CIB Performance Based Building (PeBBu)  
Thematic Network  
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Summary: The CIB Performance Based Building (PeBBu) Thematic Network is a currently ongoing project. This paper describes the principles of and the assumed impact from Performance Based Building and gives an indication of the international state-of-the-art and main barriers for actual implementation. A summary is given of the overall approach of the PeBBu programme and organization. The main components of the Network are subsequently further elaborated into actual tasks to be performed and deliverables to be produced by the Domain dealing with Construction Materials and Components.

Keywords: Performance Based Building, Materials, Components

1 INTRODUCTION
During the period 1998 – 2000 CIB – the International Council for Research and Innovation in Building and Construction initiated and commissioned various international programmes and R&D projects related to Performance Based Building.

Based on the achievements from those projects CIB proposed in 2000 the establishment of the Thematic Network PeBBu – Performance Based Building. This Network is to elaborate on the activities carried out by CIB, its commissions and its members since it adopted Performance Based Building as a Priority Theme in the CIB Pro-Active Approach in 1998. The PeBBu Network is funded through a Network subsidy within the Growth Programme that is part of the 5th Framework Research Programme of the Commission of the European Communities that was accepted by the EU with a start date of October 1, 2001 to September 30, 2005.

2 BACKGROUND: PERFORMANCE BASED BUILDING AND THE CONSTRUCTION INDUSTRY
The prescriptive or deemed-to-satisfy building specifications and codes currently enforced in most countries inhibit both organizational and technological innovation in the construction industry. Performance Based Building strives to overcome this problem by using performance requirements to define a building product’s fitness for purpose. Performance Based Building addresses the ends rather than means. This is a strong stimulus for product and process innovation and enhances consumer-orientation.

2.1 The construction industry: potential for improvement
In terms of turnover, number of persons employed and social and economic impact the construction industry is one of the largest industries in all developed countries. In 1998 the industry’s turnover in the EU was in the magnitude of ECU 700 billion as indicated by the Federation de l’Industrie Europeenne de la Construction.

For decades in Europe and in most other industrialized parts of the world, the construction market has been primarily supply-driven and consequently the level of customer orientation amongst all professions in the industry traditionally has been rather low. It is to be assumed that that consequently both the level of fitness for use and the level of value for money as perceived by the owners, users and managers of buildings is often substantially less than is the case for many other consumer and investment goods.

Traditionally each building and construction project is dealt with as a prototype. This concerns the design and construction of the project, the technologies to be applied and the collaboration between the various types of companies that each have a role to play in the project. Consequently the level of industrialization and the level of technological innovation in the building and construction industry are rather low as compared to many other industries.

The traditional organization of building and construction projects is strongly fragmented. Especially the separate tasks, responsibilities and liabilities of respectively the architect and the construction firm and the related traditional tendering for construction based on a detailed design with the inclusion of a detailed specification of materials, components and construction
technologies, have lead to a situation, in which tendering for the lowest initial price only (as opposed to lowest user costs over time), the almost non-existence of options for technological innovation and optimization for construction firms and a far from optimal communication and information transfer, are regarded as more or less “normal”.

The traditional prescriptive or deemed-to-satisfy building regulatory systems, codes and standards as currently in place in almost all industrialized countries, are based upon and enforce the above indicated traditional characteristics of the building and construction industry.

2.2 Principles of performance based building

Performance Based Building aims at using performance requirements to define a building or building product’s fitness for purpose. Performance Based Building means the orientation on ends rather than means: it describes buildings and building products on the basis of the target performance rather than in terms of solutions and technical specifications. In a situation in which the principles of Performance Based Building are integrally applied it will serve as the basis for communication between all stakeholders in a construction project. In such a situation the respective building regulatory systems and building codes and standards will be performance based and the principles of Performance Based Building will applied on the different interrelated levels of planning (built environment, buildings and building technologies and components) and throughout all phases of the process (brief, design, construction and maintenance).

The actual application of Performance Based Building will have a major impact on the future structure and culture in the building and construction industry and will require fundamentally different business processes in construction firms. The application of Performance Based Building will provide substantial benefits to both the end-user and to the participants in the building process. These benefits stem from a better fitness for use of the building itself, improved communication throughout the building process, better possibilities for innovation in and of the building process leading to optimization of the organization of the building process and production technology, reduced costs and better building quality, increased trade possibilities and specialization in the building industry.

2.3 State-of-the-art and main barriers for implementation

In the pro-active application of the principles of Performance Based Building, tenders for the construction of buildings (and civil engineering works) are to be based upon a provisional design plus performance requirements for materials, components and technical systems, as opposed to the traditional tenders that are based upon a detailed design, in which those materials, components and systems are already defined. Performance tendering will allow a construction firm to choose its own materials, components and systems.

Amongst others, the following three major conditions must be fulfilled to make the actual application of Performance Based Building practically possible:

- The language, methods and concepts that are needed to specify those performance requirements as part of the detailed construction specifications, must exist and accepted by the construction professions concerned,
- The methods to establish / measure whether a technical solution fits with the respective performance requirements must exist for materials, components and systems in general and for new, innovative ones in particular,
- There must be performance based building regulatory systems and frameworks, including codes and standards, as a basis for both the detailed specifications and measurement methods.

In certain European countries some experience is already available as concerns the development, implementation and actual application of this approach. An example it the recently introduced Performance Based Building Code in the Netherlands. Over the past ten years however various non-European countries, like Japan, the USA, Canada, New Zealand and Australia have begun to develop and implement such systems and have in fact bypassed EU developments. Japan, for instance, is well known for its innovative building technology. Although those techniques will need adaptation to fit the European practice, it is important to learn from the concepts used. North America has established ASTM standards on performance requirements for buildings. North America also has done a substantial amount of research on safety aspects of building. The fire resistance performance is well researched and may offer learning points for the European industry. Canada, Australia and New Zealand have performance based building regulations. Their experiences may also help other European countries.

Also in the area of international standardization for building and construction, initiatives have been taken lately, aimed at re-writing standards based on the principles of PeBbu. ISO/TAG8 aims to stimulate the application of Performance Based Building principles into standards for building and construction. CEN so far has no equivalent.

More recently, Performance Based Building has also been recognized as a major incentive for consumer-oriented building. In Europe, the building market is changing from a supply-oriented market towards a demand-oriented market. The urgent need for housing is almost satisfied; in this sector, the quantitative post-war shortages have been solved to a large extend. However, today the consumer is expressing his requirements far more explicitly than was customary in the past. Consumer-orientation will be the main issue for the building industry in Europe for the years to come. Focusing on end-user requirements will be the main challenge. Finding a language to express the quality of a building in terms understandable to the end-user is a key-issue.
Performance Based Building has the potential to be such language because it tries to relate user requirements to building characteristics and performance.

Additional main components in this broader interpretation are for example:

- A definition of the clients functional and other requirements in terms of performance requirements
- The specification of the designers brief in terms of performance requirements
- Performance-based procurement for both design and construction contracts and often for integrated contracts for construction and – a substantial part of – design (often in the form of design-build procurement)
- New systems to relate costs and (in terms of performance requirements defined) quality
- A performance-based legal framework.

It is to be expected that the actual application of this broader interpretation of Performance Based Building will have a major impact on the future structure of and culture in the building and construction industry and will require fundamentally different business processes in construction firms.

It is also obvious that the application of this broader interpretation of Performance Based Building will not only contribute to stimulating technological innovation, cost optimization and international trade in construction, but explicitly also to achieving more client oriented design and building processes.

In many countries – in Europe for example in the Netherlands, Finland and the UK – a substantial amount of national R&D activities are currently focused on developing operational tools for aspects of this broader interpretation of Performance Based Building.

At the moment, research into Performance Based Building is approached in a rather fragmented way. There are many activities, but these are not coordinated, leading to inefficiency and absence of an integral approach. The “restricted” view, focusing at aspects of the construction process itself has gained substantially more attention than the “broad” view, investigating the contribution of PeBBTu to increased consumer-orientation. Some phases, aspects and stakeholders of the building processes have received quite a lot of attention. Examples are structural engineering, fire safety engineering and building project initiation and the construction phase. Other themes and phases have received hardly any attention; for instance use related service aspects, sustainability and communication issues within the building process.

2.4 Impact of performance based building: innovation in and of the building process

Although prescriptive criteria are uncomplicated and easy to follow and monitor for architects and contractors, and third parties involved, they also prove to be a significant barrier for innovation, cost optimization and trade:

- Prescriptive regulations block out the application of new, improved or altered products. Those products often do not comply with the solution-based prescription indicating materials, form, size and composition to be used. Performance Based Building would overcome this problem and stimulate innovation, leading to improved building quality.

- The same prescription of solutions hampers the introduction of cheaper products or efficiency measures as the stipulated design also fixes the manufacturing and production process. This blocks, for instance, long-term investments in technological specialization. Performance Based Building would enable optimization of the production process. This may, among other effects, lead to specialization among the parties involved in the building process: it will become worthwhile to invest in the efficiency of a specific production method. This will lead to further industrialization of the building industry, with positive effects for waste control, working conditions and employability. For example performance based tenders for construction will enable construction contractors to immediately realize a substantial optimization of their traditional work processes.

- National prescriptive regulations obstruct international trade: two countries with differing regulations cannot exchange products. Proving the compliance with performance criteria is difficult. Explicit performance based regulations would assist with overcoming this difficulty and increase possibilities for international trade in the building sector.

Performance Based Building will also lead to a reduction of miscommunication throughout the building process, as the required output will be expressed in terms of building performance. This required building performance will serve as a beacon throughout the building process: all agents within the building process will use the same “language” to express the added value of their activities to this required performance.

Performance Based Building asks for a changed attitude and way of working of the parties involved in the building process. The organization of responsibilities may need alteration. The current building process involves fragmented phase-bound and work-type oriented tasks in which each party competes for the maximization of his own profit. Manufacturers, architects and contractors will need to revalue their activities in terms of added quality to the building end-user.
Feedback information from the existing building stock will be necessary to iteratively improve the building process. To enforce the learning capacity of the building industry, the network will stimulate knowledge management: sharing, developing and using knowledge on performance based building between all research and industrial partners involved in building.

2.5 Impact of performance based building: improved customer orientation

At the moment consideration of user requirements and the way they change in time, hardly form a significant part in building processes. Buildings are usually designed to fit the first owner or, in many cases, to fit a “fictional” (average) first owner or user. Most attention is being paid at reducing investment costs, while hardly any attention is paid to the way the building will be used throughout the exploitation process and whether or not the building will match the needs of sequential users.

It can be expected that the building market in future will become even more dynamic and the consumer market even more varied. Changing work and living habits ask for new types of living and working accommodation. Various recent developments in the construction market point at a changing market, where the consumer will start defining his requirements and choosing from the available supply. The building sector will have to be able to compete with other consumer goods, such as cars and holidays.

The application of Performance Based Building will enhance consumer-orientation within the building industry, because throughout the building process the explicitly defined user requirements will be the basis for all communication. It will therefore lead to buildings, which better fit the user requirements (both functionally and in terms of costs) and the dynamics in user requirements throughout the exploitation process. It will help parties involved in the building process to take the life span and the performance over time as a key issue in the design and construction process.

A better match between building performance over time and user requirements and more attention for the need for adaptation of buildings, can be expected to decrease maintenance and renovation activities and their impact. Maintenance and renovation activities account for an increasingly large share of the overall volume of output in the building industry (FIEC, 1998). This will lead to resource saving and less building waste from renovation activities required to keep buildings up to date over time.

2.6 Overall cost savings after the integral implementation of performance based building

As said already Performance Based Building is a strong stimulus for product and process innovation and enhances consumer-orientation, cost-optimization, and trade possibilities in construction. Performance Based Building is therefore expected to reduce total construction costs by as much as 25% in the long term, as is suggested in table 1.

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<tr>
<th>Table 1. Estimated savings</th>
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<tr>
<td>Cost optimisation construction</td>
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<td>Innovation of products and processes</td>
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<td>Specialisation construction firms</td>
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<td>Less barriers to international trade</td>
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<td>Total process innovation</td>
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<td>Improved user orientation</td>
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<td>Total estimated savings in %</td>
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As concerns the above table however it must be realized that the data in this table are in fact not based upon real scientific evidence. They are an indication of a possible magnitude and cannot be more than that as long as international and consensus based methods to measure economic benefits do not exist. Nevertheless, the application of Performance Based Building is anticipated to provide substantial benefits to both the end-user and to the participants in the building process.

3 SUMMARY PROGRAMME AND ORGANIZATION NETWORK

3.1 Network objectives

The objectives of the PeBBu Network are:

- Stimulation and pro-active facilitation of international dissemination and implementation of Performance Based Building in building and construction practice,

and in that context:

- Maximization of the contribution to this by the international R&D community,

through:

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Stimulation and facilitation of the international programming and coordination of research and implementation projects as concerns Performance Based Building as effectively as possible in order to make optimal use of limited available resources and to prevent unnecessary recurrences.

- Stimulation of actual investments in such research and implementation projects.
- Providing the EU Network Members with an optimal access to knowledge and experience as available in non-EU countries in which respective developments have progressed further than in the EU.
- Coordinated dissemination and implementation of results of international research in the area of Performance Based Building.

The Network aims at combining fragmented knowledge in the area of Performance Based Building in order to build a systematic approach towards innovation of the building industry and applying user requirements throughout the building process. From this, white spots and a coherent future research agenda can be derived. End-users, policy makers, building industry and regulatory communities will be closely involved in this development in order to facilitate dissemination and implementation of research results.

The Network will especially stimulate investments in research that may be expected to produce practical recommendations for the adoption and application of Performance Based Building throughout the building industry and in all phases of the building process.

### 3.2 Overall approach

- An infrastructure is established for the programming, coordination and facilitation of research and for the dissemination of research results in the area of Performance Based Building. The main components of this program infrastructure are the following:
  - International programming and coordination of research projects in nine scientific domains;
  - Involvement of target groups / stakeholders from the start of the programme through three User Platforms for respectively i) buildings owners, users and managers, ii) building and construction industry and iii) the international (pre-) standardisation community;
  - Mapping of national and international research as far as related to – aspects of – Performance Based Building;
  - Four regional platforms in Europe to act as the bridge to and the initiator of aligned national activities;
  - Network Management, including the establishment of a Network Steering Committee, a Technical Committee and a Network Secretariat that among others will be responsible for: i) annual technical and financial reporting to the EU, ii) final report, iii) designated website including among others a newsletter and iv) overall project management.

It is envisaged that at a later stage the following components will be added and that where appropriate separate funding for these will be attracted:

- Three Compendium projects that will serve as a scientific basis for those research projects and that will establish a common framework, a shared language, and the state of the art in terms of research and best practices in the area of i) Validated Models, ii) Economic Benefits and iii) Statements of Requirements
- Development of an advanced IT based facility for the full scale integration of an accessibility to all information in those Compendia and in all other components of the PeBBu Network;
- Various R&D projects related to Performance Based Building, including the about 30 projects that already have been initiated by CIB Task Groups and Working Commissions. The further elaboration of those projects into proposals/request for additional funding has already commenced;
- Various aligned National R&D projects related to Performance Based Building.

### 3.3 Network members

The PeBBu Network includes i) 33 organisations in EU and EU Associated countries and ii) 15 organisations in other countries that have committed to participation under the condition that the required funding will become available.

The Network Consortium consists of nine Principal Contractors. The other initial 25 European organisations in the Network will work as subcontractors to those nine Principal Contractors.

Now that the Network is established and operational, it is open to new membership. New CIB member organizations can submit proposals to the Network Steering Committee. New members accepted will be asked to sign an observer contract that does not provide any funding but allows those members to seek outside funding to support their participation in PeBBu.

Details of the PeBBu network and more information can be viewed by accessing the URL [http://www.cibworld.nl/pages/ftp/PeBBu_dir/Default.html](http://www.cibworld.nl/pages/ftp/PeBBu_dir/Default.html).
In this context an explicit objective for the Network project Management is to attract new Members from East European and non-European countries and new Members that represent the Building and Construction Industry and other stakeholders as concerns the actual implementation of Performance Based Building.

In principle new PeBBu Members will all be given an “Observer status” and will be linked as such to the Principal Contractor CIBdf; the Technical Coordinating Contractor for the Network.

3.4 Nine scientific domains

For each Scientific Domain, in principle, separate international research programming and coordination will take place to ensure internationally accepted prioritizing of research, avoidance of unnecessary doublers, maximum stimulus for international collaboration and a maximum of compatibility between the results from the research projects.

The following nine separate Scientific Domains are distinguished.

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<th>IN THE AREA: BUILDING TECHNIQUE</th>
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<td>- Construction Materials and Components</td>
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<td>- Building Physics</td>
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<th>IN THE AREA: BUILDINGS AND THE BUILT ENVIRONMENT</th>
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<td>- Built Environment</td>
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<td>- Legal and Procurement Practices</td>
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<td>- Innovation</td>
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<td>- Information and Documentation</td>
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At a later stage it may be necessary to combine, split up and/or add such Domains if research developments so require.

4 DOMAIN 1 - CONSTRUCTION MATERIALS AND COMPONENTS

As most closely related to the issue of Durability of Building Materials & Components, Domain 1 in the PeBBu project is concerned. This domain has joint CIB leadership by Prof. Christer Sjostrom from Sweden and Dr. Robert Cope from France.

For many years a pronounced trend in the area of building and construction technologies, materials and components, towards a performance approach in declaration, assessment and validation of building and construction products, as well as of the functional properties of a constructed works during its lifetime. The trend is pushed by industry and market, but still to a large extent driven by close-to-market and pre- and co-normative research.

4.1 Background

In most countries the structural codes has since long moved from simple deemed-to-satisfy approaches to a performance thinking where account is taken of the inherent stochastic variability of material properties and loads. A continuous work is ongoing to fully implement in codes and the resulting engineering the latest development of research and the possibilities offered by new technologies. Computerisation and IT play a decisive role.

As regards the properties of non-load bearing parts of buildings and hence building products the state-of-the-art is still more complex, but the performance road is as evident. As an example, energy conservation and efficiency of building is normally expressed as a performance requirement that then feeds back on the used materials and components. The requirements have then to be declared, assessed and validated for each product. The statistical variability of loads, e.g. degradation factors, and of the material or product properties should ideally be taken into account in a performance assessment. The objective is to in general develop the tools used in engineering design of load bearing and non-load bearing building parts towards the same conceptual approach.

The European Construction Products Directive, CPD (Council Directive 89/106/EEC), which states that the Essential Requirements on constructed works should be met during the intended working life of the building results in essence in a performance requirement on all building products. The life performance of the materials and products has to be assessed and declared.
In the field of Service Life Planning of Buildings and Constructed Assets ISO (TC59/SC14 “Design Life”) is developing performance-based standards. This work was initiated from Europe as a necessary step towards implementing the CPD. Such standards, guiding building design, operation and management as well as the building products producing industry, are intended to assist harmonised design and materials selection in construction, and thus encourage trade liberalisation and in perspective help countries in developing a more safe and sustainable built environment. The main workload lies on completing existing product standards with descriptions of performance based service life assessment and validation methods. There is an increasing international support towards achieving this objective.

4.2 State-of-the-art
ISO TC59/SC14 has released two standards (ISO 15686 part 1 and 2) guiding life design of buildings and life prediction procedures of products, respectively.

The bearing idea in life design is that for each building part/product a reference service life is adjusted by factors (environmental load, material quality, workmanship, etc.) describing deviations from the reference situation to the actual building construction scheme, thus reaching a adjusted service life estimate which is then used in the building design. This Factorial Approach needs further development and refinement as regards the factors, the theoretical calculation methods, and the reference life data to be used.

4.3 Barriers and opportunities
Of utmost importance to successful development in the Domain, given the above background, is the involvement of the sector industry and other stakeholders in the work. As an example, the main supplier of reference life data on materials and products must be the relevant industry. The involvement of the materials and products producing industry in the process is crucial. The PeBBu network offers obvious possibilities to speed up the process and strengthen the interaction between stakeholders.

4.4 Objectives
To foster, through the planned PeBBu workshops and reports, the further development, and anchoring this with sector stakeholders, of the performance concept in the domain of materials and products. This will focus on

− Further development of the Factorial Approach as regards:
  • theoretical and engineering approaches
  • basic knowledge foundation of different factors
  • development of pedagogic application examples
  • test training of practitioners
− exploring and describe the conditions and prerequisites for reference life (performance) data for classes of building materials and components with account of sub-sectorial industry structure, and thus provide guidelines of pre-standardisation support type on (life) performance of materials and products.

4.5 Workplan
The objectives will be met through a step-by-step approach with the purpose to thoroughly describe the pre-conditions to make data on reference service lives and other appurtenant life performance governing data available, i.e. the conditions for establishing reference databases. This will be undertaken by involving major European and international producers of building materials and products, as well as European and international bodies for standards and technical approvals, in the process of establishing information on:

− current policy concerning establishment of durability and service life data
− current format and range of the declaration of durability and service life data, including recommended performance requirement and service environment, that goes with the products.
− current methods to establish such data
− possible availability of today classified data that would be reasonable to make public in case agreement on standards how to report or declare data is made
− opinions on and readiness to meet requirements of ISO 15686-2 as for establishment of data and proposed standards work item on Reference Service Life as for reporting of data
− arguments on the need for corresponding standards at the product level, providing detailed material/product-specific requirements.
In a first step, a questionnaire will be developed and issued addressing the (European, other world regions and national) branch and business organisations of material producers. As an example, on the European scene CEPMC (Council of European Producers of Materials for Construction) is intended to be a major body to be addressed.

Within each country covered by the PeBBu network, a number (3-5) of the major producers will be selected, supported by the mentioned branch/business organisations, representation of at least all types of high-volume materials/products being ensured. The submitted information will be processed and analysed in relation to the above-mentioned ISO/CEN documents. Workshops together with representatives of the producers will be arranged to discuss the outcome and how to combat obstacles likely to be found. The outcome as well as the findings of the workshops will be documented and reported (see Deliverables below).

The premier international platform for the work to meet the Objectives is the PeBBu Network. In the work process of the Domain Construction Materials and Components will additionally be included, as indicated above, stakeholders and actors from the construction sector and the materials and components producing industry. Examples of main actors to be addressed – in most case contacts on the relevant issues are already well established – are:

- CEPMC and its national “umbrella” organisations and similar organisations in other world regions encompassed by PeBBu
- ISO; relevant ISO TC’s
- CEN; CEN-STAR
- EOTA (European Organisation for Technical Approvals)
- WFTAO (World Federation of Technical Approval Organisations)

4.6 Deliverables
The deliverables will in general consist of pre-workshop reports documenting the state-of-the-art as to the issues to be discussed and post-workshop reports developing on the results of the Workshop.

The post-workshop reports will address and develop on the items accounted for under Objectives, i.e.:

- theoretical basis and proposals for engineering approaches of the Factorial Method
- knowledge base of the different factors
- pedagogic application examples showing service life planning of constructed works and parts thereof
- the requirements of and conditions for establishment of generally accessible data bases on (life) performance data

The development of the pedagogic application examples will be performed as test training exercises. The experiences from these exercises will be summarised to a Domain deliverable. Whether to edit the Domain post-workshop reports to one or several Final Deliverable(s) will be discussed during the pace of the PeBBu work.