	1	1			1	1				
9	Corrector magnets				1	1	1			1	6				
10	Undulator				1	1			1	1	1				
11	Septum and kickers				2	2	1			1	2				
12	Insulated copper wire					1	1			1	5				(55)

	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	Manage the project	Prepare PM documents	Perform basic design	Perform detailed design	Prepare specifications	CFT, award contract	Supply equipment (order)	Negotiate agreement	Prepare manufacturing file	Manufacture, assemble	Measure, test, validate	Refurbish, maintain	Build, install	Commission
13 Beam instrumentation														
14 Beam position monitors				1					1	2	1			
15 Profile monitors				1					1	1	1			
16 Intensity monitor				1					1	1	1			
17 Acceleration				1						1		2		
18 Vacuum systems														
19 Vacuum chambers					1					7				
20 Pumps and gauges							1							

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		Manage the project	Prepare PM documents	Perform basic design	Perform detailed design	Prepare specifications	CFT, award contract	Supply equipment (order)	Negotiate agreement	Prepare manufacturing file	Manufacture, assemble	Measure, test, validate	Refurbish, maintain	Build, install	Commission
21	Ancillary equipment												3		
22	Ring and access control...														
23	Hardware							2							
24	Software					1		1				1			
25	Power converters				1	1	1			1	6				
26	Cooling and ventilation				1	1	1			1			1		
27	Electricity and cabling				1	1	1						2		
28	Installation and commis...														

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	Manage the project	Prepare PM documents	Perform basic design	Perform detailed design	Prepare specifications	CFT, award contract	Supply equipment (order)	Negotiate agreement	Prepare manufacturing file	Manufacture, assemble	Measure, test, validate	Refurbish, maintain	Build, install	Commission
28 Installation and commis...														
29 Infrastructures													7	
30 Ring equipment													4	
31 Commissioning														1
32														

$$\sum a_{ij} = 125 \text{ WUs needed}$$
for managing this project.

✋ Work Unit vs. Planned Unit.

- It is not mandatory to identify all the WUs of the project with the same level of accuracy!
- WUs that are scheduled to be carried out at the early stage of the project should be defined more precisely than the ones scheduled to be performed at the end of the project.
- Practically, this means that the content or the breakdown of long lead WUs can be reviewed.
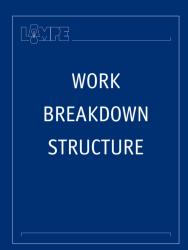
The procedure is straightforward: the list of WUs is generated from the WBS Matrix by scanning all its intersections.

1 or n Work Units are appended to the list according to the number that has been specified at the intersection.

2002-01-25
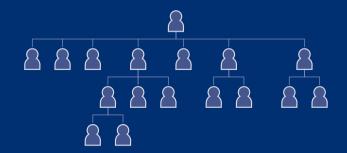
- The Work Breakdown Structure
  of the project is released.
  This document includes the list
  of Work Units.

LAMPE

WORK
BREAKDOWN
STRUCTURE
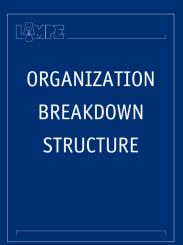
③ Organization Breakdown Structure.

It is no more than the organization chart of the project.

2002-01-25

- The Organization Breakdown
  Structure is released.

LAMPE

ORGANIZATION
BREAKDOWN
STRUCTURE

Personnel

RESOURCES

Materiel

RBS

④ Resource Breakdown Structure.

RESOURCES

- Personnel
  - Internal
  - External
    - Temporary work
    - Collaborations
- Materiel

RESOURCES

Personnel
- Internal
- External
  - Temporary work
  - Collaborations

Materiel
- Stores & orders
- Contracts

Others

Tools

RBS

④ Resource Breakdown Structure.

Non-renewable RESOURCES

- Personnel
  - Internal
  - External
    - Temporary work
    - Collaborations **M3**
- Materiel
  - Stores & orders
  - Contracts
  - Others
    - Logistics
    - Energies
    - Space
    - Duty travels
    - Quality control
- Tools

RBS

④ Resource Breakdown Structure.

	A	B
1	type	name of the resource
2	L1	Art > lead engineer, cooling & ventilation
3	L1	Ben > lead engineer, magnet systems
4	L1	Bill > project manager
5	L1	Billie > lead engineer, vacuum systems
6	L1	Bud > engineer, intensity monitor
7	L1	Carla > engineer, beam position monitors
8	L1	Cassandra > lead engineer, controls
9	L1	Chet > engineer, sextupole magnets
10	L1	Count > engineer, dipole magnets
11	L1	Django > engineer, insulated copper wire
12	L1	Ella > lead engineer, power converters

	A	B
1	type	name of the resource
13	L1	Errol > engineer, undulator
14	L1	Fats > engineer, septum & kickers
15	L1	Gil > lead engineer, mechanical & installation coord.
16	L1	Helen > engineer, dipole corrector magnets
17	L1	Jacky > engineer, controls
18	L1	Joshua > designer, magnet systems
19	L1	Lester > designer, integration studies
20	L1	Max > lead engineer, acceleration
21	L1	Melba > PM assistant
22	L1	Nina > engineer, profile monitors
23	L1	Oscar > head design office, deputy PM

④ Resource Breakdown Structure.

	A	B
1	type	name of the resource
24	L1	Pat > lead engineer, electricity & cabling
25	L1	Ray > surveyor
26	L1	Sarah > engineer, quadrupole magnets
27	L1	Sonny > technician, magnet systems
28	L1	Sweet > lead engineer, beam instrumentation
29	L1	Tools > technician, beam instrumentation
30	L1	Waine > technician, mechanical & installation coord.
31	L2	S02 - Designers
32	L2	S03 - Vacuum technicians
33	L2	S04 - RF technicians
34	L2	S09 - Installation team

④ Resource Breakdown Structure.

	A	B
1	type	name of the resource
35	M1	F02 - Supply and installation of cooling network
36	M1	F06 - Supply of quadrupole magnets
37	M1	F07 - Supply of vacuum chambers
38	M1	F09 - Supply of septum and kicker magnets
39	M1	F10 - Supply of insulated copper wire
40	M1	F11 - Supply of power converters
41	M1	F12 - Supply of sextupole magnets
42	M1	F13 - Supply of corector magnets
43	0	F16 - Logistics
44	M1	F19 - Electical Works
45	M2	Off-the-shelf components *COTS*

④ Resource Breakdown Structure.

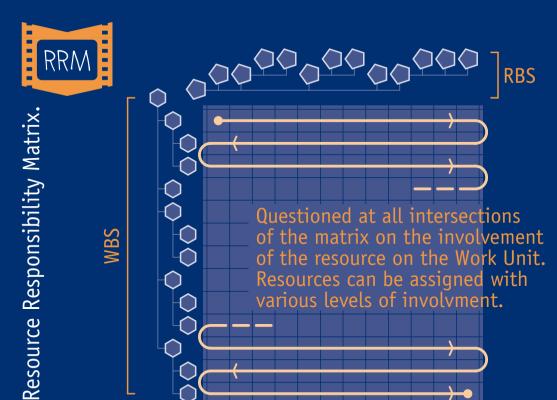|	A	B
1	type	name of the resource
46	M2	P02 - CAT Protocol (50% funded by the Lab)
47	M3	P02 - CAT Protocol (50% funded by CAT)
48	M3	P01 - BINP Protocol (100% funded by BINP)
49	0	Duty travels
50		
51		
52		
53		
54		
55		
56		

- The Resource Breakdown Structure of the project is released.

  This document includes the list of Budget Codes.

RESOURCE
BREAKDOWN
STRUCTURE

⑤ Resource Responsibility Matrix.

The Resource Responsibility Matrix

(a.k.a. Resource Assignment Matrix in some textbooks)

has basically two purposes:

- The identification of all the resources required to carry out all the Work Units that have been identified.

- The clarification of all the communication processes within the project.

RRM

Resource Responsibility Matrix.

RBS

WBS

Questioned at all intersections
of the matrix on the involvement
of the resource on the Work Unit.
Resources can be assigned with
various levels of involvment.

⑤

The different levels of involvement:

X $\longrightarrow$ e**X**ecutes the work.

RRM ⑤ Resource Responsibility Matrix.

The different levels of involvement:

X $\longrightarrow$ e**X**ecutes the work.

R $\longrightarrow$ **R**eviews the work done.

⑤ Resource Responsibility Matrix.

The different levels of involvement:

X ⟶ e**X**ecutes the work.

R ⟶ **R**eviews the work done.

I ⟶ must be **I**nformed.

⑤ Resource Responsibility Matrix.

The different levels of involvement:

X $\longrightarrow$ e**X**ecutes the work.

R $\longrightarrow$ **R**eviews the work done.

I $\longrightarrow$ must be **I**nformed.

H $\longrightarrow$ provides **H**elp or tuitions.

⑤ Resource Responsibility Matrix.

RRM

The different levels of involvement:

X	$\longrightarrow$	e**X**ecutes the work.
R	$\longrightarrow$	**R**eviews the work done.
I	$\longrightarrow$	must be **I**nformed.
H	$\longrightarrow$	provides **H**elp or tuitions.
N	$\longrightarrow$	is **N**eeded to complete the work.

⑤ Resource Responsibility Matrix.

The different levels of involvement:

Dark b.g.
or circled

X	$\longrightarrow$	eXecutes the work.		X	Ⓧ
R	$\longrightarrow$	Reviews the work done.		R	Ⓡ
I	$\longrightarrow$	must be Informed.			
H	$\longrightarrow$	provides Help or tuitions.			
N	$\longrightarrow$	is Needed to complete the work.			

leads the WU and monitor its progress.

RRM ⑤ Resource Responsibility Matrix.

The different levels of involvement:

	Dark b.g. or circled	Grey b.g. or underscore
X → eXecutes the work.	X Ⓧ	X X̲
R → Reviews the work done.	R Ⓡ	R R̲
I → must be Informed.		I I̲
H → provides Help or tuitions.		H H̲
N → is Needed to complete the work.		

leads the WU and monitor its progress. ⌐

contributes to decision making w.r.t. the WU. ⌐

	Bill	Melba	Oscar	Lester	S01	Ben	Helen	F13	Joshua	Sonny	COTS	Travels	Logistics
2 Manage the LAMPE Project	(X)												
3 Issue PM documents	(X)		R			X	R						
4 Perform integration studies general services	R		(X)	X	X	R	I						
5 Perform integration studies ring equipment	R		(X)	X	X	R	R						
30 Perform detailed design of MDUs	R		I			R	(X)		X				
31 Prepare specification for MDUs	R		I			R	(X)		X				
32 Call for tender & award contract for MDUs	R	X				R	(X)	N					
33 Prepare MDU manufacturing files	R		I			R	(X)	X	I				
34 Assemble & deliver pre-series MDUs (×2)	I		I			R	(R)	X		X		N	
35 Assemble & deliver series MDUs (×4)	I		I			R	(R)	X		X		N	
36 Assemble & deliver series MDUs (×4)	I		I			R	(R)	X		X		N	
37 Assemble & deliver series MDUs (×4)	I		I			R	(R)	X		X		N	
38 Assemble & deliver series MDUs (×4)	I		I			R	(R)	X		X		N	
39 Assemble & deliver MDU spare coils (×2)	I		I			R	(R)	X		X		N	

	2002	2003	2004	
N D J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J

2002-01-25

- The Resource Responsibility Matrix of the project is released.
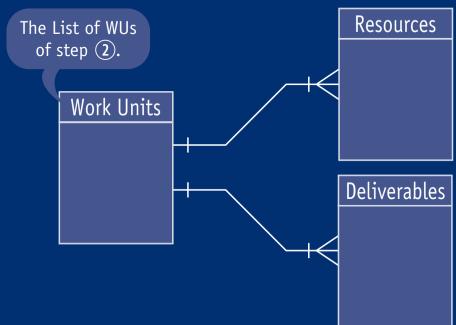
RESOURCE
RESPONSIBILITY
MATRIX

WUD ⑥ Work Unit Dictionary.

<u>Aim</u> : listing all the Work Units of the project, and for each of them: specifiying which are the resources required, and what are the deliverables expected.
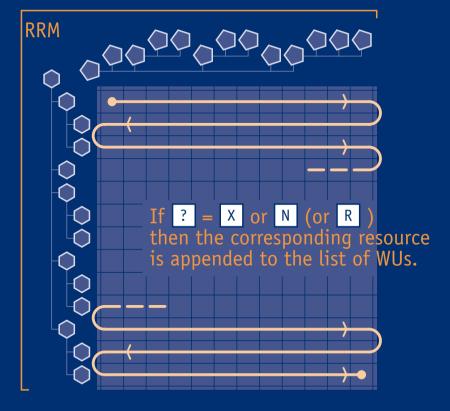
2 stages

⑥ᵃ
Identification
of the resources
required → RRM

⑥ᵇ
Identification
of the deliverables

⑥[a]
Identification of the resources required → RRM

Only those that are substantially involved in the execution of the WUs, i.e.:

> The resources that execute the work. ⟶ **X**

> The resources that are needed. ⟶ **N**

> The resources that are substantially involved in decision making processes. ⟶ **R**

If **?** = **X** or **N** (or **R**) then the corresponding resource is appended to the list of WUs.

	A	B	C	D	E	F	G	H
1	WU	WUID	type	status	Work Unit label	WU Holder	Pld Start	Pld Finish
2	type	WUID	#		Resource description	BAC	Unit	Budget Code
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								

Black lines → Work Units

Red lines → Resources assigned

	A	B	C	D	E	F	G	H	I	T	U	AU	AV	AW
1		Bill	Melha	Oscar	Lester	S01	Ben	Helen	F13	Joshua	Sonny	COTS	Travels	Logistics
25	Manage the LAMPE Project	Ⓧ	X											
26	Issue PM documents	Ⓧ	X	R			X	R						
27	Perform integration studies general services	R		Ⓧ	X	X	R	I						
28	Perform integration studies ring equipment	R		Ⓧ	X	X	R	R						
29														

	A	B	C	D	E	F	G	H
1	WU	WUID	type	status	Work Unit label	Holder	Pld Start	Pld Finish
2	type	WUID	#		Resource description	BAC	Unit	Budget Code
23	WU	103	E	PL	Perform integration studies ring equip	car@Lab.org	28-Jan-02	01-Nov-02
24	L1	103	1		Oscar@lab.org	7	M.WK	
25	L1	103	2		Lester@lab.org	15	M.WK	
26	L2	103	3		S01 - Designers	20'925	CHF	13705
27								

	B	C	D	E	L	M	T	U	AA	AF	AO	AV	AW
A	Bill	Melba	Oscar	Ben	Chet		Joshua	Sonny	Sweet	Billie	Ella	Travels	Logistics
25 Perform detailed design of LSUs	R		I	R	Ⓧ		X		I	R	R		
26 Prepare specification for LSUs	R		I	R	Ⓧ		X		I	R			
27 CFT and award contract for LSUs	R	X		R	Ⓧ							N	
28 Prepare LSU manufacturing files	R		I	R	Ⓧ		I						
29 Assemble and deliver LSUs (×4)	I		I	R	Ⓡ			X				N	

	A	B	C	D	E		G	H
1	WU	WUID	type	status	Work Unit label	WU H...	Pld Start	Pld Finish
2	type	WUID	#		Resource description	...C	Unit	Budget Code
123	WU	123	E	PL	Perform detailed design of LSUs	Chet ... rg	02-Dec-02	21-Feb-03
124	L1	123	1		Chet@lab.org	2	M.WK	
125	L1	123	2		Joshua@lab.org	5	M.WK	
126								
127								

	A	B	C	D	E	L	M	T	U	AA	AF	AO	AV	AW
1		Bill	Melba	Oscar	Ren...	Chet	?	Joshua	Sonny	Sweet	Billie	Ella	Travels	Logistics
25	Perform detailed design of LSUs	R		I	R	X		X		I	R	R		
26	Prepare specification for LSUs	R		I	R	X		X		I	R			
27	CFT and award contract for LSUs	R	X		R	X							N	
28	Prepare LSU manufacturing files	R		I	R	X	I							
29	Assemble and deliver LSUs (×4)	I		I	R	R			X				N	

	A	B	C	D	E			G	H
1	WU	WUID	type	status	Work Unit label	WU H...		Pld Start	Pld Finish
2	type	WUID	#		Resource description		C	Unit	Budget Code
126	WU	124	E	PL	Prepare specification for LSUs	Chet...rg		10-Feb-03	02-May-03
127	L1	124	1		Chet@lab.org		2	M.WK	
128	L1	124	2		Joshua@lab.org		5	M.WK	
129									
130									

	A	B	C	D	E	L	M	T	U	AA	AF	AO	AV	AW
1		Rill	Melba	Uscar	Ren	Chet	F12	Joshua	Sonny	Sweet	Billie	Ella	Travels	Logistics
25	Perform detailed design of LSUs	R		I	R	X		X		I	R	R		
26	Prepare specification for LSUs	R		I	R	X		X		I	R			
27	CFT and award contract for LSUs	R	X		R	X	N						N	
28	Prepare LSU manufacturing files	R		I	R		I							
29	Assemble and deliver LSUs (×4)	I		I	R				X				N	

	A	B	C	D	E		G	H
1	WU	WUID	type	status	Work Unit label	WU	Pld Start	Pld Finish
2	type	WUID	#		Resource description	BAC	Unit	Budget Code
129	WU	125	E	PL	CFT and award contract for LSUs	Chet...org	16-May-03	11-Jul-03
130	L1	125	1		Chet@lab.org	1	M.WK	
131	L1	125	2		Melba@lab.org	1	M.WK	
132	M1	125	3		F12 - Supply of sextupole magnets	5'000	CHF	13713
133	0	125	4		Duty travels	2'775	CHF	13713

A	B	C	D	E	L	M	T	U	AA	AF	AO	AV	AW
	Bill	Melba	Oscar	Ben	Chet	F12	Josnua	Sonny	Sweet	Billie	Ella	Travels	Logistics
25 Perform detailed design of LSUs	R		I	R	Ⓧ		X		I	R	R		
26 Prepare specification for LSUs	R		I	R	Ⓧ		X		I	R			
27 CFT and award contract for LSUs	R	X		R	Ⓧ	N						N	
28 Prepare LSU manufacturing files	R		I	R	Ⓧ	X	I						
29 Assemble and deliver LSUs (×4)	I		I	R	Ⓧ	N		X				N	

	A	B	C	D	E		G	H
1	WU	WUID	type	status	Work Unit label	WU I	Pld Start	Pld Finish
2	type	WUID	#		Resource description	BAC	Unit	Budget Code
134	WU	126	E	PL	Prepare LSU manufacturing files	Chet...org	19-Sep-03	19-Sep-03
135	L1	126	1		Chet@lab.org	1	M.WK	
136	M1	126	2		F12 - Supply of sextupole magnets	10'025	CHF	13713
137								
138								

	A	B	C	D	E	L	M	T	U	AA	AF	AO	AV	AW
1		Bill	Melba	Oscar	Ben	Chet	F12	Joshua	Sonny	Sweet	Billie	Ella	Travels	Logistics
25	Perform detailed design of LSUs	R		I	R	Ⓧ		X		I	R	R		
26	Prepare specification for LSUs	R		I	R	Ⓧ		X		I	R			
27	CFT and award contract for LSUs	R	X		R	Ⓧ	N						N	
28	Prepare LSU manufacturing files	R		I	R	Ⓧ	X	I						
29	Assemble and deliver LSUs (×4)	I		I	R	Ⓡ	X		X				N	

	A	B	C	D	E		G	H
1	WU	WUID	type	status	Work Unit label	WU Ho..	Pld Start	Pld Finish
2	type	WUID	#		Resource description	..C	Unit	Budget Code
137	WU	127	E	PL	Assemble and deliver LSUs (×4)	Chet@...rg	12-Mar-04	12-Mar-04
138	L1	127	1		Sonny@lab.org	..0.5	M.WK	
139	M1	127	2		F12 - Supply of sextupole magnets	5'150	CHF	13713
140	O	127	3		Duty travels	2'775	CHF	13713
141								

⑥ b

Identification
of the deliverables

From a deliverable point of view,
Work Units can be of 3 types:

2 deliverables
Standard WUs

WORK UNIT

1 deliverable
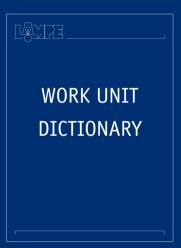'Result-oriented' WUs
i.e. outsouced WUs

multi-deliverables

	A	B	C	D	E	F	G	H
1	WU	WUID	type	status	Work Unit label	WU Holder	Pld Start	Pld Finish
2	type	WUID	#		Resource description	BAC	Unit	Budget Code
3	DE	UID	#	weight	Deliverable description	Pld Qty	Unit	Pld Date
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								

Black lines → Work Units

Red lines → Resources assigned

Green lines → Deliverables

	A	B	C	D	E	F	G	H
1	WU	WUID	type	status	Work Unit label	WU Holder	Pld Start	Pld Finish
2	type	WUID	#		Resource description	BAC	Unit	Budget Code
3	DE	WUID	#	weight	Deliverable description	Pld Qty	Unit	Pld Date
137	WU	127	E	PL	Assemble and deliver LSUs (×4)	Chet@Lab.org	12-Mar-04	12-Mar-04
138	L1	127	1		Sonny@lab.org	0.5	M.WK	
139	M1	127	2		F12 - Supply of sextupole magnets	35'150	CHF	13713
140	O	127	3		Duty travels	2'775	CHF	13713
141	DE	127	1	0	LSUs assembled and delivered to the Lab	4	U	12-Mar-04
142					Date at which the 4th LSU magnet is planned to be delivered.			
143								
144								
145								
146								
147								
148								
149								
150								
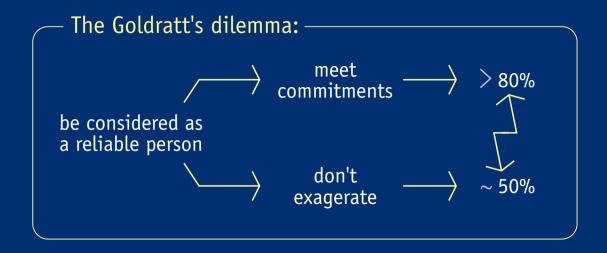
	A	B	C	D	E	F	G	H
1	WU	WUID	type	status	Work Unit label	WU Holder	Pld Start	Pld Finish
2	type	WUID	#		Resource description	BAC	Unit	Budget Code
3	DE	WUID	#	weight	Deliverable description	Pld Qty	Unit	Pld Date
129	WU	125	E	PL	CFT and award contract for LSUs	Chet@Lab.org	16-May-03	11-Jul-03
130	L1	125	1		Chet@lab.org	1	M.WK	
131	L1	125	2		Melba@lab.org	1	M.WK	
132	M1	125	3		F12 - Supply of sextupole magnets	5'000	CHF	13713
133	0	125	4		Duty travels	2'775	CHF	13713
134	DE	125	1	0	CFT for LSUs issued	1	U	16-May-03
135	DE	125	2	1	Contract for LSUs awarded	1	U	27-Jun-03
136	DE	125	3	1	Downpayment to LSU manufacturer done	1	U	11-Jul-03

2002-01-25

- The Work Unit Dictionary
  of the project is released.

LAMPE

WORK UNIT
DICTIONARY

✋ Estimating vs. budgeting...

The Goldratt's dilemma:

```
                      meet
                   commitments  ──────►   ＞ 80%
      ┌────────►                               ▲
be considered as                              │
a reliable person                             │
      └────────►      don't                    ▼
                   exaggerate   ──────►   ~ 50%
```

Eliyahu M. Goldratt. *Necessary and sufficient. Vol. 4: a look into the rules of project management.* Goldratt's Marketing Group. 2002 www.TOC-Goldratt.com

✋ Estimating vs. budgeting...

Within the project, budgets (i.e. commitments)
shall be set up at system level (i.e. budget codes)
and not at
Work Unit level.
→ This is the purpose of budget codes!

Every system owner must then contribute to the setting up
of the Project Mangement Reserve.

→ ~ 10% of the system budget.

no Project Management Reserve ⟹ no Project Management!

✋ Estimating vs. budgeting...

The Project Management Reserve aims at:

- covering the technical and programmatic risks:
  system forgotten or underestimated, rework,
  delays, technical difficulties;

- covering the commercial and economical risks:
  bids are always higher or lower w.r.t. the initial estimates!
  bankrupt, price escalation, FX...

2002-01-25

- The Budget of the project
  is released.

LAMPE

BUDGET

2002-01-25

- The Coordination Schedule
  of the project is released.

LAMPE

COORDINATION
SCHEDULE

The Planning & Costing Phase

of the LAMPE Project

is completed.

Before continuing ...
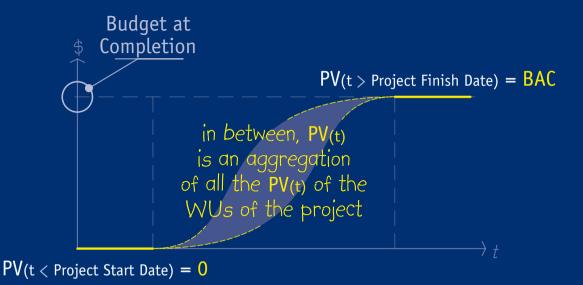
... let's say a few words about
Earned Value Management.
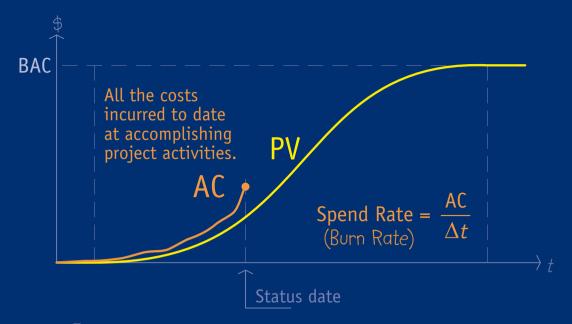
Earned Value Management Basics.

The Earned Value Criteria is a methodology developed
by the US DoD in the late '60s. At that time it was known
as the C/SCSC (Cost/Schedule Control System Criteria).

This methodology is now managed by ANSI,
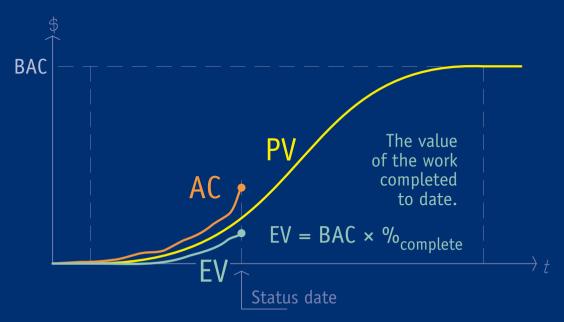under standard #748.

Earned Value Management Basics.

① Setting up the Planned Value curve of the project.

Budget at Completion

$PV_{(t > \text{Project Finish Date})} = BAC$

in between, $PV_{(t)}$ is an aggregation of all the $PV_{(t)}$ of the WUs of the project

$PV_{(t < \text{Project Start Date})} = 0$

Earned Value Management Basics.
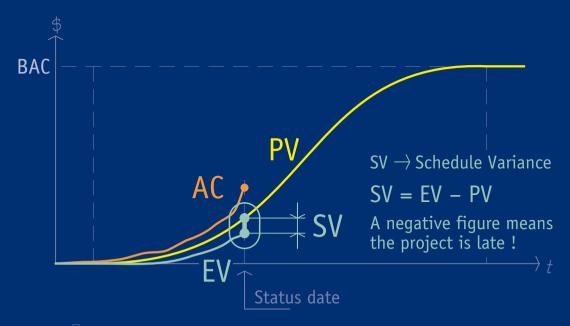
③ Recording the Actual Costs of the project.

BAC

All the costs incurred to date at accomplishing project activities.

PV

AC

$$\text{Spend Rate} = \frac{AC}{\Delta t}$$
(Burn Rate)

Status date

Earned Value Management Basics.
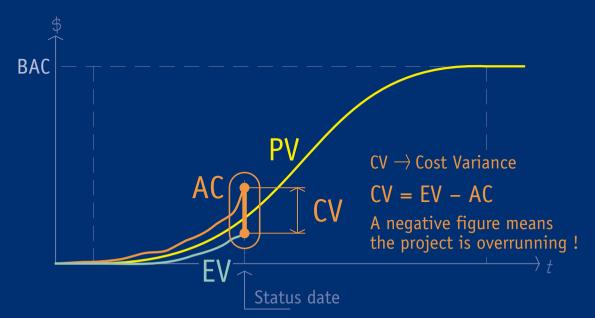
④ Calculating the Earned Value of the project.

BAC

PV

AC

The value
of the work
completed
to date.

EV = BAC × %complete

EV

Status date

$t

Earned Value Management Basics.
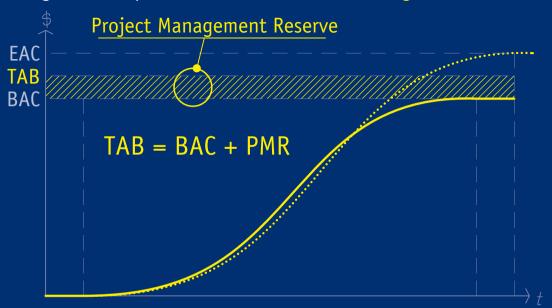
⑤ Calculating variances and performance indices.

CV → Cost Variance

CV = EV − AC

A negative figure means the project is overrunning !

Earned Value Management Basics.
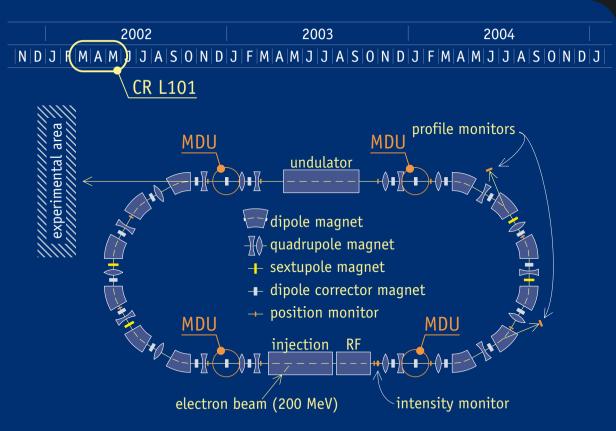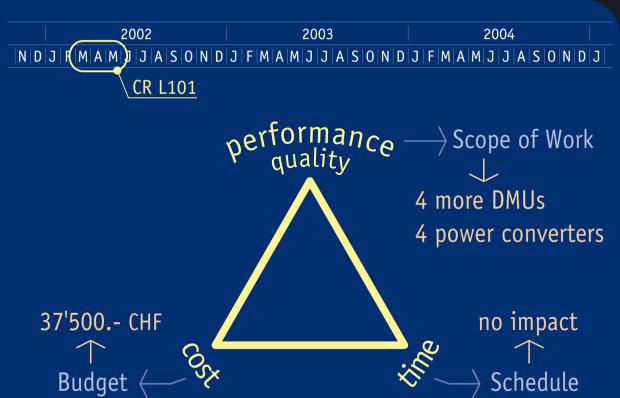
Budget at Completion vs. Total Allocated Budget vs. EAC.

Project Management Reserve

TAB = BAC + PMR

| | | | 2002 | | | | | | | | | 2003 | | | | | | | | | 2004 | | | | | | | | | |
|N|D|J|F|M|A|M|J|J|A|S|O|N|D|J|F|M|A|M|J|J|A|S|O|N|D|J|F|M|A|M|J|J|A|S|O|N|D|J|

Jan.–Mar. & Apr.–June 2002 reporting periods

- The project started in the early days of January as scheduled.
- Project contributors have recorded the time they have spent on completed or on-going Work Units (personnel Actual Costs).
- Some (material) Actual Costs have been recorded in the Lab accounting database, and charged on Budget Codes.
- The first unforeseen event occured:

  4 DMUs (dipole corrector magnets) have been forgotten in the preliminary design.

  ⇒ Change Record.
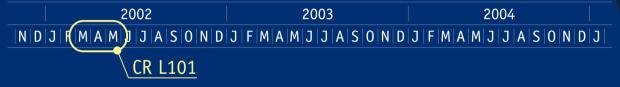
2002 · 2003 · 2004

N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J

CR L101

performance
quality → Scope of Work
↓
4 more DMUs
4 power converters

37'500.- CHF
↑
Budget ← cost

no impact
↑
time → Schedule

	2002	2003	2004
N D J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J

CR L101

WUs impacted: 130 131 133 134 135 136   198 199

4 DMUs   4 PCs

	A	B	C	D	E	F	G	H
1	WU	WUID	type	status	Work Unit label	WU Holder	Pld Start	Pld Finish
2	type	WUID	#		Resource description	BAC	Unit	Budget Code
3	DE	WUID	#	weight	Deliverable description	Pld Qty	Unit	Pld Date
211	WU	133	F	PL	Assemble and deliver series DMUs (×5)	Bill@Lab.org	24-Oct-03	24-Oct-03
212	L1	133	1		Helen@Lab.org	5	M.WK	
213	M1	133	2		F13 - Supply of DMUs	27'100	CHF	13714
214	M1	133	4		F13 - Supply of DMUs	6'775	CHF	13714
215	O	133	3		Duty travels	2'500	CHF	13714
216	DE	133	1	1	Series DMUs assembled & delivered	5	U	24-Oct-03
217								

2002 | 2003 | 2004

N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J

CR L101

How this change is funded? → Management Reserve!

CHF
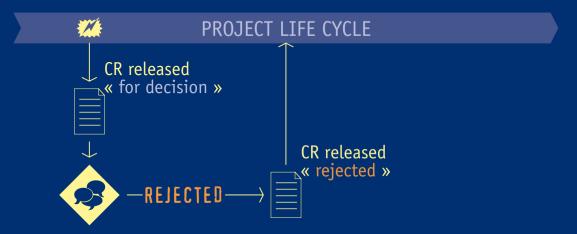
before   after

300 k
273 k

CR L101

t

Purpose

Presenting you CERN's approach to project management
i.e. the approach developed for the **LHC project**
used on the **CNGS project**
in use on the **Linac4 and LIU projects**
implemented on the **NICA project** at Dubna
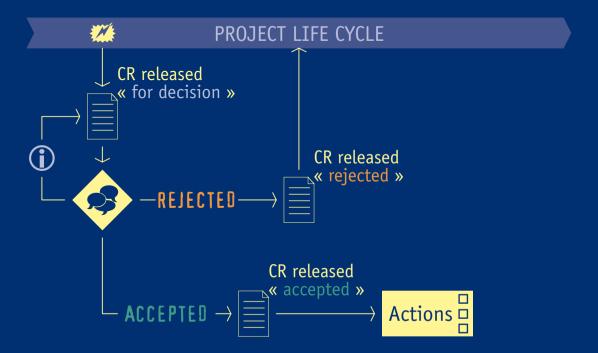
A project control approach that fully complies
with state-of-the-art practice (even better)
Benoit Daudin ⋯⋱ more on the tools used at CERN
Luisela Lari ⋯⋱ more on installation planning

Change Record Life Cycle.

PROJECT LIFE CYCLE

CR released
« for decision »

Change Record Life Cycle.

PROJECT LIFE CYCLE

CR released « for decision »

CR released « rejected »

REJECTED

Change Record Life Cycle.

PROJECT LIFE CYCLE

CR released « for decision »

CR released « rejected »

REJECTED

CR released « accepted »

ACCEPTED

Actions

Change Record Life Cycle.

Quality ⇒ All actions are supported by documents.

Clever strategy towards changes:

Integration of all the consequences
of the change into the project databases
so the change record doesn't need
to be handled as such.
Change traceability is done through
the project databases.

Change Record Life Cycle.

2002 | 2003 | 2004

N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J

CR L101

| LAMPE | 0.1 |
| | 2002-03-14 |

CHANGE
RECORD

FOR DECISION

| LAMPE | 1.0 |
| | 2002-04-26 |

CHANGE
RECORD

ACCEPTED

| LAMPE | 2.0 |
| | 2002-05-10 |

CHANGE
RECORD

CLOSED