

# **Evaluation of the Research and Professional Activity of the Institutes of the Czech Academy of Sciences (CAS) for the period 2010–2014**

## **Final Report on the Evaluation of the Institute**

**Name of the Institute:** Institute of Information Theory and Automation of the CAS, v. v. i.

**Field, in which the Institute registered 2 teams:**

Mathematics

Observer representing the Academy Council of the CAS: Michal Haindl

Observer representing the Institute: Dr. Antonín Otáhal

### **Commission No. 1: Mathematics**

Chair: Professor Willi Jäger

Date of the visit of the Institute: December 2, 2015

Program of the visit of the Institute: see attached Minutes from the visit

Evaluated research teams:

No. 1 - Department of Decision Making Theory

No. 2 - Department of Stochastic Informatics

## **A. Evaluation of the Institute as a whole**

### Remark:

*Several of the statements, the Commission has to make, apply also to other Institutes and the teams, which had to be evaluated. The Commission decided to formulate them more in detail and to send them in a letter to the President of CAS and the Chair of the Coordination Board of the Evaluation. We are going to refer to them by S and their number, as listed in the letter.*

*The Commission Mathematics has to evaluate only 2 of 8 departments of the Institute. It is not able to evaluate the Institute as whole, due the obvious lacking information, however it is trying to make some comments, just from the perspective of the evaluated teams. (S9)*

## **1. Introduction**

The Institute has developed as center in fundamental and applied research, not only reaching with approximately 200 employees considerable size but also achieving with its scientific activities substantial results in Mathematics and Computer Sciences and their transfer to real life applications. The Institute has 8 scientific departments carrying names connected to their main research areas

1. Decision Making Theory
2. Stochastic Informatics
3. Pattern Recognition
4. Image processing
5. Signal Processing
6. Control Theory
7. Adaptive Systems
8. Econometrics

The first two departments were assigned to the Commission Mathematics. All of the research areas, reflected by the names of the departments, are mathematical sciences in the sense that they are based on mathematical concepts and methods. This also holds true for Signal Processing, which is in this Institute mainly oriented to the engineering aspects. (S1, 2)

There are many relations to teams allocated to Mathematics in this evaluation, which might get not the attention they deserve, due to the fact, that the interdisciplinary character requires also an interdisciplinary approach in the evaluation process.

The spectrum of the scientific areas involved is rather broad. The program includes topics and projects ranging from mainly basic research to dominantly application oriented research. Experience shows that having such a broad positioning is offering chances for progress and innovations as well as may lead to loss of quality and efficiency. Considering the Departments, evaluated by the Commission, the following difference becomes obvious:

Whereas the Department Stochastic Informatics is rather focused and mainly involved in basic research, the Department Decision Making Theory is very diversified in its topics with a very broad range of possible applications.

## **2. Strengths and Opportunities**

The challenges and the perspectives of the Institute lie in the fact that its research fields are mainly located at interfaces between disciplines, where innovations have a better chance to happen, and that they are linked to important application areas. So far, the Institute has been very successful in establishing and developing several departments, achieving excellent results in a large number of areas, in fundamental and applied research. Many of the teams are at the forefront of research in their disciplines. Several of the investigated applications have direct positive impact on the area of application. This Commission is not able to identify highlights or deficits in all departments, due to lack of information, however it feels enough justified to acknowledge the very special strengths of the Institute. The integration into teaching and educating students is rather intensive, despite some complaints about the access to students, raised by the Institute. With few exceptions, the Institute seems to be quite successful in attracting students.

The Institute is female, family and senior friendly. Three out of ten leading positions in the institute are occupied by women. A remarkable amount in the budget of the institute is allocated to a social

program, showing already positive effects.

### 3. Weaknesses and Threats

The following statement was essentially formulated in one of the reports of the departments, identifying the following deficits:

- weakening of connections between research subgroups: excessive focusing on a particular sub-problem causes overlooking a common, more general problem behind,
- a growing tendency to prefer applied research: omnipresent call for applied solutions suppresses interest in fundamental research, necessary for substantial progress also in applications (S1),
- a short-term perspective of applied research influences personal research objectives. As a result no long-term personal vision may be present.

The Committee shares these concerns and fully agrees. It appreciates the fact that the leaders, responsible for the Departments and the Institute, are aware of not only the excellent achievements, but also of the weaknesses, which could be observed more or less in general in this evaluation.

The situation in the PhD studies in general and in connection to the Institute absorbed much of the time for discussion during the visit. The Institute provided the current figures, which showed that based on 22 students finishing their PhD in the evaluation period in cooperation with the Institute the average time needed was 6,2 years. This is only one of more indicators, identifying as a crucial weakness

- the poor conditions in the education of PhD students in Czech Republic. (S4, 5, 6)

### 4. Recommendations

The Committee is recommending the following measure to reduce at least the weaknesses and to improve the co-operations also with other Institutes and team of CAS and of Universities:

- focusing and integrating the scientific program of some of the departments, so far more a disconnected union of research interests of members,
- allocation of stable resources, to follow long time projects and to improve the situation in important areas like Mathematical Statistics,
- improving the cooperation of teams of the Institute with teams of other Institutes of CAS, e.g. in Numerical Mathematics, Stochastics and Statistics, Dynamical Systems, Optimization and Control Theory, also with the aim to strengthen basic research in this fields (S2, 5, 7)
- supporting changes in the PhD education e.g. by the establishment of Research Training School for PhD students, with Nečas Center as possible host (S4, 5, 6)

### 5. Detailed evaluations

*Declaration on the quality of the results and share in their acquisition*

The selected outputs of the Institute as whole were rated as

10% “world-leading”, 40% “internationally excellent”, 39% “recognized internationally”,  
11% “recognized nationally”

The impact of scientists and their achievements, the quality of departments and institutes cannot be measured just by indices. Evaluation of publications by independent experts, based on studying selected papers and their influence are delivering a better rating. The Institute as whole achieved a

convincing result with 50% in top levels. Usually interdisciplinary research has disadvantage in such evaluation since most referees are disciplinary oriented. Since the Institute is rather interdisciplinary positioned, this has to be taken into account. Nevertheless, it should be an important aim to lift all contributions to the international level.

The Institute deserves acknowledgement for starting and developing research area at the interfaces between disciplines. Thus it builds a good basis in Mathematics and Information Technology for Strategy AV21, the recent Initiative of CAS.

*Declaration on the involvement of students in research*

The numbers of students involved in research seem to be good on average. The difficulties in particular with PhD that arise in most departments seem to depend on available stable resources.

The main problem is the length of the PhD studies, which by no means is acceptable, however cannot be billed just to the advisors or the departments.

*Declaration on societal relevance*

The Institute is by its research, its participation in teaching and education and many additional activities contributing to progress in society.

*Declaration on the position in the international and national context*

The Institute has build up an important national and international position in its scientific areas. Its departments are well imbedded in international networks of experts. It also has build up good connections to industry and business, contributing not only to the resources but also to the start of new research projects.

*Declaration on the vitality and sustainability*

The Departments, we visited, as well as the Director and his staff and the Board appeared as very active, competent and co-operative. The management side seems to be running very well. As far as the scientific aspects are concerned, co-operation between the members of some Departments and between the different Departments can be improved. Improving the connections inside the Institute and within the CAS is important to maintain international competitiveness.

Experience shows that there are thresholds for size of scientific centers, which when crossed may lead to decrease of efficiency and quality. The Institute should take this into account

*Declaration on the strategy and plans for the future*

The materials available to this Committee are:

The general report of the Institute, the reports of the Department of Decision Making Theory and the Department of Stochastic Informatics

Whereas our detailed statements to this topic concerning the two departments are presented in part B, a detailed comment for the Institute as whole cannot be presented, since relevant information on the remaining 6 Departments is not available.

The Institute is presenting a list of scientific topics, which are just headlines for future research, adding the statement that

*„management does not directly determine particular research directions. That is the responsibility of the Department heads, who take into the account not only the current state of the art but also the policy of grant agencies and other relevant things.“*

This approach might be successful, however can also lead to a compilation of the individual plans of the researchers. The Committee is convinced that a coordination and focusing of the research topics

within Departments, within the Institute and finally also within CAS are required. (S8)

## **B. Evaluation of the individual teams**

### **Evaluation of the Team No. 1: Department of Decision Making Theory**

#### **1. Introduction**

The team *Decision Making Theory* is a mixed group of mathematicians working on a wide range of topics. The presence of theoretical mathematicians open to applications is vital for an institute as the Institute of Information Theory and Automation, since the main subject areas of this institution require a deep understanding of the underlying mathematical methods. Also, it is necessary to allow the members of team to pursue their own research interests besides the services they render to other research activities of the institute. The team fulfils both roles: the research output both in theory as well as in applications meets international standards.

#### **2. Strengths and Opportunitites**

The versatility of the team can, and in the past did, contribute to various research projects of other teams of the institute. The individual members of the team have good international relations, they publish their best results in journals and conference proceedings of significant reputation.

#### **3. Weaknesses and Threats**

The diversity of the team is both an advantage and a disadvantage. On the negative side sometimes the critical mass is missing, only lone researchers pursue an important direction of investigations. This might be a factor behind the insufficient outside funding from grants. As a general problem, the committee observed here as well that the number of students involved in the work of the team is quite low.

#### **4. Recommendations**

We recommend

- to select only a few core areas, while keeping the current spectrum of research.
- to concentrate their (seemingly limited) resources – both personnel and funding – to these core areas in order to increase their successes in research, international visibility and obtaining grants.

- to identify teams inside the Institute and also the CAS as whole, with which cooperations has to be established or to be strengthened, in order to use the existing knowledge and potentials better

## 5. Detailed evaluations

### Declaration on the quality of the results and share in their acquisition

The research team works on a wide spectrum of research topics with limited interaction between the different topics. The team consists of 18 researchers with the core researchers' FTE about 10.

The overall quality of the research output is high at an international level as it is reflected by the Phase I evaluation results.

The selected outputs were rated as

10 % "world-leading", 62% "internationally excellent", and 28 % "recognized internationally".

As typical for this area, a large part of the papers are published in conference proceedings. Several articles were published in important international journals as *SIAM Journal on Optimization*, *SIAM Journal on Applied Mathematics*, *Annales de l'Institut Henri Poincaré*, *International Journal of Approximate Reasoning*. The main research topics include:

- optimization and nonsmooth analysis
- numerical methods in mechanics of solids
- computational mechanics
- numerical analysis
- Bayesian networks
- game theory
- information theory
- compositional models
- mathematical logic
- decision-theoretic troubleshooting

This list reflects the research interests of the individual scientists, but lacks a clear focus for the research team. The name of the group does not describe adequately the conducted research.

### Declaration on the involvement of students in research

Most team members are very actively involved in teaching at various universities (Charles University, Czech Technical University, etc.) on all levels (bachelor, master, doctoral) and so they can find students to join in their research. In the report they included results coauthored by four doctoral students; two of them defended their thesis during the reporting period. Unless the general conditions for doctoral students would improve nationwide, it is not realistic to expect greater involvement of students in research.

### Declaration on societal relevance

A large part of the team's research has significance for other sciences, engineering and economics. Although it cannot be expected that basic mathematical research has direct societal relevance, through the various applications it has measurable impact on economy.

Four team members belong to the editorial board of the institute's reputed journal *Kybernetika*.

From the outreach activities of team members the seminar *Mathematical problems of nonmathematicians* at Charles University has great importance.

### *Declaration on the position in the international and national context*

Team members have strong international contacts through collaborations, invitations to international conferences (France, Italy, Australia, etc.), organizing international conferences, workshops and schools in the Czech Republic, etc. Six team members serve on editorial boards of international journals.

This team of mathematicians has a vital role in the Institute of Information Theory and Automation as the institute's research topics inevitably involve deep mathematical problems for which an "in-house" collaboration might be more fruitful than seeking outside advice.

### *Declaration on the vitality and sustainability*

The team is able to recruit young researchers. 44% of the team members are under 40, those over 50 are of the same number, while the 40-50 age group is underrepresented (as it is the case for most research teams we have evaluated). The research topics of the team belong to internationally active areas.

Team members are able to obtain grants from various sources (GAČR, Marie Curie actions, etc.), but not on the desirable level.

### *Declaration on the strategy and plans for the future*

The detailed plans of the research team promise the continuation of their high level research. However, this is just a compilation of the individual plans of the researchers. A clear vision of the research group's role within the institute is missing. Moreover, focusing on a fewer topics would enhance the productivity and the international visibility of the team.

## **Evaluation of the Team No. 2**

### ***Department of Stochastic Informatics***

#### **1. Introduction**

The Department is covering Stochastics and Mathematical Statistics, mathematical disciplines of greatest importance, due to fact that real life processes are more or less stochastic, and deterministic descriptions are approximations with more or less limited validity. Randomness of processes, of the parameters in their model systems, of in- and output data are posing challenges, which can be handled only with help of basic research in these fields. The faster the growth of Information Technology, the larger is the demand for concepts and tools to control risks and uncertainties. The name of the Department is at least unconventional, but contains a grain of truth. CAS is well advised to strengthen these fields and to integrate them in basic mathematical research as well in applied, data based research.

#### **2. Strengths and Opportunities**

The team is highly qualified and known by their excellent publications in Probability Theory and Statistics. The expertise in stochastic differential equations and in stochastic many particle systems

is of special interest in mathematical modeling ranging from physics to life sciences and social sciences, This potential can be used by other teams of CAS. Co-operations were started and are going to be intensified with the team Evolution Differential Equations, which deal with mainly deterministically formulated model equations for fluids, which have to be derived as limits of interacting, stochastic many-particle systems. Also the expertise in statistical methods for signal processing or survival analysis and in multiple regression analysis, can be made accessible and developed to the profit of more data based research in CAS and co-operating Universities.

The members of the department are integrated in international network of top experts.

### **3. Weaknesses and Threats**

The Department is missing resources in particular to strengthen and to extend the activities in basic research in Mathematical Statistics. Since third party funding is very time limited, more stable resources are needed to develop innovative research directions and to attract the best junior scientist for such innovative projects.

The number of bachelor, master and in particular PhD students finishing their thesis in the Department is too small, due to the generally known reasons.

### **4. Recommendations**

The Commission recommends the following measures intended to strengthen the research fields Stochastics and Mathematical Statistics. It recommends

- to increase of the number of postdocs and Ph.D. students in the teams
- to increase institutional funding, necessary to start new research directions
- to strengthen Stochastics and Statistics as mathematical basic research in CAS, making use of the existing potential

### **5. Detailed evaluations**

#### *Declaration on the quality of the results and share in their acquisition*

The team is active in three distinct sub-areas of stochastics:

- 1) Stochastic analysis, stochastic differential equations
- 2) Interacting particle systems, in particular interacting branching systems
- 3) Statistics, with emphasis on multiple output regression, signal processing, and survival analysis.

The team is strong in all three areas. It is internationally well connected and highly recognized and makes significant scientific contributions.

The publication record is very good both with respect to quantity and quality. The team publishes mainly in the highest ranking international journal in their field of specialization, such as Annals of Probability, Probability Theory and Related Fields, Electronic Journal of Probability, Annals of Statistics, Journal of Multivariate Analysis, etc. . The team is focused on high-end publication rather than large mediocre output.

The Phase I evaluation rated the submitted outputs as follows,

12 % „world leading“, 52 % „internationally excellent“, 36 % „recognized internationally“.



#### Declaration on the involvement of students in research

The team does involve students, in particular Ph.D. students in its research, but due to difficulties that are common to all CAS Institutes, the number of students is lower than the team would like it to be. The number has even dropped to zero by 2014, which is definitely not acceptable. The involved students were contributing substantially to the research and are visible as co-authors of the team's publications.

#### Declaration on societal relevance

The team's research contributes to the development of applicable mathematics that has a major if not the most significant impact on the welfare of a developed nation.

The team contributes to mathematics education at several Universities, mostly at Charles University, through a very substantial number lectures that are taught at various levels and that help to disseminate the specialized knowledge of the team members to the young generation of mathematics students. Team members also serve in exam committees and as supervisors of Bachelor- and Master-theses.

The team has some limited co-operations with the business sector. This appears rather natural given the more basic research orientation of the team.

The team has also been engaged in a limited way in activities aimed at the popularization of mathematics.

#### Declaration on the position in the international and national context

The team is working in some aspects at the leading edge of research in their fields.

It has numerous international collaborations (19 papers with foreign co-authors) and has attracted international visitors for research visits.

The team organized and co-organized a number of conferences and schools. Its members are invited regularly to research visits abroad and to present lectures at major international conferences and workshops.

At the national level, the team has engaged collaboration with the team of Evolution Equations at the CAS Institute for Mathematics in the area of stochastic evolution equations. This is a very promising initiative and it is to be hoped that this collaboration can be intensified and involve further members of the team. There other possible links to teams e.g. in the Institute of Mathematics, to the teams

Algebra, Geometry, and Mathematical Physics (information geometry)

Numerical Analysis (stochastic finite elements, uncertainty)

#### Declaration on the vitality and sustainability

The current composition of the team is fairly reasonable, with the exception of the statistics group that has suffered some recent losses in manpower and is aiming to recruit new members. The qualification of the existing team members is excellent.

It would be very desirable to increase the number of postdocs and Ph.D. students in the team, but this is depending on increased funding. The topics of the research team should be highly attractive to young people but the financial situation regarding funding for young scientists makes it difficult to realize this. The same is true for the recruitment of foreign nationals to the team.

The funding situation is as for all visited institutes not optimal. It would be desirable to increase the level of fixed institutional funding. Project funding should not be used to finance the permanent members of the staff, but to allow temporary hiring of Ph.D. students, postdocs and foreign visitors.

*Declaration on the strategy and plans for the future*

The proposed research plan for the near future is reasonable. It would be desirable that the team had formulated a more inspired long-term vision. This was partly hampered by the insecurities regarding funding. In the commissions view the team has the potential to strengthen its position in an important area of mathematics, in particular if links with other excellent areas of the CAS institutes are further developed. A key direction here is the intensification of the collaboration with the Mathematics Institute of CAS mentioned earlier. In particular, the particle systems sub-team could play an important role in the efforts to engage in the field of mathematical modeling and simulations in life sciences.

**Date:** December 31, 2015

**Commission Chair:** Professor Willi Jäger