NVAO • THE NETHERLANDS

INITIAL ACCREDITATION

ACADEMIC MASTER
SYSTEMS AND CONTROL
University of Groningen

FULL REPORT
2 JUNE 2022

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1 Peer review

The Accreditation Organisation of the Netherlands and Flanders (NVAO) determines the quality of a new programme on the basis of a peer review. This initial accreditation procedure is required when an institution wishes to award a recognised degree after the successful completion of a study programme.

The procedure for new programmes differs slightly from the approach to existing programmes that have already been accredited. Initial accreditation is in fact an ex ante assessment of a programme. Once accredited the new programme becomes subject to the regular review process.

The quality of a new programme is assessed by means of peer review. A panel of independent peers including a student reviews the plans during a site visit to the institution. A discussion amongst peer experts forms the basis for the panel's final judgement and the advisory report. The agenda for the panel visit and the documents reviewed are available from the NVAO office upon request.

The outcome of this peer review is based on the standards described and published in the limited NVAO Assessment framework for the higher education accreditation system of the Netherlands (Stcrt. 2019, nr. 3198). Each standard is judged on a three-point scale: meets, does not meet or partially meets the standard. The panel will reach a conclusion about the quality of the programme, also on a three-point scale: positive, conditionally positive or negative.

NVAO takes an accreditation decision on the basis of the full report. Following a positive NVAO decision with or without conditions the institution can proceed to offer the new programme.

This report contains the findings, analysis and judgements of the panel resulting from the peer review. It also details the commendations as well as recommendations for follow-up actions. A summary report with the main outcomes of the peer review is also available.

Both the full and summary reports of each peer review are published on NVAO's website www.nvao.net. There you can also find more information on NVAO and peer reviews of new programmes.

Because of COVID-19 temporary measures apply for this peer review.

2 New programme

2.1 General data

Institution	University of Groningen
Programme	Academic Master[1] in Systems and Control
Variants	Fulltime
Degree	Master of Science
Tracks	Not applicable
Location	Groningen
Study load	120 EC[2]
Field of study	Technology (CROHO sector Techniek) (confirmed by the panel)

2.2 Profile

The Master's programme in Systems and Control at the University of Groningen aims to train and prepare students to apply interdisciplinary strategies for the analysis and control of complex and heterogeneous engineering systems and processes. This involves mathematical systems modelling, control theory, analysis of dynamical data, optimization, and network theory. The focus of the programme is on 'Complex Systems and Networks'. The most challenging problems in today's engineering systems relate to systems that consist of many components that influence each other and whose structure and dynamics are very complex and difficult to control, such as the electricity network, Facebook or the human brain. In these complex systems, each individual component interacts (physically or via digital information) with a portion of all other components with the pattern of connections defining the network. The students in this master programme learn the underlying theory to analyse and control complex systems, in a way that provides provable guarantees for the regulated behaviour of the system. They learn to use this theory in a critical way in a series of applications, whereby the understanding of the methods used is paramount.

2.3 Panel

Peer experts

- Prof. dr. Gerrit Muller (*chair*), Programme manager MSc Systems Engineering, University of South-Eastern Norway, Kongsberg, Norway; Senior Research Fellow, Embedded Systems Institute TNO-ESI, Eindhoven, Netherlands;
- Prof. Bo Wahlberg, Professor and Head of the Division of Decision and Control Systems, School of Electrical Engineering and Computer Science, KTH Royal Institute of Technology, Stockholm, Sweden;
- Prof. dr. ir. Marcel Heertjes, Professor in Control Systems Technology, Eindhoven University of Technology, Netherlands; Principle Engineer and Control Competence Leader, ASML Department of Mechatronic Systems Development, Veldhoven, Netherlands;
- Laura Janssen BSc (*student*), Student MSc Civil Engineering and Management, University of Twente, Enschede, Netherlands.

Assisting staff

- Dr. Marianne van der Weiden, secretary;
- Michèle Wera MA, NVAO policy advisor and process coordinator.

Site visit (online)
Groningen, 2 May 2022

[1] In Dutch: wo-master
[2] European Credits

3 Outcome

The NVAO panel reaches a positive conclusion regarding the quality of the master's programme in Systems and Control offered by the University of Groningen. The programme complies with all standards of the limited NVAO framework.

Students of the master's programme in Systems and Control in Groningen learn to use interdisciplinary strategies to control complex systems and processes. The programme distinguishes itself from the other Systems and Control programmes in the Netherlands, offered by the three technical universities, by its theoretical approach and focus on mathematics and control theory. This focus fits well with the research projects of the teaching staff. The regional industrial partners have been involved in the design of the programme. They have indicated their willingness to welcome not only the graduates, but also students who wish to do a design project in their company.

The first year of the programme consists of compulsory and elective courses. The programme offers a good mix of mandatory courses forming the foundation. Because students entering the programme have different bachelor's degrees, the first course is specifically intended to bring all students to the same level in mathematics and control theory. By choosing their elective courses students can tailor the programme to their interest and ambitions. The teaching and assessment methods in most courses are rather traditional. The panel advises adopting a more activating didactic approach. The panel also advises organising teaching team meetings to ensure coherence between the courses. In the second year, students work on a design project in a company and a research project within one of the programme related research groups of the university. In the design project students learn to apply their knowledge to current challenges and gain practical experience. In the research project they prepare their master's thesis. In the design project, the academic supervisor should be involved from the beginning to avoid a divergence of expectations with the company supervisor. The panel advises to have an evaluation early in the project. A go/no go decision only half-way during the project will make it almost impossible for a student to make adjustments in time. The teaching staff is substantively and didactically well-qualified and eager to teach students state-of-the-art knowledge in the domain of complex systems and networks. Students are given timely and sufficient information about the programme. They can call upon a tutor and an academic advisor for guidance in choosing their courses and projects. The examinations and assignments are of good quality. Both the design and the research project are assessed by two academic supervisors on the basis of well-defined criteria and clear assessment forms. The Board of Examiners plays an active role in ensuring the assessment quality and the level of the degree.

The panel agrees with the programme that a two-year curriculum is necessary to cover all intended learning outcomes and relevant topics. A one-year programme could not include the design and research project, while these are essential for students to gain experience with academic and industrial projects. A study duration of two years is also in line with that of related international and national programmes.

Standard	**Judgement**
1. Intended learning outcomes	meets the standard
2. Teaching-learning environment	meets the standard
3. Student assessment	meets the standard
Conclusion	*positive*

4 Commendations

The programme is commended for the following features of good practice.

1. Balanced curriculum – The programme has a solid theoretical base in mathematics and control theory and also pays explicit attention to engineering aspects. In addition to the mandatory courses, students can choose a set of relevant elective courses in line with their interest and ambition.

2. Strong foundation – The programme builds on experiences from existing Systems and Control programmes in the Netherlands and on its academic staff's strong research profile.

3. Projects – The second year consists of a design project and a research project. In these projects students learn to actively apply their knowledge in solving scientific and practical problems.

4. Teaching staff – The programme is taught by a large number of well-skilled staff members with extensive expertise in the field of Systems and Control.

5. Student assessment – The quality of examinations and assignments is good and the Board of Examiners plays a proactive role in monitoring and assuring this quality.

5 Recommendations

For further improvement to the programme, the panel recommends a number of follow-up actions.

1. Programme profile – Clarify to potential new students the more mathematical, theoretical position of the programme in Groningen, as compared to the other Systems and Control programmes at the technical universities. Also, explain to industrial partners that the programme in Groningen is not a standard systems and control programme, but that it focuses on complex systems and networks.

2. Coherence of the curriculum – Organise regular teaching team meetings to align the courses and ensure that the programme is more than the sum of its parts.

3. Teaching methods – Adopt a more activating didactic approach in teaching and assessment in the theoretical and elective courses.

4. Projects – Arrange regular academic supervision and early design project and research project evaluation; a no-go only half-way the project is not in time. Liaise with industrial partners to make sure that assignments in the design project focus on the complex interconnected systems, rather than on more ‘standard control design’ systems.

6 Assessment

6.1 Standard 1: Intended learning outcomes

The intended learning outcomes tie in with the level and orientation of the programme; they are geared to the expectations of the professional field, the discipline, and international requirements.

Judgement
Meets the standard.

Findings, analysis and considerations

Intended learning outcomes
Graduates of the master's programme in Systems and Control (further: S&C) offered by the University of Groningen have learned to use interdisciplinary strategies to control complex systems and processes. They have acquired the underlying theory to analyse and control complex systems and to provide provable guarantees for the regulated behaviour of the system.

Level
The programme has used appropriate frameworks to formulate the intended learning outcomes at master's level, such as those of the European Accreditation of Engineering programmes (EUR-ACE), the Accreditation Board for Engineering and Technology (ABET-USA), the Dublin descriptors at master's level and the review written by the International Federation of Automatic Control (IFAC). A matrix shows how the intended learning outcomes fit with these frameworks. The learning outcomes are clear, balanced and focused on this specific programme without being over-specific. The academic nature of the programme is well-reflected in the focus on theoretical and methodical content and a substantial academic research project.

Profile
Currently, three other programmes in S&C are offered by the technical universities of Delft, Eindhoven and Twente. The four programmes have a common core, including the most important aspects of modelling, identification and analysis of data, the theory of systems and control and control engineering, while each also has its own distinct character. The profile of the programme in Groningen has its focus on network systems and distribution optimisation, on non-linear control and the mathematical theory of systems and control. The panel recognises that the programme, not being organised by a technical university, distinguishes itself by a solid basis in mathematics and control theory, while also paying attention to the engineering side. The panel commends the programme for this focus, building on the experiences from existing systems and control programmes and its own strong research profile in the domain. It is advisable to clarify this focus to potential new students so they will recognise the difference compared to the other systems and control programmes.

Relation to professional field
The documentation describes how professionals from the industrial sector in the region were consulted, indicated their support for the new programme and gave feedback on the learning outcomes and the curriculum. Several companies have shown their interest in graduates of the S&C programme. The programme intends to set up a dedicated External Advisory Panel composed of engineers from the industrial sector to ensure that graduates are well equipped for their future careers. During the site visit the panel met with a number of representatives from the professional field, who confirmed this support, including their willingness to accommodate students with design projects. The discussion showed, however, that Industry considers this as a standard systems and control programme. The panel notes that the focus on complex systems and networks apparently needs further clarification for a good positioning of the programme.

Conclusion
The panel concludes that the programme's intended learning outcomes are clear and balanced, defined at an academic master's level, and reflecting the requirements formulated by international professional bodies. They combine the common core of the other S&C programmes in the Netherlands with the university's own strength in mathematics and control theory. The panel advises stronger positioning the programme by clarifying its distinctive profile to both potential students and the regional industry partners to avoid misunderstandings. The intended learning outcomes meet the standard.

6.2 Standard 2: Teaching-learning environment

The curriculum, the teaching-learning environment and the quality of the teaching staff enable the incoming students to achieve the intended learning outcomes.

Judgement
Meets the standard.

Findings, analysis and considerations

Curriculum
The programme offers a good mix of mandatory courses forming the foundation (25 EC) and elective courses (35 EC) in the first year, and project work (20 EC design project and 40 EC research project) in the second year. The academic year consists of two semesters, each divided in two blocks. Courses are taught in parallel, and students can take three courses per block. The first mandatory course (Advanced Systems and Control) is designed for the new programme and is meant to bring all students, with their diversity of bachelor backgrounds, up to the same level and have them speak the same language. Other mandatory courses are Fitting Dynamical Models to Data, Robust Control, and Modeling and Control of Complex Nonlinear Engineering Systems. The final mandatory course will be an integration project. Some of the mandatory courses and all electives are existing courses in related master's programmes and lecturers informed the panel that these courses will be adapted to the new audience of S&C students. Electives can be chosen from a set of thirteen courses. Theoretically, students can ask permission to choose an elective in an S&C programme at another university, which could be an attractive addition for some students, but the panel agrees that, logistically, this is not feasible. The proposed set of electives is based on the lecturers' expertise and will allow students to tailor their own learning process sufficiently. From the discussion with the teaching staff, it appears that teachers are highly motivated to offer state of the art teaching in their courses, but that there is limited interaction among them to ensure a cohesive programme. They expect that any shortcomings will be pointed out by the programme committee, based on student evaluations. The panel advises to approach this more proactively and organise regular teaching team meetings to align the courses and ensure that the programme is more than the sum of its parts.

The design and research project provide a basis for active contextual learning. In the design project, students have the opportunity to explore the industrial sector and apply their knowledge to current challenges and gain practical experience. Thus, the design project plays a critical role in the programme. Students will be supervised by a company supervisor and two university supervisors. The project will be executed at the company premises and be guided by the company supervisor. In a kickoff meeting before the start of the project, the student, first university supervisory and company supervisor will discuss the project proposal. Halfway through the project, the student will have a mid-term evaluation with the first university supervisor. The project is completed with a final report and presentation, to be assessed by both university supervisors. The panel appreciates the combination of company and university supervision, but considers a mid-term evaluation with a go/no go decision to be too late. At that stage, it will not be possible to adapt the project in a meaningful way. The panel advises to arrange regular academic supervision and early project evaluation. Based on the discussion with the professional field, the panel notes that assignments from industry appeared more 'standard control design' systems rather than complex interconnected systems and suggests that this requires some alignment.

The research project takes place in the research groups of the Engineering and Technology Institute Groningen (ENTEG) and the Bernoulli Institute. The student and first supervisor will have a kickoff meeting to discuss the project and a mid-term evaluation. The research will be completed by a master's thesis and a presentation to an academic and professional audience, assessed by two university supervisors. Similar to the design project, the panel considers the mid-term evaluation to be too late and advises arranging regular academic supervision and early project evaluation.

Teaching philosophy
Teaching in the S&C programme is based on research driven education: current scientific articles and the lecturer's own research are essential elements in all courses and students spend a significant part of their studies on an individual research project. The panel agrees that this is a suitable approach for an academic master's programme. Most lecturers apply a traditional way of teaching, i.e. lectures, followed by a written exam. The panel wonders if this is an appropriate method to teach students to apply their knowledge. It advises to evolve in

the theoretical and elective courses more toward active learning with related assessments forms to ensure that the learning objectives can be achieved. From the discussions during the site visit, it appears that first steps in this direction are taken by new lecturers. The panel encourages the programme to continue these efforts.

Admission
The S&C programme has formulated suitable admission requirements to ensure that all students will be able to complete the programme. Students should have sufficient knowledge of mathematics, basic control theory and engineering, and an adequate level of English language proficiency. A list of bachelor programmes offering direct admission is provided. For other diplomas, an individual decision of the Admission Board is necessary. As mentioned above, the first course in the programme will bring the students, regardless of their bachelor programme, to a comparable level by providing an overview of current developments in the theory and applications of systems and control.

Student information and guidance
The programme director, programme coordinator, academic advisor and programme secretary are all available for students with questions. At the start of courses, introductory sessions are organised by the lecturer. The Teaching and Examination Regulations (TER) and all course information are available online via the student portal. In addition, a tutor and an academic advisor will have regular meetings with students to discuss their career ambitions and choice of electives. The panel expects that these facilities will help students well to steer their learning paths.

The panel appreciates the attention to career guidance in the S&C programme. In addition to the design project mentioned above, students will meet professional practice through guest lecturers from industry partners who will bring in new innovations, and through industry safaris where students do a challenge in a company for one or a few days. These activities are organized by the Groningen Engineering Business Center. The representatives from the professional field added that they may offer internships as well. The Faculty of Science and Engineering (FSE) organises Career Days and Beta Business Days and supports a vacancy database for internships and assistantships.

English language
The panel fully agrees with the programme's arguments to use English as its working language, as described in the documentation. The S&C programme prepares students for a career in an international environment in which colleagues of different nationalities work together and in which English is the main language, both for daily conversations and in scientific literature and meetings. The S&C programme has therefore an English name and is taught in English to an international cohort and by international staff. This international classroom offers students a versatile and challenging context for their training in knowledge and skills. It acquaints them with functioning in a heterogeneous group, which will come in useful in future job situations. In addition, students participate in internationally oriented research groups and learn from English-language textbooks and scientific literature. The majority of future employers of the graduates of this master's programme require that they speak fluent English and are able to work together with international colleagues. The field of engineering is extremely international and English is the main language of the engineering master's programmes at Dutch universities. The majority of staff members involved do not speak Dutch as natives. Qualified staff are recruited nationally and internationally. They form an international education and research community in which the students of the programme are included. English proficiency is therefore a requirement for all staff members who are involved in lecturing and research. The panel appreciates that for personnel that might feel uncomfortable using the English language, the University of Groningen language center offers a wide range of English courses and coaching on the job, to be followed on their own initiative or on the initiative of the programme director.

Staff
Eight full professors, one associate professor and five assistant professors will be teaching in the programme. The CVs provided confirm the active involvement of (senior) teachers that well match the academic standards in S&C. All coordinating lecturers have a PhD and are actively engaged in research, enabling them to incorporate the latest developments in their field of research into the curriculum. All lecturers either have obtained the University Teaching Qualification or are in the process of doing so. Even taking into account that all lecturers have teaching responsibilities in other programmes as well, the panel is convinced that the available teaching staff will be sufficient for the expected influx of 20-30 students per year. As mentioned above, guest lectures will be invited as additional lecturers. The panel is also convinced that the lecturers are well-skilled and experts in their field. Less

clear is how individual teachers will cooperate to come to a joint proactive ownership and be responsible for a strong cohesion within the programme. The panel advises to establish such ownership.

A programme committee will be responsible for issuing advice on the quality of the programme, including the annual assessment of the implementation of the TER. The programme committee for the S&C programme will be a joint committee for the master's programmes in (Applied) Mathematics and S&C. Half of the members will be students enrolled in one of these programmes, while the other half will consist of academic staff members teaching in one or more of these programmes.

Facilities
The programme's facilities will offer adequate laboratories and equipment for the S&C students, specifically the Discrete Technology & Production Automation labs with a variety of robotic and mechatronic systems. In 2023, the research groups of ENTEG and some lecture halls will relocate to the new Feringa building.

Conclusion
The curriculum offers courses and projects that will enable students to achieve the intended learning outcomes, offered by a sufficient number of qualified lecturers with a good coverage of knowledge areas and a solid teaching track-record in applied mathematics and control. The elective courses are a good complement to the mandatory theoretical courses. Because the programme, however, seems to lack clear ownership and coordination between courses, the panel advises improving synergy and interaction among the different courses, electives and lecturers. The panel also suggests evolving toward a more active learning approach. The design and research project in the second year are an excellent way for students to apply their theoretical knowledge in practice. Since the professional field appears to have assignments in mind that are 'standard control design' systems rather than complex interconnected systems, this requires some alignment of expectations. The panel also advises an earlier project evaluation than the proposed mid-term evaluation in both design and research project. The admission criteria and procedure, guidance of students, use of the English language, programme committee and facilities are all adequate and convincing, and contribute to the programme's strength. The panel concludes that the teaching-learning environment meets the standard.

6.3 Standard 3: Student assessment

The programme has an adequate system of student assessment in place.

Judgement
Meets the standard.

Findings, analysis and considerations

Assessment policy
Assessment in the S&C programme follows the well-designed assessment policy of the Faculty of Science and Engineering. Annually, an assessment plan is drawn up and must be approved by the FSE Board. This plan contains the learning outcomes of the programme and its courses, the examiners and assessment modes per course and a list of supervisors, appointed by the Board of Examiners (BoE). An assessment programme must include varied and transparent modes of assessment and provide opportunities for regular feedback. At course level, a course unit assessment overview will be available for relevant lecturers and committees, while a general course description, including information on assessment, will be provided to students. As a rule, examinations and assignments will be drafted or checked by two lecturers to ensure that they are clear and unambiguous, and sufficiently assess whether the learning outcomes of the course have been attained. The panel considers that the implementation of this assessment policy ensures the validity, reliability, and transparency of student assessment in the S&C programme.

Assessment methods
The panel reviewed a sample of examinations and assignments provided with the documentation and confirms that they are of the right level and complexity. The panel was pleased to hear during the site visit that in most courses these theoretical exams are complemented by other assessment modes, such as presentations. As mentioned in the previous paragraph, the design and research project are examined by two academic supervisors. In the design project, the company supervisor plays an advisory role in the assessment procedure. This is, in itself,

a suitable arrangement, but the panel sees a risk in having two parties (staff members and company supervisor) with different responsibilities and possibly different interests. If in disagreement, this may come at the expense of the student. Another point of attention is the mid-term evaluation as a go/no go moment for the student. To address both issues, the panel advises to arrange regular academic supervision and early project evaluation. The latter point also applies to the research project. The panel appreciates the elaborate assessment forms and rubrics for both projects and the requirement that the examiners must provide a written explanation of their grade.

Board of Examiners
The BoE is responsible for the quality of examinations and final assessments, and thus that of degree certificates, and monitors compliance with the TER. The BoE advises the programme management on the assessment plan in terms of knowledge and skills and whether the modes of assessment are in line with the intended learning outcomes. The Board looks at the modes of assessment at course level, once a year for new courses, or else every three years. Exemptions and extensions requested by students must be approved by the BoE. Cases of suspected fraud are handled by them as well.

Conclusion
The panel concludes that the student assessment system is commendable: all statutory requirements are met. For the design and research project, the panel advises an earlier project evaluation than proposed, and in the design projects, the expectations of the company supervisor and university supervisors should be well-aligned. These comments do not, however, detract from the panel's positive conclusion that the programme's student assessment meets the standard.

6.4 Degree and field of study

The panel advises awarding the following degree to the new programme: Master of Science.
The panel supports the programme's preference for the following field of study: Technology (CROHO: Techniek).

6.5 Programme extension

Findings, analysis and considerations
As required by law, the university has substantiated the 120 EC duration of the S&C programme according to the NVAO protocol. As described in this protocol (updated per March 2022), the programme should demonstrate that the extended study duration is required to achieve the final level as desired in an international perspective and/or achieve the final level as determined, based on the criteria of the professional domain.

A comparison with similar programmes in Europe is provided in the application dossier and shows that the majority of these programmes has a duration of 120 EC. In addition, a comparison with other master's programmes in S&C in the Netherlands is given, which shows that all these programmes have a duration of 120 EC. The panel agrees with this and adds that, from a European perspective, a study duration of two years is necessary for an S&C programme, especially for students who want to do a PhD abroad.

The intended learning outcomes for the S&C master's programme have been formulated by considering the domain-specific frameworks of reference of the European Accreditation of Engineering programmes (EUR-ACE) and the Accreditation Board for Engineering and Technology (ABET) in the USA, and by discussions with scientific staff and representatives of the industrial sector to tailor the learning outcomes and, subsequently, the curriculum toward the academic and industrial needs.

All FSE degree programmes are based on research-driven education. For master's degree programmes, the students spend at least seven to eight months working on individual research projects. In addition, S&C students spend three months on a design project in the industrial sector. The design and research project together amount to 60 EC of the 120 EC programme. Both the international perspective and the requirements of the professional domain expect the S&C graduates to have acquired not only a solid theoretical basis, but also extensive experience with performing research and design projects, both in academia and in the industrial sector. The time required to perform these projects, corresponds with the additional 60 EC of the programme.

The learning outcomes of the S&C programme comply with the expectations of international and professional stakeholders and fit the civilian effect of the programme, i.e. the engineer's title, paving the way to a career in engineering research and industry. The learning outcomes are translated into the courses provided in the first year of study and into the research and design project in the second year. They guarantee that the programme delivers the graduates that the job market desires. The panel agrees that without the 60 EC of the research and design project, students will not be able to gain the experience and additional knowledge to compete and be of added value to the job market and academia.

Conclusion

The panel concludes that it is not possible to cover all intended learning outcomes and relevant topics in one year. In a 60 EC programme, without the design and research project, the achievement of the intended learning outcomes cannot reasonably be expected. A study duration of 120 EC (two years) is in line with that of related international and national programmes. The panel advises NVAO to submit a positive advice to the Ministry of Education and Science for an extended study duration of 120 EC of the S&C master's programme.

Abbreviations

ABET-USA	Accreditation Board for Engineering and Technology
BoE	Board of Examiners
CROHO	Centraal Register Opleidingen Hoger Onderwijs (Central Register of Higher Education Programmes)
EC	European Credit
ENTEG	Engineering and Technology Institute Groningen
EUR-ACE	European Accreditation of Engineering programmes
FSE	Faculty of Science and Engineering
IFAC	International Federation of Automatic Control
NVAO	Nederlands-Vlaamse Accreditatie Organisatie (Accreditation Organisation of the Netherlands and Flanders)
S&C	Systems and Control
TER	Teaching and Examination Regulations

The full report was written at the request of NVAO and is the outcome of the peer review of the new programme
MSc Systems and Control of the University of Groningen

Application no: AV-1188

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