Implementing Astroparticle Projects
Challenges and Solutions
Report from the ASPERA Workshop
@ Gran Sasso (18-19 Oct 2012)

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Recent actions on standardisation of project management of the large-scale ApP infrastructures

I. ASPERA (EU funded astroparticle coordination) produced recently a document on synchronisation of project planning, and implementation procedures of Astroparticle Infrastructures. It was the basis of discussion in the Gran Sasso meeting and will be presented here.

II. During the Gran Sasso meeting the models used in ground/underwater (AUGER, CTA, KM3NEt) and underground infrastructures (Borexino, Xenon) as well as KATRIN, were discussed. Surprisingly for some participants, expecting “boring” discussions, it was a very lively meeting.

III. The Astroparticle Physics International Forum (APIF), reporting to OECD, prepares a similar document at the global level.


ASPERA-2 DELIVERABLE 5.5-5.8

PROPOSAL FOR THE SYNCHRONISATION OF PROJECT PLANNING AND IMPLEMENTATION PROCEDURES FOR LARGE EUROPEAN ASTROPARTICLE PHYSICS INFRASTRUCTURES

ASPERA

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SEPTEMBER 2012

45 pages

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The need for a more coherently global approach to the planning, construction and operation of the large-scale ApP infrastructures

I. Astroparticle Physics entered in the era of Large Infrastructures

II. The deployed infrastructures have implemented organisational modes that extend from a simple collaboration scheme (MoU) to a limited liability structure. A rich experience has been obtained on constructing and operating infrastructures in “green field” territories (e.g. Auger)

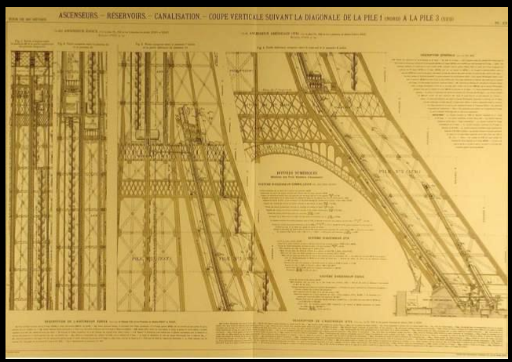
I. Future ApP infrastructures will have to be implemented in a competitive programmatic environment, where neighbouring disciplines have a strong tradition of large program management and where large infrastructures engage the attention of many stakeholders in the public and private sectors.

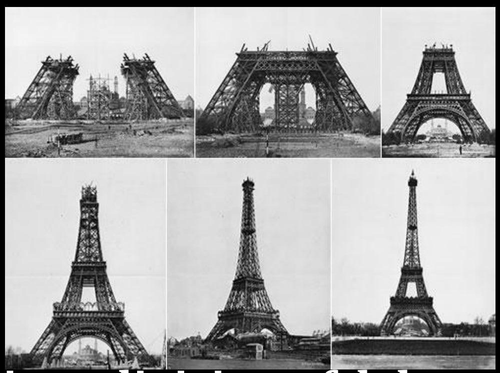
I. ApP has developed many interfaces with geosciences, climatology, biology and extreme instrumentation applications, among others. The future infrastructures need to develop further these synergies.

II. Data access and availability issues have come recently at the centre of the attention both of society and of funding instances

Evolution of Project Planning I

- From the Engineering Drawing as a means of communication





- Through the "Scientific Management" Taylorian division of labor (Gantt, 5 year plans, etc)

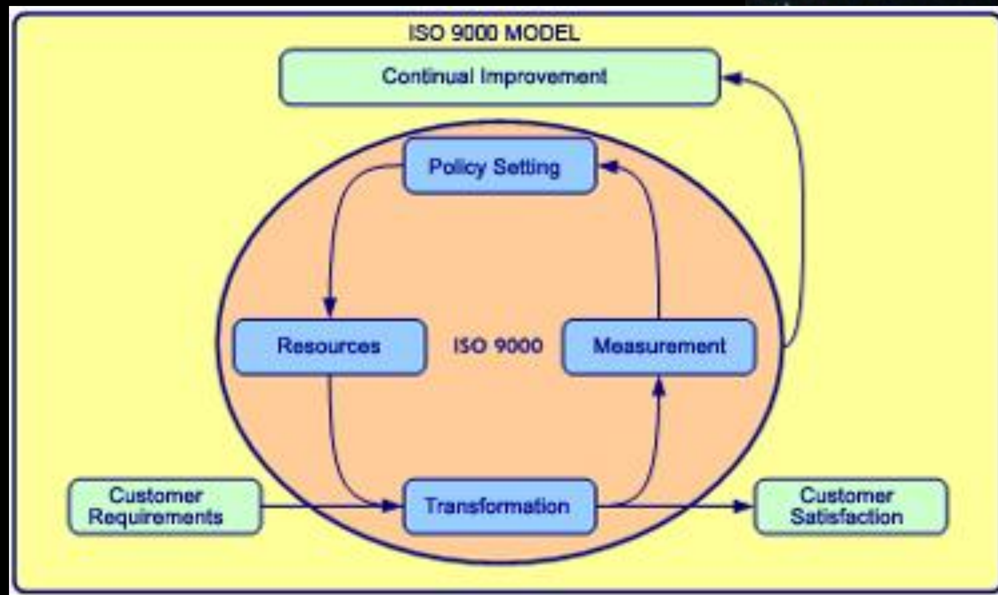
Temps Modernes

Metropolis

« American efficiency is that indomitable force which neither knows nor recognises obstacles; which continues on a task once started until it is finished, even if it is a minor task; and without which serious constructive work is impossible.... The combination of the Russian revolutionary sweep with American efficiency is the essence of Leninism. » J. Stalin

Evolution of Project Planning II

- **To ISO 9000**



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Project planning and implementation encompasses a **coherent** set of processes for all aspects of project management and control

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- **Defining phases (A to to F) and critical decision points (DP-A to DP-E)** enabling the progress of the project to be controlled with respect to cost, schedule and technical objectives.

- **Defining the set of authorities providing, scientific and technical/operational expertise as well as oversight and guidance** over the life-cycle of the project.

- **Defining project breakdown structures,** which constitute the common reference system identifying the tasks and responsibilities of each actor, facilitating the coherence between all activities, and identifying the deliverables of each phase, performing scheduling and costing activities.

Particularities of ApP infrastructures (I)

I. Astroparticle Physics research infrastructures are of 2 kinds:

   I. Either constructed in a “green field”, far from a specific laboratory or an established observatory able to provide project management and expertise. This fact implies also a certain complexity in site selection issues.

   II. Or are part of a laboratory, e.g. an underground laboratory, or a host laboratory (VIRGO/LIGO, KATRIN, etc) but their size imposes a feedback role with the organisation of the laboratory, sometimes the experiments are “born” together with the laboratory. They do not deal with a previously fixed and streamlined infrastructure.

➔ THE IMPORTANCE OF ORGANIGRAMS

Particularities of ApP infrastructures (II)

Construction is very often financed by a consortium of agencies from different countries, with different funding cycles, processes and procedures, so

I. distributed sources of funding, acquisition and property are implicated,

II. strong constraints are put on cost and performance tracking,

III. a challenge for project assurance, governance and oversight is constituted

IV. often new institutional entities are necessary to manage funds, personnel, ownership and other legal matters.

V. data access, availability and interdisciplinary use of the infrastructure are all issues of increased complexity

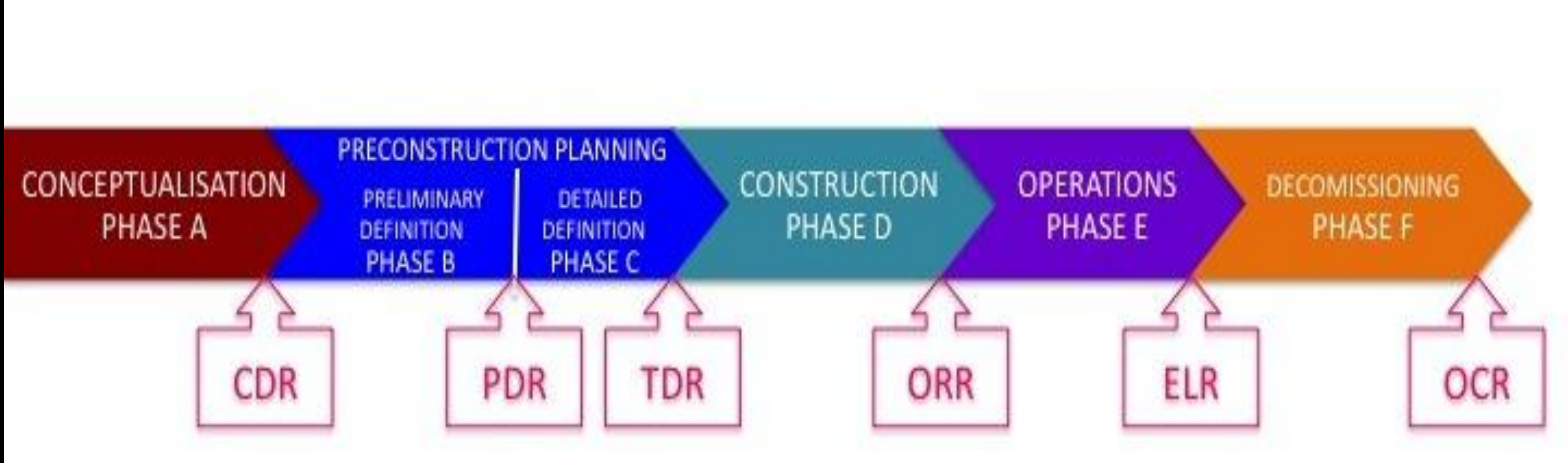
→ NEED TO MANAGE THIS MIDDLE GROUND BETWEEN AGENCIES WITHOUT BEING NORMATIVE WITH RESPECT TO NATIONAL AGENCY PRACTICES

Phases

Need to divide the life cycle of large-scale projects into 6 major phases

- **PHASE A: CONCEPTUALISATION**
  - equivalent to the Conceptualisation phase in DOE/NASA/NSF and the Mission analysis (0) and Feasibility (A) phases in ESA;
- **PHASES B and C: PRE-CONSTRUCTION PLANNING**
  - equivalent to the Pre-construction Planning phase in DOE/NASA/NSF, where it comprises of a number of sub-phases, and to the Preliminary Definition (B) and Detailed Definition (C) phases in ESA;
- **PHASE D: CONSTRUCTION**
  - equivalent to Construction/Implementation phases in DOE/NASA/NSF, and to the Qualification and Production (D) phase in ESA;
- **PHASE E: OPERATIONS**
  - equivalent to the Operation phase in DOE/NASA/NSF and to the Utilisation (E) phase in ESA; and
- **PHASE F: DECOMMISSIONING**
  - equivalent to Decommissioning phase in DOE/NASA/NSF and to the Disposal (F) phase in ESA.

Project lifecycle



PRECONCTRUCTION

✓**CDR: Conceptual Design Review, Report, DP-A**

✓**PDR: Preliminary Design Review, Report, DP-B**

✓**TDR: Technical Design Review, Report, DP-C**

CONSTRUCTION AND OPERATIONS

✓**OPR: Operation Readiness Review, DP-D**

- ✓ **+ partial Qualification Reviews (QR)**
- ✓ **+ periodic Extension of Operation Reviews (OPR)**

Pre-construction reports, reviews and decision points

I. At the end of phase A and in view of DP-A the project presents a **Conceptual Design Report** and is expected to defend the science case in the context of ongoing strategic (roadmap) and programmatic activities (community input and proposals, prioritisation of research portfolios and adjustment of the later based on funding availability and estimated costs) to have converged into a system and operations concept(s) and to have specified the technical requirements.

II. At the end of phase B and in view of DP-B the project presents a **Preliminary Design Report** and is expected to have confirmed technical solution(s) and operations concept(s), and their feasibility with respect to programmatic constraints. Determined prototype philosophy and verification approach. Examined site qualities towards a site selection. Finalised the project management, engineering and product assurance plans. Established the baseline timeline for design and construction and baseline cost at completion. Finalised the product and specification trees of PBS and the WBS and elaborated a preliminary OBS.

III. At the end of phase C and in view of DP-C the project presents a **Technical Design Report** which is the final design of the project and should be sufficiently detailed for construction to start. The following need to have be completed: production, development testing and pre-qualification of selected critical elements; assembly, integration and test planning for the system and its constituent parts; production and development testing of engineering models; detailed definition and assessment of compatibility of internal and external interfaces, including site selection risk assessment and definition of a preliminary data access model

construction, operation, decommissioning

I. **CONSTRUCTION (phase D).** Complete manufacturing, assembly testing and deployment of hardware, software and associated data management. During this phase several **Qualification Reviews** will judge the readiness of each sub-component deliverable. The **Operation Readiness Review** verifies that the infrastructure is ready for operation; accepts the operational procedures and examines their compatibility with the operation of the infrastructure; accepts and releases the data-centre for operations.

II. **OPERATIONS (phase E).** Commissioning activities; monitoring of data acquisition and access issues; maintenance activities; multidisciplinary access activities; outreach and education activities. A number of reviews are associated with this phase:

   I. **Extension of Operations Review (EOR)**: held at the end of the predetermined lifetime of operations of the project, to assess reasons of the extension of the project lifetime.

   II. **Upgrade Readiness Review (URR)**: part or the entire scientific collaboration may propose upgrades of the infrastructure. These extensions will follow the construction lifecycle defined above (Phases A to D)

   III. **End-of-Life review (ELR)**: held at the completion of the operations to verify that the operations have been completed and to ensure that all elements are configured to allow decommissioning.

III. **DECOMISSIONING (phase F).** The major task of this phase is the implementation of the decommissioning plan and to hold the **Operations Close-out Review (OCR)**.

Governance and Oversight

Modes of governance and oversight

Governance and oversight, one is not just referring to the decision-making and governing bodies, but to a set of structures, principles, rules and procedures according to which a collaboration operates and takes decisions (OECD, 2010).

Governance and oversight comprises regular internal and external reviews of project performance, followed by critical decisions and disposition of proposed changes in the project baseline. These functions are carried out by a number of different bodies, in each of the following categories:

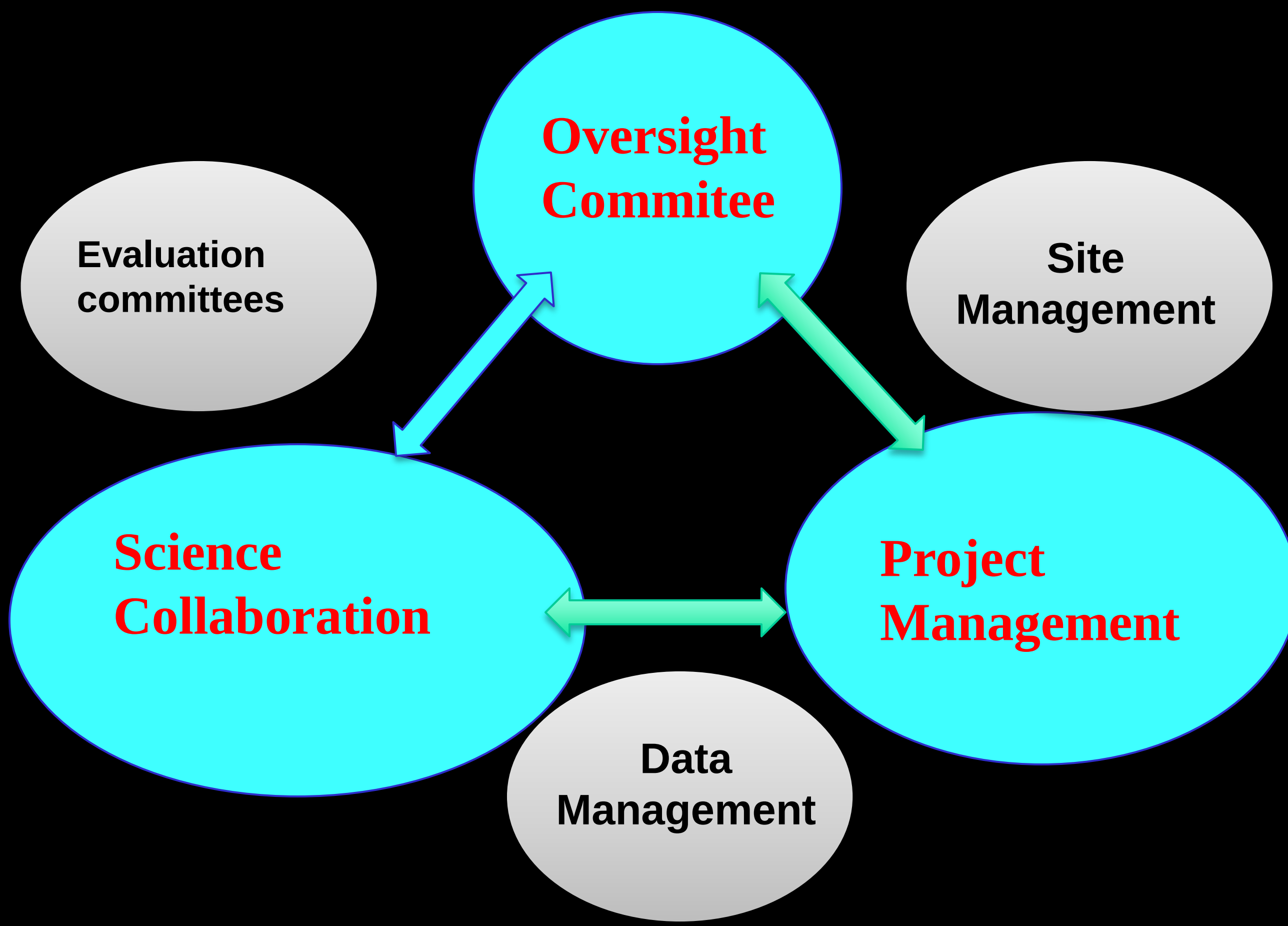
I. **Oversight Committee**: formed by the funding bodies, having the **programmatic authority** to approve a project and authorise transitions from one phase to the next. Linked by an **Agreement.**

II. **Scientific Collaboration:** a set of bodies representing **the scientific authority,** assuring the scientific responsibility for the project status, the data analysis, proposing eventual upgrades, the accession of new scientific teams to the project consortium, etc. Linked by an **MoU.**

III. **Project Management:** the Project Management team or Project Office, have the **operational responsibility** of the project. Follows a **Project Management Plan** (codifying work breakdown structures)

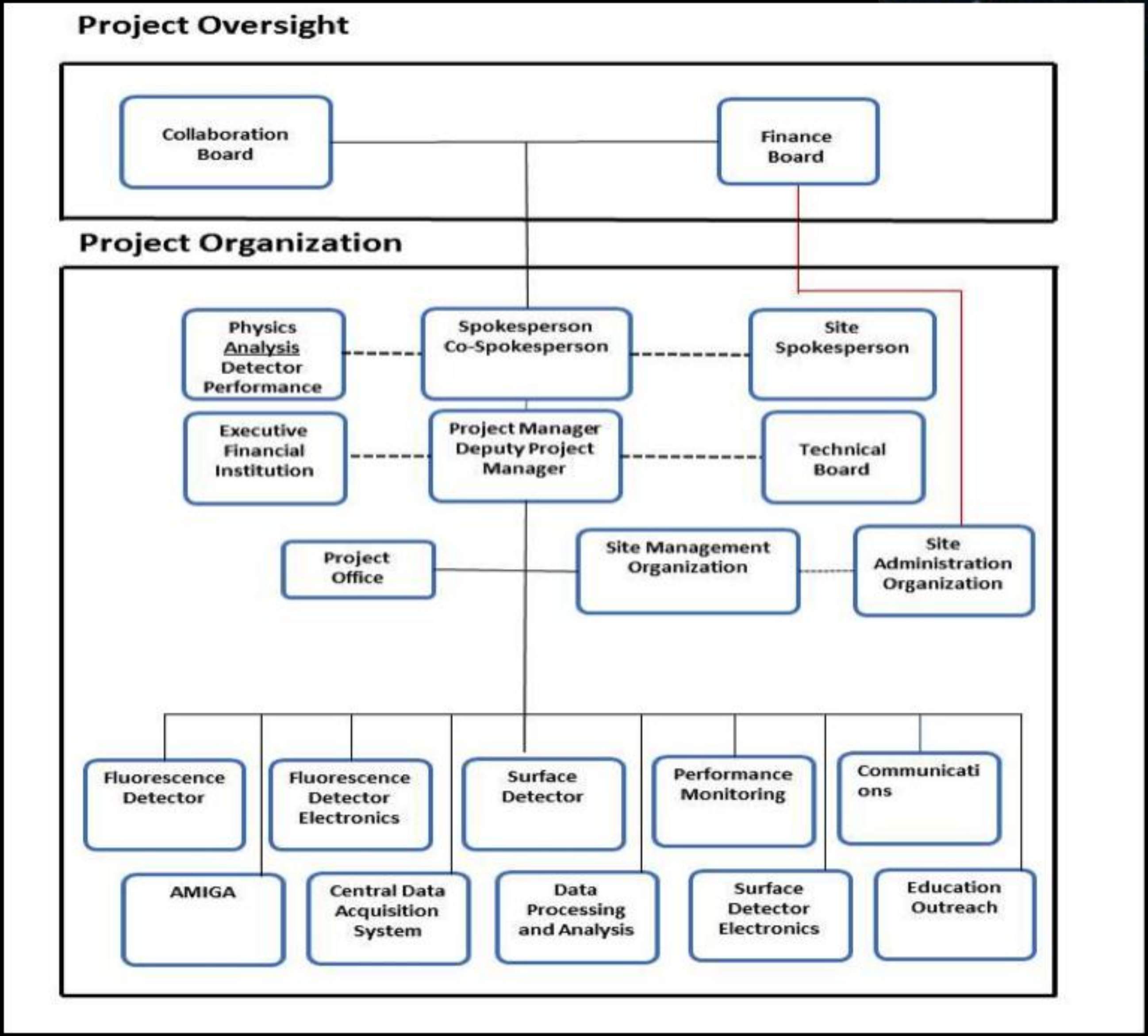
To the above one must to add **External Advisory Committee(s)**: panels of individuals charged with assessing the scientific and technical health or progress of a project

3 types of authorities



Their disposition in the hierarchy chart shows the management model and the type of community

The Auger exemple



Project Breakdown Structures

Project breakdown structures

It is essential that the project breakdown structures are arranged to include all expertise essential to implement the project with well-defined functions, clear reporting lines, integration procedures and interfaces. It should provide a clear and unambiguous definition and allocation of individual roles and responsibilities together with the necessary authority to implement them.

The general questions one asks are:

I. what needs to be produced?

II. how will one produce it?

III. who will be responsible to produce it?

They are mirrored in the

I. Project Breakdown Structure (PBS),

II. Work Breakdown Structure (WBS)

III. Organisational Breakdown Structure (OBS)

Project breakdown structure (PBS)

The PBS provides the basis for creating a common understanding between all actors of what needs to be produced by "breaking" the project down into manageable elements.

These elements are a tool for analysing, documenting and communicating the outcomes of a project.

The PBS provides an exhaustive, hierarchical tree structure of deliverables (which may be physical, such as a specific instrument, or functional, such as the data monitoring)

In particular, the PBS is composed of a **Product tree**: the breakdown of the project into successive levels of hardware and software products or elements.

It includes the development models, the integration tools and test equipment, and external items necessary to validate the end product. The product tree forms the basis for the elaboration of the project WBS

Code	Acronym	Product Description
1	**OBS**	**Observatory Facilities**
1,1	OBS-HEAD	Headquarters
1,2	OBS-SOUTH	South Observatory infrastructure
1,3	OBS-NORTH	North Observatory Infrastructure
2	**ARRAY**	**Array control**
2.1	ARRAY-MON	Instrument monitoring software
2.2	ARRAY-SLOW	Instrument slow control software
2.3	ARRAY-OPS	Instrument operation software
2.4	ARRAY-DAQ	Data acquisation software
2.5	ARRAY-TRIG	Array trigger
2.6	ARRAY-ONLINE	Online IT infrastructure
3	**DATA**	**Data management**
3.1	DATA-MODEL	Data model
3.2	DATA-PIPE	Data pipelines
3.3	DATA-ARCH	Data archives
3.4	DATA-ACCESS	Observer data access
3.5	DATA-ICT	ICT-infrastructures
4	**SST**	**Small Size Telescope**
4,1	SST-MECH	Mechanical System
4,2	SST-OPT	Optical System
4,3	SST-CAM	Camera
4,4	SST-FOUND	Foundation
4,5	SST-AUX	Auxiliary Systems
8	**xST**	**Components common to all telescope types**
8,1	xST-MECH	Mechanical System
8,2	xST-OPT	Optical System
8,3	xST-CAM	Camera
8,4	xST-FOUND	Foundation
8,5	xST-AUX	Auxiliary Systems

Work Breakdown Structure (WBS)

The WBS is "an exhaustive, hierarchical (from general to specific) tree structure of deliverables and tasks that need to be performed to complete a project" (DOE). While the PBS includes only the physical architecture of a product, the WBS includes the data and service elements necessary to complete the system.

The WBS is derived from the product tree, including support functions (i.e. management, engineering, product assurance) and associated services (e.g. test facilities).

The WBS divides the project into manageable work packages, breaking down the total work to be performed into increasing levels of detail.

The WBS provides a common approach and framework for cost estimates among all subsystems thus producing a comprehensive, accurate, and defensible cost estimate (Cost Book). WBS will also structure schedule planning, tracking of actual costs and progress.

Column name	Description
WBS	The WBS number, e.g., 1.2.2.4
Activity	A brief description of the deliverable or activity
Quantity	The quantity required per component
Base unit	Units of Quantity column. Typically "each" for deliverables, "hours" for labour
Trade code	Further specifies the activity e.g. the labour type (e.g. Engineer, Technician etc).
Cont. %	Contingency percentage
Wastage	Units wasted in the process of implementation, expressed as a fraction of the total quantity,
Spares	Spare units, expressed as a fraction of the total quantity.
Cost / Unit	The cost for the Base Unit.
Materials/component	Total materials cost for one component = Quantity * (Cost/Unit) * (1 + Wastage + Spares)
Labour / Component	Total labour cost for one component = Quantity * (Cost/Unit)
N	The number of components
Esc. Factor	Escalation factor. An estimate of the percentage that costs will rise during the procurement
Total M&S	The total Materials & Services (M&S) cost for the deliverable = (Materials/Component) * N
Total Labour	The total Labour cost for the deliverable = (Labour/Component) * N
Total EDIA	Estimated cost of Engineering, Design, Inspection, and Administration (EDIA)
Esc.	Total Escalation = (Esc. Factor) * [(Total M&S) + (Total Labour) + (Total EDIA)]
Estimated Cost (Escalated)	= (Total M&S) + (Total Labour) + (Total EDIA) + (Esc.)
Total Cont	Total contingency = (Estimated Cost Escalated) * Cont %
Total Project	Sum of previous 2 columns. Total cost of this WBS element.

WBS cost book

The **WBS Cost Book** contains supporting information, such as vendor quotes, invoices from previous procurements, etc. The Cost Book also contains a **contingency analysis**, required to ensure the project's success. Contingency costs are explicitly part of the total cost estimate.

Labour rates are also a common source of cost estimate divergence, so all generic labour categories charged to the project should be defined from the beginning. These categories should not be based only on the labour to be hired at the beginning of the project: roles that could be needed when the project matures should also be included.

A cost estimate for each item should be the expected cost of the item excluding unusual or adverse risks. The project should separately estimate the technical, cost and schedule risks for that item. These funds should be held in the reserve by the Project Manager.

Table 1 Generic cost contingency based on quality of the source

Estimate Source	Contingency (%)
Actual Cost – for deliverables already purchased	0%
Vendor Quote	10%
Vendor Information	20%
Engineering Estimate	30%
Physicist Estimate	≥50%

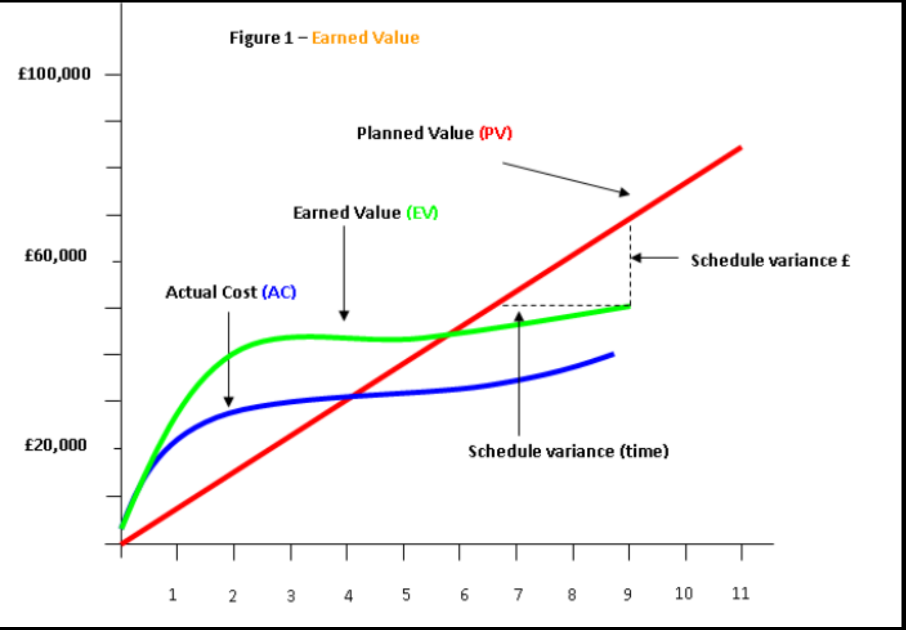
More sophisticated methods (Sanders 2009) use **Standard Risk Factors** and **Risk Percentages**. According to this method the percentage Contingency is calculated as Technical risk factor x Technical risk % + Cost risk factor x Cost risk % + Schedule risk factor x Schedule risk %. It goes from 5 to 98%.

Earned Value Management Systems

The **Cost Baseline**, i.e. the direct costs and contingency funds estimated before the start of the project, must be entered into a database and maintained throughout its lifecycle. As the project progresses, direct cost estimates are exceeded necessitating the use of contingency funds. Costs ideally should be measured monthly against the Cost Baseline in order to detect cost deviations as early as possible. (Earned Value Management Systems)

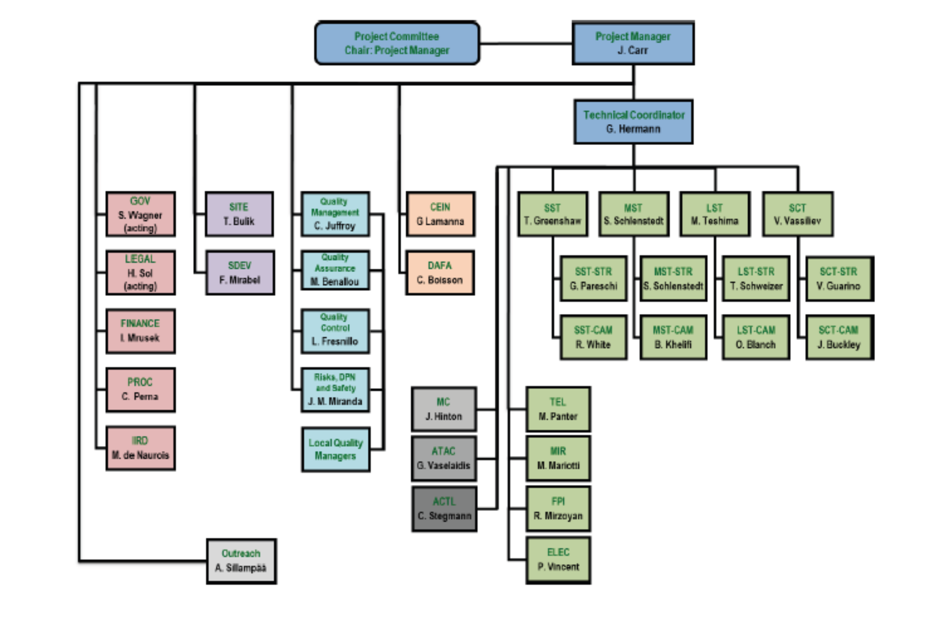
There is a number of unpredictable factors that could affect cost estimated. These can be external (e.g. delays in partner funding contributions, cuts in national funding, changes in fuel prices, inflation and exchange rates, etc), or internal (e.g. increased cost associated with delays in one project can contribute to an extended "domino" effect on agency project portfolios, leading to loss of funding previously dedicated to new projects).

Accepting a common Cost Baseline and its updates may be a challenge for different agencies and their practices. For better synchronisation of Astroparticle Physics infrastructures and given that many of the components used in the construction of these infrastructures are similar among different projects, funding agencies should consider using an institution that can provide independent cost estimates for these large-scale infrastructures, an equivalent to NASA's Independent Program Analysis Office (IPAO) ?



Organisation Breakdown Structure (OBS)

The OBS is a hierarchical model describing the established organisational framework for project planning, resource management, time and expense tracking, and cost allocation. Thus, it is used to define the responsibilities for project management, cost reporting, billing, budgeting and project control. Its hierarchical structure allows the aggregation of project information to higher levels. provides an organisational rather than a task-based perspective of the project.



It groups together similar project activities (the WBS WPs) and relates them to the structure of the organisation, showing key personnel and the assigned responsible parties for each WP.

Challenges and Solutions lessons learned I

- **Astroparticle infrastructures convergence point of different traditions. An asset** .
  - AUGER is an important legacy on project management matters in ApP. Its international and and interdisciplinary character forced the dialogue between different management traditions. The point of equilibrium was the right blend of pragmatism and formalism.
  - FERMI also was important since "ground" management traditions blended with "space" methodologies. Astrophysics and particle physics traditions are also an enrichment.
- **Project management scientists are a key factor to the success of a project.**
  - A scientist assuming management tasks or an standard engineer do not suffice. Project management of large projects demands special skills. It is also not similar to industry since an ApP infrastructure is one well tuned specimen and not mass production. The project is supported by technically skilled scientific communities and therefore initiative and scientific argumentation should not be eclipsed by the blind allegiance to the rules. This is even more important in ApP, where the tradition of the community to build at home is quite strong. Special care should be taken to attract, and/or train qualified managerial and technical project leadership, which becomes a central element in the deployment of future large infrastructures.

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Challenges and Solutions lessons learned II

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- **As infrastructures start to age legal matters become more and more important.** Property, labor obligations, decomissioning provisions, etc…
  - Experience of EGO/VIRGO but also AUGER etc.
  - Underground laboratories also make the transition from friendly hosting to organised service providers.
- **The relationship with a major laboratory providing a "heat bath" of expertise, testing infrastructures, administrative support etc, has been important in the first infrastructures deployed. Can we do without ?**
  - **Relationships with FNAL, CERN, SLAC, Wisconsin University, …**
- **Absence of international centre.** There is no equivalent to ESA, ESO, CERN, JINR, …, for ApP. Its infrastructures are placed in a great variety of locations and their funding is coming from multiple agencies (no unity of place, time and action). As a result, synchronisation of project planning and implementation procedures becomes of paramount importance in this field.

Final remarks

- The above grid of analysis (lifecycle phases, governance and oversight bodies, breakdown structures) provides a framework to project and analyse past and current experience of construction of large infrastructures and finally use it for the preparation of the future.

- The recommendations above cannot be neither normative for each agency, having its own procedures, neither a simple wish list. They are addressing the middle and uncharted ground of agency collaboration and are also aimed as an aid to the scientific/technical community for the establishment of good practices

- It is also a list of issues to be tackled in planning and implementation. If the issues are not addressed early enough, diffuse relationships can be installed between the scientific/technical authority (collaboration/project management) and the programmatic authority (consortium of funding bodies). These diffuse relationships can be the source of major programmatic delays.

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Final word of caution

Project management should strive to organize the scientists in the project

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cherenkov telescope array

not like this:

but more like this

Metropolis Fritz LAng

Pina Bausch

THANKS

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