Preface

The strategic plan of the Department of Mathematics is based partly on the existing strategy plan from 2012, and partly on contributions from the mathematical disciplines represented at the department.

The present draft was discussed by the department’s research committee at meetings on 13 August 2015 and 12 November 2015.

The purpose is to formulate objectives for the department's future research profile and to bring new study programs and new educational approaches into the department's educational profile.
**Executive Summary**

Department of Mathematics at Aarhus University was established in 1954 and has existed for more than sixty years. For the majority of the time the department has been the primary center for a number of key areas within the Mathematics in Denmark, and has maintained a very high international profile. The aim of the strategy is to create conditions that can lead to innovation and thereby strengthen and maintain the current status and provide the right conditions for attracting the best students and the best young researchers. At the same time, the department wants to raise the general mathematical level of all ST students, for example by offering courses which are taught in cooperation with other ST departments.

**Research**

We have very strong research groups which we aim to strengthen further by employing 3-4 highly acknowledged young, international researchers, who will further attract young ambitious researchers and strengthen an already active and inspiring research environment. This strategy has been extremely successful within the field of Probability Theory where we have employed an excellent young researcher who has already taken a leading role in the group and cooperates with researchers at the Department of Mathematics as well as other departments at AU.

We have two research centers, the DG center QGM, and the Villum Center of Excellence CSGB, who are among the best in the world within their respective fields of research, and who contribute substantially to the active research environment within the department, and act also as important recruitment instruments.

It is also notable that within the two last years, researchers at the department have received three Sapere Aude grants.

Our aim is to strengthen the interdisciplinary activities, both in terms of research and education. Our new Applied Statistics Laboratory is a strong initiative for providing the department’s strong competence within Statistical Analysis to the more experimentally focused departments to help processing their experimental data for the benefit of the entire ST. We are currently working on a comprehensive interdisciplinary center focused on Data Analysis and Big Data/Machine Learning.

**Education**

Our goal is to provide students at Aarhus University with the best available courses in mathematics in Denmark, and give all students a solid mathematical foundation within their individual subject areas. In the near future, we will aim at developing interdisciplinary education similar to the extremely successful MAT-ØK (Mathematics-Economics) study program currently being taught in cooperation with ECON.

We are in the planning phase of a new study program within Data Analysis in cooperation with ENG, ECON and CS. It is anticipated that this program will be introduced in 2017. It is very likely that other interdisciplinary educational programs will attract the best students and produce graduates with the strong qualifications requested by the business community both in Denmark and internationally.

Introduction of new teaching methods in mathematics is of high priority. We will significantly strengthen teaching at Bachelor’s degree level, and carry out a comprehensive analysis and, if necessary, restructure
the department’s bachelor courses. We will provide a more flexible program and make it possible for students to choose courses within other subject areas, such as ENG and other ST departments. As mentioned above, we will also introduce courses that are offered and taught in cooperation with other ST departments. We are currently planning a course in cryptography in cooperation with CS and a course in mathematical biology in cooperation with BIOS.

Our large first-year courses Calculus 1 and 2 are now entirely media-based. This enables us to differentiate the courses for the different subject areas at ST, and makes it possible for each subject area to integrate specific material addressed specifically at their own students. It also means that all first-year mathematical teaching at ST will be concentrated at the Department of Mathematics, which is also a major strategic goal.

**Summary**

The department exhibits great research strength and will, by appointing the appropriate spearheads (we have proved that it is possible), be able to reach the top of the international ranking lists. Interdisciplinary activities and cooperation with other ST departments must be strengthened. It is also important to further develop both the applied mathematics and pure mathematics, as it is the interaction between these two branches that generates strength and inspiration for both.
Organization and physical framework

51 academic staff: 16 professors, 22 associate professors, 1 senior researcher, 9 post-docs and 3 research assistants.

Age distribution

Organisational chart
Administrative support of activities

Over the years, MATH has established a strong administrative support of the departmental activities, partly through the committee structure and partly through the departmental secretariat currently comprising nine persons, including the head of secretariat.

The defined tasks of the ST Administrative Center are performed in good dialogue with the academic and administrative staff of the department. Regular dialogue meetings are held between the head of MATH administration and the division managers/partners of the various administrative areas.

Proximity is a descriptive key word characterizing the administrative support offered by the departmental secretariat both to the MATH academic staff and the ST Administrative Center. This applies, for example, also to the study administration where proximity is essential for the cooperation between the administration and the academic staff/MATH administration.

Physical framework of the department

MATH is situated on campus in buildings 1530-1535. In addition to the office facilities, the MATH staff has access to the newly refurbished ST Library. The building complex is also home to a large number of lecture rooms / auditoriums, as well as the very popular Mathematics Laboratory where some of the teaching support takes place.

The MATH Guest Floor (6 apartments and 12 rooms) is situated in building 1530, 1535 and 1540 (on the top floors) and are extremely popular and widely used by all AU. The occupancy rate is between 90 % and 95 %.

Staff and culture

Department of Mathematics was established by Professor Svend Bundgaard more than 60 years ago. He built a strong foundation from which the department still benefits, both with regard to the physical and the scientific framework.

He managed to build up a department consisting of many talented and prominent researchers and sent some of the young Danish mathematical talents to USA for further education. Most of these talents returned to Denmark later and helped build the department we know today.

This is one of the reasons why the department still enjoys great respect and recognition within the mathematical research community. The commitment of the department to appoint very highly qualified researchers indicates that this respect and recognition can continue and be enhanced in future.

The research groups regularly hold seminars and invite both Danish and often invite international colleagues to visit the department and to give lectures, and are thereby inspired by the latest research.

In addition, there is also a strong tradition for holding workshops, conferences, symposia, summer schools and Master classes.

The students also hold regular events. The organization Euler's Friends, for example, arranges lectures given by both students and employees.
The department management team holds 2-4 staff meetings per year, and once a month all staff meet for coffee and social interaction across all research groups, and this includes the administrative staff. The idea of gathering all research groups is fairly new, approx. 6 months, and has proved a success as the event is always very well attended. It is an excellent opportunity for the staff to talk interdisciplinary and establish new contacts at the department. It is a clear objective of the department to strengthen the sense of community and a strong identity of belonging to the Department of Mathematics, but at the same time we want to strengthen the identification with ST and the closeness to the faculty.
Strategy 2016-2020

Research and recruitment

Department of Mathematics at Aarhus University has a long history as being the foremost center for Mathematics in Denmark, and for attracting strong, international researchers who stay at the department for longer or shorter periods. The objective of the strategy is to create conditions that will strengthen the department’s international profile and maintain its position as a primary center for Mathematics, both nationally and internationally.

For many years the department has had highly qualified researchers with a strong academic profile. These researchers are internationally educated, mainly in the USA, and therefore have extensive international networks.

It is of utmost importance that our young scientists gain international experience and build a network by studying abroad, preferably for a longer period of time. This could be achieved by making it mandatory for the PhD students at our department to study abroad for a period of time. When recruiting permanent staff we must give Danish and foreign candidates equal status and base new appointments solely on quality.

In order to attract the most promising young researchers at the Postdoc and Assistant Professor (tenure track) levels, it is imperative to have a number of young prominent researchers with high international standing; This must be our highest priority for hiring permanent staff for the next five years. It is a strategy that will take time and involves some risk. But it can be done: in 2014 we managed to employ a very talented young researcher in Probability Theory (in competition with the University of Copenhagen and some other prominent foreign institutions). This appointment is a good example of what we should pursue.

Following several years with a rather uneven age distribution within the department, we are approaching a more balanced age distribution, although some work remains to further renew the Department.

Educational Activities

The department has very substantial teaching obligations and it is our goal, under the given circumstances, to have the best programs in the country. We must provide the right conditions to attract the best students and we must keep developing, in particular our first-year teaching, to constantly ensure that the education program matches the students’ qualifications. We will also introduce a fast-track option which will enable highly qualified students to finish the elementary first-year courses quickly, and proceed to the more challenging courses as soon as possible.

The quality of the first-year courses must be improved; a process that has already been initiated, and Calculus 1 and 2 should be common for all study programs at ST. By the use of media-based teaching it is possible to differentiate and adapt the courses to the different subject areas represented at ST. Mathematics is a common language for all ST subject areas, and it is of the utmost importance that the students finish the first-year courses with the mathematic skills required for their chosen study.

We also need to establish new interdisciplinary study programs, modelled over the Mathematics/Economy study program, which is a very successful program taught in cooperation with the Department of
Economics and Business and has been in existence for more than forty years. We are working on plans to establish a completely new study program within Data Analysis and Big Data/Machine Learning, in cooperation with ENG, ECOM and CS. The preliminary plan is to allow only the best and highly qualified students access to this education, and consequently the admission requirements must be very high. In addition, we are working to create courses in collaboration with other ST departments based on a model where the same course has one or several lecturers. These courses will thus be able to attract students from the Department of Mathematics as well as other departments. In addition, it will improve the level of mathematics among the students at the other departments and give our own students an insight into the way mathematics is applied in other sciences.

**Interdisciplinary Activities**

We want to strengthen the interdisciplinary activities both in education and research.

Our strong capabilities in Statistics, for example, can be used with great advantage by many of the other, more experimentally focused departments at ST. We have introduced an Applied Statistics Laboratory in order to assist other departments with their data analysis. There is a need for statistics analysis at ST and we are working to expand this initiative further by appointing more staff.

The department has strong capabilities both within pure and applied mathematics, for example, and our statistics and probability theory groups belong to the world elite. The fact that both directions are strongly represented in our department is of great importance and enhances both the applied and pure mathematics. We must be aware of the need to strengthen both directions to the same degree.

**External funding**

Employees at the department have recently had good success in obtaining external funding. In 2015 alone we were awarded two new Sapere Aude grants in addition to the Sapere Aude grant from 2014 and some other minor grants.

In the autumn of 2015, the Villum Foundation donated a substantial grant to one of the department's research groups under the leadership of Professor Mark Podolskij.

The primary sources for external grants have so far been government foundations and the Villum Foundation. In the future, we will look for alternative sources also, for example, the new interdisciplinary initiatives we are working on will be of strong interest for the business community.

**Career development**

It is of utmost importance that the most talented employees see a professorship as a natural career. Therefore, it is necessary to improve the opportunities to promote the most research-active employees to a position as professor with special responsibilities (MSO) as a rule rather than an exception.
Staff and summary of visionary reports of research groups

Algebra group:

Permanent staff:

Henning Haahr Andersen, professor
Jens Carsten Jantzen, professor
Johan P. Hansen, associate professor
Niels Lauritzen, associate professor
Jesper Funch Thomsen, associate professor
Sergey Arkhipov, associate professor

Significant academic trends within the field:

Some of the most significant results in recent years deal with modular representations, especially counter examples to Lustig's assumption. Increased use of diagrammatic methodologies, including Kontsevic.

It should also be mentioned that cryptography and coding theory are important disciplines that can be used both within quantum information theory and practical applications within data analysis and communication security.

The department has a strong tradition within this field, but currently has only one researcher within the area.

At the moment, there are no researchers within commutative algebra and category theory.

Two members of the group are expected to retire within the next 5 - 6 years, and there is therefore a need for new appointments. Currently, we have advertised an associate professorship in algebra with application deadline 1 September and we have received 15 applications. Four applicants have been selected for further interviews and the appointment committee expects to recommend a candidate in mid-December 2015.
Geometry group:

Permanent staff:
Jørgen Ellegaard Andersen, professor
Marcel Bökstedt, professor
Andrew du Plessis, associate professor
Andrew Swann, associate professor

Significant academic trends within the field:

Some of the most significant results within the most recent years concern especially the connection between geometry/topology and theoretical physics. Mathematical aspects of quantum field theory, in particular, have been the focus due to the DG center QGM’s internationally leading position within topological quantum field theory and quantization of moduli spaces.

A highlight is the construction of TQFT’s for non-compact gauge groups, which has been a challenge for decades, as well as the proof that he combinatorial model for TQFT is consistent with the model produced by quantization of moduli spaces. In addition, the researchers at QGM also managed to build up a new and ground-breaking use of moduli space techniques within Molecular Biology in the study of both RNA and protein folding.

The research group has also obtained significant results within the study of Einstein metrics and special holonomy (G2 and nK structures) and a differential geometric description of ‘T-duality’ from string theory. In addition, the group has achieved strong results within the branch of theory of singularities referred to as stratification theory.

One member of the group is expected to retire within the next 4-5 years.

There is a contractual obligation to fill three positions at the DG center QGM, and we hope to fill in two of these this year.
Theoretical statistics research group

Permanent staff:

Jens Ledet Jensen, professor

Eva Vedel Jensen, professor

Søren Asmussen, professor (also probability theory)

Kristjana Jonsdottir, associate professor

Markus Kiderlen, associate professor

Lars Nørvang Andersen, associate professor

Ute Hahn, associate professor (also applied statistics)

Significant academic trends within the field:

The most important research direction in recent years concerns high-dimensional data and survival analysis. Powerful computers, in particular, have made it possible to process very large datasets with particular application on image analysis of MRI and CT scans. Complex Bayesian models are now being used widely.

Big data and high dimensional data, e.g. genetic data, are important areas represented at AU by BiRC (the Bioinformatics Research Center), with which the group has a close collaboration.

One member of the group is expected to resign within the next 3-4 years.

The research group has many interdisciplinary projects both at AU and outside. Graduates in Statistics are in great demand by the business community.
**Probability theory research group**

*Permanent staff:*

Søren Asmussen, professor (also theoretical statistics)

Mark Podolskij, professor

Andreas Basse-O’Connor, associate professor

Jan Pedersen, associate professor

Steen Thorbjørnsen, associate professor

*Significant academic trends within the field:*

Stochastic processes and related areas such as stochastic matrices. The Foundation is a center for research in AMBIT stochastics, a type of stochastic processes discovered by Ole E. Barndorff-Nielsen and Jürgen Schmiegel. Other important areas are Malliavin Calculus, rough path theory and Levy processes.

Applied probability theory, such as insurance mathematics (it may be mentioned that the University of Copenhagen has built up a strong group in insurance mathematics as well as a successful study program), stochastic optimization and computational stochastics.

The group has a close and comprehensive cooperation with researchers at BSS, especially researchers at the DG center CREATE.

One member of the group is expected to resign within the next 3-4 years.
Mathematics-Economics research group

Mathematics-Economics is, of course, a study program at the department, and the group members who teach the different subjects comprised in the study program, are each experts within their own mathematical field.

The study program is an interdisciplinary collaboration between MATH and ECON. This cooperation has proved itself very rewarding, and the structure could very well serve as a model for other interdisciplinary projects.

Permanent staff:

Andreas Klose, associate professor
Kent Andersen, associate professor

Mathematics-Economics Study Program Committee:

Andreas Klose, Jan Pedersen (MATH)
Kim Allan Andersen, Peter Jensen (ECON)

Notes:

The Mat ØK study program needs to be strengthened, and restrictions on admission should be considered in order to only admit the best students. The quality of the students' basic skills has been declining, and it is of the utmost importance that the quality of the graduates we produce remains high. The graduates from this program have be very employable and the business community is very pleased with the Mathematics-Economics graduates, they have hired. In order for this trend to continue we must ensure that the quality remains high.

There is a need for a detailed evaluation and analysis of the Mathematics-Economics study program and an updating of the contents of the courses. Initially, an external committee ought to review the study program. Subsequently, a permanent user committee should evaluate the courses on an ongoing basis and propose relevant changes.

To a great extent, the program has become focused on future employability and we need to encourage more students to start a PhD program. It is also important that the students are introduced to more of the latest research.
Center for Science Studies

Permanent staff:

Kristian Hvidtfelt Nielsen, associate professor, center director
Matthias Heyman, associate professor
Samuel Schindler, associate professor
Henrik Kragh Sørensen, associate professor

Significant academic trends within the field:

In recent decades, science studies has witnessed a marked international increase in strength, visibility and importance with added emphasis on studying social and cognitive aspects of scientific and engineering practice, including science-technology-society relationships. There are strong interactions between science studies and other fields such as interdisciplinary global change research, public understanding of science, science education, innovation studies, research policy studies, general history and general philosophy.

In the nearest future, CSS will be strongly committed to continuing its successful development and to consolidate its strong international position. This requires attracting excellent researchers and younger scholars in science studies, but also developing teaching in science studies at the Bachelor and Master’s level.

Notes:

CSS has major teaching obligations and is currently understaffed. A professor/associate professor position was posted in the autumn of 2015.
Analysis research group:

Permanent staff:
Søren Fournais, professor
Bent Ørsted, professor
Jacob Schack Møller, professor, MSO (professor with special responsibilities)
Klaus Thomsen, professor, MSO (professor with special responsibilities)
Simon Kristensen, associate professor
Erik Skibsted, associate professor

Significant academic trends within the field:
The analysis group's strongest disciplines are the mathematical analysis of quantum physical models, non-linear partial differential equations, variational mathematics, global analysis, representation theory for Lie groups, operator algebra, discrete dynamic systems and analytical number theory.

Topics that have received considerable international attention in recent years include: Non-linear PDE problems (General Relativity, Ricci/Mean render box flow) and in mathematical physics (Abrikosov Lattices, Navier-Stokes ). Another area in major progress is the analytical number theory, where several famous conjectures are under pressure (limited gap between distinct primes, Littlewood’s conjecture).

Notes:
One member of the group is expected to retire within the next 4-5 years. The research group will then no longer cover representation theory and global analysis. Recruitment should focus on maintaining a strong international profile within these central areas of analysis.
**Applied statistics research group**

**Permanent staff:**

Rodrigo Labouriau, senior researcher

**Significant academic trends within the field:**

There is a great demand for statistical support at ST. At least five large departments at ST (AGRO, ANIS, Food, Bio and ENV) require comprehensive statistical expertise for many of their research and educational activities. Statistical support spans simple statistical consultancy support, development and maintenance of statistical courses for non-statisticians at PhD and Master’s level, participation of statisticians in complex research projects for the preparation of new, customized statistical methods. The Applied Statistics Laboratory (ASL) at MATH was established to meet this demand.

Recently, new technologies have been developed to automatically register enormous data sets (e.g., genetics data, climate data, plant and animal production, disease registers, economic data, etc.), thereby enabling us to observe data which could not be observed previously (for example, large genomic data sets, gene expression data, remotely sensed data of agricultural production or soil type determination and other kinds of GIS data).

**Notes:**

ASL is still at an early stage, but the great need for statistical analysis at ST requires more scientists to be appointed. Initially, we will seek to appoint a couple of postdocs. AGRO has offered to pay for one postdoc position, and at least one additional position can be financed through government contracts.

Two positions are advertised in the autumn of 2015. There is also a great need for instruction in applied Statistics, both at MATH and other departments at ST, and to a great extent ASL will come to cover this need. In connection with the planned Data Analysis study program, ASL will play an equally significant role.
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<tr>
<th>Strategy card: Department of Mathematics</th>
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<tbody>
<tr>
<td><strong>Vision</strong></td>
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<tr>
<td>To become the primary center for Mathematics in Denmark both for research and for education. Maintain an international reputation as a strong research department</td>
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<td><strong>Mission</strong></td>
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<td>To produce candidates of the highest caliber for the educational sector as well as for business and industry. Conduct excellent and influential research in pure and applied mathematics on an international level</td>
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<td><strong>Stakeholders</strong></td>
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<tr>
<td>Employers in businesses that use quantitative methods such as banks, insurance companies, biomedical and pharmaceutical companies. Higher education, high school and university. Government.</td>
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<tr>
<td><strong>Outcome areas</strong></td>
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<td><strong>Research</strong></td>
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<tr>
<td>• Promote research with high impact</td>
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<td>• Promote the interaction between pure and applied mathematics</td>
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<td>• Encourage increased interaction and joint research projects with other sciences</td>
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<td>• Increase the research in Data Analysis and have a strong scientific impact in the new Big Data Center</td>
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<td>• Increase production of highly skilled candidates with strong quantitative skills</td>
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<td>• Produce candidates with strong educational capabilities to improve the mathematics education in high schools</td>
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<td>• Produce strong research mathematicians both by sending talented young mathematicians abroad to study at</td>
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<td>• Develop new and innovative methods to teach mathematics through media based teaching. Make Aarhus the center for innovating and experimenting with new forms of communicating and teaching</td>
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<td>• Develop joint courses with other departments that show both the pure and the applied sides of mathematics</td>
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<td>• Start a new</td>
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<td>• Assist the departments that are heavily involved in public sector advice through our Applied Statistics Lab, to improve the analysis of their research data</td>
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<td>• Involve companies like Vestas and Novo which have employed our graduates in planning and financing our Data Analyst program</td>
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<td>• Offer Statistical Consultation to industry through our Applied Statistics Lab</td>
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<td>Strategic requirements</td>
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<tr>
<td>Values</td>
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<tr>
<td>Focus areas</td>
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</table>
| Research   | Raise our research profile by hiring a few stars and several young talents who can become leaders of research groups | Identify and hire outstanding young talent both domestically and internationally         | Increase publications in category 2 journals to 20 per year. Host at least one international conference every year. Continue and expand the research groups around the two centers and find new private funding after their funding from DG and Villum runs out. Build a strong research group in Data Analysis and create strong research ties with other ST departments, particularly CS and ENG and also continue the strong ties | 2016: Hire two Associate professors in Algebraic Geometry and Statistics-Data Analysis  
2017: Hire a strong senior researcher in Algebra as Full Professor. Hire several postdocs in Applied Statistics  
2018: As more senior colleagues retire, replace them with strong international researchers to rebuild and build new research groups  
We expect 5-6 retirements of senior researchers at the professor level in 2017,2018, 2019-2010  
Expand the group in Data Analysis by adding 2-3 Assistant Professors and postdocs.  
2019: Seek funding from private funds and businesses to create a named professorship in Data Analysis  
2020: |
<table>
<thead>
<tr>
<th>Focus areas</th>
<th>Strategic goals</th>
<th>Critical success factor</th>
<th>Goals</th>
<th>Initiative 2016-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Talent development</td>
<td>Increase the number of young researchers affiliated with the department. Both as local PhD students and increasingly by sending promising students to study at foreign universities. Long term this will build up our talent within the department.</td>
<td>Persuade more students to go abroad to study for PhD degrees.</td>
<td>Get at least 3 young talents a year accepted into PhD programs at prestigious foreign universities. Accept at least 2 foreign students every year into our PhD program. Use our international connections to initiate exchange agreements for PhD students.</td>
<td>2016: Send 2 local students to foreign PhD programs. Market our PhD program internationally 2018: Accept 2 foreign students into our PhD program 2019: Send 3-4 students abroad, 2020:</td>
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<td>Strategic goals</td>
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<td><strong>Talent development</strong></td>
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<td></td>
<td>International profile and provide a pool of talent to hire from</td>
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<td><strong>Education</strong></td>
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</table>
|               | To make the department a top innovator in media based education. Develop new cross- | Strong engagement from other ST departments in developing joint courses               | Offer at least 4 courses a year in collaboration with other ST departments, where each course is planned and taught by people from both MATH and another department | 2016: Roll out new Calculus 1 – 2 course  
Start topics course in Data Analysis for qualified students in MATH-ECON and also from qualified students from other departments  
2017: Roll out an advanced track in Data Analysis, at first within the MATH-ECON line but also open to advanced. |
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<td></td>
<td>departmental courses to benefit both students in MATH and also to increase the mathematical competences of students in other departments</td>
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<td>students from other departments. Start cross-departmental courses with lecturers from several ST departments 2018: Roll out a whole new Data Analysis education, joint with ECON, CS, ENG. 2019: 2020:</td>
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<td>Public sector advice</td>
<td>Expand our Applied Statistics Group to undertake projects from both private firms and government agencies, as well as assist departments that are heavily dependent on public sector advice contracts, to produce better analyses.</td>
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<td>2016:</td>
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<td><em>Industrial collaboration</em></td>
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<td>Leverage the Big Data/Data Analysis Center to increase collaboration with businesses that are heavily dependent on data, such as financial firm, insurance companies and medical/pharmaceutical companies</td>
<td>Giving the Applied Statistics Lab a more autonomous status in the department, with a director and budget</td>
<td>2016: 2017: 2018: 2019: 2020:</td>
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<td>Increase the industrial projects for ASL to at least 5 per year. If ASL can expand the number of VIPs a larger increase is possible Systematically market ASL as a service to industry</td>
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