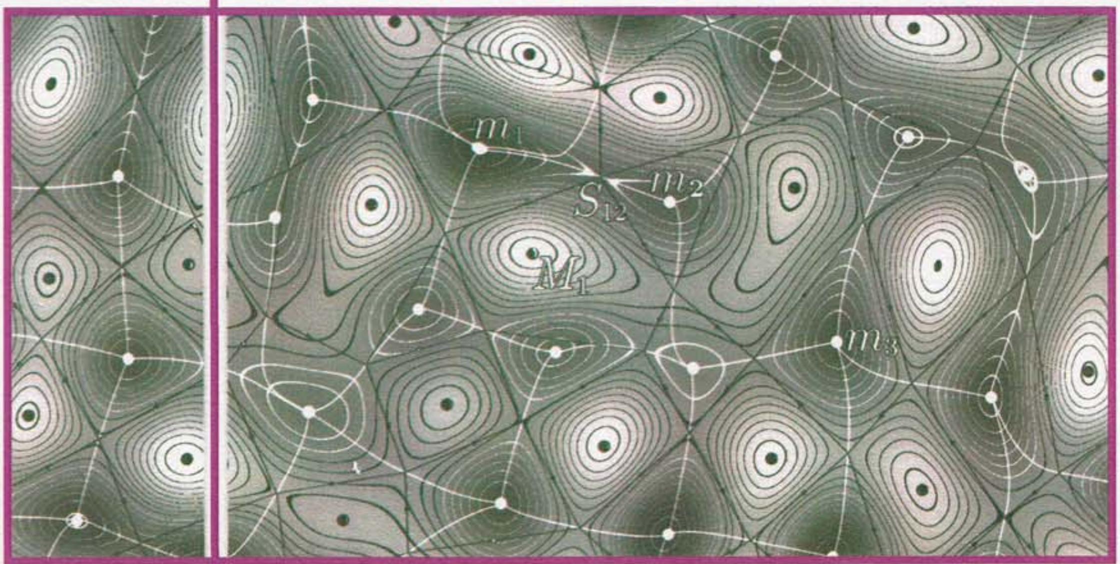
CENS

CENTRE FOR NONLINEAR STUDIES



2010 ANNUAL REPORT

Tallinn

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Institute of Cybernetics at Tallinn University of Technology
Research Laboratory for Proactive Technologies, Tallinn University of Technology

CENS

Centre for Nonlinear Studies

Annual Report

2010

Tallinn, Estonia

Contents

Abstract

This Report gives a brief overview on activities of CENS in 2010. Described are studies and results in: (i) dynamics of microstructured materials and solitons; (ii) general nonlinear wave theory; (iii) fractality and econophysics; (iv) software development; (v) water waves and coastal engineering; (vi) biophysics and cell energetics; (vii) optical nonlinearity and photoelasticity; (viii) nonlinear and robust control systems; (ix) proactive technologies. The full records of papers, reports, conferences, teaching activities, promotions, etc are all included. The Annex reflects some activities of CENS.

Keywords: nonlinear dynamics, soft matter physics, microstructured solids, solitons, acoustodiagnostics, photoelasticity, cell energetics, water waves, extreme waves, coastal engineering, differential equations, control theory, proactive technology.

The International Advisory Board

Sisukord

Lühikokkuvõte

Aruanne sisaldab ülevaadet CENSi (Mittelineaarsete Protsesside Analüüsi Keskuse) tegevusest 2010. a. Põhitulemused on kirjeldatud järgmiste alateemade kaupa: (i) lainelevi mikrostruktuursetes materjalides ja solitonid; (ii) üldine mittelineaarne laineleviteooria; (iii) fraktaalsus ja ökonofüüsika; (iv) tarkvara arendus; (v) lained veepinnal ja rannikutehnika; (vi) biofüüsika ja rakuenergeetika; (vii) optiline mittelineaarsus ja fotoelastsus; (viii) mittelineaarsed ja robustsed juhtimissüsteemid; (ix) proaktiivtehnoloogia. On esitatud publikatsioonide, konverentsiettakannete, seminaride jm nimekirjad, samuti kokkuvõte rahastamisest. Eraldi on esitatud ka õppetöö, eeskätt kraadiõppe kirjeldus. Lisas on mõned kirjeldused CENSi tegevusest.

Võtmesõnad:
mittelineaarne dünaamika, pehmisefüüsika, mikrostruktuuriga materjalid, solitonid, akustodiagnostika, fotoelastsus, rakuenergeetika, pinnalained, hiidlained, rannikutehnika, diferentsiaalvõrrandid, juhtimisteooria, proaktiivsus.

1. Introduction

This Report covers, like the previous ones, all the activities carried on by the staff including fellows and student. Section 2 is a short summary on the structure of CENS (for more detailed description see Annual Report 2008). Then in Section 3, an overview on current research in 2010 is presented. Next Sections describe the funding (Section 4) and publications, conferences, seminars, etc. (Section 5). Section 6 covers all the other activities like the courses, graduate studies, visitors, etc. Finally, in Section 7 some conclusions are given. Some additional materials are given in the Annex.

2. Overview on CENS

Structurally CENS is based on the following departments and laboratories:

Institute of Cybernetics at Tallinn University of Technology:
Department of Mechanics and Applied Mathematics (head: J.Engelbrecht);
Laboratory of Photoelasticity (head: H.Aben);
Laboratory of Systems Biology (head: M.Vendelin);
Laboratory of Wave Engineering (head: T.Soomere);
Department of Control Systems (head: Ü.Kotta).
Tallinn University of Technology, Department of Computer Control:
Research Laboratory for Proactive Technologies (head: L.Mõtus).

The following long-term block grants support the studies:

Nonlinear dynamics and complex systems (supervisor J.Engelbrecht);
Synthesis of complex nonlinear control systems (supervisor Ü.Kotta);
Proactivity and situation awareness (supervisor L.Mõtus).

The international grants, etc. are listed in Section 4.

CENS has been awarded with the title "Centre of Excellence in Research" within Tallinn University of Technology for years 2009–2011.

3. Current results 2010

3.1 Institute of Cybernetics, Department of Mechanics and Applied Mathematics, Tallinn University of Technology

3.1.1 Dynamics of microstructured materials and solitons

Multiscale modeling of microstructured solids.
Wave propagation in solids with microstructures characterized by different internal length scales are considered in the framework of a Mindlin-type microstructure model. The Mindlin's idea on describing a microstructure is enlarged to multiple scales by using the concept of internal variables. The models and the corresponding dispersion relations are physically well grounded and display essential differences for medium-range wavelengths. This opens possibilities to distinguish the microstructured solids by measuring the wave-field characteristics. It is clear that the complexity of microstructure can be increased by means of the combination of simple microstructure models considered (A.Berezovski, J.Engelbrecht, T.Peets).

Solitary waves in Mindlin-type microstructured solids: numerical simulations.
Mindlin-Engelbrecht-Pastrone (MEP) model is used for describing the longitudinal deformation waves in microstructured solids. MEP models include Mindlin theory of continua with microstructure and the concept of wave hierarchies and they are able to take into account non-linear and dispersive effects on the micro- as well as on the macrolevel. After introducing free

energy function one gets a system of equations of motion from the Euler-Lagrange equations (referred as full system of equations below). Next, by applying slaving principle the micro-deformation can be eliminated from the latter, which results in hierarchical wave equations of Boussinesq type (in terms of displacement or in terms of deformation). Equations are solved numerically under localized initial conditions. For numerical integration Fourier transform based pseudospectral method is used. In 2010 results from earlier years were generalized and summed up. Main results are: (i) hierarchical equation is a good approximation to the full system of equations, (ii) if there exists nonlinearity in microstructure then propagating waves evolve to be asymmetric and waves propagating in opposite directions evolve differently in time, (iii) interactions between propagating solitary waves are not fully elastic, however over the short time intervals and over low number of interactions the behaviour of waves is soliton-like, (iv) in the nonlinear dispersionless case a 'peakon'-type waveprofiles can emerge (K.Tamm, A.Salupere).

Waves in materials with microstructure: Theory and numerics.
A linear model of the microstructured continuum based on Mindlin theory is adopted and represented in the framework of the internal variable theory. Fully coupled systems of equations for macro-motion and microstructure evolution are represented in the form of conservation laws. A modification of wave propagation algorithm is used for numerical calculations. Numerical simulations of pulse propagation in a laminated medium and in a medium with microstructure were performed to compare the results in order to check the validity of the microstructure model. Material properties and the characteristic lengths used in calculations were chosen correspondingly to match both cases. The comparison of the results of numerical simulations shows that the coefficients in the improved microstructure model can be adjusted to achieve the accordance of the amplitude and location of the leading transmitted pulses in both cases. This means that the microstructure model is able to describe the wave propagation in complex media. At the same time, it is clear that the influence of the shape and orientation of inclusions need to be investigated in the framework of two-dimensional formulation (M.Berezovski, A.Berezovski, J.Engelbrecht).

Solitary waves in microstructured solids.
Studies are based on the basis of the nonlinear Mindlin–Engelbrecht–Pastrone model for which an evolution equation is derived already earlier. This nonlinear evolution equation as an extended Korteweg-de Vries equation is solved approximately by a series expansion in a small parameter representing the micro-nonlinearity. Already the first approximation indicates the asymmetry of the solitary waves. It is shown that solitary waves will propagate only if the micro-nonlinearity does not exceed some upper bound. For the limiting case, an analytical solution of the extended Korteweg-de Vries equation can be provided and used as a reference for the approximate solutions.

The classical sech^2 soliton can be considered as the long-wave limit of the cnoidal waves. In the same way the asymmetric solitary waves governed by the extended KdV equation are the limits of periodic wave trains when their wave length tends to infinity. Periodic waves emerging from the cnoidal waves of the KdV equation are studied using the same perturbation procedure as for the solitary waves. Compared with the cnoidal waves, these more general periodic waves are asymmetric, i.e. inclined to the direction of propagation (M.Randrüüt, M.Braun).

Mathematical conditions for the existence of solitary waves in a one-dimensional coupled system of equations of motion of microstructure were deduced. Several inverse problems to determine the parameters of this system on the basis of solitary waves were posed and analysed. In particular, uniqueness results for these inverse problems were obtained (J.Janno).

Solitary deformation waves in a compressible hyperelastic rod.
The propagation of axisymmetric deformation waves in circular cylindrical rods made of compressible hyperelastic material is studied. The corresponding model equation which describes propagation of waves of moderate wave-lengths takes into account the coupling effect of the material nonlinearity and the geometric size of the rod is derived by Hui-Hui Dai. Numerical simulations are carried out over a wide range of material parameters making use of the discrete Fourier transform based pseudospectral method and harmonic initial conditions. Three different solution types were detected and one of them has the solitonic character. The latter is analysed in detail: the influence of different material parameters on the time-space behaviour of solutions is established (A.Salupere, M.Rätsep).

The Balance of Spin from the Point of View of Mesoscopic Continuum Physics for Liquid Crystals.
Mesoscopic continuum physics has been reviewed using generalized coordinates. This approach has the advantage, that only 5 coordinates and 5 component equations for the velocity are necessary instead of 6 coordinates, 6 balance equations for linear and angular momentum and 1 constraint in the standard formulation. It has been shown that the balance of spin (internal angular momentum) follows naturally from the balance of momentum as component equations in the higher dimensional space – this is a difference to the standard formulation of mesoscopic continuum theory, which postulates an additional balance of total angular momentum. The stress tensor on this space contains the spatial stress tensor, the couple-stress tensor (mixed rotational-spatial components) and in addition purely rotational and mixed spatial-rotational parts. These additional terms are not known from the macroscopic theory. In macroscopic theory the balance of spin is usually deduced from the balance of total angular momentum, which has to be given separately. This balance contains the couple-stress tensor and is coupled to the balance of momentum by the skew-symmetric part of the stress tensor. The component equations are not *a priori* coupled, but the constitutive functions in the different parts of the stress tensor may introduce this coupling, depending on the choice of the constitutive functions, in particular the production can be chosen as a function of the skew-symmetric part of the spatial stress tensor (H.Herrmann, J.Engelbrecht).

Theory of short fibre reinforced materials.
Different methods of describing the orientation of fibres in short fibre reinforced composite have been discussed. It has been clearly shown, that the two commonly used methods for steel fibre reinforced concrete, the orientation number and orientation profile, are insufficient. The newly proposed alignment tensors and corresponding (orientational) order parameter and macroscopic director overcome these limitations. The order parameter has the advantage over the orientation number, that it is related to the expectation value of the second Legendre polynomial, a special case of spherical harmonics, which are well known in electrodynamics and quantum mechanics. Especially by use of higher order alignment tensors it is possible to describe the orientation distribution of the fibres accurately in three dimensions. In addition the alignment tensors can be easily used to formulate constitutive equations. These constitutive equations are tensor equations and contain only objective quantities, especially they are independent from any pre-chosen projection direction. They can be used to calculate the stresses in any direction. Furthermore all quantities are fields, i.e. they can vary along the material. Although steel fibre reinforced concrete has been chosen as an example, the methods are applicable to all kinds of short fibre reinforced composites (H.Herrmann, M.Eik).

Mesoscopic Continuum Physics: Evolution Equation for the Distribution Function and Open Questions.
Different usage scenarious of the distribution function with its evolution equation together with different versions of the balance of mass have been described. Although these may seem obvious, they have not been mentioned in the literature before. The problem of (virtually) disconnected mesoscopic domains has been discussed. The problem that continuous three dimensional domains may become discontinuous when using the mesocopic space is not inherent to the strict high dimensional formulation used here, but just more visible. It also appears in the "traditional formulation"used by other authors. Under certain circumstances, i.e. when the mescoscopic domain becomes non-connected, mesoscopic continuum physics requires a strongly non-local formulation of constitutive functions, a weakly non-local formulation – containing gradients – is not sufficient anymore (H.Herrmann, J.Engelbrecht).

Microstructured Media: Challenges of Steel Fibre Reinforced Concrete in load bearing structures.
Cement-matrix composites are one of many composite material systems, usually consisting of two phases, fibre as reinforcement and concrete as matrix. This article focuses on the composite, reinforced with metal fibers The main role of fibres is to carry the load, while the concrete matrix serves to transfere and distribute the load to the fibres. The efficiency of load transferring from matrix to fibres depen on the matrix- fibre bonding interface and anchorage length of the fibre. Additionally the problem associated with the orientation of fibres in the matrix, is one of the most important and plays a significant role in determining the yield stress of the composite. Also explores a possible parallel between the conventional and steel fibre reinforced concrete (M.Eik).

3.1.2 General nonlinear wave theory

Complexity of nonlinear waves.
Highlights of studies into a variety of phenomena reflecting the complexity of underlying nonlinear processes in a selection of research disciplines in the Centre of Nonlinear Studies (CENS), presented in the International Conference on Complexity of Nonlinear Waves, 5-7 October 2009, Tallinn, Estonia are reflected. The similarity of mathematical description of and potential synergy arising from complementary studies in general soliton science, wave propagation in microstructured and functionally graded materials, related inverse problems, issues of nondestructive testing, weak resonant interactions of water waves, wave transformation and run-up, soliton interactions in shallow water, and selected problems of passive scalar turbulence, is emphasized (J.Engelbrecht, A.Berezovski, T.Soomere).

Acoustodiagnostics of inhomogeneous solids.
The theoretical investigation of inverse problems to characterize the strongly variable properties of functionally graded materials (FGMs) on the basis of direct solutions to the problems of ultrasonic wave propagation is carried on. The specimens of FGMs designed with strongly changing properties close to the boundaries are studied. The variation of these properties has an exponential description. Such materials may be employed in many important areas as coatings and interfacial regions for the purpose of reducing residual and thermal stresses and increasing bounding strength.

The counter-propagation and interaction of waves in the physically nonlinear elastic FGM with exponentially changing properties was studied theoretically. The governing equation was solved numerically making use of the routine pdsolve/numeric of the symbolic manipulation software Maple that uses finite difference method to obtain the numeric solution. Analyses of the results of numerical simulations led to the conclusion that the profiles of the recorded boundary oscillations are informative and may be used for nondestructive characterization of material properties. Algorithm for qualitative ultrasonic nondestructive characterization of exponentially graded materials on the basis of the data of counter-propagation and interaction of harmonic waves was proposed in 2009. This year the method for qualitative characterization of the properties of exponentially graded materials was elaborated on the basis of counterpropagating bursts. The numerical experiments were implemented with different types of bursts (harmonic, polynomial, step type, etc.). It was concluded that the harmonic bursts are most suitable for this problem.

The distortion of the profiles of oscillations on the boundaries and on the axis of symmetry of the specimen caused by the interaction of counterpropagating harmonic bursts is studied in detail. On the basis of boundary oscillation profile data evoked by ultrasonic counterpropagating harmonic bursts in the material it is possible to propose a method for qualitative nondestructive characterization of FGMs with exponentially changing continuous properties. This qualitative method enables to distinguish specimens made by
(i) homogeneous material,
(ii) symmetrically distributed material properties,
(iii) asymmetrically distributed material properties
and also to distinguish the most relevant property of the material responsible for inhomogeneity.

The propagation of an ultrasonic harmonic burst in a sample of the weakly exponentially graded nonlinear elastic material was studied analytically. Multiple reflections of the burst from the specimen's boundaries were described using the perturbative solution. The dependence of the amplitude, the phase velocity and the phase shift on the material properties was cleared up. The phenomenon of the decrease of nonlinear effects of the burst propagation after the first reflection from the free boundary was observed. Interesting was that the variation of bursts frequency enables to obtain more information about material properties after the reflection of the bursts from the stress-free excitation boundary. The obtained results are useful for elaboration of algorithms for ultrasonic characterization of the weakly exponentially graded nonlinear elastic materials (A.Ravasoo, A.Braunbrück).

Vibration of the string with nonlinear contact conditions and deformation wave propagation in the piano hammer felt.
The main goal is investigation of vibrations of the ideal flexible string, which one end is rigidly clamped, or coupled with a linear damped oscillator, and another one is terminated on the curved contact surface (cast iron frame). The vibrating string touches repeatedly this termination, and this, in turn, causes the modulation of fundamental frequency of the string, and the train of high frequency oscillations is generated. The problem is studied both analytically, and numerically. The effects of the contact nonlinearity and the shape of the contact surface on of the spectral structure of the string vibration are considered. The mathematical model of the string-frame interaction is also derived. The influence of the impact amplitude on the vibration spectra of struck string is estimated and discussed. Numeric study of deformation wave in piano hammer felt is conducted. The results obtained give a possibility to estimate the characteristics of the compression wave in the piano hammer felt material (A.Stulov, D.Kartofelev).

3.1.3 Fractality and econophysics

We have generelized the stochastic triplet-map model of turbulent mixing to the evolution of the droplet-size spectra in warm clouds. In particular, we have explained theoretically the experimentally observed anomalously fast growth of the width of these spectra. We have derived and verified numerically the scaling exponents of arbitrary-order moments of tracer particle displacement vectors in stationary self-affine two-dimensional velocity fields. We have derived the k-spectrum of decaying, aging and growing particles in smooth chaotic flows, addressing, in particular, the problem of plankton patchiness.

We have developed and studied numerically a two-stage lattice model, which explains reasonably well the formation of nanotubes, observed in the experiments at UT. At the first stage, a mesh of craks is formed due to an inhomogeneous contraction of the polymer-bonds of the drying film; at the second stage, the film is released from the substrate, and the film fragments roll into tubes.

Electrical conductivity in thin films of PEDT/PSS complex has been studied using the morphology, created by the Mesodyn-software, and application of percolation theory methods. It has been shown that the strongly anisotropic global conductivity can reasonably well be estimated as the bottleneck-conductivity.

We have calculated numerically the following fractal dimensions of self-affine surfaces as a function of the Hurst exponent $H < 1$: a single isoline (corresponds to the hull at the percolation-problem limit, $H < 0$), unscreened perimeter, percolation cluster, oceanic coastline. The results are in agreement with qualitative theoretical conciderations.

We have revisited our studies regarding the multiscaling of financial time-series and nonlinear portfolio optimization by positioning them in the context of recent development in econophysical studies, and writing a review of econophysical studies in Estonia (J.Kalda et al.).

3.1.4 Software development

- P.Peterson. PyLibNIDAQmx: exposes NI-DAQmx software driver to Python. `http://code.google.com/p/pylibnidaqmx/`;
- P.Peterson. PyLibTiff: wraps libtiff library to Python. `http://code.google.com/p/pylibtiff/`;
- P.Peterson, M.Laasmaa. IOC Microscope: tools for manipulating and analyzing 3D microscope images.

The project for developing C^{++} software for driving experiment protocols on fluorescence and confocal microscopes has been continued.

3.1.5 Laboratory of Wave Engineering

Spatio-temporal variations in the Baltic Sea wave climate.
The wave climate and its variability in the north-eastern Baltic Sea are estimated using the wave model WAM driven by adjusted geostrophic winds for 1970-2007 under ice-free conditions and a spatial resolution of 3 nautical miles. The hindcast qualitatively reproduces the time series of the sea state and replicates the seasonal patterns of wave intensity and different statistical properties of wave fields in both offshore and coastal regions. It is shown that the hindcast generally underestimates the wave heights even if the very best wind information (e.g., ECMWF reanalysis) is used but still adequately reproduces trends and spatial variations in the wave properties.

Spatial variations in wave properties are studied based on a comparison of the hindcast data with visual wave observations from the north-eastern coast of the Baltic Proper and from the southern coast of the Gulf of Finland. The areas of the largest overall wave activity are located in the eastern parts of the Bothnian Sea and northern Baltic Proper, south of Gotland, and in the Arkona basin. The windiest season (September-February) and the time with the largest measured or modelled wave activity (October-March) occur with a time lag of 0.5-2 months. It is shown that in extreme storms the extreme wave heights and periods are about 7 m and 10-12 s in the northern Baltic Proper, about 6 m and 8-11 s at the entrance to the Gulf of Finland, and about 4 m and 6-8 s in the eastern part of this gulf.

Spatial patterns in linear trends of numerically reconstructed Baltic Sea wave fields for 1970-2007 reveal extensive spatial variations in long-term changes in both average and extreme wave heights whereas almost no changes exist in the basinwide wave activity and wave periods. A significant decrease in the wave activity has occurred between the islands of Öland and Gotland and in the southward sea area, and a substantial increase to the south-west of Bornholm, near the coast of Latvia, between Åland and the Swedish mainland, and between the Bothnian Sea and the Bothnian Bay. Variations in extreme wave heights (defined as the threshold for 1% of the highest waves each year) show similar patterns of changes. In several areas the trends in average and extreme wave heights are different.

Both long-term average and maximum wave heights in the Gulf of Finland are about a half for those in the Baltic Proper. The average wave heights have insignificantly changed in the gulf since the 1970s whereas the extreme wave heights have considerably increased in the northern and in the northeastern sections of the gulf; probably because of the enhancement of SW winds over the last 40 years. Significant changes in the directional distribution of waves (that are not represented in numerical hindcasts) are identified for Narva-Jõesuu from the 1980s. Consequently, different regions of the Baltic Sea basin have experienced widespread but essentially different changes in wind properties. The results suggest that many seemingly controversial trends and variations established in wave properties at different sites in the recent past may reflect the natural spatial variability in the Baltic Sea wave fields.

A comparison of the modelling results with historical visual observations shows that although the WAM model with the used wind forcing does not replicate certain features of long-term changes in wave properties, short-term variations of observed and simulated wave parameters match well each other. A highly interesting feature is the substantial turn of the predominant observed wave propagation direction in Narva Bay more than 90^o over a half-century. This peculiarity can be interpreted as an evidence of certain changes in the wind fields over the entire Gulf of Finland, possibly connected with the overall increase in the role of SW winds over Estonia. Preliminary analysis of visual wave data from Lithuania shows that the monthly mean wave height at both Estonian and Lithuanian stations follows the seasonal variation in wind speed in this region but long-term changes in mean wave height at the Lithuanian coast do not show clear coherence with similar variations at the Estonian coast (A.Räämet, T.Soomere, I.Zaitseva-Pärnaste).

Theory of shallow-water waves.

Long wave dynamics along a quartic bottom profile: the problem of transmission of wave energy in strongly inhomogeneous media is discussed with application to long water waves propagating in a basin with a quartic bottom profile. Using the linear shallow-water theory it is shown that the wave component of the flow disturbance is described by a travelling wave solution with an amplitude and phase that vary with distance. This means that the kinetic part of the wave energy propagates over large distances without reflection. Conditions for wave breaking in the nearshore are found from the asymptotic solution of the nonlinear shallow-water theory. Wave runup on a vertical wall is also studied for a quartic bottom profile (I.Didenkulova, E.Pelinovsky).

Statistical estimates of characteristics of long wave runup on a beach: a run-up of irregular long sea waves on a beach with a constant slope is studied within the framework of the nonlinear shallow-water theory. This problem was solved earlier for deterministic waves, both periodic and pulse ones, using the approach based on the Legendre transform. Within this approach, it is possible to get an exact solution for the displacement of a moving shoreline in the case of irregular wave run-up as well. It is used to determine statistical moments of run-up characteristics. It is shown that nonlinearity in a run-up wave does not affect the velocity moments of the shoreline motion but influences the moments of mobile shoreline displacement. In particular, the randomness of a wave field yields an increase in the average water level on the shore and decrease in standard deviation. The asymmetry calculated through the third moment is positive and increases with the amplitude growth. The kurtosis calculated through the fourth moment turns out to be positive at small amplitudes and negative at large ones. All this points to the advantage of the wave run-up on the shore as compared to a backwash at least for small-amplitude waves, even if an incident wave is a Gaussian stationary process with a zero mean. The probability of wave breaking during run-up and the applicability limits for the derived equations are discussed (I.I.Didenkulova, A.V.Sergeeva, E.N.Pelinovsky, S.N.Gurbatov).

Inverse problems of current-driven transport in coastal management and maritime spatial planning.

The BalticWay team (M.Berezovski, N.Delpeche, E.Quak, T.Soomere, M.Viidebaum, B.Viikmäe) performed extensive statistical analysis of trajectories of current-driven surface transport in the Gulf of Finland, the Baltic Sea, for the period of 1987-1991, with the goal to construct a map of probabilities for adverse impacts released in different sea areas to hit the coast and to establish the offshore areas that are statistically safe to travel in. The properties of the net transport of surface water and time scales for reaching the nearshore of pollution released in different areas of the Gulf of Finland, the Baltic Sea, are analysed based on Lagrangian trajectories of water particles reconstructed using the TRACMASS model from three-dimensional velocity fields calculated by the Rossby Centre (Swedish Hydrological and Meteorological Institute) circulation model for 1987–1991.

The number of particles reaching the nearshore exhibits substantial temporal variability whereas the rate of leaving the gulf is almost steady. It is shown that using an about 3 grid cells wide nearshore area as a substitute to the coastal zone and about 10–15 day long trajectories for calculations of the probability of reaching the nearshore will lead to credible results of the analysis. An appropriate time window for estimates of the properties of net transport patterns is 4–10 days. A sensitivity study demonstrated that the majority of simulated particles reach the coast between 8 to 10 days and the model results are in relatively good agreement with some older results.

Several conference presentations (and subsequent printed proceedings) addressed the question: how can we make practical use of the statistics about the simulated trajectories and how is the choice of simulation parameters in different models affecting the results.

The concept of the equiprobability line (from which the chances of the propagation of adverse impacts to either of the coasts are equal) has been introduced. The calculations of its location are based on the above technology of particle tracking. There is a clearly defined curve (equiprobability line) in the western part of the gulf whereas the current-driven propagation of tracers from a wide area (of reduced risk) to the coast in the central and eastern parts of the gulf is unlikely within about three weeks. The location for this line was calculated for the Gulf of Finland with two different methods. A small difference of the locations of the lines indicates a reasonable level of uncertainty connected with this type of solution.

A high-resolution bathymetry, with spatial resolution down to 0.25 nautical miles, has been constructed and implemented for circulation modelling in the Gulf of Finland. The models with a resolution of 1 mile or finer are capable of resolving typical mesoscale eddies in this basin where the internal Rossby radius is usually 2-4 km. An increase in the model resolution from 1 to 0.5 mile leads to a clear improvement of the representation of the key hydrophysical fields. A further increase in the resolution to 0.25 mile has a lesser impact but may lead to some changes in the instantaneous patterns of currents. The parameterization of the spreading effect of subgrid-scale turbulence on the trajectories of initially closely located drifters is realized by means of accounting for the largely rotational character of the dynamics in this basin. The modelled average spreading rate for initially closely located particles for 1991 was 2 mm/s (T.Soomere, B.Viikmäe, N.Delpeche, M.Viidebaum, M.Berezovski, R.Värv, in cooperation with O.Andrejev and K.Myrberg, Finland, and A.Sokolov, Sweden).

The performed calculations indicate that there exist areas of considerably reduced risk (propagation of pollution from which to the coast is small) in the Gulf of Finland. Such areas are good candidates for the location of the optimal navigation fairway. Their location was obtained with four different methods based on (a) the largest times for coastal hits, (b) the smallest probabilities for coastal hits, (c) the equiprobability line concept and (d) areas of low probability and no probability gradient for coastal hits. A pilot study demonstrates that the configuration of these areas substantially varies depending on the particular ecological application.

Theory of rogue waves and wave propagation in different environments.
The known features of rogue waves are discussed in the context of a possible unifying concept for their analysis and prediction. Most of the processes resulting in the formation of freak waves in deep water (such as dispersive and geometrical focusing, interactions with currents and internal waves, reflection from caustic areas, etc.) are active also in shallow areas. Only the mechanism of modulational instability is void in finite depth conditions. Instead, wave amplification along certain coastal profiles and the drastic dependence of the run-up height on the incident wave shape may substantially contribute to the formation of rogue waves in the nearshore. A unique source of long-living rogue waves (that has no analogues in the deep ocean) is the nonlinear interaction of solitary shallow water waves and an equivalent mechanism of Mach reflection. Its characteristic features are (i) extreme amplification of the steepness of the wave fronts, (ii) change in the orientation of the largest wave crests and (iii) rapid lateral displacement of the extreme wave humps. Also, the possibility of conversion of rogue waves into sneaker waves with extremely high run-up and the potential drastic the reaction of bottom sediments and the entire coastal zone to the rogue waves is discussed (T.Soomere, in cooperation with the authors of papers in the special issue of European Physical Journal Special Topics).

A statistical analysis of *freak waves of different types in the coastal zone of the Baltic Sea* measured during 203 hours of high-resolution recording of sea surface elevation at a location in the coastal zone of the Baltic Sea (2.7 m depth) during June-July 2008 is presented. The dataset contains 97 freak waves occurring in both calm and stormy weather conditions. All of the freak waves are solitary waves, 63% of them having positive shape, 17.5% negative shape and 19.5% sign-variable shape. It is suggested that the freak waves can be divided into two groups. Those of the first group, which includes 92% of the freak waves, have an amplification factor (ratio of freak wave height to significant wave height) which does not vary from significant wave height and has values largely within the range of 2.0 to 2.4; while for the second group, which contain the most extreme freak waves, amplification factors depend strongly on significant wave height and can reach 3.1. Analysis based on the Generalised Pareto distribution is used to describe the waves of the first group and lends weight to the identification of the two groups. It is suggested that the probable mechanism of the generation of freak waves in the second group is dispersive focusing. The time-frequency spectra of the freak waves are studied and dispersive tracks, which can be interpreted as dispersive focussing, are demonstrated (I.Didenkulova, in cooperation with C.Anderson, Sheffield).

Internal waves and wave propagation in laminates with substructures: In coastal seas and straits large amplitude, horizontally propagating internal solitary waves are often observed. Typically these waves occur in regions of variable bottom topography, with the consequence that they are often modeled by nonlinear evolution equations of the Korteweg-de Vries type with variable coefficients. The review describes these models that are used to describe the propagation, deformation and disintegration of internal solitary waves as they propagate over the

continental shelf and slope are reviewed from the viewpoint of the contribution of various non-linear effects to the wave fields (O.Kurkina, in cooperation with R.Grimshaw (Loughborough), E.Pelinovsky and T.Talipova (Nizhny Novgorod).
Results of a detailed oceanographic survey in the Saint John River Estuary, New Brunswick, Canada demonstrate that interfacial mixing occurs in this highly stratified basin at discrete locations at a particular phase of the tide leading to a plunging pycnocline at most of these locations. This process is possibly initiated by different kind of internal waves or/and the changing velocity direction on interaction with the irregular bathymetry. Analysis of the flow structure in terms of the critical Richardson number, based on previous studies in the Baltic Sea, shows that these mechanisms and similar phenomena evidently occur at strong density interfaces in the Baltic Sea area where internal waves are less regular but still essentially contribute to diapycnal and interfacial mixing (N.C.Delpeche, T.Soomere, in cooperation with M.-J.Lilover, Marine Systems Institute).
The influence of the presence of a complex internal structure of laminates, consisting of layers of different properties and variable thickness, on the dynamic response of the material and accompanying distortion of the signal propagation are studied numerically using several examples for periodic and double periodic laminates. It is discovered that the influence of the mutual position of layers with different internal structure can be significant (M.Berezovski, in cooperation with A.Berezovski).

Coastal processes.
The structure and morphology of the coastal profile in the eastern Gulf of Finland are analysed based on surveys by the Karpinskii All-Russia Research Institute of Geology (VSEGEI). The morphogenesis of the submarine sand terrace, found at depths of 4–5 m to 8–12 m, and the potential ways of the development of the entire system of terraces over the Late Holocene is reconstructed using a mathematical model. The key assumption is that, at the earlier stage of the evolution of the system, the tectonic processes, particularly glacio-isostasy, played the main role while later on the sea-level changes were of greater importance. The earlier terraces are now located on dry land, while the later terraces are observed on the submarine slope. The most recent submarine terrace has been developed 3.2-1.2 kyr ago as a result of both coastal recession and sediment accumulation on its outer edge. During this time, the coast has retreated by about 500 m, with a maximum rate up to 0.5 m year^{-1}. The average accumulation rate has been as high as 0.7 m^3 m^{-1} year^{-1} (D.Kurennoy, in cooperation with I.O.Leontyev, D.V.Ryabchuk, V.Zhamoida, M.A.Spiridonov, VSEGEI).

The basic rules governing the occurrence, structure and genesis of sand deposits in the coastal area of the north-eastern Baltic Sea are analysed based on the existing data about industrial sand deposits in Estonian coastal waters. Such deposits extend down to a depth of about 25 m and contain over 90 million m^3 of material. They are predominantly formed as a result of the abrading of glacial or glacio-fluvial material. The deposits normally lie at the foot of bedrock escarpments or on the slopes of positive landforms consisting of glacial deposits in shallow sea areas in regions where equilibrium conditions for the settling of sand particles exist. Sand is poorly sorted in eastern study areas (e.g, slopes of Naissaar) that reflect rapid sedimentation and short distances between the sand sources and accumulation area. Deposits located near the islands and those located at shoals develop largely step-like terraces and are governed by infrequent strong storms. (A.Kask, T.Soomere, in cooperation with S.Suuroja, Estonian Geological Survey, and J.Kask, Marine Systems Institute).

During the last 30–40 years, substantial coastal retreat has occurred in the entire Valgerand sandy beach area in Pärnu Bay, the Baltic Sea. Simulations of the beach planform and analysis of the morphology indicates that a cafeteria, constructed at the waterline area decades ago, affects the sediment transport only locally and the erosion is mainly due to storms (K.Kartau, T.Soomere). The classical method of transect lines and the method of laser data from LiDAR (Light Detection and Ranging) were applied to establish changes to sediments in Zvejniekciems beach (Latvia), incl. sediment movement, changes to the coastal slope and also in order to predict future processes (M.Viška).

Forcing of marine hydrodynamic processes.
The spatial structure of wind patterns over the Gulf of Finland are analysed based on data from two lighthouses (Tallinnamadal near the southern coast of the gulf and Kalbådagrund near the northern coast) that are compared with the HIRLAM (High Resolution Limited Area Model) 6.4.0 outputs for the period of April 2007 - March 2008. It is shown that both the average air flow and the average wind direction turn considerably clockwise when the air masses cross the gulf obliquely. Consequently, the influence of the Estonian mainland on the wind properties over the Gulf of Finland extends at least to a distance of 20 km to the Tallinnamadal area but hardly reaches to a distance of 60 km where Kalbådagrund is located. The HIRLAM model captures well the wind direction at Tallinnamadal whereas at Kalbådagrund the modelled wind direction is turned by $> 20^o$ counter-clockwise from the measured direction. The HIRLAM output matches well wind speed at Kalbådagrund, but underestimates it at Tallinnamadal by more than 1 m/s (T.Soomere, in cooperation with S.Keevallik, Marine Systems Institute).

Highlights.

- The main properties of wave climate and its spatial variability in the Baltic Sea are estimated using the wave model WAM driven by adjusted geostrophic winds for 1970–2007 under ice-free conditions.
- It is shown that linear trends in both average and extreme wave heights in the Baltic Sea reveal extensive spatial variations but almost no changes exist in the basinwide wave activity and wave periods.
- The location of the equiprobability line (from which the chances of the propagation of adverse impacts to either of the coasts are equal) has been calculated for the Gulf of Finland.
- It is demonstrated that the nonlinear interaction of solitary shallow water waves is a unique source of long-living rogue waves that has no analogues in the deep ocean and that may cause a change in the orientation of the largest waves and their rapid lateral displacement.
- The detailed structure of the underwater coastal profile in the eastern Gulf of Finland has been established and its evolution over the Late Holocene has been mathematically replicated.
- The basic rules governing the occurrence, genesis and formation conditions of industrial sand deposits in different coastal areas of the NE Baltic Sea have been established.
- Shown is that the influence of the Estonian mainland on the wind properties over the Gulf of Finland extends at least to a distance of 20 km but hardly reaches to a distance of 60 km.

3.1.6 Laboratory of Systems Biology

ADP compartmentation analysis reveals coupling between pyruvate kinase and ATPases in heart muscle.

Cardiomyocytes have intracellular diffusion restrictions, which spatially compartmentalize ADP and ATP. However, the models predicting diffusion restrictions have used data sets generated on rat heart permeabilized fibers, where diffusion distances may be heterogeneous. This is avoided when using isolated, permeabilized cardiomyocytes. The aim of this work was to analyze the intracellular diffusion of ATP and ADP in rat permeabilized cardiomyocytes. For that, we measured respiration rate, ATPase rate and ADP concentration in surrounding solution. The data was analyzed by mathematical models reflecting different levels of cell compartmentation. In agreement with previous studies, we found significant diffusion restriction by the mitochondrial outer membrane and confirmed a functional coupling between mitochondria and a fraction of ATPases in the cell. In addition, our experimental data shows that a considerable activity of endogenous pyruvate kinase (PK) remains in the cardiomyocytes after permeabilization. A fraction of ATPases was inactive without ATP-feedback by this endogenous PK. When analyzing the data, we were able to reproduce the measurements only with the mathematical models that include a tight coupling between fraction of endogenous PK and ATPases. To our knowledge, this is the first time such a strong coupling of PK to ATPases has been demonstrated in permeabilized cardiomyocytes (M.Vendelin, et al.).

Modulation of energy transfer pathways between mitochondria and myofibrils by changes in performance of perfused heart.

In the heart, the energy supplied by mitochondria to myofibrils is continuously and finely tuned to the contraction requirement over a wide range of cardiac loads. This process is mediated both by the creatine kinase (CK) shuttle and by direct ATP transfer. The aim of this study was to identify the contribution of energy transfer pathways at different cardiac performance levels. For this, five protocols of (31)P-NMR inversion and saturation transfer experiments were performed at different performance levels on Langendorff perfused rat hearts. The cardiac performance was changed either through variation of external calcium in the presence or absence of isoprenaline or through variation of LV balloon inflation. The recordings were analyzed by mathematical models composed on the basis of different energy transfer pathway configurations. According to our results, the total CK unidirectional flux was relatively stable when the cardiac performance was changed by increasing the calcium concentration or variation of LV balloon volume. The stability of total CK unidirectional flux is lost at extreme energy demand levels leading to a rise in inorganic phosphate, a drop of ATP and phosphocreatine, a drop of total CK unidirectional flux, and to a bypass of CK shuttle by direct ATP transfer. Our results provide experimental evidence for the existence of two pathways of energy transfer, direct ATP transfer and PCr transfer through the CK shuttle, whose contribution may vary depending on the metabolic status of the heart (M.Vendelin, et al.).

3.1.7 Laboratory of Photoelasticity

Optical nonlinearity and photoelasticity.

The aim of the investigations has been development of the theory and algorithms of photoelasticity for the determination of complicated three-dimensional stress fields.

Possibilities for the measurement of residual stresses in glass bottles of non-axisymmetric shape have been investigated. In case of bottles of elliptical cross-section one possibility is to use algorithms of integrated photoelasticity, elaborated for the axisymmetric stress field. As radius of the bottle the local radius of curvature of the elliptical cross-section is used. The second possibility is to use the scattered light method. The third possibility is to determine the surface stress with the local approximation method. All three methods have been used to measure residual stress in several bottles of elliptical and quadratic cross-section. By measurements the transmission polariscope AP-07 and the scattered light polariscope SCALP have been used. As a rule all the three methods gave close to each other values of stresses near the bottle surface.

Several experiments have been carried out by measuring residual stress in the conical part of the stem of wine glasses using the non-linear algorithm of photoelastic tomography. The algorithm is based on the method of differential evolution. Dependence of the convergence of the iterative algorithm on the value of the initial solution has been investigated. To prove theoretically the uniqueness of the solution is difficult. However, using the macrostatic equilibrium condition and boundary conditions the non-linear algorithm gives practically satisfactory results.

Correlation of the value of the residual stress and the bending strength of glass panels was investigated. Stresses in the panels were measured with the scattered light polariscope SCALP. After that the bending strength of the panels was determined by four-point bending at a glass factory. Linear correlation between the residual stress and the bending strength was established. This work was carried out in cooperation of the Institute of Physics at Tartu University (H.Aben).

3.2. Institute of Cybernetics: Control Systems Department

Transfer equivalence and realization of nonlinear input-output delta-differential equations on homogeneous time scales.
Nonlinear control systems on homogeneous time scales are studied. First the concepts of reduction and irreducibility are extended to higher order delta-differential input-output equations. Subsequently, a definition of system equivalence is introduced which generalizes the notion of transfer equivalence in the linear case. Finally, the necessary and sufficient conditions are given for the existence of a state-space realization of a nonlinear input-output delta-differential equation (Ü.Kotta, M.Tõnso).

Mathematica application for nonlinear control systems on time scales.
The Mathematica applications are developed for nonlinear control systems defined on homogeneous time scales. The package deals with symbolic computations. The functions for solving reduction and realization problems as well as operators implementing the time scale calculus are described. The novelty of the programs consists in the fact that time-scale formalism allows to treat jointly the continuous- and discrete-time systems (Ü.Kotta, M.Tõnso).

Reduction and transfer equivalence of nonlinear control systems: unification and extension via pseudo-linear algebra.
The the pseudo-linear algebra has been applied to unify the results on reducibility, reduction and transfer equivalence for continuous- and discrete-time nonlinear control systems. The necessary and sufficient condition for reducibility of nonlinear input-output equation is presented in terms of the greatest common left factor of two polynomials describing the behaviour of the 'tangent linearized system' equation. The procedure is given to find the reduced (irreducible) system equation that is transfer equivalent to the original system equation. Besides unification, the tools of pseudo-linear algebra allow to extend the results also for systems defined in terms of difference, q-shift and q-difference operators (Ü.Kotta, P.Kotta).

Theorem on the differentiation of a composite function with a vector argument.
A theorem is provided about the differentiation of a composite function with a vector argument. The theorem shows how the partial derivative of the total derivative of the composite function can be expressed through the total derivative of the partial derivative of the composite function.

The proof of the theorem is based on Mishkov's formula, which is the generalization of the well-known Faà di Bruno's formula for a composite function with a vector argument (V.Kaparin, Ü.Kotta).

Transformation of the transfer matrix of the nonlinear system into the Jacobson form.
A detailed algorithm has been worked out for computation of the Jacobson form of the polynomial matrix, associated with the transfer matrix describing the multi-input multi-output discrete-time nonlinear control system using the theory of skew polynomials. The algorithm has been implemented in Mathematica package NLControl, developed over years in the Control Systems Department (J.Belikov, Ü.Kotta).

Reduction of MIMO nonlinear systems on homogeneous time scales.
A necessary and suffcient condition for reducibility of multi-input multi-output nonlinear delta differential system is given in terms of the greatest common left divisor of two delta differential polynomial matrices, associated with the set of the input-output (i/o) equations of the system, defined on a homogenous time scale. This condition provides a basis for system reduction, i.e. for finding the transfer equivalent minimal irreducible representation of the set of the i/o equations (Ü.Kotta).

Towards application of coordinate invariant approach in detection of the surgeon hand gestures during laparoscope surgery.
Surgeon's hand gestures recognition (during laparoscope surgery) on the basis of velocities and accelerations of certain characteristic points of the hand has been studied. Applicability of neural networks based, statistics based and Kohonen-map based techniques were evaluated for this purpose (S.Nõmm, J.Vain).

Application of Volume Bounding Box Decomposition for Surgeon's Hand Gestures Recognition.
Possibility to apply volume bounding box decomposition to surgeon's hand movements analysis and gesture recognition during laparoscope surgery has been explored. Volume bounding box decomposition allows to approximate non-convex sets by a number of bounding boxes which leads fast and easy way to verify whether a given point belongs to certain set or not. This unique feature is applied to analyze trajectories of surgeon's wrist and to recognize different hand gestures (S.Nõmm, J.Vain).

Application of bidding automata for measuring the informativeness of hand motion characteristic features.
It has been evaluated how informative are the features (coordinates, velocities and accelerations) captured by 3D motion tracking system for segmentation of human hand movements. Six gestures and their transitions have been studied. To measure the informativeness of the features the bidding automaton was constructed that compares the human-defined segmentation points (teacher reference data set) to the changes of the real feature values in neighborhood of those gesture transition/switching points. Based on the comparison certain weights, describing correlation between changes of certain feature and teacher defined switching, were assigned to each feature at each switching point (S.Nõmm, J.Vain).

Synthesis of on-line planning tester for non-deterministic EFSM models.
We describe a method and algorithm for model-based construction of an on-line reactive planning tester (RPT) for blackbox testing of state based systems specified by non-deterministic extended finite state machine (EFSM) models. The key idea of RPT lies in off-line preprocessing of the System Under Test (SUT) model to prepare the data for efficient on-line reactive test

planning. A test purpose is attributed to the transitions of the SUT model by a set of Boolean conditions called traps. The result of the off-line analysis is a set of constraints used in on-line testing for guiding the SUT towards taking the moves represented by trap-labelled transitions in SUT model and generating required data for inputs. We demonstrate the results on a simple example and discuss the practical experiences of using the proposed method (J.Vain, K.Raiend).

Timed automata based provably correct robot control.
A feasibility study on the usage of Uppaal Timed Automata (UPTA) for deliberative level robotic control has been presented. The study is based on the Scrub Nurse Robot case-study. Our experience confirms that UPTA model based control enables the control loop to be defined and maintained during the robot operation autonomously with minimum human intervention. Specifically, in our robot architecture the control model is constructed automatically using unsupervised learning. Correctness of the model is verified on-the-fly against safety, reachability, and performance requirements. Finally, it is demonstrated that UPTA model based robot control, action planning and model updates have natural implementation based on existing model execution and conformance testing tool Uppaal Tron (J.Vain).

Stable polytopes of reflection vector sets.
The geometry of stable discrete polynomials using their coefficients and reflection coefficients is investigated. The aim was to find less conservative inner approximations of the stability domain by polytopes starting from different sets of reflection vectors generated by simple stable polynomials. The volumes of these stable polytopes are calculated in order to compare the approximation quality (Ü.Nurges, S.Avanessov).

Maximizing volume of stable polytope of reflection vector sets.
It is a well known fact that the stability domain in the space of polynomial coefficients is not convex in general. Since most of the modern robust control design problems for discrete-time systems are formulated as optimization problems, the non-convexity of the stability domain poses the main problem for the effective development and analysis nowadays. An essential objective of developing a convex approximation of a stability domain is to attempt to achieve the largest volume of the approximation. The purpose is to consider the geometry of a polytopic stability approximation method using reflection coefficients, analyze its volume maximization options. In order to maximize the volume of a reflection vectors (RV) polytope, the results of merging of two different RV polytopes are analyzed. To compare the efficiency of the proposed method with already known stability area maximization methods, the volume of stable polytopes of different reflection vectors sets were calculated by the triangulation method. We demonstrated that the maximal volumes of two RV sets are considerably greater than the volumes of RV polytopes for a single generating polynomial (S.Avanessov, Ü.Nurges).

3.3 Research Laboratory of Proactive Technologies, Tallinn University of Technology

Executive summary provides a synopsis of PROLAB report 2010, which will be published separately and can be found at www.proactivity-lab.ee.

This year's report focuses on attempts to extract common essential knowledge and insufficiently studied theoretical problems from several pragmatic application research projects - for instance, SIMPLE project of ARTEMIS Joint Undertaking, ATHENA project of European Defence Agency, and research area 3 in IMECC which is Enterprise Estonia supported competence centre - where the Lab is being involved for some years.

The extracted information and experience is used to adjust the methods and goals applied for long term, on-going, in-Lab research projects - for instance, developing situation-awareness for individual agent and team situation-awareness for a collaborating group of agents; enhancing the concepts and properties of unified interface for mixed human-machine, machine-machine, and human-human collaborating groups; and a new project for formal analysis of the behaviour of self-X systems.

As usually, part 2 of the report provides common statistical data that characterises the quantitative aspects of our activities (L.Mõtus, et al.).

3.4 Research within international programmes

3.4.1 FP7, FET (Future and Emerging Technologies), CA (Coordination Action) GSD "Global System Dynamics and Policies: simulation and visualisation technologies" (01.05.2008 – 30.04.2010), led by University College London (United Kingdom); partners: Utrecht University (Netherlands), Max Planck Institute of Meteorology (Germany), European Climate Forum e.V. (Germany), Chalmers Tekniska Hoegskola AB (Sweden), Unit for Research into Changing Institutions (United Kingdom), IMCS Intercollege Ltd. (Cyprus), Universidad de Alcala (Spain), Ecole des Hautes Etudes en Sciences Sociales (France), Potsdam Institute for Climate Impact Research (Germany). Responsible scientist T.Soomere.

3.4.2 FP7 Marie Curie Re-integration grant ESTSpline (FP7-PEOPLE-2007-2-2-ERG) "Educational, Scientific and Technological aspects of Splines"(01.05.2008 – 30.04.2011), Principal Scientist E.Quak.

3.4.3 EEA grant EMP41 "Shoaling and runup of long waves generated by high-speed ferries", 2008–2010) Collaboration between Irina Didenkulova and (i) University of Bergen, Norway: Tomas Torsvik, (ii) Dept. of Mathematics, University of Oslo, Norway: Prof. Geir Pedersen, and (iii) Inst. of Applied Physics, Nizhny Novgorod, Russia: Prof. E.N.Pelinovsky. Responsible scientist I.Didenkulova.

3.4.4 FP7 ICT Coordination Action FOCUSK3D (ICT 214993) "Foster the comprehension and use of knowledge intensive 3D media"www.focusk3d.eu (01.03.2008 – 28.2.2010), led by National Research Council Institute for Applied Mathematics and Information Technology - Genova (Italy), partners: Laboratory for Information Systems and Services, Center for Research and Technology – Thessaly (Greece); Vrlab – Ecole Polytechnique Fédérale de Lausanne (Switzerland); Fraunhofer Institute for Computer Graphics Research (Germany); INRIA – Institut National de Recherche en Informatique et Automatique (France); MIRALab – Université de Genève (Switzerland); Stiftelsen SINTEF (Norway); Utrecht University (The Netherlands); Task Leader Project Evaluation and Assessment: E.Quak.

3.4.5 FP7 Marie Curie Initial Training Network (FP7-PEOPLE-1-1-ITN) Shapes, Geometry, Algebra www.saga-network.eu (01.11.2008 – 31.10.2013), led by Stiftelsen SINTEF (Norway); partners: University of Oslo (Norway); Johannes Kepler Universität Linz (Austria); Universidad de Cantabria (Spain); Vilnius University (Lithuania); National and Kapodistrian University Athens (Greece); INRIA – Institut National de Recherche en Informatique et Automatique (France); Fondazione GraphiTech (Italy); Missler Software (France); Kongsberg SIM (Norway); Participating Scientist: E.Quak.

3.4.6 BONUS+ (Baltic Organisations' Network for Funding Science) project BalticWay "The potential of currents for environmental management of the Baltic Sea maritime industry"(2009 – 2011). Collaboration with the Swedish Meteorological and Hydrological Institute (Norrköping), Laser Diagnostic Instruments (Tallinn), Danish Meteorological Institute, Department of Meteorology, University of Stockholm, Institute for Coastal Research, GKSS Geesthacht, Finnish Institute of Marine Research, and Leibniz Institute of Marine Sciences at the University of Kiel. Project coordinator T.Soomere.

The project aims at developing the innovative concept of fairway design to reduce the danger to vulnerable areas through a substantial decrease of marine-industry-induced environmental risks and impacts on bio-diversity, particularly on fragile ecosystems. The core objective is to develop a scientific platform for a low-cost technology of environmental management of shipping, offshore, and coastal engineering activities. The technology will be applied to place dangerous activities in areas, where an accident will have a minimum impact to vulnerable areas. The approach makes use of the existence of semi-persistent current patterns that considerably affect the properties of pollution propagation: the probability of transport of dangerous substances from different open sea areas to the vulnerable areas is largely different. For certain regions (called areas of reduced risk) this probability is relatively small. The location of areas of reduced risk will be established numerically and verified experimentally. A combination of the classical risk analysis with novel mathematical methods (such as inverse methods) will be applied to identify the persistence, properties, and potential effect of such areas, and to establish generic criteria for their existence. Based on existing results, the investigations concentrate on the Gulf of Finland and the Darss Sill.

3.4.7 FP7 Project ESTwave "Educational, Scientific and Technological Aspects of Mesoscopic Continuum Physics for Waves in Complex Materials", PERG04-GA-2008-238191, 1.4.2008–31.3.2012, H.Herrmann.

3.4.8 NordForsk (Coordinating and Funding Nordic Research Advisory Body on Nordic Research Policy) project "Nordic Network on Dependability - NODES"2006 – 2011 (Member of board: J.Vain).

3.4.9 COST action IC0603 - "Antenna Systems & Sensors for Information Society Technologies "(ASSIST). Member of the management committee is J.-S.Preden (ProLab), (2007–2011).

3.4.10 COST Action IC0801 – "Agreement Technologies", (2009–2012), http://www.agreement-technologies.eu/.

3.4.11 Innovative Manufacturing Engineering Systems Competence Center (IMECC)
Duration: June 2009 – June 2013 Partners: Alise Technic OÜ, AQ Lasertool OÜ, Bestnet AS, Datel AS, Fujitsu Services AS, Favor AS, Hanval Metall OÜ, Ferreks TT AS, Paide Masinatehas AS, Sumar Instrument OÜ, AMS Elektronic OÜ, Robomente OY, ELI OÜ, Norcar BSB Eesti AS, Pro-Step OÜ, Tallinn University of Technology (Dept. of Computer Control (Lab for Proactive Technologies), Dept. of Mechatronics, Dept. of Materials Engineering, Dept. of Machinery).

3.4.12 Joint research project "Scurb Nurse Robot"between TUT and Tokyo Denki University. Duration: 2007–2010 (Estonian project coordinator: J.Vain)

3.4.13 Estonian-Polish joint research project under the agreement on scientific cooperation between the Polish Academy of Sciences and the Estonian Academy of Sciences "Nonlinear control systems on time scales" 2010–2012 (Estonian project coordinator: Ü.Kotta).

4. Funding

4.1 Target funding through the Ministry of Education and Research

1. Block grant SF0322521s03 “Nonlinear dynamics and complex systems”, PI: J.Engelbrecht.
2. Block grant SF0140018s08 “Synthesis of complex nonlinear control systems” PI: Ü.Kotta.
3. Block grant SF0140113s08 “Proactivity in the artificial world”, PI: L.Mõtus.

4.2 Estonian grants (Estonian Science Foundation)

1. H.Aben, ETF grant 7840, “Complex algorithms for tomography of photoelasticity”, (2009–2011).
2. A.Berezovski, ETF grant 7037, “Multiscale dynamics in microstructured solids”, (2007–2010).
3. T.Soomere, ETF grant 7000, “Real time optical measurements and modelling of wave-induced resuspension of bottom sediments”, (2007–2010) (together with Ants Erm, Marine Systems Institute).
4. T.Soomere, ETF grant 7413, “Spatial and temporal variability of the Baltic Sea wave fields in changing climatic conditions”, (2008–2011).
5. A.Salupere, ETF grant 7035, “Deformation waves in microstructured solids — multiscale models”, (2007–2010).
6. J.Kalda, ETF grant 7909, “The role of turbulent mixing in the dynamics of the complex systems”, (2009–2012).
7. Ü.Kotta, ETF grant 6922, “Control systems on time scales”, (2007–2010).
8. J.Vain, ETF grant 7667, “Synthesis of model-based reactive planners for nondeterministic and distributed systems”, (2008–2011).
9. M.Vendelin, ETF grant 7344, “Mechanoenergetics of an isolated single cardiomyocyte”, (2008–2011).
10. I.Didenkulova, EEA grant EMP41, “Shoaling and runup of long waves generated by high-speed ferries”, (2008–2010).
11. R.Savimaa, ETF grant 7693, “Modelling of time-sensitive processes and emergent behaviour in multi-functional and virtual organisations”, (2008–2011).
12. J.Janno, ETF grant 7728, “Inverse problems for materials with complex properties”, (2009–2012).
13. R.Birkedal, ETF grant 8041, “Role of the Na+/Ca2+-exchanger in excitation-contraction coupling and energetics in rainbow trout cardiomyocytes”(2009–2012).
14. S.Nõmm, ETF grant 8365, “Modeling and recognition of human gestures”(2010–2013).

4.3 International grants (see also 3.4)

1. Wellcome Trust International Senior Research Fellowship (2007–2012) – M.Vendelin.
2. FP7, Future and Emerging Technologies), CA (Coordination Action) "Global System Dynamics and Policies: Simulation and Visualisation Technologies"(GSD) – T.Soomere.
3. EEA grant EMP41 "Shoaling and runup of long waves generated by high-speed ferries"– I.Didenkulova.
4. FP7 Marie Curie Re-integration grant "Educational, Scientific and Technological Aspects of Splines"(ESTSpline) – E.Quak.
5. FP7 ICT Coordination Action "Foster the comprehension and use of knowledge intensive 3D media"(FOCUSK3D) – E.Quak.
6. FP7 Marie Curie Initial Training Network "Shapes, Geometry, Algebra"(SAGA) – E.Quak. Norwegian Centre of Excellence "Mathematics for Applications"(CMA) – E.Quak.
7. BONUS+ project "The potential of currents for environmental management of the Baltic Sea maritime industry"(BalticWay) – T.Soomere.
8. Feodor Lynen fellowship of the German Alexander von Humboldt foundation (initially awarded 2008–2011) – H.Herrmann.

4.4 Additional funding

1. Institute of Cybernetics at TUT – basic funding.
2. TUT funding for CENS as a TUT Centre of Excellence in Research.

4.5 Supportive grants (travel, etc.)

1. V.Kaparin, J.Belikov. European Embedded Control Institute grants for attending HYCON-EECI Graduate School on Control 21.03.2010–27.03.2010.
2. Ü.Nurges, EITSA travel grant for attending 18th Mediterranean Conference on Control and Automation.
3. S.Nõmm. EITSA travel grant for attending ECON-2010 36th Annual Conference of the IEEE Industrial Electronics Society.
4. M.Tõnso. EITSA travel grant for attending the 2010 International Congress on Comuter Applications and Computational Science.
5. J.Belikov. EITSA travel grant for attending the 2010 IRAST International Congress on Computer Applications and Computational Science.
6. J.Belikov. SA Archimedes Doctoral Studies and Internationalisation Programme DoRa travel grant for attending UKACC International Conference on CONTROL 2010.
7. V.Kaparin. SA Archimedes Doctoral Studies and Internationalisation Programme DoRa travel grant for attending UKACC International Conference on CONTROL 2010.
8. N.Sokolova. Activity 6 of the ESF DoRa grant funding a research scholar position at University of Rochester, Medical center, Rochester, USA, 30.01.10–30.06.10.

9. M.Sepp, M.Laasmaa, A.Illaste. Activity 8 of the ESF DoRa travel grant for attending The Biophysical Society's 54rd Annual Meeting in San Francisco, California, 20–24.02.10.
10. D.Kartofelev, K.Jaak's Mobility Scholarship (Archimedes Foundation), issued October 2010.
11. M.Berezovski received the Kristjan Jaagu Travel Award for a research visit to the Department of Structural Mechanics in the Faculty of Civil Engineering at University of Pavia, March 30 – 21 April 2010, Italy.
12. M.Berezovski received the European Social Fund's Doctoral Studies and Internationalisation Programme DoRa grant to attend the SIAM Conference on Mathematical Aspects of Materials Science (MS10), May 23–26, 2010, Philadelphia, USA.
13. M.Berezovski received the European Social Fund's Doctoral Studies and Internationalisation Programme DoRa grant to attend 20th International Workshop on Computational Mechanics of Materials (IWCMM 2010) September 7–10, 2010, Loughborough, UK.
14. M.Berezovski received the Kristjan Jaagu Travel Award to attend STAMM 2010 International Symposium on Trends in Applications of Mathematics to Mechanics August 30 – September 2, 2010, Berlin, Germany.
15. H.Herrmann, EITSA grant, 3D visualization system and parallel computer.
16. I.Astrov, 70% of participation costs in WASET International Conference on Machine Intelligence and Systems Engineering (ICMISE 2010, Singapore, December, 18-20, 2010) was reimbursed by the Estonian Information Technology Foundation (EITSA).
17. T.Lints. The costs of participating in 4th IEEE International Systems Conference, April 5–8, San Diego, California, USA, covered by Estonian Doctoral School in ICT.
18. T.Lints. The costs of participating in New Kind of Science Summer School, June 21 – July 9, Burlington, Vermont, USA, covered by Estonian Doctoral School in ICT.
19. T.Lints. The costs of participating in Artificial Life XII: 12th International Conference on the Synthesis and Simulation of Living Systems, August 19–23, Odense, Denmark, covered by European Social Fund's Doctoral Studies and Internationalisation Programme DoRa via Archimedes Foundation.
20. A.Riid. 70% of the cost of attending the IEEE conference on Intelligent Systems was covered by Estonian IT Foundation.
21. M.Meriste. For attending NATO SCI TG-206, from NATO RTA.
22. M.Meriste. For attending NATO RTB meeting, from NATO RTA.

5. Publicity of Results

5.1.1 Research Reports

1.	Mech 297/09	H.Herrmann, K.H.Hoffmann. Remarks around additional 56 lines of Matlab: short parallel finite element implementation using pMatlab.
2.	Mech 298/09	J.Engelbrecht, A.Berezovski (Ed.). Workshop on Recent Problems in Nonlinear Dynamics
3.	Mech 299/10.	T.Peets. Dispersion in microstructured solids – dispersion relations and wave profiles.
4.	Mech 300/10.	J.Engelbrecht. Studies in mechanics over 20 years (1990–2010).

5.1.2 Lecture Notes

1.	Mech 7/2010	H.Herrmann, Summer-School on Scientific Computing. Focus: Iterative Solver for Large Linear Systems and Parallel Programming.

5.2 Publications

5.2.1 Books, proceedings and theses

1. J.Engelbrecht, A.Berezovski, T.Soomere, (guest eds). Proc. of the Estonian Academy of Sciences. Special issue devoted to the International Conference on Complexity of Nonlinear Waves, 2010, 59, 2, [61] 192 p.

2. J.Engelbrecht, M.Kutser, G.Varlamova (eds.). Science in the Institute of Cybernetics. TUT, Tallinn, 2010.

3. M.Berezovski. Numerical simulation of wave propagation in heterogeneous and microstructured materials. Thesis on natural and exact sciences B93. PhD thesis. IoC at TUT, TUT Press, Tallinn 2010, 137 pp.

4. M.Randrüüt. Wave Propagation in Microstructured Solids: Solitary and Periodic Waves. PhD thesis. IoC at TUT, TUT Press, Tallinn 2010.

5. A.Räämet. Spatio-temporal variability of the Baltic Sea wave fields. PhD thesis. IoC at TUT, TUT Press, Tallinn 2010, 107 pp.

6. M.Tõnso. Computer algebra tools for modelling, analysis and synthesis for nonlinear control systems. PhD thesis, TUT Press, Tallinn 2010.

7. J.Preden. Enhancing situation-awareness cognition and reasoning ad hoc network agents. PhD thesis, TUT Press, Tallinn 2010.

8. T.Mullari. On the second order relativistic deviation equation and its applications. (Thesis defended at the University of Tartu).

5.2.2 Papers (refereed)

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1. J.Engelbrecht, A.Ravasoo, J.Janno. Nonlinear acoustic nondestructive evaluation (NDE): qualitative and quantitative effects. Materials and Manufacturing Processes, 25(4), 212–220.
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3. J.Engelbrecht, A.Berezovski, T.Soomere. Highlights in the research into complexity of nonlinear waves. Proc. Estonian Acad. Sci. 2010, 59/2, 61–65.
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5. H.Herrmann, J.Engelbrecht. The balance of spin from the point of view of mesoscopic continuum physics for liquid crystals. J. Non-Equil. Thermodyn. 2010, 35, 337–346.
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7. M.Berezovski, A.Berezovski, J.Engelbrecht. Numerical simulations of one-dimensional microstructure dynamics. - In: Proc. 2nd Int. Symp. on Computational Mechanics and the 12th Int. Conf. on the Enhancement and Promotion of Computational Methods in Engineering and Science, Hong Kong- Macau, China, 30 November – 3 December 2009. Jane W.Z. Lu, Andrew Y.T. Leung, Vai Pan Iu, Kai Meng Mok, (Eds.) AIP Conf. Proc. 1233. 2010; pp. 1052–1057.
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9. A.Berezovski, J.Engelbrecht, T.Peets. Multiscale modelling of microstructured solids. Mech. Res. Comm. 37, 2010, 531–534
10. M.Berezovski, A.Berezovski, T.Soomere, and B.Viikmäe. On wave propagation in laminates with two substructures. Est. J. Eng., 2010, 16/3, 228–242.
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104. T.Lints. Coordination Issues in Modular Systems. 4th IEEE Intern. Systems Conf., April 5–8, 2010, San Diego, CA, USA, 202–206.

105. T.Lints. Diversity Issues in Adaptive Modular Systems. 4th IEEE Intern. Systems Conf., April 5–8, 2010, San Diego, CA, US, 207–210.

106. J.Ramage, P.Sanz-Aranguez, J.Campbell, T.Cimen, L.Crovella, M.Dinc, I.Kramer, S.Martin, L.Motus, J.Preden, C.Ravat, M.Robinson. Design Considerations and Technologies for Air Defence Systems, NATO RTO Publications, SCI-181, 1–260.

107. K.Vassiljeva, E.Petlenkov, J.Belikov. Neural Network Based Minimal State-Space Representation of Nonlinear MIMO Systems for Feedback Control. - In: Proc. 11th Intern. Conf. Control Automation Robotics & Vision (ICARCV 2010), Singapore, December 7–10, 2010, 2191–2196.

108. I.Artemchuk, E.Petlenkov, F.Miyawaki, A.Gladki. Neural Network based System for Real-time Organ Recognition by Analysis of Sequence of Endoscopic Images received during Surgical Operation. - In: Proc. 12th Biennial Baltic Electronics Conf. (BEC2010), Tallinn, Estonia, October 4–6, 2010, 349–352.

109. K.Vassiljeva, E.Petlenkov, J.Belikov. Automated neural network model selection algorithm for feedback linearization based control. - In: Proc. 12th Biennial Baltic Electronics Conf. (BEC2010), Tallinn, Estonia, October 4–6, 2010, 235–238.

110. K.Vassiljeva, E.Petlenkov, J.Belikov. State-Space Control of Nonlinear Systems Identified by ANARX and Neural Network based SANARX Models. - In: Proc. 2010 Intern. Joint Conf. Neural Networks (IJCNN2010), the 2010 IEEE World Congress on Computational Intelligence (WCCI2010), July 18–23, 2010, Barcelona, Spain, 3816–3823.

111. A.Riid, E.Rüstern. A Method for Heuristic Fuzzy Modelling in Noisy Environment. - In: Proc. IEEE Intern. Conf. Intelligent Systems, London, 468–473.

112. A.Riid, E. Rüstern. Interpretability Improvement of Fuzzy Systems: Reducing the Number of Unique Singletons in Zeroth order Takagi-Sugeno Systems. - In: Proc. IEEE Intern. Conf. Fuzzy Systems, Barcelona, 2013–2018.

113. A.Riid, K.Saastamoinen, and E.Rüstern. Redundancy Detection and Removal Tool for Transparent Mamdani Systems. - In: V.Sgurev, M.Hadjiski and J.Kacprzyk, (Eds.), Intelligent Systems: From Theory to Practice, Springer Verlag, Berlin-Heidelberg, 397–415.

114. R.Reeder, A.Udal, E.Velmre. Advances in Terahertz Technology with Emphasis on Quantum Cascade Lasers. Electronics and Electrical Enging., 104(8), 47–50.

5.2.3 Abstracts

1. M.Berezovski, A.Berezovski, J.Engelbrecht. Numerical simulation of wave propagation in materials with microstructure. SIAM Conference on Mathematical Aspects of Materials Science, Philadelphia, Pennsylvania, May 23-26, 2010, MS10 Abstracts, 57–58.
2. A.Berezovski, M.Berezovski, J.Engelbrecht. Dispersive wave equations for microstructured solids. CPEA'10 – Course and Conference on Continuum Physics and Engineering Applications,Rackeve (Budapest), Hungary, May 29 – June 7 2010, Programme and Abstracts, p. 35.
3. A.Berezovski, M.Berezovski, J.Engelbrecht. Multiscale Microstructure Dynamics. International Symposium on Trends in Applications of Mathematics to Mechanics (STAMM 2010), Berlin (Germany), August 30th – September 2nd, 2010, Book of Abstracts, p. 1.
4. M.Berezovski, A.Berezovski, J.Engelbrecht. Two-scale macroscopic dynamics of materials with microstructure. The 20th International Workshop on Computational Mechanics of Materials (IWCMM 2010). Loughborough University, UK, 8–10 September 2010, Book of Abstracts, 13–14.
5. J.Janno. Identification of nonlinear microstructured materials. 15 Int. Conf. Mathematical Modelling and Analysis, Druskininkai, 26–29 May 2010, p. 37.
6. A.Ravasoo. Nonlinear interaction of waves in exponentially graded materials. Book of Abstracts, 17th International Congress on Sound and Vibration. Cairo, 18-22 July, 2010, p. 3.
7. A.Salupere, M.Vallikivi, M.Rätsep, H.-H.Dai. Emergence of solitary waves and solitons in a compressible hyperelastic rod. In: Proc. of the Third International Conference on Dynamics, Vibration and Control. May 12–14, 2010 Hangzhou, China, Edited by Chinese Society of Theoretical and Applied Mechanics, 2010, p. 409
8. D.Kartofelev, A.Stulov. Influence of the edge of the cast iron frame curvature on the spectrum of the piano string vibration. Vienna Talk 2010 on Music Acoustics "Bridging the Gaps". September 19–21, 2010, Vienna, Austria.
9. T.Soomere, N.Delpeche, B.Viikmäe. Semi-persistent patterns of transport in surface layers of the Gulf of Finland. In: BONUS Joint Baltic Sea Research Programme Annual Conference 2010, Vilnius, Lithuania, 19–21 January 2010. Programme and Abstracts. BONUS EEIG, 2010, 32.
10. I.Didenkulova, E.Pelinovsky, A.Sergeeva. Statistical properties of long waves nearshore. 2010 AGU Ocean Sciences Meeting, Portland, Oregon, USA, February 22–26, 2010, PO15E–26.
11. D.Kurennoy, T.Soomere. Measurements of high speed vessel-induced wakes. 2010 AGU Ocean Sciences Meeting, Portland, Oregon, USA, February 22–26, 2010, PO25C–29.
12. B.Viikmäe, T.Soomere, N.Delpeche. The use of Lagrangian trajectories for minimization of the risk of coastal pollution. Joint Numerical Modelling Group 15th Biennial Conference, Programme and Book of Abstracts, May 10–12, 2010, Delft, The Netherlands, 7.

13. A.Sergeeva, I.Didenkulova, Pelinovsky E. Statistical estimates of characteristics of long wave runup on a beach. Geophysical Research Abstracts, 2010, 12, EGU2010–308.

14. T.Torsvik, R.Paris, I.Didenkulova, E.Pelinovsky, A.Belousov, M.Belousova. Numerical simulation of explosive tsunami wave generation and propagation in Karymskoye lake, Kamchatka, Russia. Geophysical Research Abstracts, 2010, 12, EGU2010-2456.

15. I.Didenkulova, E.Pelinovsky, A.Sergeeva. Runup of tsunami waves on a plane beach: statistical approach. Geophysical Research Abstracts, 2010, 12, EGU2010–4114.

16. T.Soomere, N.Delpeche, B.Viikmäe. The use of current-induced transport for coastal protection in the Gulf of Finland, the Baltic Sea. Geophysical Research Abstracts, 2010, 12, EGU2010–6056.

17. I.Didenkulova, E.Pelinovsky. Traveling water waves along quartic bottom profile. Geophysical Research Abstracts, 2010, 12, EGU2010–6996.

18. I.Didenkulova, E.Pelinovsky. Nonreflecting wave propagation and runup in U-shaped bays. Geophysical Research Abstracts, 2010, 12, EGU2010–8249.

19. I.Didenkulova. Marine natural hazards in coastal zone: observations, analysis and modelling (Plinius Medal Lecture). Geophysical Research Abstracts, 2010, 12, EGU2010–14748.

20. R.Värv. High resolution bathymetry for Gulf of Finland. Proceedings of the 2nd International Conference (school) on Dynamics of Coastal Zone of Non-Tidal seas, Baltiysk, Kaliningrad Oblast, Russia, June 26-30, 2010, 399–400.

21. T.Soomere. Towards a future technology of environmental management. Australian National Network in Marine Sciences, Second Conference, Program and Conference Abstracts, James Cook University, Townsville, Queensland, July 21–22, 2010, p. 7.

22. K.Kartau, T.Soomere. The evolution of semi-sheltered bayhead beaches: a study for Valgerand in Pärnu Bay. The Baltic Sea Geology-10 Abstract volume, the 10th International Marine Geological Conference, VSEGEI, St. Petersburg, Russia, August 24–28, 2010, 45–47.

23. D.Kurennoy, T.Soomere. Experimental study of fast-ferry wakes in the South-West part of the Tallinn Bay. The Baltic Sea Geology-10 Abstract volume, the 10th International Marine Geological Conference,VSEGEI, St. Petersburg, Russia, August 24–28, 2010, 68–71.

24. T.Soomere, K.E.Parnell, I.Didenkulova. The role of vessel wakes in coastal processes of semi-enclosed basins. The Baltic Sea Geology-10 Abstract volume, the 10th International Marine Geological Conference, VSEGEI, St. Petersburg, Russia, August 24–28, 2010, 122–123.

25. O.Tribštok, I.Zaitseva-Pärnaste, T.Soomere. Changes in wave heights at Estonian and Lithuanian coasts based on historical wave observations. The Baltic Sea Geology-10 Abstract volume, the 10th International Marine Geological Conference, VSEGEI, St. Petersburg, Russia, August 24–28, 2010, 135–136.

26. R.Värv. High resolution bathymetry for the Gulf of Finland. The Baltic Sea Geology-10 Abstract volume, the 10th International Marine Geological Conference, VSEGEI, St. Petersburg, Russia, August 24–28, 2010, 146–147.

27. B.Viikmäe, T.Soomere, N.Delpeche. Potential of using Lagrangian trajectories for environmental management in the Gulf of Finland. The Baltic Sea Geology-10 Abstract volume, the 10th International Marine Geological Conference, VSEGEI, St. Petersburg, Russia, August 24–28, 2010, 148–149.

28. I.Zaitseva-Pärnaste, T.Soomere. Long-term variations of wave heights and its comparison with ice conditions in Estonian coastal waters. The Baltic Sea Geology-10 Abstract volume, the 10th International Marine Geological Conference, VSEGEI, St. Petersburg, Russia, August 24–28, 2010, 156–157.

5.2.4 Submitted papers

1. A.Berezovski, J.Engelbrecht, G.A.Maugin. Generalized thermomechanics with internal variables. Archive of Applied Mechanics, (accepted).

2. A.Berezovski, J.Engelbrecht, G.A.Maugin. Thermoelasticity with dual internal variables. J. Thermal Stresses, (accepted).

3. A.Berezovski, M.Berezovski, J.Engelbrecht. Two-scale microstructure dynamics. J. Multiscale Modelling, (submitted).

4. M.Berezovski, A.Berezovski, J.Engelbrecht. Numerical simulations of one-dimensional microstructure dynamics. Int. J. Structural Stability and Dynamics, (submitted).

5. M.Berezovski, A.Berezovski. On the stability of a microstructure model. Computational Materials Science, (submitted).

6. M.Rosseau, G.A.Maugin, M.Berezovski. Elements of wave propagation in dynamic materials. Arch. Appl. Mech, (accepted).

7. H.Herrmann, M.Eik. A comment on the theory of short fibre reinforced material. Proc. Est. Acad. Sci., (submitted).

8. H.Herrmann, J.Engelbrecht. Comments on mesoscopic continuum physics: Evolution equation for the distribution function and open questions. Proc. Est. Acad. Sci., (submitted).

9. M.Eik, J.Puttonen. Microstructured Media: Challenges of Steel Fibre Reinforced Concrete in load bearing structures. Rakenteiden Mekaniikka, (submitted).

10. A.Ravasoo. Modified constitutive equation for quasi-linear theory of viscoelasticity. J. of Engineering Mathematics, (submitted).

11. A.Ravasoo. Counter-propagation of harmonic waves in exponentially graded materials. J. of Sound and Vibration, (submitted).

12. J.Kalda. *k*-spectrum of decaying, aging and growing passive scalars in Lagrangian chaotic fluid flows. Physics of Fluids, (submitted).

13. A.Stulov, D.Kartofelev. Vibration spectrum of a piano string with nonlinear contact condition, J. Advances in Acoustics and Vibration, (submitted).

14. T.Kaevand, J.Kalda, V.Kukk, A.Öpik, Ü.Lille. Correlation of the morphology and electrical conductivity in thin films of PEDT/PSS complex: an integrated meso-scale simulation study. Molecular Simulation, (accepted).

15. A.Stulov. Mathematical model of echolocation of fish-eating bats. J. of Acoustical Society of America, (submitted).
16. I.Mandre, J.Kalda. Efficient method of finding scaling exponents from finite-size Monte-Carlo simulations. Europhysics Letters, (submitted).
17. I.Didenkulova. Shapes of freak waves in the coastal zone of the Baltic Sea (Tallinn Bay). Boreal Environment Research, (in press).
18. D.Ryabchuk, A.Kolesov, B.Chubarenko, M.Spiridonov, D.Kurennoy, T.Soomere. Coastal erosion processes in the eastern Gulf of Finland and their links with long-term geological and hydrometeorological factors. Boreal Environment Research, (in press).
19. L.Kelpšaite, I.Dailidiene, T.Soomere. Changes in wave dynamics at the south-eastern coast of the Baltic Proper during 1993–2008. Boreal Environment Research, (in press).
20. T.Soomere, I.Zaitseva-Pärnaste, A.Räämet. Variations in wave conditions in Estonian coastal waters from weekly to decadal scales. Boreal Environment Research, (in press).
21. T.Soomere, N.Delpeche, B.Viikmäe, E.Quak, H.E.M.Meier, K.Döös. Patterns of current-induced transport in the surface layer of the Gulf of Finland. Boreal Environment Research, (in press).
22. T.Soomere, T.Healy. On the dynamics of "almost equilibrium"beaches of semi-sheltered bays along the southern coast of the Gulf of Finland. Proceedings of the 38th Geological Congress, Oslo 2008, Springer, (accepted).
23. I.Didenkulova, E.N.Pelinovsky. Runup of tsunami waves in U-shaped bays. Pure and Applied Geophysics, (accepted).
24. T.Soomere, K.E.Parnell, I.Didenkulova. Water transport in wake waves from high-speed vessels. J. of Marine Systems, (accepted).
25. I.Didenkulova, E.N.Pelinovsky, T.Soomere. Can the waves generated by fast ferries be a physical model of tsunami? Pure and Applied Geophysics, (accepted).
26. I.Didenkulova, E.N.Pelinovsky. On reflection of long sea waves from the underwater slope. Oceanology, (accepted).
27. I.Didenkulova, I.Nikolkina, E.Pelinovsky. Resonant amplification of tsunami waves generated by underwater landslide. Doklady Earth Sciences, (accepted).
28. I.Didenkulova, E.Pelinovsky. Rogue waves in nonlinear hyperbolic systems (shallow-water framework). Nonlinearity, (accepted).
29. O.Andrejev, T.Soomere, A.Sokolov, K.Myrberg. The role of spatial resolution of a three-dimensional hydrodynamic model for marine transport risk assessment. Oceanologia, (accepted with minor revisions).
30. O.Kurkina, T.Talipova Huge internal waves in the vicinity of the Spitsbergen Island (Barents Sea), Natural Hazards and Earth System Sciences, (accepted).
31. T.Soomere, A.Räämet. Spatial patterns of the wave climate in the Baltic Proper and the Gulf of Finland. Oceanologia, (submitted).

32. T.Soomere, M.Berezovski, E.Quak, B.Viikmäe. Modeling environmentally friendly fairways using Lagrangian trajectories: a case study for the Gulf of Finland, the Baltic Sea. Ocean Dynamics, (submitted).

33. T.Soomere, O.Andrejev, K.Myrberg, A.Sokolov. The use of Lagrangian trajectories for the identification of the environmentally safe fairways. Marine Pollution Bulletin, (submitted).

34. T.Soomere, O.Andrejev, A.Sokolov, E.Quak. Management of coastal pollution by means of smart placement of human activities. Journal of Coastal Research, 2011, Special Issue 64, (submitted).

35. A.Räämet, T.Soomere. Spatial variations in the wave climate change in the Baltic Sea. Journal of Coastal Research, 2011, Special Issue 64, (submitted).

36. B.Viikmäe, T.Soomere, K.E.Parnell, N.Delpeche. Spatial planning of shipping and offshore activities in the Baltic Sea using Lagrangian trajectories. Journal of Coastal Research, 2011, Special Issue 64, (submitted).

37. I.Zaitseva-Pärnaste, T.Soomere, O.Tribštok. Spatial variations in the wave climate change in the eastern part of the Baltic Sea. Journal of Coastal Research, 2011, Special Issue 64, (submitted).

38. K.Kartau, T.Soomere, H.Tõnisson. Quantification of sediment loss from semi-sheltered beaches: a case study for Valgerand Beach, P?rnu Bay, the Baltic Sea. Journal of Coastal Research, 2011, Special Issue 64, (submitted).

39. O.Kurkina, E.Pelinovsky, T.Talipova, T.Soomere. Mapping the internal wave field in the Baltic Sea in the context of sediment transport in shallow water. Journal of Coastal Research, 2011, Special Issue 64, (submitted).

40. D.Kurennoy, K.E.Parnell, T.Soomere. Fast-ferry generated waves in south-west Tallinn Bay. Journal of Coastal Research, 2011, Special Issue 64, (submitted).

41. I.Didenkulova, E.Pelinovsky, T.Soomere K.E.Parnell. Beach profile change caused by ship wakes and wind waves in Tallinn Bay, the Baltic Sea. Journal of Coastal Research, 2011, Special Issue 64, (submitted).

42. I.Didenkulova, E.Pelinovsky. Nonlinear wave evolution and runup in an inclined channel of a parabolic cross-section, Physics of Fluids, (submitted).

43. M.Vallikivi, A.Salupere, H.-H.Dai. Numerical simulation of propagation of solitary deformation waves in a compressible hyperelastic rod. Mathematics and Computers in Simulation, (submitted).

44. K.Tamm, A.Salupere. On the propagation of 1D solitary waves in Mindlin-type microstructured solids. Mathematics and Computers in Simulation, (in press).

5.2.5 Popular science

1. J.Janno. Positivity principle for parabolic integrodifferential equations. In: Annual Book of Estonian Mathematical Society 2009 (P.Puusemp, ed.), Tallinn University of Technology, 2010, 35–43 (in Estonian).
2. J.Kalda. The meeting point was at Tesla's homeland. Horisont, 2010, 5, 42–43 (in Estonian).
3. J.Kalda. The effect of Golden Age. Horisont, 2010, 3, 43–43 (in Estonian).
4. T.Soomere. Strong wind affects the life of island people, Maaleht (weekly newspaper targeted to countryside people), 3(1163), 21.01.2010, 10–11 (in Estonian).
5. T.Soomere. Plinius Medal for the Senior Scientist in Tallinn University of Technology, Mente et Manu 11(1785), 4.06.2010, p.2 (in Estonian).
6. T.Soomere. Nord Stream ignores the specific features of the vulnerable Baltic Sea, Yearbook of the Tallinn University of Technology 2009, TTÜ, 2010, 243–249 (in Estonian).
7. T.Soomere. Changing wave climate in the Baltic Sea. Preeden, U. Ja Laumets, L. (eds.), Global Changes. Schola Geologica VI. Eesti Looduseuurijate Selts, Tartu Ülikooli Ökoloogia ja Maateaduste Instituut, Tallinna Tehnikaülikooli Geoloogia Instituut, Tallinna Tehnikaülikooli Mäeinstituut. Sulemees, Tartu 2010, 59–73 (in Estonian).
8. T.Soomere, T.Hiidlained: Freak waves: from myths to rocket science, Estonian popular science journal, Special issue 2010, 44–45 (in Estonian).
9. CENS-CMA: Coastal research on the crest of a wave, Marie Curie Actions: Inspiring Researchers, European Commission, Directorate-General for Research, 2010, 232–235.

5.2.6 Other papers / Science policy

1. J.Engelbrecht. ALLEA role in uniting academies. 12the Baltic Conference on Intellectual Co-operation, Vilnius, 4–5 Nov. Book of Abstracts, 10–11.
2. J.Engelbrecht, European Academies and Research (talk at the Int. Conf. European Research on the Move, Wroclaw, 4–5 September, 2009). Science and Society, 2010, 5, 87–92.
3. J.Engelbrecht, Arvamusi akadeemikutelt (Academic thoughts, in Estonian). Eesti TA Aastaraamat 2009, Tallinn, Eesti TA, 2010, 218–222.
4. J.Engelbrecht, Academies in the World of Science and Knowledge, Proc of the Conference "50 years of the Israel Academy of Sciences and Humanities"(submitted).
5. J.Engelbrecht, Komplekssüsteemid (Complex Systems, in Estonian). Akadeemia, 2010, No 8, 1347–1362.
6. J.Engelbrecht, Teadusmõttest Küberneetika Instituudis. Rmt "Teadusmõte Küberneetika Instituudis", TTÜ Küberneetika Instituut, Tallinn, 2010, 11–15. (Science in the Institute of Cybernetics, in Estonian).
7. J.Engelbrecht, Internationalisation of research in Estonia. Yearbook 2010 Estonia (submitted).

8. J.Engelbrecht, Mälu, kultuur ja teadus (Memory, culture, and science, in Estonian). Eesti Rahva Muuseumi Aastaraamat 53, ERM, Tartu, 2010, 15–18.

9. J.Engelbrecht, On research in Estonia. Science and Society (submitted).

5.3 Conferences

1. SIAM Conference on Mathematical Aspects of Materials Science Philadelphia, Pennsylvania, May 23–26, 2010.
   M.Berezovski, A.Berezovski, J.Engelbrecht. Numerical Simulation of Wave Propagation in Materials with Microstructure

2. Continuum Physics and Engineering Application (CPEA10) Rackeve, Budapest, Hungary, May 29 – June 7 2010.
   A.Berezovski, M.Berezovski, J.Engelbrecht. Dispersive wave equations for microstructured solids.

3. International Symposium on Trends in Applications of Mathematics to Mechanics (STAMM 2010) Berlin, Germany, August 30th – September 2nd, 2010.
   A.Berezovski, M.Berezovski and J.Engelbrecht. Multiscale Microstructure Dynamics.

4. The 20th International Workshop on Computational Mechanics of Materials (IWCMM 2010) Loughborough University, UK, 8–10 September 2010.
   M.Berezovski, A.Berezovski, J.Engelbrecht. Two-scale macroscopic dynamics of materials with microstructure.

5. Second Vienna Talk on Music Acoustics, Institute of Musical Acoustics, University of Music and Performing Arts Vienna, Vienna, Austria, 19–21 September, 2010.
   D.Kartofelev, A.Stulov. Influence of the Edge of the Cast Iron Frame Curvature on the Spectrum of the Piano String Vibrations.

6. Third International Conference on Dynamics, Vibration and Control. Hangzhou, China, May 12–14, 2010.
   A.Salupere, M.Vallikivi, M.Rätsep, H.-H.Dai. Emergence of solitary waves and solitons in a compressible hyperelastic rod.

7. 4th Podlasiue Conference on Mathematics, Bialystok, Poland, 9–11 April 2010.
   Ü.Kotta. Pseudo-linear algebra versus time-scale tools in nonlinear control.
   T.Mullari. Transformation the nonlinear system into the observer form: simplification and extension.

8. Algebra and it's applications, Kääriku, Estonia, 30 April – 2 May 2010.
   Ü.Kotta. Irreducibility and rection of nonlinear control systems: unification and extension via pseudo-linear algebra.

9. Control Systems Theory, Intelligent Algorithms and Applications, Birmingham, UK, 20 May 2010.
   Ü.Kotta. Pseudo-linear algebra versus time-scale tools in nonlinear control.

10. The 2010 IRAST International Congress on Computer Applications and Computational Science (CACS 2010), Singapore, 4–6 December 2010.
    M.Tõnso. Mathematica application for nonlinear control systems on time scales.

J.Belikov. Transformation of the transfer matrix of the nonlinear system into the Jacobson form.
S.Nõmm. Towards application of coordinate invariant approach in detection of the surgeon hand gestures during laparoscope surgery.

11. UKACC International Conference on CONTROL 2010, Coventry, UK, 7–10 September 2010.
V.Kaparin. Necessary and sufficient conditions in terms of differential-forms for linearization of the state equations up to input-output injections.
J.Belikov. Realizability of bilinear input/output difference equations: corrections and extensions.
S.Avanessov. Maximizing volume of stable polytope of reflection vector sets.

12. 12th Biennial Baltic Electronics Conference, Tallinn, Estonia, 4–6 October 2010.
A.Anier. Timed automata based provably correct robot control.
K.Parm. Application of bidding automata for measuring the informativness of hand motion characteristic features.

13. 36th Annual Conference of the IEEE Industrial Electronics Society, Glendale, AZ, USA, 7–10 November 2010.
S.Nõmm. Application of volume bounding box decomposition for surgeon's hand gestures recognition.

14. 18th Mediterranean Conference on Control & Automation, Marrakech, Morocco, 23–25 June, 2010.
Ü.Nurges. Stable polytope of reflextion vector sets.

15. 2010 IEEE World Congress on Computational Intelligence, Barcelona, Spain, 18–23 July 2010.

16. 2010 SEM Annual Conference & Exposition on Experimental & Applied Mechanics, Indianapolis, June 7–10, 2010.
H.Aben. Presented the William Murray Lecture "Photoelastic tomography with linear and non-linear algorithms".

17. 14th International Conference on Experimental Mechanics, Poitiers, July 4–9, 2010.
A.Errapart. Photoelastic residual stress measurement in nonaxisymmetric containers.
H.Aben. Photoelastic tomography as hybrid mechanics.

18. The 17th International Congress on Sound and Vibration (ICSV17). Cairo, Egypt, 18–22 July, 2010.
A.Ravasoo. Nonlinear interaction of waves in exponentially graded materials.

19. The Joint Baltic Sea Research Programme BONUS Annual Conference, Vilnius, Lithuania, January 19–21, 2010.
B.Viikmäe, R.Isotamm and N.Delpeche. An empirical method to determine patterns of risk of coastal pollution in the Gulf of Finland.
T.Soomere, N.Delpeche, B.Viikmäe. Semi-persistent patterns of transport in surface layers of the Gulf of Finland.

20. Hydralab Young Researchers Workshop at the Hydralab III Closing Event, Hannover, Germany, February 02–04, 2010.
I.Didenkulova. Perspectives of modelling of landslide tsunamis with the use of ship wakes.

21. International workshop Bonus Day, Academy of Finland, Helsinki, February 09, 2010.
    T.Soomere participated.

22. FOCUS K3D conference on Semantic Media and Content, Sophia-Antipolis, France, February 11–12, 2010.
    E.Quak participated.

23. International workshop "Water Seminar Day", Frederick University, Nikosia, Cyprus, organised in the framework of GSD cooperation, March 18, 2010.
    T.Soomere. Implications of intense fast ferry traffic on nearshore water quality and beach erosion.
    B.Viikmäe participated.

24. BONUS+ BalticWay project annual meeting and international workshop "Towards the smart use of marine currents for environmental management", Frederick University, Nikosia, Cyprus, March 18–20, 2010.
    T.Soomere. The potential of the use of marine currents for environmental management.
    N.Delpeche, T.Soomere, B.Viikmäe. Spatial patterns of transport by surface currents in the Gulf of Finland.
    B.Viikmäe, T.Soomere, N.Delpeche. Spatial distributions of probabilities of coastal hit in the Gulf of Finland.

25. Industry Challenges in Geometric Modeling, CAD, and Simulation, Darmstadt University of Technology, Germany, March 25–26, 2010.
    E.Quak participated as co-organizer.

26. International conference BIG-STEP (Business, Industry and Government – Science and new Technologies for Enhancing Policy), Brussels (GSD network), April 14–15, 2010.
    T.Soomere participated.

27. EGU General Assembly, Vienna, Austria, May 02–07, 2010.
    I.Didenkulova: Marine natural hazards in coastal zone: observations, analysis and modelling (Plinius Medal Lecture). Runup of tsunami waves on a plane beach: statistical approach.
    I.Didenkulova (posters): Numerical simulation of explosive tsunami wave generation and propagation in Karymskoye lake, Kamchatka, Russia. Traveling water waves along quartic bottom profile. Nonreflecting wave propagation and runup in U-shaped bays. Statistical estimates of characteristics of long wave runup on a beach.
    T.Soomere, N.Delpeche, B.Viikmäe and M.Viidebaum (poster). The use of current-induced transport for coastal protection in the Gulf of Finland, the Baltic Sea.

28. 15th Biennial Workshop of Joint Numerical Sea Modelling Group (JONSMOD), Delft, The Netherlands, May 10–12, 2010.
    B.Viikmäe. The Use of Lagrangian Trajectories for Minimization of the Risk of Coastal Pollution.

29. The Coordinators' Forum of the BONUS consortium, Helsinki, June 08, 2010.
    T.Soomere participated.

30. The BONUS Advisory Board meeting, Helsinki, June 09, 2010.
    T.Soomere participated.

31. 6th Study Conference on BALTEX, Międzyzdroje, Island of Wolin, Poland, June 14–18, 2010.

A.Räämet, T.Soomere. A reliability study of wave climate modelling in the Baltic Sea.
B.Viikmäe, T.Soomere, N.Delpeche, H.E.M.Meier and K. Döös. Utilizing Lagrangian trajectories for reducing environmental risks.
O.Andrejev, B.Viikmäe, A.Sokolov, T.Soomere, K.Myrberg. Using multi-year circulation simulations to identify areas of reduced risk for marine transport. Application to the Gulf of Finland.
N.Delpeche, T.Soomere, B.Viikmäe (poster).Towards a quantification of areas of high and low risk of pollution in the Gulf of Finland, with the application to ecologically sensitive areas.

32. 2nd International Conference "Nonlinear Waves: Theory and Applications", Tsinghua University, Beijing, June 26–29, 2010.
T.Soomere, K.E.Parnell, I.Didenkulova. Water transport in groups of nonlinear wake waves from high-speed vessels.

33. 2nd Conference (school) on Dynamics of Coastal Zone of Non-tidal Seas, Baltiysk, Kaliningrad Oblast, Russia, June 26–30, 2010.
I.Zaitseva-Pärnaste, A.Räämet, T.Soomere. Comparison between modelled and measured wind wave parameters in Estonian coastal waters.
K.Kartau, T.Soomere. The evolution of semi-sheltered bayhead beaches: a study for Valgerand in Pärnu Bay.
O.Tribštok, I.Zaitseva-Pärnaste. Reconsidering wave observation data from Estonian coastal waters.

34. ESCONET Trainers Workshop in Science Communication, Dubrovnik, Croatia, July 19–24, 2010.
E.Quak participated.

35. The ANNiMS Student Conference, Townsville campus, James Cook University, July 21–22, 2010.
T.Soomere (keynote lecture). Towards a future technology of environmental management.

36. Humboldt Kolleg Ukraine "Mathematics and Life Sciences", Kiev, Ukraine, August 5–8, 2010.
E.Quak. The BalticWay Project: The Potential of Currents for Environmental Management of the Baltic Sea.

37. Summer School "Scientific Computing", Tallinn University of Technology, Tallinn, Estonia, August 5–10, 2010.
E.Quak. Some things that went wrong due to bad numerical computing.

38. 10th International Marine Geological Conference "The Baltic Sea Geology — 10", St. Petersburg, Russia, August 24–28, 2010.
T.Soomere, K.E.Parnell, I.Didenkulova. The role of vessel wakes in coastal processes of semi-enclosed basins.
I.Zaitseva-Pärnaste, T.Soomere. Long-term variations of wave heights and its comparison with ice conditions in Estonian coastal waters.
B.Viikmäe, T.Soomere, N.Delpeche. Potential of using Lagrangian trajectories for environmental management in the Gulf of Finland.
K.Kartau, T.Soomere (poster). The evolution of semi-sheltered bayhead beaches: a study for Valgerand in Pärnu Bay.
O.Tribštok, I.Zaitseva-Pärnaste, T.Soomere (poster). Changes in wave heights at Estonian

and Lithuanian coasts based on historical wave observations.
T.Soomere was member of the advisory board of this conference.

39. Intellectual Property Rights Workshop for Marie Curie Fellows, European Patent Office, Munich, Germany, September 8–10, 2010.
E.Quak participated.

40. ICT Event 2010: Digitally Driven, Brussels, Belgium, September 27–29, 2010.
E.Quak participated.

41. X Festival of Science of Western Pomerania, Szczecin, Round Table Discussions "Climate Change - and We?", Szczecin, Poland, September 30 – October 1, 2010.
I.Zaitseva-Pärnaste participated.

42. SAGA Project Fall School, Kolympari, Greece, October 4–8, 2010.
E.Quak (participated as co-organizer). Some remarks on Intellectual Property Rights.

43. XXIII International Coastal Conference in commemorating of the 100th Anniversary of professor Vsevolod Zenkovich "Coastal Evolution Studies: Traditions and Modern Concepts", RSHU, Saint Petersburg, October 4–9, 2010.
D.Kurennoy, K.E.Parnell, T.Soomere. Measurements of wakes generated by fast ferries in Tallinn Bay, poster presentation.

44. 5th International Student Conference "Biodiversity and Functioning of Aquatic Ecosystems in the Baltic Sea Region", Palanga, Lithuania, October 6–8, 2010.
B.Viikmäe, T.Soomere, N.Delpeche. Using Lagrangian trajectories to find areas of reduced risk of coastal pollution in the gulf of Finland.
M.Viidebaum, B.Viikmäe, N.Delpeche. Sensitivity study of the Lagrangian trajectory model TRACMASS.
K.Kartau, T.Soomere (poster). The evolution of semi-sheltered bayhead beaches: a study for Valgerand in Pärnu Bay.
I.Zaitseva-Pärnaste, T.Soomere (poster). Wave climate in the eastern part of the Baltic Sea.
M. Viška (poster). Coastal erosion analysis using LIDAR data and field measurements in Zvejniekciems Beach, east coast of the Gulf of Riga.

45. Baltic Conference on Intellectual Cooperation, Vilnius, Lithuania, November 4–5, 2010.
I.Puura, T.Soomere (co-author). Science, society and environment: the case of Nord Stream.

46. In Biophysical Society's 54rd Annual Meeting in San Francisco, California, February 20–24, 2010.
M.Sepp, M.Vendelin, H.Vija, R.Birkedal. Analysis of intracellular ADP compartmentation reveals functional coupling between pyrovate kinase and ATPases inrat cardiomyocytes.
M.Laasmaa, M.Vendelin, P.Peterson. 3D Confocal Microscope Image Enhancement by Richardson-Lucy Deconvolution Algorithm with Total Variation Regularization: Parameters Estimation.
A.Illaste, F.Fabris, M.Park, E.D.Adler, E.A.Sobie. Mechanisms underlying spontaneous beating in human embryonic stem cell-derived cardiac myocytes.

47. Eesti Inimesegeneetika hingu Aastakonverents, Rakvere, Eesti, October 21–22, 2010.
M.Vendelin. Molekulide liikumisest südamelihase rakus (in Estonian).

48. Session IV at ICMISE 2010, the WASET International Conference on Machine Intelligence and Systems Engineering. ICMISE 2010, Singapore, December, 18–20, 2010.
I.Astrov. Chairman.

49. 15th Estonian Winter School in Computer Science, Palmse, Estonia, February 28 – March 5, 2010.
T.Lints.

50. 36th Estonian Spring School in Theoretical Biology: The Theory of Movement, Tuhalaane, May 21–23, 2010.
T.Lints.

51. Annual Conference of the Estonian ICT Doctoral School, Essu, Estonia, November 26–27, 2010.
T.Lints.

52. Joint Estonian-Latvian Theory Days, Rakari, Latvia, September 30 – October 3, 2010.
T.Lints.

53. Space Downstream Services 2010 Conference, Tallinn, Estonia, May 6–7, 2010.
T.Lints.

54. (Stephen Wolfram's) New Kind of Science Summer School, Burlington, Vermont, USA, June 21 – July 9, 2010.
T.Lints.

55. Artificial Life XII: 12th International Conference on the Synthesis and Simulation of Living Systems, Odense, Denmark, August 19–23, 2010.
T.Lints.

56. 4th IEEE International Systems Conference, San Diego, California, USA, April 5–8, 2010.
T.Lints.

57. International Joint Conference on Neural Networks (IJCNN2010), the 2010 IEEE World Congress on Computational Intelligence (WCCI2010), Barcelona, Spain, July 18–23, 2010.
A.Riid. Interpretability Improvement of Fuzzy Systems: Reducing the Number of Unique Singletons in Zeroth order Takagi-Sugeno Systems.
E.Petlenkov. State-Space Control of Nonlinear Systems Identified by ANARX and Neural Network based SANARX Models.

58. IEEE International Conference on Intelligent Systems, London, UK, July 7–9, 2010.
A.Riid.

59. COST ICT Annual Progress Conference in Tallinn, June 2010.
M.Meriste.

60. Seminar on Smart Buildings and their Control, Institute of Technology, Tartu, 12 November, 2010.
M.Meriste.

61. 11th International Conference on Control Automation Robotics & Vision (ICARCV 2010), Singapore, December 7–10, 2010.
E.Petlenkov, (attended by K.Vassiljeva).

62. 12th Biennial Baltic Electronics Conference (BEC2010), Tallinn, Estonia, October 4–6, 2010.
E.Petlenkov, (attended by K.Vassiljeva and I.Artemchuk).

63. Lecture course "Optimality, Stabilization, and Feedback in Nonlinear Control", Prof. F.Clarke, Institut Universitaire de France et Université de Lyon, May 22–26, 2010.
E.Petlenkov, (attended by J.Belikov).

5.4 Seminars

5.4.1 Tallinn Seminars on Mechanics (CENS)

1. 4.01 M.Kree. Turbulent mixing - experiments and theory.

2. 11.01 M.Randrüüt. Solitary waves in microstructured solids: Approximate and exact solutions of an extended Korteweg-de Vries equation.

3. 18.01 A.Berezovski. Generalized thermomechanics and internal variables.

4. 25.01 St.Tinti. University of Bologna: Tsunami risk and tsunami early warning system in the Euromediterranean Region.

5. 1.02 A.Ravasoo. Modified constitutive equation for quasi-linear theory of viscoelasticity.

6. 8.02 A.Räämet. Long-term wave climate changes in the Baltic Sea.

7. 15.02 A.Stulov. Physics of the piano string pitch formation.

8. 22.02 Ch.Kurkjian. University of Southern Maine (USA): Strength and mechanical properties of glass.

9. 22.02 M.Predoi. Politechnica University of Bucharest. Faculty of Mechanical Engineering and Mechatrinics: Dispersion curves of guided waves. Numerical methods and experimental validation.

10. 8.03 I.Didenkulova. Coastal freak waves with an application to the Baltic sea.

11. 12.04 A.Berezovski. Dispersive wave equations for microstructured solids.

12. 19.04 A.Braunbrück. On multiple reflections of a harmonic burst in inhomogeneous material.

13. 26.04 A.Räämet. Variability and trends of the wave climate in the Baltic Sea.

14. 3.05 J.Kalda. Statistical topography of random surfaces: scaling laws and applications.

15. 24.05 T.Soomere, K.Parnell. James Cook University (Australia), I.Didenkulova. Water transport in groups of nonlinear wake waves from high-speed vessels.

16. 18.06 I.Gitman. University of Sheffield (UK): Multi-scale methods and the determination of representative volume elements in solid mechanics.

17. 18.06 H.Askes. University of Sheffield (UK): The use of inertial penalty functions in computational mechanics.

18. 4.10 D.Kartofelev, A.Stulov. Influence of the Edge of the Cast Iron Frame Curvature on the Spectrum of the Piano String Vibrations.

19. 11.10 A.Berezovski. Dynamics of Two-scale Microstructure.
20. 18.10 I.Didenkulova. Statistical characteristics of long waves nearshore.
21. 1.11 H.Herrmann and M.Eik. Steel fibre reinforced concrete. Overview: fibre orientation.
22. 8.11 I.Mandre. Correlated percolation. Scaling properties of percolation clusters.
23. 12.11 E.Pawluszewicz. Bialystok Technical University (Poland): Linear fractional systems with finite memory.
24. 22.11 M.Heidelberg. On the turbulent transport in 2D quasi-stationary velocity fields.
25. 29.11 A.Braunbrück. Multiple reflections of a harmonic burst and resonances.
26. 6.12 T.Peets. Coupled modes of wave propagation in microstructured solids.
27. 13.12 A.Ravasoo. Counter-propagation of bursts in functionally graded material.

5.4.1.1 Seminars of the Wave Engineering Group

1. 25.03 K.Kartau. Classification of Estonian Coasts. Modeling Beach Processes in Valgerand with CEDAS Program.
2. 01.04 O.Tribštok. Hydrographical Works by the Example of Raahe Port.
3. 08.04 R.Värv. High Resolution Bathymetry for the Gulf of Finland.
4. 15.04 A.Giudici. Stereoscopic 3D Visualization of Large Terascale Datasets.
5. 22.04 T.Soomere. Pirita Beach: changes and challenges.
6. 29.04 N.Delpeche. The use of current-induced transport for coastal protection in the Gulf of Finland, the Baltic Sea.
7. 09.11 O.Tribštok. Comparison of wave climates at Estonian and Lithuanian coasts.
8. 16.11 M.Viidebaum. Experimental study of water currents in the Baltic Sea.
9. 07.12 B.Viikmäe. Spatial planning of shipping and offshore activities in the Baltic Sea using Lagrangian trajectories.
10. 14.12 I.Zaitseva-Pärnaste. Spatial variations of the wave climate change in the eastern part of the Baltic Sea.

5.4.1.2 Seminars of the Laboratory of Proactive Technologies

1. P.Uba, P.Kukk, P.Miidla, K.Rannat. Studies on GPS tomography in Estonia, In: Space Downstream Services 2010 Conference: Space Downstream Services 2010 Conference, Boosting the Competitiveness of Business & Science: Satellite Services in Modern Society; Tallinn; 6–7 May.
2. T.Lints. The Concept of Adaptation, Estonian ICT PhD school conference 2010, Essu.
3. M.Meriste. Post-processing software for UAV collected information, invited talk at NATO RTB meeting in Tallinn.

5.4.2 Lectures and seminars outside CENS

1. J.Engelbrecht. Complexity in solid mechanics. Basque Centre of Applied Mathematics, Bilbao, 26 April, 2010.

2. J.Engelbrecht. Solitons – one face or many? Conference 50 years of the Institute of Cybernetics, Tallinn, 3 September, 2010.

3. M.Berezovski. Numerical simulations of one-dimensional microstructure dynamics. Dep. Structural Engin., University of Pavia, 15 April, 2010.

4. Continuum Physics and Engineering Application (CPEA10), Rackeve (Budapest), Hungary, May 29 – June 7, 2010:
   A.Berezovski. An introduction to continuum mechanics in material space;
   M.Berezovski. Material thermomechanics with internal variables;
   M.Berezovski. Numerical simulations and thermodynamic consistency.

5. A.Salupere. Solitonic structures in hierarchical KdV-type systems. Department of Mathematics, City University of Hong Kong, 10 May, 2010.

6. T.Soomere. Nord Stream as a challenge for the society. Annual meeting of the Estonian Water Society, 5 February, 2010.

7. T.Soomere. Nord Stream as a challenge for the Baltic Sea marine science. Tallinn House of Teachers, 7 February, 2010.

8. M.Berezovski. Numerical simulation of wave propagation in materials with microstructure. Department of Structural Mechanics in the Faculty of Civil Engineering at University of Pavia, Pavia, Italy, 17 April, 2010.

9. T.Soomere. Offshore secrets: sea waves and currents. Open University of the Tallinn University of Technology, 14 May, 2010.

10. I.Didenkulova. Mathematical modelling of extreme waves. Summer school on Scientific Computing, (August 7–11), Tallinn, Estonia, 9 August, 2010.

11. T.Soomere. Towards a future technology of environmental management: the use of properties of currents for minimizing coastal pollution;
    T.Soomere. Are regional wave climates changing?
    T.Soomere. New aspects of the meaning of extreme waves in maritime engineering design.
    Technical Meeting Series of the Tasmanian Divisions of RINA (Royal Institute of Naval Architects) and IMarEST (Institute of Marine Engineering, Science and Technology), Australian Maritime College, University of Tasmania, Launceston, August 17–18, 2010.

12. I.Didenkulova. Statistical characteristics of long waves nearshore. The Group of Statistical Physics and Theory of Chaos at the University of Potsdam, Potsdam, Germany, 14 September, 2010.

13. I.Didenkulova. Long waves induced by high-speed ferries: their modelling, measurements, sediment transport, impact on coasts. Woods Hole Oceanographic Institution, Woods Hole, MA, USA, 28 September, 2010.

14. T.Soomere. The changing wave climate of the Baltic Sea. Invited lecture to the 6th autumn school of young geologists “Schola Geologica – 6”, Roosta, 8–10 October, 2010.

15. I.Didenkulova. Statistical characteristics of long waves nearshore. School of Engineering, University of Warwick, Coventry, UK, 27 October, 2010.

16. E.Quak. Experiences as an evaluator, a lecture to the BIONET project seminar "Succeeding in the framework programme: not just a dream", Tallinn, Estonia, 28–29 October, 2010.

17. T.Soomere. Patterns of changes to the regional wave climate. School of Earth and Environmental Sciences, James Cook University, Townsville, Australia, 2 November, 2010.

18. M.Berezovski. Numerical simulation of wave propagation in heterogeneous materials and materials with microstructure. King Abdullah University of Science and Technology, KAUST, Kingdom of Saudi Arabia, 9 November, 2010.

19. T.Soomere. Towards the use of properties of currents for environmental management, with applications to ship-caused pollution, public lecture to the Institute of Marine Engineering, Science and Technology (IMarEST), Queensland Branch, Townsville Marine Museum, Australia, 11 November, 2010.

20. T.Soomere. Contribution of fundamental research towards solving challenges of changing times, Oceans Institute, University of Western Australia, Perth, 24 November, 2010.

21. T.Soomere. Patterns of changes to the regional wave climate, School of Environmental Systems Engineering, University of Western Australia, Perth, 25 November, 2010.

22. I.Didenkulova. Experimental study of long waves in the coastal zone of the Baltic sea and their impact on coasts. Institute of Applied Physics, Nizhny Novgorod, Russia, 3 December, 2010.

23. E.Quak. The Baltic Way project: The potential of currents for environmental management of the Baltic Sea. Universität Ulm, Germany, 17 December, 2010.

24. J.Kalda. IRPHE, University of Marseille. Statistical topography of smooth and rough random surfaces: applications to correlated percolation and turbulent mixing. 16 April 2010.

25. H.Herrmann. Computer Architectures for High Performance Computing. Tartu University, 5 May, 2010.

26. H.Herrmann. Shared Memory parallel programming with OpenMP, Tartu University, 27 October, 2010.

27. H.Herrmann. Open Source Software in (Geo-)Sciences, Klaipeda University, 30 March, 2010.

28. H.Herrmann. Complex Materials: From Liquid Crystals to Steel Fibre Reinforced Concrete, Technische Universität Chemnitz, 19 November, 2010.

29. M.Eik. Steel Fibre Reinforced Concrete – Overview, Rudus Eesti, 22 December, 2010.

30. K.Rannat. "BACnet tester", seminar on Smart Buildings and their control, Institute of Technology, Tartu, 11 November, 2010.

31. K.Rannat. Sounding the atmosphere with GPS, IPW, Sodankyla, LAPBIAT (Lapland Atmosphere-Biosphere Facility) workshop, 16 March, 2010.

32. K.Rannat. Measurements of atmospheric precipitable water using the GPS technique, Helsinki, LAPBIAT workshop, 2 September, 2010.

33. K.Rannat. Measurements of atmospheric precipitable water by ground-based GPS receivers along Struve - Tenner Meridian Arc, K.Rannat, R.Kivi, P.Uba, in Toulouse Space Show 2010 proc. 8–11 June, 2010.

34. M.Meriste. Interactive maps for unmanned vehicles, NATO RTO SCI workshop on Challenges of Autonomous Systems: Manned /Unmanned Integrated Operations, Antalya, Turkey, 2010.

35. A.Kull. Model-based TTCN-3 testing of a mobile operator charging subsystem, TTCN-3 User Conference, Beijing, China, 9 June, 2010.

36. A.Kull. IMS networks PSTN/ISDN simulation services conformance testing using ETSI standardized test suites and commercial TTCN-3 test tools, ETSI Workshop: 3GPP Release 8 IMS implementation, deployment & Testing, Sophia Antipolis, France, 24 November, 2010.

37. A.Kull. Experiences from MBT Industrial Usage, Dagstuhl Seminar 10421, Model Based Testing in Practice, In 10421 Abstract Collections, 2010.

38. J.-S.Preden. Situation awareness in distributed systems, NATO RTO SCI workshop on Challenges of Autonomous Systems: Manned /Unmanned Integrated Operations, Antalya, Turkey, 2010.

5.5 Meetings and events

5.5.1. Meetings and events in CENS

Humboldt Colloquium, September 02–04, 2010, National Library, Tallinn, Estonia.
The team of the Wave Engineering Laboratory supported the organisation of the Estonian-Finnish Alexander von Humboldt Colloquium “The Baltic Sea as a Bridge”in National Library, Tallinn, with over 80 participants from 12 countries. The colloquium, financially supported by the Alexander von Humboldt Foundation, gathered wide media coverage. It was mentioned in the news sections of several radio channels in the morning of September 3; journalists from two leading radio channels (Vikerraadio and Kuku Raadio) reported about the colloquium and T.Soomere gave interviews to Vikerraadio (by phone, broadcast in the afternoon of September 3) and to Kuku Raadio Marine Hour (about 10 min, broadcast twice on September 4).

Summer–School “Scientific Computing”
Focus: Iterative Solver for Large Linear Systems and Parallel Programming
Acknowledgements: The summer-school has been supported by the European Union through the FP7 Marie Curie Reintegration Grant ESTwave (PERG04-GA-2008-238191).
Support by the Alexander von Humboldt Foundation in form of a Feodor-Lynen-Fellowship for the organizer (HH) is gratefully acknowledged.
During the period 7–11 August 2010 a summer-school on scientific computing with the focus on iterative solvers for large (sparse) systems of linear equations and parallel computing was held at CENS, Institute of Cybernetics.
The main lecturers have been Prof. A.Meister (University of Kassel, Department of Analysis and Applied Mathematics, Germany) and Prof. B.Fischer (University of Lübeck, Institute of

Mathematics and Image Computing, Germany). Both are well known for high quality classes at German High Performance Computing Centres. The third invited lecturer has been Prof. E.Vainikko (University of Tartu, Institute of Computer Science, Estonia), he gives high quality courses about distributed systems and scientific computing regularly at the University of Tartu. The school was organized by Dr. Heiko Herrmann.
The course was held by invited lecturers from Estonia and Germany. In particular the following topics were covered:

1. Prof. Dr. Andreas Meister. University of Kassel, Department of Analysis and Applied Mathematics. *Krylov subspace methods; splitting methods; CG; preconditioning*.

2. Prof. Dr. Bernd Fischer. University of Lübeck, Institute of Mathematics and Image Computing. *Polynomial based methods*; CG, CR; MINRES, SYMMLQ; GMRES; BiCG, BiCGSTAB, QMR; Multigrid methods (slides by Andreas Meister).

3. Prof. Eero Vainikko. University of Tartu, Institute of Computer Science. *MPI – Message Passing Interface for parallel programming*.

4. Dr. Jaan Kalda. Tallinn UT, Institute of Cybernetics. *Optimization of x86 source code*.

5. Dr. Heiko Herrmann. Tallinn UT, Institute of Cybernetics. *Modelling; HPC computer architectures; OpenMP; OpenCL and GPGPU*.

Iterative solver for large linear systems of equations are an important topic, they appear in FEM, CFD, image analysis and many other areas. These methods are the most important numerical method and in the core of simulations in continuum mechanics and continuum physics.

As one of the lecturers put it: “No matter what you do, at the end of the day you have to solve a linear system.”(Bernd Fischer).
This is in severe contrast to the fact that these methods are usually not tought at university classes. Usually the best chance to learn about these methods is to attend a special course of one of the high performance computing centres, like the German HLRS.

The scientific part was accompanied by social events, like an excursion to Padise and Haapsalu, evening lectures and a banquet, to encourage contact between participants and lecturers outside the formal environment of the lecture room.

Altogether 10 Participants from Tallinn University of Technology and University of Tartu as well as Aalto University School of Science and Technology (Helsinki) attended the summer-school, the students were from several departments and institutes, among them the department of structural design, Institute of Cybernetics and Centre for biorobotics.

The summer-school was evaluated by the participants using an online questionary, and received very good marks. The result is attached. Some participants also have been able to establish new contacts for their research. Also the foreign guest lecturers were very content/satisfied, both scientifically and also by the hospitality.

Workshop “Recent Problems in Nonlinear Dynamics”, October 22, 2010, Tallinn.
A.Porubov. Institute of Problems in Mechanical Engineering RAN, St.Petersburg).
Application of nonlinear waves for the problem of growth of long bones.
F.Pastrone. University Turin. *Wave propagation in solids with vectoral microstructures*.
M.Braun. University Duisburg-Essen. *Discrete models of micro-structured solids*.
A.Berezovski, M.Berezovski, J.Engelbrecht. CENS, Tallinn. *Computation of wave propagation in solids with microstructure*.

6. Research and teaching activities

6.1. Meetings and events organised elsewhere

International workshop "**Water Seminar Day**", March 18, 2010, Frederick University, Nikosia, Cyprus, organised in the framework of GSD cooperation jointly by Frederick University and the Wave Engineering Laboratory team. The partners within this project have recognised that society currently faces a set of new challenges that are both global in scale and highly dynamic, in areas as diverse as climate change, security, health, transport and the globalisation of the economy. In order to assess the way forward, policy makers need access to the best available advice, covering all aspects of science, social studies, industry and economics, as well as to predictions of the implications of any suggested actions. The workshop comprised a unique blend of academia (including local scientists and academics coming from abroad) and policy makers from the finance and water development sectors plus contributions from the interested public. The participants represented six countries (Cyprus, Greece, United Kingdom, Sweden, Finland and Estonia). The content was focused on mathematical treatments for decision-making and revolved around the topics of water resource management, water shortage and water quality improvement.

Conference "**Towards the smart use of marine currents for environmental management**", 19 March 2010, Frederick University, Nikosia, Cyprus, organised by the Wave Engineering Laboratory, served as the major scientific event of the BONUS+ project BalticWay Annual Meeting. The conference reviewed the key progress of the efforts targeted at a substantial decrease of marine-industry-induced environmental risks and impacts. The focus of the conference was a scientific platform for an innovative low-cost technology of environmental management of shipping, offshore, and coastal engineering activities that makes use of the existence of semi-persistent current patterns that considerably affect the probability of pollution propagation from different open sea areas to the vulnerable areas. For certain regions (areas of reduced risk) this probability is relatively small. A combination of the classical risk analysis with novel mathematical methods is applied to identify the persistence, properties, and potential effect of such areas, and to establish generic criteria for their existence. The two events, their outcome and significance for Cyprus were reflected in 2nd most well known and sold newspaper in Cyprus "Politis".

Workshop **"Industry Challenges in Geometric Modeling, CAD, and Simulation**,"March 25–26, Darmstadt University of Technology, Darmstadt, Germany, organized by E.Quak and U.Reif (Darmstadt).
This annual event (since 2003) is set up to promote the co-operation of industry and academia in addressing relevant and challenging mathematical problems from geometry, computer-aided design, shape modelling, and other related areas such as simulation. Practitioners from industry and application-minded people from academia are brought together to discuss current research issues, investigate future trends and explore concrete opportunities for collaboration.
I.Didenkulova was a co-convener of the session NH5.1 "Tsunamis of different origins: new developments in modeling hazard, vulnerability and risk (including Plinius Medal Lecture)" [European Geosciences Union General Assembly 2010, Vienna, Austria, 2–7 May 2010].

Wave Workshop **"Furious Sea**", July 19–20, 2010, James Cook University, Townsville campus. T.Soomere presented a lecture course on wave dynamics and applications (14 academic hours) to the wave workshop "Furious Sea"organised in the framework of the Australian National Network in Marine Sciences (ANNiMS) for young scientists (mostly PhD students; a few well-prepared MSc students also accepted. The workshop comprised 24 student participants from all three ANNiMS partners: James Cook University, University of Tasmania, University of Western Australia).

SAGA Project Fall School, October 4–8, 2010, Kolympari, Greece, co-organized by E.Quak. The School included tutorial presentations, industrial talks, and open problem sessions in Computer-Aided Geometric Design and related fields as well as a Poster Session where all participants could present their work.

6.2 International cooperation

- Estonian-Hungarian Joint Research Project under the Agreement on Scientific Cooperation between the Estonian Academy of Sciences and the Hungarian Academy of Sciences 2010 – 2012 "Multi-scale thermomechanics of complex systems."
- Scientific cooperation on WAVE MOTION IN NONLINEAR MEDIA for 2009 – 2011 between Institute of Thermomechanics of Academy of Sciences of Czech Republic and Centre for Nonlinear Studies of Institute of Cybernetics at TUT.
- Laboratory of Photoelasticity of the Institute of Cybernetics participates in an informal academic cooperation on the topic "Stress fields in locally plastically deformed glass". Head of the team is Prof. C.R.Kurkjian from the University of Southern Mayne (USA). Other participants are the Purdue University (Prof. S.Chandrasekar), and in Japan the Shiga Prefecture University (Prof. S.Yoshida) and Nippon Electric Glass. In the framework of this cooperation A.Errapart calculated 8 stress fields in glasses, loaded by conical intentors. The experiments and photoelastic measurements wer carried out in Japan. A.Errapart visited from 24 August to 1st September Japan, carrying out experiments and stress calculations in indented glasses. He also delivered lectures on photoelastic tomography at the Shiga Prefecture University and in Nippon Electric Glass. H.Aben visited Purdue University on 9 June and delivered a lecture on photoelastic tomography.
- Collaboration with the University of Bergen: Tomas Torsvik, Dept. of Mathematics, Uni of Oslo: Prof. Geir Pedersen, and Inst. of Applied physics: Prof. E.N.Pelinovsky in the framework of the EEA grant EMP41 "Shoaling and runup of long waves generated by high-speed ferries"(2008 – 2010).
- Swedish Meteorological and Hydrological Institute (Norrköping), Laser Diagnostic Instruments (Tallinn), Danish Meteorological Institute, Department of Meteorology, Univ. of Stockholm, Institute for Coastal Research, GKSS Geesthacht, Finnish Institute of Marine Research, and Leibniz Institute of Marine Sciences at the University of Kiel in the framework of the pan-Baltic BONUS-169 project BalticWay: The potential of currents for environmental management of the Baltic Sea maritime industry (2009 – 2011).
- Collaboration between CENS and Akhiezer Institute for Theoretical Physics, NSC Kharkov Institute of Physics and Technology on Intermittent Transport Processes (2008–2011).
- Collaboration between Ira Didenkulova and (1) Dept of Mathematics, University of Oslo: Prof. John Grue, (2) Institut de Recherche sur les Phenomenes Hors-Equilibre (IRPHE), Marseille, France: Prof. Christian Kharif, (3) University of Antilles and Guyane, Guadeloupe: Prof. Narcisse Zahibo, (4) University of Bologna, Italy: Prof. Stefano Tinti, (5) Geolab UMR 6042 CNRS-UBP, University Blaise Pascal, Clermont-Ferrand, France: Dr. Raphael Paris, (6) University of Warwick, Coventry, UK: Dr. Petr Denissenko.
- Collaboration with the Finnish Environmental Institute and University of Helsinki: Physical oceanography of the Gulf of Finland and the Baltic Sea (K.Myrberg, M.Leppäranta), Planetary Boundary Layers (S.Zilitinkevich).

- Collaboration with the GKSS Geesthacht (H.Günther): Pre-operational modelling of wave regime in the Gulf of Finland, Implementation of WaMoS in the Baltic Sea.
- Collaboration with the Academic partners:
  - Leeds University (UK); Microsoft Research at Redmond (USA); Microsoft Innovation Centre, Aachen (Germany).
- Collaboration with the Industrial partners:
  - Bestnet Ltd; ELIKO; ELI Military Simulations; Elvior OÜ; IB Krates; Defendec.

6.3 Teaching activities

6.3.1 CENS seminars for graduate students

1. Seminar on confocal microscopy – P.Peterson.

6.3.2 Courses:

1. J.Engelbrecht – advanced courses in TUT:
   - Mathematical Modelling
   - Nonlinear Dynamics and Chaos (assisted by T.Peets).
2. A.Salupere – courses in TUT:
   - Continuum Mechanics
   - Theory of Elasticity
   - Seminars and Special Seminars for MSc and PhD students.
3. A.Braunbrück – courses in TUT:
   - Technical Mechanics I
   - Technical Mechanics II
   - Statics
   - Dynamics.
4. M.Randrüüt – courses in TUT:
   - Technical Mechanics I
   - Technical Mechanics II.
5. H.Herrmann – Scientific Computing (EMR 9802).
6. T.Soomere – course in TUT:
   - EMH0090 Coastal processes

     – course in Estonian Marine Academy:
   - Coastal hydrodynamics.
7. I.Zaitseva-Pärnaste – courses in Estonian Marine Academy:
   - General and Mathematical Cartography
   - Water Quality Modelling.
8. M.Meriste and J.S.Preden - lectures in TUT:
   - Proactive Technologies
9. A.Udal (together with Prof. V.Kukk, Dep. of Computer Control) – course in TUT:
   - ASIC design and nano-scale information technology

10. A.Udal, K.Meigas, and I.Fridolin – course in TUT:
    – Optoelectronics and Integrated optics

11. A.Udal – course in TUT:
    – Nano-scale Information Technology

12. L.Mõtus - course in TUT:
    – Software dynamics
    – Multi-Agent Systems

13. T.Naks and R.Savimaa - lectures in TUT:
    – Introduction to Real-time Software Engineering

14. J.Vain – courses in TUT:
    – ITI0020 Logic Programming (BSc and MSc)
    – ITI0060 Formal Methods (MSc)
    – ITX8025 Formal Methods of System Design (MSc)
    – ITI9120 Advanced Topics in Computer Science (PhD)
    – IXX9601 Doctoral Seminar I (PhD)

15. S.Nõmm – course in TUT:
    – ITI9100 Special course on Hybrid systems (MSc and PhD)

16. S.Nõmm – courses in EBS:
    – YMM3731 Calculus I (BSc)
    – ECO234 Introduction to Econometrics (BSc)
    – ECO 134 Introduction to Econometrics (BSc)
    – ECO 234 Introduction to Econometrics (BSc)
    – MAT105 Mathematics and Statistics for Business I (BSc)
    – MAT406 Mathematics and Statistics for Business II (BSc)

17. M.Tõnso – courses in TUT:
    – YMR0062 Nonlinear Control Systems and Computer Algebra II (PhD)

18. J.Belikov – courses in TU:
    – MLM6022 Calculus (BSc)

19. Ü.Nurges – courses in TUT:
    – ISS0030 Modeling and Optimization (MSc)

20. T.Mullari – courses in TUT:
    – YFT0250 Electrodynamics (BSc)
    – YFR0020 Physics (BSc)
    – YFR0030 Physics (BSc)
    – YFR0080 Refresher Course in Physics (BSc)

21. Prof. Alexey N.Zhirabok – course organized by the Institute of Cybernetics at TUT as the partner of Information and Communication Technology Doctoral School IKTDK
    – Algebraic methods in nonlinear control systems.

6.3.3. Participation in other events, transfer of knowledge:

1. V.Kaparin, J.Belikov, participation in module “Optimality, Stabilization, and Feedback in Nonlinear Control”. HYCON-EECI Graduate School on Control (March 21–27, 2010).

6.4. Visiting fellows
For shorter period

1. Prof. Alexey N.Zhirabok, Far Eastern State Technical University, 22 April – 7 May, 2010.
2. Dr. Miroslav Halás, Slovak University of Technology, 26 June – 3 July, 2010.
3. Dr. Małgorzata Wyrwas, Białystok University of Technology, 23 – 29 August, 2010.
4. Dr. Ewa Pawluszewics, Białystok University of Technology, 7 – 13 November, 2010.
5. Dr. Janusz Jakubiak, Wroclaw University of Technology, 24 February – 2 March, 2010.
6. Dr. Kitaro Yoshimitsu, Tokyo Women's Health Medical University, 25 February – 3 March, 2010.
7. Hiromi Nakimi, Tokyo Denki University, 25 February – 2 March, 2010.
8. Miho Suzuki, Tokyo Denki University, 25 February – 2 March, 2010.
9. Prof. Alain Glumineau, Institut de Recherche en Communications et en Cybernétique de Nantes (IRCCyN), 26 – 28 January, 2010.
10. Prof. Felix L. Chernousko, Institute for Problems in Mechanics of the Russian Academy of Sciences, 26 January – 28 January, 2010.
11. Prof. Dr. Matti Leppäranta (University of Helsinki, Finland), a short visit to discuss details of cooperation in marine science of the Baltic Sea between the Wave Engineering Laboratory and the University of Helsinki, 13 January, 2010.
12. Prof. Dr. Stefano Tinti (University of Bologna, Italy), to visit I.Didenkulova and to discuss the future cooperation between the IoC and Uni Bologna, and to present the CENS seminar paper "Tsunami risk and tsunami early warning system in the Euromediterranean Region"(January 25, 2010), 25–28 January, 2010.
13. Dr. Oleg Andrejev (Finnish Environmental Institute), BalticWay local working session. 6–7 May, 2010.
14. Dr. Tomas Torsvik (University of Bergen, Norway) 30 March – 5 April, and 1–5 September and 6–14 November, 2010 to collaborate on the EEA project EMP41.
15. Dr. Arno Behrens (Institute for Coastal Research, GKSS Geesthacht, Germany), 20–24 June, 2010, the first opponent and a member of the scientific committee for the defence of PhD thesis of A.Räämet.
16. Dr. Heidi Pettersson (Finnish Meteorological Institute, Helsinki, Finland), 21–22 June, 2010, an external member of the scientific committee for the defence of PhD thesis of A.Räämet.
17. Dr. Gisela Janetzke (Vice General Secretary, Alexander von Humboldt Foundation, Germany), August 31 – September 04, 2010, in the framework of the 50th anniversary of the Institute of Cybernetics and the Humboldt Colloquium "The Baltic Sea as a bridge".

18. Ms. Lu Xi (Institute for Coastal Research, GKSS Geesthacht), 20–26 June, 2010, to undertake training in the TRACMASS software and to implement this software in GKSS in the framework of BalticWay project.

For longer periods

1. Andrea Giudici (University of Genova (Università degli Studi di Genova), 4 March – 13 July, 2010, visiting MSc student, with the main focus on three-dimensional visualization of large datasets.

6.5 Graduate studies

Department of Mechanics and Applied Mathematics:
Promoted:

1. MSc:

K.Kevvai.	Numerical simulation of densification fronts in cellular materials using finite volume method (supervisor A.Berezovski).
I.Mandre	Statistical topography of scale-invariant random surfaces (supervisor J.Kalda).

1. PhD:

M.Berezovski.	Numerical simulation of front tracking in inhomogeneous solids (supervisor J.Engelbrecht).
M.Randrüüt.	Wave Propagation in Microstructured Solids: Solitary and Periodic Waves (supervisors J.Engelbrecht and A.Salupere).

In progress:

1. PhD:

T.Peets.	Dispersion in microstructured solids (supervisor J.Engelbrecht).
K.Tamm.	Deformation waves in microstructured solids (supervisor A.Salupere).
D.Kartofelev.	Piano string vibration: the role of bridge impedance (supervisor A.Stulov).
I.Mandre.	Percolation phenomena in complex systems (supervisor J.Kalda).
M.Eik.	Microstructured media: Steel Fibre Reinforced Concrete. Developing of theoretical basis for design rules (supervisors H.Herrmann, J.Puttonen).

2. MSc:

M.Heidelberg.	Diffusion in Stationary Turbulent Media (supervisor J.Kalda).
J.Jõgi.	Modelling of Nanostructures in Materials Sciences (supervisor J.Kalda).
E.Vaselo.	Applications of statistical topography in complex systems (supervisor J.Kalda).

Laboratory of Systems Biology:
Promoted:

1. MSc:

I.Shabarova.	Recording the intracellular chloride concentration in trout cardiomyocytes using perforated patch clamp (supervisor R.Birkedal).

In progress:

1. PhD:

A.Illaste.	Mathematical model of mitochondrial energy metabolism (supervisor M.Vendelin).
D.Schryer.	^{13}C impulse labeling studies with Saccharomyces cerevisiae (supervisor M.Vendelin).
M.Kalda.	Mechanoenergetics of a single cardiomyocyte (supervisor M.Vendelin).
M.Sepp.	Estimation of diffusion restrictions in cardiomyocytes using kinetic measurements (supervisor M.Vendelin).
N.Sokolova.	Energetics and contractility in heart of rainbow trout (supervisor R.Birkedal).
N.Jepihhina.	Heterogeneity of energetic parameters in cardiomyocytes (supervisor M.Vendelin).
M.Laasmaa.	Studies of the relationship between excitation-contraction coupling and energetics on trout cardiomyocytes (supervisors P.Peterson, R.Birkedal).
J.Branovets.	Structural and energetic modifications in cardiomyocytes from mice with modified creatine kinase system (supervisor R.Birkedal).

Laboratory of Wave Engineering:
Promoted:

1. MSc:

A.Giudici	3D visualization of large terascale datasets 29 October 2010, Genova (supervisor Prof. Leila De Floriani (Genova), co-supervisors E.Quak and H.Herrmann).

1. PhD:

A.Räämet.	Spatio-temporal variability of the Baltic Sea wave fields in changing climate conditions (supervisor T.Soomere).

In progress:

1. MSc:
   - K.Kartau. Coastal processes and human impact in Estonian coasts (supervisor T.Soomere).
   - O.Tribštok. Comparison of wave regimes along Estonian and Lithuanian coasts (supervisors T.Soomere and I.Zaitseva-Pärnaste).

2. PhD:
   - I.Zaitseva-Pärnaste. Wave climate changes of the Baltic Sea and their economical consequences (supervisor T.Soomere).
   - N.Delpeche. Using improved understanding of the circulation pattern in the Gulf of Finland to minimize coastal pollution (supervisor T.Soomere), promotion expected 2012.
   - O.Kurkina. Nonlinear dynamics of internal gravity waves in the Baltic Sea (supervisor T.Soomere), promotion expected 2012.
   - M.Viška. Evolution and forecast of open sedimentary coasts in the Baltic Sea conditions (supervisor T.Soomere), promotion expected 2013.

Control Systems Department:
Promoted:

1. MSc:
   - S.Juurik Proof method of emerging behavior properties by example of robot swarms coordination algorithm (supervisor J.Vain).
   - K.Parm Scrub nurse robot voting automaton for detecting and learning movements (supervisor J.Vain).

2. PhD:
   - M.Tõnso. Computer algebra tools for modelling, analysis and synthesis for nonlinear control systems (supervisor Ü.Kotta).
   - T.Mullari. On the second order relativistic deviation equation and its applications.

In progress:

1. PhD:
   - V.Kaparin. Transformation of the nonlinear state equations into the observer form (supervisor Ü.Kotta).
   - J.Belikov. Identification and control of complex nonlinear multi input multi output systems based on methods of artificial intelligence (supervisor E.Petlenkov).
   - A.Anier. Motion recognition via abstract interpretation (supervisor J.Vain).
   - M.Markvardt. Test data generation methods for input validation (supervisor J.Vain).
   - S.Avanessov. Robust adaptive output controller (co-supervisor Ü.Nurges).
   - K.Haavik. Model-based distributed control method for on-line banking (supervisor J.Vain).
   - K.Sarna. Distributed control methods and architectures (supervisor J.Vain).

Laboratory for Proactive Technology:
Promoted:

1. PhD:
   J.-S.Preden. Enchancing situation-awareness, cognition and reasoning of ad-hoc network agents (supervisor L.Mõtus).

In progress:

1. PhD:
   R.Pahtma. Physical modelling as complementary tool for studying emergent behaviour and self-organisation.

6.6 Distinctions and awards
Fellows:

1. H.Aben. The 2010 William M.Murray Award of the Society for Experimental Stress Analysis. Society's Annual Conference on June 7–9, Indianapolis, (USA).
2. J.Engelbrecht was elected into WAAS.
3. J.Engelbrecht was elected into the Academy of Sciences of Lisbon.
4. I.Didenkulova was awarded the Plinius Medal 2010 by the European Geosciences Union in recognition of her outstanding contributions to solve complex problems of oceanography and coastal engineering by applying nonlinear wave theory to marine natural hazards, including tsunamis, freak waves and storm waves. The medalist has been invited to give a key-note medal talk at European Geosciences Union General Assembly in 2010.
5. T.Soomere was invited to Townsville, Hobart/Launceston and Perth as a guest researcher to the Australian National Network in Marine Sciences; nominated as Honorary Professor of James Cook University, Townsville and Cairns, Australia, for July 1 – December 1.
6. A.Räämet received the Heinrich Laul Fellowship 2010.

Students:

1. J.Belikov – received Scholarhip of J.Poska.
2. M.Sepp – received Scholarhip of T.Mõis.
3. M.Berezovski – received the K.Jaak Travel Award for a research visit to the Department of Structural Mechanics in the Faculty of Civil Engineering at University of Pavia, Italy.
4. M.Berezovski – received the European Social Fund's Doctoral Studies and Internationalisation Programme DoRa grant to attend the SIAM Conference on Mathematical Aspects of Materials Science (MS10), Philadelphia, USA.
5. M.Berezovski – received the European Social Fund's Doctoral Studies and Internationalisation Programme DoRa grant to attend 20th International Workshop on Computational Mechanics of Materials (IWCMM 2010), Loughborough, UK.

6. M.Berezovski – received the K.Jaak Travel Award to attend STAMM 2010 International Symposium on Trends in Applications of Mathematics to Mechanics, Berlin, Germany.

6.7 Other activities

6.7.1 Participation on programme committees, reviewing papers:

1. Member of the steering committee of the Baltic Geology 2010, T.Soomere.
2. Reviewer for G.S.Prasetya PhD thesis "Catastrophic tsunamis in the Indonesian Archipelago", University of Waikato, New Zealand, T.Soomere.
3. Member of European Geosciences Union, I.Didenkulova.
4. Member of Plinius medal committee, European Geosciences Union. I.Didenkulova.
5. Vice-chair of the Mathematics-Engineering panel for the evaluation of Marie Curie Initial Training Networks proposals in the EU FP7 People program, E.Quak.
6. Member of the Expert Panel for the ex-post evaluation of 44 Belgian interuniversity networks in the framework of the IAP-VI programme, E.Quak.
7. Member of the Program Committee, FOCUS K3D Conference on semantic 3D media and content in Sophia-Antipolis, France, February 11–12, E.Quak.
8. Member of the Program Committee, Conference Shape Modeling International 2010 in Aix-en-Provence, France, June 21–23, E.Quak.
9. Member of the Program Committee, SAGA Fall School in Kolympari, Greece, October 4–8, 2010, E.Quak.
10. Member of the Program Committee, Euromed 2010 Conference on Digital Heritage in Lemesos, Cyprus, November 8–13, E.Quak.
11. Evaluator of the ComplexityNet call, representing the Estonian Academy of Sciences, E.Quak.
12. Reviewer for Patrick Salamin PhD thesis "Context Aware, Multimodal, and Semantic Rendering Engine", EPFL, Lausanne, E.Quak.
13. Review papers for Zeitschrift für Angewandte Mathematik und Mechanik, J. of Physical Chemistry, Fatigue and Fracture of Engineering Materials and Structures, J. of Polymer Engineering, Mathematical Problems in Engineering, ASCE J. of Engineering Mechanics. Proc. of International Conference on Complexity of Nonlinear Waves (Proc. of Estonian Academy of Sciences), A.Berezovski.
14. Programme committee of 15-th International Conference Mathematical Modelling and Analysis, Druskininkai, J.Janno.
15. UKACC International Conference on CONTROL 2010, Ü.Kotta.
16. 8th IFAC Symposium on Nonlinear Control Systems, Ü.Kotta.
17. Reviewer for Alexander Mendelson PhD thesis "Identification and Control of Deposition Process", Aalto University, Finland, Ü.Kotta.

18. International Conference on Evolutionary Computation, ICEC 2010), October 24–26, Valencia, Spain International ACM Conference on Management of Emergent Digital EcoSystems, Bangkok, Thailand, October 26–29, IPC member, A.Riid.
19. Fourth International Conference On Genetic and Evolutionary Computing (ICGEC 2010), December 13–15, Shenzhen, China Second World Congress on Nature and Biologically Inspired Computing (NaBIC2010), Kitakyushu, Japan, December 15–17, IPC member, A.Riid.
20. International Conference on Computer as a Tool (EuroCon 2011), Lisbon, Portugal, April 27–29, IPC member, A.Riid.
21. 18th World Congress of the International Federation of Automatic Control (IFAC 2011), Milano, Italy, August 28 – September 2, IPC member, A.Riid.
22. 4th International Symposium on Bio and Medical Informatics and Cybernetics (BMIC 2010), Orlando, USA, June 19 – July 2, IPC member, A.Riid.
23. 1st International Conference on Cloud Computing and Services Science (CLOSER 2011), IPC member, M.Meriste.
24. Member of the Advisory Board of the International Physics Olympiads, J.Kalda.
25. Member of the Directing Committee of the 43rd International Physics Olympiad, J.Kalda.
26. Member of the Jury of the Estonian Physics Olympiads, J.Kalda.

6.7.2. Participation in journal editorial boards:

1. J.Engelbrecht, Applied Mechanics Reviews.
2. J.Engelbrecht, Applied Mechanics, (Kiev).
3. J.Engelbrecht, J. Theor. Appl. Mech., (Warsaw).
4. J.Engelbrecht, Estonian J. Engineering.
5. Ü.Kotta, Abstract and Applied Analysis, Hindawi Publishing Corp.
6. Ü.Kotta, Proceedings of Estonian Academy of Sciences.
7. T.Soomere, Estonian Journal of Engineering.
8. T.Soomere, Journal of Marine Systems.
9. T.Soomere, Oceanologia, member of the Editorial Board.
10. E.Quak, Journal of Mathematics in Industry (JMiI), member of the Editorial Board.
11. J.Janno, Mathematical Modelling and Analysis.

6.7.3. Participation in professional organizations:

1. ALLEA President: J.Engelbrecht.
2. EASAC, Council members: J.Engelbrecht, L.Mõtus.
3. ESF, Governing Council observer: J.Engelbrecht.

4. IUTAM General Assembly: A.Salupere.
5. IFAC technical committee for nonlinear systems: Ü.Kotta.
6. IFAC contact person in Estonia: S.Nõmm.
7. IEEE technical committee on Computational Aspects of Control System Design – Chairman of the Action Group on Polynomial Methods for Control System Design: Ü.Kotta.
8. Marine Board of the European Science: T.Soomere, Estonian representative.
9. Marine Board of the Estonian Academy of Sciences: T.Soomere, Chair.
10. EASAC Environmental Steering Panel: T.Soomere, Estonian representative.

6.7.4 Science and Politics:

1. T.Soomere participated in the spring meeting of the Environmental Steering Panel of the European Academies Scientific Advisory Council (EASAC. Palace of Academies, Brussels, 11.05.2010).
2. T.Soomere participated in the European Science Foundation Marine Board Plenary Meeting (Istanbul, 03–04.07.2010).
3. T.Soomere participated in the marine science policy conference EurOCEAN2011, (Thermae Palace, Oostende, Belgium, 12–13.10.2010) where the Oostende (Ostend) Declaration "The Seas and Oceans are one of the Grand Challenges for the 21st Century"was adopted by the representatives of the European marine and maritime research community.
4. T.Soomere participated in the European Science Foundation Marine Board Plenary Meeting (Oostende, 14.10.2010).
5. A.Salupere participated at the IUTAM General Assembly meeting, (Paris, 16–19.07.2010).

6.7.5. Media reflections
About us

1. Anonymous, Scientist from TUT receives the Environmental Deed 2009, Mente et Manu, No 2(1776), 29.01.2010, p.1.
2. Anonymous, "Capturing tsunamis in equations: Ira Didenkulova to receive Plinius Medal" in the EGU Today, Daily newspaper from the General Assembly, 07.05.2010.
3. Margus Maidla, The scientist riding the ninth wave (Tarmo Soomere), (monthly journal focusing on various aspects of culture), Kultuuri KesKus, May 2010, 07.05.2010, 48–49.
4. The article "Estonian scientist is studying tsunamis" in the Russian version of the daily newspaper Postimees highlighted a story about cutting edge tsunami research conducted by I.Didenkulova, Postimees in Russian, No 97(1141), 20.05.2010, p.5.
5. The newspaper Mente & Manu of Tallinn University of Technology published the article "Plinius Medal for Irina Didenkulova", Mente et Manu, No 10(1784), 21.05.2010, p.3.
6. Anonymous, "EGU Awards and Medals during the 2010 General Assembly"in The EGGS E.G.U. Newsletter (Issue 31, July 2010) about Ira Didenkulova receiving Plinius Medal, 01.07.2010.

7. Raul Sulbi, Marine scientist Soomere invited to become honorary professor in James Cook University, Postimees Online, 28.09.2010, 17–52.
8. Anonymous, Australian university nominates Soomere as a honorary professor, Postimees, 224(6005), 29.09.2010, p.3 (in Estonian).
9. Anonymous, Scientist from TUT nominated as a honorary professor of James Cook University, Mente et Manu, 16 (1790), 08.10.2010, p.1 (in Estonian).

Media outreach

1. The TV channel Kanal 2 broadcast a comment by T.Soomere on the case of issuing the permit to the Nord Stream by Finland (12.02.2010).
2. Anonymous, The pipeline construction phase is the most dangerous, Postimees Online 12.02.2010; 23:54 (online version of the daily newspaper The Postman), based on comments of T.Soomere to the TV channel Kanal 2 (12.02.2010).
3. Interview with T.Soomere to the state radio channel Vikerraadio in the series "Fellows of the Academy of Sciences"(12.03.2010), broadcast also (17.04.2010).
4. Comment by T.Soomere to Radio Kuku Marine Hour about launching construction of the Nord Stream gas pipeline in the Baltic Sea and about the request of the Nord Stream AG for a permission of environmental monitoring in the Estonian Exclusive Economic Zone (10.04.2010).
5. Interview with T.Soomere in the national TV channel ETV broadcast in the series "2020" dedicated to foresights to the future of the Baltic Sea (18.04.2010).
6. Comment by T.Soomere to Radio Kuku morning broadcast about the state-of-the-art and future of the problems caused by ash clouds stemming from the Islandic volcano eruption (21.04.2010).
7. Heli Saavalainen. Fast ferries to Tallinn pose a serious threat to boats and yachts in shallow waters off Helsinki: Surge caused by passing ship nearly kills boater in Gulf of Finland, Helsingin Sanomat (09.05.2010), pp. A12–A13, the leading daily newspaper in Finland published a story about ship-wave-induced boat accident in the Gulf of Finland, with an expert comment about the possible reasons by T.Soomere; English version: http://www.hs.fi/english/article/Fast+ferries+to+Tallinn+pose+a+serious+threat+to+boats+and+yachts+in+shallow+waters+off+Helsinki/1135256773766.
8. Tiina Jõgeda. High-speed ferries excite killer waves. Eesti Ekspress, 10(1087), (20.05.2010), p.4.
9. Comment by T.Soomere to Radio Kuku about studies into killer waves performed in the Wave Dynamics Laboratory (20.05.2010).
10. A 'live on air' interview of T.Soomere to TV channel TV3 focusing on the properties of ship waves in Tallinn Bay and their potential for studies into killer waves (20.05.2010).
11. An interview of T.Soomere to the Reporter's Hour, state radio channel Vikerraadio, about the meaning and potential consequences of the oil pollution in the Gulf of Mexico (by phone from Istanbul, 04.06.2010).

12. Interview with T.Soomere about the Alexander von Humboldt Colloquium "The Baltic Sea as a Bridge"was broadcasted by the state radio channel Vikerraadio (03.09.2010).
13. Interview with T.Soomere about the key ideas of the Alexander von Humboldt Colloquium "The Baltic Sea as a Bridge". Kuku Raadio in Marine Hour (04.09.2010).
14. Interview with I.Didenkulova to TV channel ETV reflecting common features of ship waves in Tallinn Bay and tsunamis (12.09.2010).
15. Ulvar Käärt. The central government should clean up the sea, say Tallinn City officers that also reflects an interview with T.Soomere. Eesti Päevaleht, No. 223, (28.09.2010), p.8, (in Estonian).

7. Summary

After the anniversary years (CENS 10 in 2009, Institute of Cybernetics 50 in 2010), CENS is looking forward with clear perspectives in all the research fields. As said before (see Annual Report 2009), we deal with analysis, synthesis and control of complex systems.

Several PhD students were promoted in 2010, new students started their research. The highlights in the research into complexity of nonlinear waves were represented in the Special Issue of Proc. Estonian Acad. Sci. (2010, 59, 2, 61–65) in which talks at the Conference on Complexity of Nonlinear Waves (Tallinn, 2009) were collected. Highlights in econophysics were described in an overview (Science and Culture, 2010, September – October, 374–378). We plan to continue publishing such overviews and foresights.

For 2011, we restructured our target funding. Instead of one long-term block grant (Nonlinear dynamics and complex systems) we shall have two: the Wave Engineering Laboratory has gained strength and now is going on with its own long-term block grant "Wave dynamics for coastal engineering" while the previous one will be continued with a little it reduced staff. Such a change will allow more focusing but the topics are in close contact under the umbrella of CENS.

In the long-time perspective, CENS will beside direct research which is the main aim of activities, focus also on cooperation and disseminating knowledge. CENS has several bilateral cooperation agreements and many international projects (see previous chapters). In addition to that CENS plans to enlarge our network in Estonia: the groups working in Swedbank (econophysics; R.Kitt, M.Säkki) and in Tallinn University (nonlinear stochastic processes in nano- and eco-systems; R.Mankin) would like to be associated with CENS. Disseminating knowledge means first of all explaining the complexity ideas to scientific community and society. The participation in the EC Complexity -NET Programme (J.Engelbrecht, L.Mõtus) and in the EC funded Global Systems Dynamics project (T.Soomere) has served this purpose from a general viewpoint. We worked together with the Department of Mathematics; University of Turin (F.Pastrone) in preparing the session "Artematica"at ESOF 2010, Turin, July 2–7, 2010. Several seminars at the Estonian Academy of Sciences (J.Engelbrecht, L.Mõtus) and an overview on complex systems (Estonian magazine "Akadeemia"by J.Engelbrecht) have disseminated the ideas to larger audience. CENS tries to explain the ideas of the complex world widely and to our surprise, in 2010, T.Soomere and J.Engelbrecht were cited by influential Estonian thinkers (J.Jõerüüt and T.Paul, respectively).

Annexes

1. Summer–School on Scientific Computing, August 7–11, 2010, Tallinn (H.Herrmann).
2. Recent Problems in Nonlinear Dynamics, Tallinn, October 22, 2010: abstracts and discussion.
3. Regional Report: Research in Estonia, Nature, November 2010. Studies into complexity in nature and technology (M.Vendelin).

Centre for Nonlinear Studies
TTÜ Küberneetika Instituut
Tallinn, Estonia

Summer-school:
Scientific Computing

August 7–11, 2010 in Tallinn, Estonia

Overview

Numerical simulations are probably the most well known and oldest category of scientific computing, nevertheless also today they still require detailed expert knowledge to be done in a correct and efficient way. The summer-school will give an overview of modelling in science (physical, mathematical and numerical) and parallel programming and will focus on solving large systems of (sparse) linear systems of equations with iterative methods. These kind of systems arise in many different numerical schemes, i.e. finite element methods and computational fluid dynamics are popular examples.

Topics

- modelling (physical, mathematical, numerical)
- computer architectures for HPC
- iterative solver
  splitting methods, preconditioners, MINRES, SYMMLQ, CG, BiCG, BiCGStab, GMRES, multigrid methods
- parallel programming
  MPI, OpenMP, OpenCL

The Lecturers

The invited lecturers are well known in their fields. Prof. A. Meister (University of Kassel, AG analysis and applied mathematics) and B. Fischer (University of Lübeck, insitute of mathematics) are lecturers at parallel programming courses and workshops on a regular basis. Both are authors of well received books in the field of iterative solvers, they have excellent didactic skills and will bring a unique contribution to this summer-school. Prof. E. Vainikko gives classes on scientific computing, including parallel programming, regularly at University of Tartu.

Evening Lectures

Possible talks are:

- Some things that went wrong due to bad numerical computing
- 3D visualisation of scientific data, example "Baltic Way" project
- Open-source software in science: means of making numerical research transparent and reduce costs of teaching and research

About Tallinn

The summer-school will be held in the beautiful medieval city of Tallinn, an old hanseatic town known also as Reval. Tallinn will be Europe's cultural capital in 2011.

Kiek in de Kök

TTÜ Küberneetika Instituut

Schedule

	Saturday	Sunday	Monday	Tuesday	Wednesday	
09:00 - 09:15	09:00-09:30			09:00-10:00	09:00-10:00	09:00 - 09:15
09:15 - 09:30	Registration		09:00-10:30	Fischer:	Vainikko:	09:15 - 09:30
09:30 - 09:45	09:30-09:45 Opening		Meister:	Polynomial methods	MPI	09:30 - 09:45
09:45 - 10:00	09:45-10:30		Classical splitting methods 1			09:45 - 10:00
10:00 - 10:15	Herrmann:			10:00 – 10:15 break	10:00 – 10:15 break	10:00 - 10:15
10:15 - 10:30	Modelling			10:15-11:15	10:15-11:15	10:15 - 10:30
10:30 - 10:45	10:30 – 10:45 break		10:30 – 10:45 break	Fischer:	Vainikko:	10:30 - 10:45
10:45 – 11:00	10:45-11:30	09:00		Polynomial methods	MPI	10:45 – 11:00
11:00 - 11:15	Herrmann:		10:45-12:00	(computing a basis)		11:00 - 11:15
11:15 - 11:30	Computer architectures	excursion	Meister:	11:15 – 11:30 break	11:15 – 11:30 break	11:15 - 11:30
11:30 - 11:45	11:30 – 11:45 break	to	Classical splitting methods 2	11:30-12:30	11:30-12:30	11:30 - 11:45
11:45 - 12:00	11:45-12:30	Padise		Fischer:	Vainikko:	11:45 - 12:00
12:00 - 12:15	Herrmann:	snd	12:00 – 12:15 break	Polynomial methods	MPI	12:00 - 12:15
12:15 - 12:30	HPC	Haapsalu	12:15-13:15	(CR, CG)		12:15 - 12:30
12:30 - 12:45			exercises			12:30 - 12:45
12:45 - 12:00			(using GNU Octave)	12:30-13:30	12:30-13:30	12:45 - 12:00
13:00 - 13:15				lunch break	lunch break	13:00 - 13:15
13:15 - 13:30						13:15 - 13:30
13:30 - 13:45		(return late at night)	13:15-14:30	13:30-14:30	13:30-14:30	13:30 - 13:45
13:45 - 14:00			lunch break	Fischer:	Herrmann:	13:45 - 14:00
14:00 - 14:15				Indefinite problems	OpenMP	14:00 - 14:15
14:15 - 14:30				(MINRES, SYMMLQ)		14:15 - 14:30
14:30 - 14:45	12:30		14:30-15:30	14:30 – 14:45 break	14:30 – 14:45 break	14:30 - 14:45
14:45 - 15:00			Meister:	14:45-15:45	14:45-15:45	14:45 - 15:00
15:00 - 15:15	sightseeing		classical preconditioners	Fischer: Non-symmetric problems	Herrmann:	15:00 - 15:15
15:15 - 15:30	in		and PCG-method	minimizing methods (GMRES)	OpenMP	15:15 - 15:30
15:30 - 15:45	Tallinn		15:30 – 15:45 break			15:30 - 15:45
15:45 - 16:00			15:45-16:45	15:45-16:30	15:45 – 16:00 break	15:45 - 16:00
16:00 - 16:15			Meister:	Fischer: Non-symmetric problems	16:00-17:00	16:00 - 16:15
16:15 - 16:30			CG method	short recursions (BCG, BiCGStab, QMR)	Herrmann:	16:15 - 16:30
16:30 - 16:45				16:30 – 16:45 break	OpenCL	16:30 - 16:45
16:45 - 17:00			From 16:45			16:45 - 17:00
17:00 - 17:15			exercises	16:45-18:00	Summary and Q&A	17:00 - 17:15
17:15 - 17:30			(using GNU Octave)	Fischer:	Closing	17:15 - 17:30
17:30 - 17:45				Principles of multigrid methods		17:30 - 17:45
17:45 - 18:00						17:45 - 18:00
20:00-	evening lecture		evening lecture	banquet		20:00-

Location	TTÜ Küberneetika Instituut
	Akadeemia tee 21
	12618 Tallinn, Estonia
Fee	750 EEK (50 Euro) for students
	1500 EEK (100 Euro) for others
	some supported places are available
Accomodation	not included; please arrange yourself;
	the Academic Hostel is very close
	(http://www.academichostel.com/)
Contact	Dr. H. Herrmann
	sc-summer-school@cens.ioc.ee

NB! In case of registered participants not showing up these will be blocked from *all* classes given by the organizer for one year, this includes future seminars, summer/winter-schools and also regular university courses.

Marie Curie Actions
Human resources and mobility

ESTwave (PERG04-GA-2008-238191)

Institute of Cybernetics, CENS

Workshop on Recent Problems in Nonlinear Dynamics

Tallinn, Oct 22, 2010

Programme:

1. A.Porubov (Institute of Problems in Mechanical Engineering RAN, St Petersburg): Application of nonlinear waves for the problem of growth of long bones

2. F Pastrone (University Turin): Wave propagation in solids with vectorial microstructures

3. M.Braun (University Duisburg-Essen): Discrete models of micro-structured solids

4. A.Berezovski, M.Berezovski, J.Engelbrecht (CENS, Tallinn): Computation of wave propagation in solids with microstructure

Abstracts:

A.Porubov: The problem of the description of the growth of long bones has attracted considerable attention in the last years. Only in a few regions is the growth straightforward while a more complicated process happens in the long bones while two tightly coupled processes are at work in the growth of long bones, the production of cartilage tissue and the replacement of a part of it by osseous tissue. Many papers are devoted to the modeling and explanation of the biological processes responsible for the cartilage enlargement, the resorption and the regulation of the growth rate. Mechanical factors first arise due to the fact that growing parts become geometrically incompatible and residual stresses appear. One has to note that growth and typical elastic strains evolve at different time scales that should be taken into account in the coupled governing equations. Then two approaches may be developed. According to one of them strains are considered static while biological growth is assumed to vary in time. The description of the growth of long bones in the above mentioned papers is mainly based on this approach. Another approach may be suggested that allows to study prints of biological processes by means of acoustic nonlinear dynamical methods that are well developed for compressible materials like metals, polymers etc.

Following the last approach a nonlinear dynamic model is developed to account for material inhomogeneities in a growth plate in long bones. The governing equations are obtained to account for nonlinear dispersive, viscoelastic and inhomogeneous features of the growth plate. The evolution of nonlinear strain waves over the material inhomogeneities is obtained via the asymptotic solutions. It is shown that variations in the amplitude and the width of both the bell-shaped and kink-shaped waves reflect the position and the size of the inhomogeneity. This may be used for a detection of the growing plate features and in the development of the reaction-diffusion equation for the stimulus of the growth of long bones.

F.Pastrone: Recently a considerable attention has been paid to the materials which exhibit a complex structure often called as “complex materials". The term has different meanings, referring to the theory of complexity, but in our context it means materials characterized by intrinsic spatial scales in the matter, such as the lattice period, the size of a crystalline or a grain, the distance between micro-cracks etc. In other words, all properties typical for materials used in modern technology, as for polycrystalline solids, ceramic composites, alloys, granular materials may be described in corresponding spatial scales. Since '70-es the general theories introduced by Mindlin, Capriz and Eringen are widely used to underline an essence of dispersive effects due to the scale dependence in various physical models of wave propagation.

The renewed attention nowadays to modelling of materials with different intrinsic spatial parameters is caused by nanotechnology. For example, dielectric materials supplied with nano-inclusions may become conductors due to enormously high surface-volume ratio of nanoparticles, 2-5 % of nanoparticles may increase the stiffness of alloys in times, etc.

The goal of this article is to provide different frameworks to the study of the wave propagation in complex elastic solids. As usual in these models, the field equations are obtained as the Euler-Lagrange equations of a suitable Lagrangian, assuming the absence of dissipation. However, as a rule the governing nonlinear equations contain spatial parameters, become quite awkward for analytical treatment and, consequently, require numerical simulations. For this reason any exact solution is of original interest.

A new point of view for the model of vectorial microstructures is given, and one-dimensional models (widely studied in the literature) are briefly presented. A two-dimensional nondissipative model is analyzed in detail using the “slaving principle” and the Jacobi elliptic functions. A hierarchical structure of the field equations can be exhibited in all such cases, obviously in suitable approximations. In many of such cases the existence of solitary waves is proved.

Finally, we deal with a micro-structured model having two different scale levels, e.g., the micro- and the nanoscale. A particular choice of the strain energy function, similar to one used in the case of the only microstructure, will allow us to deal with more explicit field equations. The usage of the slaving principle and the introduction of a phase variable provides us a reduction of the coupled governing equations to the one leading PDE, and, to the 6-th order ODE. In Sec.3 this ODE is reduced to the 4th order ODE, and we find some exact solutions in terms of the Weierstrass elliptic function, that can be animated using *Mathematica*^{TM}. Finally, in appropriate limiting cases we can use the Jacobi functions to obtain, upon some additional restrictions on the coefficients, the soliton solutions, having typical "Mexican hat" shape. In Sec.4 the physical meanings of the results obtained above of the parameter relations and the restrictions required are discussed.

M.Braun: Mindlin's theory of microstructured solids describes the motion of the material by two field quantities, namely the macroscopic displacement and the homogeneous deformation of the microstructure. In the one-dimensional version as provided by Engelbrecht and Pastrone, these are scalar functions of the space coordinate and time. The strain-energy density is assumed as a quadratic form of the displacement, the microstrain and its gradient, leading to a coupled system of linear partial differential equations. The present contribution deals with the question how such a one-dimensional microstructured solid can be illustrated by a discrete chain composed of springs and mass elements.

Beforehand the simple particle-spring model is discussed. In the continuum limit it leads to a nonlocal functional equation for the displacement field. The dispersion relation is provided both for the full nonlocal equation and for its approximation by partial differential equations. The periodicity of the dispersion diagram is explained in detail, and it is emphasized that the dispersion relation becomes inappropriate for wavelengths smaller than the spacing of the particles.

In a first attempt, the microstructured material is exemplified by a chain of rods connected by springs. Each of the rods is allowed to undergo a homogeneous deformation that represents the micro-deformation. In the continuum limit one obtains a system of nonlocal equations, and their Taylor expansions lead to a system of partial differential equations which formally coincides with the equations of Engelbrecht and Pastrone. However, the modulus of the gradient of microstrain becomes negative. Although this is acceptable if the wavelength is large enough, the discrete model does not represent the Mindlin-type material. The reason is that different strains of neighboring rods do not contribute to the strain energy as they should according to Mindlin's assumption. Therefore an alternative arrangement of the springs is chosen, which reacts on the difference of the extensions of neighboring rods. Now the decisive modulus gets the correct sign. The coupling of the two equations, however, is lost. Combining the two discrete models finally leads to the correct system of equations. The corresponding dispersion diagram assumes the well-known form.

The main conclusion of the above considerations is that a Mindlin-type material must contain an internal mechanism that "feels" the gradient of the micro-deformation. Not every microstructured material has this property. It should always be analyzed how, in principle, the gradient of micro-deformation can contribute to strain energy. Otherwise Mindlin's theory might not be the appropriate basis to describe the material behavior.

A.Berezovski et al: Results of theoretical research and numerical simulations of wave propagation in micro-structured solids presented in the report allow to indicate three essential aspects of the whole problem:

- a mathematical model consisting the governing equations, initial and boundary conditions;
- a material model, which suggests the knowledge of the free energy dependence and material parameters;
- a stable and accurate numerical algorithm.

It is shown that balance equations for macro-fields and evolution equations for internal variables describing microstructure can be derived consistently by means of dual internal variables concept. At the same time, the influence of size, shape, and direction of microstructure constituents remains undiscovered. The form of the free energy function is more or less well understood, but the values of material parameters as well as nonlinearity effects need additional theoretical and experimental investigations. The finite-volume wave-propagation algorithm is well suited for the computation of wave propagation problems in media with rapidly-varying properties. Stability and accuracy of the numerical method are provided by the proper choice of the mesh size. The derived model can be applied to the high frequency wave propagation in rods, plates, and even more complex structure elements made by composites, laminates, and meta-materials.

Discussion

The world is characterized by multiple scales starting from elementary particles up to the large-scale structure of the universe. Wave propagation in microstructured materials must also be analyzed from the viewpoint of multiple scales. Usually we limit ourselves to two-scale models by defining the macro- and microstructure of a material under consideration. The crucial problem how to model the interaction between the constituents is then also limited to interaction between two levels only, ie between the macro- and microstructure. This problem has been intensively studies by the participants of this seminar and the recent results in the field are described in abstracts above. In what follows are some discussion points concerning the accuracy of models and their predictive characteristics.

The Mindlin-type model is widely used for describing waves is micro-structured materials.
In his seminal paper (1964), Mindlin has interpreted the microstructure "as a molecule of a polymer, a crystallite of a polycrystal or a grain of a granular material". Then the micro-displacement is introduced but further the micro-deformation enters into the governing equations. Actually the microdisplacement is proposed as a linear function of local coordinates multiplied by an unknown function. When microdeformation is calculated then only this unknown function remains and can be interpreted as a microdeformation. Mindlin shows also that a gradient of this function can be accounted for. Taking into account the microdeformation only then it can be intuitively compared with the M.Braun's model (see above) where the macrodisplacement is influenced by the deformation of deformable particle, ie rod. So the full set of governing equations of a Mindlin-type model is written in macro-displacements and micro-deformations.
In general terms, governing equations for microstructured solids can be derived by means of:

- Lagrangian formalism, postulating the form of the corresponding Lagrangian (Capriz, Pastrone);
- Generalized continua theories, postulating the balance of micromomentum (Mindlin, Eringen, H. Askes, A. S. J. Suiker, L. J. Sluys, A classification of higher-order strain-gradient models – linear analysis. Archive of Applied Mechanics 72 (2002) 171–188);
- Homogenization approach, starting from microforce balance (J. Fish, W. Chen and G.Nagai, Non-local dispersive model for wave propagation in heterogeneous media: one-dimensional case. Int. J. Numer. Meth. Engng 2002, 54:331–346; Z.-P. Wang, C.T. Sun, Modeling micro-inertia in heterogeneous materials under dynamic loading. Wave Motion 36 (2002) 473–485;
- Internal variables, exploiting the dissipation inequality.

It is remarkable that resulting balance equations look similarly (but not identically). All the approaches expand the state space (amount of independent variables) by certain morphological descriptors (microdeformations, microforces, internal variables). The mathematical description of them is based on the geometry of abstract manifolds (P. M. Mariano and F. L. Stazi, Computational aspects of the mechanics of complex materials. Arch. Comput. Meth. Engng.Vol. 12, 4, 391-478 (2005)).
The question about the possible influence of gradients has been studied by A. V. Metrikine, H. Askes, One-dimensional dynamically consistent gradient elasticity models derived from a discrete microstructure. Part 1: Generic formulation. European Journal of Mechanics A/Solids 21 (2002) 555–572)

An interesting question is about the sign of forces between the constituents of a micro-structured materials. Mentioned by M.Braun (see above), such a question was also evident in calculations done by M.Berezovski (M.Berezovski, Numerical Simulation of Wave propagation in Heterogeneous and Microstructured Materials, PhD thesis, Tallinn UT, 2010).
Similar phenomenon was observed by R.Marangati and P.Sharma, A novel atomistic approach to determine strain-gradient elasticity constants, J Mech and Phys Solids, 55, 1823-1852 (2007). Intuitively this phenomenon may be related to a weak non-convexity of the elastic potential.

Finally one should mention that the multiscale models were analysed by J.Engelbrecht, F.Pastrone, M.Braun, A.Berezovski, Hierarchies of waves in nonclassical materials. In P.-P. Delsanto (ed) Universality of Nonclassical Nonlinearity:Applications to Non-destructive Evaluations and Ultrasonics, Springer, Berlin, 29-47 (2006); A.Berezovski, J.Engelbrecht, T.Peets, Multiscale modelling of microstructured solids, Mech. Res. Comm., 37, 531-534 (2010).

The modelling of materials with a internal structure composed of fibres seems to be interesting to be developed. A.Porubov showed such a need for an appearance of strain wave dispersion in a cartilage in the growth plate in long bones, in CENS H.Herrmann and M.Eik constructed a model for such a material using the concept of alignment tensors. See, for example: H.Herrmann, M.Eik. A comment on the theory of short fibre reinforced materials. Proc. Estonian Acad Sci (submitted).

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REGIONAL REPORT

EESTI TEADUSFOND

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Investing in your future

Research in Estonia:
race for quality and competitiveness

The history of science in Estonia spans centuries; however, never has its scale been so comprehensive and its targets so high.

PROMOTIONAL FEATURE

Studies into complexity in nature and technology

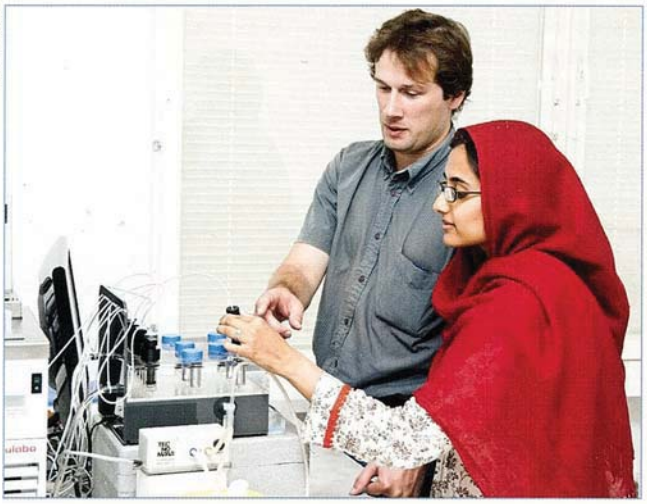
The Institute of Cybernetics (IoC), founded in 1960 as a multidisciplinary research institute of the Estonian Academy of Sciences, is nowadays an autonomous research unit at the Tallinn University of Technology. Having limited human resources, research institutions in small countries need to fight constantly to sustain a critical mass of researchers. Multidisciplinary institutes like the IoC are one way to provide working infrastructure to motivated researchers in different fields of study, resulting in a broader spectrum of expertise and higher potential to participate in international projects.

The IoC has three departments (Mechanics and Applied Mathematics, Control Systems, and Software) and four laboratories (Photoelasticity, Wave Engineering, Systems Biology, and Phonetics and Speech Technology). The activities of two scientific centres are also coordinated from the IoC: the Centre for Nonlinear Studies (CENS) and the Estonian Centre of Excellence in Computer Science (EXCS). The spectrum of research fields in the IoC has always been broad, but the common denominators are applied mathematics and complexity. The keywords describing our activities include the following: complex and nonlinear phenomena in wave dynamics and coastal engineering, solitons and solitary waves, acoustodiagnostics, turbulence, fractality, econophysics, acoustics of the piano, integral photoelasticity and photoelastic tomography, cell energetics, semantics of programming languages and type theory, visual and ontology oriented programming, knowledge representation and program synthesis, cybersecurity, analysis and synthesis of nonlinear control systems, inverse and ill-posed problems, speech synthesis, speech analysis and speech recognition.

The high level of our research can be characterized, for example, by the fact that the IoC hosted two out of the 10 national centres of excellence in research: the CENS and the Centre of Dependable Computing. The IoC has always been the driving force for nationwide collaborative initiatives in computer science and mechanics. It takes part in numerous international projects, including activities of the Marie Curie Actions programme and projects funded by the European Structural Funds, the Framework Programme and the Wellcome Trust.

Because of our high-level results in different research fields and the inspiring atmosphere, the IoC has become an internationally recognized research centre that attracts more and more talented young researchers worldwide.

Eiko Lainjärv



Wellcome Trust senior research fellow Marko Vendelin and Mobilitas postdoctoral fellow Hena Ramay study heart muscle cells at the IoC.

CENS

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