# Viewpoints on Improving the Standards Making Process: Document Factory or Consensus Management?

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### Abstract

*Emerging standards and guidelines need to be timely and reflect the requirements of the industrial sector they are designed to support. However, often, the delay between the identification of a need for a standard and its eventual release is too long. There is a need for increased understanding of the sources of delay and deadlock within the standards process. In this paper we describe an application of PERE (Process Evaluation in Requirements Engineering) to the standards process. PERE provides an integrated process analysis that identifies improvement opportunities by considering process weaknesses and protections from both mechanistic and human factors viewpoints. The resulting analysis identified both classical resource allocation problems and also specific problems concerning the construction and management of consensus within a typical standards making body. A number of process improvement opportunities are identified that could be implemented to improve the standards process. We conclude that consensus problems are the real barrier to timely standards production. Ironically the present trend for more distributed working and electronic support (via email etc.) may make the document factory aspect of standards production more efficient at the expense of consensus building.*

## 1 Introduction

The strategic importance of standards is widely acknowledged in industry (e.g. see [1, 2] and past proceedings of ISESS [3]). However, the standards process is typically long and protracted—e.g. it can take up to 10 years per standard—and there is a need for increased understanding of the causes of delay and deadlock within the standards process. The purpose of standards is to support the industrial sector they are designed for. Therefore, the standards process fails if this delay results in out-of-date standards, or standards that are not useful (e.g. if the production of standards cannot keep up with the rate of technological advance.)

These deficiencies in the standards making process are well known: in Europe at least going back to the CEC Green Paper on standardisation [4] and in the safety related area to the UK Government Consultation documents [5]. If the standards community is to meet the needs of the market and the expectations of users there is a clear need for a realistic process improvement based on analysis of the actual problems of the standards process.

If we take a viewpoint-based approach to looking at the standards process, we can identify a number of different kinds of activity:

1. *Document producing*—the standards process can be seen as a dispersed document factory. However, as such it is rather inefficient (e.g. it may take 5–10 years to produce an agreed international standard).
2. *Consensus building*—one aim of standardisation is consensus building. At the start of the process, there are many different stakeholders with differing backgrounds and goals; at the end there is a document that in some way represents a consensus between the standardisation participants. The standards process directs the reaching of this consensus.
3. *Market influencing*—participants in the standards process include representatives from industry. These representatives have an interest in expressing concerns related to their sponsors (e.g. with respect to the economic and legal implications of the

standard). More generally, harmonisation, interchangeability and compatibility within industry have economic advantages for all in the long run.

4. *Career enhancing*—participants might gain prestige and reputation as a result of participating in the standards procedure, either as reviewers or as members of standards committees. On an individual level, therefore, participants may indirectly enhance their career prospects.

There is a certain amount of conflict between these different viewpoints, especially between the *document producing* and *consensus building* aspects; for one document production is a goal in itself, for the other it is only a tool to aid consensus formation and a symptom of it. In this paper we primarily consider these first two aspects, since although the latter two are both goals of standards making, they manifest themselves through difficulties in achieving the first two goals.

Our research has been to look at the standards process in terms of the conflicts and interaction between the document factory and consensus building aspects of standards development. In particular we employed a systematic process evaluation method, PERE, to look at the latter stages of the standards development process in terms of both the mechanistic and human aspects of the process.

The objectives of this paper are to present our analysis of the problems of standards development, the generic process method that we used, and some practical process improvement suggestions for standards development. In Section 2 we briefly outline our approach. In Section 3 we describe the process capture and in Section 4 the process analysis. The following sections present the results of the analysis, the improvement suggestions as well as our conclusions.

## 2 PERE

Within the dependable systems community there has been considerable interest and effort looking at improving the development process, especially the Requirements Engineering (RE) process, recognising that the early stages are typically the hardest to get right, and the most costly to fix later in the lifecycle. In particular, the importance of the *human factors* of development processes is increasingly recognised as being an important source of process weaknesses and improvement opportunities [9].

There is a wealth of human factors literature (e.g. [10]) that is relevant to the design and execution of development processes, and also human factors techniques that can be used to aid analysis (e.g. ethnographical techniques, task analysis, video analysis and so on). However, systems engineers and process designers are not broadly aware of this human factors knowledge and how it may be applied: an approach is needed that makes such techniques feasible in real industrial settings.

In response to this need, the REAIMS[1] project has developed practical improvement strategies for RE. One of these is PERE (Process Evaluation in Requirements Engineering—see Figure 1) which is a method designed to address the improvement needs of processes that depend crucially on human activity and co-operative work [6, 7]. Although PERE has been developed in the context of RE it is in fact applicable to many forms of engineering processes that are heavily human-centred. PERE integrates two complementary viewpoints onto the process under analysis:

1. *Mechanistic viewpoint*—an analysis of the process in mechanistic terms, as a number of interconnected process components. This analysis uses techniques adopted from classical safety analysis, adapted for a consideration of the development process, and firstly builds a process model and then systematically looks for generic process weaknesses
2. *Human factors viewpoint*—an analysis based on the application of human factors and social scientific principles to assess weaknesses and protections at an individual, group and organisational level using the results of the mechanistic viewpoint to scope the analysis. The analyst is guided through the human factors analysis in which process weaknesses and improvement opportunities are identified and discussed.

The standards process itself can be considered a RE process in which user requirements are captured, negotiated, analysed and defined. This development process hopefully results in a document that expresses the requirements of the industry and standards process participants. Like many RE processes it is an inherently socio-technical process, constructed from a number of integrated social and technical activities, including various document production, distribution and reviewing activities which are co-ordinated at the plenary, sub-group and individual levels; in short, a good candidate for a PERE analysis.

Although space does not permit a full explication of the PERE method here, the benefits of PERE's dual viewpoint approach to looking at standards making include:

- *Sensitive to actual standards process improvement needs*—since the standards process includes both "hard" mechanistic (e.g. document flow) and "soft" human aspects (e.g. consensus building), it is

[1] Requirements Engineering Adaptation and IMprovement for Safety and dependability

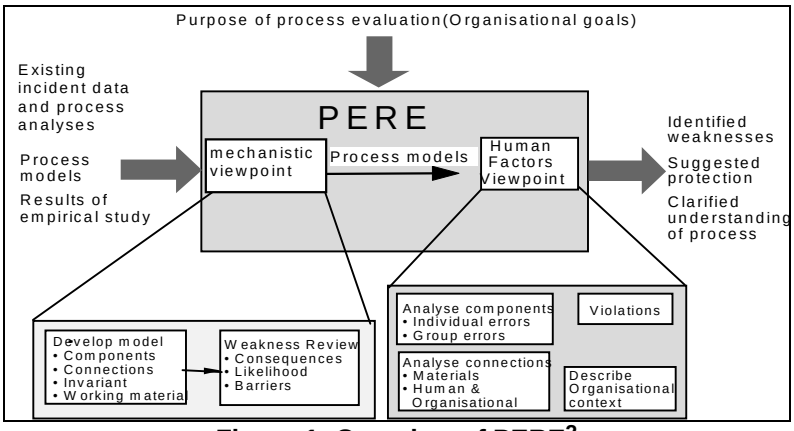


**Figure 1: Overview of PERE[2]**

appropriate to look for improvements in both aspects of the process. This also provides enhanced coverage of the process, as process weaknesses are trapped under different guises in each viewpoint.

- *Knowledge dissemination*—PERE's integrated analysis approach provides wider access to human factors knowledge across a wider engineering domain. As a result a certain amount of demystifying of human factors knowledge may take place, although we do not expect a complete deskilling of PERE to be possible or desirable.

The application of PERE requires a description of the process in terms of components, working material etc.—a process model. There are a number of models for the standards process, for example, so-called meta-standards such as BS 0 [11] prescribe a specific standards making process. Our process model was based on analysis of these "official" process models, augmented with process capture activities to determine the details—the "how, where, when and who"—of the real standards process. To do this we observed and interviewed standards process participants of a standards-like body—EWICS TC7—at work to ascertain the details of the process used and the actual problems experienced by the participants.

EWICS TC7 (European Workshop on Industrial Computer Systems Technical Committee 7) is a European cross-sector committee currently producing a set of guidelines on safety, security and reliability implications of the use of industrial computer systems. This body has a plenary-group structure and organisation of work that is typical of many standards producing bodies. Many of its participants are also members of other national and international standards bodies.

Appendix A provides the questionnaire that we used for our in-depth interviews. We found that most interviewees were acutely aware of the need to improve the standards process within EWICS and other bodies of which they were members and provided many useful insights into the causes of the problems.

## 3 Process capture

Standards and standards-like bodies (guideline-producing bodies, national and international standards bodies etc.) are typically hierarchical in structure, with the whole body being divided up into groups which may be further decomposed into subgroups and individuals. The general principle of organisation is that actions are agreed at a group level and allocated to subgroups or individuals in that group. These subgroups or individuals propose documents which must be integrated together and approved back up at the group level.

Generally, the standards process can be thought of as having three interlocking stages:

- *Identification of user requirements*—information on user requirements is gathered from different sources and the need for a standard is expressed.
- *Advancement of user requirements*—user requirements are collated, examined and made concise (typically in the form of a proposal for a NWI—New Work Item), which if agreed goes on for development and review.
- *Development and review*—groups and subgroups work on different sections of the standard. The documents are reviewed within their subgroup, and if approved, are passed on for integration into the current draft, which is subject to further plenary and draft review.

[2] Other REAIMS modules such as PREview-PV and MERE can be used to supply process data or complement any existing process documentation.

To limit the analysis for this paper we consider this third stage of the standards process. That is to say we shall assume that the user requirements have been successfully identified and expressed in a NWI. We further assume that actions regarding the production of original position papers have been allocated to groups, which in turn have been allocated to individuals within that group. As we iteratively expand the top level processes we start to build a process model (see Figure 2) and identify the main process components within this stage.

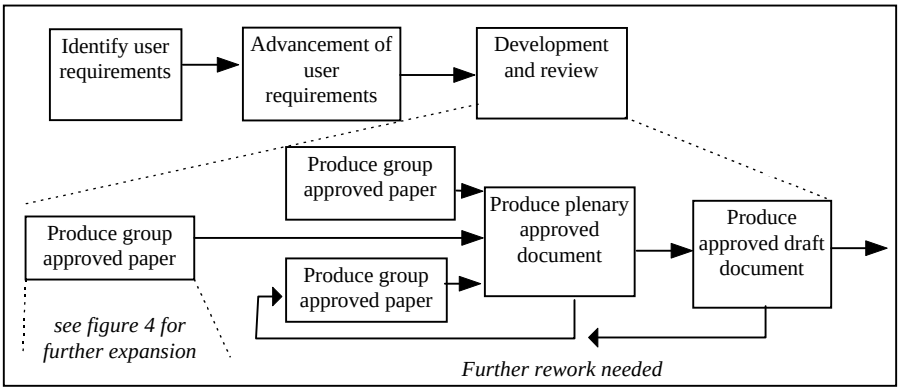


**Figure 2: Expansion of top-level standards process model**

*Produce group-approved paper:* The first stage of the development and review process is the production of a group-approved position paper. This process involves a document containing individuals' work being passed to the group for comment and review. The paper is reviewed within the group and a subsequent group meeting will assign actions to individuals in the group to edit the document and implement the agreed resolutions of the comments made. This cycle is iterated until a group-approved document is produced.

*Produce plenary-approved document:* Once a group has approved its own position paper, the document is added to other group papers, and the whole document is sent out for a plenary review. In a similar manner to the group review, the reviewers make comments on the document, and these comments are passed back to the appropriate groups, which in turn allocate them to individuals for resolution. If major rework is required, the group may have to perform another group review before the document is passed back for plenary acceptance.

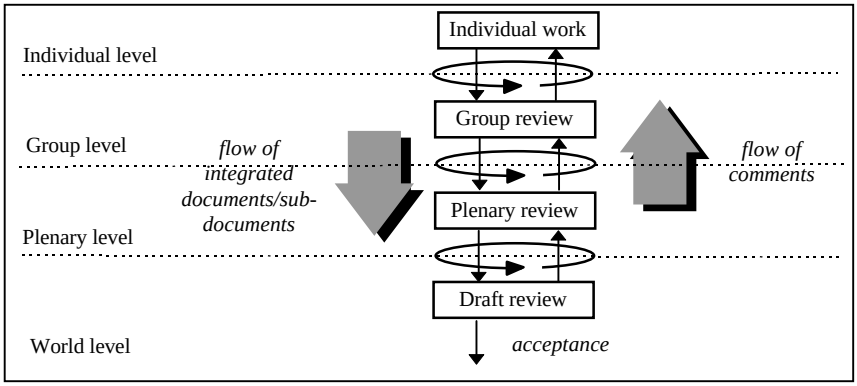


**Figure 3: A 'circulation-percolation' model of the standards**

*Produce approved draft document:* Once accepted by the plenary, a document is passed out for general review and comment from external reviewers. The comments are again fed back to the appropriate groups, who in turn allocate actions to individuals within that group. Eventually the document is issued, hopefully without becoming locked in an indefinite production and review loop.

At each stage of production, the document may pass through several iterations before being approved

for the next stage, where it is reviewed and may be returned for further rework and editing.

However, there is a certain amount of recurring structure within the process (e.g. document review), and this whole document production and review process can be thought of as a circulatory refinement process at four different levels; *individual*, *group*, *plenary* and *world* (see Figure 3). The document flow starts at the

between the process activities. One of the major sources of delay in the standards process is the co-ordination of the many parallel activities and persons writing and reviewing documents.

One other important component for the process is the control from individuals' sponsors (see Figure 4). These components represent the interactions that individuals have with their sponsor bodies or other

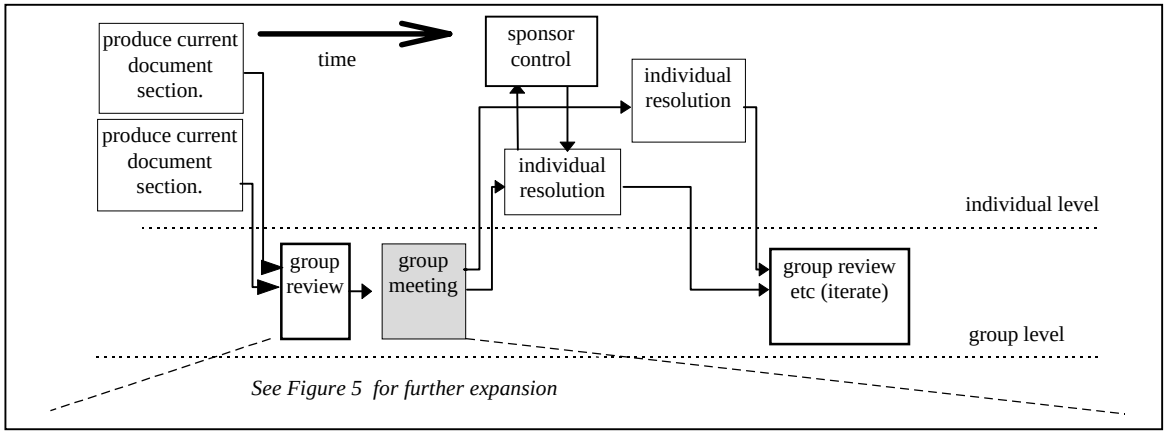


**Figure 4: Production of group approved document**

individual level, these papers are integrated and passed down to the group level for review, and when approved, groups of documents are passed down to the plenary level for review and so on until the document is passed out to the world as an accepted standard. However, at each level the document may be interrupted by a review and passed back to the previous level for further work. How much the document gets caught in indefinite circulation in the document refinery determines how long it takes for the standard to be released.

There is a tension between two main opposing "forces" that regulates the circulation of documents within the standards groups and reviewers. This tension mirrors the tension between the different concerns of the differing viewpoints on the standards process. For example, from the viewpoint of the standards process as a *document producing factory*, there are concerns to produce documents in an effective and efficient way. On the other hand, from the viewpoint of the standards process as *consensus building* activity, concerns to express a consensus of those involved in its construction will mean that documents that do not will be returned with comments for further work.

### 3.1 Timeline model

We can expand the process model along a timeline to provide a view that highlights the temporal relations

bodies that they represent (e.g. an individual may represent their sponsoring company or another standards or technical body). Such interactions are a potential source of delay in the standards process, since individuals may have to consult these sponsors at the document production and review stages. This control can be formal and overt, or it may just mean that the attendee has second thoughts about what is being proposed when he or she revisits the subject in the workplace context.

The efficiency and efficacy of the standards process as a whole is largely dependent on the number of iterations needed at each level, and on how effective these iterations are at reaching consensus. Due to space limitations here, we only show the model for the iterative loop of the process, that of producing a *group-approved* document (see Figures 4 and 5). The later stages share similar review and document production activities and so this first stage can be considered as a template for the whole of the document production and review cycle; generic weaknesses identified in this stage occur throughout the process.

## 4 Process Analysis

In the PERE approach there are two complementary analyses. The mechanistic analysis is normally performed first as this results in a greater focus

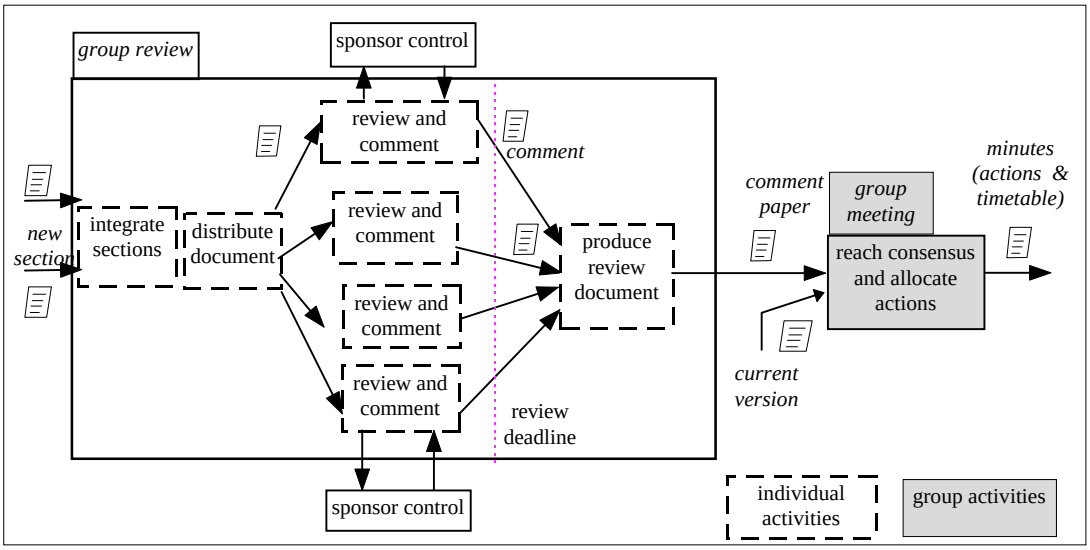


**Figure 5: Expansion of group review and group meeting activities**

for the human factors analysis: it is often not feasible, in an industrial context, to apply the full human factors analysis to all components of the process model.

The PERE method provides a systematic process which serves as a set of prompts for the process analyst. For the mechanistic analysis this is in the form of generic component and class weaknesses; for the human factors viewpoint this is in the form of detailed checklists and reviews of relevant human factors literature. This systematic approach supports consistent and repeatable analyses.

## 4.1 Mechanistic analysis

### *4.1.1 Method*

The mechanistic analysis uses methods adapted from object-oriented and classical safety analysis techniques to look for process weaknesses and improvement opportunities. This is done by systematically classifying the process components into the five main classes recognised by PERE, namely—process, transduce, channel, store, and control—and also describing the *control functions* and *interconnections* between components. For example, a description (taken from the PERE Component Table—PCT) for the process component *review-and-comment* is given in Figure 6.

Once the process description is complete, the process undergoes a weakness review in which generic and specific weaknesses are identified from the process description. This is done heuristically by:

- specialising generic component class weaknesses (e.g. process components may execute wrong process, fail completely, become deadlocked and so on)
- negating, re-quantifying and re-scoping the component attributes (e.g. not enough time available to review document, current versions of documents are not available)

The process weaknesses identified are then subject to a risk based analysis, in which the likelihood and consequences are evaluated.

### *4.1.2 Application*

The mechanistic analysis picked up many of the classical problems associated with decentralised concurrent processes, such as:

- concurrency problems between multiple authors and reviewers
- absent or incomplete documents at key process stages

| **Component name** | **Class** | **Interfaces and working material** | **(Optional) State** | **Invariant** | **(Optional) Pre-conditions and resources** | **(Optional) External control** |
|---|---|---|---|---|---|---|
| *review-and-comment* | Control/Process: Review document | Current working paper | | Errors and problems are picked up by review | 1. Current version of document<br>2. Time available to review | Any requirements from consultation with sponsors |

**Figure 6: Excerpt from PERE Component Table**

- insufficient resources to work on a document

## 4.2 Human factors analysis

### *4.2.1 Method*

The process models and generic weaknesses from the mechanistic analysis are fed into the second phase of the analysis in which those components that are primarily composed of human activity are assessed from a human factors viewpoint. The human factors analysis is guided and structured by the PERE method which contains a:

- *Decision tree*—which guides and scopes the analysis by asking a series of structured questions concerning each process component. Figure 7 presents an excerpt from this decision tree for group processes.
- *Human factor checklist*—which further expands the analysis, identifying weaknesses and possible protections. Each item in the checklist references uncontroversial human factors and social scientific literature

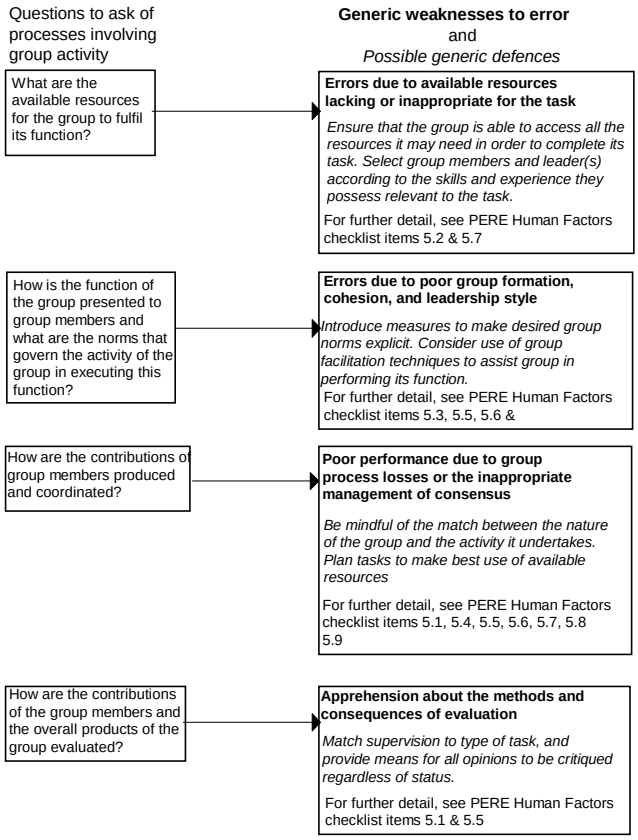


**Figure 7: Excerpt from human factors decision tree for group processes**

The resultant analysis considers process improvements and defences against:

- individual weaknesses—e.g. to what extent are the activities subject to skill-based, rule-based and knowledge-based weaknesses?
- group weaknesses—e.g. in what way is the performance, functioning, consensus building and coherence of the group determined by the social group structures, group norms, leadership and so on?
- interconnections and working material—e.g. to what extent are the documents and other circulating materials designed for, and supporting, the activities they are actually used for?
- organisational culture and context—e.g. what are the patterns of communication and learning within the organisation. What is the organisational culture and learning environment?
- violations—e.g. do the current operating procedures encourage or require procedural violation?

### *4.2.2 Application*

From the perspective of the human centred analysis, standards making can be seen more in terms of consensus-building activity. Although document production is clearly a *symptom* of standards making, what determines whether a standard is approved at each stage of the process is a function of the amount and type of consensus associated with the document. Persistent problems arise when the consensus-forming process is disrupted, or when the document is not seen to reflect the consensus of the group. For example, when an author takes on homework to resolve issues raised in review, critical delays can occur if the implementation is not seen to reflect the requirements of the group.

# 5 Results

The results of the combined PERE analysis identified a number of process improvements. PERE's mechanistic viewpoint was easily able to identify classical weaknesses associated with concurrent document production processes, such as,:

- latest versions not available when required (e.g. at review meetings)
- "homework" on the critical path not done
- insufficient resources or time to work on a document

Furthermore because of the explicit shift of emphasis towards a more human centred view of standards making, PERE identified a number of problems associated with the formation and recording of the consensual aspects of standards making (such as

challenges to "agreed" consensus, poor consensus formation, premature consensus formation etc.). This echoed problems raised by standards participants that the standards process could be severely disrupted when the assumed consensus of the group was deliberately or inadvertently challenged.

Consensus problems are picked up by the PERE human factors analysis, since each individual's activity can be understood within the context of the resources, norms, performance, and evaluation of the group, and each group's activity within the organisation and culture of the whole standards body.

These consensus problems, which are essentially social problems of group interaction, are further exacerbated by the geographical dispersion of the standards participants and the temporal dispersion of the standards body meetings.

## 5.1 Improvements

The analysis identified a number of process improvement opportunities. These could be taken on board and developed into proposals for evaluating and improving either the specific standards process we studied in this paper or, if applicable, more widely. A summary of the opportunities is given below:

*Organisational*

- increasing parallelism between subgroups can help reduce timescale; however shared working membership between groups can result in overloading of authors and reviewers, causing resource bottlenecks.
- increasing funding for standards bodies to fund critical work, reduce timescale and support members' participation

*Process*

- building-in to the standards process more specific consensus-enhancing activities, such as including workshops and other user-centred activities to look at how the standard will be used
- improving corporate memory and knowledge dissemination to encourage the reuse of experience of participants. This could be done by providing a resource centre (e.g. on a www home page or maybe some groupware tool) that provides information on the evolving history of the documentation
- providing multiple means of information dissemination and document access to ensure that access to current versions is easily available (e.g. via email, internet)
- focusing more on consensus formation rather than just document production, for example by (1) shifting the focus of standards making towards attaining agreement on principles before moving on to writing detailed clauses, (2) identifying the area where consensus will be difficult, developing an approach to resolving these issues, (3) explicitly recording the development of the consensus to help stabilise it and make it less easily changed subsequently
- investigating the use of more appropriate technologies to support the distributed groupwork and consensual aspects of standards production (e.g. "groupware" and those emerging from CSCW[3]). Currently many standards groups use word processing and some simple communications technology (email, fax) although often the default distribution mechanism is still paper-based. However there are a number of options which already have a wide user base and are therefore of low risk and cost, including (1) standard electronic file formats that support document exchange, annotation and mark-up (2) internet technologies to support centralised document distribution and co-ordination

*Management*

- prioritising activities of standards process at a plenary and subgroup level
- maintaining informal as well as formal contacts between group members to encourage dissemination of experience and background knowledge. This could be done by arranging social events alongside standards body meetings
- establishing resource commitment of participants before work is undertaken
- co-ordinating the allocation of work commitment at a plenary level to avoid unreasonable, if enthusiastic, over-commitment by individuals in more than one group
- encouraging participation from minority voices within group to avoid catastrophic consensus challenges later in development process
- encouraging good leadership styles enabling the appropriate co-ordination of work, participation of group members, and adherence to production timetable

[3] Computer Supported Co-operative Work—these tools are still relatively new and in a state of flux and further work is needed to look at the contribution they could make.

*Document design*

- explicitly capturing and recording existing group consensus in resources and working materials. This could be done by attaching some measure of consensus to negotiated documents such as working papers, or by maintaining a "history" document for each clause

## 5.2 Validation

These recommendations have had a certain amount of validation, since we found that the process analysis was able to pick up the problems actually experienced by the standards participants themselves as revealed by the field work and responses to the associated questionnaire (see Appendix A).

Some of these recommendations are already being applied within EWICS, and we are currently investigating the use of generic web technologies to support the development and use of standards. Although there are obviously differences between every standards body—e.g. in terms of group culture, allocation of work, level of formality— we believe that EWICS is typical in its organisation and structure to serve as a model for many distributed consensual document production processes. Indeed this model may be optimistic, since the development of guidelines within EWICS is largely driven by technical, and less by covert, political user constraints that may be more apparent within other standards bodies.

# 6 Conclusions

This study has identified a number of improvement opportunities for the standards process. Although other process improvements have been suggested from other analyses, we feel that the advantage of the PERE approach is that it delivers systematic process evaluation. As such the process improvements generated are both:

- *reviewable*—in that the systematic process description and references to the literature can be subject to external scrutiny
- *defensible*—a systematic approach is more easily defended and hence makes the subsequent process change easier to negotiate

The process improvement recommendations fall broadly into two categories. Those concerning the need for good resource management, document flow and consistent member participation can be implemented by improving the management and resourcing of the group and exploiting existing document and communication technologies

However, we see the consensus problems as the real barrier to timely standards production. Standards bodies need to look at these aspects in a much more explicit way; the typical current practice of the consensus being available in an unspoken, implicit way—for example if the primary access mechanism to this consensus is via individual's memories—is quite vulnerable to changes in membership, political constraints and changing user requirements. Ironically the present trend for more distributed working and electronic support (via email etc.) may make the document factory aspect of standards production more efficient at the expense of consensus building. Although we are sceptical about any technical fixes revolutionising the age old problem of negotiating consensus there may be some scope for employing tools that are explicitly designed to support distributed groupwork.

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## Appendix A Questionnaire for EWICS process participants

1. What are the main sources of delay in the reaching of consensus for an EWICS guideline? Can you think of a particular event or set of events that delayed or disrupted EWICS work (or other similar body e.g. standards body)?
2. Do you feel that some subgroups are more successful at reaching consensus and getting work done than others? How do different operating styles make this possible?
3. Do the quarterly EWICS meetings have the right balance between technical and organisational work? If not how might it be changed?
4. What sort of organisational features of EWICS that distinguish it from other committees (e.g. deadlines, prompt distribution of documents, good attendance...etc.) help the subgroups and individuals in getting their work done?
5. What documents or other means of communication (e.g. emails, faxes etc.) let members know about the work that other members of their subgroups are doing in between the quarterly EWICS meetings?