YAMAGUCHI UNIVERSITY

GLOBAL LINKS

by YU-RCES

Graduate School of Science & Engineering, Yamaguchi University

NEWSLETTER OF RESEARCH CENTER FOR ENVIRONMENTAL SAFETY No 2(April 2008 issue)

《OUR CHALLENGE TO GLOBAL COE (G-COE) PROGRAM!!》

1. Outline of plan for establishing COE

1.1 Introduction of our COE program

The objective of our proposed COE program is to establish a rational and worldwide framework for the sustainable civil (eco-civil) society on the foundation of the Research Center for Environmental Safety (***RCES***) of Yamaguchi University (core department), while fostering young researchers with rich knowledge and technologies needed for the development of advanced infrastructures management system and for appropriate maintenance of the ecosystem with expertise in biology. Because lifetime management of civil infrastructure in an environmentally-friendly way has become recognized as a critical issue, it is imperative to build safer and securer eco-civil system to be passed on to the next generation not only in advanced countries but also in developing countries. By actively seeking the goal, through advancing and applying science & technology, we have gained global competitiveness in the field of research, and thus we can take initiative to develop technologies for establishing the sustainable civil society.

Figure 1 shows a road map to achieve the final goal of our COE program. All three most internationally active research groups in Yamaguchi University (multidisciplinary group of different faculties) collaborate for the task of implementing the COE program.

As shown in **Figure 1**, our mission and goals are as follows:

- To organize a multidisciplinary research unit and to develop a safe and secure eco-civil societies,
- To contribute to the establishment of sustainable civil-society in well developed mature countries/ regions such as US, EU and Japan,
- To contribute to construction of societies in developing Asian countries in harmonization with the environment,
- To educate outstanding and next-generation researchers in the field of safety and environmental studies through the state-of-the-arts research activities.

In order to establish safer and securer eco-civil societies, we will utilize our unique and outstanding research seeds (technologies) developed by three internationally active research groups, listed as follows as premise to complete the goals,

- Public infrastructure (social capital) maintenance, and monitoring technologies,
- Preservation and restoration of the ecosystem,
- Nanostructured molecular sieve membrane technology.

1.2 How to achieve the final goal and make core values

Because the object of our COE program is to establish a multidisciplinary center both on *Research* and *Education* towards safe and secure eco-civil society, our steering committee members and also researchers with a wide-range of expertise participating in collaborative activities have to be considered as,

①Research Center for Environmental Safety (RCES) organizes research around the issues,

②Educating and training young researchers, and advancing existing seed technologies,

③Evaluating the impact of the project to the society, education, business, etc.

Then, we will be able to reach to final goal (“sustainable eco-civil society” and on bringing up young researchers) and make some core values during the COE program based on both of education program and research project (see **Figure 1**).

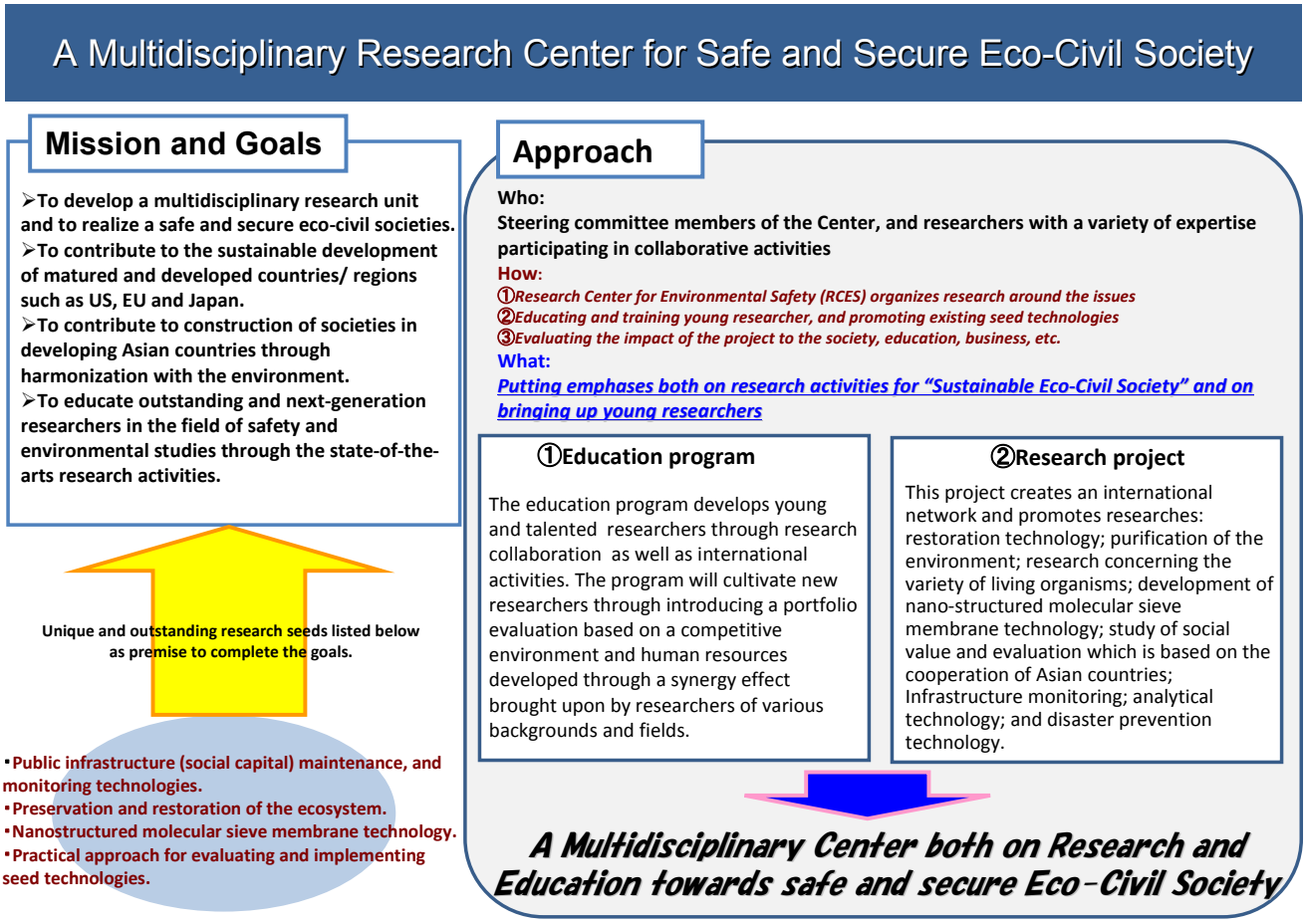


Figure 1 Road map to the realization of safety and securer eco-civil societies in our COE program

1.3 What is our mission and role?

Our main role is to establish practical education system for both young researchers and PhD students all over the world. And the mission for each group in the COE program is described below and schematically shown in the following figure:

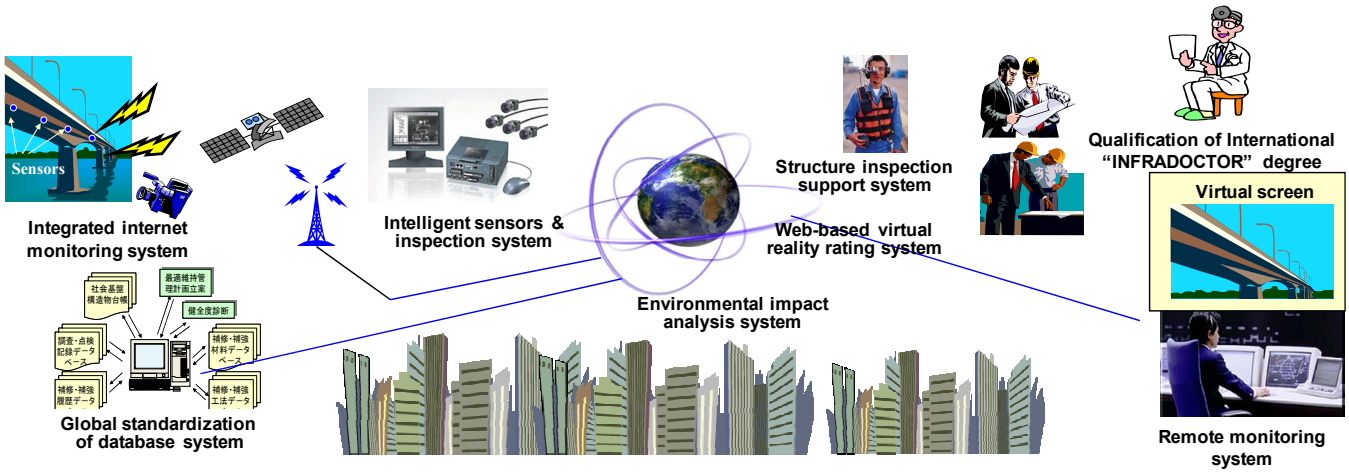
[Civil Infrastructure Management group]

Genuine cooperation and engineering-based innovation on the field of sustainable civil society are needed to develop an integrated lifetime management system for infrastructures combined with the latest information processing technologies and intelligent health monitoring techniques, while establishing the "**INFRADOCTOR**", that is,

① Integrated analysis of diagnostic parameters monitored from existing structures and global standardization of the data format,
② Rearrangement of the diagnostic and repair/strengthening technologies, and applicability investigations for foreign countries,
③ Damage data (include digital image) acquisition for Database System and Application of the image processing technologies to quantitative damage assessment,
④ Development of knowledge acquisition system regarding progression of structural damage using the latest image processing technologies,
⑤ Development of an education system on management of infrastructure damages making use of advanced information technology and virtual reality techniques,
⑥ Release of a prototype Web-based internet system for J-BMS Database System, Integrated Lifetime Management System (J-BMS) and Automatic Crack Recognition System of infrastructures,
⑦ Organization of international conferences on lifetime/maintenance engineering, and Others.

[Applied & Environmental Science group (2 groups)]

Subdivision of "Utilization of Biological Functions" is aimed to prevent and restore various damages in the ecosystem caused by public infrastructure maintenance activities and global warming, using organisms with specialized functions. Subdivision of "Membrane Science and Engineering" is aimed to apply nano-structured molecular sieve membranes to environmental areas and future energy development.



Civil infrastructures for safety & securer society to be carried over into next generation

Utilization of Biological Functions

Application of Organisms Having Special Functions for Prevention and Restoration of Damages in Ecosystem Caused by Public Infrastructure Development/Maintenance and Global Warming

Damaged Ecosystem

Polluted Aquatic Environment

Restore of Stable Ecosystem
Use of Stress-Resistant Protozoa by Endosymbiosis

Maintenance of Water Quality
Use of Yeasts with Specialized Metabolic Functions

Maintenance of Stable Plant Ecosystem and Recovery of Plants from Damages
Use of Bioactive Organic Chemicals Excreted by Plants

Ethanol Production from Non-edible Biomass
Use of Polysaccharides-Degrading Microbes and Yeasts

Restoration of Ecosystem

Depuration of Aquatic Environment

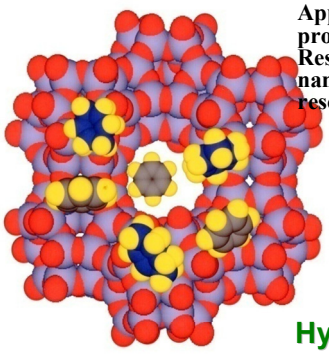
Membrane Science and Engineering

Application of Nanostructured Membrane to Environmental Study and Future Energy System toward Low Carbon Society

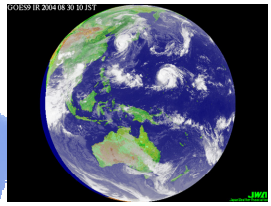
Biomas・Unused Resources
Application of nanostructured membrane to production of biofuel
Research and development of new process of nanomembrane formation from unused bio-resources (lignin material)

Life time Engineering of Civil Infrastructure
Sensor technology, based on nano membrane, supporting life time Engineering of civil infrastructure

Hydrogen Energy System
Development of hydrogen selective membrane for fuel cell and efficient hydrogen production



Nanostructured Molecular Sieve Membranes supporting Safe and Secure Society



Low Carbon Society
Cool Earth 50

Global Links Development of Human Resources for Environmental Engineers Promoting Next-generation Technologies for Environmental Industry

2. Objectives, significance and prospective impacts of proposed COE

2.1 Description of the disciplines to be covered by the proposed COE

The proposed COE program has great significance and prospective impacts in a strategic capital stock management (integrated life-cycle management system) considering the environmentally- friendly requirements as shown in **Figure 2**. As shown in **Figure 2**, the COE program has to be considered an organic integration of studies(researches) in a wide range of academic fields including Environmental science, Medical, Biological science, Nano-structured membrane science, Agricultural and Economical fields, beyond the scope of the traditional engineering field, such as Civil, Advanced systems, Electrical and Mechanical engineering fields.

As an example, the life-cycle management system for civil infrastructure management incorporates life-cycle costs(LCC) and the concepts and analysis methods for management into the field of maintenance to be considered a wide range of academic fields including not only the traditional civil engineering field but also systems, electrical and mechanical engineering fields, that is, in order to establish a common global goal, it is an environmentally-friendly system aided by the latest information technologies such as network-based databases systems, multimedia virtual reality, intelligent monitoring, artificial life and artificial intelligence. In advanced countries in Europe and the United States, life-cycle management of social infrastructures has recently become a hot issue gathering much attention. An example is LIFETIME Thematic Network, an organization based in VTT Finland that is now being launched by the European Union as an area-wide project.

Then, it is most important for Japan to establish an advanced management system in the relevant field and to lead the world in the task (project). As a part of the final goal, we are considering how database systems are shared by combining health-monitoring and next-generation information technologies and how world standards for an integrated life-cycle management system are developed through international research alliance. If we can take the initiative in this technically challenging field, young excellent researchers will be attracted and thus the field will get more dynamic in the near future.

2.2 How to create a top world-level research hub

Based on the three most active and world wide research fundamentals of our RCES which collaborate with other domestic/international research units until now and the international research alliance, listed in **Figure 2**, our COE

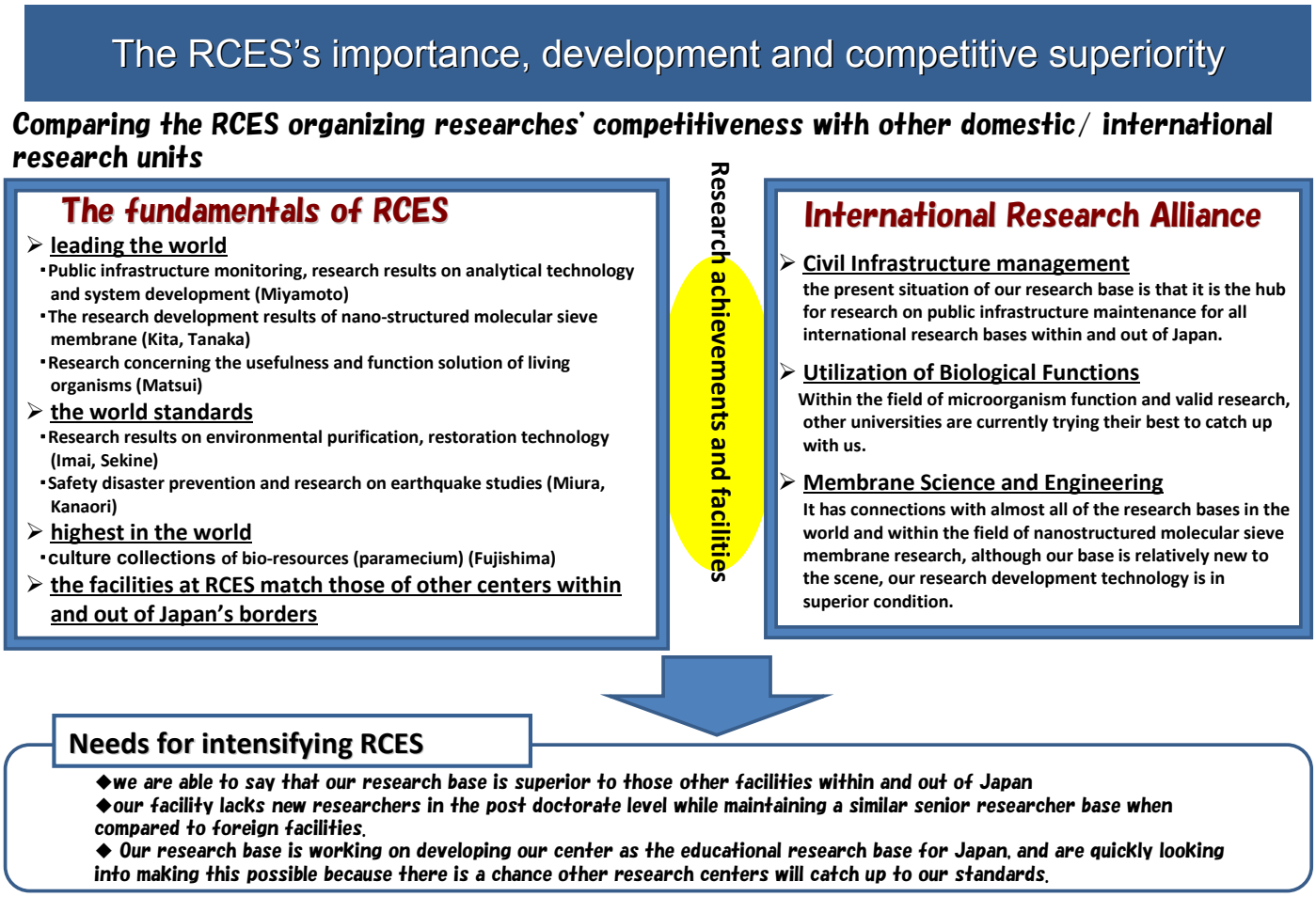


Figure 2 Significance and feature of our COE program as a frontier research center

program creates a top world-class research hub with close international network and promotes researches, such as: restoration technology; purification/detoxication of the environment; research concerning the variety of living organisms; development of nano-structured molecular sieve membrane technology; study of social value and evaluation which is based on the cooperation of Asian countries; Infrastructure monitoring; analytical technology; and disaster prevention technology, etc.

At the same time, as a competitive education program for young excellent researchers, we would develop young and talented researchers through research collaboration as well as international activities. The program will cultivate new researchers through introducing a portfolio evaluation based on a competitive environment and human resources developed through a synergy effect brought upon by researchers of various backgrounds and fields.

According to the impact and side effect of expected results by above programs and projects developed at RCES and also mutual influence between research site and education site, we are able to establish the COE program to lead the world and to make more dynamic future in the relevant field (see **Figure 3**). In order to establish our COE program, the concepts, objectives and direction of our plan are summarized as follows: 1) a multidisciplinary research unit and to establish a safe and secure eco-civil societies, 2) the sustainable development of matured and developed countries/ regions such as US, EU and Japan, 3) construction of societies in developing Asian countries through harmonization with the environment, and 4) outstanding and next-generation researchers in the field of safety and environmental studies through the state-of-the-arts research activities.

About the needs for intensifying the COE and RCES(see **Figure 2**), we are able to list up as: 1) we are able to say that our research base is superior to those other facilities within and out of Japan, 2) our facility lacks new researchers in the post doctorate level while maintaining a similar senior researcher base when compared to foreign facilities, and 3) our research base is working on developing our center as the educational research base for Japan, and are quickly looking into making this possible because there is a chance other research centers will catch up to our standards.

2.3 What is the most unique point compared with the other research centers

a) New innovations (uniqueness, etc) for future competitiveness

As shown in **Figure 2**, our world-level research fundamentals are classified as follows:

[*for leading the world*]

- Public infrastructure monitoring, research results on analytical technology and system development. (Profs. A. Miyamoto & K. Ichihara, et al.)
- The research development results of nano-structured molecular sieve membrane. (Profs. H. Kita & K. Tanaka, et al.)
- Functional analyses of bioactive organic chemicals excreted from plants and its utilization for maintenance of plant ecosystem. (Prof. K. Matsui, et al.)

[*for world standards*]

- Research results on environmental purification, restoration technology. (Profs. M. Sekine & T. Imai, et al.)
- Safety disaster prevention and research on earthquake studies. (Profs. F. Miura, Y. Kanaori, et al.)

[*for highest in the world*]

- The biggest culture collections of bio-resources in the world (ciliated protozoa, *Paramecium* species). (Prof. M. Fujishima, et al.)
- The facilities at RCES match those of other centers within and out of Japan's borders. (All staffs)

As mentioned above, due to compare the organizing researches' competitiveness with other domestic/international research units, we are able to say that the possibility of new innovations for future competitiveness of the COE program in the world becomes quite high level.

b) International research alliance and standards

In advanced countries such as Japan, Europe, the United States, etc., it has become important to develop an innovative system related to long-term lifetime management engineering for infrastructures in harmony with the natural environment as shown in **Figures 1 and 2**. International research alliance and standards in each group of the COE program are described as follows:

[**Civil Infrastructure Management group**]

An example is LIFETIME Thematic Network, an organization based in VTT Finland that is now being launched

by the European Union as an area-wide project. Another groups led by the United States and Canada have also been accumulating expertise and know-how as "PONTIS" utilize society & IABMAS Committee (organized by Lehigh University, etc., USA) and ISIS Canada (organized by University of Manitoba, etc., Canada) respectively. Thus, there has been a move, mainly among the countries with well-developed social capital, to establish a common global goal.

The present situation of our research group is that it is the hub (more than 150 professors and researches invited for both long-term and short-term and 13 organized international conferences, etc) for research on public infrastructure maintenance for all international research bases within and out of Japan.

[**Utilization of Biological Functions group**]

For example, in a research field of endosymbiosis, our group is the most active and advanced in the world. Acquisition of various stress resistances of the host *Paramecium* by endosymbiotic bacteria *Holospora* is a phenomenon discovered by us. So far, International symposium on *Holospora* had been held four times under our leadership. We are intimately communicating with all research groups on *Holospora* in Germany, Russia, Canada, Italy, and Japan. M. Fujishima is now editing a book, "Endosymbionts in *Paramecium*" that will be published from Springer-Verlag in 2009 with major endosymbiosis researchers in the world as authors of each chapter of the book. We established research field on bioactive organic chemicals excreted from plants. In every year, symposium on "green flavors" is held in Tokyo organized by us. Applications of organisms with stress resistances and bioactive organic chemicals excreted from plants for restoration, bio-remediation, and maintenance of the ecosystem are unique and superior in the aspects of "prevenience" and "evaluation by competition".

[**Membrane Science and Engineering group**]

Examples are NanoMemPro project by the European Union which is a joint initiative of 13 European partners, the center for membrane applied science and technology (MAST center) which is a NSF multi-site industry/university cooperative research center in USA and UNESCO center for membrane Science and technology in Australia. We have connections with almost all of the research bases in the world. And within the field of nano-structured molecular sieve membrane research, our research development technology is in superior condition. Nano-structured membrane technologies contribute to prevent global warming, restore and maintain water and air environment. We are a global leader in membrane research and our research program is cutting edge and applicable to environmental industry. We provide timely education program for young and talented researchers of environmental engineering.

As mentioned above, the importance, we would say that the development and competitive superiority of the COE program are also becoming quite important and high level in the world.

3. Plan for research activities

3.1 Description of the detailed objectives to be achieved

The main objective (goal) of the proposed COE program is to establish a multidisciplinary education/ research center to allow the realization of safety and securer eco-civil societies in conjunction with three most active and world wide research groups in Yamaguchi University, as shown in **Figure 1**.

Figure 3 summarizes not only the concrete objectives toward to the goal in both the research projects and education program but also the expected achievements and it's impacts & side effects on academic, social and business. The concrete objectives (major) of our research activities in here can be summarized as follows:

- Development of a global standard integrated lifetime management system for infrastructure systems (J-BMS),
- Development of an education system on management of infrastructure damages making use of advanced information technology and virtual reality techniques,
- Development of new technologies for prevention and restoration of damages in ecosystem caused by public infrastructure maintenance using organisms having special functions,
- Development of nano-structured molecular sieve membrane and application of nano-structured membrane to environmental study and future energy system.

Based on the expected achievements listed in **Figure 3**, we will be able to make not only academic impacts but also social and business impacts in the relevant field of the world, as follows:

- Promotion of advancement and systemization of environmental symbiotic studies,
- Promotion of guidance in the fields of humanities and environmental studies,
- Establishment a comprehensive study known as the environmental symbiotic study,
- Standardization in the world the public infrastructure monitoring and analytical systems,

➢ Promotion the internationalization of information in environmental purification and restoration technology.

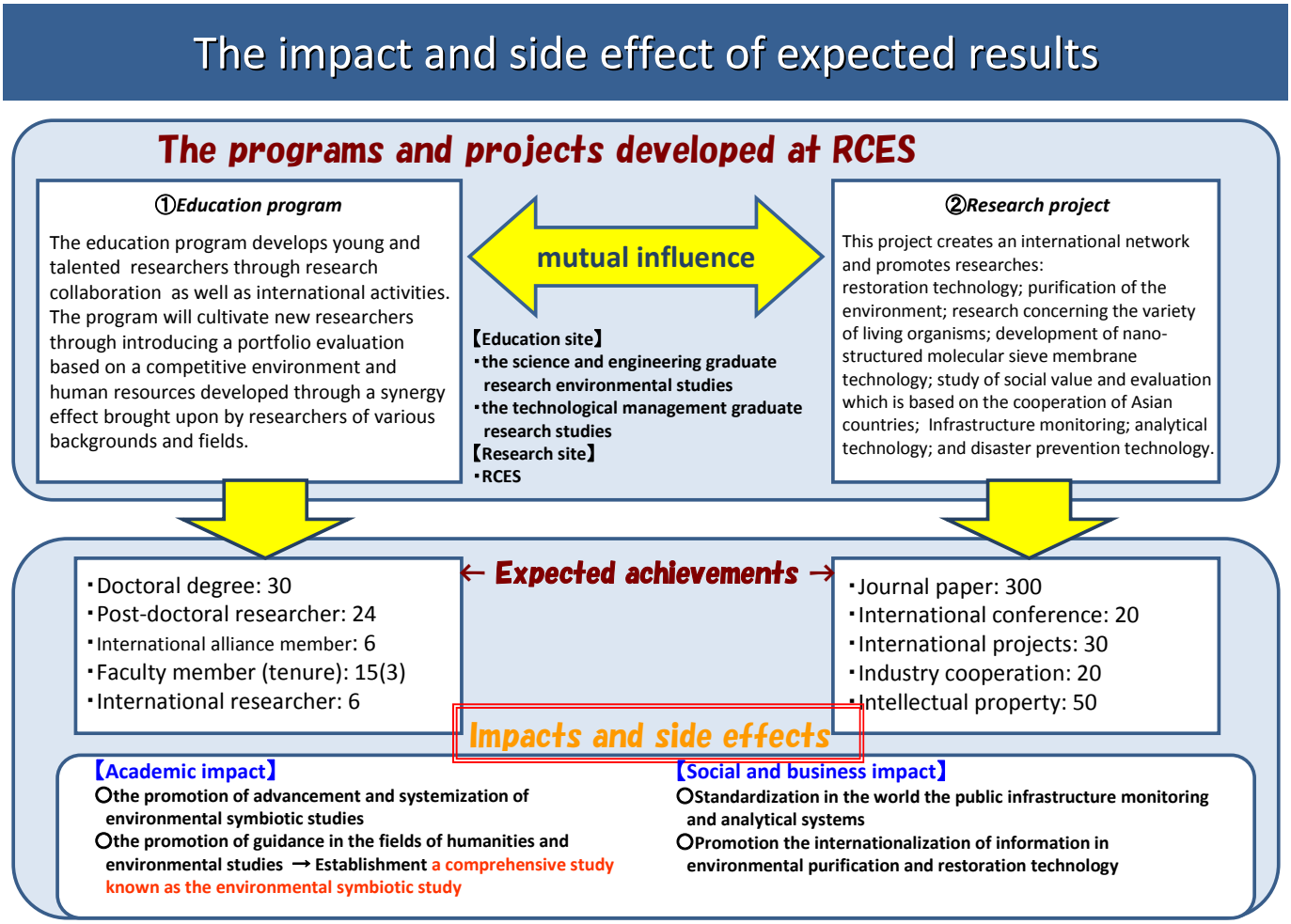


Figure 3 Expecting core values from the COE program

3.2 Plan and method for achieving the above detailed objectives

a) How to create an international COE program

The research effort will consist of two phases performed over 18 months and 42 months respectively. The first phase will be methodology development toward to the goals for individual research groups and establishment a multidisciplinary research center by employing/inviting the respected professors, excellent researchers, post doctoral researchers as international standard networks. The second phase will be the illustration of the integrated methodology through collaborative activities of our steering committee members and also excellent researchers with a variety of expertise participating, and finally achieved the final goal and made expecting core values as an international COE program. For employing/inviting excellent researchers, conducting national/international exchanges, etc., a newsletter for our COE program named "**GLOBAL LINKS**" has been published on both paper-based print version and Web-based home page (HP) respectively.

[Phase 1(18 months)]

① Setting up a "G-COE platform" shared research facilities.
② Developing education and training programs from the Doctor level to continuous education.
③ G-COE of "Frontier program for sustainable civil (eco-civil) society" is created under the following research framework programs at the first phase.
   - ➢ Development of an integrated lifetime management system for civil infrastructures combined with the latest information technologies and intelligent health monitoring techniques and establishment of qualification of international "INFRADOCTOR" degree.
   - ➢ Developing of organisms having special functions for the prevention and the restoration of damages in ecosystem.
   - ➢ Application of nanostructured membranes for the production of biofuel and the development of hydrogen selective membranes for efficient hydrogen production.

[Phase 2(42 months)]

The second phase is focused on research, training and exchange activities in the following fields.

- Methodology development for civil infrastructures for safety & secure society to be passed on the next generation, and case studies will be done for many network level examples in different countries.
- Application of organisms in ecosystem caused by public infrastructure development. Maintenance of water quality by using of yeasts with specialized metabolic functions.
- Maintenance of stable plant ecosystem by using of bioactive organic chemicals.
- Ethanol production from non-edible biomass and efficient separation of bioethanol by nanomembranes.
- Development of sensor technology based on nanomembranes supporting life time engineering of civil infrastructure.

b) Facilitate cooperation and communication among all members of the COE

As shown in following 3.3 a), using various domestic and international workshops, symposiums and seminars which are concerning on environmental safety and organized by us, we are exchanging information on recent researches and keeping intimate relationships in each other. Our university established "Research center for Environmental Safety (RCES)" in January 2008. The RCES is publishing a newsletter "GLOBAL LINKS", and activities of RCES are proactively transmitting abroad through our web site (http://rces.ese.yamaguchi-u.ac.jp/). So far, over 150 foreign researchers are visiting to our member's labs during recent 3 years for meetings and for joint researches. In this program, 3 tenure-tracks, 6 assistant professors, 24 post-doctoral fellows, and 12 senior research fellows are employed from domestic and foreign countries per year for 5 years for joint researches and educations. These positions are informed by public offering using international journals and various web sites, and excellent candidates are selected by pier reviews.

3.3 Members' research activities for establishing a world-class COE

a) Major research achievements for the COE & international appeal

Based on our unique & outstanding research seeds at Yamaguchi University, we have established newly a Graduate School of Environmental Science & Engineering at 1998 for leading of the sustainable civil (eco-civil) society for the next generation, such as providing safe, healthy and convenient conditions for the living and working of people. According to a number of core values form the international active researches we have achieved until now, listed below in figures:

- PhD degree: 37(including 12 foreign students) during past 3 years.
- Organized international workshop/symposium/seminar: 12 during past 3 years.
- Foreign visiting professors/research scientists: over 150 including long & short term employment during 3 years.
- International academic exchange program: 19 (7 countries, 8 universities such as UCL (UK), etc)
- Partnership research project with customers: 717 (both domestic and foreign companies) during 5 years.

b) Major scientific papers and publications

[Scientific Papers]

- B.Yan, A.Miyamoto, E.Bruhwiler, Wavelet Transform-based Modal Parameter Identification Considering Uncertainty, J. of Sound and Vibration, 291, 1&2, 285-301, 2006. (IF: 0.898)
- K.Shiojiri, K.Kishimoto, R.Ozawa, S.Kugimiya, S.Urashimo, G.Arimura, J.Horiuchi, T.Nishioka, K.Matsui, Takabayashi, *Proc. Natl. Acad. Sci. USA*, 103, 16672, 2006. (IF=10.2)
- K.Uemura, Y.Yamazaki, Y.Komagawa, K.Tanaka, H.Kita, *Angew. Chem. Int. Ed.*, 46, 6662, 2007. (IF=9.6)
- M.Hori, I.Tomikawa, E.Przybos, M.Fujishima, Comparison of the Evolutionary Distances Among Syngens and Sibling Species of *Paramecium*, Mol. Phyl. and Evol., 38, 697-704, 2006. (IP=3.431)
- K.Kishimoto, K.Matsui, R.Ozawa, J.Takabayashi,Volatile C6-aldehydes and Allo-ocimene Activate Defense Genes and Induce Resistance Against, *Botrytis cinerea* in *Arabidopsis thaliana*. Plant Cell Physiol, 46,1093-1102, 2005. (IP=3.317)

[Scientific Books]

- A.Miyamoto, X.Zhou, X.Shao (ed.), Lifetime Engineering of Civil Infrastructure 2, Practical Maintenance Engineering Institute of Yamaguchi University, 2008. (ISBN 4-9901161-9-4 C3058)
- H.Kita, Zeolite membranes for pervaporation and vapor permeation, in Materials Science of Membranes for Gas and Vapor Separation, Wiley, 373-390, 2006. (ISBN-13: 978-0-470-85345-0)

c) Significant prizes/awards and scientific honors

[Awards]

- Hidetoshi Kita, et al., Thomson Scientific Research Front Award 2007, 2007.