# Using Soft Systems Methodology (SSM) in Understanding Current User-Support Scenario in the Climate Science Domain of Cyber-Infrastructures

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**Abstract.** Cyber-infrastructures have transformed the practice of research. Researchers can now access distributed data worldwide with the help of cyber-infrastructures. User support services play an important role to facilitate researchers to accomplish their research goals with the help of cyber-infrastructures. However, the current user-support practices in cyber-infrastructures are not properly organized (at least in climate cyber-infrastructures) thus over-burdening human support agents. The paper describes the study conducted to evaluate the geographically distributed user-support system currently in practice in the leading cyber-infrastructure namely Earth System Grid Federation (ESGF). The members of the investigation team found out that the user-support in ESGF, a global climate cyber-infrastructure need more attention to make it resourceful as well as standardized. The findings about end-user support system were modelled using soft systems methodology (SSM). This approach helped to present the findings of this study to stakeholders in order to capture their feedback about the current system to further improve the system.

**Keywords:** Information visualization, e-Science, systems, research, user support, help desk, soft systems methodology, rich picture building.

## 1 Introduction

Cyber-Infrastructures (CI) has widely been deployed to access and share the knowledge, data, computing and even human resources to facilitate intra-disciplinary and inter-disciplinary research, also known as e-Research. Cyber-infrastructure is the coordinated aggregate of software, hardware and other technologies, as well as human expertise, required to support current and future discoveries in science and engineering. Networks that constitute cyber-infrastructure(s) are complex networks; users need an interface to access its resources usually data [1]. The interface includes command line tools, web portals, different application interfaces or Graphical User Interface (GUI) to access data holdings which are the main resources. However,

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during an interaction of a user with a cyber-infrastructure, a user may require help due to outages of some resources or any other anomaly in cyber infrastructure or a user requires particular scientific or technical information. In order to meet user support challenges, cyber infrastructures offer support, which even being a core activity has not received adequate attention since inception of cyber-infrastructures [2].

This paper describes the results of an investigation of the current user support system in climate cyber-infrastructure ESGF. The results are depicted using soft systems methodology (SSM). To improve a system or to develop an effective system to support users of a cyber-infrastructure, it is essential for all stakeholders to understand how support employees perform the tasks of helping users along with performing other core operational tasks of cyber-infrastructure development. For this purpose, SSM is used to portray the current user support practices that constitute user support system in ESGF (Earth System Grid Federation). Though various approaches have been used to model user support systems in industry [3–6] and education sector [7], hardly any study has been done using SSM approach. Secondly, few studies have been conducted that have investigated user support practices in cyber-infrastructures so far [2].

The rest of the paper is organized as follows: Section 2 describes the background of cyber-infrastructures, user support and the significance of user support in cyber-infrastructures. Section 3 describes the contemporary user support practices in ESGF as captured from diverse data and sources of information. Finally, section 4 describes the critique of the existing user support, followed by conclusion and discussion in section 5 and 6.

## 2 Background

The background related to this paper is divided into three main headings given in the sub-sections:

### 2.1 Cyber-Infrastructures

Cyber-infrastructures, also called e-Science, e-Science infrastructures, e-research, collaboratories, virtual science and Big Data Science [8], are based on technically connected networks through grid-computing technology [9], [10]. Furthermore, they are formed through collaboration of many organisations across national boundaries where hardware, software, human resources, and other instruments are under the jurisdiction of one or more institutes having their particular norms, standards and policies [8], [11]. The active domains supported by cyber-infrastructures include Earth Sciences, Climate Sciences, Bio-Informatics, and other fields. In cyber-infrastructures, much of funding and effort has been dedicated to develop and improve technologies such as anatomy of data-grid [5], middleware, storage of data in grid environment [8] as well as socio-structural aspects of e-Science for instance “Virtual Organisations” (VOs), CWE (Collaborative Work Environments), VRE

(Virtual Research Environments) [12]. Yet, the organization of user support has not been the subject of study in cyber-infrastructures [4].

Much has been changing over-time about cyber-infrastructures, as they are evolving with changing technologies and other socio-structural factors. Therefore this change has a direct effect on the user support. Investigating user support in cyber-infrastructures will reveal the common problems and their categorization scheme. Other contributions of this study include: organizing and managing user support in a better manner in CI by introducing a recommendation framework that will lead to user and employee satisfaction over the services of cyber-infrastructure. Furthermore, this study will contribute to cyber-infrastructure in letting it adapt to changes, scientific changes in the domain that a cyber-infrastructure serves.

### 2.2 Servicing Users

User support has been always seen as a subsidiary or additional function to the core services of corporations until start of 2000s, when it was realized that customer support should be made better with the application of business process frameworks to improve service quality and provide customer satisfaction [13]. Since then different support models and structures have been tried to suit the corporation business model of servicing customer and end-user concerns. User-support technologies and processes have evolved with the passage of time. The first help desk (HD) in the 80's had only a desk, pen and a telephone used by human support agent [13], [14].

Since then, the traditional HD afterwards had gone through different levels of evolution with the change in the commercial organizational set-up and needs of customers to employ techniques like Automatic Call Distributions systems (ACD) [15], Interactive Voice Response (IVR) systems [16], help desk management system (HDMS) along with associated reporting tools [17], help desk expert systems, knowledge-management centric help desks [18], embedding case-based reasoning (CBR) engine in help desk [19], [20], help desks based on corpus-based analysis (CBA) mechanisms [21], [22], use of remote control technologies to support end-users and web based e-support techniques with and without human support agents [23]. Studying ESGF user support as a use case will contribute to the "service desk" or "customer services" concept in distributed, research oriented, non-commercial environments.

### 2.3 Significance of User Support in Cyber-Infrastructures

In the last decade, the user-support in ESGF has been evolving mainly due to the change in ESGF cyber-infrastructure. For instance; looking at the history of ESGF development, the technological changes, organizational changes, introduction of new data projects served by the ESGF data archive system and the number of users and their needs have been on constant rise [24–27]. It is the right time to perceive and understand the dynamics of user support situation, its role and its interconnection with cyber-infrastructure operations because ESGF has reached a state of modular services-oriented architecture (SOA) forming a federated and distributed network.

The architecture of ESGF has been developed in such a way that new partners can easily join the federation with few changes in configuration through a central configuration scheme known as XML registry. The dynamics and complexity of ESGF operations influences the user support process thus making it also a dynamic process where a user request from any part of the world can come and is handled by any person in the participating institute of the federation. In order to save time and supporting efforts of human resources (cyber-infrastructure staffs) viz-á-viz user satisfaction, it is vital to investigate user support process using SSM so that the process may be made efficient in the near future.

## 3 Contemporary User Support Practices in Cyber-Infrastructures

### 3.1 Case Selection

An important practical use-case in the field of climate science cyber-infrastructures) is ESGF (Earth System Grid Federation) project. ESGF is the first inter-agency and international effort in the domain of Climate Science used for Earth Science Modeling (ESM) [8], [25], [27]. At the moment, more than two thousand researchers accessing huge amount of climate data for climate-model inter-comparison purposes from ESGF distributed data-archive worldwide that makes ESGF a effervescent infrastructure that supports ESM [2,7], which is a main reason to take ESGF as a use-case for this research.

Moreover, ESGF facilitates to study climate change and impact of climate change on human society and Earth's eco system [27]. Since physical phenomenon that govern Earth's climate are so complex and diverse, it is the most important scientific challenges of our time to undergo sophisticated model simulations that generate huge amount of data, collect observational data from various sources and share that data at a global scale. This is made possible by ESGF to discover, analyze and access the Climate data sets which are stored at multiple geographic locations across the globe [27–30].

### 3.2 Research Method and Its Justification

In this study single case study method is chosen as a research method. The information about current user support practices in ESGF, and similar cyber-infrastructures, was captured via; survey-questionnaire, participatory observation of the first author, ten interviews with stakeholders (of ESGF and C3Grid e-Science infrastructures having different backgrounds and roles), observing relevant documents such as reports, publications and archival analysis of user and staff communication within the user's mailing list of ESGF. The triangulation of sources of information was chosen to capture different perspective to validate and to contrast the findings [31–33].

### 3.3 Findings

This empirical qualitative cum quantitative investigation revealed number of issues where attention of ESGF executive team is needed in order to improve the existing user-support process in climate cyber-infrastructure projects. The issues about the existing user-support process in climate cyber-infrastructure projects include allocation of time, human resource, time to solve the user-problems, characteristics of user requests, support tools, support structure and many others. Following Checkland's seven stage overview "mode 1" of SSM, the current user-support situation in climate cyber-infrastructure projects (especially ESGF and its associated projects) is expressed in figure 1 in the form of *rich picture mind map*.


**Fig. 1.** The figure shows the user support process in climate-Science infrastructures in the form of rich picture mind map

The authors being the analyst found the current situation of user support problematic and expressed the situation in the form of what they call a *rich picture mind map*. Pictures can provide an excellent way of sorting out and prioritizing complex problem areas and therefore are used in SSM. In traditional SSM approach rich pictures are normally hand drawn and they describe elements of structure, process, issues, concerns or developments. There are no rules used in SSM rich pictures approach though matchstick people and bubbles coming out of people are common.

In figure 1, the current user support system scenario is described using thick lines that describe a particular concept associated to the user support system with in ESGF. The lined arrows originating from the main oval shaped system describes that the system contains or is dependent on these various concepts depicted via a thick line and a textual description on top of them. The dashed-lines arrows depict that a particular concept might have different attributes depicted by these lines. For example, if we look at the figure 1, user support system in ESGF cyber-infrastructure has communication channels via which users and staffs communicate in case of a problem. These communication channels are divided into asynchronous and synchronous type of communication channels, currently present in user support in cyber-infrastructures (in fig. 1 top left). The asynchronous communication channels in user support of ESGF are mailings lists (ML) and request tracking software (RT) (in fig. 1 top left). Most of the communication between users and climate cyber-infrastructure employees is via e-mail (through ML and RT). This result is in accordance to the distributed model and global nature of cyber-infrastructure.

Time is an important issue in user support in cyber-infrastructures. Staff's response time and solution time to a user request are important elements of an effective user support. Response time is further categorized into support staff's reply time, reply time between support staffs, i.e. response time of a support staff if a user request is escalated from another support staff who is the receiver of the user request at first. Finally, user response time to the support staffs response. For the time being response time and solution time though not systemized with the help of a service level agreement (SLA) works well for user support in ESGF cyber-infrastructure.

The user requests also known as incoming incidents can either be due to a problem in the cyber-infrastructure; e.g. outages of notes, or a user requires an information about a particular phenomenon; e.g. how a user shall register etc. All of these incidents or user requests can be categorized into respective categories. After analyzing the results of the survey questionnaire, these categories can be cited as: Data access and data download problems, user authorization; authentication and registration problems. These are the most common problems encountered in a current user support. Unfortunately, there is no central repository maintained by the current user support system in ESGF where the information about user requests can be stored and redundant user support enquires can be triggered. Moreover, currently there is no information retrieval system where users or support staff can search the relevant problem cases. However, partly some user support staffs do update the information useful for staff and users of ESGF system. The usability of the online help resources is not determined yet. Update of the online help websites is done if there is a new version or release of a software component of an ESGF cyber-infrastructure.

User support in ESGF cyber-infrastructure is present to facilitate ESGF users and is operated by its employees (see figure 1 top right). The operation of user support is based on employees' attitude, knowledge, analytical skills and satisfaction level with the support process that provide support to users. Similarly, users in their interaction with the cyber-infrastructure depend on their behavior of interaction (attitude) towards systems as well as their knowledge, analytical skills and level of satisfaction. According to survey results the employees who support users are skillful and qualified. Moreover, both users and employees are satisfied to some extent with the current user support facilities in ESGF and ESGF-like cyber-infrastructures but not completely satisfied.

The users of ESGF and ESGF-like cyber-infrastructures are divided into four main categories, working group 1: Advanced core climate scientists, working group 2: Impact scientists, working group 3: Integrated Assessment Modelling (IAM) scientists and finally non-climate scientists such as; policy makers, journalists and anyone who is interested in climate science. The employees of ESGF and ESGF-like climate science cyber-infrastructures are technical experts such as computer scientists, network administrators, data curators and climate scientists. The roles amongst the staffs of climate science cyber-infrastructures (ESGF and ESGF-like) are not completely specified. Therefore, there is no formal assigned role of *user support manager* in cyber-infrastructure organization. Any climate science cyber-infrastructure employee from any part of the world can jump in and answer a user request and provide solution to user's problem. Answering a user request or providing a solution to user's problem is a initiative of an employee (at least in ESGF). There are no explicit long-term support positions financed by the ESGF sponsors.

The ESGF data archive system and its sub-components such as authorization and registration sub-system, UI of gateways (portals) available to users to browse and access climate data-sets and others depends on user support. For instance if there is any disturbance in any function in any geographically distributed component of archive system, then the users experience it: Hence sending user requests which are entertained by cyber-infrastructure employees. There is no split of user support into user support levels such as first level support (FLS) or second level support (SLS).

### 3.4 Root Definitions and CATWOE

According to SSM; there is a *transformation process* in each conceptual system having a purpose, where an input is transformed into an output. The transformation depicted as "T" is a *Weltanschauung,* a German word equivalent to *worldview* in English. *Weltanschauung* "W" is a very dominant concept in SSM that determines the belief or point of view that makes transformation "T" rational. W and T form the core of a mnemonic CATWOE[1]. CATWOE analysis in SSM is used to create a root definition which is the third stage in Checkland's seven stage of SSM investigative process which has come to be known as "mode 1" SSM. ESGF user support system is a system that has a purpose (or purposes), it exists for a reason and achieves some change, or 'transformation'. ESGF promotes user problem solving; in the long run it educates users and promotes learning about its sub-systems. It 'transforms' unresolved user problems into solutions.

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[1] In CATWOE, C stands for *customers*, A for *actors*, T for *transformation process*, W for *worldview*, O for *owners* and E for *environmental constraints.*

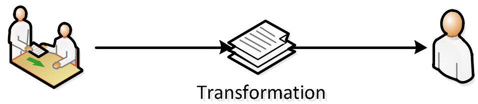


**Fig. 2.** The transformation process in ESGF user support

Using SSM mode 1, CATWOE analysis in the context of ESGF user support system can be stated as in the following table 2:

**Table 1.** CATWOE analysis of user support system in ESGF cyber-infrastructure

| **Mnemonic** | **Description** |
|---|---|
| **C**= Customers | users of ESGF system (victims or beneficiaries) |
| **A**= Actors | ESGF staff (Support staff and developers) |
| **T**=Transformation process | Transformation of user incidents into solutions monitored by E1[2] E2[3] E3[4] |
| **W**="Weltanschauung" or Worlds perspective | the belief that providing user support will benefit users in their research activities and interaction with the ESGF system monitored by E1 E2 E3 |
| **O**=Owners | All stakeholders of ESGF |
| **E** = Environmental Constraints | Geographically distributed environment with components under control of different authorizes operated by different human resources |

E1, E2, E3 can be defined in terms of ESGF user support system as:
E1: Are user support requests answered properly? E2: How many user support requests are answered keeping what standard and how many resources consumed? E3: Do users find user requests solved by employees and UI for self-help a useful way of reaching the research goals of users and interacting with cyber-infrastructures?

An ESGF user support system which is part of the ESGF system in the wider context can be defined in the form of SSM root definition as: *An ESGF user support system owned by ESGF-stakeholders (investors), operated by ESGF staffs (partly staff from node administrative bodies), to support users of ESGF by fulfilling their information needs in order to get information to achieve their research-oriented goals while constrained by ESGF financial, technology, human resources, cultural norms, geographic administrative and general policies.*

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[2] Efficacy- does the system work?, is transformation achieved?
[3] Efficiency- a comparison of value of output versus value of input- is the system worthwhile?
[4] Effectiveness- does the system achive its longer term goals?

## 4 Critique

From the findings of survey questionnaire, one can observe that there is multiple communication channels offered in a user support system which is not bad. Nonetheless, different administrative nodes that form a user support unit have their own local usage of communication channels. For instance request tracking software (RT) are used by some locally and at the same time there does a mailing-list exist. Nevertheless, there is no storage of all the cases of user problem or information needs that have been already treated by user support employees. Since there is no incident repository or knowledge-base (KB), there is no central information retrieval system present in user support process that would help users (for self-help) and the staff. Though efforts made in the last several months, the online help websites are not updated regularly. Usability as well as accessibility of the websites can be further improved.

There is no formal designation of user support managers or employees, hence, no one is responsible for this activity rather user support activity is carried out by the employees on their own. This is the reason that user support requests are sometimes completely ignored, though this takes place not too often. Neither there is a user support task force nor committee, which collects the funding from the ESGF cyber-infrastructure sponsors, to standardize, measure, and control user support practices of ESGF. Partly this is because the research focus till now has been on stabilizing and developing the ESGF cyber-infrastructure itself. But since now the minimum level of maturity in ESGF cyber-infrastructure has been achieved it now time to streamline its user-support. At the moment, no formal concrete policy has been included in the manifesto of ESGF. Though the user support system works for now but as the number of users are on increase the user support needs monitoring, control of user support activities in order to streamline it.

## 5 Discussion

At first glance, information systems or cyber-infrastructures seem to be 'hard' designed physical systems, but experience shows that they seldom add value unless they are closely married to their organizational context and the people who use them [34]. Softer issues are important in information system planning, design, and implementation. 'Soft' has another, more specialist meaning. It includes people’s perspectives; depending on the type of person you are, and your training and experience, you may understand 'systems' as tangible things which are really present in the world. In this paper user support process is shown in the form of a system where organizational and human context plays an important role as their influence cannot be ignored.

The aim of ESGF user support is to 'transform' unresolved user problems into solutions. Its performance though not formally measured at this point in time, however can be measured. With a measurement scheme the user support activities can be shown to be more, or less efficient, rate of service (transformation) can be judged with the help of resolution of queries and problems. It is important to introduce a mechanism for control of the whole user support process and a decision making process within a user support should be laid down i.e. a management structure of user support activities. The current user support is based on geographically distributed components (physical and human), which can themselves be taken to be systems administrative units as well as climate modelling units. All components are related, and sub-systems with a user support system interact with each other. The topic of user support in cyber-infrastructures is needed to be included in board meetings and face to face meetings of ESGF.

## 6 Conclusion

Since a human behavior is unpredictable, organizational and management problems are seldom clear-cut and well-defined; normally they are complex, with many indeterminable variables 'soft' systems. User support system in climate cyber-infrastructure can be represented with the help of SSM to represent its root definition, rich picture mind map and the conceptual model understandable to all stakeholders of cyber-infrastructures, which forms basis of enhancement needed to a system. Another governing principle of SSM is representation of user support as the idea of 'emergence' most simply expressed as 'the whole is greater than the sum of the parts.' When the constituent parts of a system act together they have properties which the individual parts do not have. Thus, staff and researchers are needed (as well as many other things) to make a cyber-infrastructure; not just a piece of hardware. The user support system is a major platform for collaborative development of cyber-infrastructure itself as well as its services.

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