



Collaborative methods and tools to remotely develop multi-sites engineering standards: the case of GE renewable energy-hydro

Rachad El Badawi El Najjar

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THÈSE

Pour obtenir le grade de

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préparée au sein du **Laboratoire G-SCOP**

dans l'**École Doctorale I-MEP2**

Collaborative methods and tools to remotely develop multi-sites engineering standards.

The case of GE Renewable Energy - Hydro

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*For mom and dad.
You dedicated your life for our happiness.*

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Abstract

In a global economy, the conquest of exploring and acquiring new markets has led many companies to expand their business around the globe. Many companies adopted a strategy of shifting from a centralized company where products were designed and manufactured in one region to a decentralized company, and then to a distributed organization over the regions. Our thesis context is GE Renewable Energy – Hydro solutions that designs and manufactures hydraulic power plants. GE hydro organization is scattered over 5 regions (North America, Latin America, Europe, China and India). Each region became part of this distributed organization where they participated in the designing and the manufacturing of the hydraulic turbines/generators. However, new challenges arose in this distributed product development process: specific market needs, different working practices, various design methods, multitude of design tools in addition to the cultural differences among the regions.

In order to rationalize the regional differences, the distributed development of hydraulic turbines and generators entailed several objectives. For example, standardization of engineering processes, development of common design guides for engineering tools, harmonization of quality sheets and troubleshooting procedures. Hydro organization has entrusted these objectives to the virtual engineering collectives who are dispersed in all the regions.

Our research aimed at studying and supporting the virtual engineering collectives in the co-creation of corporate engineering standards and guidelines. The virtual engineering collectives involved the designers, industrial engineers, technicians as well as the end-users. They had to remotely collaborate in order to co-develop the engineering standards and later on to adopt them in customer projects.

Since the virtual engineering collectives were at the core of our standardization approach, the thesis addressed the following research questions:

- 1- “which collaborative standardization process and platform could enable the engineering collectives to co-develop their standards at distance?”
- 2- “what are the characteristics of the different virtual collectives’ types which suit respectively the collaborative standardization process?”

- 3- “which operational process has to be defined to ease the work of the virtual engineering collectives within a project based management style?”

From the literature, we defined and differentiated the virtual engineering collectives' types as virtual communities of practice and/or interest, virtual teams and networks of learning. Through observations and reflections from the practice, we have developed and tested our propositions. The main thesis' contributions are summarized as follows:

- 1- The collaborative standardization process to co-develop the engineering standards at distance.
- 2- HySPeC templates – the collaborative standardization platform - to respond to the different requirements of the collaborative standardization process.
- 3- The virtual collectives' dynamics (VCD) model to characterize the virtual collectives in function of their development phases.
- 4- The virtual collectives' framework (VCF) to select, differentiate and fit the virtual collectives in function of the project's objectives.
- 5- The virtual collectives' operational process to facilitate the adoption and the implementation of the engineering standards in the customers' projects.

The top management at GE Hydro found the proposed collaborative standardization approach able to co-develop the engineering standards at distance. The different virtual collectives' types can fit and adapt to the collaborative standardization process and intuitively use the collaborative platform' functionalities. The approach also provided an operational process to facilitate the integration and the work of the virtual engineering collectives within the distributed hydro organization.

Résumé de la thèse

Dans un marché mondial, de nombreuses sociétés sont passées d'une stratégie d'entreprise centralisée où les produits sont conçus dans un lieu central et fabriqués dans les centres régionaux à une entreprise décentralisée, puis à une organisation répartie sur les régions. Le contexte Industriel de la thèse est GE Renewable Energy – Hydro solutions qui conçoit et fabrique des centrales d'énergie hydraulique. L'organisation GE hydro est dispersée sur 5 régions (Amérique du Nord, Amérique Latine, Europe, Chine et Inde). Chaque région est devenue une partie de cette organisation distribuée où sont conçues et fabriquées des turbines hydrauliques / générateurs. Cependant, de nouveaux défis ont surgis dans ce processus de développement de produits distribués : les besoins spécifiques à un marché, les différentes pratiques de travail, des différentes méthodes de conception, en plus des différences culturelles entre les régions.

Afin de rationaliser ces différences, le développement de produits distribués comportait plusieurs objectifs. Par exemple, la standardisation des processus d'ingénierie, le développement des guides de conception commune pour les outils d'ingénierie, l'harmonisation des procédures de qualité et de résolution des problèmes. L'organisation Hydro a confié ces objectifs aux collectifs d'ingénierie virtuels qui sont dispersés dans toutes les régions.

Notre recherche vise à étudier et à soutenir les collectifs d'ingénierie virtuels dans la co-crédation des standards techniques propres à l'entreprise. Les collectifs d'ingénierie virtuels impliquent des concepteurs, des ingénieurs industriels, des techniciens ainsi que les utilisateurs finaux. Ils devaient collaborer à distance afin de co-développer les standards techniques et plus tard de les adopter dans les projets des clients.

Les collectifs d'ingénierie virtuels ont été au cœur de notre démarche de standardisation, la thèse a abordé les questions de recherche suivantes :

1. "Quel processus et plateforme collaboratifs de standardisation pourront permettre aux collectifs d'ingénierie de co-développer leurs standards à distance ?"
2. "Quelles sont les caractéristiques des différents types de collectifs virtuels qui conviennent respectivement au processus collaboratif de standardisation ?"

3. "Quel processus opérationnel doit être défini pour faciliter le travail des collectifs d'ingénierie virtuels dans une organisation gérée par projets ?"

De la littérature, nous avons défini et différencié les types des collectifs d'ingénierie virtuels en tant que communautés de pratiques ou d'intérêt virtuelles, des équipes virtuelles et des réseaux d'apprentissage. Grâce à des observations et des réflexions autour de la pratique, nous avons développé et testé nos propositions. Les contributions principales de la thèse sont résumées telles que :

1. Un modèle de processus collaboratif de standardisation pour co-développer les standards techniques à distance.
2. HySPeC - une plateforme collaboratif de standardisation - pour répondre aux différentes exigences du processus collaboratif de standardisation.
3. Un modèle dynamique pour caractériser les collectifs virtuels en fonction de leurs phases de développement.
4. Un cadre des collectifs virtuels pour sélectionner, différencier et adapter les collectifs virtuels en fonction des objectifs du projet.
5. Un processus opérationnel des collectifs virtuels pour faciliter l'adoption et la mise en œuvre des standards d'ingénierie dans les projets.

La direction chez GE Hydro a considéré les propositions comme un facteur de succès pour co-développer les standards d'ingénierie à distance. Les différents types des collectifs virtuels peuvent s'adapter au processus de standardisation collaboratif et utiliser intuitivement les fonctionnalités de la plateforme collaborative. L'approche a également fourni un processus opérationnel pour faciliter l'intégration et le travail des collectifs d'ingénierie virtuels au sein de l'organisation hydro.

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CONTEXT AND PROBLEMATIC

GE History

It all begins in 1878; Thomas Edison shown in figure 1 was a young industrial inventor, founded the Edison Electric Light Company along with some business entrepreneurs. It allowed him to patent the light bulb in 21 October 1879. Later in 1889, the company Thomson-Houston Electric Company was created and quickly it became the main competitor to the Edison Electric company in the manufacturing of electrical installations. It became increasingly difficult for the two companies to produce complete electrical installations relying solely on their own patents and technologies. In 1892, they merged to form the General Electric (GE) Company. Since then, GE Company had always been a major player in the United States and worldwide.



Figure 1: Thomas Edison. Credit Museum Innovation and Science Schenectady

Today, the company is one of the flagships of the US economy and it operates in eight industries:

❖ **POWER & WATER**, Combustion Science and services, installed base.

- ❖ **ENERGY MANAGEMENT**, Electrification, controls and power conversion technology
- ❖ **RENEWABLE ENERGY**, Sustainable power systems and storage
- ❖ **OIL & GAS**, Services and technology, a first-mover in growth regions
- ❖ **AVIATION**, Advanced materials, manufacturing, and engineering productivity
- ❖ **TRANSPORTATION**, Engine technology and localization in growth regions
- ❖ **HEALTHCARE**, Diagnostics technology, a first-mover and anchor in growth markets
- ❖ **APPLIANCE & LIGHTING**, LED is gateway to energy efficiency

[GE Renewable Energy](#)

The hydropower history started in France over a century ago. Grenoble was the origin of hydroelectric projects. Established in 1917, the Company “Neyrpic” became “Alsthom” site in 1967, then “Alstom” in 2000. In April 2015, General Electric started a buyback process of Alstom Power to reach a positive conclusion in November 2015. Due to its remarkable history with hydraulic energy, Grenoble helped with the creation of design offices in all regions. The Grenoble site leads the research & development of hydraulic turbines, hydromechanics and control systems. The site capitalized an extensive knowledge and expertise in the field of designing and manufacturing hydraulic turbines.

With the acquisition of Alstom Power, GE is now the world leader in energy production for both thermal and renewable energies. As leader in the field of renewable energy, GE is committed to a clean production and sustainable energies. The GE Renewable Hydro organization is located in five regions: North America, Latin America, Europe, China and India. With this global footprint, GE has become the largest renewable energy producer in the world, providing a comprehensive portfolio of offerings for its customers. Table 1 presents the hydro offerings in function of the potential customer segments.

	Catalogue	Standardized	Customized	Breakthrough
Description	A fixed design or guideline is utilized without design adaptations	Frozen standard designs, adaptations possible within limits following the tools, modules, guidelines defined by product management	When necessary, adaptations are possible outside limits following the tools, modules, guidelines defined by product management	Market first of a kind, requiring important upstream development
Examples	<ul style="list-style-type: none"> • Vertical Pelton <10MW • Maintenance Program • Diagnosis Toolbox 	<ul style="list-style-type: none"> • Retrofit ‘as-is’ on GE unit. • SAM units >1.9m runner diameter • ... 	<ul style="list-style-type: none"> • Gavet • Teles Pires • Retrofit with output increase 	<ul style="list-style-type: none"> • Linthal • Gilboa • WuDongDe
Potential Customer type	<ul style="list-style-type: none"> • New: IPP* • Installed base: All 	<ul style="list-style-type: none"> • New: IPP*, public utilities in export markets. • Installed base: all 	<ul style="list-style-type: none"> • New: public utilities in their domestic market • Installed base: all 	<ul style="list-style-type: none"> • New: public utilities in their export and domestic market • Installed base: all
*IPP: Independent Power Producer				

Table 1: Hydro offerings segmentation

In a world of growing electricity demand, rising fuel costs, and climate change concerns, GE Renewable Energy is focused on providing wind, hydro and innovative power solutions for its customers around the globe. To meet the basic needs of clean

electricity, GE created and developed innovative solutions. These solutions take into consideration the economic development, social and environmental responsibilities. Figure 2 presents the hydro store that is composed of hydro products and services for the customers.



Figure 2: Renewable Energy - Hydro Store. Source GE Hydro Solutions – Standard Presentation 2016

The hydro store products and service are described as follows:

❖ Hydropower Products

- Flexible, industry-leading portfolio of single component to turnkey hydro power plant solutions – encompassing all turbines, generators, control systems and mechanical equipment
- Fixed and variable speed pumped storage plants, with low/medium/high head

❖ Hydropower Services

- Solutions for optimizing assets and addressing customer needs: “*Hydro PlantLife*” to assess, secure, extend, reset and upgrade fleets, plants and components

Turbine/ Generator functioning

A turbine is a complex product where its main function is to transform the potential and kinetic energy of a water fall into mechanical energy that rotates the turbine shaft. The turbine shaft is connected to the rotor of generator that induces an electric current into the stator. Figure 3 illustrates the main components of a hydraulic turbine and its generator. A turbine can be parameterized by the head (m), and the discharge (m^3/s). The head measures the height of the water fall, and the discharge measures the flow of the water. The mechanical energy is expressed by torque and rotational speed and the electric power is expressed as the tension and the intensity of the electric current.

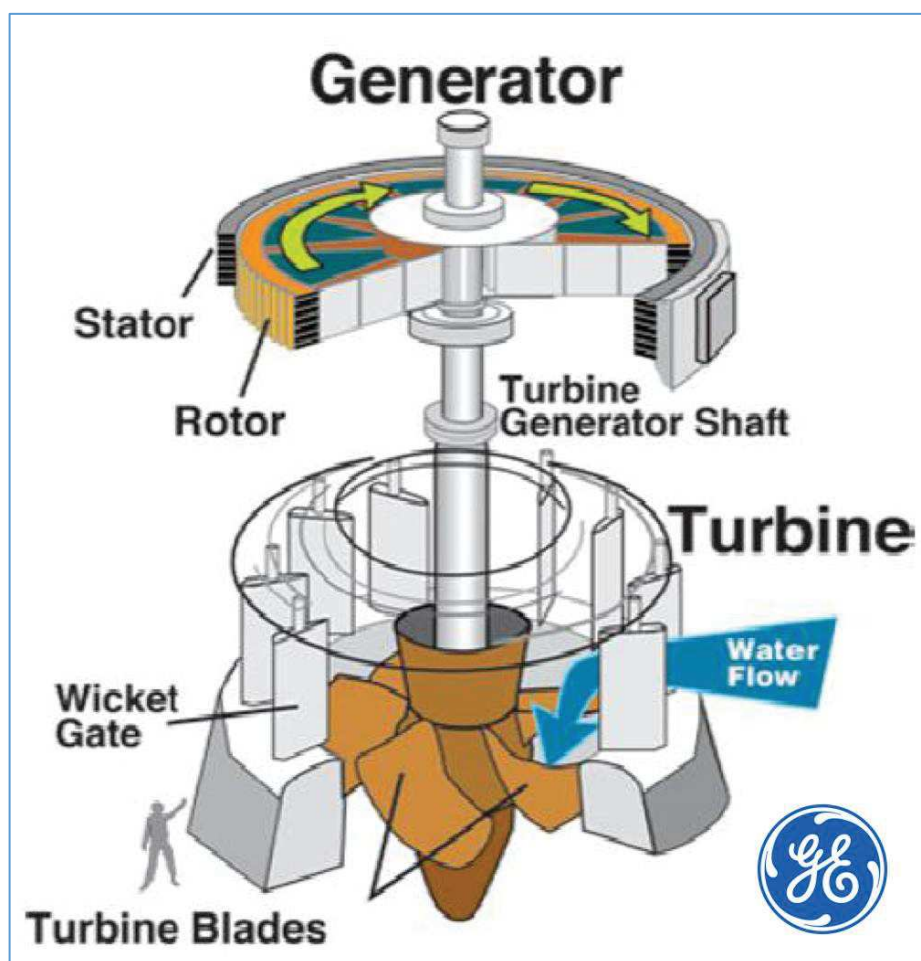


Figure 3: Kaplan Turbine/Generator main components. (GE Renewable Energy, 2015)

There are several types of hydraulic turbines and they are adapted to the various water fall environments:

- For High-Head plants from 200 to 1500 meters in altitude, the Pelton is recommended with maximum power generated of 400MW.

- For Medium-Head plants from 10 to 700 meters in altitude, the Francis turbine is the most commonly implemented with maximum power of 1000MW.
- For low-head plants from 12 to 50 meters, the Bulb and Kaplan are suitable with maximum power of 220MW.
- The pump turbines are mainly used to store energy during overproduction periods. The water is pumped at night from the lower basin to the higher basin.

Figure 4 presents the 5 different turbine types with their corresponding generator type.

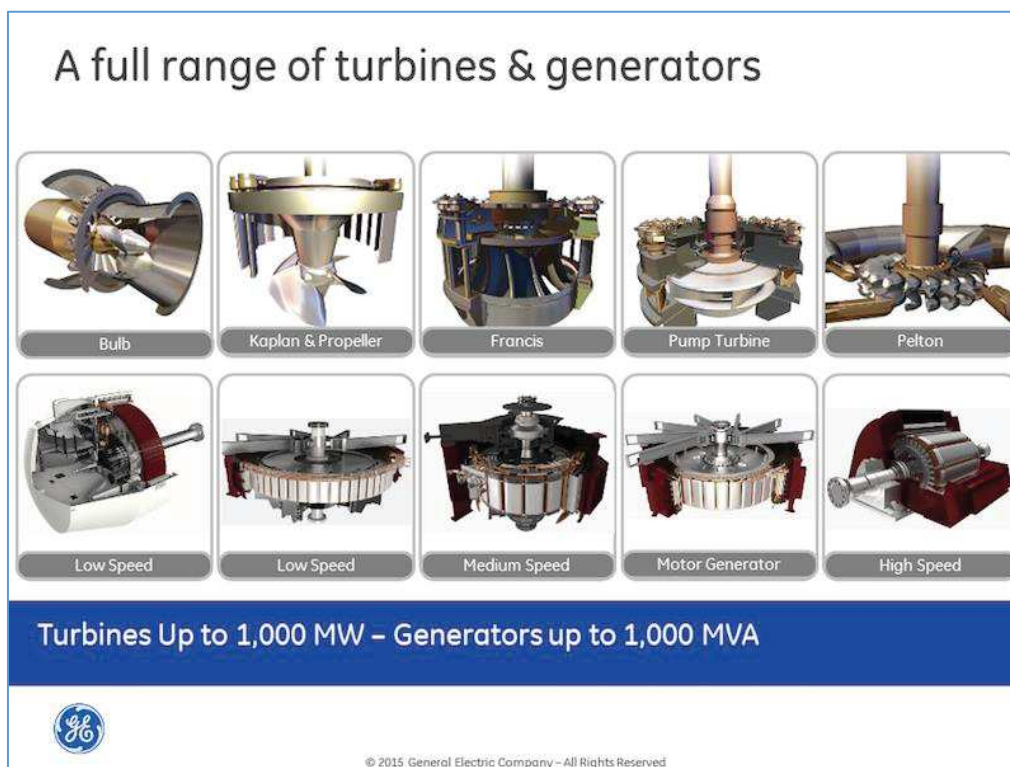


Figure 4: Full Range of turbines & generators. Source GE Hydro Solutions – Standard Presentation

The hydro power status report for 2015 indicated that 16% of total worldwide electricity generation came from hydropower as communicated by the international hydropower association (IHA, 2015). By definition, the maximum generated electrical power by a hydro plant is referred to the installed capacity and measured in megawatts (MW). And the actual generated power is measured in megawatt-hours (MWh) (BChydro, 2013). For example, in 2012, the Three Gorges, China hydropower plant which spans the Yangtze river is the world largest hydro plant with installed capacity of 22,500MW. The Itaipu dam which spans the Paraná river located on the border between Brazil/ Paraguay is the second with 14,000MW of installed capacity (WEC, 2013). The hydro status report estimated that the global hydropower installed

capacity is at 1,036 GW (gigawatts) (IHA, 2015). GE's Hydro business is one of the world's leading companies. Quarter of the global hydropower installed capacity is equipped with GE technology. In fact, GE technology empowers the Three Gorges with 14 Francis turbine units of total 32 rated at 700MW each. And it supplied 10 of total 20 units rated at 700MW each for the Itaipu hydropower plant (GE Reports, 2015).

Figure 5 shows the different components of a standard hydropower plant: the reservoir and the dam where water is stored. The penstock drives the water to the turbine that is connected to the generator. Power is generated, and transformed to the grid through the power transmission cables. Finally, water speed is decreased when departing from the downstream outlet. The higher is the difference of level between the reservoir and the downstream outlet, the greater is the amount of electricity generated. Hydropower plant size is defined in function of the generated electricity varying from small-hydro (<20MW) to large-hydro (>100MW). Typically, the total installed capacity cost for a 500MW large-hydro project range from \$1000/kW to around \$3500/kW. The minimum cost for a 500MW hydropower plant will be \$500B. The powerhouse equipment's, the engineering, the procurement and construction management cost represented 37% of the total cost (IRENA, 2012). GE hydro vision is to be the undisputed hydro leader in all market segments: small & medium, large, retrofit, service and digital. Cost reduction of powerhouse equipment's will be a major challenge to fulfill this vision while maintaining the same brand quality.

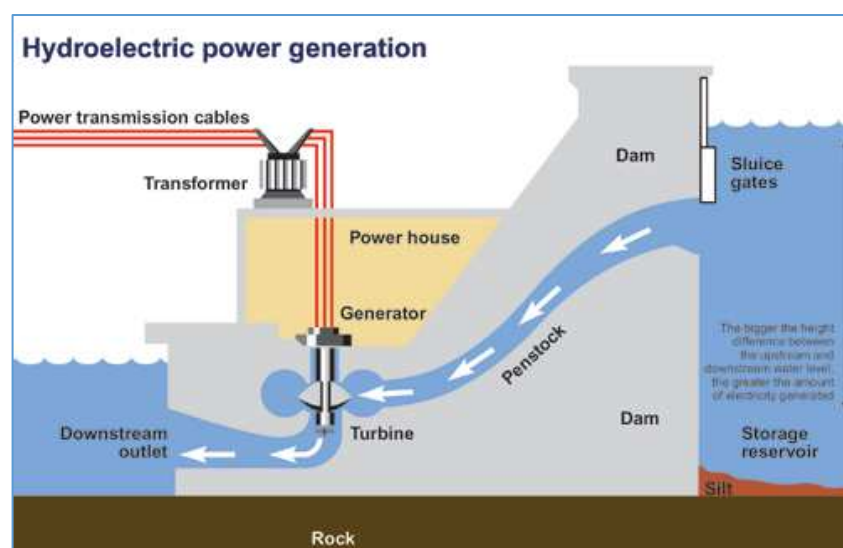


Figure 5: Main components of a standard hydropower plant. Source: Environment Canada, 2010

GE hydraulic units operate in an international market close to the customers. Globalization has now changed the design process of turbine /generator. The hydraulic units scattered around the world that previously worked independently found themselves interconnected in complex networks. These hydraulic units are composed of engineering collectives who are dispersed in all regions. The engineering collectives should collaborate seamlessly to produce the full range of hydraulic turbines – Francis, Kaplan, Bulb and Pelton – along with generators, Balance of Plant and control systems. From engineering design to manufacturing, to installation and commissioning, the GE engineering collectives share their knowledge and expertise to deliver turnkey power plants to the customers.

At the heart of a hydro project is the water itself, around which a custom-built power plant must be designed. Every river is different and every project has its own requirements that match different river configurations. Every region has its own engineering practices, different product specification methods and different tools configuration. These natural and regional variances had constrained different design blueprints, multiple manufacturing technologies and various site installation procedures. These diversifications also impacted the supplier's relationships, the procurement prices, the productivity plans, and the quality inspections criteria's. These variances summed with the cultural differences can easily turn into real obstacles for engineering design when scaled at global level. The top management has required to modularize the variances presented in the hydro projects. It has also recommended to reduce the diversity in design by defining a list of standard components applicable to all projects. The top management set the objective to harmonize the design guidelines and to standardize the technical purchase specifications.

Standardization of engineering practices is a possible answer to the necessity for multinational firm to rationalize their development activities across their local sites. Stating that a collaborative platform could be valuable for supporting the collective and distant activities for defining corporate engineering standards.

In 2013, The GE hydro organization was still under the “Alstom Power” hydro organization. It is composed from various functions such as R&D, engineering, manufacturing, quality, supply chain and site installation. A synergy between all the

functions is recommended, and the regional working practices should converge into global best practices. The top management has considered the standardization initiative as a top priority to maintain a high level of product performance and the same brand quality in all its operating markets. This initiative is expected to help “Alstom Power” organization to have a single point of trust by reducing the dependency on specific suppliers. The standardization initiative has the following objectives:

- 1) Unify the engineering design and review processes for products.
- 2) Re-use the same design for as many projects as possible.
- 3) Develop common design methodologies for the engineering tools (CAD)
- 4) Use the same procurement specifications list with the suppliers.

A Steering committee was created to include representatives from the different functions and to manage their center of interests. It had a directive role to monitor the progress of the standardization initiative during the development and the adoption of the standards.

The hydro engineering (HEN) function was the owner of the standardization initiative and was accountable to reach these objectives. HEN has organized the standardization process between global and local activities. From one hand, the global activities are led by product experts gathered in co-located teams where the objective is to develop the common technologies, methods, and tools. On the other hand, the local activities are led by localized resources mandated to adapt these common work practices to the context of local projects. These localized resources represented their respective hydraulic units in every engineering region.

The top management had preconized the creation of engineering communities where both global and local resources can exchange information on the standards. The top management used the expression “engineering communities” to describe the virtual engineering collectives. However, the ‘engineering communities’ expression can’t designate all the virtual engineering collectives. We have defined, differentiated and classified the “engineering communities” in Cycle 2 of this report.

The hydro organization had implied that the “engineering communities” to be distributed all around the world but engaged in the standardization activities. The

engineering communities' members are diverse and they have different profiles. Therefore, members from the R&D function may have discussions with the engineering operations function inside the community. The engagement of the engineering communities' members is based on either the developed practice or a common interest to solve problems. The engineering communities' members had to travel in order to meet up, exchange their local practices and co-develop one global standard. However, the meeting frequency was bi-annual and required a huge amount of preparation time and budget allocation. The welding community is one of the engineering communities that was created by the standardization initiative.

Before this initiative, the prior welding practices was to reuse the welding technical documents by making an analogy to past projects. However, the reused technical documents weren't adapted to some new project specifications. There was extra information for some projects, missing information for others or even incompatible information for specific projects because they correspond to the original project. The supplier is obliged to debug, and get back to the project team with a list of questions. This process takes a long time. The solution was to define standard welding documents. For example, the tender sketches that will give minimum but reliable information during the tendering phase. By having the tender sketches, the project team can quickly have an offer and reach a framework agreement with the supplier.

A co-located workshop to harmonize the engineering practices

A co-located welded structure workshop (see appendix A for additional workshop information) was conducted to develop the standard welding documents. The workshop gathered 30 experts from all regions (India, China, North America, Latin America, and Europe) and different functions (R&D, Engineering & Manufacturing, Quality, Sourcing and Site Installation). These experts were clustered into 3 groups who were responsible to develop the following standard welding technical documents: manufacturing and inspection rules, supplier instruction, documents management and follow-up, and pre/order activities such as R&D industrialization, technical tendering and engineering design.

The co-located workshop has strengthened the relationships between the community' members and boosted their interactions. The participants were involved in multiple discussions in their respective groups. This dynamic has enabled the participants to

fulfill the major workshop objectives. For example, some of the workshop outputs are listed below:

1. Technical checklist was defined based on Brazil checklist and integrating Europe and China practices.
2. Procurement specifications are defined from ASME that will be globally the base for welding requirements.
3. Quality working plan is completely defined and has to be used by all regions.
4. Post weld heat treatment (PWHT) instruction is discussed, commented and approved.
5. Measurement instruction (028-300) is reviewed at 75%.

The workshop concluded by defining and assigning actions to the participants to follow-up upon the return to their respective regions. For example, some of the follow-up actions are listed below:

1. Finalize the post weld heat treatment instruction.
2. Build the PWHT sketch as annexes for each type of product.
3. Review and complete the measurement instruction with the welding specialists.
4. Finalize traceability sheet and Welding book template in 4 languages
5. Share basic checklist items with global quality for finalization.

Reflections from the “welded structure” workshop

After the workshop, the standardization manager has observed that the participation to the remote community meetings had diminished. The interactions between the dispersed welding standardization community’ members had decreased. As result, the welding community hasn’t delivered on time. The standardization manager had to postpone many times the deadline for the follow-up actions. A quick diagnostic by the standardization manager has yielded to the following conclusions:

- 1- The use of e-mail as a communication medium where the topics discussed through e-mails can easily diverge outside the initial scope. The number of

emails exchange had quickly grown exponential which made the discussions hard to follow. The mailbox could be spammed in short time leaving the team member frustrated by the number of emails to read.

- 2- The lack of a central access point hindered the sharing of standardization documents between the central team and the local teams in regions. A good amount of time was wasted by asking the team members for the documents. Beside the fact that the documents were always evolving and different versions were produced. Additional requests were made to get the latest version. The lack of a central access point also hindered the exchange of documents between different functions i.e.: engineering process & tools, R&D, product development and quality.
- 3- The lack of a collaborative standardization process had slow down the collect of the changing regional requirements or the local practices. The annual co-located meeting wasn't enough for a frequent information exchange and it could quickly make the standard obsolete.
- 4- The lack of a collaborative standardization process had limited the assessment of standard's adoption in the projects. A continuous feedback loop should be added to the collaborative standardization process. In the feedback activity, the standards should be updated to better reflect the projects requirements.
- 5- The lack of a collaborative standardization process couldn't allow the standardization manager to coordinate the actions between the regions. As result, two different regions could end up doing the same action without knowing. The standardization manager couldn't optimize the resources for the project tasks.
- 6- The lack of a collaborative standardization process also prevented the standardization manager to measure and control the execution of the standardization actions. As result, the manager had no track whether the project was falling behind the schedule or not. The top management wasn't getting timely report for the project progress.

Needs to better manage the standardization project

The standardization manager had communicated his needs to the top management to better manage the standardization project. The needs can be summarized as follows:

- Need to align the different engineering regions with common objectives.
- Need to collect the local engineering practices and diffuse them globally.
- Need to improve the communication between the engineering regions.
- Need to define a work process for the engineering communities.
- Need to share efficiently the documents locally and globally.
- Need to measure the progress of an action and its performance in relation to others

The standardization manager proposed the development of a collaborative standardization platform. It should be designed with an attention to the challenges faced after the co-located welded structure workshop. In other words, the collaborative standardization platform should adapt its functionalities to the collaborative standardization process. The platform's functionalities should also enable the remote community members to consistently exchange the information, their needs and their local practices in an easy and intuitive way. It should also respond to the standardization manager requirements. For example, the ability to consolidate all the actions data of different regions into a progress report. The standardization manager considered the collaborative standardization platform as the central access point to all the standardization activities including documents, and discussions for the community members.

Expected benefits of the collaborative standardization platform

The collaborative standardization platform is expected to have the following business impact:

- 1- Improve the communication between the engineering process & tools team, R&D, product development and quality functions. It will be easier to participate or to consult a discussion since the collaborative standardization platform will feature a discussion forum. The standardization communities

along with the functions will have a shared place to exchange the documents throughout the standards development.

- 2- Improve the quality of the existing Hydro standards. Quantitative and qualitative indicators will be set up to measure the adoption of standards by regions. Through the collaborative standardization process, the regions will be able to provide continuous feedback on the standards application in projects. The collaborative standardization platform will provide the necessary functionalities to support the feedback activity.
- 3- Improve the global process and tools team's efficiency. The collaborative standardization platform will enable the concurrent standards development for different standardization communities. Every standardization community will have its own site to develop the standards and metrics for project control. The standardization manager will be able to track the progress for every community and report the status to the top management.

Current vs future configuration of the Hydro organization

The hydro engineering function (HEN) had the ownership to develop and implement the collaboration standardization process and platform in all the regions. However, the current hydro organization does “everything, everywhere”. Actually the project management approach is regionally driven. Although the regional dimension is important to understand the local constraint, hydro engineering collectives need to be globally collaborative. From previous projects, it has been proven that by “doing everything, everywhere” the company loses its competitiveness. GE Hydro competitors such as ‘Andritz’ or ‘Voith’ act as one business where both Headquarters & the regions are involved into Global decisions. They are truly Global & Local, but with less redundancies and optimized usage of resources.

The future HEN function aims to have a clear understanding of what are the customer's expectations in terms of product offering, not only from a pure technological point of view, but also in terms of energy cost, services and environmental impact. In close collaboration with the product management, the level of standardization should be defined in function of both the level of realistic customization of the product and the level of suitability to the market demands. The

HEN objective is to reorganize the engineering footprint to ensure that the company brings the best product at cost, at quality, on time and with the necessary level of standardization for every market.

To attain this objective, the new HEN function should allocate the best competencies for each specific product. In other words, to reach the best fit between the skills that already exist in Engineering, R&D, Product Management in the proximity of the Supply Chain, the market and the customers. The new organization of engineering collectives will be built around centers of excellence which are centers of execution for all projects around the globe. Centers of excellence (COE) for engineering are locally based but addressing Hydro global demand and serving all regions. The systems integrators units for market segments (Large, Small & Medium, Retrofit, Service and Digital) will start with a customer focus and will be working as a link with product management and project management. The organizational transformation will consist of two main steps. The first step is to move from a regional organization (6 engineering centers) to a global organization with COEs being hosted in one region with a global reach. All these COEs will have the same engineering KPIs for performance assessment. The 3 main KPIs will be On Time Delivery (OTD), Budget, and cycle time. The second step is to implement worldwide engineering communities to improve the knowledge sharing between the regions and to create connections which facilitate the identification of experts. Figure 6 shows the transition from the current configuration where every region had lead its own projects to the future configuration where COE's will lead globally the projects in function of the specialty.

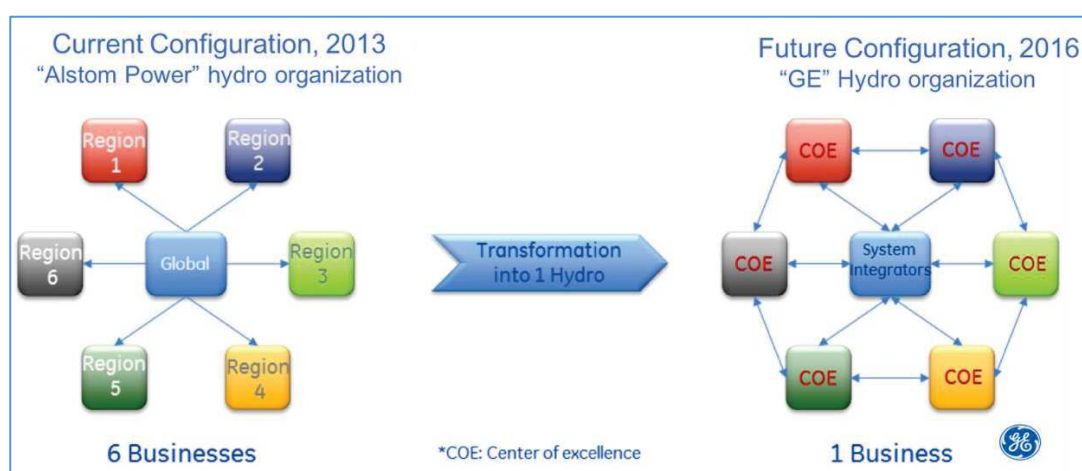


Figure 6: The current Vs future configuration of hydro engineering (HEN) function

From the management literature, Bartlett and Ghosal identified the current hydro engineering configuration as the international model and the future hydro engineering configuration type as the transnational model (Barlett & Ghosal, 2003) . Three main factors characterized the future hydro engineering configuration or the transnational model:

1. The configuration of assets and capabilities is dispersed, interdependent and specialized. In GE future context, they will be called Centers of Excellence.
2. The role of regional operations is different but integrated to worldwide operations. In GE future context, the system integrators will have the role to dispatch the project requirements to the COEs.
3. The knowledge is developed jointly and is shared worldwide. In GE future context, the worldwide engineering communities will have the role to improve the knowledge sharing among the experts and solve recurrent problems in projects.

Likewise, three main factors characterized the current hydro engineering configuration or the international model:

1. The configuration of assets and capabilities is to exploit parent company knowledge and capabilities through worldwide diffusion. In GE current context, the hydro engineering function (HEN) was playing the role of the global function. HEN developed the engineering standards and diffused them to the engineering regions or the local functions.
2. The role of regional operations is to adapt and leverage the parent company competencies. In GE current context, the engineering regions had to adapt the standards to their local requirements and constraints.
3. The knowledge is developed at the center and transferred to subsidiaries. In GE current context, regular trainings, workshops and knowledge transfer sessions were organized by the global function for the local functions. The engineering regions had to allocate the necessary budget for their participations.

Problematic

This research study was entirely conducted within the current hydro engineering configuration or the international model, we formulated our initial research question to be as follow:

“How to co-develop the standards with the regions and improve the collaboration of the engineering communities in an international context?”

Four main challenges for the engineering communities arise when co-developing technical standards at distance within the hydro engineering international configuration.

The first challenge is related to the fact that it requires the involvement of many experts and future users. The standardization process can be particularly cumbersome and time-consuming in the context of physical and cultural differences between the participants in this remote process. From practice, we observed that collaboration between practitioners is an enabling factor for any standardization process. All of them are involved in similar engineering activities in the product development life cycle but implementing different reasoning, depending of habits, techniques, and culture of their country site. Engaging the practitioners in the definition and development of standards will facilitate the adoption of the standards and its utilization in future projects (Beylier, Pourroy, Villeneuve, & Mille, 2009; Slob & DeVries, 2002). The standardization process has to be collaborative and take into account the physical distance constraint.

The second challenge is related to the technology supporting the collaborative standardization process. The Standard Design Process is a work of sharing and co-production with a large team spread around the world. This type of project requires a well-developed collaboration tool to achieve their goals. The technology should enable dispersed members to co-develop together their engineering standards. Most of the standardization activities should be supported by ICT tools and rely on collaborative tools to be developed asynchronously. Collaborative platforms are classified as knowledge management systems. ‘Broadly defined, knowledge management systems (KMS) are a class of information systems aimed at supporting and facilitating the codification, collection, integration, and dissemination of

organizational knowledge' (Chandrasegaran et al., 2013). Enterprises continue to invest in the underlying technologies of these information systems. They aim to establish a single entry point to find all product related information. The employees interact with the system on daily basis where they hope to find information related to their work quickly and with minimum guidance. With the standardization manager, we made the assumption that the functionalities of these collaborative platforms had to respond to the requirements of the collaborative standardization process.

The third challenge is related to the virtual engineering collectives performing the collaborative standardization process. These virtual engineering collectives are essentially characterized as "informal social group" (Bettoni et al., 2007). In informal social groups, the members have informal discussions around a common interest and are bounded by a shared goal rather than the organizational hierarchy. The informal human interactions and relationships are of great importance for knowledge management (Wenger et al. 2002). However, these virtual engineering collectives may take several forms and manifest into multidisciplinary teams, design communities, or networks for learning (Hustad, 2010; Lipnack & Stamps, 2000; Wenger, McDermott, & Snyder, 2002). Often, these virtual engineering collectives tend to be cross-functional, span organizational boundaries, have multiple cultural values and rely on Information and Communication Technology (ICT) (Ebrahim, Ahmed, & Taha, 2009). These virtual engineering collectives are of importance since they "allow organizations to improve efficiency and productivity, procure expert knowledge from internal and external sources, and transfer best practice information" (G. Huber, 1990). They extend their local experiences by integrating similar or complementary skills or competences. They offer organizations a global pool of expertise to compose tailored virtual collective that rapidly encounter an emerging organizational need (El Badawi El Najjar, Prudhomme, Pourroy, Maussang-Detaille, & Blanco, 2014).

The fourth challenge is related to the organizational context of the virtual engineering collectives. The hydro organization performed and managed its activities as projects with defined budgets, planning and deliverables. In order to respond to the operational requirements of the Hydro organization, as researchers, we had to develop an operational process to implement the virtual engineering collectives.

Our initial research question related to the collaborative standardization process involving dispersed engineering communities is refined to the following questions:

- 1) Which collaborative standardization process could enable the practitioners to collectively develop their standards at distance?
- 2) What are the collaborative platform functionalities that implement the collaborative standardization process requirements?
- 3) What are the characteristics of the virtual engineering collectives that best suit the collaborative standardization process?
- 4) Which operational process has to be defined to ease the work of the virtual engineering collectives within a project management framework?

Thesis Report Structure

In the next chapter, we presented the strategy to answer the research questions and justify our choice for the research methodology. We defined the research project' objectives and explained the role of the researcher within the current hydro engineering configuration.

Next to the research methodology chapter, the thesis report is structured in 3 main parts; each represent one cycle at a time. Needless to say, that every cycle will seek to attain its own objective. The 3 parts are as follows:

The first part will elaborate the first cycle and will accomplish the first objective which is: the collaborative standardization process and platform. This objective will allow distant engineering to co-develop their engineering standards. The process activities will be supported by a collaborative standardization platform as online shared workspace.

The second part will elaborate the second cycle and will realize the second objective which is: the virtual collectives' framework. This objective will characterize and differentiate the virtual collective's types for engineering activities. The framework will allow the community manager to select the collective type that best fits a given engineering activity.

The third part will elaborate the third cycle and will achieve the third objective which is: the virtual collectives' operational process. This objective will define a process to

set-up a community within a project management framework. This cycle will test the propositions on a new project in a broader context that will involve additional functions.

The final chapters of this document will be utilized for conclusions, discussions, and managerial implications.

RESEARCH METHODOLOGY

Presentation of the research project and the research team

The research project featured a collaboration between the G-SCOP laboratory and GE Renewable Energy – Hydro. The research project aimed to solve real world problems but also to generate new scientific knowledge. The project team was composed of 3 researchers and 4 representatives from the industrial organization, in addition to the PhD candidate who was employed by GE Renewable Energy - Hydro. Figure 7 presents the researcher's role and relationships with the setting: the laboratory, the organization functions, the researcher/ practitioner job title, and the interactions within its environment. The researcher/ practitioner is attached to the hydro engineering (HEN) function and was active participant in the projects. He acted as collaborator and facilitator between his function and the other functions. In the standardization project, he played the role of community analyst for the engineering communities. His responsibilities were to develop, implement and improve the engineering methods and tools for the standardization communities. This role required to have dual profiles: a researcher to draw from the theory and a practitioner to reflect from the practice. He had to constantly alternate between these two mindsets, adjusting the propositions and questioning the theory based on the situation conditions.

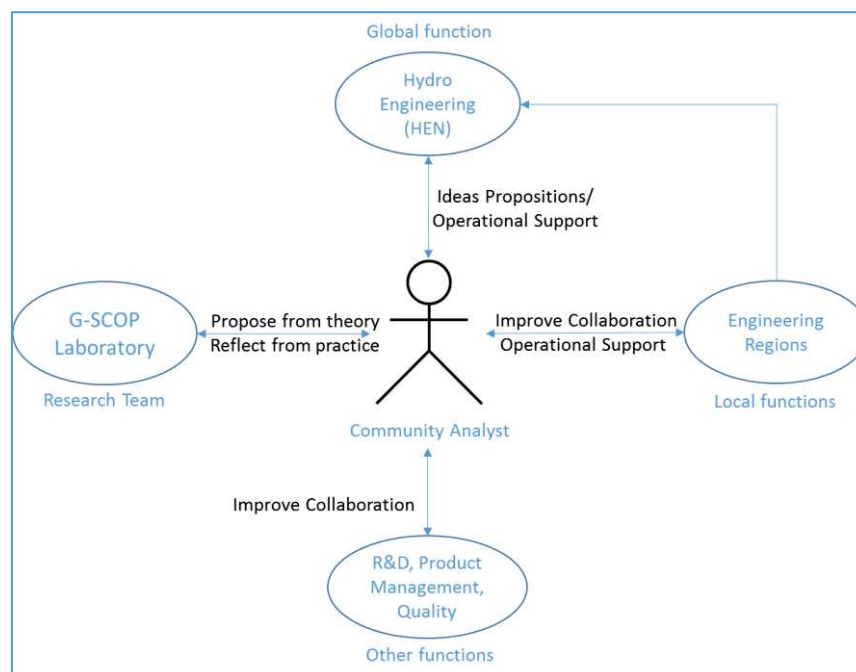


Figure 7: Researcher's role and Relationship with the settings

From one hand, as practitioner, his responsibilities were to improve the collaboration between the HEN function and the engineering regions or the local functions. He also collaborated with the other global functions such as: R&D, product management and quality. He organized and animated community building sessions between global and local engineering functions. Similarly between global engineering, R&D and product management. As operational support within the HEN function, the practitioner had additional responsibilities related more to the technological aspect of the communities. He had to develop, implement and maintain the collaborative standardization platform that supported the collaborative standardization process. For example, he developed HySPeC - the collaborative standardization platform to support the co-development of standards between the engineering communities' members.

On the other hand, as researcher he had to propose improvements ideas inspired from the scientific literature. He was responsible to observe the collaboration dynamics within the engineering communities. In addition, he collected the different working methods and processes between the hydro engineering function and the engineering regions. Based on these observations, he proposed new ideas, framework and working methods to improve the collaboration between the engineering communities' members. For example, he designed a questionnaire from the scientific literature and interviewed the engineering communities' leaders to better understand the factors influencing the collaboration within the engineering communities. Following this questionnaire, he analyzed the results and proposed a new framework to improve the collaboration between the engineering community' members.

Challenges facing the researcher/ practitioner

The transition from the researcher mindset to the practitioner operational mode and vice versa wasn't trivial and was confronted by many challenges. In most of the cases, the development of the propositions and their implementations was done concurrently between the theory and the practice. The researcher/ practitioner had to deal with different types of challenges:

1. The working modes of the laboratory and the hydro engineering function.
2. The collaboration between hydro engineering, R&D, and product management.
3. The operational support for hydro engineering function.
4. The technical support for hydro engineering function and the engineering regions.

First, the researcher/ practitioner played the role of mediator between the conceptual knowledge developed at the laboratory and the operational knowledge required for the hydro engineering function. As researcher, he had to go through the knowledge creation process to develop the conceptual knowledge and as practitioner he followed the knowledge reuse process to develop the operational knowledge (Davenport, Jarvenpaa, & Beers, 1996) . These two processes associated each their own languages, vocabularies and working modes. The engineering working mode focused on results and is committed to solve organizational problems at minimum cost. Conversely, the research working mode consisted of understanding the underlying elements that constitute the problem context and the method used to generate the solution. The main challenge for the researcher/ practitioner was to work concurrently in both modes. The proposed framework to improve the collaboration between the engineering communities' members was simultaneously constructed based on both the reflections from the practice and the synthesis of the scientific literature. He had also to adapt his speech in function of the target audience. He adopted an explicit approach supported by examples whenever he communicated it with the engineers. The framework couldn't be implemented without the development of operational tools. Whereas, he had to justify the choices he made to construct the framework whenever he discussed it in an academic context.

Although, the concurrent approach between the engineering and research working modes had shaped the intellectual experience in its best forms, but it was intercepted by many issues. By default, the laboratory and the HEN expectations, operational rhythm and performance evaluation criteria aren't of same nature or type. The first issue was that the HEN function is expecting to have quick efficient solutions for its problems while the laboratory is expecting to have solid and original scientific knowledge. The second issue was that the HEN function had fast operational rhythm

where priorities are perpetually changing and today's operational problems could quickly be irrelevant in tomorrow's context. However, the laboratory had to some extent a set of research questions defined around a research theme. The third and final issue was the performance evaluation criteria's. The main performance indicators for the laboratory are in function of published papers in scientific journals and their impact within the scientific community. However, for HEN, the performance indicators are always in function of cost reduction, quality and lead time improvements. Having in mind those 3 issues, the researcher/ practitioner had to invest extra efforts and time to put in harmony the two different working modes.

Second, the researcher/ practitioner acted as collaborator and facilitator between the hydro engineering function, the R&D and product management as well as the engineering regions. In a project to standardize the control systems for the hydropower plant, he animated the community building session with R&D, product management and the engineering regions to set the roadmap and the project's deliverables. The roadmap had defined a series of technical workshops. Their objectives were to collect the local practices and requirements of the engineering regions and converge them into one best practice. Prior to the workshop, his role as animator was to organize and communicate the agenda, select the participant's profiles in function of the workshop objectives, define the parallel sessions and make sure that the participants had prepared the necessary materials. During the workshop, his role as animator was to keep the discussions within the defined scope, establish consensus on the requirements, make sure that everyone has the same understandings for the deliverables and define an action plan for the workshop follow-up.

Although, leading the animation sessions between different functions had enabled the researcher/ practitioner to extend the perimeter of his propositions, but he had to pay attention to the political conflicts. He had to be aware of the cultural and political tendencies between the functions, especially every function had its own strategy and performance evaluation criteria. The functions had differences in perspectives of who the internal clients were, what the problem was, and what constituted an appropriate resolution of the problem. Moreover, he had restricted time to pass with engineers working outside the hydro engineering function. It was difficult to conduct interviews and get their point of views especially from engineers working on customer projects.

Third, the researcher/ practitioner had directly participated in the implementation of the hydro engineering' operational objectives. He provided the support for his team members in the operations. For example, he supported the change manager for the application of the CHEF (Change Hydro Engineering Framework) methodology. The CHEF methodology ensured a proper change management process with the engineering regions. The CHEF provided the necessary tools to mobilize the stakeholders, reduce and anticipate the resistance due to the changes, and define a suitable plan for implementation. He also proposed and developed ideas contributing to the overall improvement of his function. For example, he proposed a mechanism to transform the hydro engineering function into a learning team. The team members participated in monthly sessions to present and discuss general management or technical topics that will improve the team cohesiveness. One of the sessions was titled 'Process Communication Model'. PCM is a tool that will help the managers to identify the key characteristics of different personalities. And then chose the communication mode that best fit a given personality type.

Although the involvement in the hydro engineering operations had helped the researcher/ practitioner to better integrate his function, some of the operational activities didn't contribute directly to the resolution of the research questions. The observations and the reflections from the operational involvement could enrich the practitioner experience but it couldn't be fully capitalized as new scientific knowledge. The choice of the operational activities should be guided by the research scope.

And finally, the hydro engineering function used corporate collaborative tools to work with the engineering regions. The researcher/ practitioner was the collaborative tool expert for the hydro engineering function. He played the role of the technical support for the collaborative tool users. In Total, he received 215 demands ranging from simple ones like granting permissions to access an online site, to complex ones like developing a new functionality or even organizing a training session. The researcher/ practitioner set a key performance indicator (KPI) to sustain a reliable service level. The response time for any demand should be less than 2 hours as a KPI to monitor the service quality. If the demand resolution required exceeded the 2 hours, a status mail is sent to the demander notifying him with the actual resolution time. As the collaborative tool expert, he had also to test and report the bugs due to any

malfunctioning or migration to a new version. Aside from the technical support, he also responded to priorities and urgencies from the senior VP (Vice President) of hydro engineering function. For example, the VP has demanded a project follow-up tool to be developed, and implemented within two weeks. A training on the tool should also be organized for the hydro engineering leaders. In addition, the leaders had been supported to customize some functionalities and meet specific requirements for their projects.

Although the technical support for the hydro engineering and the local functions had enabled the researcher/ practitioner to establish links with the end-users - eventually the engineering communities' members - it didn't contribute directly to the resolution of the research questions. Technical support could easily turn into a time consuming activity and a deviation factor from the research scope. In fact, demands can interrupt the researcher/ practitioner' focus on the research questions. The technical support activity should be governed by a well-defined schedule and communicated to all the users.

Feedbacks from the researcher/ practitioner

We quoted the researcher/ practitioner personal verbatim to describe his personal experience during the thesis development:

“I lived in uncertainty, in constant doubt, and always questioning my abilities if I can match up between the industrial never ending challenges and the laboratory quest to generate original knowledge. The only question that I kept asking myself was: “how my results will make a difference?” I had to push my limits and face my weaknesses at many occurrences. I had to understand deeply the need and the pain. It was a difficult task to reach the 5th why, and sometimes it was impossible. Since I worked with the people for the people, I had to show strength and confidence in every single task even though plenty of questions were popping in my mind. I tried to unbox everyone personality, to gain their trust and to influence their behaviors. It was neither about the technicality of the problem nor its resolution. The problem rested in the people's attitude towards improvements and the will to change. Whenever I had to animate a workshop or conduct a training, I spent my nights simulating different scenarios, creating conflicts and resolving them. At the laboratory, I was always challenged to justify the results and the choices. At the beginning it was frustrating,

but later I understood that behind the solution, a richer knowledge resided and that knowledge will potentially help with the prevention of the problem metamorphism. Beside acquiring new academic knowledge or professional experience, doing an industrial PhD has evolved my personality in real life, enabled me to see the world through a new lens. It was an attitude changer and a critical mindset builder. I learnt that without the research we can't advance and without the practice we can't deliver. Now, I'm writing my PhD manuscript and learning again from what I did, opening the research to new perspectives and asking myself again "how my perspectives will make a difference?" Maybe the answer lays within the journey itself and not the finish line, if there's ... a finish line!"

Action research methodology to co-construct knowledge

The researcher/ practitioner had to overcome multiple challenges to conduct his research project. He was immersed in the organizational environment. He tried to solve organizational problems and implement the solutions provoking change in the organization. At the same time, he had to publish original propositions that contributed to the scientific literature. A research methodology is required to guarantee the rigor in his research project taking into consideration the researcher/practitioner setting.

One of possible candidate was the action research methodology. It aims to solve current practical problems while expanding scientific knowledge. Unlike other research methods, where the researcher seeks to study organizational phenomena but not to change them, the action researcher is concerned to create organizational change and simultaneously to study the process (Baburoglu & Ravn, 1992). It is strongly oriented toward collaboration and change involving both researchers and subjects. Typically, action research is an iterative research process that capitalizes on learning by both researchers and subjects within the context of the subjects' social system. Coughlan and Coughlan preconized that the usage of action research methodology requires a deep understanding of the enterprise culture, business conditions, organization structure and the operation of its different systems (Coughlan & Coughlan, 2002).

To address our research questions, the action research methodology is adopted. In our case the distance between the subject (observer) and the observation object is reduced

to zero. The research tried to solve engineering management issues relying on theories from the collaborative design field. This research tends to define and experiment collaboration methods and tools between the engineering collectives applying remote standardization activities. In an action research method, the researcher is the practitioner where he seeks to improve his own practice, see table 2 (Coughlan & Coughlan, 2002). In this thesis the researcher/ practitioner has the role of community analyst where he is responsible to develop and deploy methods and tools to support the standardization process. The thesis scope lies at the intersection between the management practices and the engineering sciences. These propositions are expected to contribute to both the industry and the academia. The propositions are based on analyzing the existing practice, reflecting on it from the literature, and tested it back in practice.

Aim of research	Theory Building and testing in action
Type of knowledge acquired	Particular and situational
Nature of data validation	Contextually embedded and experiential
Researcher's role	Take actions as practitioner/ agent of change
Researcher's relationship to setting	Immersed

Table 2: Action Research Summary

We managed these propositions through an iterative process. Figure 8 describes the action research iterative process that is consisted of 4 main activities for every cycle: Diagnosis, planning for actions, taking actions and finally evaluating these actions.

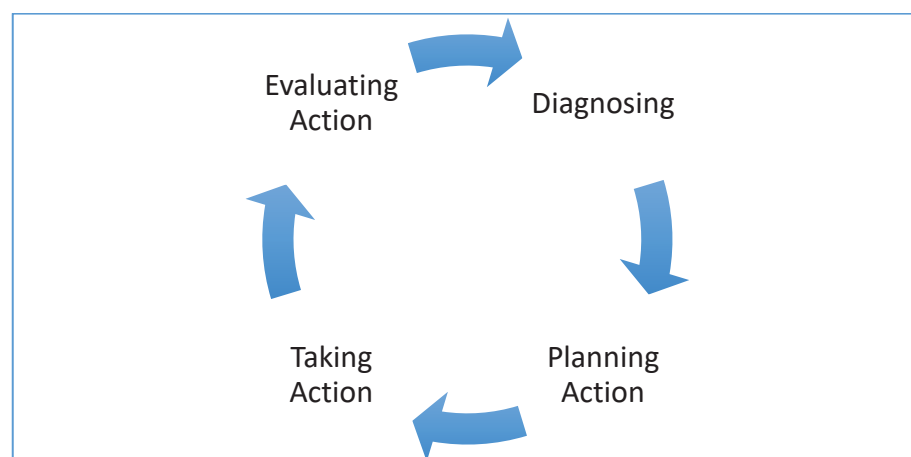


Figure 8: Action Research Methodology. Source Coughlan & Coughlan 2002

- *Diagnosis* phase examines the “as-is” situation of the organization. It investigates the concepts, models and methods shaping the current situation. The diagnosis will help to find suitable solution and set the guiding principles for the “to-be” situation.
- *Planning Action* based on the recommendations resulted from the diagnosis phase. In this phase a list of actions is defined with proper scheduling for implementation.
- *Taking action* is to implement the planned actions and react within the current situation. Actions can be adjusted through this phase to have a better answer for the current situation problems.
- *Evaluating Action* involves measuring the impact of these actions, both intended and unintended. Reflections and feedbacks on the whole cycle should be collected to improve the development of the next cycle.

Application of the action research methodology to the thesis

Figure 9 shows the thesis’ objectives and the iterative process that is repeated for 3 cycles and related to our research questions. Every objective will be realized in one cycle at a time following the same process activities.

- ❖ Cycle 1 objective: define and develop the collaborative standardization process and platform.
- ❖ Cycle 2 objective: propose and apply the virtual collectives’ framework.
- ❖ Cycle 3 objective: propose and apply the virtual collectives’ operational process.

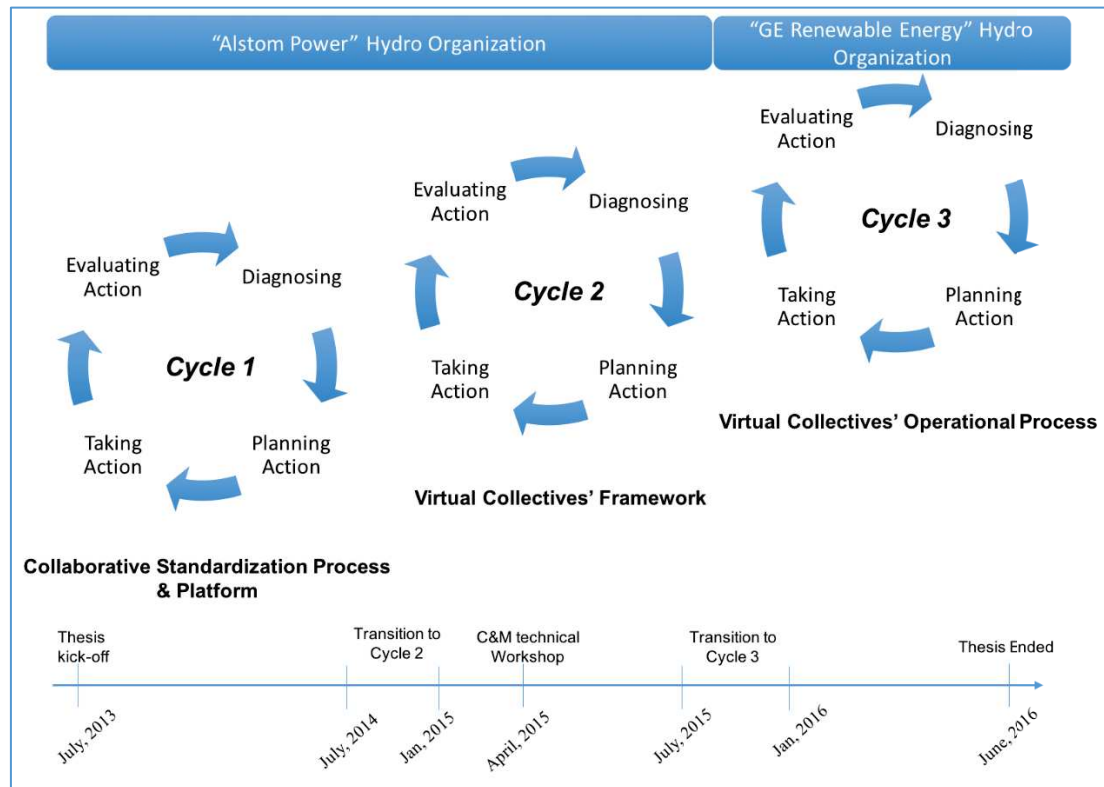


Figure 9: Thesis' objectives with respect to the action research cycles

In order to attain our objectives and develop new framework or improvement ideas, case studies were used. They will form the basis for the propositions (Voss, Tsikriktsis, & Frohlich, 2002). The case studies vary from a complex program like product platforms, to a common CAD methodology and finally the development and implementation of engineering management tool. Table 3 lists below the cases studies and shows the data collection methods for every case study.

Case Study	Data collection method
Cycle 1 case studies: engineering design tool, industrial and plant & system communities.	<ul style="list-style-type: none"> • Observations made through workshops. • Interviews with the engineering communities' leaders • Conversations with the communities' members. • Documents on HySPeC • Activity logs of HySPeC • Self-reflections made by the researcher/ practitioners
Cycle 2 case study: The control & monitoring platform community (C&M)	<ul style="list-style-type: none"> • Observations made while immersing within the C&M community. • Conversations with C&M community' members. • Documents on HySPeC • Activity logs of HySPeC • Self-reflections made by the researcher/ practitioners.
Cycle 3 case studies: the engineering management tool (EMT)	<ul style="list-style-type: none"> • Observations made while immersing within the EMT community. • Conversations with the EMT community' members. • Documents on HySPeC. • Activity logs of HySPeC. • Self-reflections made by the researcher/ practitioners.

Table 3: Data collection methods for every case study

The quality assessment of an action research is based on four criteria: participation, real-life problems, joint meaning construction and workable solutions. These criteria will be evaluated at the end of the 3 cycles.

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CYCLE 1 – THE COLLABORATIVE STANDARDIZATION PROCESS AND PLATFORM

Cycle 1: Introduction

The first cycle's objective is to develop the collaborative standardization process supported by the collaborative standardization platform. Figure 10 shows the methodology to accomplish this cycle's objective, starting from July, 2013 till July 2014.

- 1) The diagnosis phase is detailed in chapter 1. First, we explained the standardization initiative and described the engineering communities at GE. Then, we examined the existing standardization process which is based on e-mail exchange between the engineers. The research team with the standardization manager observed and modeled the e-mail based standardization process. The diagnosis phase concluded with recommendation for the new collaborative standardization process and platform.
- 2) The planning for action phase is detailed in chapter 2. We reviewed from literature the collaborative standardization process and platform. We required that the standardization process is able to collaboratively develop the standards at distance. We also required that the platform adjusted its functionalities to the collaborative standardization process. The literature review resulted in highlighting a gap between our requirements and the literature findings.
- 3) The taking action phase is detailed in chapter 3. We observed a technical workshop that served as a basis to define the collaborative standardization process. As for the collaborative standardization platform, we based its development in MS SharePoint® - the default IT solution at GE. The proposal was a collaborative standardization process implemented in HySPeC: the collaborative standardization platform. The platform's functionalities were adjusted to the standardization process. We developed 4 templates for HySPeC to respond to the different standardization activities.

- 4) The evaluating action phase is detailed in chapter 4. The objective is to evaluate the interactions dynamics for the engineering communities implementing our collaborative standardization process and platform. Interviews were conducted and based on the evaluation grid developed in previous PhD work (Fraslin, 2013). The interaction dynamics level was measured and compared among the engineering communities. A list of recommendations was proposed to improve the online collaboration.

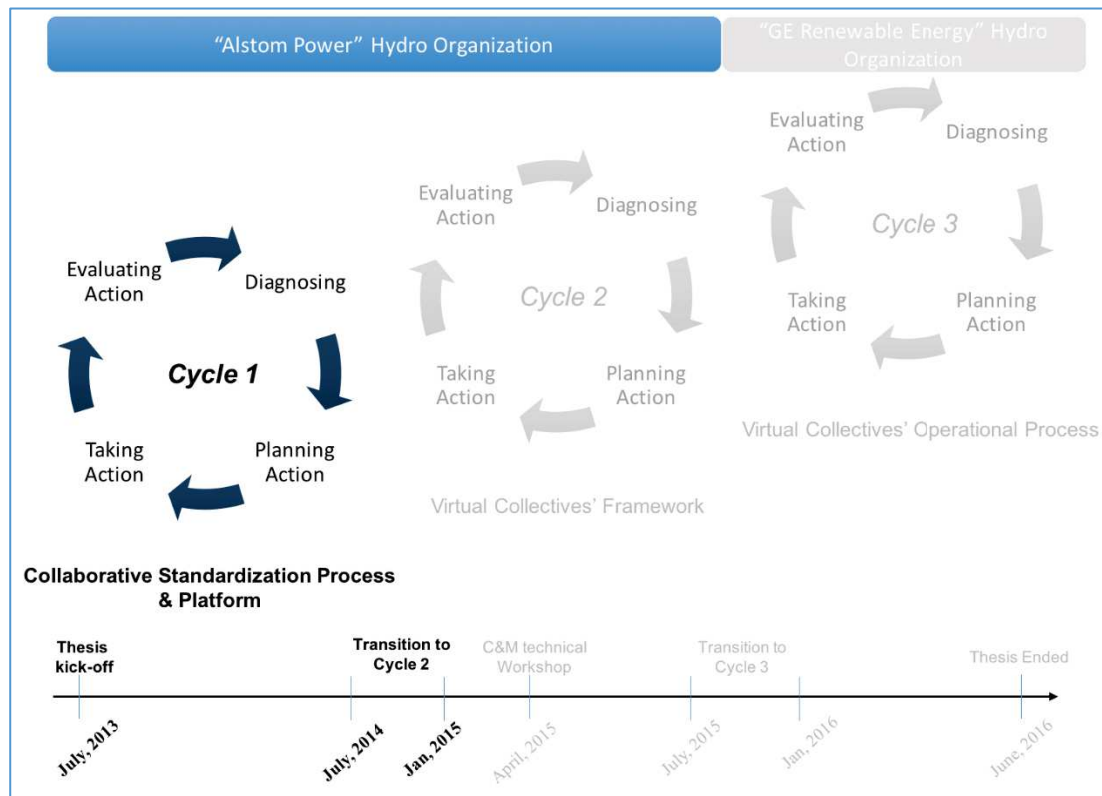


Figure 10: Methodology for Cycle 1 between July 2013 and July 2014

CHAPTER 1 – Standardization of engineering activities in the GE international context

1.1 Standardization initiatives at Hydro Engineering function

Standardization of engineering practices involved learning from the recurrent problems and formalizing the solutions into best practices. However, putting learning into actions had always been a challenging question for organizational development as well as individual growth. The hydro engineering function is transforming and knowledge will be jointly developed and shared worldwide.

The hydro engineering function considered the engineering communities as a strategic asset to improve learning and capitalize on solving the recurrent problems. They will bring the engineering expertise together, enable social learning and exchange of experiences. They will also help to create connections and expand the network. The engineering communities are the social structures for the inquiries, problems resolution and even acquiring new skills and competences.

The participation to these communities will be recognized, rewarded and help the engineers to advance in their career. They will be empowered in the community where everyone will lead his own subject or improvement idea. The engineers will have the choice to identify their community of interest that best suit their daily roles and responsibilities.

Back in July 2013, the standardization program was initiated within the “Alstom” Company, officially “GE” company in November 2015. Table 4 lists the engineering communities, their outcomes and the organizational function at HEN. For example, the piping community produced standard design specifications for the Plant & System function. We selected the engineering communities to cover the different organizational functions at HEN. For example, Plant & System, manufacturing, engineering design tool, etc. The diverse engineering communities are our case studies for the 3 research cycles.

Community Name	Community outcomes	Organizational function
Piping	Standards, Design Specification	Plant & System
Governing System	Standards, Design Specification	Plant & System
Casting & Forging	Standards, Troubleshooting	Industrial
Welding	Standards, Troubleshooting	Industrial
Pro/Engineer®	Standards, Support	Engineering Design Tool
AutoCAD®	Standards, Support	Engineering Design Tool
Control & Monitoring Platform	Standards, Industrialization	Product Management/ Engineering Design
Engineering Management Tool (EMT)	IT Development, Support	Engineering Operations Tool

Table 4: Engineering communities at HEN - July 2013

We will characterize our engineering communities with three characteristics: the domain of knowledge, the community and the practice (the community outcomes) (Wenger & Trayner-Wenger, 2015).

1.1.1 The Piping Community

- Domain of knowledge: exchange of pipes models, design guidelines and expertise.
- The community: Bearing Engineer, Technical Project Manager, Drafting Technician, Designer.
- The practice: Engineering Procurement Documents, Pro/Engineer models library, piping methodology

1.1.2 The Governing System Community

- Domain of knowledge: exchange of governing system drawings, and specifications.

- The community: Technical Project Manager, Key Commodity Manager, Speed Governor Engineer, Plant & System Engineer
- The practice: Standard procurement specification, product catalog list, Supplier integration.

Figure 11 shows an example of a standardized hydraulic speed governor co-defined by the governing community.



Figure 11: Hydraulic Speed Governor

1.1.3 The Casting & Forging Community

- Domain of knowledge: exchange of casting & forging techniques
- The community: Casting engineer, quality engineer
- The practice: Quality Sheet, Quality working plan, procurement specification, troubleshooting procedures.

1.1.4 The Welding Community

The community objective is to respond to project requirements, and react to client's problems related to manufacturing. For example, welding of non-standard material like 690QL, 500QL, and martensitic stainless steel.

- Domain of knowledge: exchange of welding techniques and metals fusion know-how
- The community: welding engineer
- The practice: welding procedures, materials sheet, troubleshooting procedures.

1.1.5 The Pro/E Community

Pro/E's value added in the Engineering process is the reuse of the 3D CAD models, which aims at reducing the cycle time at Engineering stage and improving quality. Due to the complexity of the drawings and the requirement of high skilled designers, today Pro/Engineer® is only used on 20% of our drawings for Hydro core components. The improvements on Pro/Engineer® methodology are based on the reuse of the models, the light components and the Shared library. Figure 12 shows partially the Pro/E new methodology that allows duplicating the drawings of different shapes keeping the same structure, skeleton and methodology in a reuse context.

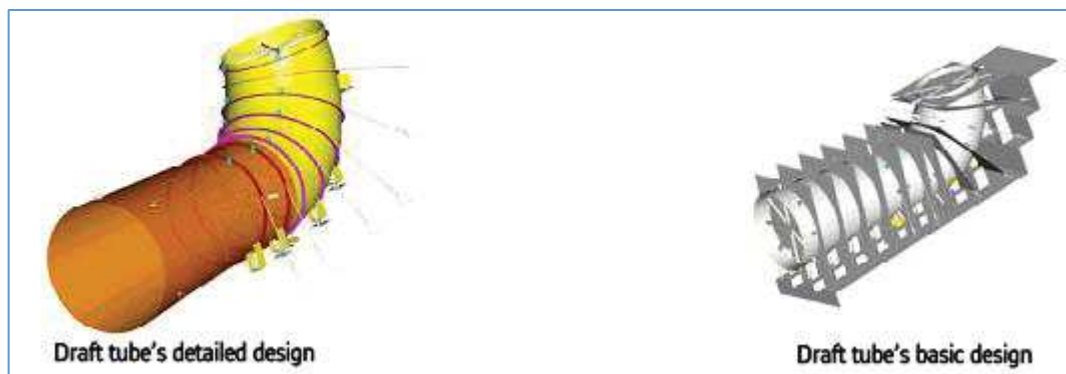


Figure 12: 3D Pro/Engineer® Model for Draft tube

The Pro/Engineer® community objective is to standardize and continuously improve the common methodology developed on Pro/ENGINEER 3D design tool for products. The Pro/ Engineer community is characterized by:

- Domain of knowledge: PTC Pro/Engineer® CAD tool (Creo®)
- The community: Mechanical Engineer, Designer
- The practice: Design guidelines, 3D Models

1.1.6 The AutoCAD Community

AutoCAD® which is part of the Hydro core tools, is used on 80% of our drawings for installation & environment plans (non-core components). It is also used to meet the requirements of some subcontractors and customers. Its widespread utilization generates the need to have a common methodology and configuration among the locations.

- Domain of knowledge: Autodesk AutoCAD tool.
- The community: Draftsman, engineers, generator & turbine experts.
- The practice: Global customized interface; model-paper space

The control & monitoring platform community and the engineering management tool community will be detailed in section 6.1 and 7.3 respectively.

1.2 Diagnosis of the e-mail based standardization process

The diagnosis phase has been conducted in the Hydro global engineering function within the “Alstom Power” company. The e-mail based standardization process consisted in co-production and sharing of documents with a large team spread around the world. The standardization project’s team is composed of members from all the engineering regions (Latin America, North America, Europe, China and India). In some cases, subject matter experts are invited to participate in the discussions. It’s important to collect the know-how from all members who will participate in the standard’s development.

The collaboration between the engineering team members is a big challenge to overcome. The geographical distance and time differences increased the complexity of this process. The top management at HEN required to establish a collaborative environment and a customized collaborative platform to successfully achieve the team goals in a global context.

In the following sections, we present the diagnosis phase which included the problems associated with its execution. Then, we identify the drivers behind a new standardization process and its relationship with the collaborative platform specification process. Finally, we state the expected benefits of the collaborative standardization platform.

1.2.1 Modeling the e-mail based standardization process

Based on observations made during the welded structure workshop and discussions with the standardization manager, we concluded that the standardization process followed 4 main steps:

Step 1: The team leader created a document that was shared among all team members. He communicated the document (version 1) via e-mail to all team members.

Step 2: The team members analyzed the document and sent back all their inputs to the leader. They sent by e-mail a new file (versions 1.a, 1.b, 1.c) with their modifications or comments about the document.

Step 3: The leader analyzed all the recommendations and comments and made a new version of the file (version 2) to consolidate all the inputs. He sent again by e-mail the new version to the team for a new analysis.

Step 4: The team members approved the new version of the document with all the inputs and sent back new recommendations to the team leader (version 2.a, 2.b, 2.c). The leader consolidated all the recommendations and made a new version of the file (version 3)

Figure 13 shows the process that is iterated over the multiple steps. A new document version was attached at every iteration. The process stopped when an agreement was established on a specific version. The team leader published the final version and made it accessible to all the team members. Face-to-face meetings are organized once a year. They enable participants to make big leap in standards definition but they are time consuming and costly due to trip expenses.

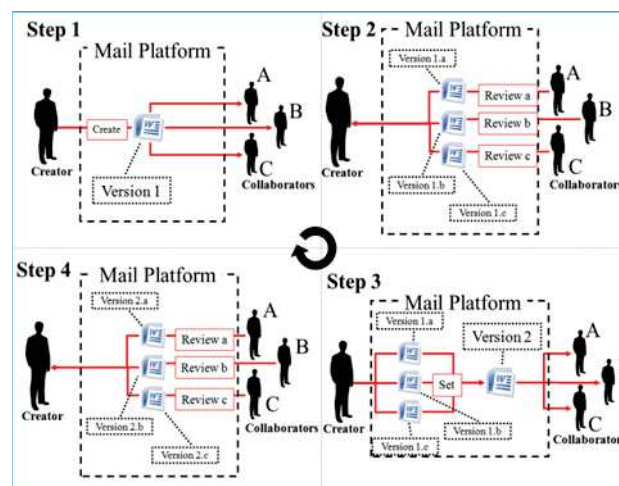


Figure 13: E-mail based standardization process

The email based standardization process model was discussed with the welding community members and later presented to the standardization manager who approved it. We interviewed the welding community members to identify any difficulties in the email based standardization process. We concluded that it had two major problems.

The first problem was that valuable comments might be omitted and urgent agreements might be delayed. Since there was the lack of spontaneous discussions, the team members had to wait for the leader to publish a new version. They might lose interests of time sensitive discussions and they might face lack of motivation.

The second problem was related to the data consolidation. As the process iterated, e-mails exchange could grow exponentially and the team members could be confused from the mass mailing. In addition, as the team size went larger, the number of documents received by the leader increased which demanded more integration efforts. Tracking document versions and managing feedbacks could be burdensome tasks. Hence, this process was time consuming, demanded many consolidation efforts and was hindering real-time decision-making.

1.2.2 The need for a Collaborative Standardization Process & platform

In order to find a new standardization process that responds to problems described for the email based standardization process, we have proposed a collaborative standardization process and its collaborative standardization. These proposals have been discussed and co-constructed with the standardization manager and the welding community members. The collaborative standardization process' objectives were:

- 1) To have a single-entry point for all the standardization documents, which are accessible, to the whole standardization team;
- 2) To reduce the agreement time on decisions and discussions from all regions;
- 3) To allow asynchronous integration of comments and feedbacks into one shared document.

Figure 14 shows the engineers or “the collaborators” interacting through the collaborative standardization platform. The team leader or “the creator” creates a standard working document that is shared among all team members. He uploads the document into a “Collaborative Platform” and provides permission access to the document for authorized team members. Team members analyze the document and make all the necessary modifications online. The team members can see others modifications or propositions. After each modification, the leader receives a notification from the system to approve or not the changes. All comments and recommendations can be made in a forum associated with the document. Easy

consolidation of discussions and posting comments are possible with the collaborative platform.

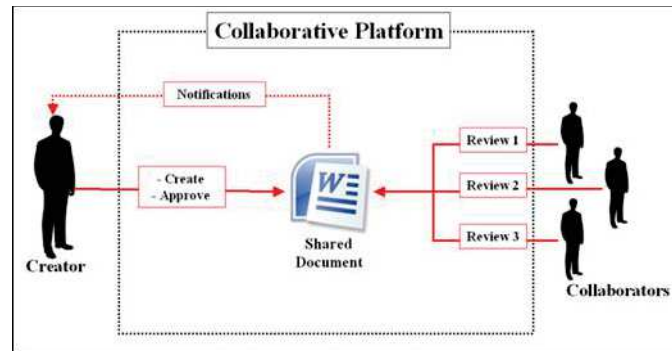


Figure 14: Collaborative Standardization Process & Platform

Within the “Alstom Power” hydro engineering configuration, the diagnosis phase resulted in the need to define a collaborative standardization process & platform between the regions. It’s expected to allow a more comprehensive management of engineering activities, for example: a relevant distribution of workloads at different sites; a comprehensive integration of different competencies and skills.

The recommendations from the diagnosis phase lead us to the first two research questions:

- 1) Which collaborative standardization process could enable the practitioners to collectively develop their standards at distance?
- 2) What are the collaborative platform functionalities that implement the collaborative standardization process requirements?

In chapter 2, we conducted a literature review in order to answer these two research questions. The two main aspects of our literature are the collaborative standardization process and the collaborative standardization platform. We searched the literature using the following keywords: standardization process model, collaborative tools, standards, standards lifecycle and collaborative processes. Our findings are presented in the chapter 2.

CHAPTER 2 – Literature review on the collaborative standardization process and platform

The economy of scale, the global cost efficiency, the convergence in customer preferences and demands have facilitated the standardization of components and products in international industries. In “design-to-order” companies, the design effort typically involves the reuse of existing technologies that will be adapted to meet the needs of specific customers. Standards improve technology sharing and reuse when facing similar needs and situations. Standards deliver “competitive advantages to the industries and countries where they are most developed – embedding intellect and expertise” (UNIDO, 2006).

In the first section, we will look for the standard definitions, its types, and its lifecycle. Moreover, we will try to find the standardization process with special interest for the collaborative processes. In the second section, we will search for the collaborative tools that support a collaborative standardization process with a focus on the tool specification methods. We will conclude in the final section with our findings and a gap identification.

2.1 Literature review on the standards

The definition of a standard depended on its type and the purpose to fulfill. The international organization for standardization has defined international standards as “documents, established by consensus and approved by a recognized body, which provides, for common and repeated use, rules, guidelines, or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context” (ISO/IEC, 2004). Broadly, standard is defined as “the consensus of different agents to do certain key activities according to agreed-upon rules” (Nickerson & Zur Muehlen, 2006). However, a technology standard can be viewed as “a set of specifications to which all elements of products, processes, formats, or procedures under its jurisdiction must conform” (Tassey, 2000). Standards should be based on the consolidated results of science, technology and experience, and aimed at the promotion of optimum community benefits (ISO, 2010).

Many classification schemes were developed to respond to multiple needs. Standards can be classified into product-element and non-product categories because the two

types arise from different technologies and require different formulation and implementation strategies (Tassey, 1997). Standards can also represent the technology developed in certain industry especially for telecommunication. Another classification is based on the scale, the sector they serve and the subject that is treated:

- 1) The scale (business, industry, regional, national, international voluntary and international mandatory),
2. The sector (energy, electrical equipment, textiles, transportation, food, information technology, health care...),
3. The subject (legislation, products, testing, monitoring, environment...) (Spivak & Brenner, 2001).

A typology of standards relevant to product lifecycle management (PLM) addressed the exchange of information and the interaction between different stakeholders, is defined as follows (Rachuri et al., 2008):

1. Stages of the Product Life Cycle: development, production, use ...
2. Scope: commercial, specific application, data models ...
3. Origin: open standards, industry standards, de facto standard ...
4. Development process: regulatory standards, consensus standards ...
5. Intent: measure or metric standards, process oriented, performance, interoperability ...

Only approved technical standard documents related to products are stored in the PLM system. The diffusion process has to make sure that always the right version of the standard is applied (Slob & DeVries, 2002).

The standards can also be public or private and formal or informal. International companies that operated in multiple regions developed private informal standards for internal use. Whereas public informal standards are published by other standards development organizations, many of which are very well known and highly respected, e.g. ASTM (American Society for Testing Materials), IEEE (Institute of Electrical and Electronic Engineers) (Hatto, 2013). Only formal standards are approved and diffused by the national or international standards bodies (Hatto, 2013). For example, the French association of normalization (AFNOR) was founded in 1926 as the French national standardization body and a member in the international organization for

standardization. Similarly, the British Standards Institution (BSI) was founded in 1901 as the national standard body in the United Kingdom. Both AFNOR and BSI develop and publish formal technical standards for products and services. They organize training programs and issue certification with key partners in the respective industries.

For any type, standards lifecycle passed through many phases. A two key interrelated phases of a standard's life cycle are: its development and its adoption (Folmer & Verhoosel, 2011).

Conclusion of standards definition with respect to "Alstom Power"

The standards developed by the engineering communities at the hydro engineering function (HEN) can be classified as informal, private and product or technology related technical standards. The objective of these standards was to provide technical specification and design guidelines for the hydraulic turbines, generators, electrical, mechanical and control systems. They were developed and adopted by the different engineering regions to serve internal need to the company. The diffusion process was done through a custom PLM system. Standards in the PLM system can be organized in function of the product architecture where different versions can be controlled and managed.

2.2 Literature review on the standardization process

Standardization appeared as a management tool of corporate operation in order to keep companies from underperforming, low productivity, impairment of in product quality, resources waste and increase in cost. Cost savings in engineering and maintenance, because know-how and experience, have been laid down in standards (Ping, 2011; Slob & DeVries, 2002). If firms want to standardize their products, pricing and communication across nations they need to have long international experience (Zou & Cavusgil, 2002). A fit between a high cross-national homogeneity of demand for a specific product and a high degree of international product standardization enhances foreign product profit. A fit between a high cost of modification of a specific product and a high degree of international product standardization may enhance foreign product profit (Schmid & Kotulla, 2011).

The standardization is the process of developing, implementing and evolving standards. The process is defined as “activities that people develop bases or rules for measuring things and thus codes of conducts by establishing regularity from disorder” (Ping, 2011). Standardization is the process of establishing and recording a limited set of solutions to actual or potential matching problems directed at benefits for the party or parties involved. A substantial number of the parties repeatedly and continuously will use these solutions, during a certain period (Slob & DeVries, 2002). In two separate studies Krechmer and Cargill had an objective to define a generic standardization process that are independent of any company process. Both had identified five activities for their processes. As for Krechmer, the five activities are: standard creation, fixes, maintenance, availability, and rescission (Krechmer, 2006). As for Cargill, he described the activities of the standardization process as follows (Cargill, 2011):

- Pre-conceptualization and definition of initial requirements
- Conceptualization and development of base standards
- Discussion of product profiles
- Writing and testing
- User Implementation and feedback loop

Moreover, the most common activities in a standardization process are: identify market need and build constituency, consensus on requirements, technical work, approval process, Testing and implementation, and Maintenance (CORPAS, 2007).

However for private company standardization, the process began with uniform dimension and interchangeability of parts and afterward continued with essential forms of standardization such as unification, simplification and modularization in product design, processes and manufacturing (Ping, 2011).

Usually, companies develop private standards having in mind its implementation. For example, figure 15 describes a company standardization process that is triggered by a company need. The 4 main process activities are: prioritization of model parts, development of the company standard, introduction of the standard to the company and finally distribution to the end users. The standard is then implemented into projects and a feedback loop is executed to update the standard and verify its application in future projects. The company standardization process is supported by 4

activities: the policy process to define the rules and regulations for its applicability, the funding process to cover the development cost, the human resources management to staff the development and the facility management for any site compatibility issues (Slob & DeVries, 2002).

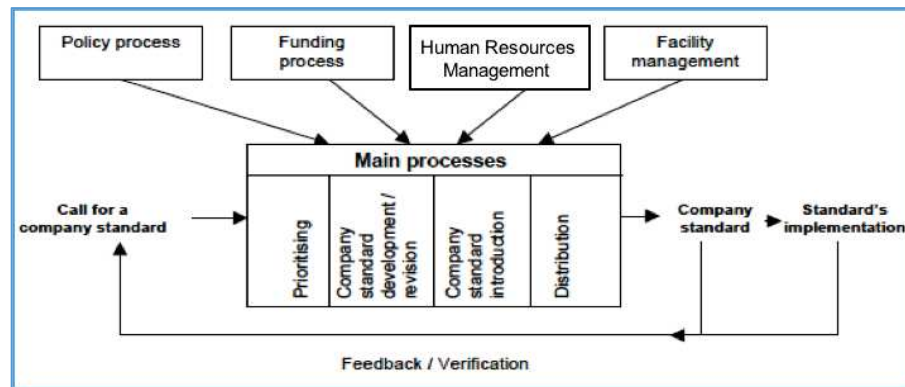


Figure 15: company standardization process (Slob & DeVries, 2002).

Another process model is derived from “kaizen method”. The first steps consist of identifying the work processes that need improvements and list the products or services that are realized. Later on, information about the process is collected and communities are formed. Customer’s requirements should be verified and different ways of implementing the work processes are identified. Only implementations that meet the quality evaluation criteria are selected in order to be documented and published. And finally, change management is conducted and training sessions are carried out in order to ensure the correct application of the standards (Vitalo, Butz, & Vitalo, 2003).

2.2.1 Synthesis of the standardization process in the literature

The literature review proposed multiple standardization processes. These process models complemented each other. Table 5, we proposed a mapping among the standardization processes activities presented in the literature. For example, the “call for a standard”, “standard creation”, “identify market need”, “initial requirements” and “initial improvements” activities are mapped at the same level. These activities captured the need for a standard and triggered the standardization process.

(Slob & DeVries, 2002)	(Krechmer, 2006)	(CORPAS, 2007)	(Cargill, 2011)	Kaizen method (Vitalo et al., 2003)
Call for a standard	Standard Creation	Identify Market need	Initial requirements	Initial Improvements
N/A	N/A	Build Constituency	N/A	Formation of Communities
Prioritizing	Creation	Consensus on requirements	conceptualization	Requirements Verification
Development	Creation	Technical work	Writing	Alternatives Identification
Revision	Fixes	Approval Process	N/A	Quality Evaluation
Introduction	Availability	Testing	Testing	N/A
Distribution	Availability	N/A	N/A	Publication
Implementation	Availability	Implementation	Implementation	Change management
Feedback/ Verification	Maintenance	Maintenance	Feedback loop	Training sessions
N/A	Rescission	N/A	N/A	N/A

Table 5: Synthesis of standardization process in literature

2.2.2 Literature inputs to the proposed collaborative standardization process

The collaboration dimension at distance is missing in the proposed processes in the literature and our requirement is to enable the geographically dispersed engineers to collaboratively develop their technical standards. The collaborative standardization process should be designed in a way that facilitate the adoption of the standards by the end-users. It should also take into consideration the review cycles and that the standards should be updated on regular basis.

During the welded structure workshop, we defined the requirements with the standardization manager. They were based on the analysis of the welding community members' needs. Table 6 shows the link between the literature findings and the requirements for the collaborative standardization model. The “co-develop the

standard at distance with the experts and the end-users” requirement could not be fulfilled from the literature. The rest of the requirements could be fulfilled from the literature by integrating multiple activities. For example, the “follow-up on the standard’s development” requirement was achieved through the ‘revision’ activity as defined by Slob and DeVries.

Requirement Number	Requirements for the collaborative standardization process	Literature Input to the collaborative standardization process
R1	Prioritize the product parts to be standardized that have maximum impact on the business.	<ul style="list-style-type: none"> - Prioritizing activity (Slob & DeVries, 2002). - Initial requirements (Cargill, 2011)
R2	Co-develop the standard at distance with the experts and the end-users.	<ul style="list-style-type: none"> - No Input from the literature
R3	Follow-up on the standard’s development.	<ul style="list-style-type: none"> - Revision activity (Slob & DeVries, 2002)
R4	Release the standards in the PLM and communicate it to the project teams.	<ul style="list-style-type: none"> - Distribution (Slob & DeVries, 2002) - Publication (Vitalo et al., 2003) - Availability (Krechmer, 2006)
R5	Apply the standard in projects and maximize the reuse of design models.	<ul style="list-style-type: none"> - Implementation (Cargill, 2011; CORPAS, 2007; Slob & DeVries, 2002)
R6	Review on standards applicability and regularly update the standard based on feedbacks.	<ul style="list-style-type: none"> - Feedback (Cargill, 2011; Slob & DeVries, 2002) - Maintenance (CORPAS, 2007; Krechmer, 2006)

Table 6: Literature inputs to the collaborative standardization model.

2.3 Literature review on the collaborative tools

In order to standardize in a distributed environment, collaboration is required in the development phase of the remote standards. Various stakeholders jointly work together within an activity to effectively and efficiently deliver the project's objectives. "Collaboration is a process where people work together for a common goal through knowledge sharing, consensus building, and teamwork among group members" (Tan, Tripathi, Zuiker, & Hock Soon, 2010). One possible solution to remotely standardize is to promote the collaboration between the engineers through a collaborative platform. A platform is the central technology architecture of a complex system that facilitates interoperability among separately developed technological units (Eisenhardt, 1989). 'E-collaboration formulates a new working relationship in a virtual network space among members to achieve a common goal' (Tan et al., 2010). And with today's information communication technology, there is an ever increasing dependence on this ability to share knowledge and information across parties. According to Desanctis and Gallupe, there are different categories of collaboration tools that can be classified in function of the time and space as shown in Table 7 (DeSanctis & Gallupe, 1987).

		Time	
		Same Time	Different Time
Space	Same Place	Electronic Supported Meeting	E-mail Document Management System Web-based team/Project rooms Calendar & Scheduling systems Workflow management systems Electronic bulletin boards
	Different Place	Audio Conferencing Video Conferencing Data Conferencing Instant Messaging Desktop Conferencing	E-mail Document management systems Web-based team/Project rooms Calendar & Scheduling systems Workflow management systems
			Electronic bulletin boards

Table 7: categories of collaboration tools

Collaborative platforms are classified as knowledge management systems. KMS differ from transactional and decision support information systems. They are usually not process-based, as enterprise systems (ERP) are, and they do not support decision making in the same way as data mining and data warehousing systems. In KMS, knowledge is usually stored in an unstructured way, as in documents, as opposed to the structured electronic records of transactional and decision-support information systems. When people interact with a KMS, they can fulfill one of three roles: the knowledge provider, the knowledge seeker, and the knowledge intermediary (Markus, 2001). In a team, people can potentially play any of these roles at any given time. As knowledge providers, people have to provide the system with knowledge about their experience or the case at hand (G. P. Huber, 2001; Markus, 2001). As knowledge seekers, people need to filter, find, extract, and actually use the knowledge contained in the system. As knowledge intermediaries, people prepare, index, transform, and disseminate knowledge in order to make it usable (Markus, 2001).

Enterprises continue to invest in the underlying technologies of these information systems. They aim to establish a single entry point to find all product related information. The employees interact with the system on daily basis where they hope to find information related to their work quickly and with minimum guidance. The enterprises can deploy few types of collaboration solutions today. Each type offers different capabilities and delivers a different level of value:

- Standalone Wikis - such as MediaWiki and Twiki. Many of these are based on the open-source development model.
- Social Software Suites - A relatively new class of solution is Enterprise 2.0 social software suites such as Microsoft SharePoint, Jive-n, Telligent, include many attractive social components, such as profiles, forums, blogs, and social networking. (Enterprise 2.0 Integrated Communication and Collaboration Platform)

Hence, a useful way to think about KMS is to consider them from the perspective of levels, in which basic tools are used to build generators, which are then used to build specific applications and features (Gallupe, 2001). Three types of KMS generators can be identified:

- Knowledge repositories, which provide document and information databases, search engines, and intelligent agents (G. P. Huber, 2001; Kankanhalli, Tanudidjaja, Sutanto, & Tan, 2003; Nunamaker, Romano, & Briggs, 2001);
- Expert directories, such as yellow pages and knowledge maps (G. P. Huber, 2001; Markus, 2001) ;
- Collaborative tools, such as groupware, email, listserv, newsgroups, chat, and conferencing (Kankanhalli et al., 2003; Nunamaker et al., 2001).

Although all enterprise technologies make a contribution to the ability to share information, but to reach their full potential they need to be tied together via a single interface. The best interface for doing this is the wiki, the essence of the social collaboration movement. With their ease of deployment and ability to spread virally, wikis can transform how enterprise employees access the data in their existing systems and collaborate around intranets and file servers, knowledge bases, content and project management systems. (Enterprise 2.0 Integrated Communication and Collaboration Platform)

Classical software specification methods such those associated with UML models are static and lack the co-construction and the co-development aspect. Once the specifications are defined, it's hard to change them throughout the development phase. "The specification of this collaborative information system is supported by a succession of UML models". UML models used in the proposed specification method. This approach is essentially driven by the "use cases diagrams", and considered as guidelines throughout the project (Yesilbas & Lombard, 2004).

'As virtual teamwork involves collaboration between virtual groups, whose members work across time and location, their collaborations must be strengthened by communication technology. It is therefore important to incorporate multiple communication media and e-collaboration tools as it has been observed to yield more gratification with the process, more balanced levels of participation, and more desirable results in contrast to single communication means. Specification method that present a collaborative approach to co-define the platform functionalities

continues to stay uncultivated. Moreover, methods of incorporating technology support for e-collaboration still remain a relatively unexplored field' (Tan et al., 2010).

Many papers describe collaborative platforms for specific usage. For example, Lecet proposes an implementation of a collaborative platform based on the social web 2.0 technologies (Lecet, 2012). It supports the teacher's community who use a teaching method called MAETIC. Another collaborative platform is developed to support tutor's forum (Stirling, Beaumont, & Percy, 2009). 'It plays a vital role in facilitating engagement and professional development for teachers working at a distance'. However, the specification processes are not presented in these papers.

Gap identification in the literature and recommendations for the collaborative standardization platform

Through this literature review, it came that most of the existing platforms offer a large set of functionalities to the user, but without a clear correlation with specific users' activities. None of them were specifically designed for the standardization process. Users are faced to a set of functionalities and are not guided to choose the right one in a specific context. From practice, we made the observation that there is a strong interest to associate the platform functionalities to the standardization process. We made the assumptions that this association may help the engineering communities' members to efficiently use the collaborative standardization platform. Our requirement is to adjust the platform's functionalities to the collaborative standardization process. A specification method is required in order to do this adjustment.

We quoted the AutoCAD leader verbatim on using the default configuration of SharePoint which is the corporate collaborative tool deployed for all GE Renewable energy.

"I accessed the collaborative platform to launch some standardization action but I didn't know from where to start and functionalities to use".

This statement analysis showed that there was lack of guidance and intuitiveness in the default configuration of the collaborative platform.

In the next chapter we proposed a method to develop a collaborative platform functionalities adjusted to the standardization activities. The proposed platform is called HySPeC. The Hydro Specification Platform Collaborative (HySPeC) is an online platform. We made the hypothesis that HySPeC might improve the global collaboration, facilitate the implementation of the collaborative standardization process and guide the engineering communities' members to use the platform functionalities.

CHAPTER 3 – Proposal of the collaborative standardization process and platform

This chapter's objective is to co-define the collaborative standardization process and the associated collaborative platform functionalities. The objective is fulfilled through observations and formalization of the “welded structure” workshop. These observations are confronted to the experts' opinions working in the field of standardization at HEN function. The research team with the standardization manager participated in the workshop. The collaborative standardization process and platform were published in a joint Conference on Mechanical, Design Engineering & Advanced Manufacturing on June 18th, 2014 (El Badawi El Najjar et al., 2014).

3.1 Specification method for the collaborative standardization platform

Figure 16 shows the three main phases for the specification method: the observation, the formalization and the specification. Firstly, the observation phase is conducted through a participative observation of engineering workshops and discussion with experts. These lead to semi-formal process model. Secondly, the formalization phase relied on a functional language that is used to formally model the standardization activities. It helped us to define the inputs/outputs, the resources and the controls of every activity. Finally, the specification phase maps every activity context into the platform's functionalities. In other words, the platform functionalities are shaped to fit these activities and their corresponding information. As result, the formal standardization process acted as a specification process to define the platform functionalities.



Figure 16: Specification method phases

The observation, discussions, formalization and specification phases were interdependent. We conducted the phases as pairs: the observation, discussions & formalization (Section 3.1.1) and the formalization & specification (Section 3.1.2)

3.1.1 Observation, discussions & formalization Phases

The observation and the formalization phases are complementary. In fact, we have looped through these phases to fine tune and improve the proposed standardization process model. As a starting point, as researchers, we decided to study the existing engineering practices so we participated in an actual engineering workshop: the “welded structure” workshop. Observations are also gathered from several meetings with the standardization managers as well as e-mails exchanged among the welding communities’ members. We had a close view to understand the standardization main objectives, identify discussion types discuss different practices and identify main activities to build a standard. Table 8 shows the observations as modeled using a semi-formal process. It described how every activity was done and who participated in it. We referred to the creation of a standard as an action.

Standardization Activity	Scenarios
Collect local practices	Action Owner creates a document library where all members share local standards. If the regions don't have standards, action owner creates a forum for them to share local practices.
Define general concept	Action owner with the document library expert analyze the standards objectives and define the key concepts.
Define the best local standard	Action owner with the document library expert analyze the local practices at the Forum and choose the best practice to include in the draft of the global standard.
Conduct a survey	Action Owner shares in a forum with team members the local standard (or practice) chosen and asks if everyone agreed. If necessary, Action Owner can create a survey to choose the best. All remarks in that Forum must be considered for the next activity (write draft standard).
Write the standard's draft	Action Owner writes the draft Standard based on the defined template and all discussion in the forum.

Table 8: Semi-formal collaborative standardization process.

In order to propose a formal standardization process model, we studied the possible modeling tools. We get inspired from the IDEF0, a functional modeling tool to formalize the standardization activities. It is designed to model the decisions, actions,

and activities of an organization or a system. As a communication tool, IDEF0 enhances domain expert involvement and consensus decision-making through simplified graphical models. Inputs/outputs are characteristics of the information flow altered by the activities. The resources and the controls are the necessary conditions for each activity to take place.

Figure 17 details ‘collaborative development of standards’ activity that had an objective to collectively create a standard draft version. The draft standard started with the collect of all local practices from all regions. General concepts, bill of materials and common selection criteria were defined. Then the team leader identified the optimal local standard based on these criteria. This optimal local standard was the baseline document for the global one. A survey is then conducted to collect comments and feedbacks for this baseline document and discussions are made to write the first standard draft version.

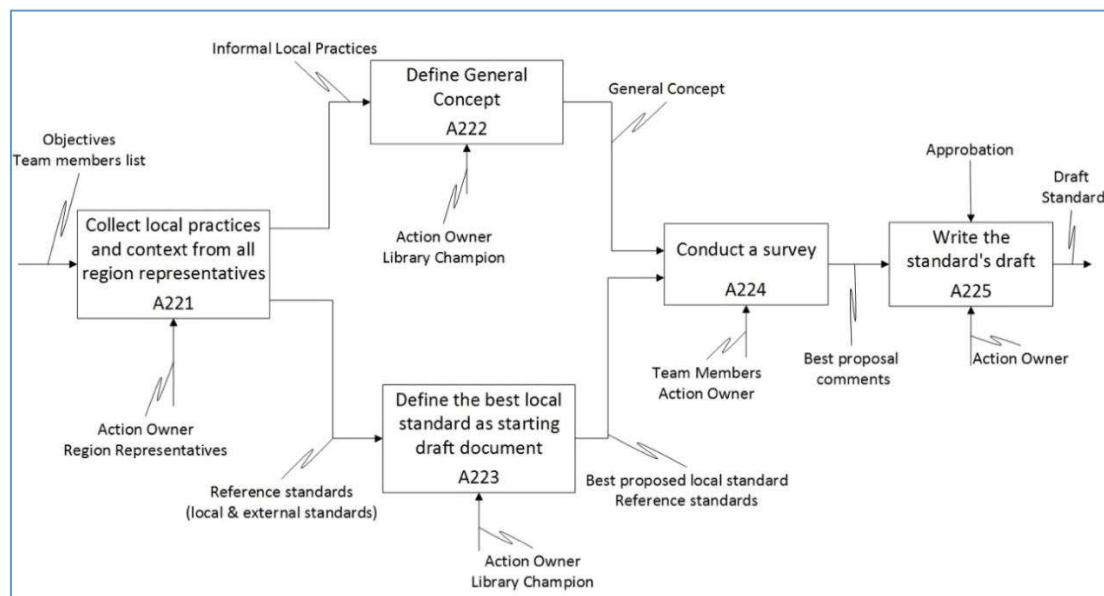


Figure 17 Detailed view of the "collaborative development of standards" activity

In fact, the “collaborative development of standards” is one of six activities that defined the collaborative standardization process (Figure 18, A22 activity). Figure 18 identifies the six main activities for the collaborative standardization process. It started with the planning, co-development, and follow-up then the release, the re-use in project and finally the feedback of experiences in Hydro global engineering and manufacturing team. The proposed model is continuously discussed and updated. In fact, regular discussions are conducted with the standardization managers to get

feedback of experience for the proposed process model. The evolved process model was then communicated to all the engineering communities' members.

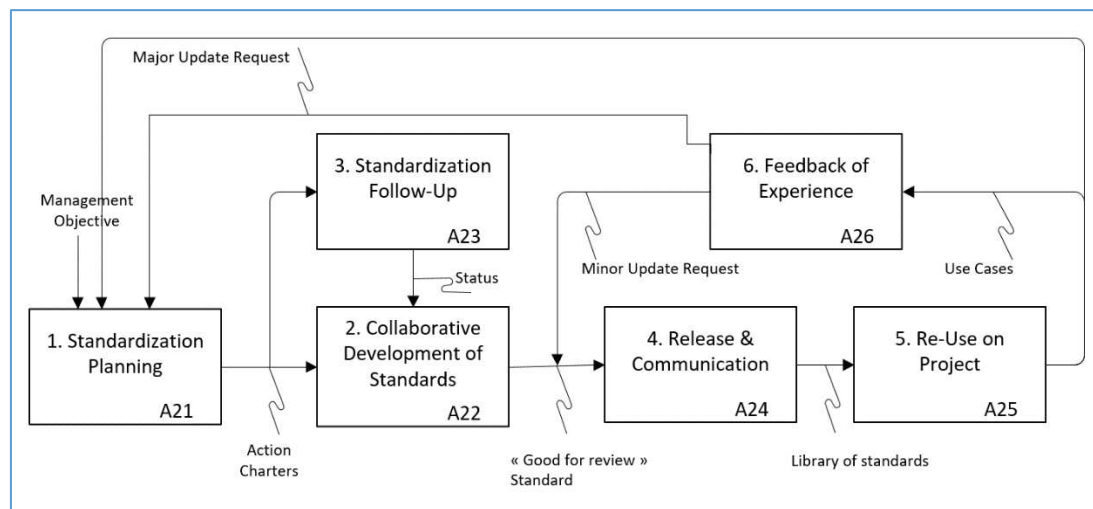


Figure 18: Formal collaborative standardization process - 2013

3.1.2 Formalization & Specification Phases

The formalization and the specifications phases are complementary. For example, we carried the A22 activity and looped into these phases to well define the collaborative platform functionalities. These functionalities defined a set of features that mapped the standardization activities and their contextual information into the platform. The features created a solid structure for the collaborative standardization process. The features are developed into MS SharePoint®, the default collaborative IT tool, which was used to respond to the collaborative standardization process requirements. SharePoint® presented several features of great importance to our proposal, such as site pages, wiki pages, discussion boards, document libraries and item lists. In addition, site permissions can be assigned to the members with different roles (contribute, read, approve...). Figure 19 shows how we mapped the 'collaborative development of standards' sub-activities and their contextual information into the collaborative platform functionalities.

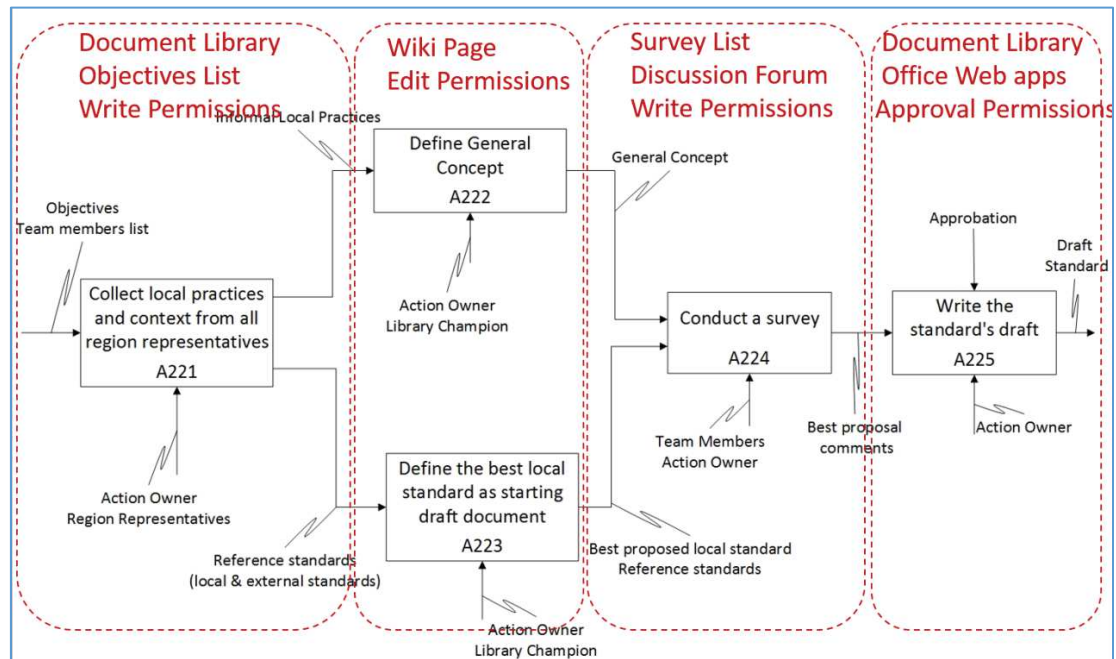


Figure 19: Mapping the sub-activities to the platform functionalities.

First, the mapping of the ‘collect local practices and context from all region representatives’ sub-activity with its corresponding inputs/outputs, resources and controls is done through the identification of the following functionalities in SharePoint®: a document library is created to collect all the local practices with ‘write’ permissions assigned to the region representatives; a custom list is also created to make visible all the agreed objectives. Likewise, the ‘conduct a survey’ sub-activity is mapped into the collaborative platform by creating a survey list to collect the comments of the baseline standard document. A discussion forum is also created to elaborate on the feedbacks. The ‘write the standard’s draft’ sub-activity is mapped into an office web app to collaboratively create the document. The team leader approves the baseline standard document and proceeds to the ‘A2.4 - release and communication’ activity.

3.2 Proposal of HySPeC templates

The functionalities associated with the systematic process for the Hydro collaborative platform are performing as expected. The result is an online platform, based in SharePoint®, and it is the hydro collaborative way to improve the distant standardization work. It allows the team members to dynamically share information in a global context. Figure 20 shows the 4 templates developed by the researcher/

practitioner to meet different collaborative standardization activities and they are as follow:

- The standardization template is developed to implement the standardization planning (Figure 17, A21) and the collaborative development of standards (Figure 17, A22). It fulfilled the requirements R1, R2 described in Table 6.
- The platforming template is developed to implement the re-use on projects (Figure 17, A25). It fulfilled the requirement R5 described in Table 6.
- The engineering portal template is developed to implement the release & communication (Figure 17, A24). It fulfilled the requirement R4 described in Table 6.
- The project review template is developed to implement the standardization follow-up (Figure 17, A23) and the feedback of experience (Figure 17, A26). It fulfilled the requirements R3, R6 described in Table 6.



Figure 20: HySPeC - The collaborative standardization platform templates

3.2.1 HySPeC – The standardization template

The researcher practitioner has developed the HySPeC homepage for the “Engineering Management Tool” Project shown in figure 21. The members can directly launch the collaborative standardization process. The same template was developed for the AutoCAD® community. We quoted the AutoCAD® community’ leader: “The homepage experience is intuitive and guided the AutoCAD® engineers throughout the different process activities.” For example, all the objective related tasks are listed below the objective icon e.g. create, communicate and discuss a new objective. A dashboard of all the objectives is accessible when clicking on the objective icon.

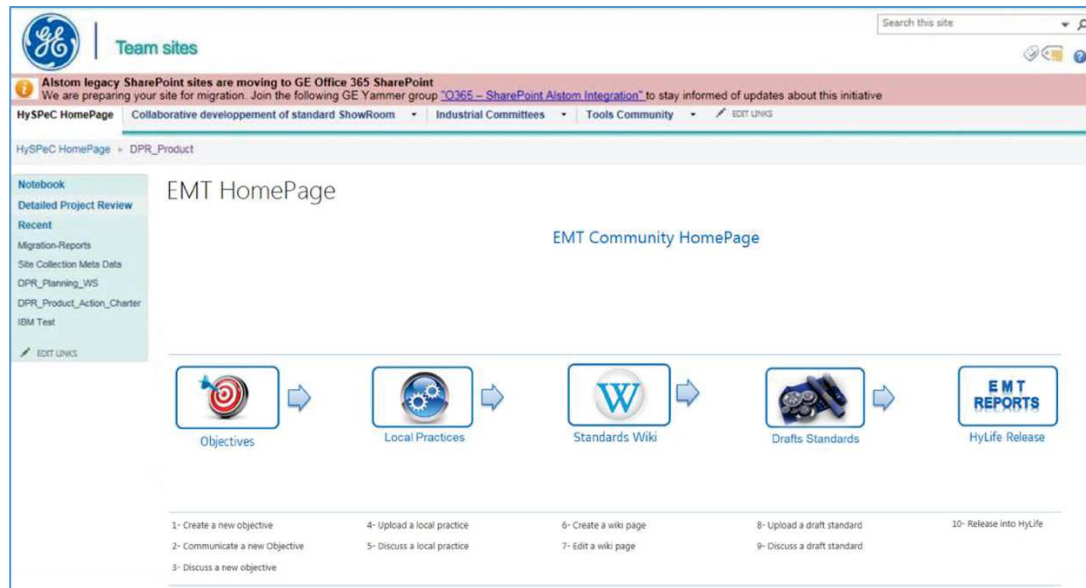


Figure 21: HySPeC Standardization Template

3.2.2 HySPeC – The platforming template

The platforming template is further developed for the community based working environment. The functionalities were specified having in mind the community needs. For example, a shared workspace and an automated workflow are developed to comment and approve the same document. Another example is the shared planning where the community members update their assigned task progress in the same planning. All the members can track the progress or the delay for the list of tasks in one shared planning. Finally, the members' contributions in the discussion forums are rewarded by points and the list of top contributors can be visualized by all the community.

Figure 22 shows the platforming template. The community member could start the process by either creating and/ or responding to a discussion, update his tasks progress or comment/ approve a document through the shared workspace. The community member could just communicate information in the news feed i.e. the link to the “Smart Control” document should be updated in the HySPeC- engineering portal template. Finally, the list of the top contributors is shown on right side. Every contributor had a contribution level (from 1 to 5), number of discussions created and number of replies to discussions. A “Join this community” button is also available for potential members in order to benefit from all the platforming template features.

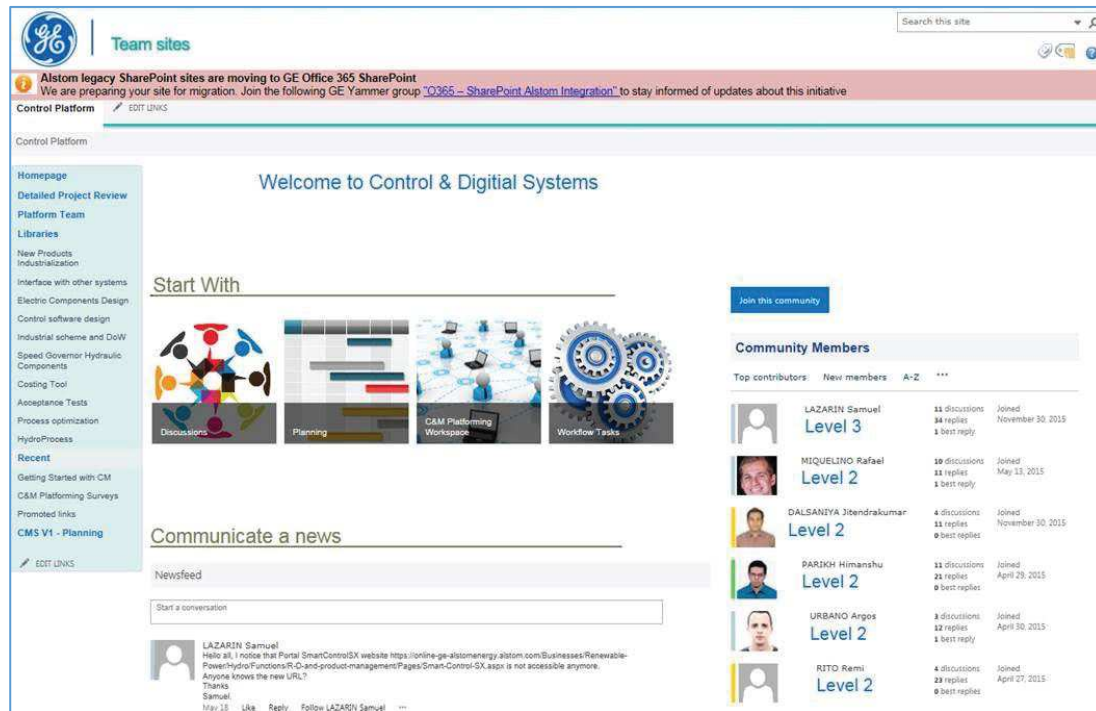


Figure 22: HySPeC Platforming Template

3.2.3 HySPeC – The engineering portal template

The global engineering portal's objective is to enable the engineers to have a quick and easy access to standardization documents e.g.: list of instructions, guides and catalogues managed at Global level and which are available in HyLife (Product Lifecycle Management), HySPeC, Lotus Notes database or HMS (Hydro Management System) database (see appendix D). Figure 23 shows the 'news' feed in the top section and the 'category access point' in the bottom section. The news feed helped the engineers to keep them informed to all information updates. The category access point provided a direct access to catalogues (software methodology, library of technical specifications, application guides, design drawings and training materials).

The global engineering portal was developed to satisfy to following motives:

- Saving time to retrieve documentation.
- Giving easy, direct and exhaustive access to all information managed by Global Engineering function.
- Providing feedbacks on documents created by Global Engineering function from the local engineering functions.

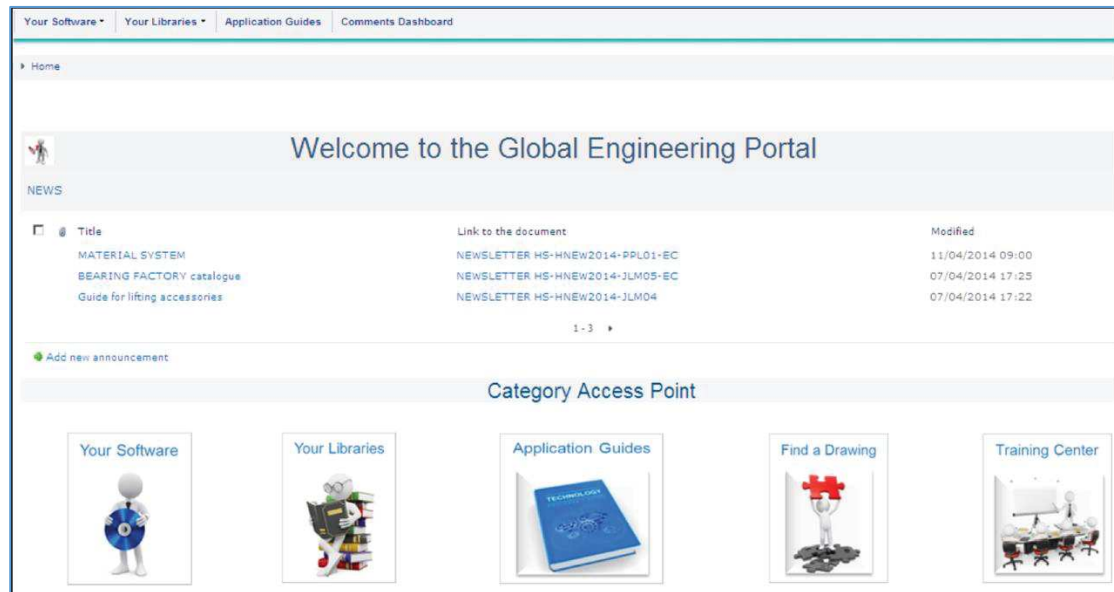


Figure 23: HySPeC Engineering portal template

3.2.4 HySPeC – the project review template

The detailed project review template aimed to visualize the progress, the risk and the issues associated with the development of the standards. This template is mainly used by the standardization manager to communicate the project advancement to the top management. Figure 24 shows the 4 main parts of this template:

- 1) The project review included key performance indicators (KPI's) that described the status, problems or issues associated with the standards development.
- 2) The risk & opportunities identified the potential risks, their impacts and their mitigation actions. The risks are evaluated and prioritized for quick actions.
- 3) The planning in “Gantt chart” view visualized the actual progress of every standard along with the assigned engineers.
- 4) Finally the action charter is a contractual document between the global engineering function and the regional engineering functions. It defined the budget hours and the scope for the engineering regions.

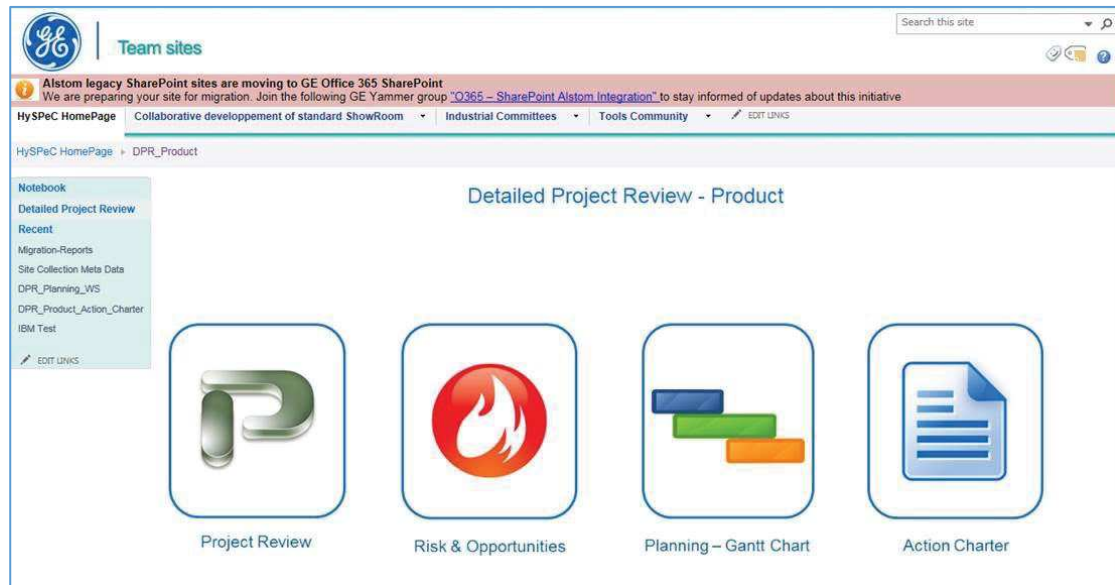


Figure 24: HySPeC Detailed project review template

Designed from the practice, the collaborative standardization process has been implemented and tested in HySPeC. The engineering communities have adopted HySPeC in their standards development. The usage of the collaborative standardization platform is collected through the logs of MS SharePoint® or through regular interviews with the communities' leaders.

Chapter 3 Conclusion

Within the “Alstom Power” Hydro business, six main standardization activities were identified and formalized based on observation made from the co-located “welded structure” workshop and thoroughly discussed and evaluated by Alstom experts and managers. A collaborative standardization process was then formalized inspired from IDEF0. This makes it possible to precisely describe the inputs/output of each activity and to identify the different stakeholders to be involved in every process steps. This description of the standardization process was useful and necessary for the technical specification of the collaborative standardization platform. Each standardization activity had its own profile in the platform, with associated functionalities and contributors. Giving this, a user involved in a standardization activity is rapidly aware of the global process stage, and the operational task in which he had to participate, along with the correspondent platform’s functionalities.

We proposed the collaborative standardization process implemented in HySPeC – the collaborative standardization platform - in order to answer the two research questions:

- 1) Which collaborative standardization process could enable the practitioners to collectively develop their standards at distance?
- 2) What are the collaborative platform functionalities that implement the collaborative standardization process requirements?

In the next chapter, we will evaluate and assess the proposed models. Specifically, the interactions on HySPeC by the “engineering communities” as described by the top management, and draw from the experience some improvements and recommendations.

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CHAPTER 4 – Evaluating the virtual engineering communities

This chapter's objective is to evaluate the usage of HySPeC – the collaborative standardization platform by the “engineering communities”. Specifically, we assessed the interaction dynamics for every engineering community in other words its online collaboration level. In addition, we compared the communities' interaction dynamics with respect to each other's.

The interaction dynamics' level can be measured by evaluating the communities' configuration for online collaboration. The objective has two dimensions: quantitative and qualitative and the expected result for every dimension is defined as follows:

- Expected result for the quantitative dimension: radar chart to position every community in function of its characteristics. In addition to the communities' activities on HySPeC.
- Expected result for the qualitative dimension: list of recommendations to improve the online collaboration dynamics for every community.

In a previous thesis conducted at GE Renewable Energy – Hydro power (formerly “Alstom Power”), Marie Fraslin has evaluated the capacity of a co-located community to go online (Fraslin, 2013). She has developed an evaluation grid to assess the collaboration dynamics of a potentially virtual community that is defined as a geographically distributed community that relies on information and communication technologies to collaborate (Fraslin & Blanco, 2013). The evaluation grid is composed of a set of characteristics to configure the communities in order to be capable to collaborate online. Based on the evaluation grid (Appendix B), a survey is developed (appendix C).

We relied on the survey to evaluate the collaboration dynamics for the online engineering communities at GE. The objective is to assess the interaction dynamics level for every community. The interactions dynamics are scaled on 4 levels (Fraslin, 2013):

- The information level (Scale =1): A message is sent and it doesn't lead to an answer from the recipient.

- The communication level (Scale =2): A message is sent and the recipient replied by a new message to express an idea, a question etc. in response to the sender.
- The coordination level (Scale =3): the message exchange is more likely to be arguments between the sender and the recipient leading to the co-production of a solution.
- The production level (Scale =4): the message exchange is creation of a new shared understanding for a situation. Potentially a new solution is proposed.

The methodology steps to achieve the objective were:

- 1) Define the pilot communities that will participate in this assessment. The pilot communities were selected to cover all the product aspects and to include different functions. For example, piping and governing systems for the technical aspect, ProE and AutoCAD for the tools aspect and finally the casting & forging and welding for the industrial aspect.
- 2) Design the evaluation grid questionnaire using SharePoint® Survey functionality. The choice was made to easily manage the survey access, results' analysis and communication. The results were analyzed by the tool and the graphs were automatically generated. The results were accessible by the communities' leaders and other team members with the right permissions.
- 3) Interview the communities' leaders and assist with the questionnaire application. Some leaders had difficulties to understand some key concepts about the communities. The researcher/ practitioner had to explain the concept in question and helped the leader to answer the question. The research/ practitioner tried to stay as objective as possible and to avoid any potential influence on the course of the interview. The interview sessions were recorded to keep trace of the discussions.
- 4) Analyze the questionnaire responses at two levels: quantitative and qualitative. The quantitative is done through SharePoint survey module. Mainly statistical techniques like the total number of communities having stable membership or total number of communities having operational objectives. Contrary to the

qualitative analysis where we seek to understand any inconsistencies, poor collaboration levels or contradictions in the answers.

- 5) Communicate the results in a steering committee meeting where both the quantitative and the qualitative results were challenged and discussed with the project research team.

4.1 Quantitative dimension : communities' configuration for online collaboration.

The evaluation grid is composed of 4 major characteristics families: community orientation, organizational context, membership characteristics and technological environment. Every characteristic family grouped a set of characteristics that determine the community's configuration. The interaction dynamics level will be determined based on the community's configuration.

The six pilot communities were selected from different organizational functions:

- Engineering Design Tools communities: Pro/Engineer and AutoCAD
- Technical communities: Piping and Governing System
- Industrial communities: Casting/ Forging and Welding

The intention is to compare the communities' configuration and how the different profiles may impact the interaction dynamics level.

4.1.1 Determining the communities' configuration

In order to determine the communities' configuration, the researcher/ practitioner has interviewed the communities' leaders and guided the discussions to answer the survey (Appendix C, figure 64). Table 9 shows the survey assessment results for the six pilot communities.

Community Characteristics		Piping	Governing System	Casting/ Forging	Welding	Pro/E	AutoCAD
Community Orientation	Objectives	2	2	4	2	3	2
	Life Span	2	4	1	1	1	1
	Age	2	1	1	1	2	1
	Mutual commitment	Voluntary Action	4	4	3	2	3
		Mutual Support	2	2	3	2	3
		Mutual Apprehension	4	4	1	1	3
		Mutual Knowledge	3	3	2	1	4
		Management tool	2	2	4	3	1
		Practices	1	3	3	3	3
		History	2	2	2	1	3
		Common Knowledge need	4	2	3	1	3
Organizational Context	Creation Process	1	1	3	1	2	1
	Level of commensurability	3	3	2	4	4	4
	Context	4	4	2	4	3	3
	Level of Sponsorship	3	2	1	4	1	3
	Degree of corporate recognition	1	2	2	2	2	3
	Consensus on leadership	1	2	3	1	4	1
Membership Characteristics	Size	4	4	4	4	4	4
	Geographic dispersion	1	1	1	1	1	1
	Member selection process	4	4	3	3	4	3

	Member enrolment	1	3	3	3	1	2
	Prior community experience	2	2	1	2	3	2
	Membership Stability	3	3	3	3	3	3
	Member ICT Literacy	2	3	2	3	3	3
	Cultural Diversity	1	3	2	1	4	1
	Topics relevance to members	2	3	4	3	2	4
Technological Environment	Degree of reliance on ICT (Information & Communication Technology)	4	3	1	2	1	4
	ICT Availability	4	4	4	4	4	4

Table 9: Assessment of the communities' configuration.

Table 9 analysis of the survey results showed common characteristics for all the communities:

1. For the community orientation family, the community objective was to develop and support the Hydro strategy.
2. For the organizational context family, the communities' creation process was intentional and followed a top-down approach. In addition, the top management facilitated the creation process for these communities where they haven't faced any obstacles at launch.
3. For the membership characteristics family, the communities' size is small where the average number of members is 16 persons. The communities are all geographically dispersed, cross-regional but belong to the same domain of knowledge. The level of commensurability is high among the members. The community membership is relatively stable and the members' selection process was closed. Only members with specific expertise were drafted for the membership in addition the members' enrollment tend to be compulsory.
4. For the technological environment family, all the communities were supported by highly available IT network. A multitude of the technologies were deployed to improve the remote work between the members. For example,

video conferencing, instant messaging, internal intranet, and social networks. In addition, with the ability to access the company resources via VPN connection.

4.1.2 Evaluating the communities' interaction dynamics

The second activity was to visually represent the communities' configuration on the radar chart and assess the interaction dynamics for every characteristics family.

The scores in table 10 are calculated based on Table 9 where the average value for all characteristics belonging to the same family characteristics is the final score for this family. For example, knowing that the following characteristics: Voluntary Action, Mutual Support, Mutual Apprehension, Mutual Knowledge, Management tool, Practices, History, Common Knowledge need constituted a sub-family called 'Mutual commitment'. The community orientation score for piping community is calculated as follows: $(2+2+2+(4+2+4+3+2+1+2+4)/ 8)/ 4 = 2.18$ rounded to 1 digit for the decimal value which is 2.2. Table 10 shows the interaction dynamics level for every community.

Configuration	Ideal	Piping	Governing System	Casting/ Forging	Welding	Pro/E	AutoCAD
Community Orientation	4	2,2	2,4	2,2	2,2	1,5	1,8
Organizational Context	4	2,2	2,3	2,2	2,7	2,7	2,5
Membership Characteristics	4	2,2	2,9	2,6	2,7	2,6	2,6
Technological Environment	4	4	3,5	2,5	2,5	3	4

Table 10: identification of the interaction dynamics level

Table 10 values are visualized as radar chart to evaluate the interaction dynamics level. For the technical communities: piping and governing, their configuration is compared to each other's in figure 25. The piping community had a greater ease of use for the technological environment over the governing system (GS) community. However, the GS community had greater membership characteristics over the piping

community. The GS' members had established a level 3 collaboration dynamics among them which mean they went through many discussions to jointly develop solutions for their common problems.

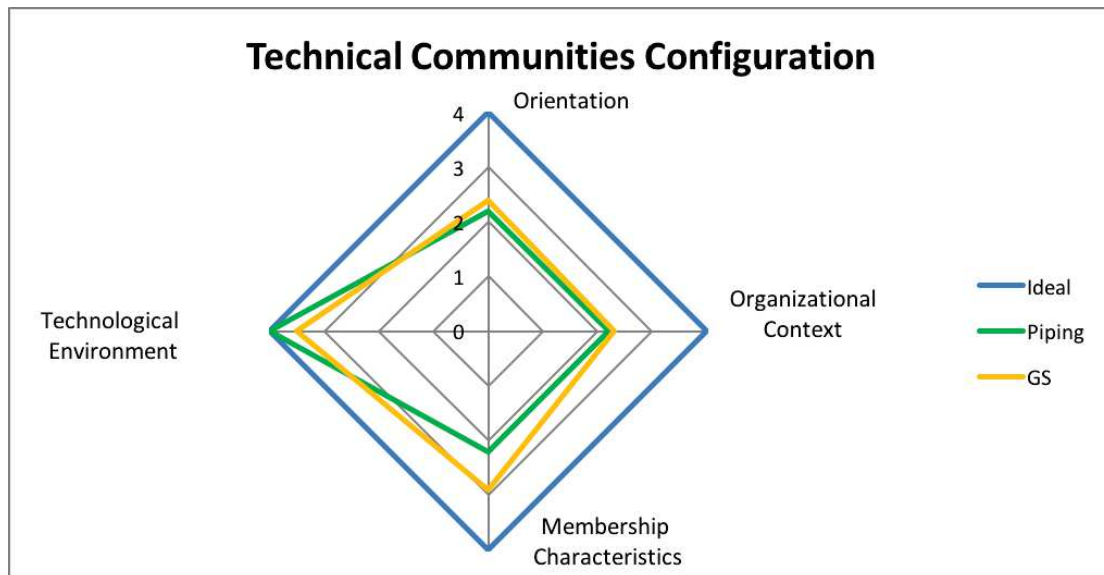


Figure 25: Radar chart for the technical communities' characteristics.

As for the industrial communities: casting & forging and welding, figure 26 shows that both had the same collaboration dynamics for most the characteristics dimensions except for the organizational context. The welding community was more integrated in the organization structure and as a consequence it was more sponsored then the casting & forging community. Moreover, the level of commensurability among the welding members was higher than casting & forging. C&F included members from the quality functions who "missed the practice" as communicated by the casting members.

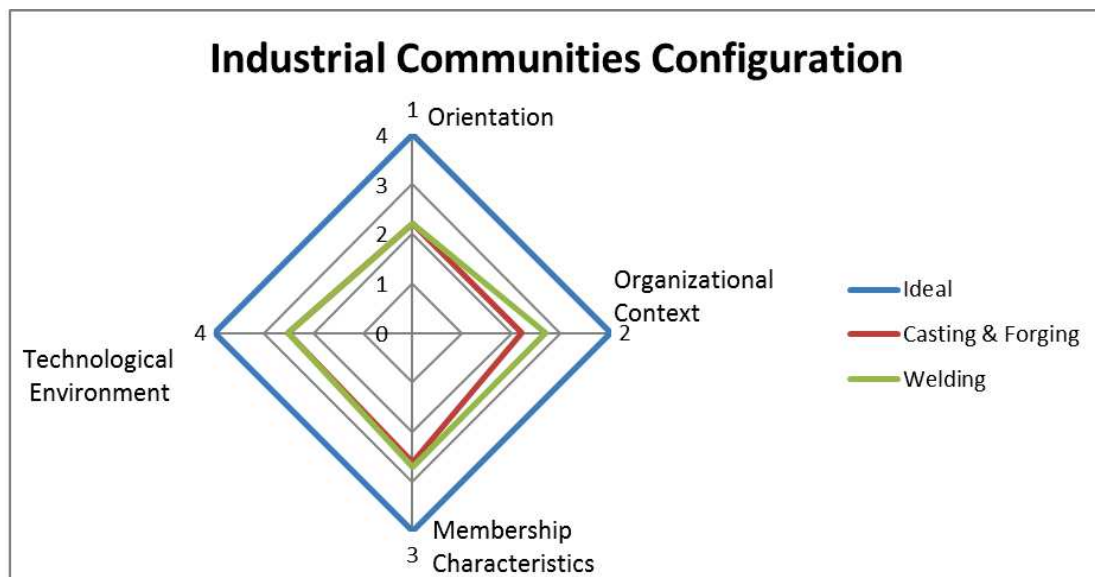


Figure 26: Radar chart for the industrial communities' characteristics.

As for the tools communities: AutoCAD and Pro/ Engineer. Figure 27 shows that both had almost the same configuration except for the technological environment where the AutoCAD community' members were familiar with the technology and they used to develop custom tools to facilitate and automate their work.

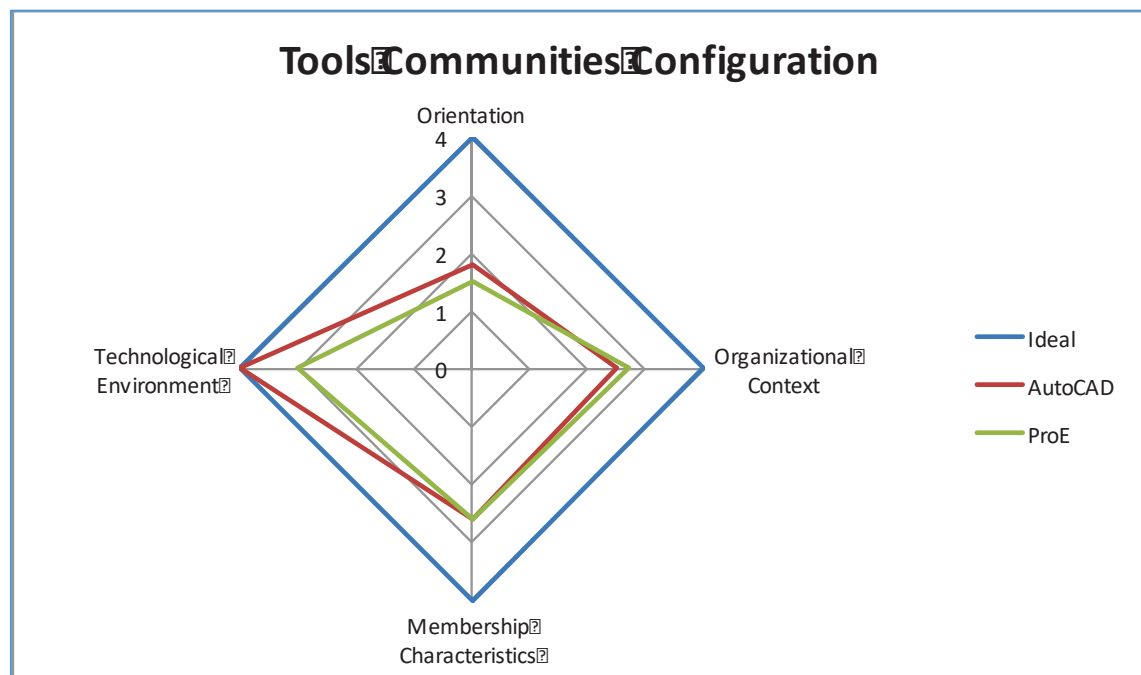


Figure 27: Radar chart for the tools communities' characteristics.

Overall, the three types of communities: technical, industrial and tools, had average collaboration dynamics, their interaction dynamics levels ranged from communication (Scale 2) to coordination of solution production (Scale 3). However, the objective is to reach level 4 of interactions which is strong collaboration dynamics. In this level, the members are engaged in joint-learning activities that lead to the co-construct of new knowledge about problem and propose novel solutions.

4.1.3 Analyzing HySPeC activities

In order to get more insights on why the communities had average collaboration dynamics, the third set of results are the community activities on HySPeC. We analyzed the interactions on the collaborative standardization platform and we wanted to see if the activities log matches the interaction dynamics level obtained from the evaluation grid questionnaire. We wanted to know which functionalities are the most used and which interaction patterns are established around HySPeC. At individual level, we analyze everyone contributions and compared the members' participation to the leader participation. This is of importance to verify if a real sense of community is established between the members or they still adopting the project team mindset.

The communities' size was small and the average number of the communities' members were 16 persons. However, the average number of active and effective members inside of community was 6 persons. In other words, 80% of contributions came from 6 members which is less than half of the community capabilities.

Excluding from the piping community, the average number of posts was 21 compared to 158 for the piping community. Moreover, the number of stored documents inside HySPeC is relatively high marking 61 documents on average. Knowing that HySPeC is a collaborative space and not a document storage database.

Table 11 shows detailed statistics for the communities' activities on HySPeC. A post can be a new question, an answer or a comment on a discussion. Page view is an access to a wiki page, a document library, or an objective list.

HySPeC Characteristics	Piping	Governing System	Casting/ Forging	Welding	Pro/E	AutoCAD
#Members	17	22	12	14	15	19
#Posts	158	4	13	20	8	62
#Documents	135	82	4	68	8	68
#Wiki Pages	2	3	3		0	8
#Meetings	18	2	4	18	56	3
#Standardization Objectives	4	4	4	3	3	2
#Standardization Tasks	12	12	12	12	414	12
#Page views	28178	3974	1231	4984	3266	11130
#members having 80% page views	8	7	5	5	4	8

Table 11: HySPeC activities for the engineering communities.

An analysis of Table 11 shows that the low number of posts, and the high number of documents stored on HySPeC strongly correlated with the communication level (scale= 2) resulted from the evaluation grid (see figures 25, 26, 27). Moreover, the low members' participation level presented in Figure 28 correlated also with the communication level (scale = 2). For example, the average leader participation was 40% rivalled to only 6% for an average member's participation.

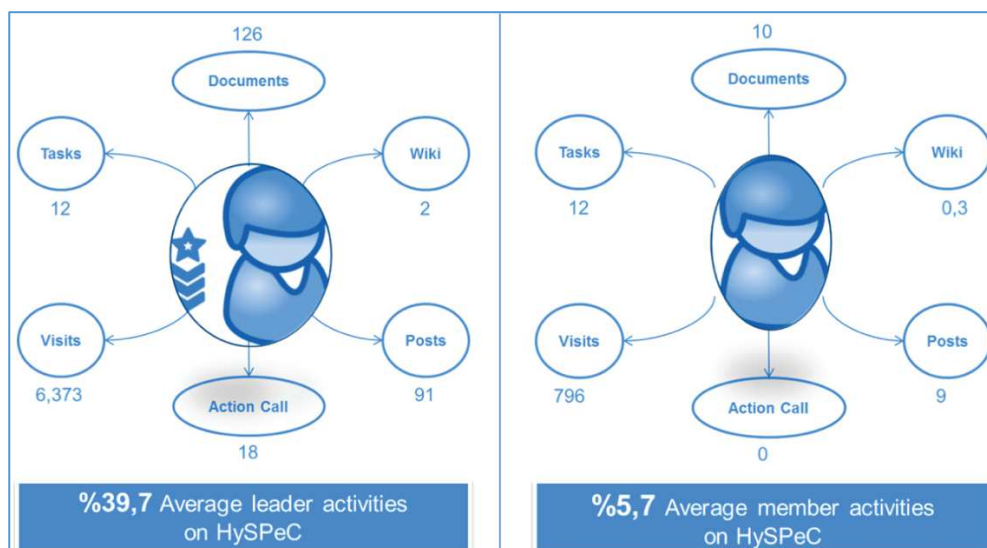


Figure 28: Leader Vs Member average activities on HySPeC.

4.1.4 Conclusion of HySPeC activities

A further analysis of the leaders' interviews showed many reasons for the average collaboration dynamics inside the communities. It explained the variances in the HySPeC activities among the engineering communities. The reasons can be categorized into 3 groups:

- For all the communities, there were no formal links with the top management, and the communities lacked the proper integration into the organization structure. The communities received support during their launch, but lack the continuous support for the rest of their lifecycles. We quoted the welding leader statement *“Top management facilitated the creation of the community. However, never assisted the meetings and said okay this subject interested me or followed the progress of the community. The community is important but no follow-up from top management”*. Moreover, there were no functional link between the community Key-users “members” and the community champion “leader”. The community champion had to manage by influence and constantly face the organizational constraints. For example, the community members had to respond to their direct managers in their respective regions. The missing functional link between the key-user and the champion has hindered the interaction dynamics to evolve and to reach the collaboration level (Scale 4) inside the community.
- For all the communities, there was lack in the community long term vision and how it's going to evolve in addition to how the members are going to advance in their career path. The link between the community members' participation and the individual objectives was absent. In fact, the participation in the community was perceived as additional charge and extra work without clear recognition or rewards.
- For some communities i.e.: Pro/ Engineer, we quoted the Pro/ Engineer leader statement *“the community has passive participation, it's not in the sense where every member actively participates, initiates his own actions and collectively make decisions”*. The leader assigned the tasks to the members and they communicate back the results when they finish. As shown in Table 11, the number of assigned standardization tasks was 414. In fact, the ProE

leader considered HySPeC as a management tool for project follow up and progress monitoring. The members had a project mindset while working inside the community. They were used to predefined roles and responsibilities and faced difficulties to shift into the community working mode.

Other reasons were related to the adoption and diffusion process of the standards. The piping community has fulfilled its objectives and co-developed the purchase specifications sheet for fasteners, pipes, and metal sheets. However, the members found difficulties to search, find and access the developed standards. We quoted the welding leader statement *“if there’s a tool to facilitate the diffusion and the access to the standards, it may look like google search”*. HySPeC interface were developed to facilitate the co-development of the engineering standards and a new interface should be developed to match the diffusion process. A global engineering portal was proposed to centralize the access to any standard (see appendix D).

4.2 Qualitative dimension: improve the online collaboration dynamics for every community.

Following the analysis results of the community’s evaluation grid, the collaboration dynamics level needs to be increased. Table 12,13,14,15 and 16 grouped the characteristics by their families and propose some recommendations for every community characteristic. The recommendations were either proposed from literature, from the top management or from the researcher/ practitioner experience.

Community Mutual Commitment Characteristics		
Characteristic	Short Description	Recommendation
Identity	A shared domain of knowledge that creates a sense of belonging. A set of issues and topics that defines its purpose and value to the members.	A group of members should engage in a joint action (Wenger et al., 2002). i.e.: create and maintain Pro/Engineer models for generators.
Mutual Engagement	Members build collaborative relationships based on mutual respect and trust.	Indicators for mutual engagement (Dubé, Bourhis, & Jacob, 2006): <ul style="list-style-type: none"> - People are helping & supporting each other

		<ul style="list-style-type: none"> - People set up a common understanding of their activities - People are aware of their respective knowledge. A knowledge map is defined to show who knows what. - People meet on a regular basis (2 meetings/ month) to share their experiences and to promote learning.
Shared Practices	A set of frameworks, ideas, tools, information, styles, stories, or documents that community members share and develop.	<p>Indicators for shared practices (Dubé et al., 2006):</p> <ul style="list-style-type: none"> - People develop and adopt a set of practices. - People gather frequently to share their Feedbacks of Experience. - People use technology to discuss their practices, develop and store them in electronic format.

Table 12: Recommendations to improve collaboration for the mutual commitment characteristics.

Community Orientation Characteristics		
Characteristic	Short Description	Recommendation
Objectives	Objectives can be strategic or operational.	From the top management: Objective should be measurable, defined to support GE Hydro strategy, and to implement a project with concrete operational aspects.
Life Span	The community may be defined on a temporary basis to serve a specific mission or on a permanent basis with no time frame.	It's encouraged that the community has a clear mission that is communicated to all members with clear working methods (Fraslin & Blanco, 2013).

Age	The community age to grow and improve may vary from young (1 year) till old (5 years).	From experience: A community may start to deliver within 9-12 months. i.e.: Piping community has fulfilled its 3 objectives within 10 months. Later it may grow, evolve or dissociate.
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Table 13: Recommendations to improve collaboration for the orientation characteristics.

Community Context Characteristics		
<i>Characteristic</i>	<i>Short Description</i>	<i>Recommendation</i>
Creation Process	Communities can be created intentionally or spontaneously.	The top management at GE Hydro would create the community where it will define its purpose and it will endorse some key members.
Level of commensurability	Refers if the community integrates members from same workgroups, different units or even collaborators to Alstom.	Community's members should work in similar units (Fraslin & Blanco, 2013). i.e.: Casting & forging community integrated people from Quality to define the inspection sheet.
Context	Refers if the environment (management style, financial, resources...) is facilitating or obstructing the creation and the development of the community.	Top management recommended that conflicts between different stakeholders will be resolved before the launch of the community.
Level of Sponsorship	Refers if the community is receiving support to overcome difficulties and mitigate any possible risk.	An active sponsor plays a major role to manage community relationships with the top management (Fraslin, 2013).
Degree of Corporate Recognition	Refers if the community is integrated into the formal GE organization structure.	The community should be integrated with official status and functional links (Fraslin, 2013).
Consensus on Leadership	A leader has a social influence on the group.	From experience, the leader should organize monthly meetings to follow

	He's entrusted to support the others to accomplish the mission. The leader may represent the community in front of the top management. He will be accountable for the community deliverables.	up on the progress. He should be a subject matter expert in his field. He has also a social role to maintain the professional relationships inside the community.
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Table 14: Recommendations to improve collaboration for the context characteristics.

Membership Characteristics		
Characteristic	Short Description	Recommendation
Size	Refers to the number of involved members in the community: small (<20), big (>1000)	From experience, on average GE communities have 16 members; however, statistics shows that 80% of contributions are from 6 members. Gap analysis should be conducted to identify the dysfunctions.
Geographic Dispersion	Refers to the physical location of the participants. Low dispersion (same building), high dispersion (around the world)	From experience, GE communities are dispersed around the globe, on average 6 regions constitutes every community.
Member Selection Process	Refers to open membership (anyone interested in the organization), or closed membership (only people who meet a predetermined criteria)	Top management recommended for specific missions that the community have closed memberships elsewhere community should integrate any motivated member who shares the same interests.
Member enrollment	Refers to voluntary participation, to strongly encouraged, to compulsory membership	Member's enrollment is encouraged to be flexible and voluntary. This will encourage a willingness to share ideas, ask difficult questions and listen carefully (Fraslin, 2013).
Member Prior	Low (no experience in	From experience, a basic knowledge

Community Experience	community working methods), medium (moderate experience in groupware methods), high (already members in other communities)	in community working method is encouraged. Quick formation may be held to explain the difference between a team and a community.
Membership Stability	Stable (membership is along the community lifespan), temporary (need to be involved in particular activity)	It's highly encouraged that membership will be stable. Long-term relationships will empower the trust among the community members (Greenberg, Greenberg, & Antonucci, 2007).
Cultural Diversity	Homogeneous (members have similar professional profile, share same organizational value and lives in the same country), or heterogeneous (difference in professional, organizational and national profile)	From experience, GE communities are heterogeneous. They should integrate and discuss differences that exist in engineering regions.
Topics Relevance to members	High relevance (topics close to the daily work of its members), low relevance (far from members' day-to-day preoccupations)	Topics with high relevance to the members can tighten their collaboration and promote learning between them. This will impact the deliverables quality (Fraslin, 2013).

Table 15: Recommendations to improve collaboration for the membership characteristics.

Technological Environment		
Characteristic	Short Description	Recommendation
ICT Availability	Low variety (few IT tools are available to support the daily work), High variety (multiple communication medias are available to communicate and collaborate in projects. i.e.: forums, wiki's, IM, intranet...)	Using multiple types of media for communication enable the transmission of complex messages. Multiple data format (visual, audio, text...) can enrich the information

		exchange (Daft & Lengel, 1986).
Reliance on ICT	Familiar (members are competent and rely on ICT to accomplish their tasks) , unfamiliar (members don't rely/ use ICT to complete their tasks)	Relying on technology to complete the tasks can provide the management with clear insights to improve the work (Hara, Shachaf, & Stoerger, 2009).

Table 16: Recommendations to improve collaboration for the technological environment characteristics.

Cycle 1: Conclusion

With the initiative to standardize the engineering practices in collaborative way and remotely, the email based standardization process was burdensome and time consuming. The standardization manager preconized the development of a collaborative standardization process supported by a collaborative standardization platform. We have observed a co-located workshop that served as a basis to co-define the process and MS SharePoint® to develop the platform. The result was 4 templates of HySPeC to collaboratively define, develop, and diffuse the standards with the ability to monitor and track the standardization process at distance. It helped the engineering communities to understand and analyze all the standardization related activities. The identification and the proposition of the standardization projects are not made by mail anymore, but through the collaborative standardization platform.

HySPeC was used by the “engineering communities”. In order to assess the usage of HySPeC, we applied the online evaluation grid developed in prior PhD work at “Alstom Power”. The evaluation grid helped us to assess the interaction dynamics level of every community. In addition, it helped us to identify the configuration of every community and its ability for online collaboration. Based on the assessment, we compared the communities’ configuration and provided recommendations to improve the online collaboration for the engineering communities. Table 17 presents the actions that we implemented for cycle 1 phases and throughout the chapters 1, 2, 3 and 4.

Cycle 1		
Diagnosis in chapter 1	-	<ul style="list-style-type: none"> Understanding the standardization initiative at GE Hydro Presenting the engineering communities at GE Hydro Assessing the e-mail based standardization process Recommendations for a collaborative standardization process
Planning Action in chapter 2	-	<ul style="list-style-type: none"> Literature review on the collaborative standardization processes & platform Gap identification and defining the requirements for the collaborative standardization process & platform
Taking Action in chapter 3	-	<ul style="list-style-type: none"> Specifying the collaborative platform through the collaborative standardization process Developing the 4 HySPeC templates Train the standardization communities on the collaborative platform Monitor the usage of the collaborative platform
Evaluation in chapter 4	-	<ul style="list-style-type: none"> Plan interviews with standardization communities' leader Application of the evaluation grid to assess the interaction dynamics of the engineering communities. Compare the communities' configuration with respect to each other's. Recommendations to improve the online collaboration for the engineering communities.

Table 17: Methodology actions for Cycle 1 phases

Problematic and Third research question

We expected that the collaborative standardization platform significantly improves global collaboration and to accelerate solution finding by sharing resolutions to similar problems. However, through observations collected from the practice, the engineering communities have faced difficulties while implementing the collaborative standardization process and working with HySPeC. Furthermore, some activities were unsuccessful and others were delayed. The P&S director at the global engineering function stated:

“The Balance of Plant (BOP) expert has faced problems related to the working mechanisms that hindered him to co-define the BOP design guidelines”.

Additional inquiries to better analyze the root cause of this statement has revealed that the lack of proper knowledge exchange mechanism inside the community had prevented the expert to co-define the design guidelines. We observed that not all communities had worked in the same way. Also, not all project phases should be conducted with the same working modes. We made the hypothesis that the communities may be configured and composed differently in function of the project's objectives.

We are interested to discover all the communities' types or engineering collectives. We wanted also to find the characteristics that can clearly define the frontiers of every virtual collective. In addition, we seek to define a framework that associate and configure the virtual collective type to the project phase. We refined our initial objective to inquire furthermore the following research challenges:

- 3) What are the characteristics of the virtual engineering collectives that best suit the collaborative standardization process?
 - a. What are the characteristics that define and differentiate the virtual engineering collectives' types?

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CYCLE 2 – THE VIRTUAL COLLECTIVES’ FAMEWORK

Cycle 2: Introduction

The second cycle’s objective was to develop a virtual collectives’ framework that characterized and differentiated the virtual engineering collectives. The framework is implemented and tested through a case study: the “Control & Monitoring platform”. Figure 29 shows the methodology to accomplish this cycle objective effectively starting from Jan, 2015 till July 2015.

- The diagnosis phase (section 5.1). In this phase we analyzed the lack of engagement to apply the collaborative standardization process within the engineering communities. We preconized that the working methods for the virtual collectives’ types should adapt and fit the collaborative standardization process (Cycle 1, Chapter 3).
- The planning for action phase (section 5.2, 5.3, 5.4, 5.5 and 5.6). First we selected and defined the 4 virtual collectives’ types. We searched the literature for a model to characterize them. However, we identified a gap in the literature. We proposed a new model to characterize the virtual collectives in function of their development phases. Out of this model we derived a framework to differentiate these virtual collectives.
- The taking action phase (section 6.1): we presented the “control & monitoring platform” as a case study for our proposal. The C&M platform was composed of 3 subsystems: the distributed control, the excitation and the governing systems. We defined also an operational framework for the project.
- The evaluating action phase (section 6.2): we applied and tested the virtual collectives’ framework along with the operational tools. First, we presented the results of the “control & monitoring platform” project, then we discussed the contributions of our proposal to the success of the project. We collected also the feedbacks from the C&M platform director regarding our proposal.

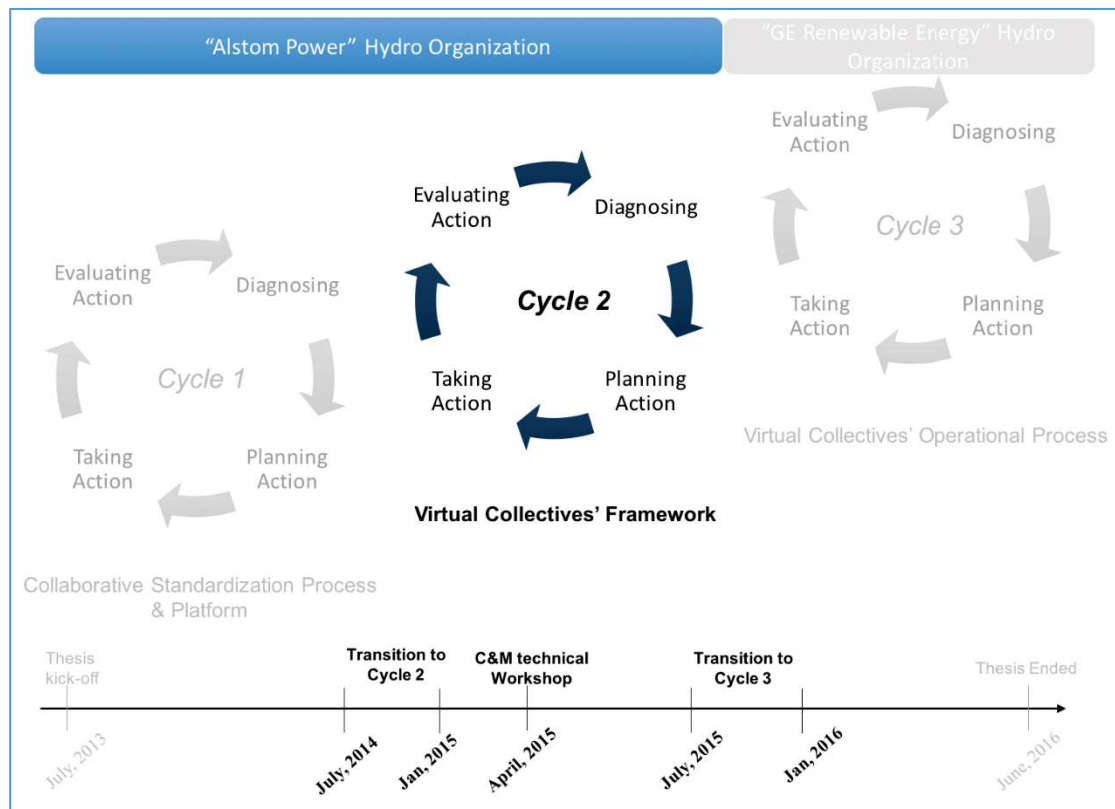


Figure 29: Methodology for cycle 2 between Jan, 2015 and July, 2015

CHAPTER 5 – Proposal of the Virtual Collectives Framework

This chapter objective is to define, characterize and differentiate the virtual engineering collectives. Our hypothesis is to be able to clearly define the design choice of a virtual engineering collective's type for a specific objective related to knowledge creation or knowledge exchange. The choice of a virtual engineering collective is expected to improve the interaction dynamics level for online collaboration.

This chapter is structured as follows: in the first section, we conduct a diagnosis phase for the engineering collectives within the hydro organization. In the second section, we review the literature to define the 4 virtual collectives' types. In the third section, we searched for characteristics models that characterize the virtual collectives in function of its development phases. We identify a gap in the literature and we define the requirements for our proposal. In the fourth section, we propose a virtual collectives' dynamics model. We defined also the critical differentiation factors to differentiate the virtual collectives' types. In the fifth section, we propose the virtual collectives' framework and apply it to our selected collectives' types. Finally, in the sixth section, we develop tools to facilitate the implementation of the framework within an operational environment.

5.1 Diagnosis of the virtual engineering collectives at “Alstom Power”

At “Alstom Power” Hydro organization, the collaborative standardization process (section 3.1) included different task types e.g. standardization planning, collaborative development of standards, standardization follow-up, release and communication, re-use on project and feedback of experience. Usually the HEN assigned these tasks to virtual project teams. As result of this assignment, we observed that the standards are partially developed, don't cover all the requirements and are poorly adopted by the engineering regions. For example: the purchase framework agreement is repeatedly negotiated with the supplier; site installation of the turbine faced again the same recurrent problems which causes delays in the delivery; feedbacks of experience on the standard application are not sufficiently collected. In the standardization project, we asked the following questions: how can we improve the engagement of engineers and their participation in the collaborative standardization process? How can we ensure the application of standards in projects? In a company environment, which

operational mechanism has to be implemented co-develop the standards? How to involve the other functions e.g.: R&D, sourcing, manufacturing and site installation? How to make them propose shared tasks? And ensuring that there is budget and resources for these shared tasks?

Through observations and analysis of the situation we assumed that the problem lies in the assignment of different types of tasks to the same virtual engineering collective type. In HEN case, it's the virtual project teams. In fact, we make the hypothesis that every task type demanded different working methods, different combination of skills and different success factors. The fit between the task and the collective type will improve the participation of engineers in the development of standards. Having multiple virtual engineering collectives may enable us to co-develop and to facilitate the application and the adoption of standards in projects. For example, to convince other functions to participate in the definition of the standardization tasks, we should find a common interest with them and align the expectations.

In order to find the existing different virtual collectives types, the first thing we did is to go back to the literature, try to find different types of collectives that are adapted to a specific objective. Many collectives' types exist in the literature. For example, parallel team, management team, service team, community of circumstances, virtual work group (Bal & Teo, 2000; Fischer, 2001; Hacker & Kleiner, 1996; Zhang & Watts, 2008). Based on the industrial context, the collective selection criterion was to support the collaborative engineering activities. We are interested in 4 specific types which are virtual teams (VT), virtual community of interest (VCOI), virtual community of practice (VCOP), networks for learning (NfL) (Engel & Alders, 1993; Lipnack & Stamps, 1997; Wenger, 1999). The research question is refined to: "what define, characterize and differentiate the 4 virtual collectives' types?"

5.2 Defining the virtual collectives Types from literature

We defined the teams, communities and networks inside the organizational boundaries as professionals who are interrelated, established communication habits and seeking the power of the collective in order to achieve a shared endeavor. However, similarities and differences existed among these collectives and it's advantageous to understand these variances to fully exploit the potential of every collective type. Particularly, we are interested in virtual collectives for engineering

activities. We selected the following virtual collectives' types: virtual teams, virtual communities of practice, virtual communities of interest, and networks for learning. Our extensive literature review was done on the four types to better understand their compositions, their dynamics and their purpose.

5.2.1 Virtual Teams

Virtual as an adjective is defined as “very close to being something without actually being it”, (Merriam-Webster's Learner's Dictionary, 2016). In other words, it's an incomplete state of an idea, a concept or an object and thus it needs to be compensated. On the other hand, team is defined as “a group of collocated people who interact through interdependent tasks guided by common purpose” (Lipnack, J. & Stamps, J. 1997). We defined a virtual team as “a group of dispersed people whose interactions need to be compensated by the means of the information and the communication technologies while maintaining their cohesion”. In the following paragraphs we searched what is said about the virtual team in the literature.

This group interaction is expressed through Face-to-Face (F2F) communication. With the advent of information technologies, electronic communication enabled dispersed members to interact and exchange information. However, assuming that electronic communication can imitate and replace face-to-face communication is a misinterpretation. A closer look at collocated teams indicates that multiple characteristics are implicitly present by being in proximity. Boundedness (Hackman, 1990), proximity collaboration (Allen T., 1977) as cited by (Lipnack & Stamps, 2002), team cohesiveness (Dineen, 2005), trust (Paul et al. 2004), non-verbal cues, social relationships are all nurtured through F2F communication. As a consequence, some of these characteristics are called into interrogation when trying to disperse the team geographically, temporally and organizationally. New management practices coupled with meticulous effort need to be capitalized when trying to build a virtual team that attempt to compensate the absence of physical interaction.

Due to the tight competition, organizations are designing, developing and implementing complex systems and/or products. This requires new working methods as well as much demanding resources and human expertise. “By employing virtual teams, companies can do things that are impossible within the prevailing model of side-by-side nine-to-five work” (Lipnack & Stamps, 2002). Virtual Teams is one of

the eminent forms that had been adopted by organizations. They are playing an increasingly important role in international business by offering organizations the opportunity for reaching beyond traditional boundaries (Pauleen & Yoong, 2001).

The scientific as well as the professional literature had addressed thoroughly the virtual teams concepts and it is in early 1990 that the first notion of virtual teams has appeared (Lipnack & Stamps 1997; Maznevski & Chudoba 2000; Lurey & Raisinghani 2001; Cascio & Shurygailo 2003; Powell et al. 2004; Staples & Zhao 2006; Anderson et al. 2007; Huber 1990). These authors have agreed to some extent that virtual teams are teams with geographically distributed members, cross time and organization boundaries, are culturally diverse, utilize computer mediated communication to perform non-routine but interrelated tasks and are united around a common goal. Lipnack & Stamps (1997) defined VT as “groups that work across space, time and organizational boundaries with links strengthened by webs of communication technologies”. Lurey & Raisinghani (2001) defined virtual teams as “groups of people who work together although they are often dispersed across space, time, and/or organizational boundaries”. Powell et al. (2004) defined virtual teams as “groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks”. The following authors Bal and Teo, (2000), Gassmann and von Zedtwitz (2003), Paul et al. (2005), Wong and Burton (2000) included in their definitions the temporary aspect in the virtual team lifetime or for some team members. As summary, a team will become virtual if it meets four main common criteria:

1. geographically dispersed and over different time zones.
2. driven by common purpose.
3. enabled by communication technologies.
4. involved in cross-boundary collaboration.

In their review of literature, Ebrahim highlight others characteristics of virtual teams: the team is small, non-permanent. Members are mainly knowledge workers, and teams can cross companies' boundaries (Ebrahim et al., 2009).

5.2.2 Virtual Communities of Practice

Another noticeable virtual collective that comes out from the knowledge management literature is Virtual Communities of Practice (VCoP), which is gaining reputation in

the business context. Latest reports show that VCoP are being considered as strategic assets for multinational corporations to bring people together and to share knowledge in multisite working environment (Davenport, 1996; Cohen & Prusak, 1996; Ellis, 2001; Haimila, 2001) as cited by (Ardichvili, Page, & Tim, 2002). Lave and Wenger (1991) first introduced the term community of practice (CoP). Lave and Wenger (1991) used it in their exploration of situated learning. It is through the process of sharing information and experiences with the group that the members learn from each other, and have an opportunity to develop themselves personally and professionally (Lave & Wenger, 1991). Wenger (1999) understands a CoP as a special type of community where practice is a source of the coherence to pursue a joint enterprise. In a community of practice (CoP) “groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis”. CoP is seen as a strategic asset to create and share organizational knowledge. Using information and communication technology (ICT) such as Internet to support their ongoing interactions, CoPs are going virtual. They form a “virtual community of practice” (VCoP) (Dubé et al., 2006; Frasin & Blanco, 2013; Frasin, Blanco, & Chanal, 2011) when they collaborate online, such as within discussion boards and newsgroups. VCoPs frees their members from constraints of time and space.

5.2.3 Virtual Communities of Interest

Additional interesting type of communities that facilitate the exchange of knowledge is virtual communities of interest (VCoI) (Wenger et al., 2002). Basically, a community of interest (CoI) is a group of people who share a common interest and who want access to community information (Wenger et al., 2002). Relying on information and communication technology, we define virtual community of interest as a social group of people who share a common interest and communicate through social technology services.

5.2.4 Networks for learning

Larger forms to create and exchange knowledge are networks of practice (NoP) and networks for learning (NoL). They are considered as knowledge networking infrastructure that facilitate the knowledge management activities across temporal and spatial boundaries (Hustad, 2010).

The concept of networking for learning was coined to agricultural knowledge systems (Engel, 1997) and soft-system analysis (Checkland & Scholes, 1999). The Resource Centre for Development of the Skat Foundation (2004) as cited by Cummings and Zee (2005) had defined the term “network” as a description for institutionalized partnerships between institutions or organizations and may even take the form of a legal entity. Giving this definition, networking is about organizations, institutions and individual actors joining forces around a common concern. Most often, it is about building relationships with other independent actors to share knowledge, goods and experiences and to learn from each other with a common goal in mind (Padron 1991; Plucknett 1990; Engel 1993) as cited by (Cummings and Zee (2005)). Brown & Duguid (2001) coined the phrase “networks of practice” (NoPs) to describe one type of networking. NoPs are composed of people who are geographically separate, share similar practices but may not necessarily have regular meetings or even have to know each other’s.

When it comes to social learning theory, the literature around the virtual collective types is fragmented and studies separately the virtual teams, virtual communities of practice, virtual communities of interest and networks for learning. The literature didn’t clearly differentiate the boundaries between every type. Hence, the objective of the next section is to find a framework to clearly define the similarities and the differences between these types. We searched in knowledge management journals, engineering design journals, and organizational sciences in order to fulfil our requirements. The keywords that directed our literature review were: group’s dynamics, virtual teams’ effectiveness, communities’ performance, geographically distributed teams, and networks of experts. We find out models that described group behaviors, interactions and dynamics. In these models they studied which characteristics impacted the team’s effectiveness or the community success. The main results were obtained from the management sciences literature and few were found in the engineering design literature. The results will be presented in the next section.

5.3 Characterizing the Virtual Collectives types from literature

A model to organize and structure the collectives’ characteristics is needed. The I-P-O (Input-Process-Output) model proposed by McGrath in 1964 served as reference model for many studies and researches (S. G. Cohen & Bailey, 1997; J R Hackman,

1987, 2003; J E McGrath, 1964). Figure 30 shows the I-P-O model as a transformational process where the input characteristics are mediated via the group process to produce output characteristics. The input characteristics are grouped into 3 levels: the individual (e.g. skills, personality), the group (e.g. structure, size) and the environment (e.g. task, stress, reward). The output characteristics are grouped into two families: the performance outcome related to the actual work of the group (e.g. quality, speed of delivery, and number of errors) and the satisfaction outcomes related to the degree at which the members are comfortable with the outcome process (e.g. cohesion, personal development). In fact, the I-P-O model studied the input characteristics impact on the outcome characteristics. Input characteristics are all factors that can be manipulated in order to change processes and outcomes (S. G. Cohen & Bailey, 1997).

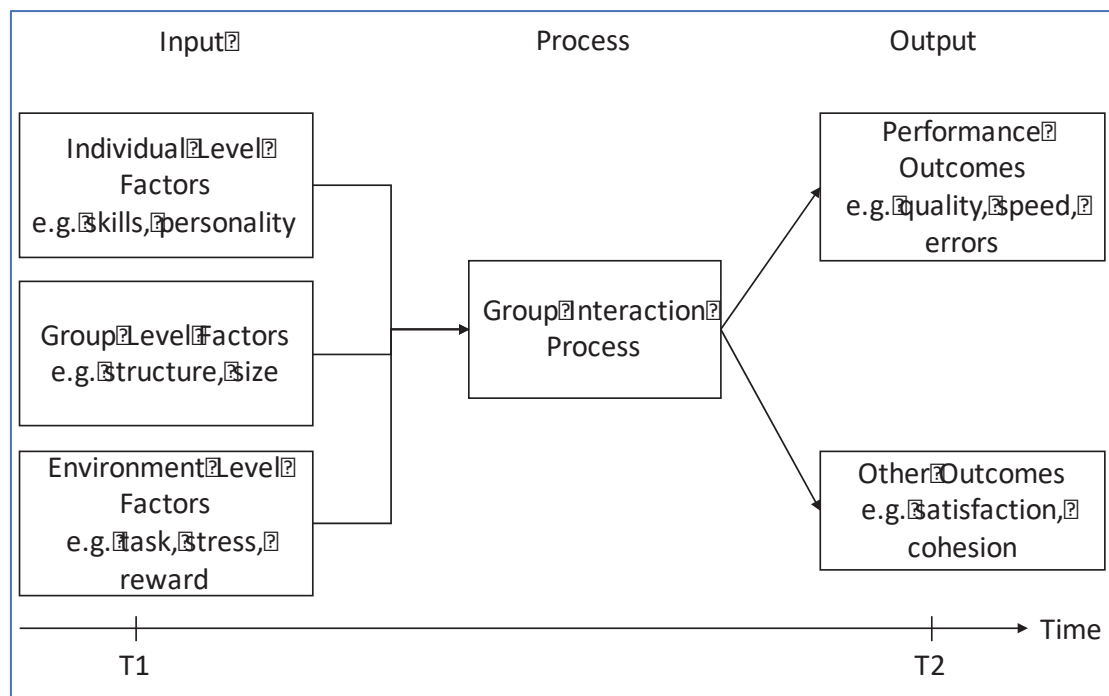


Figure 30: Input-Process-Output Model (J E McGrath, 1964).

An adaptation of the I-P-O by (Gladstein, 1984) is presented in figure 31. In this model, Gladstein divided the input characteristics in 2 levels: the group and the organization. He argued that the organizational factors can have direct impact on the group effectiveness where McGrath considered the environmental factors as input characteristics and only the group processes will affect the group effectiveness. Another adaptation of McGrath model is presented by Dennis, 1988 and it further detailed the input characteristics into 4 categories (Group, Task, Context, EMS

(Electronic Meeting System)), for example see figure 32. The new characteristics family introduced by Dennis was the EMS. He stated that groups became dispersed and rely on electronic support systems to communicate or interact. These systems should be available and provide the necessary functionalities to compensate the F-2-F meetings. The main difference between Dennis and Gladstein is the task characteristics impact where Gladstein considered that the tasks characteristics had direct impact on the group effectiveness on contrary to Dennis who considered that the tasks characteristics are mediated through the processes characteristics to impact the group effectiveness.

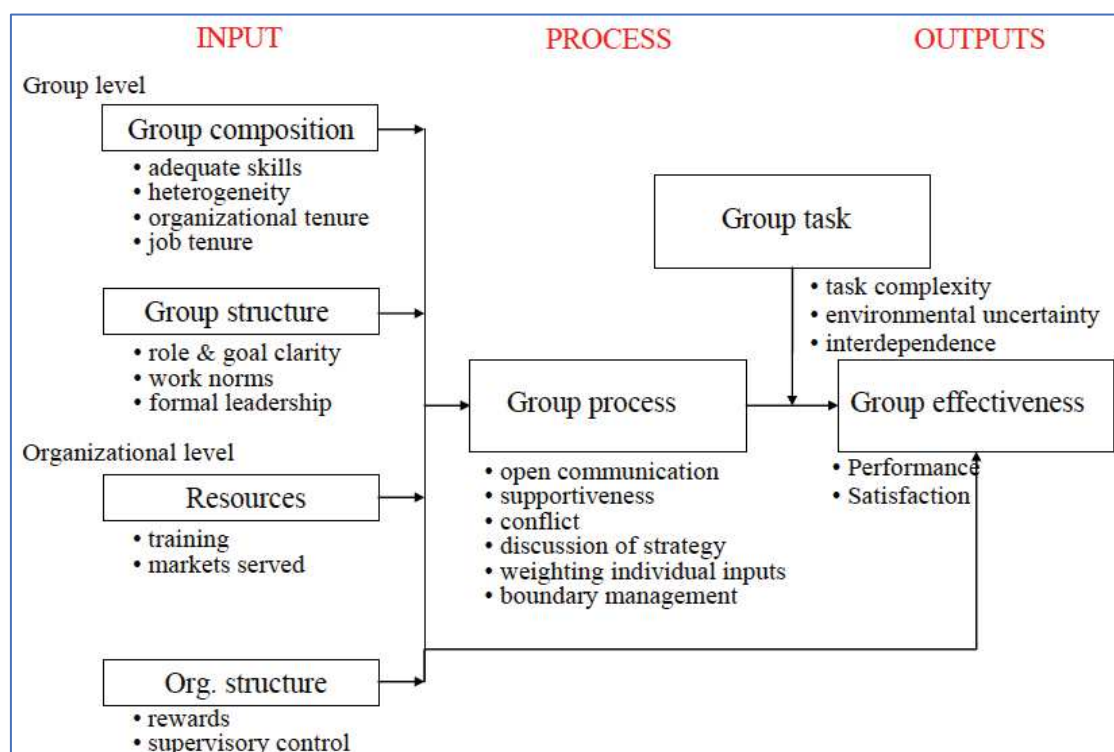


Figure 31: Adaptation of Input-Process-Output (Gladstein, 1984).

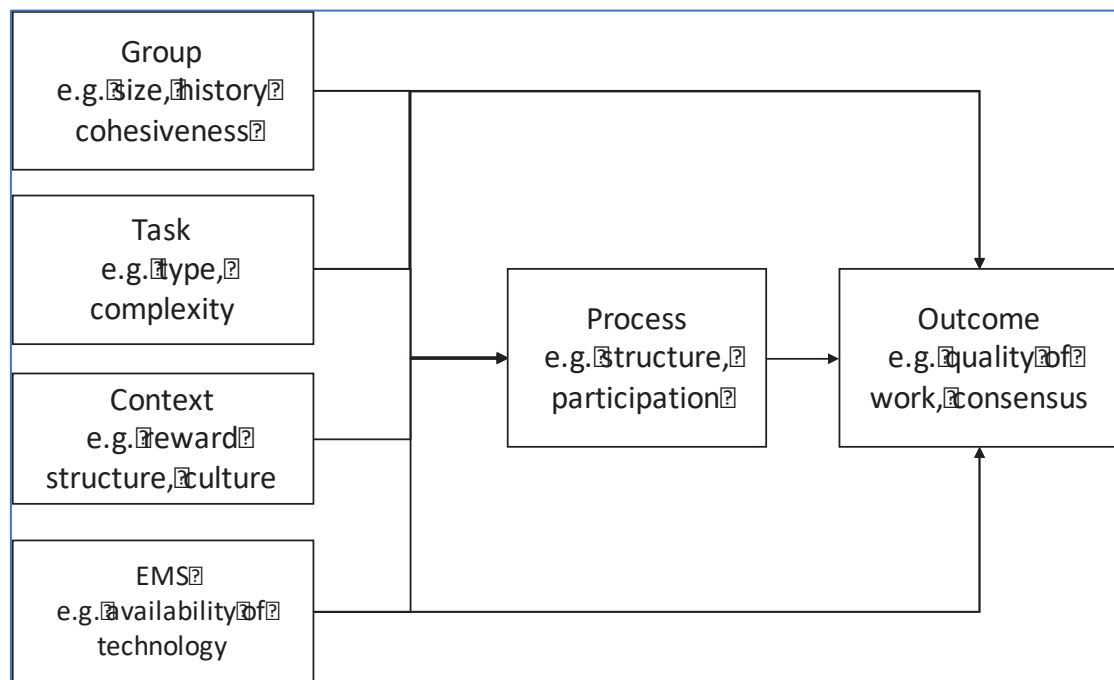


Figure 32: Integrative model for Group Decision Support System (GDSS) (Dennis et al., 1988)

However, the I-P-O framework is unsatisfactory to fully characterize the teams (Moreland, 1996). Other researchers have proposed heuristic models to characterize the teams, they studied also the impact of the team characteristics on the team effectiveness. Figure 33 illustrates the framework proposed by Lurey and Raisinghani of predictor variables expected to impact the effectiveness of virtual teams (Lurey & Raisinghani, 2001). The proposed framework resulted from a survey methodology conducted on 12 separate virtual teams from 8 different companies in multiple industries. The framework proposed the team performance and the team members' satisfaction as the measures for the team effectiveness. The variables to predict the team effectiveness are grouped into two families: internal group dynamics and external support mechanisms. For the internal group dynamics family, the predictor variables are: job characteristics, selection procedures, team member relations, team process, internal team leadership. As for the external support mechanisms, the predictor variables are: education system, reward system, executive leadership style, tools and technologies and communication patterns. The two predictor variables team process and team member relations had the highest correlations with the team performance and the team members' satisfaction. In other words, these two variables strongly impact the virtual team effectiveness. Furthermore, the two predictor variables: selection procedures and executive leadership style showed fair correlation

to the team effectiveness. The reward system predictor variable showed a strong correlation with the team members' satisfaction.

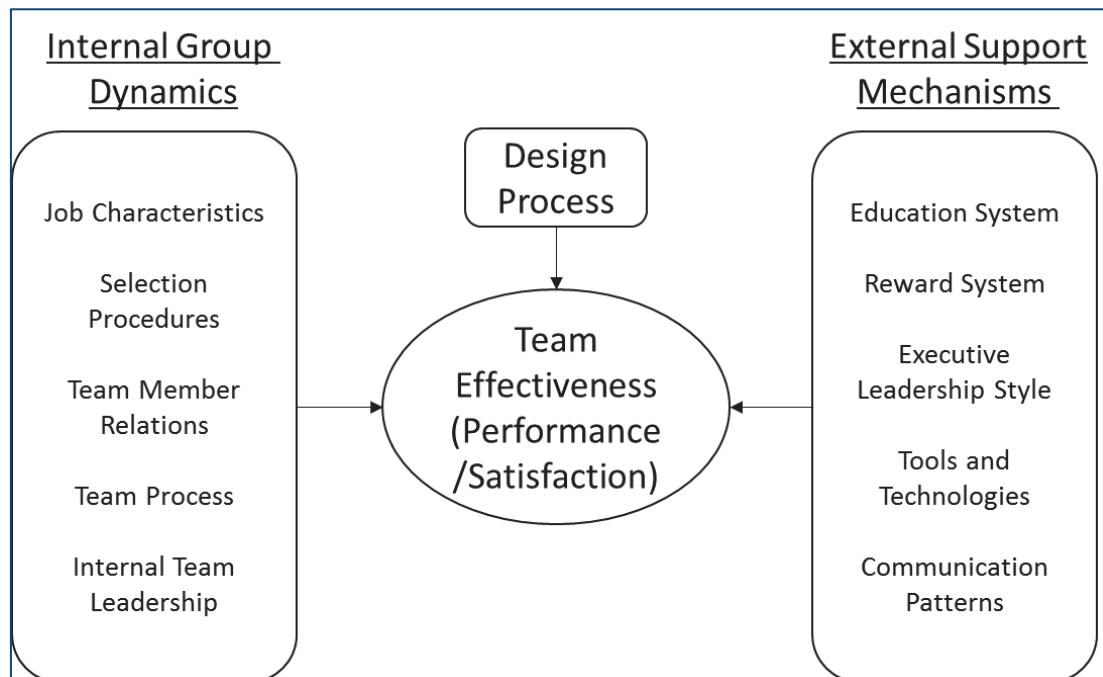


Figure 33: Virtual teams' variables influencing effectiveness (Lurey & Raisinghani, 2001).

5.3.1 Literature synthesis on the virtual collectives' model

As conclusions, the presented models in the literature are valid for groups and teams. For I-P-O based models, they characterize teams as linear, sequential, and transformational process that mediate the input characteristics to the outcome characteristics. As for the heuristics models, they focused on the relationships between the characteristics and how they correlate to team effectiveness. However, our objective is to find a model that is valid for virtual teams, virtual communities, network for learning. From practice, we observed that the engineering collectives are dynamically engaged, context-dependent and in constant evolution with their environment. We assumed that the model might describe in details the characteristics of the collectives throughout their evolution. In other terms, the model has to present multiple characteristics in function of the collective development phases.

5.3.2 Search for a model to describe the virtual collectives' dynamics

One interesting model to describe the dynamics of groups is proposed by professor Bales in his equilibrium model of group development (Hare, Borgatta, & Bales, 1955). In his model, he considered that group's members struggled to maintain an

equilibrium point between the task-oriented behaviors and their socio-emotional behaviors. The equilibrium point is the balance between the task required skills and the member's satisfaction with working process. The equilibrium point is reached through phases in a cyclical fashion, they required continuous adjustment between the two members' behaviors until the group is performing and in coherence (Hare et al., 1955).

Based on Bales work as well as others researchers in group development studies, Tuckman, in 1965, has synthesized and abstracted the previous studies into a theory of four stages for small group development (Bruce W Tuckman, 1965). This model has acted as a guide for researchers as well as managers to understand and develop groups in education, organizations and public institutes (Bonebright, 2010; Fall & Wejnert, 2005; Seck & Helton, 2014) . Figure 34 describes the model that consisted of four sequential stages: forming (members come together and start to establish relationships), storming (members start to work together and conflicts emerge inside the group), norming (members start to appreciate each other's and progress toward the objective) and performing (members trust each other's and processes are well established) (Bruce W Tuckman, 1965). A fifth stage is proposed by Tuckman and Jensen in 1977 which is adjourning (members start to dissociate after achieving the group's objectives) (B W Tuckman & Jensen, 1977).

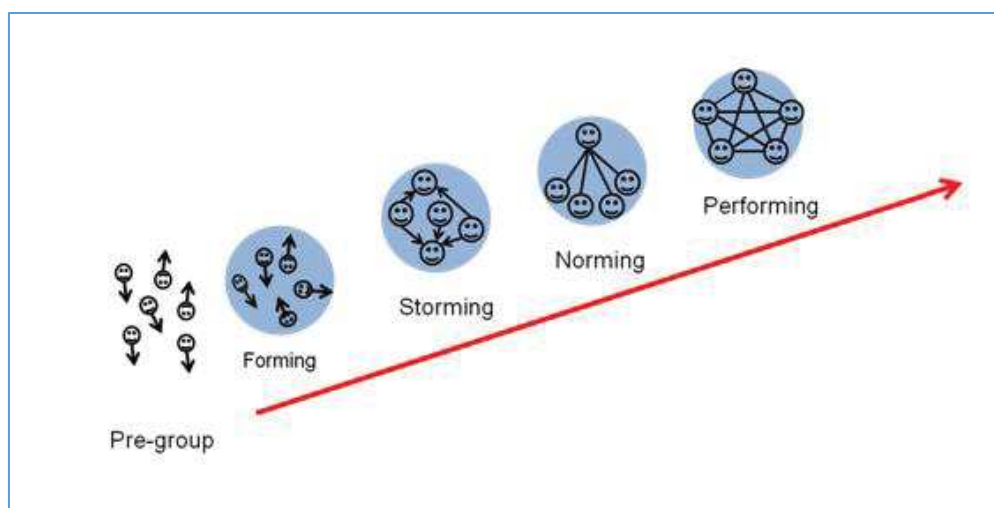


Figure 34: the sequence of group stages (Bruce W Tuckman, 1965).

In systems approach to small groups interaction, Tubbs has proposed a 4 phases development model (Tubbs, 1995). Basically, the model's objective is to reach a group consensus around a common solution to solve a problem. The development

phases are: orientation, conflict, consensus and closure. The group members gather and start discussing the problem, and then they identify the risks and opportunities of the solution alternatives. Conflicts of interests and in perspectives may emerge while selecting the best alternative. The group progress in discussions and define a set of criteria to arrive to a consensus. Finally, an agreement on the alternative solution is established and the group members communicate the results. The group members are committed and fully support the final decision.

5.3.3 Gap identification in literature and need for a new virtual collectives' dynamics model

We agree with the model proposed by professor Bales where he considered that the group performance and cohesiveness is achieved once the members reach the equilibrium point. In other words, when the individuals balance between their technical skills and their satisfaction while working inside the group. This model has assumed that the membership and the composition of the group are stable. However, the group operates in a changing environment and its membership and composition can alter at any point in time. Moreover, this model didn't state which characteristics are impacted in case of turbulence. For example, the changes in the objectives or the task types will cause the group to change in dynamics and require including new members inside the group. In this case, the group has to reform and go through all the phases again.

In the following 5.4 section, we proposed a virtual collective's dynamics (VCD) model to characterize and differentiate the virtual engineering collectives through their development phases. In addition, we assume that the model is expected to help the project managers to dynamically reconfigure the engineering collective in function of changes e.g. the task types or objectives.

5.4 Designing the Virtual Collectives' Dynamics Model from literature

In section 5.3 we conducted a literature review to survey the current frameworks or models to characterize the virtual engineering collectives, however we seek a framework that differentiates the virtual engineering collectives and characterize them in function of their development phases.

Firstly, we listed all possible characteristics from every model or framework. The researcher/ practitioner clustered this exhaustive list of characteristics into families. These families were either selected from the literature, for example: collective task design, collective's technology, or created from the practice, for example: collective's strategic directives. As result, 9 characteristic families were defined and they are as follows: collective's task design, collective's technology, collective's strategic directives, collective's structure, collective's composition, collective members' interaction, collective's health, collective members' interaction, collective's health.

Secondly, we adapted the phases proposed by Tuckman to define our development phases: the first phase is forming and transforming, the second phase is storming and norming and the third phase is performing. For example, we added the transforming phase to forming phase since the collectives' composition will change in function of the task type. We regrouped the storming and norming phase since we considered that the collectives' dynamics will always face incidents and external factors impacting its cohesiveness. As for the third phase, we kept the performing phase proposed by Tuckman since the collectives' outcome is expressed as performance and satisfaction with the outcome. The 3 development phases with their respective characteristics families are:

- The characteristics families for forming and transforming phase are: collective's task design, collective's technology, collective's strategic directives, collective's structure and collective's composition.
- The characteristics families for storming and norming phase are: collective members' interaction, collective's health.
- The characteristics families for collectives performing phase are: collective's performance and collective members' satisfaction.

The virtual collective's characteristics were found in the VT, VCoP, VCoI and NoL literature.

5.4.1 Forming and transforming the collectives

5.4.1.1 Family 1: Collective's task design

One of the advantages of VTs for the task design is that skills required to execute the tasks can be composed from all the organization independent of their physical location. As task requirements change, membership can be modified to include or remove the expertise needed to satisfy the task (Alge, Wiethoff, & Klein, 2003; Kirkman, Rosen, Tesluk, & Gibson, 2004). It's the complexity of the task that will determine the position of the VT in the virtual continuum ranging from F2F to fully virtual (B. S. Bell & Kozlowski, 2002). The 3 common task types are: (1) production; (2) discussion; (3) problem solving as categorized by Hackman (J R Hackman & Morris, 1975). In addition to, functional analysis, design, and collaboration activities such as co-development and sharing of technical documents (Dennis et al., 1988). For example, in the production task type, the team's members are required to produce new ideas or concepts, normally following a brainstorming technique. Whereas in the discussion type, the team's members will evaluate a set of alternative solutions, and in the problem-solving type they have to define an action plan that is going to solve a problem.

The realization of a VT objective can be made of interdependent and non-routine tasks (Schlenkrich & Upfold, 2009). However, several communication problems may occur in case of novel tasks assigned to VTs. The cause for this miscommunication is due to the lack of proper information exchange patterns and processes (Gibson & Gibbs, 2006). The VTs are conceptualized to handle complex objectives of significant importance (Kirkman et al., 2004; Leenders, Van Engelen, & Kratzer, 2003). In fact, the success of an objective and the speed at which a VT make decisions highly depend on the task type (Daly, 1993; El-Shinnawy & Vinze, 1998). However, the degree of virtualness may increase the duration to achieve an objective if the tasks are poorly defined (Straus & McGrath, 1994). Thus the task definition should take into consideration its compatibility with the degree of the virtualness (A B Hollingshead, McGrath, & O'Connor, 1993).

The individual motivation to execute the tasks inside VTs is high if it matches the 5 task dimensions: skill variety, task identity, autonomy, feedback and task significance (J. Richard Hackman & Oldham, 1976). The team member valued the tasks if they involve the use of his various skills to do a complete and visible part of the work. In this way, these tasks will differentiate him from the other team's members and create his own identity. The team member should be empowered to be autonomous where he

will take initiatives to overcome the tasks challenges. The team member should learn from what he's doing and get feedback on how well he is doing. The tasks resulting work should also have significant influence on the well-being of other team's members.

5.4.1.2 Family 2: Collective's Technology

The distant interactions between the VT members are enabled by the technology. It's important that the technology is available to maintain a constant level of interactions and particularly when the VT members can't have co-located meeting. The members will select which technology will best fit their remote interaction. The VT members should have the adequate technology to perform the assigned tasks. In fact there should be a fit between the technology functionalities and the task type for individual performance (Goodhue & Thompson, 1995). VT members should perceive the technology as useful for their tasks execution, moreover the user experience should be perceived as intuitive and the functionalities should be perceived as easy to use (Bruner & Kumar, 2005; Chen & Chang, 2013; Davis, 1989).

The capabilities provided by the technology will determine the position of the VT in the virtual continuum along with the structure, and the task complexity (Griffith & Neale, 2001). The team's members had to be trained to fully exploit the capabilities offered by the technology (Hertel, Geister, & Konradt, 2005). Moreover, training on the collaborative tools may become critical for collaboration in VTs (Anderson et al., 2007). Acquiring the skills through training on computer mediated communication tools will help in improving the VTs efficacy (Fuller, Hardin, & Davison, 2006). In another study, Hertel showed that training will increase team members' satisfaction and cohesion (Hertel et al., 2005).

The type of the technology used and its richness in terms of functionalities will have a positive impact on: the team effectiveness, the amount of interactions (Carlson & Zmud, 1999; May & Carter, 2001), the members' relationships (Pauleen & Yoong, 2001), and members' commitment to the team (Workman, Kahnweiler, & Bommer, 2003).

5.4.1.3 Family 3: Collective's Strategic Directives

The lifespan is determined by the lifecycle and the synchronicity. The lifecycle refers to the working duration for which the team is temporary or long term. Whereas the synchronicity refers to the timing of the members' interaction during tasks execution. In VTs, the lifecycle is temporal and based on the project deliverables. Researchers have found that the VTs lifecycle tend to be shorter compared to F-to-F teams (Jarvenpaa & Leidner, 1999).

The success of VTs or its failure highly depends on the context in which the team works to achieve its objectives. VTs cannot achieve their missions even if the team had a well-defined structure, clear roles and responsibilities and internal processes or they lack the proper resources, the adequate training and the complete set of information about the tasks. Hence, the context defines a set of variables that need to be examined whenever setting up a VT. These variables will establish the environment where the VT' members will participate and interact to fulfill their tasks effectively (Staples & Cameron, 2005). These variables are:

- A reward system should be in place at the beginning of VTs (Bal & Teo, 2000; Hertel et al., 2005). It has to be designed in a way to encourage the members' contribution, and support the development of new capabilities. In a survey conducted by Lurey and Raisinghani 2001, in order to understand the factors affecting the success of VTs, they found out that the reward system is associated strongly with the success of VTs as external support mechanism (Lurey & Raisinghani, 2001). The achievement of objectives and tasks must be recognized and rewarded (Bal & Gundry, 1999).
- Technical training sessions and workshops should be regularly available for VT members. It will help them to do the required tasks.
- In addition to technical training, sources of information should be accessible by VT members. An incomplete set of information may impact the effectiveness to complete the tasks.
- And finally, all other resources should be available, including IT infrastructure.

5.4.1.4 Family 4: Collective's Structure

The structure as described by McGrath, refers to “the nature and the strength of patterns of relationships among individuals in work groups” (Joseph Edward McGrath, 1984). The common two patterns of relationships are the line and the lateral. The line relationships exist between a manager and the members directly reporting to them. The lateral relationships exist between the members on the same level in the organization chart and reporting to their respective line managers. In cross-functional project, the lateral relationships between the functions' leaders can improve the visibility and clarify the project's objectives for the teams' members, secure and allocate the project's resources, and affect the operational performance of projects (Anthony, Green, & McComb, 2013; McComb, Kennedy, Green, & Compton, 2008). Ghosal found also that lateral relationships activities can develop interpersonal relationships that may increase the communication effectiveness e.g. joint action in project teams, task forces and committee meetings (Ghoshal, Westney, & Westney, 1995). Practically, a flatter reporting structure or delayering will reduce the hierarchical structure levels and coupled with the use of communication technologies can increase the lateral communication in virtual context (Wong & Burton, 2000). However, a changing and a dynamic team structure may increase uncertainty and risks. This uncertainty will manifest into reluctance to share information until the VT members reestablish trust with the new members (Gibson & Gibbs, 2006).

The VT structure can be formed from mono-site or multiple sites members. In addition, the members can have the same line manager or multiple managers. Cascio and Shurygailo have identified 4 forms of reporting structures (Cascio & Shurygailo, 2003):

- Teleworkers: members located at one site and reporting to a single manager.
- Remote team: members distributed at multiple sites and reporting to one manager.
- Matrixed teleworkers: members located at one site and reporting to multiple managers.
- Matrixed remote team: members distributed at multiple sites and reporting to multiple managers.

Size

VT's size refers to the number of members constituting the team's structure and working together to achieve common objectives. The size varied between small teams constituted of 5 to 7 members and large teams constituted of more than 20 members. In case of large teams, the team dynamics may decrease and the interactions between the members can deteriorate (Bal & Teo, 2000). Controversially to another group of researchers who argued that the size limitations may hinder the realization of the team's objectives (Duarte & Snyder, 2007; Harris & Harris, 1996). The team size may go as large as it required to include all the necessary expertise and skills to complete the tasks. The impact of the size of the VT effectiveness may also depend on the task complexity and the technology capabilities. The use of multiple technologies may ease the exchange of information in large teams. So, in a discussion type task relying solely on audio-conferencing technology, the increase in size may impact negatively the communication inside the team (Hansen, 2004). Thus there is no one-size-fits-all for teams. The optimum size should be determined in function of the team's objectives, required skills and the multitude of technologies used.

Cohesiveness

Cohesiveness or bonding is the links that tie together the team members. The classical definition of group cohesiveness is described by Festinger as "the resultant forces which are acting on the members to stay in a group" (Festinger, 1950). A more developed definition is described by Carron as "a dynamic process which is reflected in the tendency for a group to stick together and remain united in the pursuit of its goals and objectives" (A. V. Carron, 1982). Researchers have agreed that group cohesiveness have two main components: social cohesion and task cohesion. The first being the interpersonal attraction among the members and to the group. The second being the members' commitment to the tasks (Beal, Cohen, Burke, & McLendon, 2003; B. S. Bell & Kozlowski, 2002; a. V. Carron & Brawley, 2000).

Over the years, the studies in the literature considered the group cohesiveness as a possible predictor of group performance. It will be inappropriate to study the organizational performance without taking into consideration the group cohesiveness (Elenkov, 2002). Groups with high social cohesiveness and specially within VTs had greater group satisfaction (Chidambaram, 1996). Similarly, a student VT working on

educational projects were effective to meet the project's deliverables. Task cohesiveness was positively correlated with the VT effectiveness (González, Burke, Santuzzi, & Bradley, 2003). On the contrary to Aiello 1995, the task cohesiveness didn't lead to higher level of VT effectiveness over F-to-F teams for simple tasks (Aiello & Kolb, 1995). Some studies considered that both components; social cohesiveness and task cohesiveness should be developed in order to impact positively the group performance (Craig & Kelly, 1999; Zaccaro & McCoy, 1988). In cooperative movements context - autonomous organization whose members come together to achieve jointly a common interest - Harun has concluded that the degree of group cohesiveness can increase the movements' performance and steer its future direction (Harun & Mahmood, 2012). In the banking industry study, it showed that the group cohesiveness and members with higher organizational tenure has positive impact on the organizational performance (Banwo, Du, & Onokala, 2015).

5.4.1.5 Family 5: Collective's Composition

The collective composition characteristics were found in both the VT and the VCoP literature.

Composition characteristics from VT literature

The VT members are composed from different functions and potentially multiple networks based on their skills and competences. Actually, the VT will be composed of various know-how, technical expertise and abilities that enable it to complete the tasks, in addition to information system skills and communication skills (Martins, Gilson, & Maynard, 2004). The right selection of VT's members having the desired technical expertise is associated positively with the VT's success (Kayworth & Leidner, 2000).

Members are diverse but working together in multidisciplinary and cross-cultural environments, assumptions, motivations and working modes (Shapiro, Furst, Spreitzer, & Von Glinow, 2002). This diversity will impact the internal group relationships and members' interactions (Duarte & Snyder, 2007). Yet, this diversity can have negative consequences on the cost, the stress level (AitSahlia, Johnson, & Will, 1995), the cohesiveness among the members (Jehn, 2001), the conflicts and difficulties to achieve consensus among functions, and political issues (Lovelace, Shapiro, & Weingart, 2001). A functionally diversified VT can stimulate

misunderstanding and frustration in problem and conflict resolution (Church, 1995). It may affect the personal attitude and behavior toward the team's ability to generate solutions (Duarte & Snyder, 2007).

Composition characteristics from the VCoP literature

The cross-functionality is the principle and the nature of VT formation. Therefore, a special attention and extra efforts should be invested whenever the top management want to put in place virtual teams. These additional characteristics are:

- 1) the membership selection process can be closed with predetermined criteria to have tighter control over the team/ community or open to all members for organization-wide knowledge sharing purposes (Plant, 2004; Wenger & Synder, 2000). In case of open membership, the interested members have to contribute to the community in order to pass from peripheral members to core members (Wenger et al., 2002).
- 2) The members' enrollment can be voluntary, encouraged or compulsory (Leavitt & Paige, 2001). In a top down approach, undesirable results could be obtained where the members are drafted and their participation is compulsory (Schwen & Hara, 2003). The drafted members may face legitimacy problems as the community is expecting meaningful contribution from this forced participation. Advantageous results may be obtained from self-motivated members who chose willingly to enroll in the community (Bridges & Mitchell, 2000) . The top management has to encourage the enrollment of hesitating members and make their participation appealing in the communities.
- 3) The members' prior community experience to the actual VT and/ or virtual community. It can range from extensive, to moderate, to low and even no experience at all (Dubé et al., 2006; Hara et al., 2009). The top management can leverage members who are already working in networks and groups to form a new virtual community (E. Lesser & Everest, 2001; Mcdermott, 1999). The prior community experience had double-sided effects while transitioning from the existing groups to the newly created virtual community: from one side, it can remove the members' hesitation to work as a collective and from

the other side, it can create resistance in adopting the new working methods and technologies. Especially if they had success stories while working in co-located environment.

- 4) Membership can be stable where members are permanent or fluid if the members are changing. It's normal to find a fluid membership in organizational restructuring or transformations (Storck & a, 2000). However, a radical change in the membership will alter the negotiated norms, value and interaction habits. A socialization process between the new members and an adaptation process to the new organization may be triggered to re-establish the balance to the community (Wenger et al., 2002).
- 5) Community leadership can either be defined by the management in a top-down approach (Gongla & Rizzuto, 2001) or negotiated by the community's members in function of the required expertise for a specific practice (E. L. Lesser & Stork, 2001). As community size grow, the top management may clearly assign specific roles inside the community as needed (Fontaine & Prusak, 2004).

These additional characteristics for the collective's composition may bring outstanding results if carefully designed and managed.

Synthesis of 5.4.1 Forming and transforming the collectives

Table 18 summarizes the proposed characteristics for the forming and transforming phase.

Collective's phase	Characteristics family	Characteristic
Forming and Transforming	Collective's task design	Complexity
		Novelty
		Interdependence
		Autonomy
		Feedback

	Collective's technology	Availability
		Tools Training
		Perceived usefulness
		Perceived ease of use
		Task-technology fit
	Collective's strategic directives	History
		Technical training
		Purpose
		Reward System
		Life Span
		Context
	Collective's structure	Relationship
		Physical distribution
		Structure
		Size
		Cohesiveness & Bonding
	Collective's composition	Skills
		Diversity
		Member selection process
		Member's enrolment
		Prior group experience
		Level of commensurability
		Membership
		Consensus on leadership

Table 18: Summary of the proposed characteristics for forming and transforming phase.

5.4.2 Storming and norming the collectives

5.4.2.1 Family 6: Collective members' interactions

The collective's interactions are developed through interdependent actions. These interactions are formalized as collective's processes which are sequences of tasks on how the collective should perform and achieve its objectives (Weingart, 1997). Three main process types can be identified to cover multiple interactions aspects and they are: planning, action and interpersonal processes (Marks, Mathieu, & Zaccaro, 2001).

The planning processes set the collective's strategic direction and guide the collective's effort towards the future destination. It will include the mission statement, priorities identification, resources allocation and any other process related to satisfy the collective's objectives. The action processes put in order the internal collective's dynamics during the tasks' execution. For example, the communication, the coordination, the evaluation and the reporting. Finally, the interpersonal processes denoted to relationships among the collective's members. For example, trust, cohesiveness, attitude during the interactions, socialization, and affection, among others.

The processes need to be aligned with the collective's capabilities in a virtual environment contrary to F-2-F teams (Ebrahim et al., 2009). The alignment required a deep understanding of the process's tasks and what is necessary for their execution in a virtual context (Bal & Gundry, 1999). However, the members' participation in the process is not only dependent on the virtual capabilities but it's conditioned with their willingness to be active in these processes (Rosen, Furst, & Blackburn, 2007). Many researchers have studied the effect of virtual interactions on the participation levels. They noted that the participation levels in virtual settings become as important as in F-2-F since electronic communication had reduced the social status which lowered the distinctions among the members (Dubrovsky, Kiesler, & Sethna, 1991; Andrea B. Hollingshead, 1996; Straus, 1996).

In virtual communities of practice, the members' interactions are established through mutual engagement. The members participate in the processes as a joint enterprise in a given domain of knowledge. Over time, they learn, share and develop their knowledge through a shared repository where they stock and retrieve their common resources (e.g., guidelines, artefacts, practices...) (Wenger, 1999).

5.4.2.2 Family 7: Collective's health

A healthy collective will have significant impact on its effectiveness and its ability to perform the tasks. In a virtual context, a common identity was of greater importance to maintain the team's ability to work on future projects (Walther, 1997). A common identity had been associated with a healthy group and it has influenced the members' interaction, their commitment to the group and the trust for each other's (Kramer & Brewer, 1986). The trust had also significant impact on the collective's health (Sarker,

Valacich, & Sarker, 2003) and the success of the project's tasks (Greenberg et al., 2007). It can ease the impact of the geographic dispersion on psychological intimacy (Walther, 1994). Trust was described as the "glue of global workspace" (O'Hara-Devereaux & Johansen, 1994). It is considered as a good indicator for a healthy collective work. Trust can be evaluated with respect to reputation and collaboration. Reputation referred to the trustworthiness of members and collaboration referred to the extent the members engage in joint activities (Fan, Suo, Feng, & Liu, 2011). Group potency referred to the group trust or belief in its capabilities to attain the group's objectives (Guzzo, Yost, Campbell, & Shea, 1993). The group potency is found to be a strong influencer on the group effectiveness (Shea & Guzzo, 1987). Members who considered that their group have high capabilities had higher satisfaction for their participation and higher motivation to perform their tasks (Staples & Cameron, 2004). The work assigned to these collectives' may be of high relevance to their daily responsibilities or low relevance but still related to the organizational goals (Dubé et al., 2006; Frasin & Blanco, 2013).

The collectives are not isolated entities inside the organization, and their corporate recognition degree will offer them the required legitimacy and funding (Leavitt & Paige, 2001). In the case of virtual communities, the corporate recognition degree is referred to the extent at which the communities are integrated into the formal organization's structure (Wenger et al., 2002). The formalization level may take several forms ranging from unrecognized, bootlegged, legitimized, supported and finally to institutionalized. A virtual community with unrecognized formalization level is invisible to the organization's functions, whereas an institutionalized community had official status and role inside the organization (Wenger et al., 2002). In the case of institutionalized virtual communities, they are considered as strategic assets to capitalize on the created knowledge, improve it and reuse the new practices in other projects (Wenger, Trayner, & De Laat, 2011). However, they will face external forces from the wider organization environment, this will include: economical, cultural, political and management styles especially in multi-national companies (Mcdermott & O'Dell, 2001). The organizational slack referred to the organizational ability to provide the necessary resources for the community and accept the inherited cost of the non-productive phase (Dubé et al., 2006; Frasin & Blanco, 2013). The organization should be also committed to provide all the

necessary resources to facilitate the success of these institutionalized virtual communities.

Synthesis of 5.4.2 Storming and norming the collectives

Table 19 summarizes the proposed characteristics for the storming and norming phase.

Collective's phase	Characteristics family	Characteristic
Storming and norming	Collective members' interactions	Processes
		Process alignment
		Participation level
		Mutual Engagement
		Joint Enterprise
		Shared Repository
	Collective's health	Identity
		Trust
		Potency
		Shared mental model
		Topics relevance to members
		Growth Opportunities
		Corporate recognition degree
		Organizational commitment

Table 19: Summary of the proposed characteristics for storming and norming phase.

5.4.3 Collectives performing

During the performing phase, the collectives will produce outcomes as result of their efforts. The evaluation of these outcomes has two measurement dimensions: the performance and the satisfaction.

5.4.3.1 Family 8: Collective's performance

The collective's performance is mainly defined as the ability of the group to meet its objectives or fulfill its mission (S. T. Bell, 2007). The evaluation of the team's performance is based on 5 criteria as defined by Gluckler and Schrott : "cooperation, quality of work, reliability, communication and flexibility" (Glückler & Schrott,

2007). The collective's effectiveness is defined as the extent to which the goals are fulfilled, contrary to the efficiency that embed the cost metrics in defining the goals' success.

Peter Drucker considered effectiveness as an organizational competency that can and must be learned by the executives (Drucker & Maciariello, 1967). For that, he identified 5 management practices for business effectiveness:

1. Managing time.
2. Choosing what to contribute to the organization.
3. Knowing where and how to mobilize strength for best effect.
4. Setting the right priorities.
5. Knitting all of them together with effective decision-making.

According to prominent researchers in the field of team performance (S. Cohen & Bailey, 1997; J R Hackman, 1987), the team effectiveness has 3 main aspects to evaluate:

1. the productivity level or the actual work done, it has to be evaluated by external stakeholders such as the customers, or the experts outside the team.
2. the team's ability to improve its internal processes and the capability of the team's members to carry out together a future project. In situations where the team consumed all its efforts or reached a burnout state, it's difficult to consider that the team was effective.
3. the member's satisfaction with the working process and the produced outcome. As social entity, the team had to provide the members with growth opportunities and career development, and not only perceive its members as resources to solve the targeted problems.

5.4.3.2 Family 9: Collective members' satisfaction

The collective members' satisfaction or the affective outcome of the team. It's defined as the extent to which the team's members are satisfied with the decisions made, the agreements and the conflict resolution process to produce the actual work (Chidambaram, 1996). It measures also the extent to which the members like working with their team's members and willing to stay in the team. The satisfaction is an

intrinsic factor like trust and integrity and can only be measured through qualitative methods e.g. surveys and interviews (Hiba, Abdou, & Idrissi, 2012).

Synthesis of 5.4.3 Collectives Performing

A summary of the proposed characteristics for performing phase is presented in Table 20.

Collective's phase	Characteristics family	Characteristic
Performing	Collective's performance	Quality of work
		Controlling costs
		Productivity
		Supervisory behaviors
		Product reliability
	Collective members' satisfaction	Satisfaction with the process
		Satisfaction with the deliverables
		Social relationships

Table 20: Summary of the proposed characteristics for performing phase.

5.4.4 Proposal of the Virtual Collectives' dynamics (VCD) model

Based on the analysis of the literature, we synthesized the characteristics into families. We proposed a model to characterize the virtual collectives' dynamics for every collective's development phase. Figure 35 illustrates the 9 families of characteristics with respect to the three development phases (forming & transforming, storming & norming, and performing). For example, the collective members' satisfaction and the collective's performance families characterized the "collectives performing" phase.

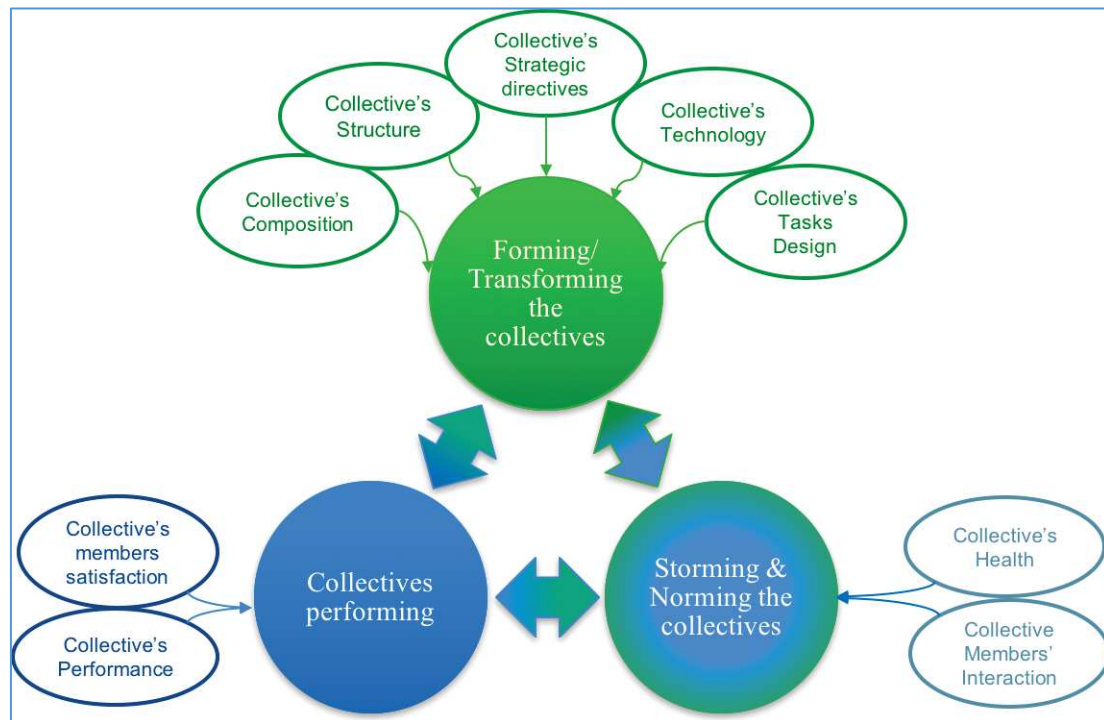


Figure 35: Proposal of the Virtual collectives' dynamics (VCD) model

5.4.5 Defining the Critical Differentiator Factors (CDFs) from literature

Having in mind that we are interested in dominant characteristics that can clearly define the frontiers of every virtual collective we are searching for characteristics that differentiate the virtual collectives. The 9 characteristics families included 51 characteristics that portrayed the virtual collectives. For example, the size characteristic for all the four virtual collectives' types can range from small to large. However, we identified 7 from the 51 characteristics that allowed the separation of the virtual collectives' types. We classified them as critical differentiator factors (CDFs). Table 22 presents the 7 CDFs and to which characteristic family they belong to. The 7

CDFs are: Purpose, membership, bonding, diversity, structure, life span and processes.

Characteristic family	Characteristic as differentiator	Description
Collective's strategic directives	Purpose	What is the virtual collective for and if there are any produced capabilities?
Collective's composition	Membership	Who belongs and what are the belonging's conditions?
Collective's structure	Bonding	What ties the members together and why they collaborate together?
Collective's composition	Diversity	Do they have different cultures, values, profiles and expertise?
Collective's structure	Structure	How the virtual collective is organized and connected?
Collective's strategic directives	Life span	What is the virtual collective duration and when does it disband or evolve?
Collective members' interactions	Processes	How the members work together or interact in the virtual collective?

Table 21: Selection of the critical differentiator factors

Table 22 shows the literature references for these CDFs. We supposed that with these CDFs, we can eventually draw a virtual frontier between the virtual teams, virtual community of interest, virtual community of practice and networks for learning.

Characteristic as differentiator	Virtual Teams	Virtual Community of Interest	Virtual Community of Practice	Networks for learning
Purpose	(G. Huber, 1990; Lipnack & Stamps, 1997; Lurey & Raisinghani, 2001)	(Fischer 2001; Wenger et al. 2002)	(Wenger, 1999; Wenger et al., 2002)	(Engel & Alders 1993; Engel 1997; Checkland & Scholes 1999)
Membership	(Lipnack & Stamps, 2000; Sadri & Tran, 2002)	(Nousala & Hall, 2008; Wenger et al., 2002)	(Murillo 2011; Lave & Wenger 1991)	(Engel, 1997)
Bonding	(Granovetter, 1973; Joseph Edward McGrath, 1984)	(Andriessen, 2006; Mcdermott, 1999)	(Murillo, 2011b; Wenger et al., 2002)	(Engel & Alders, 1993)
Diversity	(S. G. Cohen & Bailey, 1997; Lipnack & Stamps, 2000)	(Fischer & Ostwald, 2005)	(Dubé et al., 2006; Wenger et al., 2002)	(Engel, Carlsson, & Zee, 2003)
Structure	(Jarvenpaa & Leidner 1999; Wong & Burton 2000)	(Fischer, 1995; Wenger et al., 2002)	(Leavitt & Paige, 2001; Wenger et al., 2002)	(Engel & Alders 1993; Hustad 2010)
Life Span	(Bell 2002; Bal & Teo 2000; Paul et al. 2005)	(Fischer, 2001)	(Dubé et al., 2006; Wenger et al., 2002)	(Engel, 1997; Engel & Alders, 1993)
Processes	(Bradford S Bell, 2002; Joinson, 2002)	(Fischer, 2001; Wenger et al., 2002)	(Hildreth & Kimble 2004; Lave & Wenger 1991)	(Cummings & Zee, 2005)

Table 22: Literature references for the critical differentiator factors.

5.5 Proposing the Virtual Collectives Framework from literature

Up till now, we have defined the virtual collectives' types: Virtual Team, Virtual Community of interest, Virtual Community of Practice and Networks for Learning. We have also differentiated them by the critical differentiator factors (CDFs). In this section, for every virtual collective's type, we applied and attributed values to the CDFs.

5.5.1 CDF's application to the virtual teams

In the business context, virtual teams are defined to run and accomplish projects. Apparently they are virtual project teams and they are initiated for specific purposes. Lipnack & Stamps state that virtual project teams are like any team whose tasks are interdependent but guided by specific purpose (Lipnack & Stamps, 1997). This purpose can involve multiple departments to implement a specific management system, to study technical proposals or to improve existing processes. It appears also essential that the common purpose is supported through visual communication like team charter (Joinson, 2002). Team members are selected with different profiles from different functional units and are bonded together to execute the project's deliverables and to meet the project's milestones. Cohen & Bailey reflect that a multitude of knowledge and expertise should be applied in project teams (S. G. Cohen & Bailey, 1997). Memberships in VTs tend to be temporal and in function of the project planning. For example, a quality engineer may be called to inspect a welded structure and if it meets the quality sheet criteria's. VT boundaries are more permeable than traditional project teams where the expertise may be located anywhere in a multi-site company. VT context is one of the characteristics introduced by Wong & burton, to qualify virtual teams highlights the dynamics of teams that can be quickly setup to face new problem or market opportunity involving dispersed expertise in a non-routine task (Wong & Burton, 2000). This point is also present in the following authors (Aziz, Gao, Maropoulos, & Cheung, 2005; Bal & Teo, 2000; Gassmann & von Zedtwitz, 2003b) definitions that include the temporary aspect in the virtual team lifetime or for some team members. VTs form and disband as organizational goals change (Jarvenpaa & Leidner, 1999). Bell suggests also that the lifecycles of virtual teams are largely determined by the nature of the tasks these teams perform (Bradford S Bell, 2002). If turnover is high, time and effort will be spent orientating new members on contrary to teams whose membership is stable. Team history can be an

important element for the team performance. The composition dimension is the second characteristic from (Wong & Burton, 2000). The composition characterizes the heterogeneity of members that can be identified by organizational belonging, cultural backgrounds, languages, expertise differences etc. The third characteristic of Wong and burton (2000) is the structure of a group that describes the nature of links between the team members referred as patterns of relationships among individuals in work groups by (J E McGrath, 1964). Virtual teams are mainly lateral and weak relationships. Lateral links are supposed to facilitate coordination and information flow. In virtual teams, the relationships between members tend to be lateral but weak due to the physical dispersion and the nature of the work that virtual team members are typically engaged in. Lateral communication ties often connect VT members. Based on Granovetter's weak tie model (combination of the amount of time, emotional intensity, intimacy, and reciprocal services) (Granovetter, 1973), Wong & Burton found that ties between virtual team members are lateral and weak (Wong & Burton, 2000). Structural dynamism within the team may be controlled by: setting up firm rules for communication to avoid loss of knowledge (Joinson, 2002); encouraging mentoring relationships between members, as this allows members to adapt quickly and feel part of the team (Sadri & Tran, 2002); and by encouraging knowledge transfer by having regular meetings. As tasks become more complex, integration and coordination among members requires formal mechanisms. Therefore, it becomes more difficult to recruit new team members. Teamwork, communication and feedback processes become more important when members' roles are interrelated and coordination is required as stated by (Bradford S Bell, 2002).

5.5.2 CDF's application to the virtual community of practice

The second virtual collective is VCOP where members participate in communal learning as they are situated in the community. Lave and Wenger saw the acquisition of knowledge as a social process, where a newcomer to the community advances in his apprenticeship by increasing his participation and getting acknowledged. The process by which a newcomer learns by being situated in the group was central to their notion of a CoP. They termed this process as legitimate peripheral participation (LPP). In such a community, a newcomer learns from seniors who share their experiences in story telling fashion. A newcomer is a debutant practitioner. The opportunity is given to him to participate in certain tasks in relation with the

community's practices. Over time the newcomer moves from peripheral to full participation. Lave and Wenger regarded a Community of Practice as "an intrinsic condition for the existence of knowledge". For Lave and Wenger, the participation in the community is crucial for developing the practice (Lave & Wenger, 1991). Being a member of a VCoP implied participation in the community's activities where members have a common understanding about their domain of knowledge. This domain creates the ties between the members, forms their joint enterprise and constitutes their unified identity (Wenger et al., 2002). Members interact together through mutual engagement as these interactions impact directly their daily work. Unlike face-to-face communications, Internet based communication enlarge the scope of mutual engagement and expand the possibilities of interactions (Murillo, 2011a). A set of communal resources result from the mutual engagement. Usually, these resources are stored in a shared repertoire such as practices, artefacts, routines and symbols. In particular, artefacts play an important role of sustaining the participation in the community. They act as knowledge objects to symbolize implicit knowledge in the process of creating and sharing knowledge. Hildreth and Kimble observed that the process of creating the artefact and mid-term face-to-face meetings are influential in maintaining the relationships that allow a CoP to function successfully in a virtual environment (Hildreth & Kimble, 2004). Thus, paradoxically, it appears that one of the keys to a successful VCoP is an occasional, non-virtual, face-to-face meeting. Wenger also identified two key processes to belong to CoP: participation and reification. He described participation as: "... the social experience of living in the world in terms of membership in social communities and active involvement in social enterprises" (Wenger, 1999) and reification as: "... the process of giving form to our experience by producing objects that congeal this experience into thingness" (Wenger, 1999). Membership commonly crosses boundaries across work groups, organizational units and even organizations. Informal discussion tends to increase the level of trust between members, which has positive consequences on sharing knowledge. While members dispersion and boundary crossing hinders the informal communication, the level of trust between members is affected (Wenger et al., 2002). A VCoP may have permanent members (i.e., a stable membership), but can also have changing membership, ranging from moderately stable to fluid. Members' enrollment can take many forms, from voluntary to strongly encouraged, to compulsory (Leavitt & Paige, 2001). VCoPs life span varies widely (Wenger et al., 2002). While it may

initially be indeterminate, a VCoP can be assembled on a temporary basis to accomplish a specific purpose (e.g., a response to an ad hoc environmental change), but is usually created on a permanent basis with no definite time frame, as an on-going mechanism to develop practices. VCoPs are often created to break organizational silos and promote collaboration, learning, and knowledge sharing (Dubé et al., 2006; Fraslin & Blanco, 2013).

5.5.3 CDF's application to the virtual community of interest

On contrary to VCoP, the purpose of a VCoI is less specific. It consists of being informed, discussing and sharing understanding about a topic, problem or concern that interested community members. VCoIs are usually temporary (Fischer, 2001) because they arise together in the context of a specific common interest and when this interest becomes less important, the community tend to dissolve itself. VCoI membership is usually open. Everybody who is interested in the information that is managed by the community can access it (Wenger et al., 2002). Individuals are involved in the community in an ad-hoc manner (Nousala & Hall, 2008), when they want to exchange questions and solutions about the common interest (Mcdermott, 1999). This exchange among community members produces mutual needs that are the motivation to hold them together (Wenger et al., 2002). VCoI members do not have a strong identity because relationships are always shifting and changing (Andriessen, 2006). A community of interest is then a different structure than a community of practice. A VCoI is characterized by a shared common interest and its purpose is that everybody interested can access and exchange information. VCoI members hold together because they want to be informed. VCoI members are bonded together just because they want access to information and participation about a collective interest or concern with the resolution of a particular problem. So whoever is interested in the common shared topic or concern of the community can join. This structure could bring together stakeholders from different domains and even CoPs (Fischer, 1995), collecting different perspectives and enhancing diversity. VCoI structure is dynamic and based just on participation. Because VCoIs are structures formed by stakeholders from multiples domains, members are considered both experts and novices at the same time: they are experts when they communicate their knowledge to others, and they are novices when they learn from others who are experts in domains outside of their own knowledge (Fischer & Ostwald, 2005). VCoI does not have any regulated

function. There is no specific way to build either a collaborative relationship or negotiated rules. As a result, it is a more suitable structure to encourage creativity and innovation.

5.5.4 CDF's application to the networks for learning

In networks for learning, the network partners share common objectives but they are still autonomous and contribute their resources, their skills and their assets voluntarily. The network partners have a set of common activities and regular events. Participants must commit act upon the network priorities. They must be motivated by self-interest because networking is closely related their daily work and a potential added value for their careers. Networks for learning often goes through a process of institutionalization (Wielinga 2001) as cited by (Cummings & Zee, 2005) . Each network develops its structure as a combination of agreements, procedures, and culture. It is important for a networking process not to lose its flexibility – which can happen when procedures and controls are becoming predominant and vitality, enthusiasm and satisfaction flow away (Cummings and Zee, 2005). Engel argued that social learning is a complex activity that manifests itself in a relatively stable change in person's behavior or a group of persons (Engel, 1997). Engel argued that actors in networking for learning invest in new ways of communication to organize themselves, to learn, to network, to cooperate and to collaborate for innovation - the output of the social learning process (Engel et al., 2003). Through these ways of communication, actors leverage their capacity to learn and implement new practices faster. It's through these communications those actors and stakeholders become practitioners. These practitioners are at the core of networking for learning: as active, as knowledgeable participants who can take decisions and resolve conflicts. The practitioners interact with each other's through interfaces and shared boundaries. They are linked together through knowledge bonds for joint learning and they continuously interchange their experience. These links allow the exchange of intangible assets such as information, expertise and techniques, tangible assets such as logistics, financial resources and other assets, such as power, status, or even good intentions. Practitioners' participation also involves their contribution to the decision making process that will impact their daily activities and it will be conducted. Strongly related to participation is the notion of volition, as described by (Engel & Alders, 1993). Volition emphasizes sense making to create comprehension, purpose and commitment to decisions that

have been taken. Volition should also be fluid: an informed and thoughtful volition, which is always subject to evaluation and re-formulation. Volition requires mutual engagement from all actors to make it possible.

As summary, the application of the critical differentiator factors to the 4 virtual collectives' types resulted in the definition of the Virtual Collectives' Framework as shown in Figure 36.

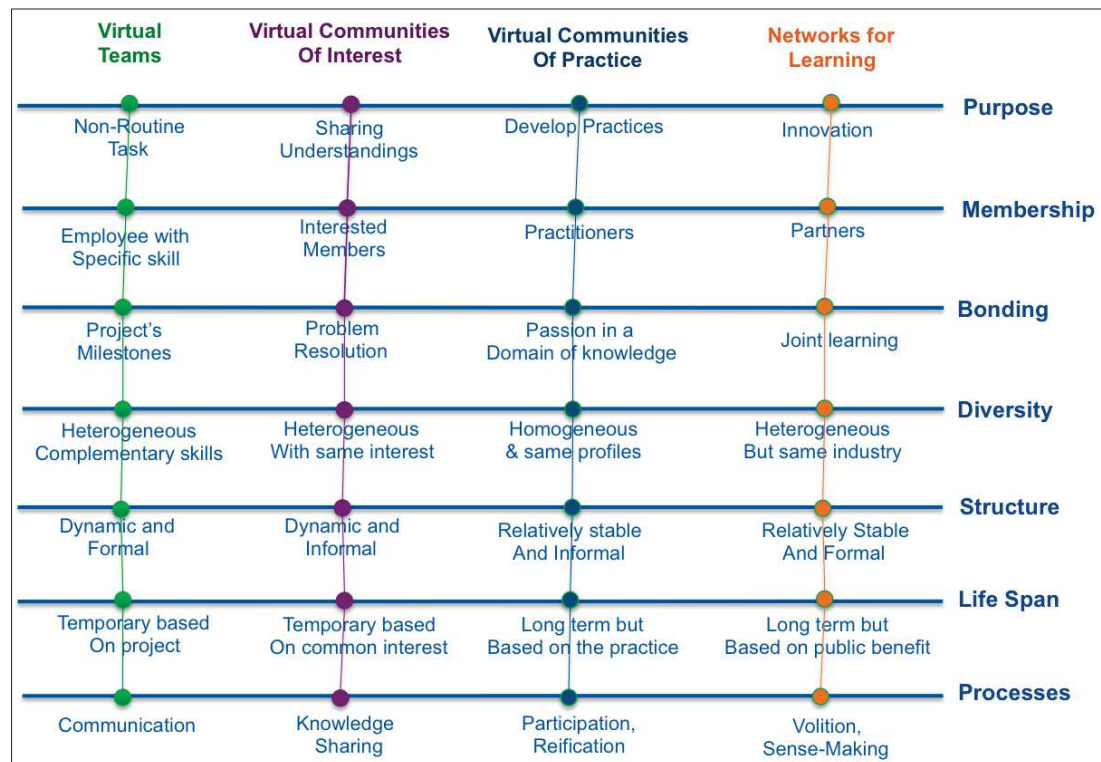


Figure 36: Proposal of the virtual collectives' framework (VCF).

5.6 Developing tools for the Virtual Collectives Framework

In order to facilitate the implementation and the application of the virtual collectives' framework by the managers, we have developed a set of tools to help the managers to operationalize this framework. The 3 proposed tools correlate with the 3 phases of the virtual collectives' dynamics model. The tools are as follows:

- Virtual collective's identification tool for the forming and transforming phase.
- Virtual collective's interactions tool for the storming and norming phase.
- Virtual collective's recognition tool for the performing phase.

5.6.1 Virtual collective's identification tool

THE NEED FOR AN IDENTIFICATION TOOL

The proposed virtual collectives' framework laid out the conceptual foundation to characterize and differentiate the virtual collectives' types (Section 5.5). However, at early phases of the project definition, the standardization manager found difficulties to fully characterize the virtual collectives in advance of the project phases. The standardization manager expressed his need for a decision making tool. He required that the tool has to enable him to quickly identify the virtual collectives' types for the project's objectives. Later on, for a specific project's objective, the standardization manager would fully characterize the selected virtual collective type.

The question raised with the standardization manager was: "which critical differentiator factor should we select from the VCF to quickly identify the proper virtual collective's types?"

In order to find the dominant CDFs, we listed and discussed them with the standardization manager. In fact, at the project's initiating phase, the standardization managers defined the project's milestones and a macro planning for the project development. The standardization manager correlated the two CDFs: purpose with the project's milestones and process with the project's planning. We made the assumption that the purpose and the process were the two dominant CDFs that would quickly identify the virtual collective's types.

However, the identification of the engineering collective type is not definitive by only relying on the purpose and process differentiators. As the project progress, the manager should refer to the VCF in order to verify the other CDFs e.g. membership, bonding, diversity, structure and lifespan.

PROPOSAL OF THE VIRTUAL COLLECTIVE'S IDENTIFICATION TOOL

The objective of the virtual collective's identification tool is to help the standardization manager to select the proper engineering collective type for a project's objective.

The researcher/ practitioner co-constructed with the standardization manager the virtual collective's identification tool. Figure 37 shows the proposed tool that it is mainly used in the first development phase of the virtual collective's dynamic model

which is the forming/ transforming phase. For example, a virtual team may be selected if the purpose is to fulfill a specific, non-routine task where the team members have to communicate regularly the progress to the team leader. In general, we have identified 4 types of purposes and processes to facilitate the selection of the engineering collectives.

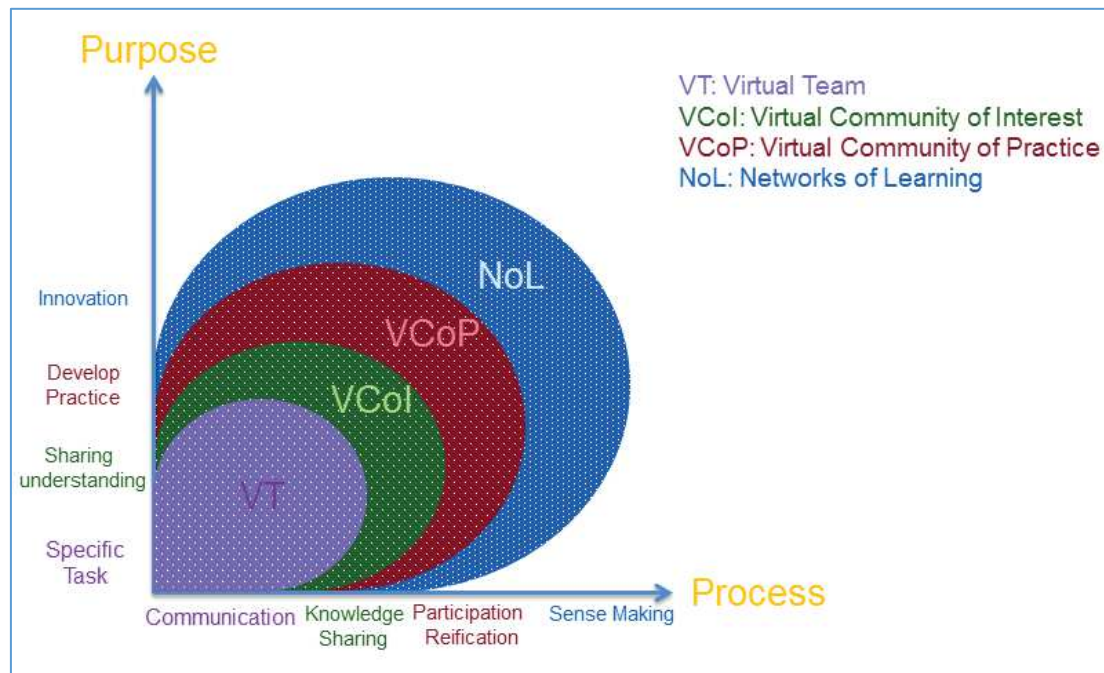


Figure 37: Virtual collective's identification tool.

For the engineering virtual collectives, there are 4 main purpose types are:

- Innovation where the existing practices are challenged and a new practice is developed.
- Develop the best practice where existing practices are collected, evaluated and converged into one best practice.
- Sharing understanding of a given transversal or multidisciplinary problem. It can also be defining a new product for development.
- Specific task or non-routine task occurring for one time. For example, developing a project follow up tool.

For the engineering virtual collectives, there are 4 main process models are represented as follows:

- Communication of information through reporting or follow-up meetings. Conflicts and obstacles can be identified and communicated during this meeting.
- Knowledge sharing and transfer of knowledge are done through trainings and workshops.
- Participation and reification of the members inside the community is done through the discussion forums or the convergence workshops where every member will submit his own practice to define the community best practice.
- Sense-making through learning loop complex is used whenever multiple information sources need to be correlated.

5.6.2 *Virtual collective's interactions tool*

THE NEED FOR AN INTERACTION TOOL

As the project progressed, the members started to work together either through co-located workshops or at distance relying on HySPeC. The standardization manager required a tool to visualize these interactions and if they matched the dynamics of the selected virtual collective type. The structure CDF in the virtual collective's framework (section 5.5) described how the collective is organized and connected for every virtual collective type. The interaction tool was based on the structure differentiator factor.

PROPOSAL OF THE VIRTUAL COLLECTIVE'S INTERACTION TOOL

The objective of the virtual collective's interactions tool was to map globally the collective's interactions and how the members are related to each other. The tool will also help the project leader to visually track and monitor the interactions between the collective's members. In case the virtual collective is a virtual community type, this tool will help the community manager to:

1. Identify the members with weak ties that are on the periphery of the community. Once the leader discovers the members with least interactions, he may take corrective actions to strengthen the relationship between the periphery members. The leader's mission will be to bring back the periphery members to the core of the community.

2. Identify the members with strong ties that form the core of the community. The leader may rely on these members to engage the periphery members into the community interactions.
3. Identify the members with absent ties that have no interactions at all. The leader should coach individually and progressively these members in order to interact with their peers.
4. Track the evolution of the community in terms of membership. And ensure that old members have transferred the necessary knowledge to the new members.

Definition of the tool's key concepts:

- **Community discussion**: A community discussion is a bi-directional communication that is initiated by a demander member and at least one respondent member. The discussion can be launched by a simple question and nurtured by many answers and argumentations (Fraslin, 2013). The discussion should be in coherence with the community domain of knowledge.
- **Community interaction**: An interaction is defined as a community discussion around a given subject that involves at least two community members.
- **Community Graph**: The community interactions are mapped into a graph, which formed the community graph. It will visualize the interactions between the members and how they position their participations in the community.
- **Graph nodes & edges**: Each graph consists of nodes and edges. The node represents the member and the edge represents the interaction between two members or nodes. A group of people with same profiles and interests may form a macro node.

Many graph forms will represent different interaction dynamics and the community graph can have multiple types:

1. Star graph: A star graph has one central node that shares at least one edge with every periphery node. There are no edges involved without the central node (West, 2001a). For example, see Figure 38.

2. Complete graph: In a complete graph, every two nodes are connected with at least one edge. There are no nodes left without an edge (West, 2001b). For example, see Figure 38.
3. Composite star graph: it's a star graph where every node is a sub-graph of type complete graph. For example, see Figure 39.

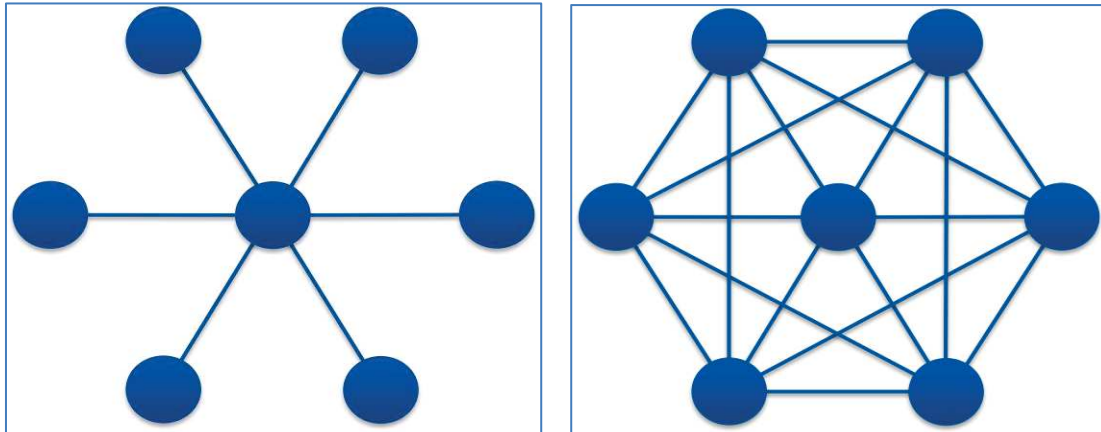


Figure 38: star graph (left) Vs complete graph (right).

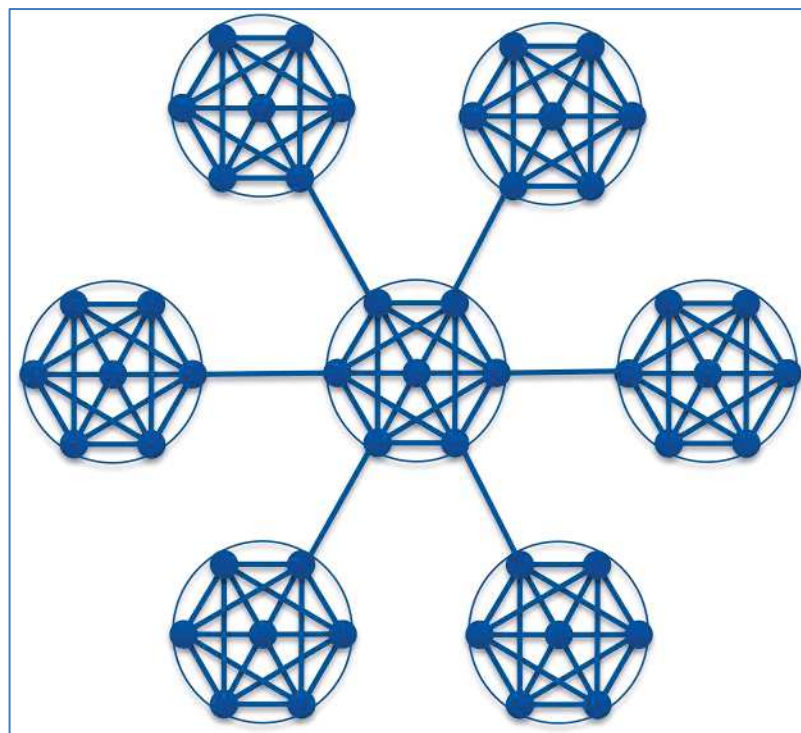


Figure 39: Composite graph

This guideline helped the communities' leaders to model the community graph based on the community development phase. The community went through several phases during its lifecycle. For every phase the rules to model the interactions or to validate the graph type are different. There is a community graph associated with every community phase. The following section detailed the modeling guideline for the community graph.

1. Forming and transforming:

- a.* Community Graph Type: Star graph
- b.* Graph (macro) Central node: project team leader/ initiative director/ sponsor/ Top management representative.
- c.* Graph (macro) Periphery node: one macro node per region
- d.* Graph edges: discussions between the leader and the regional director and any additional participants within the same meeting.
- e.* Sematic rule:
 - i.* The interactions should be around the objectives and the strategic importance of the initiative.
 - ii.* Members of the project management team are always in the central node.
 - iii.* Regional members are always in the periphery nodes.
 - iv.* Members of one macro node cannot exist in another macro node.
 - v.* Members with no interactions are modeled as a node with no edges.
 - vi.* All stakeholders identified in this phase can be modeled in the community graph.

2. Storming and norming:

- a.* Community Graph Type: complete graph
- b.* Graph (macro) central node: community facilitator/ community moderator.
- c.* Graph (macro) periphery node: community members'/ functions representatives
- d.* Graph edges: discussions between the community moderators, the functions representatives and the community members.

- e. Sematic rule:
 - i. The interactions are negotiations around the alternative solutions, their limitations and their requirements.
 - ii. The community moderators and facilitators are always in the central node.
 - iii. Functions representatives are always in the periphery nodes.
 - iv. Community members can be in the central node as well as the periphery node.
 - v. Members with no interactions are modeled as a node with no edges.
 - vi. Only members and functions representatives in this phase can be modeled in the community graph.

3. Performing

- a. Community Graph Type: composite graph
- b. Graph (macro) central node: community members/ engineers.
- c. Graph (macro) periphery node: other functions engineers.
- d. Graph edges: execution of the tasks by the community members and the other functions engineers.
- e. Sematic rule:
 - i. The interactions are reaffirmation of the selected solution, its implementation, and communication.
 - ii. The community members constitute a central macro node where the interactions are intensified.
 - iii. The other functions engineers constitute a periphery macro node where dense interactions are with their internal teams.
 - iv. Nodes with no edges shouldn't exist in the performing phase.

A software may be needed to model the community graph. We chose an open source software developed by INRIA and LaBRI called "Tulip". Tulip¹ is a data visualization tool. It models the relationships between the nodes and analyzes the connections between them. Tulip contains a library of algorithms that will be applied to the data set and model them into graphs. The interactions between the nodes can be analyzed and the data associated to them can be filtered or grouped. The nodes also can be

clustered into macro nodes if they share the same data properties. Tulip software can be downloaded from <http://tulip.labri.fr/TulipDrupal/>

5.6.3 Virtual Collective's recognition tool

THE NEED FOR A RECOGNITION TOOL

The mutual engagement characterized the members' interactions (section 5.4). As the members interacted through HySPeC, the standardization manager required to measure the mutual engagement level which quantify the members' contributions. He needed to identify the best contributors and reward them as well as the least performers and motivate them. One of the possible techniques to encourage the participation in online-communities is the gamification concept (Bista, Nepal, Colineau, & Paris, 2012). Gamification is defined as "the use of game design elements in non-game contexts" (Groh, 2012). In addition, HySPeC has built-in features that support the gamification concept.

PROPOSAL OF THE VIRTUAL COLLECTIVE'S RECOGNITION TOOL

The objective of the virtual collective's recognition tool is to recognize the contributors inside the collectives and reward them as shown in Figure 40. It helped also as a diagnosis tool to identify the underperformers and to understand why they aren't interacting and contributing to the collective.



Figure 40: Virtual collective's recognition tool

The tool has 3 main parts: the community activities, the community member's status, and the content analysis.

First, the community activities present statistics about what's happening inside the community. In this part, 3 main indicators are defined: the number of active members, the number of discussions and the number of comments. These indicators will give the community manager insights about whose participating in the discussions and making the most of comments. The manager may investigate the community dynamics if the number of active members is low. From practice, an active community has 80% of its members participating in the community.

Second, the community member's status or the top contributors demonstrates the members' contributions. This metric has two attributes: the reputation score and the rank. The reputation score is calculated automatically inside the tool with well-defined reward points, for example 10 points for a simple comment and 100 points if the comment is identified as the best solution for the problem. As for the ranking attribute, 5 titles are defined as the member accumulate points and progress from level to another. The 5 titles are: knight, elite, titan, champion, and legend.

Third, the content analysis enables assessing the contributions and the discussions of the community members. The analysis result is categorized into 4 metrics: best problem resolution, best documentation, best discussion and best improvement idea. The evaluation of these 4 metrics is done by the community leader based on two criteria: the number of replies and the number of like. For example, if the best discussion metric gets the most of replies and likes, this discussion will have the biggest impact on the community since the majority of the members have replied and liked the discussion.

This tool helped the HR managers to evaluate the achievements of engineers during their performance reviews in transparent way. It will provide them with the explicit data to support the achievement of their goals. This tool was directly implemented in MS SharePoint®.

In the following chapter, we will test the virtual collectives' framework and its associated tools on the control and monitoring platform. We will report the results and the feedbacks from the platform director on our proposition.

CHAPTER 6 – Testing the Virtual collectives' framework

6.1 Control & Monitoring platform as a case study: The introduction

Like the nervous system in the human body, the control system is the intelligence of any power plant. In order to guarantee safe, reliable and optimized power plant operation, GE Renewable Energy has developed and qualified a full range of advanced control solutions for hydropower plants. The solutions cover all plant control needs including: distributed control systems (DCS), the generator excitation system, the turbine speed governing systems, protection, condition monitoring and process application software. These systems are adapted to the size of the plant.

6.1.1 The Distributed Control System

GE Renewable Energy has a range of control systems to best fit customer needs. These systems are dedicated to power generation, providing operators with the ability to:

- Control and protect equipment to ensure the plant is operating correctly.
- Monitor the condition of equipment.
- Optimize the use of the individual asset or fleet.

As well as providing automation and plant management systems, GE Renewable Energy also supplies power electronics for generator excitation as well as grid connection and substation engineering. Such a wide scope of supply allows GE to manage turnkey projects, providing the customer with a single point of contact, which simplifies and speeds project development and execution.

6.1.2 The excitation system

The excitation system Alspa® ControGen™ for generator/ alternator offers a maximum of flexibility for optimal performance. The automatic voltage regulator (AVR) is available for all generators/ alternators types ranging from small to large size requiring complex control solutions. Alspa® ControGen™ portfolio has two main products:

- Alspa® ControGen HX for medium, large and very large size generators.
- Alspa® ControGen SX medium size generators.

6.1.3 The Governing system

A crucial part of the overall plant control system, the governing system regulates the flow of water passing through the turbine to adjust the power output to the grid as well as ensuring turbine, generator and penstock protection against over-speed in the event of load rejection.

With more than 100 years in the field of turbine speed regulation, GE has developed and qualified a universal turbine governing system that offers customers a cost-effective, reliable solution for all types of turbines. GE's governing system is:

- Extremely reliable and robust,
- A modular design for best cost/function configuration,
- Easy to install, operate and service.

The Neyrpic® T.SLG is illustrated in figure 41. This state-of-the-art controller can perform far more functions than standard systems. Proven at plants around the world, the system includes two dedicated, optimized modules – the unit processing controller and the servo positioning controller. When combined, the two modules meet the governing application requirements for all types of turbines. Oil pressure unit is the complete solution for the oleo-hydraulic part of the governing system. Actuators are safety critical and must have guaranteed availability. GE's actuators are extremely durable and have a proven lifetime of over 40 years, requiring little or no maintenance during this period.



Figure 41: Neyrpic® T.SLG

Figure 42 shows the decomposition of the advanced control solutions for hydro power plant: The Smart Control product for the distributed control systems, the Alsipa® ControGen product for the excitation system and the Neyrpic® T.SLG for the governing system.

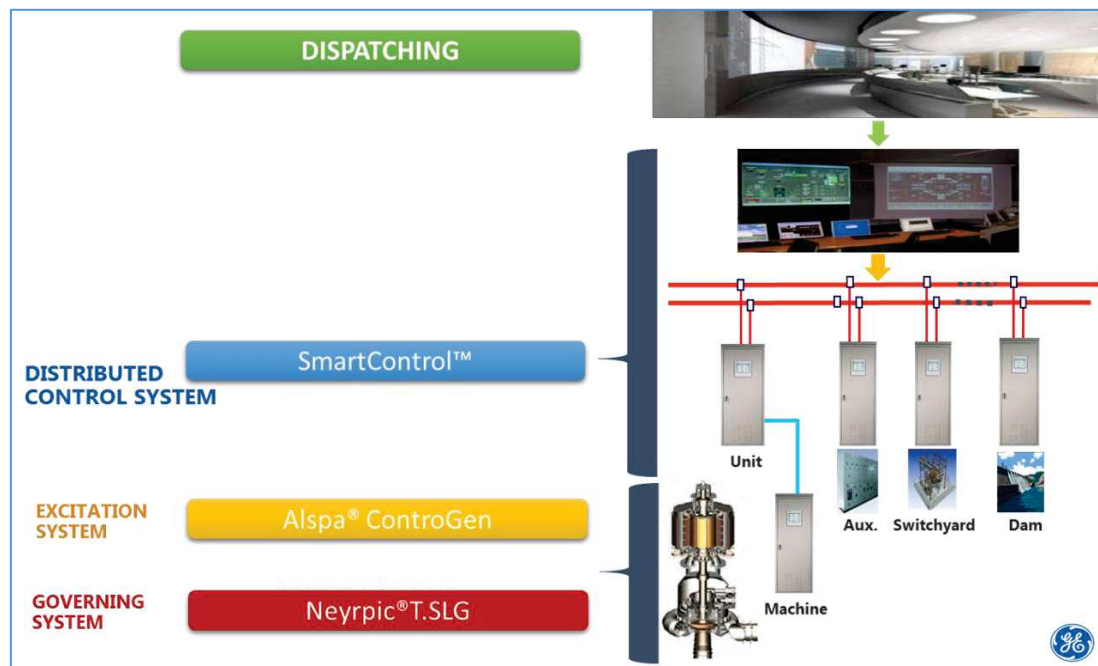


Figure 42: Advanced control solutions for hydro power plant

6.1.4 Defining the C&M platform mission and objectives

Due to the strategic importance of the advanced control solutions in Hydro projects, GE Renewable Energy - Hydro decided to strengthen its position in the market by developing new features that maximize the hydro plant intelligence and improve its competitiveness. The strategy is to find measures to enhance competitiveness and to implement them with special attention to services business where the competition comes from small and local competitors. The advanced control solution is key for the business; it plays an important role to define the service business:

- It will enable future-state technologies, discovering new business opportunities for services as well as for other Hydro products.
- The advanced control solution will generate optimization and intelligence to the hydro power plant.
- The advanced control solution is the interface between the customer and the hydro power plant.

The top management has initiated the control & monitoring (C&M) platform within the Hydro engineering function. The C&M platform is composed of a multi-disciplinary teams who will optimize the whole value chain of projects involving the

advanced control solution through industrialization, modularization and standardization actions.

The researcher/ practitioner has animated series of team building sessions between the key stakeholders to define a common mission. The C&M Platform mission was defined as follows:

“Take advantage of the GE’s global presence to continuously increase the competitiveness of the Control and Monitoring products, by creating solutions that allow to apply families of products designed to maximize commonality across projects and division of work between the different regions”

One of the main C&M platform objectives was to co-develop uniform solutions and standard products. These solutions will be used by different countries/regions in order to optimize and reduce the efforts during the project execution for a particular customer. To accomplish this objective, the C&M platform must work in a worldwide global organization, identifying commonalities, develop global standards as well as work in multidisciplinary environment. It had to integrate the different functions like sourcing, engineering, R&D, tendering and services where each had different interests, drivers and objectives to achieve. In addition to the functional diversity, the specific regional technical requirements, different cultures, idioms, mindsets and time zones are also part of this complex configuration.

6.1.5 Identifying the C&M platform as a case study for the VCF

To deal with all these complexities, it was very important to identify all the collaboration modes. Alternating between the different collaboration dynamics will help to create synergies among the different functions that should work together in efficient way despite the geographic and the temporal constraints. Being aware of all these elements, the community approach was important for the C&M platform in multidisciplinary and global mission within the same organization. The community approach wasn’t the natural choice to work for a cross-functional, cross-regional project. For example, the generator platform and turbine platform adopted a traditional project management style based on central teams to develop common design practices. The C&M platform was our case study where we developed and tested the propositions and the virtual collectives’ framework. Practically, the HySPeC standardization template and HySPeC platforming template implemented the

collaborative standardization process and platform. The project operational mechanisms were also implemented. For example: The C&M platform director defined regional ambassadors or “the facilitators” to deploy the standards in their respective regions.

6.1.6 Defining from practice the C&M operational framework

It was necessary to develop an operational framework to organize the activities of the C&M platform, make them visible, mitigate the risks and solve any potential conflicts between the functions. The operational framework included several components:

- *Cost base & savings:* For every system, the C&M platform had gone through cost analysis for the sub-systems and their components. Figure 43 shows the average split of total direct costs for a control system project over all regions. it was identified 3 main cost drivers: the equipment & spares, the engineering work and the site costs. As result, the C&M platform had identified key levers (standardization actions) that will reduce the cost, improve the competitiveness and bring savings.

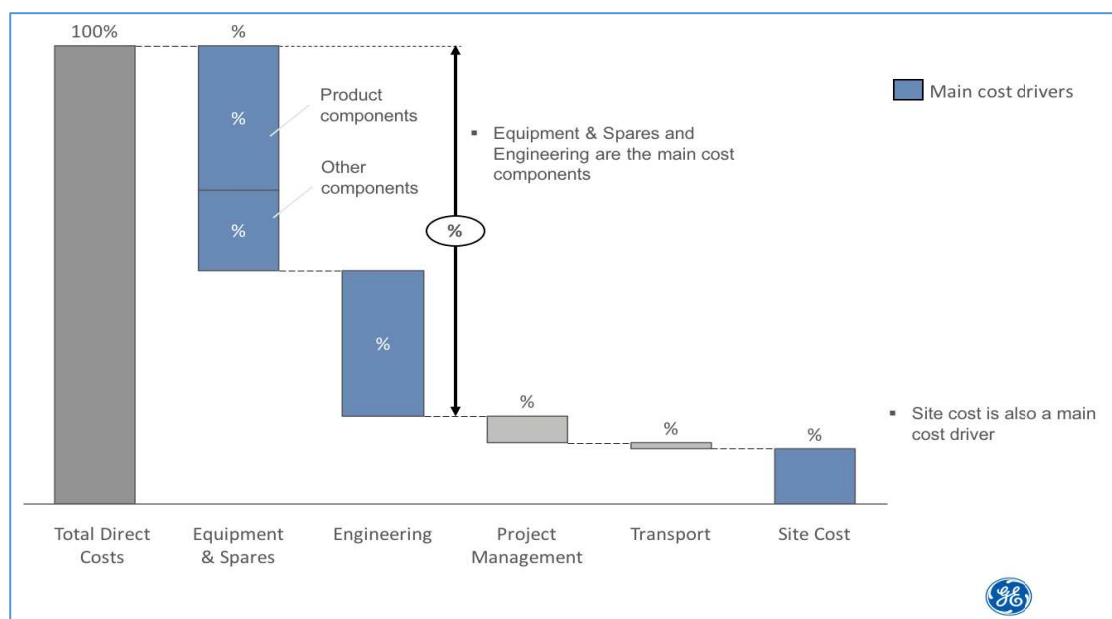


Figure 43: Average split of total direct costs for a control system project

- *Business case by region:* to assess the potential savings from the key levers, one case study per engineering region was considered as project reference. The application and the evaluation of the standards will be done on these references project.

- *Proposals*: the outcomes of the C&M platform are proposed to the engineering regional directors as business cases. It shows the savings and the benefits when applying the developed standards in customer projects.
- *Action plan*: the development of standards follows an action plan clearly defining the assigned tasks, the roles and responsibilities, the deliverables and the planning. The action plan is co-developed with the lever leaders.
- *Processes*: the operational mechanisms to implement, communicate, and apply the actions with the engineering regions. For example, the platforming weekly meeting was the progress follow-up mechanism with the lever leaders. Another example is the CMB (control & monitoring board) monthly meeting to renew the commitment of the top management and resolve any conflicts with other functions.
- *C&M platform community*: the levers leaders, the levers development team, the regional representatives work together inside the community to co-develop the standards. The community will assess the technical feasibility of local practices and potentially converge them into global best practices. The members co-develop, implement and update the standards following the collaborative standardization process.

Figure 44 summarizes the different components of the C&M operational framework and illustrates their relationships. The cost base & savings along with the business case by region are the starting point for the platform work, then the community is responsible to deliver the actual work as proposals to the engineering regional directors. The community changed its dynamics and its working modes in function of the different milestones and task types during the project's phases.



Figure 44: C&M Platform Framework

In the following section 6.2, we applied the virtual collectives' framework to the C&M platform then we presented the evaluation of the VCF and from the C&M platform director.

6.2 Control & Monitoring platform as a case study: The VCF application & evaluation

The VCF application started with the identification of potential collectives throughout the project development phases. The researcher/ practitioner has met with the C&M platforming director and project manager to identify the project's milestones for every project phase. We used the VCF identification tool to assign the proper virtual collective type to the respective project's phases: initiating, design & plan, execute, monitor & control, and closing.

The project initiating phase had milestones related to defining the C&M platform mission, the project's stakeholders, the project's deliverables, and the macro-planning, among others. For this initiating phase, the virtual collective's type will be virtual team whose membership is members with specific skill to manage the project deliverables within the budget, on time and expected quality. The virtual team's

purpose was to execute specific and non-routine tasks like defining the C&M platform mission and then communicating it with the project's stakeholders. The virtual team had to follow up on the project's progress and regularly report to the management board throughout the project phases.

In the design & plan project's phase, the milestones are to define a supplier strategy with the sourcing function, to prioritize the design components for standardization to maximize the savings, to define the design components' specifications, and to define a planning for the execution phase, among others. The virtual collective's type will be the virtual community of interest whose membership is interested members from different functions, regional, and technical profiles. The purpose of the virtual community of interest was to establish a shared understanding about the supplier strategies and technical choices.

In the execute, monitor and control phase, the milestones are to implement the actual supplier's strategy and technical specification defined in the design phase. The virtual collective's type will be the virtual community of practice whose membership is homogeneous having same profiles. The purpose of the virtual community of practice was to co-develop the design guidelines or the technical purchase specifications. The engineers will be recognized by a common identity while participating in the co-development of the standards.

6.2.1 Applying the virtual collectives' framework to the C&M Platform

The different collectives' types identified for the C&M platform are represented in figure 45. The critical differentiator factors: purpose and the process have primarily identified the different collectives' types. For example, the purpose for the virtual community of practice is to develop the key levers (standardization actions with higher cost savings) and the process to co-develop them will be through continuous discussions in HySPeC in addition to technical convergence workshops.

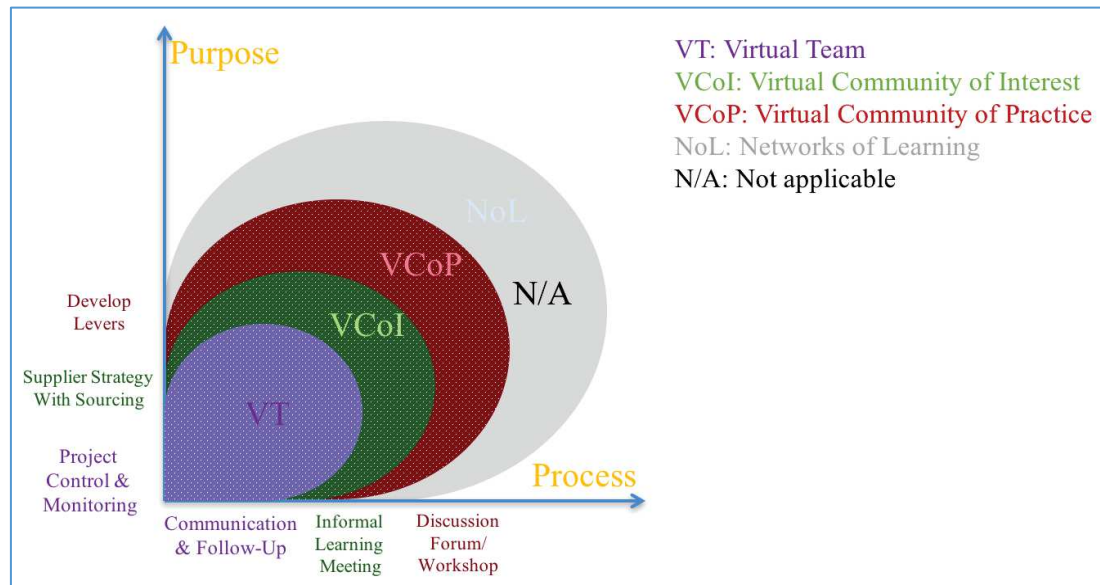


Figure 45: VCF Identification for the C&M Platform

The virtual collectives' identification tool helped us to identify the potential collectives' types, however the virtual collectives should be fully characterized including the bonding, diversity, structure and lifespan factors.

The collective's bonding or what will tie are the project's milestones for the virtual team's members, problems resolution for the virtual communities of interest and the passion in control systems for the virtual community of practice. The adjustment of the bonding factor in function of the project's phases will hold together the C&M platform's collectives all over the project's lifetime.

The collective's structure factor was directly influenced by the organization structure, in other words, the relationships between the global and the regional engineering functions. The members had to report to their direct manager and to the C&M platform director who didn't have a functional link with the C&M platform's members. Although the structure factor should be stable for the virtual community of practice but it was dynamic. The members working in the regional engineering functions were constantly changing due to local project priorities.

The virtual collectives' framework has identified and dynamically configured the different collectives in function of the project milestones. Figure 46 shows the configuration of the C&M collectives throughout the project's phases.

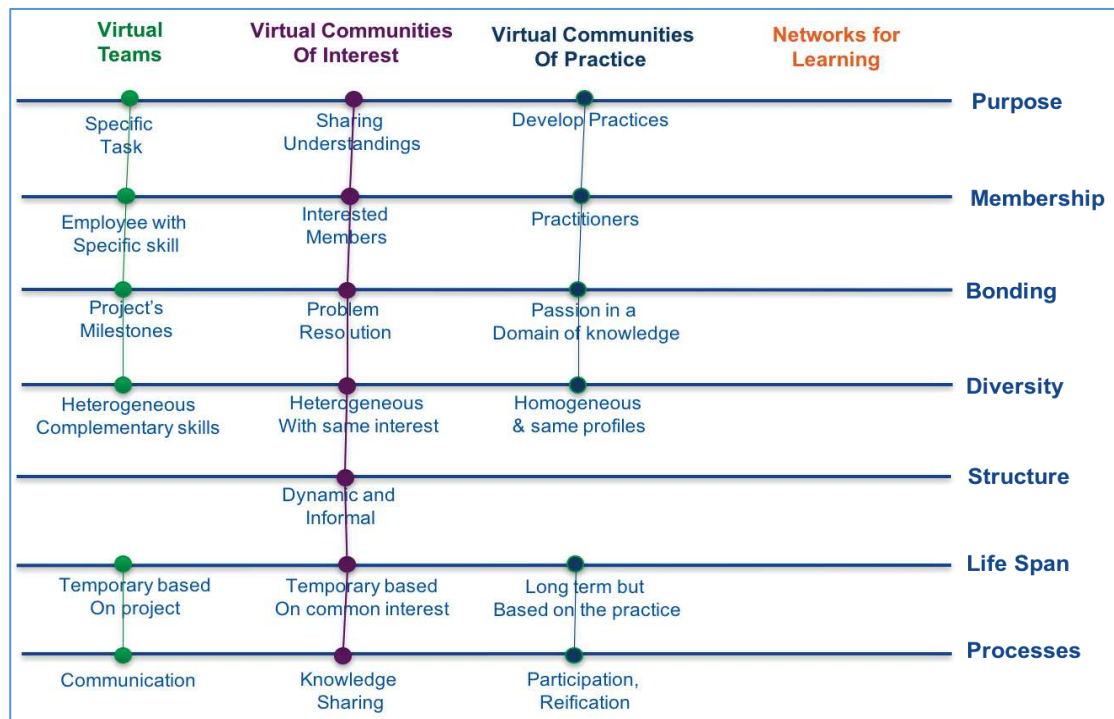


Figure 46: VCF application for the C&M Platform

Once the virtual collectives' types were identified, it was necessary to put them in place. A first technical convergence workshop was organized with double folded objectives: 1) assess the technical feasibility of local practices and converge into global levers, 2) build and inaugurate officially the C&M platform community.

6.2.2 C&M Technical Convergence Workshop

To leverage the synergies among the regions (Canada, Brazil, Europe, India and China) and the Functions (R&D, Sourcing, Site installation, Service) to close the gap of competitiveness and to respond to regional specific needs and requirements, a technical convergence workshop was organized in Grenoble from April 20 to 24th, 2015, gathering different regional representatives. The C&M platform director had organized and invited the representatives of the engineering regions to participate in the workshop. The researcher/ practitioner played the role of an animator to build the C&M platform community.

The objective was to identify communalities, share technical know-how and experiences, have a common view of the solutions and validate them in a community configuration.

Different technical scopes of the projects have been considered. Existing procedures and guidelines had been checked for executional proof of concept – in terms of gaps and fits during the workshop. Based on the cost data, a methodology was developed and validated to determine savings of the already identified key levers. Within the workshop those items were validated and further on other interdisciplinary additional levers, as well as short-term deliverables have been identified.

The first workshop outcome was the build and launch of the C&M Platform community. It presented the opportunity of sharing the work among Hydro regions. As an example, China participated in the detail design for a European project. The global sourcing function participated in this workshop to identify opportunities to optimize the cost of material at global and local levels. Global site installation has important contribution in identifying collaboration between project office and site installation.

Figure 47 shows the C&M platforming community. It is composed from the platform team, the lever leaders, the Key-Users, and the engineering regions (HIN, HNA, HCN, HLA, HEU). The lever leaders had the role to connect the platform team with the engineering regions. They lead the development and the validation of the levers with the local resources in regions. Once the levers are validated, they act as facilitators to deploy and train the engineers in the regions. The levers' leaders played the role of first level support in the application of levers to collect the feedback of experiences.

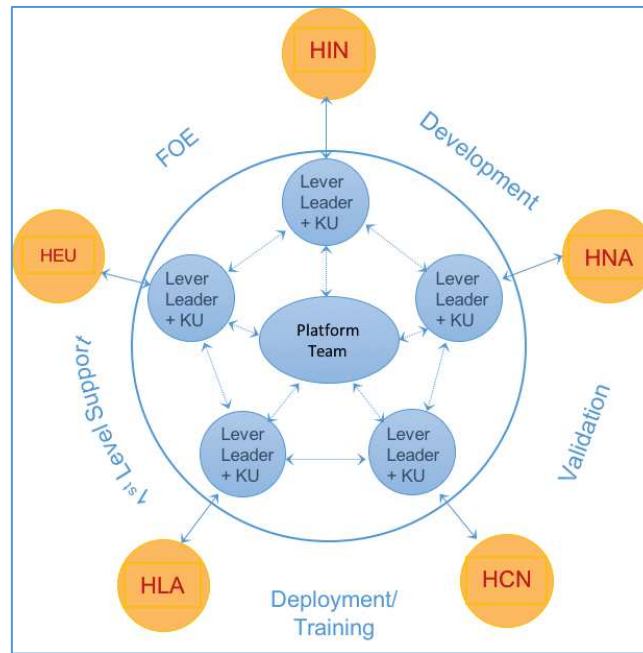


Figure 47: C&M Platforming Community

During the workshop, the researcher/ practitioner had modeled the members' interactions into the community graph where he applied the virtual collective's interactions tool developed in section 5.6.

Figure 48 shows the members interactions during the workshop. The inner interactions showed the highest members' engagement. In fact, this inner circle constituted the core of the C&M community after its launch. For example, the members 'Urbanos', 'Lopes', 'Rito', 'Parikh' (blue color) were assigned as lever leaders and formed the virtual community of practice. Complementary to the lever leaders, the peripheral interactions formed the virtual community of interest. For example, the members 'Petit', 'Jalier' and 'Sebastien' were representative of their respective functions i.e. Sourcing, services and product management.

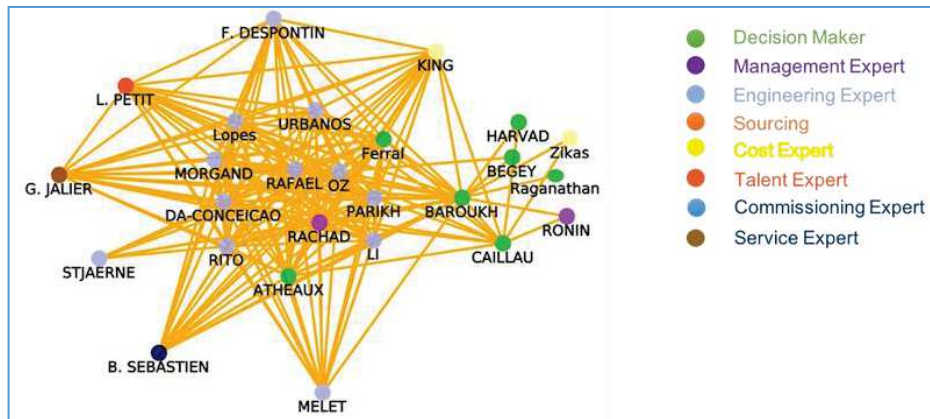


Figure 48: Community graph for the co-located workshop on DCS

The second workshop outcome was the key levers. They have been identified for future application in most projects in a standard and modular way. For example: cubicle standardization, modular architecture, modular software and standardization of interfaces between control system and Hydro process sub-systems.

To understand different market segments and respective solutions to be applied, a dedicated session with product management function was carried out. Service has led a specific session to understand the different market segments and to identify respective solutions. The approach is to be more products oriented to optimize the engineering, the site and the Sourcing efforts as well as material costs. This will contribute to increase the quality of our products.

6.2.3 Implementing the workshop outcomes.

A C&M platform community has been inaugurated and key levers have been identified for co-development in a global way. The implementation of these levers has started in different regions and it is planned to be done by the end of June 2016. Table 23 shows the key levers for the distributed control system identified during the co-located workshop. The researcher/ practitioner has recommended the virtual community of practice mode to implement the control system key levers.

System	Key lever	Description
Distributed Control System	1- Standard modular architecture	Standardization of control system architecture and definition of remote I/O approach
	2- Standard modular signal list	Standardization and validation among other systems' variables to be controlled and monitored
	3- Modular cubicles	Standardization of modular cubicles
	4- Modular software	Standardization of control software modules
	5- DOW, industrial scheme	Set-up of spec's in terms of sub-contracting & LCC-load share
	6- Costing tool	Standardization of common costing tool
	7- Smart Control SX industrialization	Hardware cost optimization and enhancement of regional capabilities on the product

Table 23: key levers for the distributed control system

The lever “7- Smart Control SX industrialization” required because there was change in the product strategy to move from outsourced product to internally developed product. The C&M platform director recommended the creation of the Smart Control SX sub-community. It was a virtual community of practice to handle the development and the implementation of Smart Control SX product. Knowing that, every region had its own Smart Control SX team but they will go through a community transformation phase as shown in figure 49.

The Smart Control SX sub-community is expected to be central and to provide the trainings and support independent from other functional units (i.e.: R&D) or external vendors. It's anticipated that the sub-community will investigate the recurrent problems instead of repeating the analysis by every region. Consequently, the maintenance cost will be reduced since a given region will be supported by the community and don't require to ask for external support. The Smart Control SX community will leverage the learning opportunities by sharing best practices and better knowledge management. The Smart Control SX community had co-developed the Smart Control SX product as shown in figure 50.

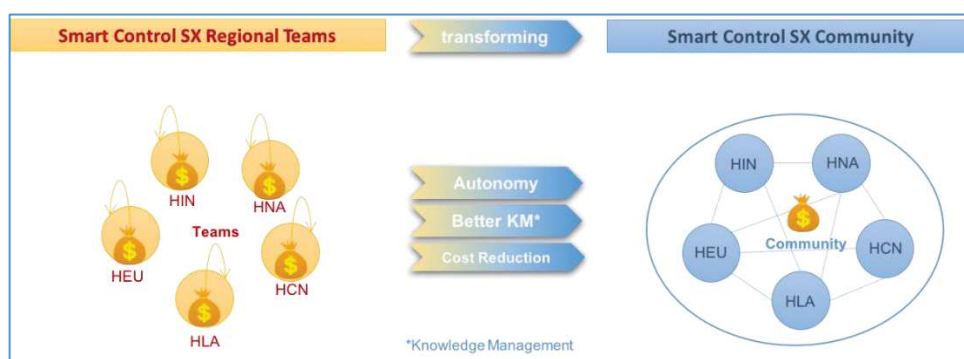


Figure 49: Smart Control SX Transforming phase



Figure 50: Smart Control SX

Table 24 shows the key levers identified during the co-located workshop. The researcher/ practitioner has recommended the virtual community of practice mode to co-develop the governing key levers.

System	Key lever	Description
Governing System – Electronic part	1- Optimization of the T-SLG internal trade costs.	Migrate speed governor solutions to PLC, allowing to integrate more than one function in the same CPU

		(Oil unit control, speed regulation, positioner and tachometer).
	2- Speed governor based on a PLC.	Cost reduction on the speed governor internal trade costs due to the current standardization level.
	3- Cubicle standardization and modularization.	Cubicle optimization due to the solution based on PLC.
Governing System – Hydraulic part	4- Extend the HEU current frame-agreements for HPUs to the other regions.	The same philosophy applied in Europe region with some key suppliers could be applied for other regions.
	5- Standardization of welded structures for pressure tanks and development of an optimized global scheme.	Mapping variations of pressure tanks and Develop Global Standard Technical Specifications for welded structures (pressure tanks).
	6- Commercial items global standardization and frame agreements development.	For commercial components from the market, it is important to have a segmentation, supplier qualification, documents standardization, cataloguing and global frame agreements.
	7- New Concept of GE Oil-Components.	The new range of oil-components will bring cost reduction due to the reuse concept of sub-assembly parts and manifolds block assembly industrialization.
	8- Standardization and modularization of other auxiliaries.	Standardization and modularization of compressors, speed measurement system and over

		speed protection system. For the last two items redesign should be done.
	9- HPUs modular design with global scheme.	Develop standards and modular design concept for the sub-assembly modules.

Table 24: key levers for the governing system

As an example, figure 51 presents the result of the key lever “Hydraulic Power Unit (HPU) modular design with global scheme”. The idea is to reduce the number of hours for the supplier drawings; this means to only make the final integration of the modules inside the project.

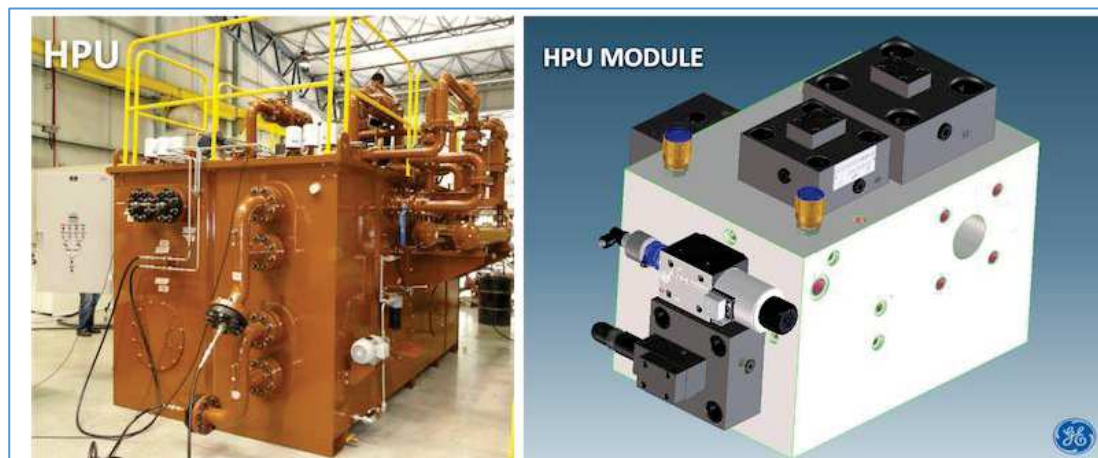


Figure 51: Governing System – Key lever main outcome – Hydraulic Power Unit (HPU)

The C&M platform community had co-developed the key levers on HySPeC. The community size was medium and had 21 active members out of 34 in total. These active members had generated 63 new discussions with 152 replies in total. The C&M HySPeC site had 5599 visits coming from 73 different visitors. (see appendix E for more details about HySPeC logs). Figure 52 shows the visits distribution in function of the visitors between January 2015 and June 2016.

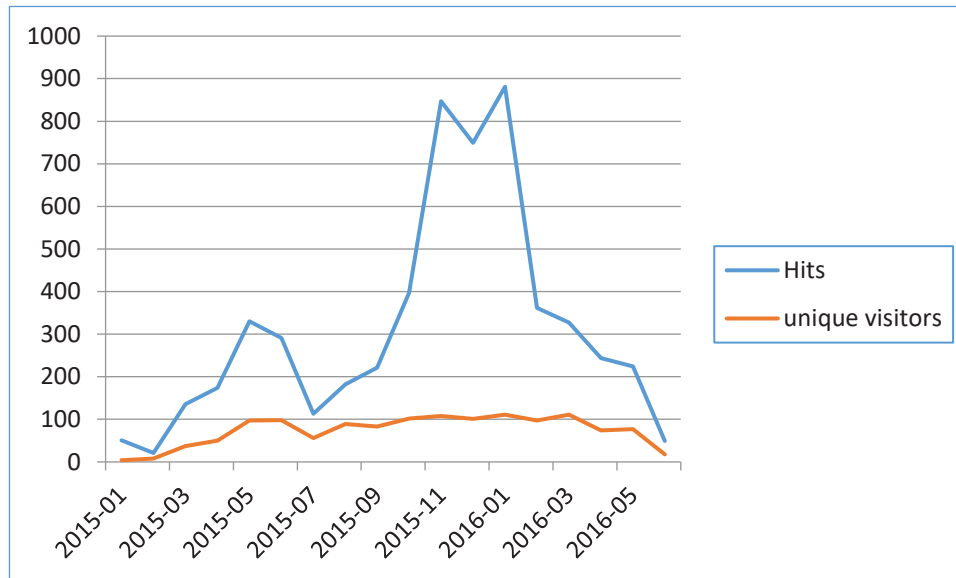


Figure 52: HySPeC activities log for the C&M platform site

6.2.2 Contributions of the VCF to the success of the C&M platform

The C&M platform had adopted the virtual collectives' framework to co-develop and deliver the key levers. For the C&M platform, the VCF helped to properly select and configure the virtual collectives' types in function of the different project's objectives. We interviewed the C&M platform director and asked him: "what were the VCF contributions to the C&M platform community?". We confronted the answers with the C&M project manager and global functions where they agreed on the contributions communicated by the C&M platform director. We listed the VCF contributions and categorized them in function of virtual collectives' types (refer to figure 46):

- The virtual team configuration helped the C&M platform to manage and follow-up on the project's milestones. In addition to the project KPIs: %Savings and %Physical progress, the researcher/ practitioner proposed community based KPIs. For example, #discussions, #replies, #interactions, top contributors. These community KPIs visualized and monitored the collaboration between the communities' members.
- The virtual community of interest configuration helped the C&M to define the standards requirements among the engineering regions, the product

management function and the global R&D function. The requirements were also communicated and managed closely through the VCoI.

- The virtual community of practice configuration helped the C&M platform to co-develop the control and governing key levers. The regions were implied in the co-development of the standards. In fact, every region was assigned as a lever leader for the C&M platform. The regions had the ownership of their standards which facilitated the release and the communication of the standards. The lever leaders lead the regional meetings explaining the interest and the benefit of implementing the standards.

The standards were collaboratively and remotely developed through HySPeC. It allowed the integration of all local requirements into one workplace. The community members accessed the same workplace, consulted and discussed the standards and collectively updated the planning. Validation & review process of standards is done simultaneously through HySPeC. It has saved time and effort compared to the e-mail based standardization process.

As conclusion, the virtual collectives' framework and HySPeC had contributed to the success of the C&M Platform. We quoted the C&M platform director statement:

“we used to work in central teams where the experts consolidated all the practices into one global standard. We missed a lot of local information. However, with the community approach, we worked in collaboration with the regions. It was challenging yet it was one of the success factors for the C&M platform.”

We have quoted the C&M platform director recommendation for our proposal:

“the community approach reached a good level of maturity and now it can be applied to global organizations producing more efficient results.”

Cycle 2: Conclusion

We concluded Cycle 1 by the fact that some engineering communities lacked the engagement in the collaborative standardization process or to online collaborate through HySPeC. We refined our third research question to be:

What are the characteristics of the virtual engineering collectives that best suit the collaborative standardization process?

- a) What are the characteristics that define and differentiate the virtual engineering collectives' types?

In cycle 2, we pursued our effort to answer its research question by selecting and defining from literature the 4 virtual collectives' types: virtual team, virtual community of practice, virtual community of interest and networks for learning. Then we proposed a virtual collectives' dynamics (VCD) model to characterize these virtual collectives with respect to the collective development phases. Not only that, but also to dynamically reconfigure a virtual collective type in function of the task type of the standardization objective. Therefore, we identified 9 characteristics families over the 3 development phases:

- The characteristics families for forming and transforming phase are: collective's task design, collective's technology, collective's strategic directives, collective's structure, collective's composition.
- The characteristics families for storming and norming phase are: collective members' interaction, collective's health.
- The characteristics families for collectives performing phase are: collective's performance and collective members' satisfaction.

In order to differentiate these virtual collectives, we opted out 7 characteristics and we classified them as critical differentiator factors (CDFs). Later, we attributed values to these 7 CDFs and applied them to our 4 virtual collectives. As result, we obtained a virtual collectives' framework that characterized and differentiated the 4 virtual collectives. Table 25 presents the activities that we implemented for cycle 2 phases and throughout the cycle' chapters.

Cycle 2	
Diagnosis	<ul style="list-style-type: none"> - Assess the difficulties faced by the engineering communities while using HySPeC - Define the requirements for the characteristics model
Planning Action	<ul style="list-style-type: none"> - Select and define the 4 virtual collectives' types - Design and propose a virtual collectives' dynamics model (VCD) - Define the critical differentiator factors (CDF) - Propose a virtual collectives' framework from literature - Identify a pilot community to implement the framework
Taking Action	<ul style="list-style-type: none"> - Present the "Control & Monitoring Platform" case study - Apply the VCF and the developed tools to the C&M platform
Evaluation	<ul style="list-style-type: none"> - Assess the interactions dynamics for the C&M platform in HySPeC - Validate the contributions of the proposal to the C&M platform

Table 25: Methodology actions for Cycle 2 phases

Problematic and fourth research question

Within the "Alstom Power" hydro organization, a project based management style is adopted. Any activity should be enrolled in a project, had its own resources and allocated budget. Although the top management had facilitated the application and the testing of the VCF but we had to deal with this reality. In fact, we had to allocate hours to the community working mode from the total C&M platform budget. For future projects, in order to ease the work of the engineering communities within a project based management style, an operational process for the virtual collectives (VC) has to be defined. We had to understand the existing management processes and then integrated the VC operational processes within the hydro organization.

Furthermore, the engineering communities have developed the standards and they should be adopted in the customers' project. The VC operational process should facilitate the adoption of the developed standards. Our fourth research question was defined and refined as follows:

- 4) “Which operational process has to be defined to ease the work of the virtual engineering collectives within a project management framework?”
- a. How the operational process would facilitate the adoption of standards?

In cycle 3, we presented the management processes such as project management process and change management process. We proposed a virtual collectives’ operational process to implement and sustain the virtual collectives. The integration of the project, change and community management processes defined the virtual collectives’ operational process.

CYCLE 3 – THE VIRTUAL COLLECTIVES’ OPERATIONAL PROCESS

Cycle 3: Introduction

The collaborative standardization process and HySPeC were developed in cycle 1. The virtual collective’s dynamics (VCD) model and the virtual collectives’ framework (VCF) were developed in Cycle 2. These propositions helped the engineering communities to collaboratively develop their standards at distance. In this cycle, we aimed to facilitate the adoption of the developed standards in the customers’ projects taking into consideration the project based management style. The first step was to develop the community management process to launch and maintain the virtual collectives and then integrated it within the organizational processes.

A new challenge has aroused in cycle 3, the “Alstom Power” organization is changing to become “GE Renewable Energy” organization. The organization went through restructuring which made our task more challenging. New strategic priorities, organizational processes and tools had been defined and we had to enroll our operational process in this turbulent period. GE managers wanted to build a community in order to support the deployment of a new tool as an internal standard of work for Engineering. Unfortunately, this cycle can be considered as incomplete with respect to the evaluation phase that had not been completed. Yet we had chosen to present this case study even if it would be less developed than other cycles. This intense change phase in the company leads us to combine our approach with the existing processes of project management and change management in GE. Due to operational pressure and time, an extensive literature review could not be realized like in the other cycle nor did the evaluation build in the same way. Figure 53 shows the methodology to accomplish this cycle’ objective, effectively starting from Jan, 2016 till June 2016.

- 1) The diagnosis phase is detailed in section 7.1. We identified 3 management processes: project, virtual collectives and change management processes. We assumed that these processes may influence the adoption of the standards and ease the work of the virtual collectives within the project based management style.
- 2) The planning for action phase is detailed in section 7.2. We presented the project and change management processes at GE and we proposed the

community management process. The integration of these 3 processes resulted in the definition of the virtual collectives' operational process. The VC' operational process is expected to facilitate the application of the standards as well as the work of the virtual collectives.

- 3) The taking action phase is detailed in section 7.3. The EMT project was our case study to implement the VC' operational process. First, we presented the EMT project, then we applied the VCF as prerequisite step for the VC' operational process. Finally, we showed the implementation results in function of the process groups.
- 4) The evaluating action phase and the validation of the results were not completed at this stage of the thesis. In fact, the transitional period from "Alstom Power" to "GE Renewable Energy" organization has shifted the company priorities and we couldn't validate the VC' operational process results. However, this step is carried into the perspective of the thesis.

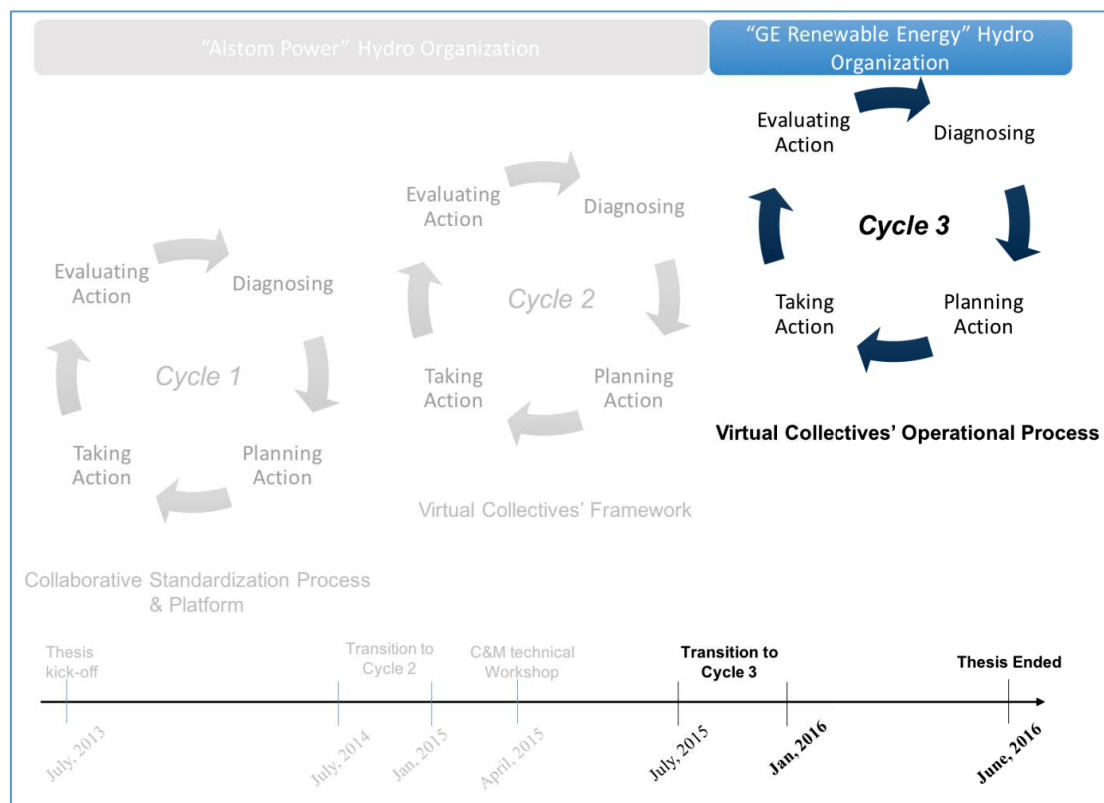


Figure 53: Methodology for cycle 3 between Jan, 2016 and Jun, 2016

CHAPTER 7 – Developing the virtual collectives’ operational process

7.1 Diagnosis of the existing management processes at “GE Renewable Energy”

At GE Renewable Energy, the engineering workload is managed as projects, where engineers justify their working hours through the projects they’re involved in. From the practice, we observed that projects fall behind the schedule and run over their budgets. The operational managers have reported the lack of proper interpretation of product requirements, which lead to poor scope definition, in addition to unplanned incidents, miscommunication during development, different mental models, and lack of continuous feedbacks.

In order to guarantee a standard quality level in customers’ projects, the top management has required an integrated set of management processes. This integration is expected to facilitate the adoption and the implementation of standards throughout the project lifecycle: from product definition to the product delivery. We argued that the integrated operational process should be able to answer the following hypothesis:

- In a project-based management style, the integrated operational process may implement and maintain the virtual collectives.
- The integrated operational process may dynamically configure the virtual collectives in function of the project’s objectives.
- The integrated operational process may manage the changes in the virtual collectives from one project’s objective to another.

Within the “GE Renewable Energy” hydro organization, we assumed that the following 3 management processes can be integrated to respond to our above hypothesis:

- 1- Project management process.
- 2- Proposed virtual collectives’ management process.
- 3- Change management process.

7.2 Proposal of the virtual collectives’ operational process

The diagnosis phases concluded with the need to integrate the 3 management processes: project, virtual collectives and change to facilitate the adoption and the implementation of the standards in projects. The integrated process is expected to ease

the work of the virtual collectives and enable their incorporation into the formal organizational structure.

In section 7.2.1, 7.2.2 and 7.2.3, we will detail the 3 management processes, integrated them and proposed the virtual collectives' operational process.

7.2.1 Project management process at GE Renewable

For the project management process, the operational managers at GE Renewable adopted the Project Management Institute (PMI) process. The PMI process is the widest adopted model by project managers and it is considered at the de-facto standard in many industries. GE renewable business has adopted this model to manage their projects. The PMI defined a project as “a temporary endeavor undertaken to create a unique product, service, or result” (Project Management Institute, 2013a).

The PMI process is composed of 6 main project process groups: pre-study, initiating, planning, execution, controlling & monitoring and closing processes.

1. Pre-Study: Develop the business case and conduct a feasibility study.
2. Initiating: Define the detailed project charter for the project and obtain the authorization to start the project. Establish consensus on the project deliverables with all the stakeholders.
3. Planning: Establish the project's scope, refine the objectives, operational mechanisms, develop the collaborative tools, develop & engage the collectives.
4. Executing: Implement the processes defined to complete the work and the deliverables. Develop the design plans. Animate and sustain the different type of collectives.
5. Monitor & Control: Processes to track, review and regulate the progress and the performance of the project. Identify any areas in which changes to the plan

are required and initiate the corresponding changes. Review the community graph and take corrective actions.

6. Closing: Processes to finalize all activities for project closure. Collect feedback of experiences and lessons learnt. Reward and recognize the achievers.

Figure 54 shows the relationship between the 5 process groups. It started with a pre-study then the initiating processes. However, the planning and the execution processes are iterated until the project's milestones are completed before the closing processing. The control and monitoring processes are governing all the project lifetime and should be continuously performed.

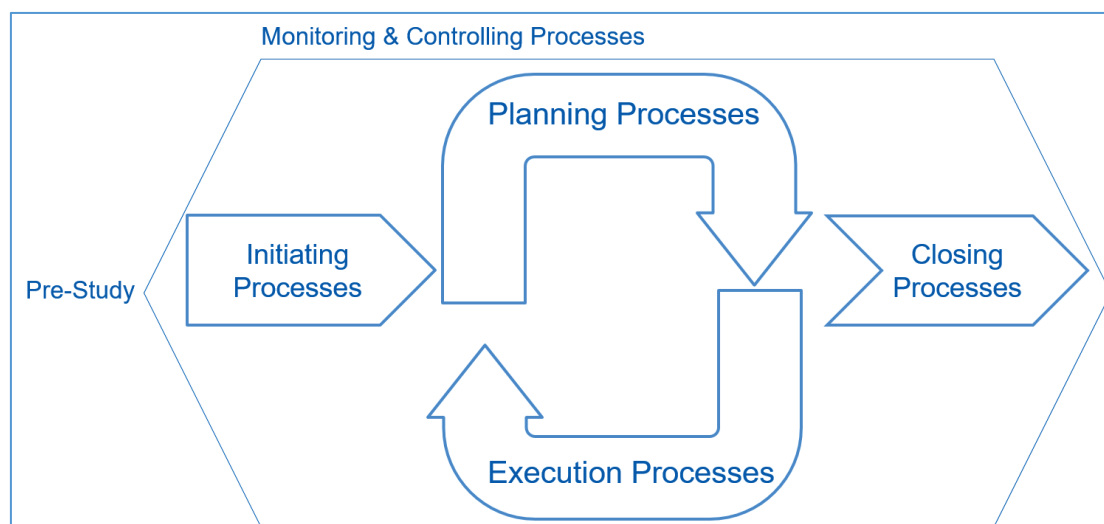


Figure 54: PMI project process groups. Source (Project Management Institute, 2013b)

7.2.2 Proposition of the virtual collectives' management process

During the C&M platform case study in cycle 2, the researcher/practitioner was immersed in the development and the operation of the C&M virtual collectives. He observed and formalized the development activities of the different virtual collectives into a management process. The C&M project manager had participated in the formalization of the management process. The management process was discussed with the engineering operational manager to get his expert feedbacks. The C&M platform director validated the management process. We proposed 5 main activities that constituted the virtual collectives' management process:

1. *Build the identity*: During this phase, the collective is not yet formed and the potential collective's leader tried to communicate and to align the different stakeholders with the collective's objectives.
2. *Define the engagement*: During this phase, the collective's members are identified. The members can be either from the engineering function or other functions (product management, sourcing, R&D...). The leader tried to find common interest between the members. This common interest will be translated into key lever actions that will engage the different functions. One potential collective type can be formed in this phase, which is the virtual community of interest.
3. *Emerge the collective*: During this phase, the potential virtual collective type may be identified as the virtual community of practice (VCoP). The leader may invite the VCoP members to a co-located workshop to emerge and officially inaugurate the virtual community of practice. The VCoP was responsible to co-develop the key lever actions that are identified during the "*Define the engagement*" phase.
4. *Maintain the engagement*: During this phase the virtual community of practice required additional efforts from the leader to maintain the community engagement. In a distributed environment with difference in time zones, weak ties can be easily created. The interactions through the collaborative platform

can degrade over time. An analysis of the community interactions is required to identify the gaps and take corrective actions.

5. *Evolve the collective*: During this phase the community of practice will be transformed into a new collective type in case of achieving its objective. New members are invited to join the new collective type and a re-formation phase is started. The members would benefit from their previous experience while working together to maintain the trust and the relationships they established in previous cycle.

The 5 activities that constituted the virtual collectives' management process are in coherence with the phases of the proposed virtual collectives' dynamics model. For example, figure 55 shows: the “Build the identity” activity that implemented the “Forming/ Transforming the collectives” phase; The “Define the engagement” and “Emerge the collective” activities that implemented the “Storming & Norming the collectives” phase; finally, the “Maintain the engagement” & “Evolve the collective” activities that implemented the “Collectives performing” phase.

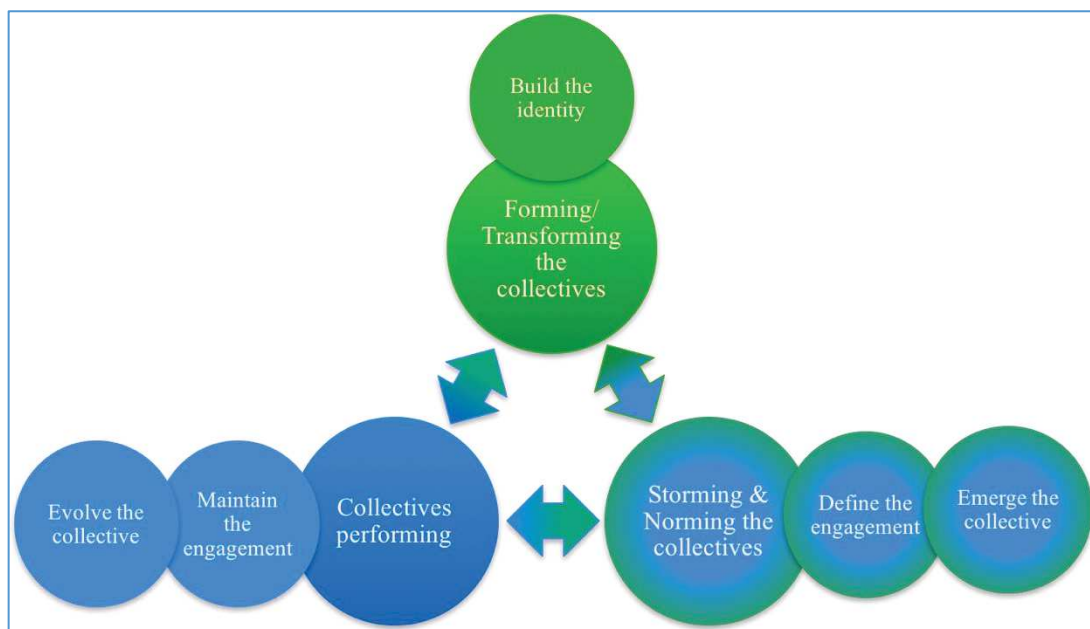


Figure 55: Proposed community process groups

7.2.3 Change management process at GE Renewable Energy

Organizations constantly encounter forces driving them to change. Because change means doing something new and unknown, the natural reaction is to resist it. Change strategies such as communicating with resisting members and involving them, increase acceptance to change. “Changes do not need to be radical; rather, small changes introduced often are better than large changes rarely introduced” (Byvelds & Newman, 1991).

Resistance to change tends to be an “emotional” and not rational response. This means that accepting change takes time and requires a calm, patience and empathy. “Change is more easily accepted by decreasing resisting forces rather than by increasing the driving forces” (Byvelds & Newman, 1991). Success will only come by removing the resisting force. The Hydro engineering functions had developed an internal change management process. Table 26 shows a summary for the change process’ objectives and actions with respect to their phases. The phases, phases’ objectives and their respective actions were defined during a change management initiative at the hydro engineering function (GE IPM, 2016).

Phase	Objectives	Actions
Mobilize	This phase will get the buy-in and the commitment of the top management. It will increase the teams’ motivation and generate positive energy.	<ul style="list-style-type: none">- Communicate with major stakeholders on the vision.- kick off meeting.- Ensure quicker alignment of everyone in organization from top management to operational levels.
Assess	This phase will estimate the gap in order to define action plan and develop awareness on the changes to come.	<ul style="list-style-type: none">- Identify issues- Define target- Estimate the gap- Assess the impact of changes- Define action plan to limit resistance- Develop awareness

Change Plans	This phase will define the detailed action plan and then roll out them to the teams.	<ul style="list-style-type: none"> - Define training needs for each team affected by the change. - Select the most appropriate training materials. - Plan the training phases.
Implement	This phase will execute all plans, follow up on the plans, and monitor the implementation actions.	<ul style="list-style-type: none"> - Monitor the progress of the implementation of change - Support the continuous improvement - Create a specific dashboard for a change project
Transition to running	This phase will ensure the change initiative and transform the new behaviors into habits.	<ul style="list-style-type: none"> - Set Follow up meetings - Assess the strong points in the management of change and areas for improvement.

Table 26: Change management process at GE (source – GE IPM, 2016)

Figure 56 shows the relationships between the change management phases as well as their sequences (GE IPM, 2016).



Figure 56: Change Hydro Engineering Framework (Source - GE IPM, 2016)

7.2.4 Proposing the virtual collectives' operational process

Within the “GE Renewable Energy” hydro organization, the integration of project, virtual collectives and change management processes defined the virtual collectives' operational process. The researcher/ practitioner, the project manager and the change manager proposed to group the operational process activities according to the PMI process groups (Project Management Institute, 2013b). Figure 57 shows the 4 main process groups:

7. Initiating processes: in addition to the PMI activities, include which type of collectives will be implemented throughout the project. Identify the collectives type in function of the project's objectives. Identify the members, their roles & responsibilities for every collective type.
- 1) Design & Planning processes: in addition to the PMI activities, include how the collective will be constructed, activated and operationalized.
- 2) Execute, control & monitoring processes: in addition to the PMI activities, include how to measure, improve and sustain the engagement in the collectives.
- 3) Closing processes: in addition to the PMI activities, include how the collective will capitalize the know-how and reward the achievers.

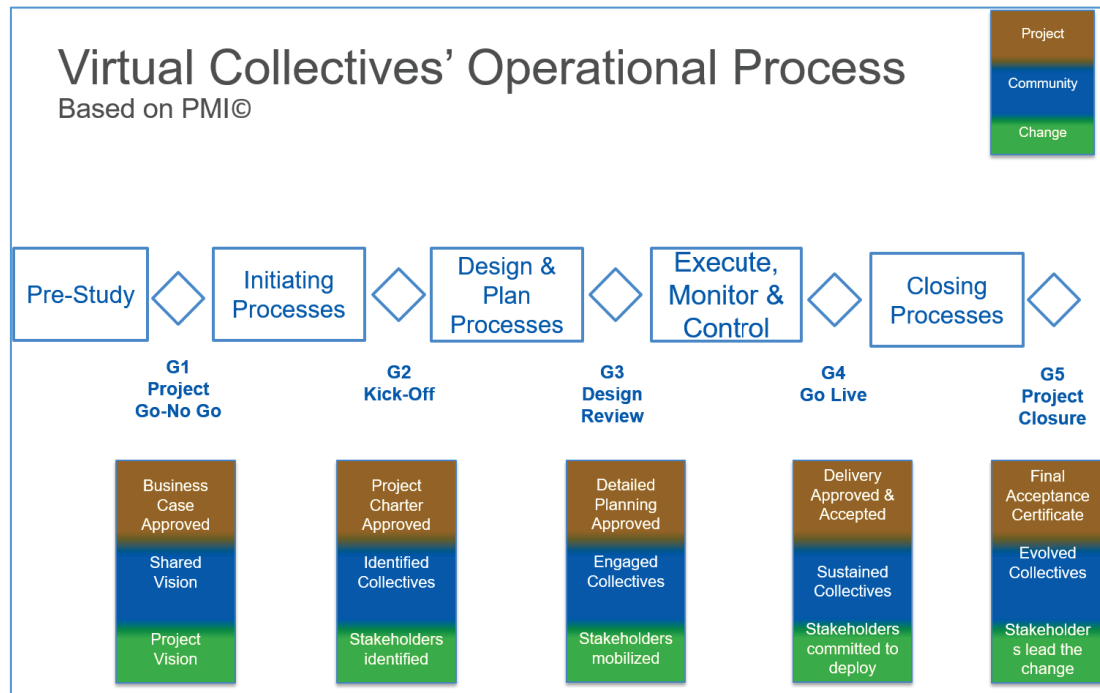


Figure 57: Proposed virtual collectives' operational process - 2016

7.3 Application of the virtual collective' operational process

We assumed that a preliminary step to the application of the virtual collectives' operational process is the application of the virtual collectives' framework. The VCF advantage is to define and differentiate the required virtual collectives' types during the project phases. In this section, firstly, we presented the EMT project as a case study. Secondly, we applied the VCF to the EMT project then we applied the VC operational process.

7.3.1 Presentation of the EMT case study

In April, 2014, the engineering region Bilbao, Spain has developed the Engineering Management Resources Tool (EMT) to manage its local projects. The project managers at Bilbao, Spain, have relied on the EMT tool to manage the engineering resources with respect to the projects' load. The EMT tool has demonstrated its effectiveness and later in July 2014, the engineering region Belfort, France has adopted the EMT tool. Few months later, it has become the default application for the engineering regions at Europe. Finally, the EMT tool is deployed worldwide for all hydro engineering regions in June 2015.

The EMT's objective was to continuously monitor and assess if the engineering load had enough resources during the project execution. Figure 58 shows that the engineers

working in project teams constituted the project resources and the sum of all project's activities determined the engineering load. The objective is to make sure that the resources are optimized to the load.

The EMT tool generated standard reports that integrated all the project management data in order to monitor the resources/ load in the project.

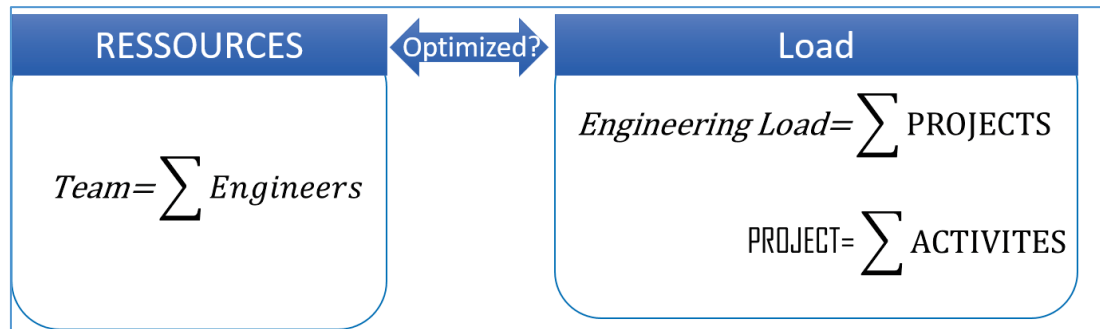


Figure 58: EMT principle

The development team at Bilbao had initially developed many functionalities for the EMT application. These functionalities included, but are not limited to:

- Management of activities by function or department.
- Cost control of engineering projects.
- Real-time display of project's data (planning, progress, budget...).
- Root cause analysis of deviations.
- Standardized key performance indicators for all projects.

Figure 59 shows the set of all the functionalities that are categorized into 4 main groups: daily report, project execution, department performance, standard tables. The daily report group is accessible by the end-users for the daily follow-up. The end-users can check their assigned activities and the corresponding progress. The project execution group is accessible by the technical project managers (TPM) for project control and monitoring. The TPM can have an overview of all the activities and track the availability of the resources. The department performance group is accessible by the regional engineering manager to track the performance of all the department projects. The regional engineering manager will follow-up the progress of his engineers involved in all projects. The standard tables group is accessible by the Key-Users who are responsible to configure the tool and support the technical issues. The

Key-Users may add some fields to the default database tables to enrich the generated progress reports.

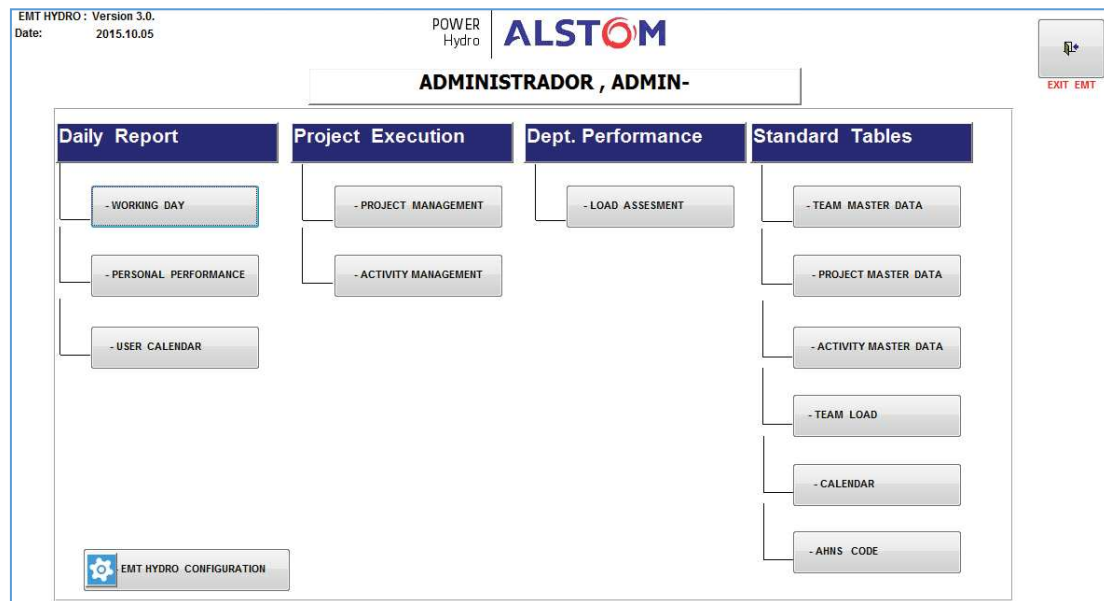


Figure 59: EMT Homepage. Source (BEGEY, 2015)

In section 7.3.2, we will show how the VCF was applied to the EMT project and we will evaluate the HySPeC usage by the EMT community.

7.3.2 Applying the virtual collectives' framework to the EMT project

The different collectives' types identified for the EMT project are represented in figure 60. The two critical differentiator factors: purpose and the process enabled to identify different collectives' types. For example, the purpose for the virtual community of interest is to facilitate the deployment of the EMT tool in the engineering regions and the deployment process was supported through continuous discussions in HySPeC. The purpose for the virtual team is to monitor and control the project progress through continuous communication and follow-up processes.

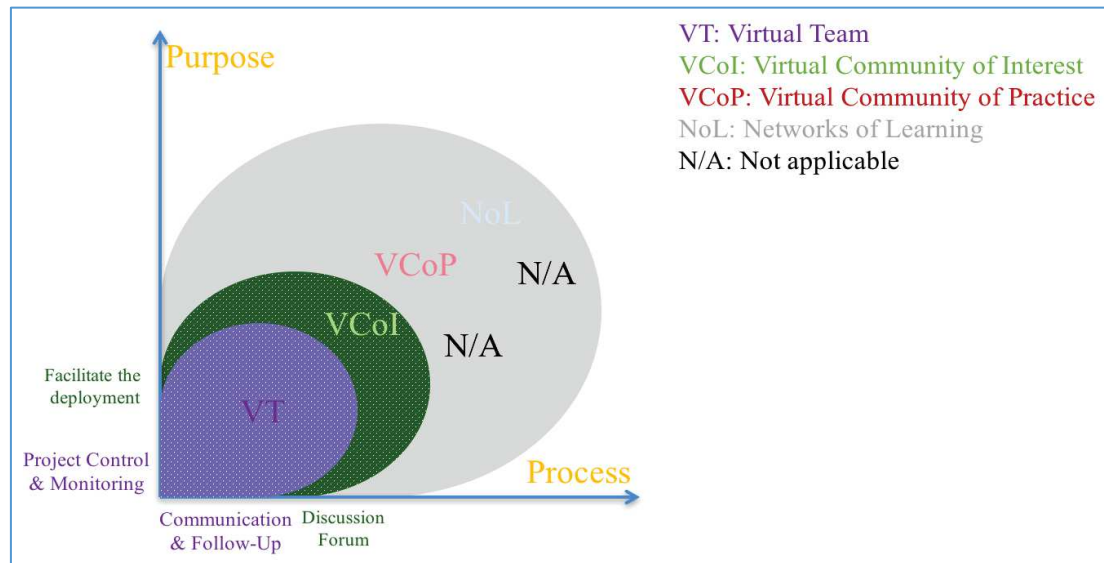


Figure 60: VCF identification for the EMT project

The virtual collectives' identification tool helped us to identify the potential collectives' types, however the virtual collectives should be fully characterized including the bonding, diversity, structure, membership and lifespan factors.

The adjustment of the bonding factor in function of the project's phases will hold together the EMT's collectives all over the project's lifetime. The collective's bonding, or what will tie are: the project's milestones for the virtual team's members, and problems resolution for the virtual communities of interest.

The collective's structure factor was directly influenced by the organization structure, in other words, the relationships between the global and the regional engineering functions. The members had to report to their direct manager and to the EMT director who didn't have a functional link with the EMT community's members. the structure factor for the virtual community of interest was dynamic and informal. The members working in the regional engineering functions were constantly changing due to local project priorities.

The virtual collectives' framework has identified and dynamically configured the different collectives in function of the project milestones. Figure 61 shows the configuration of the EMT collectives in function of the project's objectives.

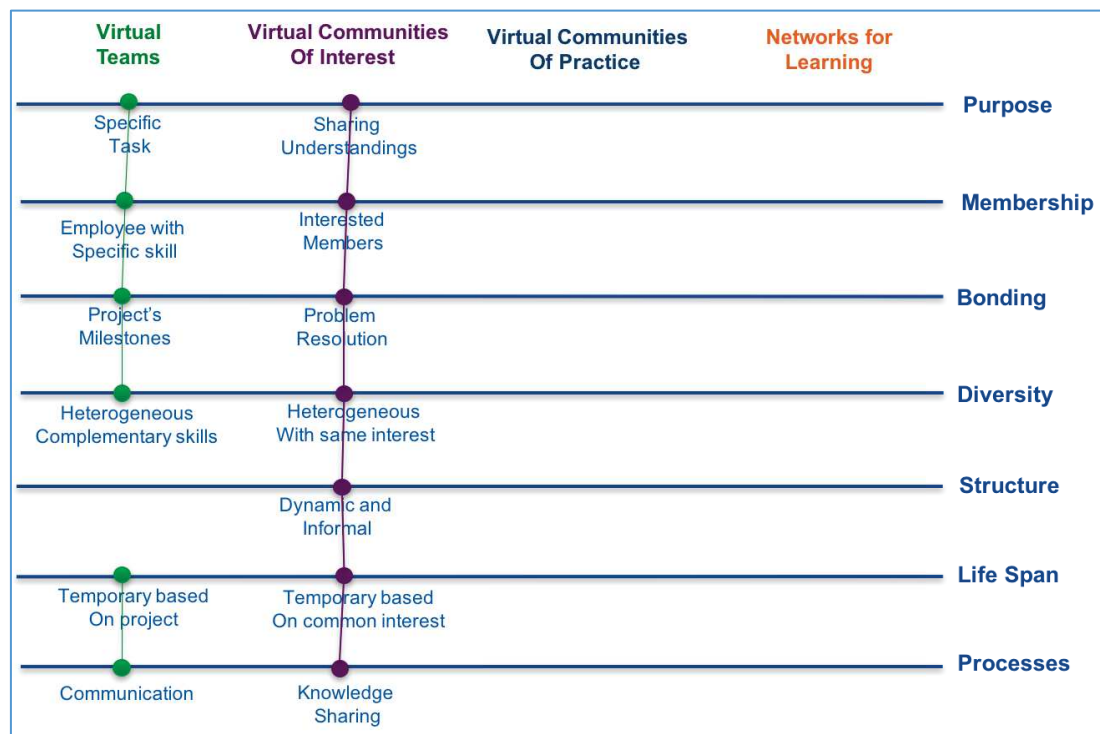


Figure 61: VCF application for the EMT project

The EMT community has supported the deployment of the tool in all the engineering regions. The community size was medium and had 20 active members out of 28 in total by May 2016. The questions and requests for bug resolution were collectively discussed through HySPeC. These active members had generated 84 new discussions with 161 replies in total. The EMT HySPeC site had maxed 285 visits coming from 112 different visitors during October 2015. (see appendix E for more details about HySPeC logs).

The EMT virtual community of interest was created to support the deployment of the EMT tool in all the engineering regions. In other words, the objective of the community was to resolve bugs and problems during the launch of the tool. Figure 62 shows the visits distribution in function of the unique visitors between August 2015 and June 2016. The peak hits (visits) were during September and December 2015. We noticed the low visits between January and June 2016. The EMT Key-User for Europe had stated “during this period the tool has become relatively stable and operational”. This statement can explain the low hits during the 2016 period.

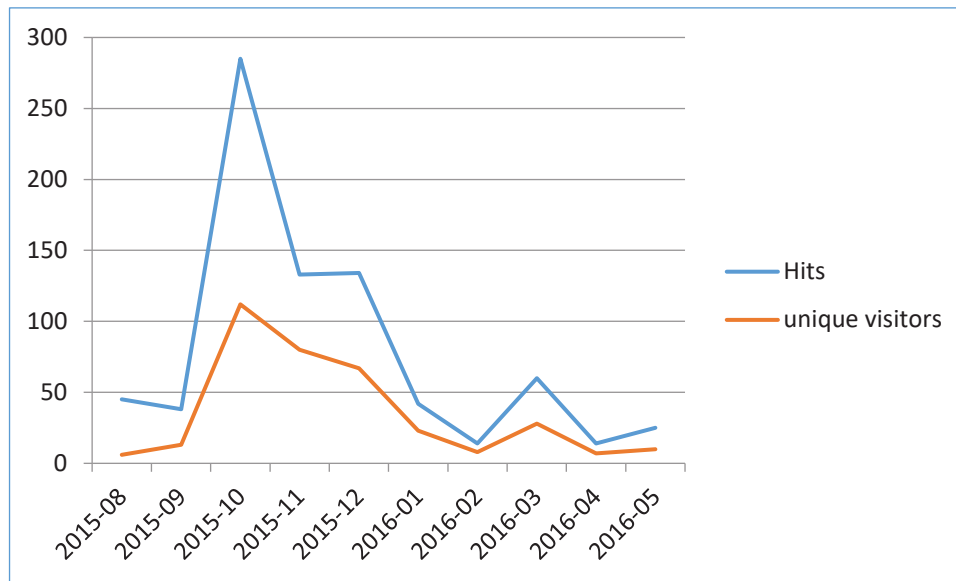


Figure 62: HySPeC activities log for EMT project

In section 7.3.3 we will explain how the VC operational process was applied to the EMT project and we will present the actions taken for every project's process group.

7.3.3 Applying the VC operational process to the EMT project

The application of the VC operational process to the EMT project was accomplished with the EMT project manager and the EMT change manager. Table 27 shows the actions taken during the application of the VC operational process for the EMT project.

VC operational process group	Actions taken
Initiating	<ul style="list-style-type: none"> - EMT director and technical project manager were selected. - Previous processes and historical information were collected. - Kick off meeting was hold. - Project charter was defined including change management plans. - The virtual collectives' types were defined.
Design and plan	<ul style="list-style-type: none"> - The community members were selected with defined roles and responsibilities. - EMT HySPeC was developed and trainings were conducted. - A communication plan was defined for the different stakeholders' groups. - Project planning and deliverables were defined.
Execute, monitor and control	<ul style="list-style-type: none"> - Stakeholders' engagement was managed and supported the changes. - KPIs were reviewed and analyzed. - Risks were continuously identified and corrective actions were taken.
Closing	<ul style="list-style-type: none"> - The community has evolved from deploying the tool to the support of the end-users. - Feedback of experience is collected and shared in the closure meeting.

Table 27: Actions taken during the application of the VC operational process to the EMT project

For example, during the initiating process group, the top management has selected the EMT director to manage the EMT deployment across the engineering regions. The EMT director wanted to understand the expectations from the new EMT tool. She surveyed the existing resource management tools in the engineering regions. After consolidating the regional expectations, she has organized a kick-off meeting. She has invited the engineering regional manager to validate their expectations. Later on, the EMT director has defined the project's charter to include the project's objectives, planning, and deliverables, in addition to the change management plans. She assigned

a technical project manager to follow up on the deployment of the EMT tool in the engineering regions. With the EMT director, the researcher/ practitioner has identified the virtual collectives' types for the EMT project: the virtual team to manage the project execution and the virtual community of interest to support the deployment of the tool.

Although the VC operational process was applied to the EMT project, the evaluation and the validation couldn't be done. In other words, we need to verify if the EMT tool was fully adopted and still considered as the standard resource management tool in all the engineering regions. The significant changes in the strategy, processes and tool within the hydro organization have hindered the evaluation phase for cycle 3.

Cycle 3: Conclusion

In Cycle 1 and 2, we helped the virtual engineering communities to develop their standards collaboratively and remotely. We proposed HySPeC as the collaborative standardization platform adjusted to the requirements of the collaborative standardization process. We proposed also the virtual collectives' dynamics model (VCD) to characterize the virtual collectives in function of their development phases. Then, we derived the virtual collectives' framework to differentiate the virtual collectives in function of the project's objectives. These propositions helped the engineering communities to co-develop their standards. However, the developed standards should be implemented in customers' projects to deliver the hydro systems. From practice, the organizational management style required the virtual collectives to be managed as project in order to develop and implement the standards in customer projects.

The cycle 3 problematic was: "Which operational process has to be defined to ease the work of the virtual engineering collectives within a project management framework? and how the operational process would facilitate the adoption of standards?". Moreover, we had to cope with the changes in the hydro organization. Risks on multiple levels: strategic, technological, human capital were highly probable.

Based on the operational managers' needs, we made our hypothesis and assumed that an integrated management process would facilitate the adoption and the implementation of standards in customers' project. We identified three management processes within the "GE Renewable Energy" hydro organization and they were: project, virtual collectives and change management processes. The integration of those 3 processes constituted the virtual collectives' operational process in section 7.2. We presented the EMT project and we considered it as a case study to implement the VC' operational process. The results were presented in section 7.3, however the validation of the results couldn't be completed due to the restructuring of the Hydro organization. The cycle 3 evaluation phase is recommended to be continued after the thesis period.

Table 28 presents the activities that we implemented for cycle 3 phases and throughout the sections of chapter 7.

Cycle 3	
Diagnosis	<ul style="list-style-type: none"> - Collect the operational managers' needs. - Define the requirements for the VC' operational process with the operational managers at GE Renewable Energy. - Extensive literature review on the operational process wasn't conducted due to the organizational changes and time constraints.
Planning Action	<ul style="list-style-type: none"> - Detail and explain the project and change management processes. - Propose the community management process. - Integrate the 3 processes and propose the VC' operational process.
Taking Action	<ul style="list-style-type: none"> - Present the EMT project as cycle 3 case study - Conduct trainings to the project managers on the VC' operational process. - Apply the VCF to the EMT project as prerequisite step. - Apply the VC 'operational process for the EMT project. - Present the results of the EMT case study.
Evaluation	<ul style="list-style-type: none"> - Couldn't be done during the thesis, recommended to complete it in the perspectives.

Table 28: Methodology actions for Cycle 3 phases

CHAPTER 8: THESIS CONCLUSION, LIMITATIONS, PERSPECTIVES, AND MANAGERIAL IMPLICATIONS

8.1 Thesis Conclusion

People are the source for the competitive advantage for organizations. They are key differentiators in a global market especially when markets and customers are diverse. It's impossible to conceive an organization without the people. In any Merger & Acquisition there's an intrinsic assumption that is there's a collective to execute the strategies (Seo & Hill, 2005). They translate short and long term strategy into actions and realize the company milestones. This collective is also responsible to create, apply and manage best practices through their daily interactions.

During the thesis, we have experienced the transformation of “Alstom Power” Hydro organization into “GE Renewable Energy” in one of the biggest merger & acquisition in the industrial history. This transformation has changed the hydro business configuration and operation. The collectives remained the core of this transformation and were responsible to its success.

The thesis started in July, 2013 under the “Alstom Power” hydro organizations and ended in June, 2016 under the “GE Renewable Energy” hydro organization. The thesis was conducted in 3 cycles: Cycle 1 and 2 within the “Alstom Power” and Cycle 3 within the “GE Renewable energy”. For Cycle 1 and 2, the top management has initiated a standardization program to improve the product competitiveness. It entrusted the realization of the engineering standards to the engineering collectives around the world and called them the “engineering communities”.

The top management has required that these engineering communities to develop collaboratively the engineering standards at distance. However, the engineering communities were dispersed in 5 regions (Europe, North America, Latin America, China and India), not well defined and lack the proper technological support. Consequently, the cycle 1 research question was: *“which collaborative standardization process and platform could enable the engineering collectives to co-develop their standards at distance?”*

From the practice, we observed and noted that the project managers tend to manage the engineering collectives in the same way during the project. Rarely they pay attention to the working practices and whether they're adapted to the project phase or not. At the heart of the project is the engineering collectives working together to deliver the same product. We noticed that not all the engineering collectives could perform equally. Specifically, the community norms, working mode and dynamics didn't fit in a project team configuration.

The collectives' structure, dynamics, and their behaviors, need to be examined and understood throughout the project phases. We intended to understand the different virtual collective's types, characterized and differentiated them in function of the project's phases. Consequently, the Cycle 2 research question was: *"what are the characteristics of the different virtual collectives' types which suit respectively the collaborative standardization process?"*

These engineering collectives were also responsible to facilitate the adoption and the implementation of the engineering standards in the customers' projects. The development and the implementation of the standards are done through an operational process. The hydro business managed its initiatives and programs as projects with defined budget, planning and deliverables. Even the community working mode has to be enrolled in project logic and integrated within the existing management practices. Consequently, the Cycle 3 research question was: *"which operational process has to be defined to ease the work of the virtual engineering collectives within a project based management style?"*

Two main operational processes at GE Renewable Energy were implemented: the project and change management processes. We have proposed a third operational process to manage and maintain the communities working mode. The integration of the project, change and community processes has defined the virtual collective's operational process. This integrated process is expected to ease the work of the virtual engineering collectives within a project management framework.

The thesis objective was to find a collaborative standardization model for the dispersed engineering collectives. The virtual collectives' type should naturally fit within the collaborative standardization process and intuitively use the collaborative platform' functionalities. The model should also provide an operational process to facilitate the integration and the work of the engineering collectives within the organization. The collaborative standardization model should validate the following hypothesis:

Hypothesis 1 presented in figure 63: The specifications of the collaborative platform's functionalities will be optimized if they are adjusted to the collaborative standardization process.

Cycle 1 propositions validated the first hypothesis:

- We started the diagnosis phase in chapter 1 where we analyzed the e-mail based standardization process. The process was time consuming and lacked a shared space to simultaneously work on the standards development. Our requirements were the ability to collaboratively develop the engineering standards at distance.
- We searched the literature in chapter 2 for collaborative standardization process and platform. The literature neither presented the specification methods to define the collaborative standardization nor functionalities adjusted to the collaborative standardization process.
- In chapter 3, we proposed four HySPeC templates – the collaborative standardization platform - to respond to the different requirements of the collaborative standardization process.
- In chapter 4, we applied an evaluation grid to assess the usage of HySPeC and the interaction dynamics of the engineering communities. We compared the communities' interaction dynamics and we concluded that the engineering communities had different interaction dynamics level. We ended chapter 4 with recommendations on how to improve the online collaboration for these engineering communities.

Hypothesis 2 presented in figure 63: The virtual collectives will be engaged in the different project's objectives if their collaboration dynamics are adapted to the collaborative standardization process.

Cycle 2 propositions validated the second hypothesis:

- In chapter 5, we identified 4 different virtual collectives' types from the literature. The proposed virtual collectives' dynamics model characterized the virtual collectives in function of the development phases. We have searched and grouped 54 characteristics found in the literature into 9 families. We selected 7 characteristics and identified them as critical differentiator factors (CDF). We organized the 9 characteristics families into the 3 development phases. The proposed virtual collectives' framework selected and differentiated the virtual collectives' types in function of the CDFs. With this framework, we recommended multiple working modes to cover the launch of projects, the execution and the closure. In addition, to the evolution of the collectives after the project completion.
- In chapter 6, we presented the "C&M platform" as the cycle case study. We applied the VCF to the C&M community. Then we discussed the contributions of the community approach to the success of the C&M platform. We collected the feedbacks from the C&M director that validated our proposals. In chapter 7, we integrated the project, change and community process then we proposed the virtual collective's operation process and apply it to the EMT project.

Hypothesis 3 presented in figure 63: In an organization that is managed as projects, the virtual collectives will adopt and use the collaborative platform's functionalities if an operational process is implemented.

Figure 63 shows the virtual engineering collectives operating in an organization that is managed as projects. They adapted their collaboration dynamics to the collaborative standardization process which adjusted the collaborative platform's functionalities. The operational process sustained the virtual engineering collectives to adopt the platform's functionalities.

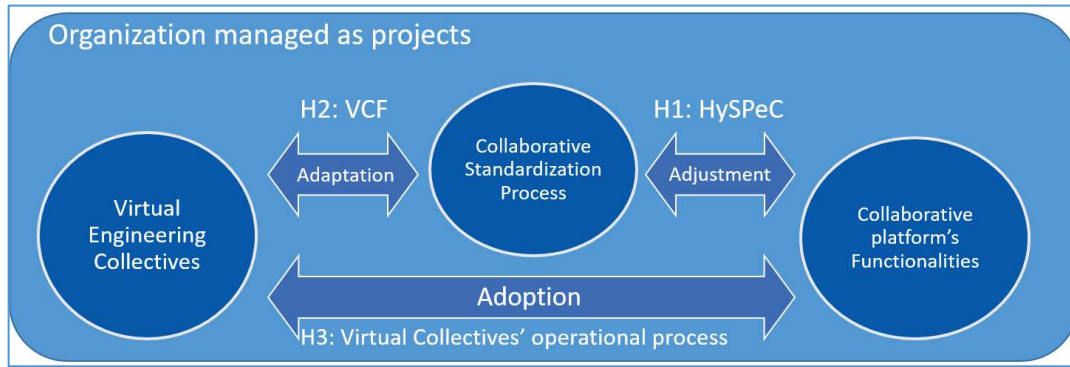


Figure 63: Thesis propositions

8.2 Thesis limitations & Perspectives

In practice, the different working modes are the implementation of the virtual collectives' framework. The alternation between the virtual team working mode and the virtual community working mode within the same project will adapt the collective interactions' dynamics to the project's objectives. This dynamic configuration may improve the collaboration and help to attain effectively the project deliverables. If the project manager adopted the virtual community of interest configuration, he would be able to keep in touch with all the project's stakeholders. In this way, he has constantly identified and validated their requirements. He will keep the stakeholders engaged and make sure the project will deliver the stakeholders' real expectations. This means high quality, effectiveness, and above all customer satisfaction.

However, the virtual collectives' framework as well as the rest of the propositions has limitations in our study. In the next sections, we presented the limitations and the perspectives for the proposed collaborative standardization process, the virtual collectives' framework and the virtual collectives' dynamics model.

8.2.1 Limitation and perspectives of the collaborative standardization process

Through observation from the welding structure, the collaborative standardization process was formalized and modeled. Later, the process model was discussed with the welding community' members and validated with the standardization manager. The limitation of the collaborative standardization process was its application to one case study: the control & monitoring platform. In order to test the genericity of the

proposed collaborative standardization model, we have to test it and apply it in additional case studies. One perspective for the collaborative standardization process is its application to other standardization communities within the GE Renewable Energy context. Another perspective is to transpose it to other companies within the energy industry and other industries.

8.2.2 Limitation and perspectives of the Virtual Collectives' Framework

The literature is rich and diversified about the informal social groups. But there were no clear boundaries between the virtual teams, virtual communities of practice, virtual communities of interest and networks for learning. We could identify dominant characteristics that can help us to clearly differentiate between the 4 virtual collective types. We identified these dominant characteristics as critical differentiator factors (CDFs) that defined the virtual collective framework. One limitation to this framework is how to guarantee the pertinence of these CDFs and their applicability to new types of virtual collectives (i.e.: workgroups, parallel teams, engineering clubs...)? Therefore, will these CDFs be able to distinguish future types of virtual engineering collectives? Another limitation may question the completeness of the defined differentiator factors set. One perspective will be to investigate what are the potential critical differentiator factors for a new virtual collective type. From practice, we assume that the leadership style may be a potential differentiator factor. A consensual, participative leadership style may fit the VCoP and the VCoI while a more directive leadership style may be suitable to VTs and networks for learning. This reflection about the leadership style will investigate from one hand the institutionalized structures vs. the informal structures and from the other hand innovation objectives vs. specific operational objectives. However, the leadership factor, as well as other potential differentiators, has to be researched in the scientific literature.

8.2.3 Limitation and perspectives of the virtual collectives' dynamics model

The 9 collectives' families defined in the virtual collectives' dynamics model characterized the virtual collectives in function of its development phases. For example, the collective's task design family characterized the virtual collectives in its forming & transforming phase. The collectives' health family characterized the virtual collectives in function of its storming & norming phase. The collective members'

satisfaction characterized the virtual collective in function of its performing phase. One limitation is related to the interdependency among the characteristic families. For example, what are the characteristics from the forming & transforming phase that are impacting the performing phase? In response to this limitation, one perspective may investigate what are the characteristics of an effective virtual team, an effective virtual community of interest/ practice, or a high-quality network for learning throughout all the development phases?

An additional perspective can be: what is the best strategy to form a virtual team? Would an effective virtual team be formed from virtual communities of practice or virtual communities of interest? If so, how to leverage the history and the previous experience between the community members to form the virtual team? And what are the mind-sets changes to perform while transitioning from a community-working mode to a team-working mode?

8.3 Managerial implications for the virtual collectives' dynamics model

From practice, we noticed that it is important to invest more effort on the team members' relationships and team leadership to promote better team dynamics. Communications among team members need to be handled with care. Excessive communication using the wrong means, such as electronic mails, may have negative effects and causes dissatisfaction among team members. We provided some managerial implications to help the project managers to deploy and animate the virtual collectives for the engineering projects.

Table 34, 35 and 36 presents a list of recommendations and practical guides when communicating inside the virtual collectives (see appendix F). These insights are collected and refined through the different case studies throughout our research. To facilitate the application of these recommendations we grouped them in function of the phases of the virtual collectives' dynamics model.

BIBLIOGRAPHY

- Aiello, J. R., & Kolb, K. J. (1995). Electronic performance monitoring and social context: impact on productivity and stress. *The Journal of Applied Psychology*, 80(3), 339–53. <http://doi.org/10.1037/0021-9010.80.3.339>
- AitSahlia, F., Johnson, E., & Will, P. (1995). Is concurrent engineering always a sensible proposition? *IEEE Transactions on Engineering Management*, 42(2), 166–170. <http://doi.org/10.1109/17.387269>
- Alge, B. J., Wiethoff, C., & Klein, H. J. (2003). When does the medium matter? Knowledge-building experiences and opportunities in decision-making teams. *Organizational Behavior and Human Decision Processes*. [http://doi.org/10.1016/S0749-5978\(02\)00524-1](http://doi.org/10.1016/S0749-5978(02)00524-1)
- Anderson, A. H., McEwan, R., Bal, J., & Carletta, J. (2007). Virtual team meetings: An analysis of communication and context. *Computers in Human Behavior*, 23, 2558–2580. <http://doi.org/10.1016/j.chb.2007.01.001>
- Andriessen, J. H. E. (2006). Knowledge Communities in fives. In *Delft Innovation System Papers* (pp. 1–29).
- Anthony, E. L., Green, S. G., & McComb, S. a. (2013). Crossing functions above the cross-functional project team: The value of lateral coordination among functional department heads. *Journal of Engineering and Technology Management - JET-M*, 31, 141–158. <http://doi.org/10.1016/j.jengtecman.2012.12.001>
- Ardichvili, A., Page, V., & Tim, W. (2002). Motivation and Barriers to Participation in Virtual Knowledge-Sharing Communities of Practice. In *OKLC*. Athens, Greece.
- Aziz, H., Gao, J., Maropoulos, P., & Cheung, W. M. (2005). Open standard, open source and peer-to-peer tools and methods for collaborative product development. *Computers in Industry*, 56(3), 260–271. <http://doi.org/10.1016/j.compind.2004.12.002>
- Baburoglu, O. N., & Ravn, I. (1992). Normative Action Research. *Organization Studies*. <http://doi.org/10.1177/017084069201300104>
- Bal, J., & Gundry, J. (1999). Virtual teaming in the automotive supply chain. *Team Performance Management*, 5(6), 174–193. <http://doi.org/10.1108/13527599910298190>
- Bal, J., & Teo, P. K. (2000). Implementing virtual teamworking. Part 1: a literature review of best practice. *Logistics Information Management*, 13(6), 346–352. *JOUR*. <http://doi.org/10.1108/09576050010355644>
- Banwo, A. O., Du, J., & Onokala, U. (2015). The Impact of Group Cohesiveness on Organizational Performance: The Nigerian Case. *International Journal of Business and Management*, 10(6), 146–155. <http://doi.org/10.5539/ijbm.v10n6p146>
- Barlett, C., & Ghosal, S. (2003). Managing across borders. *The British Journal of Administrative Management*, 24–25. <http://doi.org/10.1080/10803920.1999.10392010>
- BCHydro. (2013). Integrated Resource Plan Appendix 1A Glossary and Abbreviations. Retrieved from <https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/regulatory-planning-documents/integrated-resource-plans/current-plan/irp-appx-1a-20130802.pdf>

- Beal, D. J., Cohen, R. R., Burke, M. J., & McLendon, C. L. (2003). Cohesion and performance in groups: a meta-analytic clarification of construct relations. *The Journal of Applied Psychology, 88*(6), 989–1004. <http://doi.org/10.1037/0021-9010.88.6.989>
- BEGEY, C. (2015). EMT Communication Package. In *General Electric Renewable Energy - Hydro Solutions*.
- Bell, B. S. (2002). *A Typology of Virtual Teams : Implications for Effective Leadership A Typology of Virtual Teams : Implications for Effective Leadership*.
- Bell, B. S., & Kozlowski, S. W. J. (2002). A Typology of Virtual Teams: Implications for Effective Leadership. *Group & Organization Management, 27*(1), 14–49. <http://doi.org/10.1177/1059601102027001003>
- Bell, S. T. (2007). Deep-level composition variables as predictors of team performance: a meta-analysis. *The Journal of Applied Psychology, 92*(3), 595–615. <http://doi.org/10.1037/0021-9010.92.3.595>
- Beylier, C., Pourroy, F., Villeneuve, F., & Mille, A. (2009). A collaboration-centred approach to manage engineering knowledge: a case study of an engineering SME. *Journal of Engineering Design, 20*(6), 523–542. <http://doi.org/10.1080/09544820801898482>
- Bista, S. S. K., Nepal, S., Colineau, N., & Paris, C. (2012). Using Gamification in an Online Community. *Proceedings of the 8th IEEE International Conference on Collaborative Computing: Networking, Applications and Worksharing*, 611–618. <http://doi.org/10.4108/icst.collaboratecom.2012.250526>
- Bonebright, D. A. (2010). 40 years of storming: a historical review of Tuckman's model of small group development. *Human Resource Development International, 13*(1), 111–120. article. <http://doi.org/10.1080/13678861003589099>
- Bridges, W., & Mitchell, S. (2000). Leading transition: A new model for change. *Leader to Leader, 2000*(16), 30–36. Retrieved from <http://proquest.umi.com/pqdweb?did=724827811&Fmt=7&clientId=65345&RQT=309&VName=PQD>
- Brown, J. S., & Duguid, P. (2001). Knowledge and Organization: A Social-Practice Perspective. *Organization Science, 12*(2), 198–213. JOUR. <http://doi.org/10.1287/orsc.12.2.198.10116>
- Bruner, G. C., & Kumar, A. (2005). Explaining consumer acceptance of handheld Internet devices. *Journal of Business Research, 58*(5), 553–558. <http://doi.org/10.1016/j.jbusres.2003.08.002>
- Byvelds, R., & Newman, J. (1991). Understanding Change. In *OMAFRA*. Ontario, CA: Ministry of Agriculture, Food and Rural Affairs.
- Cargill, C. F. (2011). Why Standardization Efforts Fail. *Journal of Electronic Publishing, 14*(1), 1–20. <http://doi.org/10.3998/3336451.0014.103>
- Carlson, J. R., & Zmud, R. W. (1999). Channel expansion theory and the experiential nature of media richness perceptions. *Academy of Management Journal, 42*(2), 153–170. <http://doi.org/10.2307/257090>
- Carron, A. V. (1982). Cohesiveness in sport groups: Interpretations and considerations. *Journal of Sport Psychology, 4*(2), 123–138. Retrieved from <http://www.psychexchange.co.uk/resource/download/10918928271253730704.pdf/>

- Carron, a. V., & Brawley, L. R. (2000). Cohesion: Conceptual and Measurement Issues. *Small Group Research*, 31(1), 89–106. <http://doi.org/10.1177/104649640003100105>
- Cascio, W. F., & Shurygailo, S. (2003). E-leadership and virtual teams. *Organizational Dynamics*. [http://doi.org/10.1016/S0090-2616\(02\)00130-4](http://doi.org/10.1016/S0090-2616(02)00130-4)
- Chandrasegaran, S. K., Ramani, K., Sriram, R. D., Horváth, I., Bernard, A., Harik, R. F., & Gao, W. (2013). The evolution, challenges, and future of knowledge representation in product design systems. *Computer-Aided Design*, 45(2), 204–228. <http://doi.org/10.1016/j.cad.2012.08.006>
- Checkland, P., & Scholes, J. (1999). *Soft Systems Methodology in Action*. Wiley.
- Chen, K.-Y., & Chang, M.-L. (2013). User acceptance of “near field communication” mobile phone service: an investigation based on the “unified theory of acceptance and use of technology” model. *The Service Industries Journal*, 33(6), 609–623. <http://doi.org/10.1080/02642069.2011.622369>
- Chidambaram, L. (1996). Relational Development in Computer-Supported Groups. *MIS Quarterly*, 20(June), 143–166. <http://doi.org/10.2307/249476>
- Church, A. H. (1995). Diversity in workgroup settings: A case study. *Leadership & Organization Development Journal*, 16(6), 3–9. <http://doi.org/10.1108/01437739510092207>
- Cohen, S., & Bailey, D. (1997). What makes teams work: Group effectiveness research from the shop floor to the executive suite. *Journal of Management*, 23(3), 239–290. [http://doi.org/10.1016/S0149-2063\(97\)90034-9](http://doi.org/10.1016/S0149-2063(97)90034-9)
- Cohen, S. G., & Bailey, D. E. (1997). What Makes Teams Work : Group Effectiveness Research from the Shop Floor to the Executive Suite. *Journal of Management*, 23, 239–290. <http://doi.org/10.1177/014920639702300303>
- CORPAS. (2007). Standardization Guidelines for IST research projects interfacing with ICT standards organizations. In *Cooperation Platform for Research & Standards* (pp. 1–24).
- Coughlan, P., & Coughlan, D. (2002). Action research for operations management. *International Journal of Operations & Production Management*, 22(1995), 220–240. <http://doi.org/10.1108/01443570210417515>
- Craig, T. Y., & Kelly, J. R. (1999). Group cohesiveness and creative performance. *Group Dynamics*, 3(4), 243–256. <http://doi.org/10.1037/1089-2699.3.4.243>
- Cummings, S., & Zee, A. Van. (2005). Communities of practice and networks : reviewing two perspectives on social learning. *KM4D Journal*, 1(1), 8–22. Retrieved from www.km4dev.org/journal
- Daft, R. L., & Lengel, R. H. (1986). Organizational Information Requirements, Media Richness and Structural Design. *Management Science*, 32(5), 554–571. <http://doi.org/10.1287/mnsc.32.5.554>
- Daly, B. L. (1993). The influence of face-to-face versus computer-mediated communication channels on collective induction. *Accounting, Management and Information Technologies*, 3(1), 1–22. [http://doi.org/10.1016/0959-8022\(93\)90006-R](http://doi.org/10.1016/0959-8022(93)90006-R)
- Davenport, T., Jarvenpaa, S., & Beers, M. (1996). Improving knowledge work processes. *Sloan Management Review*, 37, 53–66.

- Davis, F. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <http://doi.org/10.2307/249008>
- Dennis, A. R., George, J. F., Jessup, L. M., Nunamaker, J. F., Douglas, R., & Vogel, D. R. (1988). Information Technology to Support Electronic Meetings. *MIS Quarterly*, 12(4), 591–624.
- DeSanctis, G., & Gallupe, R. B. (1987). A Foundation for the Study of Group Decision Support Systems. *Management Science*, 33(5), 589–609. <http://doi.org/10.1287/mnsc.33.5.589>
- Drucker, P., & Maciariello, J. a. (1967). The Effective Executive: The Definitive Guide to Getting the Right Things Done. *Administrative Science Quarterly*, 12(2).
- Duarte, D. L., & Snyder, N. T. (2007). Mastering Virtual Teams. In *International Journal of e-Collaboration* (Vol. 3, pp. 71–75). [http://doi.org/10.1016/S0737-6782\(01\)00087-X](http://doi.org/10.1016/S0737-6782(01)00087-X)
- Dubé, L., Bourhis, A., & Jacob, R. (2006). Towards a Typology of Virtual Communities of Practice. *Interdisciplinary Journal of Information, Knowledge, and Management*, 1.
- Dubrovsky, V., Kiesler, S., & Sethna, B. (1991). The Equalization Phenomenon: Status Effects in Computer-Mediated and Face-to-Face Decision-Making Groups. *Human-Computer Interaction*, 6(2), 119–146. http://doi.org/10.1207/s15327051hci0602_2
- Ebrahim, N. A., Ahmed, S., & Taha, Z. (2009). Virtual Teams: A Literature Review. *Australian Journal of Basic and Applied Sciences*, 3(3), 2653–2669.
- Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *Academy of Management Review*. <http://doi.org/10.5465/AMR.1989.4308385>
- El Badawi El Najjar, R., Prudhomme, G., Pourroy, F., Maussang-Detaille, N., & Blanco, E. (2014). AN APPROACH FOR DEFINING A COLLABORATIVE PLATFORM TO SUPPORT THE DEVELOPMENT OF CORPORATE ENGINEERING. In *Proceedings of Joint Conference on Mechanical, Design Engineering & Advanced Manufacturing* (pp. 1–7). Toulouse, France.
- Elenkov, D. S. (2002). Effects of leadership on organizational performance in Russian companies. *Journal of Business Research*, 55(6), 467–480. [http://doi.org/10.1016/S0148-2963\(00\)00174-0](http://doi.org/10.1016/S0148-2963(00)00174-0)
- El-Shinnawy, M., & Vinze, A. S. (1998). Polarization and Persuasive Argumentation: A Study of Decision Making in Group Settings. *MISQ*, 22(2), 165. <http://doi.org/10.2307/249394>
- Engel, P. G. H. (1997). *The social organisation of innovation, a focus on stakeholder interaction*. Royal Tropical Institute. Royal Tropical Institute.
- Engel, P. G. H., & Alders, C. (1993). Daring to share: networking among non-government organizations. In *Linking with farmers: networking for low-external-input and sustainable agriculture* (pp. 131–150).
- Engel, P. G. H., Carlsson, C., & Zee, A. Van. (2003). *Internalising evaluation results through learning: complementary perspectives, dilemmas and some lessons learned*. ECDPM: Maastricht.
- Fall, K. A., & Wejnert, T. J. (2005). Co-Leader Stages of Development: An Application of Tuckman and Jensen (). *The Journal for Specialists in Group Work*, 30(4), 309–327. <http://doi.org/10.1080/01933920500186530>
- Fan, Z. P., Suo, W. L., Feng, B., & Liu, Y. (2011). Trust estimation in a virtual team: A decision

- support method. *Expert Systems with Applications*, 38(8), 10240–10251.
<http://doi.org/10.1016/j.eswa.2011.02.060>
- Festinger, L. (1950). Informal social communication. *Psychological Review*, 57(5), 271–282.
<http://doi.org/10.1037/h0056932>
- Fischer, G. (1995). From Reflective Practitioners to Reflective Communities. In *HCI international conference (HCII)*.
- Fischer, G. (2001). Communities of Interest : Learning through the Interaction of Multiple Knowledge Systems. In *Informarion Systems Research Seminar in Scandinavia* (pp. 1–13). Bergen, Norway.
- Fischer, G., & Ostwald, J. (2005). Knowledge Communication in Design Communities. In R. Bromme, F. Hesse, & H. Spada (Eds.), *Barriers and Biases in Computer-Mediated Knowledge Communication SE - 10* (Vol. 5, pp. 213–242). CHAP, Springer US.
http://doi.org/10.1007/0-387-24319-4_10
- Folmer, E., & Verhoosel, J. (2011). *State of the Art on Semantic IS Standardization, Interoperability & Quality*. UT, CTIT, TNO en NOiV. Retrieved from www.semanticstandards.org
- Fontaine, M., & Prusak, L. (2004). Keeping Communities of Practice Afloat: Understanding and Fostering Roles in Communities. *Creating Value with Knowledge*, 124–134. article. Retrieved from <http://www.ingentaconnect.com/content/oso/1101064/2004/00000001/00000001/art00011>
- Fraslin, M. (2013). *EVALUATING THE CAPACITY OF A VIRTUAL R&D COMMUNITY OF PRACTICE TO GO ONLINE . The Case of ALSTOM Power Hydro*. Grenoble Alpes University.
- Fraslin, M., & Blanco, E. (2013). Characterizing collaboration through online interactions within R&D communities. In *ICED13 International Conference on Engineering Design* (p.). Seoul.
- Fraslin, M., Blanco, E., & Chanal, V. (2011). Interface qualification between the research central team and design offices in order to evaluate the knowledge sharing. In *International Conference on Engineering Design , ICED11*. Denmark.
- Fuller, M. a., Hardin, A. M., & Davison, R. M. (2006). Efficacy in Technology-Mediated Distributed Teams. *Journal of Management Information Systems*, 23(3), 209–235.
<http://doi.org/10.2753/MIS0742-1222230308>
- Gallupe, B. (2001). Knowledge management systems: surveying the landscape. *International Journal of Management Reviews*, 3(1), 61–77. <http://doi.org/10.1111/1468-2370.00054>
- Gassmann, O., & von Zedtwitz, M. (2003a). Trends and determinants of managing virtual R&D teams. *R & D Management*, 33(3), 243–262.
- Gassmann, O., & von Zedtwitz, M. (2003b). Trends and determinants of managing virtual R&D teams. *R&D Management*, 33, 243–262. <http://doi.org/10.1111/1467-9310.00296>
- GE IPM. (2016). IPM: Integrated Project Management. In *General Electric Renewable Energy - Hydro Solutions*. General Electric Company.
- GE Renewable Energy. (2015). Hydro Discovery Tour Presentation. In *General Electric*

Renewable Energy - Hydro Solutions.

- GE Reports. (2015). Digital Industrial: GE Annual Report. In *General Electric Renewable Energy - Hydro Solutions*. Retrieved from www.ge.com/annualreport
- Ghoshal, S., Westney, D. E., & Westney, G. (1995). Organization Theory and the Multinational Corporation. *Administrative Science Quarterly*, 40(1), 191.
- Gibson, C. B., & Gibbs, J. L. (2006). Unpacking the concept of virtuality: The effects of geographic dispersion, electronic dependence, dynamic structure, and national diversity on team innovation. *Administrative Science Quarterly*, 51(3), 451–495. <http://doi.org/10.2189/asqu.51.3.451>
- Gladstein, D. L. (1984). Groups in context: A model of task group effectiveness. *Administrative Science Quarterly*, 29(4), 499–517. <http://doi.org/10.2307/2392936>
- Glückler, J., & Schrott, G. (2007). Leadership and Performance in Virtual Teams. *International Journal of E-Collaboration*, 3(3), 31–52. <http://doi.org/10.4018/jec.2007070103>
- Gongla, P., & Rizzuto, C. R. (2001). Evolving communities of practice: IBM Global Services experience. *IBM Systems Journal*, 40(4), 842–862. <http://doi.org/10.1147/sj.404.0842>
- González, M. G., Burke, M. J., Santuzzi, A. M., & Bradley, J. C. (2003). The impact of group process variables on the effectiveness of distance collaboration groups. *Computers in Human Behavior*, 19(5), 629–648. [http://doi.org/10.1016/S0747-5632\(02\)00084-5](http://doi.org/10.1016/S0747-5632(02)00084-5)
- Goodhue, D. L., & Thompson, R. L. (1995). Task-Technology Fit and Individual Performance. *MIS Quarterly*, 19(2), 213–236. <http://doi.org/10.2307/249689>
- Granovetter, M. S. (1973). The Strength of Weak Ties. *American Journal of Sociology*, 78(6), 1360–1380.
- Greenberg, P. S., Greenberg, R. H., & Antonucci, Y. L. (2007). Creating and sustaining trust in virtual teams. *Business Horizons*, 50(4), 325–333. <http://doi.org/10.1016/j.bushor.2007.02.005>
- Griffith, T. L., & Neale, M. a. (2001). Information Processing in Traditional, Hybrid, and Virtual Teams: From Nascent Knowledge to Transactive Memory. *Research in Organizational Behavior*, 23(February 2016), 379–421. [http://doi.org/10.1016/S0191-3085\(01\)23009-3](http://doi.org/10.1016/S0191-3085(01)23009-3)
- Groh, F. (2012). Gamification: State of the Art Definition and Utilization. *Research Trends in Media Informatics*, 39–46. <http://doi.org/10.1145/1979742.1979575>
- Guzzo, R., Yost, P., Campbell, R., & Shea, G. (1993). Potency in groups: Articulating a construct. *British Journal of Social Psychology*, 32, 87–106. <http://doi.org/DOI:10.1111/j.2044-8309.1993.tb00987.x>
- Hacker, M. E., & Kleiner, B. M. (1996). Identifying Critical Factors Impacting Virtual Work Group Performance. In *International Conference on Engineering and Technology Management* (pp. 196–200). Vancouver, British Columbia, Canada.
- Hackman, J. R. (1987). The design of work teams. *Handbook of Organizational Behavior*, 315(10), 315–342. [http://doi.org/10.1016/0090-2616\(78\)90031-1](http://doi.org/10.1016/0090-2616(78)90031-1)
- Hackman, J. R. (2003). Learning more from crossing levels: Evidence from airplanes, orchestras, and hospitals. *Journal of Organizational Behavior*, 24, 1–18. article.

- Hackman, J. R., & Morris, C. G. (1975). Group tasks, group interaction process, and group performance effectiveness: A review and proposed integration. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 8). inbook, New York: Academic Press.
- Hackman, J. R., & Oldham, G. R. (1976). Motivation through the design of work: test of a theory. *Organizational Behavior and Human Performance*, 16(2), 250–279. [http://doi.org/10.1016/0030-5073\(76\)90016-7](http://doi.org/10.1016/0030-5073(76)90016-7)
- Hansen, M. (2004). *Virtual Teams That Work: Creating Conditions for Virtual Team Effectiveness*. *Personnel Psychology* (Vol. 57). <http://doi.org/10.1108/13665620210427294>
- Hara, N., Shachaf, P., & Stoerger, S. (2009). Online communities of practice typology revisited. *Journal of Information Science*, 35(6), 740–757. <http://doi.org/10.1177/0165551509342361>
- Hare, A., Borgatta, E., & Bales, R. (1955). *Small groups: Studies in social interaction*. New York, NY, USA: New York, Knopf. Retrieved from <http://psycnet.apa.org/psycinfo/1965-15038-000>
- Harris, P. R., & Harris, K. G. (1996). Managing effectively through teams. *Team Performance Management*, 2(3), 23–36. <http://doi.org/10.1108/13527599610126247>
- Harun, M., & Mahmood, R. (2012). The Relationship between Group Cohesiveness and Performance: An Empirical Study of Cooperatives Movement in Malaysia. ... *Journal of Cooperative Studies*, 1(1), 15–20. <http://doi.org/10.11634/216826311403110>
- Hatto, P. (2013). Standards and Standardisation: A practical guide for researchers. In *European Commission - Directorate-General for Research & Innovation*. <http://doi.org/10.2777/10323>
- Hertel, G., Geister, S., & Konradt, U. (2005). Managing virtual teams: A review of current empirical research. *Human Resource Management Review*, 15(1), 69–95. <http://doi.org/10.1016/j.hrmr.2005.01.002>
- Hiba, L. Ben, Abdou, M., & Idrissi, J. (2012). An SNA-Based Evaluation Framework for Virtual Teams Evaluating Virtual Teams : A Network Perspective. In *OTM 2012 Workshops* (pp. 597–607).
- Hildreth, P. M., & Kimble, C. (2004). *Knowledge Networks : Innovation Through Communities of Practice*. Idea Group Publishing.
- Hollingshead, A. B. (1996). Information Suppression and Status Persistence in Group Decision Making The Effects of Communication Media. *Human Communication Research*, 23(2), 193–219. <http://doi.org/10.1111/j.1468-2958.1996.tb00392.x>
- Hollingshead, A. B., Mcgrath, J. E., & O'Connor, K. M. (1993). Group Task Performance and Communication Technology: A Longitudinal Study of Computer-Mediated Versus Face-to-Face Work Groups. *Small Group Research*, 24(3), 307–333. <http://doi.org/10.1177/1046496493243003>
- Huber, G. (1990). A theory of the effects of advanced information technologies on organizational design, intelligence, and decision making. *Academy of Management Review*, 15, 47–71. <http://doi.org/10.2307/258105>
- Huber, G. P. (2001). Transfer of knowledge in knowledge management systems: unexplored issues and suggested studies. *European Journal of Information Systems*, 10(2), 72–79.

- JOUR. Retrieved from <http://dx.doi.org/10.1057/palgrave.ejis.3000399>
- Hustad, E. (2010). Exploring Knowledge Work Practices and Evolution in Distributed Networks of Practice. *Electronic Journal of Knowledge Management*, 8(1), 69–78.
- IHA. (2015). 2015 Hydropower Status Report. In *International hydropower association*. Retrieved from <https://www.hydropower.org/2015-hydropower-status-report>
- IRENA. (2012). Hydropower. In *Renewable Energy Technologies: Cost Analysis Series* (Vol. 1: Power s, p. 44). Retrieved from http://www.irena.org/documentdownloads/publications/re_technologies_cost_analysis-hydropower.pdf
- ISO. (2010). International standards and “private standards.” In *International Organization for Standardization*.
- ISO/IEC. (2004). Standardization and related activities - General Vocabulary. In *International Organization for Standardization*.
- Jarvenpaa, S. L., & Leidner, D. E. (1999). Communication and Trust in Global Virtual Teams. *Organization Science*. <http://doi.org/10.1287/orsc.10.6.791>
- Jehn, K. A. (2001). the Dynamic Nature of Conflict: a Longitudinal Study of Intragroup Conflict and Group Performance. *Academy of Management Journal*, 44(2), 238–251. <http://doi.org/10.2307/3069453>
- Joinson, C. (2002). Managing virtual teams. *HR Magazine*, June, 69–73. <http://doi.org/10.1002/ert.20205>
- Kankanhalli, A., Tanudidjaja, F., Sutanto, J., & Tan, B. C. Y. (2003). The role of IT in successful knowledge management initiatives. *Communications of the ACM*, 46(9), 69. <http://doi.org/10.1145/903893.903896>
- Kayworth, T., & Leidner, D. (2000). The global virtual manager: a prescription for success. *European Management Journal*, 18(2), 183–194. [http://doi.org/10.1016/S0263-2373\(99\)00090-0](http://doi.org/10.1016/S0263-2373(99)00090-0)
- Kirkman, B. L., Rosen, B., Tesluk, P. E., & Gibson, C. B. (2004). the Impact of Team Empowerment on Virtual Team Performance: the Moderating Role of Face-To-Face Interaction. *Academy of Management Journal*, 47(2), 175–192. <http://doi.org/10.2307/20159571>
- Kramer, R. M., & Brewer, M. B. (1986). *Social Group Identity and the Emergence of Cooperation in Resource Conservation Dilemmas*. book, Graduate School of Business, Stanford University. Retrieved from <https://books.google.fr/books?id=k0jaYgEACAAJ>
- Krechmer, K. (2006). Open Standards Requirements. *International Journal of IT Standards and Standardization Research*, 4(1), 43–61. <http://doi.org/10.4018/jitsr.2006010103>
- Lave, J., & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation* (1st ed.). Cambridge University Press.
- Leavitt, & Paige. (2001). *Building and sustaining communities of practice: continuing success in knowledge management*. Houston : APQC.
- Lecet, D. (2012). Community Computer Environment supports a COP_CBR approach to solve difficulties. In *Colloquium in Information Science and Technology (CIST), 2012* (pp. 64–68).

- Leenders, R. T. A. J., Van Engelen, J. M. L., & Kratzer, J. (2003). Virtuality, communication, and new product team creativity: A social network perspective. *Journal of Engineering and Technology Management - JET-M*, 20(1–2 SPEC.), 69–92.
[http://doi.org/10.1016/S0923-4748\(03\)00005-5](http://doi.org/10.1016/S0923-4748(03)00005-5)
- Lesser, E., & Everest, K. (2001). Using communities of practice to manage intellectual capital. *Ivey Business Journal*. <http://doi.org/Article>
- Lesser, E. L., & Stork, J. (2001). Communities of practice and organizational performance. *IBM SYSTEMS JOURNAL*, 40(4), 831–841.
- Lipnack, J., & Stamps, J. (1997). *Virtual Teams: Reaching Across Space, Time, and Organizations with Technology*. book, New York, NY, USA: John Wiley & Sons, Inc.
- Lipnack, J., & Stamps, J. (2000). *Virtual Teams: People Working Across Boundaries with Technology, Second Edition* (2nd ed.). book, New York, NY, USA: John Wiley & Sons, Inc.
- Lovelace, K., Shapiro, D. L., & Weingart, L. R. (2001). Maximizing cross-functional new product teams' innovativeness and constraint adherence: A conflict communications perspective. *Academy of Management Journal*. <http://doi.org/10.2307/3069415>
- Lurey, J. S., & Raisinghani, M. S. (2001). An empirical study of best practices in virtual teams. *Information & Management*, 38, 523–544.
- Marks, M. A., Mathieu, J. E., & Zaccaro, S. J. (2001). A temporally based framework and taxonomy of team processes. *Academy of Management Review*, 26(3), 356–376.
<http://doi.org/10.5465/AMR.2001.4845785>
- Markus, M. L. (2001). Toward A Theory of Knowledge Reuse : Types of Knowledge Reuse Situations and Factors in Reuse Success. *Journal of Management Information Systems*, 1(18), 57–93.
- Martins, L. L., Gilson, L. L., & Maynard, M. T. (2004). Virtual Teams: What Do We Know and Where Do We Go From Here? *Journal of Management*, 30(6), 805–835.
<http://doi.org/10.1016/j.jm.2004.05.002>
- May, A., & Carter, C. (2001). A case study of virtual team working in the European automotive industry. *International Journal of Industrial Ergonomics*, 27(3), 171–186.
[http://doi.org/10.1016/S0169-8141\(00\)00048-2](http://doi.org/10.1016/S0169-8141(00)00048-2)
- Maznevski, M. L., & Chudoba, K. M. (2000). Bridging Space Over Time : Global Virtual Team Dynamics and Effectiveness. *Organization Science*, 11(5), 473–492.
- McComb, S. A., Kennedy, D. M., Green, S. G., & Compton, W. D. (2008). Project team effectiveness: the case for sufficient setup and top management involvement. *Production Planning & Control*, 19(4), 301–311.
<http://doi.org/10.1080/09537280802034059>
- Mcdermott, R. (1999). Nurturing Three Dimensional Communities of Practice: How to get the most out of human networks. *Knowledge Managment Review*, (303), 1–8.
- Mcdermott, R., & O'Dell, C. (2001). Overcoming cultural barriers to sharing knowledge. *Journal of Knowledge Management*, 5, 76–85.
<http://doi.org/http://dx.doi.org/10.1108/13673270110384428>
- McGrath, J. E. (1964). *Social psychology: a brief introduction*. book, Holt, Rinehart and Winston. Retrieved from https://books.google.fr/books?id=g_i3AAAAIAAJ

- McGrath, J. E. (1984). *Groups: Interaction and Performance*. Prentice-Hall, Inc., Englewood Cliffs, N.J. 07632.
- Moreland, R. L. (1996). Lewin's legacy for small-groups research. *Systems Practice*, 9(1), 7–26. article. <http://doi.org/10.1007/BF02173416>
- Murillo, E. (2011a). Communities of practice in the business and organization studies literature, 1–33.
- Murillo, E. (2011b). *Virtual Communities of Practice: Theory, Measurement and Organizational Implications*. VDM Verlag Dr. Müller.
- Nickerson, J. V, & Zur Muehlen, M. (2006). The Ecology of Standards Processes: Insights From Internet Standard Making. *MIS Quarterly*, 30(1), 467–488.
- Nousala, S., & Hall, W. P. (2008). Emerging Autopoietic Communities – Scalability of Knowledge Transfer in Complex Systems. In *First IFIP International Workshop on Distributed Knowledge Management*.
- Nunamaker, J. F. . J., Romano, N. C. . J., & Briggs, R. O. (2001). A framework for collaboration and knowledge management. *Proceedings of the 34th Annual Hawaii International Conference on System Sciences*, 0(c), 1–12. <http://doi.org/10.1109/HICSS.2001.926241>
- O'Hara-Devereaux, M., & Johansen, R. (1994). *GlobalWork: Bridging Distance, Culture and Time (The Jossey-Bass Management Series)*. book, Jossey-Bass. Retrieved from <http://www.amazon.com/exec/obidos/redirect?tag=citeulike07-20&path=ASIN/1555426026>
- Paul, S., Illinois, S., & Mykytyn, P. (2005). Understanding Conflict in Virtual Teams : An Experimental Investigation using Content Analysis. In *Proceedings of the 38th Hawaii International Conference on System Sciences - 2005* (Vol. 0, pp. 1–10).
- Pauleen, D. J., & Yoong, P. (2001). Relationship building and the use of ICT in boundary-crossing virtual teams: A facilitator's perspective. *Journal of Information Technology*. <http://doi.org/10.1080/02683960110100391>
- Ping, W. (2011). A Brief History of Standards and Standardization Organizations: A Chinese Perspective. In *east-west center working papers*.
- Plant, R. (2004). Online communities. *Technology in Society*, 26(1), 51–65. <http://doi.org/10.1016/j.techsoc.2003.10.005>
- Powell, A., Piccoli, G., & Ives, B. (2004). Virtual teams: A Review of Current Literature and Directions for Future Research. *ACM SIGMIS Database*, 35, 6–36. <http://doi.org/10.1145/968464.968467>
- Project Management Institute. (2013a). *A guide to the project management body of knowledge (PMBOK® guide)*. Project Management Institute. <http://doi.org/10.1002/pmj.20125>
- Project Management Institute. (2013b). *A guide to the project management body of knowledge (PMBOK® guide)*. Project Management Institute. <http://doi.org/10.1002/pmj.20125>
- Rachuri, S., Subrahmanian, E., Bouras, A., Fenves, S. J., Foufou, S., & Sriram, R. D. (2008). Information sharing and exchange in the context of product lifecycle management: Role of standards. *Computer-Aided Design*, 40(7), 789–800. <http://doi.org/10.1016/j.cad.2007.06.012>

- Rosen, B., Furst, S., & Blackburn, R. (2007). Overcoming Barriers to Knowledge Sharing in Virtual Teams. *Organizational Dynamics*, 36(3), 259–273.
<http://doi.org/10.1016/j.orgdyn.2007.04.007>
- Sadri, G., & Tran, H. (2002). Managing your diverse workforce through improved communication. *Journal of Management Development*.
<http://doi.org/10.1108/02621710210420291>
- Sarker, S., Valacich, J. S., & Sarker, S. (2003). Virtual team trust: Instrument development and validation in an IS educational environment. *Information Resources Management Journal*, 16(2), 35–55. Retrieved from
http://ezproxy.net.ucf.edu/login?url=http://search.proquest.com/docview/215880980?accountid=10003&nhttp://sfx.fcla.edu/ucf?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:journal&genre=article&sid=ProQ:ProQ:abiglobal&atitle=Virtual+team+trust:+Instru
- Schlenkrich, L., & Upfold, C. (2009). A Guideline for Virtual Team Managers : the Key to Effective Social Interaction and Communication. *The Electronic Journal Information Systems Evaluation*, 12(1), 109–118.
- Schmid, S., & Kotulla, T. (2011). 50 years of research on international standardization and adaptation-From a systematic literature analysis to a theoretical framework. *International Business Review*, 20(5), 491–507.
<http://doi.org/10.1016/j.ibusrev.2010.09.003>
- Schwen, T. M., & Hara, N. (2003). Community of practice: A metaphor for online design? *The Information Society*, 19(3), 257–270. <http://doi.org/10.1080/01972240309462>
- Seck, M. M., & Helton, L. (2014). Faculty Development of a Joint MSW Program Utilizing Tuckman's Model of Stages of Group Development. *Social Work with Groups*, 37(2), 158–168. article. <http://doi.org/10.1080/01609513.2013.828908>
- Seo, M., & Hill, N. (2005). Understanding the Human Side of Merger and Acquisition An Integrative Framework. *The Journal of Applied Behavioral Science*, 41(4), 422–443.
<http://doi.org/10.1177/0021886305281902>
- Shapiro, D. L., Furst, S. A., Spreitzer, G. M., & Von Glinow, M. A. (2002). Transnational teams in the electronic age: Are team identity and high performance at risk? *Journal of Organizational Behavior*, 23(SPEC. ISS.), 455–467. <http://doi.org/10.1002/job.149>
- Shea, G. P., & Guzzo, R. A. (1987). Groups as Human Resources. *Research in Personnel and Human Resources Management*, 5, 323–356.
- Slob, F. J. C., & DeVries, H. J. (2002). Best Practice In Company Standardisation. In *ERIM report series research in management. ERS-2002-81-ORG* (p. 26).
- Spivak, S. M., & Brenner, F. C. (2001). *Standardization essentials: principles and practice*. New York, NY, USA: Marcel Dekker, Inc.
- Staples, D. S., & Cameron, A. F. (2004). *Virtual and Collaborative Teams*. (S. H. Godar & S. P. Ferris, Eds.). IGI Global. <http://doi.org/10.4018/978-1-59140-204-6>
- Staples, D. S., & Cameron, A. F. (2005). The Effect of Task Design , Team Characteristics , Organizational Context and Team Processes on the Performance and Attitudes of Virtual Team Members. In *Proceedings of the 38th Hawaii International Conference on System Sciences* (Vol. 0, pp. 1–10).

- Staples, D. S., & Zhao, L. (2006). The effects of cultural diversity in virtual teams versus face-to-face teams. *Group Decision and Negotiation*, 15, 389–406.
<http://doi.org/10.1007/s10726-006-9042-x>
- Stirling, J., Beaumont, R., & Percy, A. (2009). Tutors ' Forum : Engaging Distributed Communities of Practice Tutors ' Forum : Engaging Distributed Communities of Practice, 24(2), 141–153.
- Storck, J., & a, H. P. (2000). Knowledge diffusion through “strategic communities.” *Sloan Management Review*, 41(2), 63. <http://doi.org/10.1016/B978-0-7506-7293-1.50008-1>
- Straus, S. G. (1996). Getting a Clue: The Effects of Communication Media and Information Distribution on Participation and Performance in Computer-Mediated and Face-to-Face Groups. *Small Group Research*, 27(1), 115–142.
<http://doi.org/10.1177/1046496496271006>
- Straus, S. G., & McGrath, J. E. (1994). Does the Medium Matter? The Interaction of Task Type and Technology on Group Performance and Member Reactions. *Journal of Applied Psychology*, 79(1), 87–97. <http://doi.org/10.1037//0021-9010.79.1.87>
- Tan, M., Tripathi, N., Zuiker, S. J., & Hock Soon, S. (2010). Building an online collaborative platform to advance creativity. *4th IEEE International Conference on Digital Ecosystems and Technologies*, 421–426. <http://doi.org/10.1109/DEST.2010.5610610>
- Tassey, G. (1997). *The Economics of R&D Policy*. Quorum Books.
- Tassey, G. (2000). Standardization in technology-based markets. *Research Policy*, 29(4–5), 587–602. [http://doi.org/10.1016/S0048-7333\(99\)00091-8](http://doi.org/10.1016/S0048-7333(99)00091-8)
- Tubbs, S. L. (1995). *A systems approach to small group interaction* (11th Editi). McGraw-Hill.
- Tuckman, B. W. (1965). Developmental Sequence in Small Groups 1. *American Psychological Association*, 63(6), 384–399.
- Tuckman, B. W., & Jensen, M. A. C. (1977). Stages of small group development revisited. *Group and Organization Studies*, 2, 419–427.
<http://doi.org/10.1177/105960117700200404>
- UNIDO. (2006). Role of standards: a guide for small and medium-sized enterprises. In *United Nations Industrial Development Organization*. Vienna, Austria.
- Vitalo, R. L., Butz, F., & Vitalo, J. P. (2003). *Kaizen Desk Reference Standard: The Complete Guide for Applying Kaizen to Continuously Improve Business*. Lowrey Press.
- Voss, C., Tsikriktsis, N., & Frohlich, M. (2002). Case research in operations management. *International Journal of Operations & Production Management*, 22(2), 195–219.
<http://doi.org/10.1108/01443570210414329>
- Walther, J. B. (1994). Anticipated ongoing interaction versus channel effects on relational communication in computer-mediated interaction. *Human Communication Research*, 20(4), 473–501. <http://doi.org/10.1111/j.1468-2958.1994.tb00332.x>
- Walther, J. B. (1997). Group and interpersonal effects in international computer mediated collaboration. *Human Communication Research*, 23(3), 342.
<http://doi.org/10.1111/j.1468-2958.1997.tb00400.x>
- WEC. (2013). World Energy Resources. *World Energy Council Report*, 468.
<http://doi.org/http://www.worldenergy.org/wp->

content/uploads/2013/09/Complete_WER_2013_Survey.pdf

- Weingart, L. R. (1997). How did they do that? The ways and means of studying group process. *Research in Organizational Behavior*, 19(October), 189–239.
- Wenger, E. (1999). *Communities of Practice: Learning, Meaning, and Identity* (1st ed.). book, Cambridge University Press. Retrieved from <http://www.amazon.com/exec/obidos/redirect?tag=citeulike07-20&path=ASIN/0521663636>
- Wenger, E., McDermott, R., & Snyder, W. (2002). *Cultivating Communities of Practice: A Guide to Managing Knowledge*. book, Boston, MA, USA: Harvard Business School Press.
- Wenger, E., & Synder, W. M. (2000). Communities of Practice: The Organizational Frontier. *Harvard Business Review*.
- Wenger, E., Trayner, B., & De Laat, M. (2011). *Promoting and assessing value creation in communities and networks: a conceptual framework*.
- Wenger, E., & Trayner-Wenger, B. (2015). Communities of practice: a brief introduction. *April 2015*, 1–8. <http://doi.org/10.2277/0521663636>
- West, D. B. (2001a). *Introduction to Graph Theory*. book, Prentice Hall. Retrieved from <https://books.google.fr/books?id=TuvuAAAAMAAJ>
- West, D. B. (2001b). *Introduction to Graph Theory*. book, Prentice Hall.
- Wong, S., & Burton, R. M. (2000). Virtual Teams : What are their Characteristics , and Impact on Team Performance ? *Computational & Mathematical Organization Theory*, 6, 339–360.
- Workman, M., Kahnweiler, W., & Bommer, W. (2003). The effects of cognitive style and media richness on commitment to telework and virtual teams. *Journal of Vocational Behavior*, 63(2), 199–219. [http://doi.org/10.1016/S0001-8791\(03\)00041-1](http://doi.org/10.1016/S0001-8791(03)00041-1)
- Yesilbas, L. G., & Lombard, M. (2004). Towards a knowledge repository for collaborative design process: focus on conflict management. *Computers in Industry*, 55(3), 335–350. <http://doi.org/10.1016/j.compind.2004.08.009>
- Zaccaro, S. J., & McCoy, M. C. (1988). The Effects of Task and Interpersonal Cohesiveness on Performance of a Disjunctive Group Task1. *Journal of Applied Social Psychology*, 18(10), 837–851. article. <http://doi.org/10.1111/j.1559-1816.1988.tb01178.x>
- Zhang, W., & Watts, S. (2008). Online communities as communities of practice: a case study. *Journal of Knowledge Management*, 12(4), 55–71. <http://doi.org/10.1108/13673270810884255>
- Zou, S., & Cavusgil, S. T. (2002). The GMS: A Broad Conceptualization of Global Marketing Strategy and Its Effect on Firm Performance. *Journal of Marketing*, 66(4), 40–56. <http://doi.org/10.2307/3203357>

APPENDIX A

The welded structure workshop was held in Grenoble, France from 29th of February till 2nd of March 2012. The description of the workshop participants and organization is shown in Table 32.

Co-located welded structure workshop	
Participants	Louis Mathieu, Sanjeev Jain, Paul Lapointe, Jacques Bremond, Thierry Sazerat, Yann Triffe, Chirag Trivedi, Kleber Cunha, Antoine Vaichere, Roberto Conz, Samuel Voruz, Eric Barthelet, Stephane Meyniel, Daniel Wilke, Vincent Blin, André Zobler, Jeremy Faure, Francisco Pereira, Jean-Pierre Girard, Prasad Bhamidipati, Sn Venkataravanappa, François-Olivier Gagnon, Stéphane Roy, Decio Vieira, Kevin Zhang, Dong Zhang, Juan Wang, Zhongdong Zhang, Bertrand Fraissard, Manuel Martinez.
Guests	Florent Nivon, Arnaud Doncourt, Vinicius Muraro-Da-Silva, Franck Pourroy (INPG)
Chairman	Florent Nivon, Arnaud Doncourt, Vinicius Muraro-Da-Silva, Franck Pourroy (INPG)
Dress Code	Casual
Logistics	Meeting & Accommodation at: Salle Berges (basement, Belledonne building) in Grenoble Site Contact: Claire Ronin + 33 4 76 39 32 41
Group 1 organization	Manufacturing and Inspection rules Louis MATHIEU, Thierry SAZERAT, Decio VIEIRA, Kleber CUNHA, Prasad BHAMIDIPATI, Antoine VAICHÈRE, Daniel WILKE, Vincent BLIN, Jeremy FAURE, Sanjeev JAIN.
Group 2 organization	Supplier instruction, documents management & follow-up Paul LAPOINTE, Chirag TRIVEDI, François-Olivier GAGNON, André ZOBLER, Dong ZHANG, WANG Juan, Jean-Pierre GIRARD, Bertrand FRAISSARD, Kevin ZHANG, Stephane MEYNIEL.
Group 3 organization	3) Pre/order Activities (Tendering, Engineering and Quality Engineering) Fabio SA, Jacques BREMOND, Yann TRIFFE, Stéphane ROY, Roberto CONZ, Samuel VORUZ, Zhongdong ZHANG, Sn Venkataravanappa, Francisco PEREIRA, Manuel MARTINEZ, Eric BARTHELET.

Table 29: Organization of the co-located welded structure

Appendix B

Community Characteristics		Description
Community Orientation	Objectives	A VCoP can be operational, set up to support a project with a concrete operational or strategic goal or created to support an organizational orientation
	Life Span	A VCoP can be assembled on a temporary basis to serve a specific purpose (Specific project, mission), but can also be created on a permanent basis with no definitive time frame.
	Age	The age defines the experimental period of time where the VCoP have to improve and grow from young (less than a year), old (more than 5 years) and experimental as in try new things until you get it right.
	Voluntary Action	Low (Several individuals would like to initiate a joint Action), Average (Several persons are involved in joint actions) and high (There is a network / group which is already engaged in a joint action).
	Mutual Support	Low (Several individuals would like to receive help or support from others and provide help and support to others), average (Several persons are punctually (at least 1/month) helping or supporting each other) and high (There is a network / group where people are already helping and supporting each other)
	Mutual Apprehension	Low (Several individuals express a common understanding and vision of their activity), average (Several persons are aware that they share a common understanding and vision of their activity) and high (There is a network / group which has already set up and developed a common vision of their activity)
	Mutual Knowledge	Low (Several individuals would like to inform people of what they know and determine who knows what in order to enable people to share with the right person), average (Several persons are informed and aware of their respective knowledge) and high (There is a network / group that has already mapped their respective knowledge to enable the group to share a common vision of who knows what)
	Management tool	Low (Several individuals will be interested in developing common management tools), average (Several persons have designed and set up at least once a common management tool includes an excel file) and high (There is a network / group that has already set up or has an ongoing project to set up common management tool)

Organizational Context	Practices	Low (several individuals are developing common routines), average (Several persons have adopted at least once a common routine) and high (There is a network / group of persons who have already adopted common routines)
	History	Low (Several individuals find interest in sharing their experience), average (Several persons discuss punctually (at least 1/month) their activity and experience) and high (There is a network / group that discusses and shares its activity and experiences)
	Common Knowledge need	Low (Several individuals express a common knowledge need), average (Several persons have tried together at least once to find some common knowledge) and high (There is a network /a group that tries on a regular basis (more than 2/month) to find some common knowledge)
	Creation Process	A VCoP can be intentional, (i.e. deliberately established by the management who will define its purpose and select key members) or spontaneously emerge from the organization and created by a group of motivated member.
	Level of commensurability	It can be considered low if only members from similar work groups are involved, medium if different groups or units from the same organization are part of the community, and high if members of different organizations are involved.
	Context	The context related to the economic, environmental, management style, processes, and political factors that is facilitating, neutral, or obstructive to the creation and development of the VCoP.
	Level of Sponsorship	The sponsorship is related to the organizational slack which is the general ability of the organization to promote learning, exchange between people and accept phases inherent to the learning curve (time consuming). When organizational slack is low, VCoP may receive less support and resources than when it is high.
	Degree of corporate recognition	The degree of institutionalized formalism relates to the degree to which a VCoP has been integrated into the formal structure of an organization. The VCoP could be unrecognized (invisible to organization), bootlegged (visible only to a group), legitimized (officially sanctioned), supported (receiving direct resources) or institutionalized (official status and functions).
	Consensus on leadership	An organization can either create a formal VCoP governance structure where individuals are appointed to specific roles or leave roles and authority relationships to emerge through interaction around

Membership Characteristics		expertise (Continuously negotiated)
	Size	Size refers to the number of members involved in a VCoP. This number may be small and intimate (i.e. only a few people) to very large (i.e. more than a thousand people).
	Geographic dispersion	Geographic dispersion refers to the physical location of the participants. Members of a VCoP may all be physically located in the same building (low dispersion) or scattered around the world (high dispersion)
	Member selection process	A VCoP with an open membership means that anyone in the organization who is interested can become a member. A VCoP may also choose to have a closed membership and only admit people who meet a predetermined list of criteria.
	Member enrolment	Members' enrolment can take many forms, from voluntary to strongly encouraged, to compulsory.
	Prior community experience	Prior community experience may vary from extensive (when the community is based on an existing network), medium (when members of the community have worked in groups, although those groups may not be identical to the VCoP), low and none.
	Membership Stability	A VCoP may have permanent members (stable membership), ranging from moderately stable to fluid according to the turn over within the community, but can also have temporary membership.
	Member ICT Literacy	It refers to the level of comfort members have using ICT, either high or low.
	Cultural Diversity	Three levels of cultural influence must be considered: national, organizational, and professional. Given the three levels of cultural influence, cultural diversity is evaluated on a continuum, whereby "homogeneous" describes a community in which members come either from the same organization or from organizations with similar cultures, are located in culturally close countries, and have similar professional backgrounds. On the other hand, it can be heterogeneous when members who have various professional backgrounds, come from disparate organizations, and are located in dissimilar national cultures.
	Topics relevance to members	VCoP are usually launched by organizations with a defined objective. This topic may be close to the daily work of its members (high relevance) or, on the opposite, it can be far from the members' day-to-day preoccupations (low relevance), while still being important to the organization

Technological Environment	Degree of reliance on ICT (Information & Communication Technology)	VCoP may be familiar with technology to different degrees depending on their needs.
	ICT Availability	The technology available may also shape the objectives of the VCoP and its adopted processes. A low variety of technologies would mean a VCoP that only has access to simple media. The variety would be qualified as medium in the case of a VCoP using both a document management capacity and a discussion forum; on the other hand, a VCoP with access to a wide variety of ICT such as synchronous and asynchronous discussions and document management, would be an example of a VCoP with a wide variety of available ICT.

Table 30: Community evaluation grid from Fraslin 2013

Appendix C

The evaluation grid questionnaire was designed using MS SharePoint Survey functionality. For example, see figure 64. The respondent created a new item in the survey database, chose his community name and started to answer the questions. Every question corresponded to one community characteristic. The respondent can save his answers and continue later on the survey.

Community Diagnostic Tool - New Item

HySPeC HomePage > Community Diagnostic Tool: Respond to this Survey

Community Name

☒ [Community Name] ☐ Specify your own value: _____

Community Objectives : Strategic (support organizational orientation) , Operational (support a project)

	Strategic 1	2	3	Operation 4	N/A
Strategic --> Operational	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Community Life Span: permanent (no definitive time frame) or temporary (serve a specific purpose)

	Permanent 1	2	3	Temporary 4	N/A
Permanent --> Temporary	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Community Age : Young (< 1 year) or old (> 5 years)

	Young 1	2	3	Old 4	N/A
Young --> Old	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Community Creation Process : intentional (established by the top management) or Spontaneously (established by a group of motivated people)

	Intentional 1	2	3	Spontaneously 4	N/A
Intentional --> Spontaneously	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 64: Evaluation grid questionnaire based on Fraslin 2013

Appendix D

The portal provides a quick, easy and intuitive way to access the existing databases. However, the portal doesn't grant access to the existing databases. Thus only users who have already permissions to the existing databases can access the documents through the portal. For example, see figure 65.

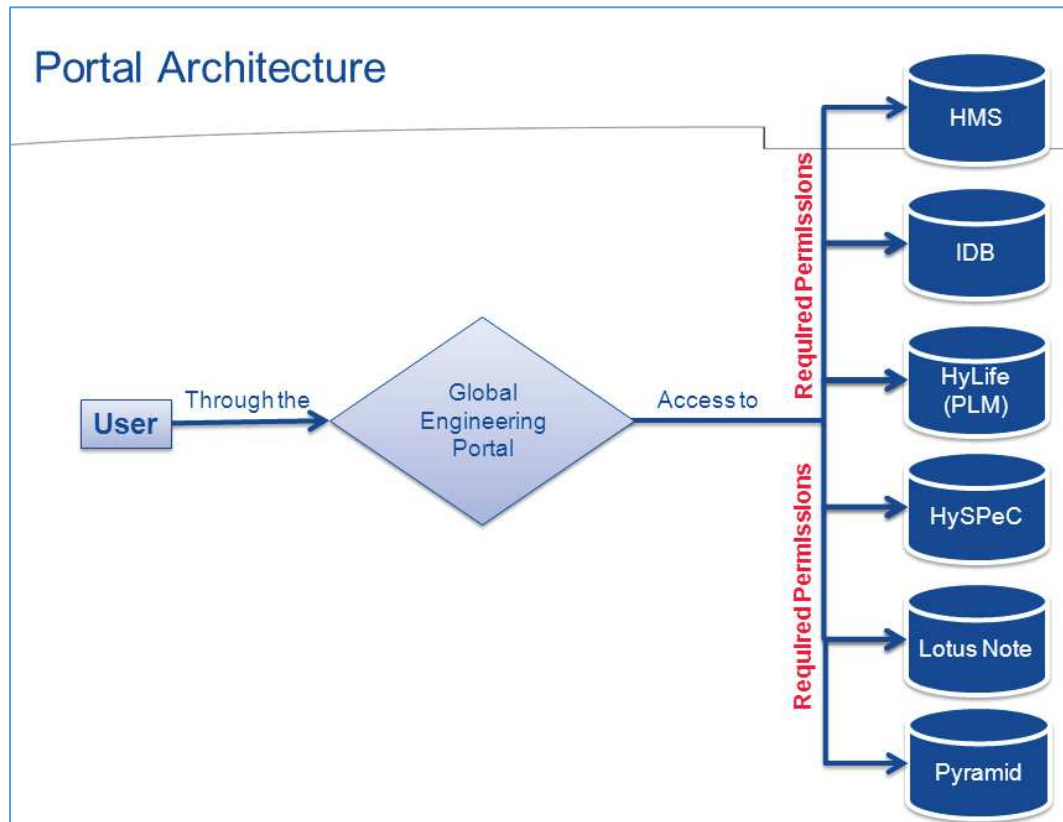


Figure 65: Portal Architecture. Source GEP 2014

Appendix E

Month	Hits	Unique Users
2015-01	51	4
2015-02	21	8
2015-03	136	37
2015-04	174	50
2015-05	330	97
2015-06	291	98
2015-07	113	56
2015-08	182	89
2015-09	221	83
2015-10	397	102
2015-11	847	108
2015-12	749	101
2016-01	881	111
2016-02	362	97
2016-03	327	111
2016-04	244	74
2016-05	224	77
2016-06	49	18

Table 31: HySPeC Visits between January 2015 and June 2016 for C&M Platform

Month	Hits	Unique Users
2015-08	45	6
2015-09	38	13
2015-10	285	112
2015-11	133	80
2015-12	134	67
2016-01	42	23
2016-02	14	8
2016-03	60	28
2016-04	14	7
2016-05	25	10
2016-06	8	3

Table 32: HySPeC Visits between August 2015 and June 2016 for EMT Project

Indicator	October + November 2015	December 2015 + January 2016	February + March 2016	April + May 2016	Total
#Active members	15 actives / 24 total	15 actives/ 26 total	20 actives / 28 total	20 actives/ 28 total	
#new discussions	38	27	15	4	84
#comments	88	24	49	0	161
#hits	418	176	74	39	707
#unique visitors	192	90	36	17	

Table 33: EMT HySPeC logs

Appendix F

Phase	Implications
Forming and Transforming	Start by getting to know and building the trust: <ul style="list-style-type: none"> • Kick-off with a face-to-face meeting with your team members • Meet as a team in one time and one-to-one with each team member another time. • Organize a team building exercise.
	Can't often meet face-to-face? <ul style="list-style-type: none"> • Display the profiles in the internal social media and a short biography with some personal information so that team members can start getting to know each other. • Use Skype webcams to see each other.
	Listen to your teams' members: <ul style="list-style-type: none"> • Encourage them to open up so you can be well guided when communicating in the future with them. You have two ears and one mouth – so you must listen more than you speak. • Use 'structured unstructured time' technique to do icebreaking. For example, ask what was the last thing you did and made you happy the first 10 minutes before you discuss the agenda.
	Be appreciative: <ul style="list-style-type: none"> • After every communication session, via whatever means you have decided, always remember to thank your listeners for their time. It will cost you nothing and it's a simple courtesy.

Table 34: Managerial implications for forming and transforming phase

Phase	Implications
Storming and Norming	Give your team a clear charter: <ul style="list-style-type: none"> • As a team articulate and agree on your team's values, vision, mission, strategy, team objectives • Discuss and agree on your operating principles (who does what, decision-making, validation, budget, tracking, reporting, ...)
	Establish a strong communication framework: <ul style="list-style-type: none"> • Specify and agree on what needs to be communicated: <ul style="list-style-type: none"> – What, how, how often, to whom, when – As a team, one-to-one / in person, by email, conference call, etc.) • Agree on the structure, agenda, chairing, etc. of each meeting • Be clear on what is expected of each team member for each meeting

Table 35: Managerial implications for storming and norming phase

Phase	Implications
Performing	Be rigorous and consistent: <ul style="list-style-type: none"> • Lead by example: rigorous, positive, consistent, open. • Do not cancel meetings: show that they are important for you. • Share the agenda before the meeting. • Start meetings on time. • Strong but flexible facilitation of the meeting: respect timing and agenda, encourage participation and contributions • Stick to the agenda – use a “parking lot” for other items and schedule a separate meeting
	Encourage feedback: <ul style="list-style-type: none"> • It will also afford you the privilege of knowing if your message was well understood.
	Continuously refer to your team’s objectives: <ul style="list-style-type: none"> • Track progress against your team’s objectives. • Set-up monthly retrospective meeting. • Acknowledge and brainstorm challenges.
	Celebrate achievements: <ul style="list-style-type: none"> • Hold monthly rewards and recognition ceremonies. • Publish the success stories in the internal social media.

Table 36: Managerial implications for performing phase