S.20-108

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MEMORANDUM

ATTENTION	Senate	**DATE**	September 15, 2020
FROM	Jon Driver, Vice-President, Academic and Provost *pro tem,* and Chair, SCUP	**PAGES**	1 of 1
RE:	Full program proposal for a Master of Engineering in Smart Manufacturing (SCUP 20-36)		

At its September 9, 2020 meeting, SCUP reviewed and approved the full program proposal for a Master of Engineering in Smart Manufacturing and Systems.

Motion:
That Senate approve and recommend to the Board of Governors the full program proposal for a Master of Engineering in Smart Manufacturing and Systems within the School of Mechatronic Systems Engineering in the Faculty of Applied Sciences, effective Fall 2021.

For Information:
Included in the full program proposal and approved by SCUP subject to approval by Senate:
New calendar entry: Master of Engineering in Smart Manufacturing and Systems
New Courses:

MSE 910 Industrial Internet of Things
MSE 923 Smart Factory I
MSE 924 Smart Factory II
MSE 980 Industry 4.0
MSE 981 Industrial Big Data Analytics

C: U. Glasser, E. Park

SFU GRADUATE AND POSTDOCTORAL STUDIES

SCUP 20-36

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MEMORANDUM

ATTENTION Senate Committee on University Priorities (SCUP)

DATE August 28, 2020

FROM Jeff Derksen, Chair of Senate Graduate Studies Committee (SGSC)

RE: Full Program Proposal: Master of Engineering in Smart Manufacturing and Systems

For approval:
At its meeting of July 7, 2020, SGSC approved the full program proposal for a Master of Engineering in Smart Manufacturing and Systems from the School of Mechatronic Systems Engineering, effective **Fall 2021.**

Motion:
That SCUP approve and recommend to Senate the full program proposal for a Master of Engineering in Smart Manufacturing and Systems from the School of Mechatronic Systems Engineering.

For Information:
Included with the full program proposal and approved by SGSC subject to approval by Senate:

1) New calendar entry: Master of Engineering in Smart Manufacturing and Systems
2) New courses: MSE 910 Industrial Internet of Things
   MSE 923 Smart Factory I
   MSE 924 Smart Factory II
   MSE 980 Industry 4.0
   MSE 981 Industrial Big Data Analytics

OFFICE OF THE DEAN
Faculty of Applied Sciences
Simon Fraser University

MEMORANDUM

Attention Dr. Jeff Derksen
Dean, Graduate Studies

Date: June 10, 2020

From Dr. Parvaneh Saeedi
Faculty of Applied Science, Graduate Studies Committee

psaeedi@sfu.ca

Re: FAS-MSE's new Professional Master's Program

The faculty of Applied Sciences Graduate Studies Committee has approved the attached FPP for the Masters of Engineering in Smart Manufacturing and Systems from the School of Mechatronics System Engineering. Please kindly review and consider it for the submission to the next SGSC meeting set for July 7th, 2020.

Regards,
Parvaneh Saeedi

FACULTY OF APPLIED SCIENCES
School of Mechatronic Systems Engineering

Central City Galleria 4, 4388
250-13450 102 Avenue,
Surrey, BC Canada V3T 0A3

Edward J. Park, PhD, PEng
Professor & Director (*Interim*)
Associate Member, Faculty of Health Sciences

TEL: 778.782.8662
FAX: 778.782.7514
EMAIL: ed_park@sfu.ca

MEMORANDUM

Date: June 9, 2020
To: Dr. Parvaneh Saeedi, Associate Dean, Research & Graduate Studies, Faculty of Applied Sciences
From: Dr. Ed Park, Acting Director, School of Mechatronic Systems Engineering
Re: FPP for MSE PMP in Smart Manufacturing and Systems (a.k.a. Industry 4.0)

Please find enclosed the FPP for the proposed Masters of Engineering in Smart Manufacturing and Systems from the School of Mechatronic Systems Engineering. Would you please review and approve it for the submission to the next SGSC meeting on July 7?

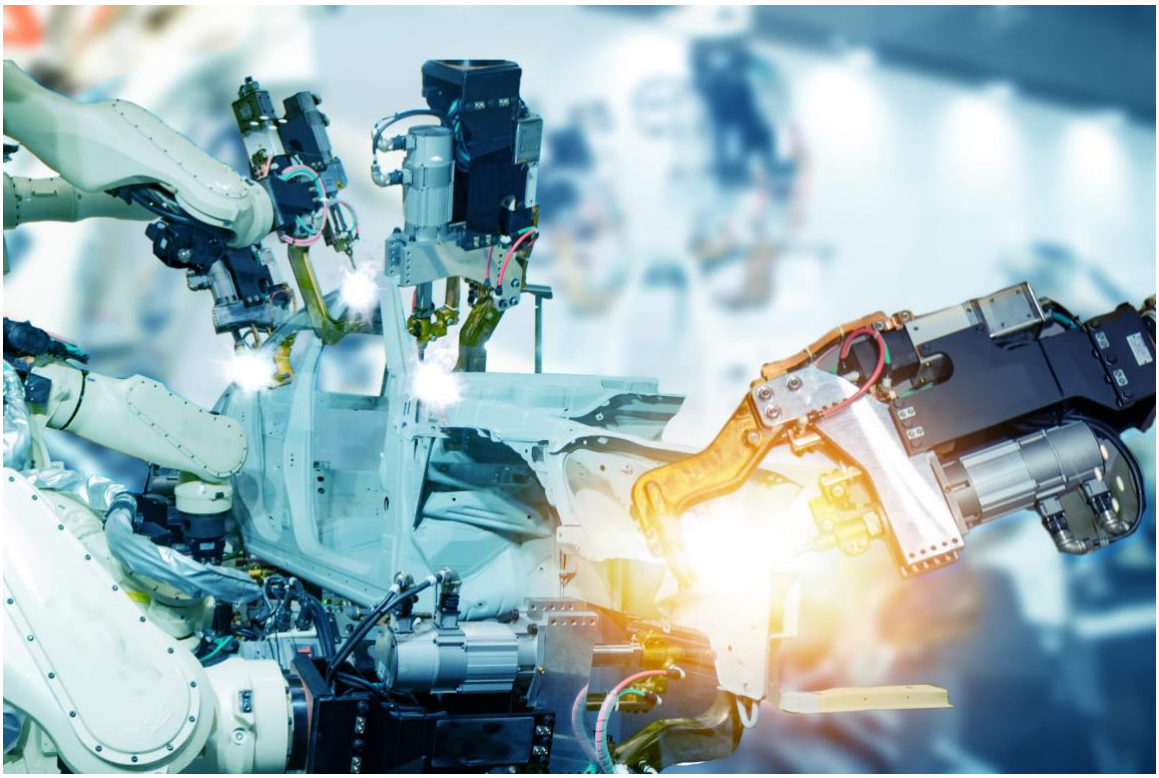
Best regards,

Ed Park

SIMON FRASER UNIVERSITY
ENGAGING THE WORLD

Smart Manufacturing and Systems

Full Program Proposal



29 June 2020

School of Mechatronic Systems Engineering

Faculty of Applied Sciences

SUMMARY

As Canada's engaged university, Simon Fraser University is defined by its dynamic integration of innovative education, cutting-edge research and far-reaching community engagement. SFU was founded in 1965 with a mission to bring an interdisciplinary approach to learning, embrace bold initiatives, and engage with communities near and far. Today SFU is consistently ranked amongst Canada's top comprehensive universities and is one of the world's leading teaching and research institutions.

The School of Mechatronic Systems Engineering (MSE) proposes the creation of a Master of Engineering in Smart Manufacturing and Systems, which will align and reinforce SFU's strategic and academic plans, as well as reinforce the Province of British Columbia's commitment to stimulate industry-focused programs that support high demand occupations in the province's technology sector. This will be achieved through the delivery of a unique interdisciplinary program in Smart Manufacturing and Systems. Students will emerge from the program with the interdisciplinary skills needed to meet the province's growing demand for Advanced Manufacturing professionals, as well as the capacity to become national and international leaders in developing engineering solutions for increasingly smart manufacturing facilities.

The future of manufacturing in the fourth industrial revolution, tagged as "Industry 4.0," emerges from AI, automation and robotics, *cyber-physical systems*[1], the Internet of Things (IoT) and other transformative technologies like *digital twins*[2]. In the Industry 4.0 future, smart factories using additive manufacturing such as 3D printing and other computer-aided manufacturing systems are able to adaptively manufacture parts on demand, direct from digital designs. Sensors keep track of needed components and order them based on patterns of demand, taking "just-in-time" manufacturing to a new level of optimization. Entire supply chains can pivot with the introduction of new products, changes in consumption, and economic fluctuation. Optical sensors and machine-learning-driven systems monitor the quality of components with more consistency and accuracy. Algorithms can predict when machines need to be fixed before they even break or dynamically reorganize production lines to enhance efficiencies because of artificial intelligence processing the massive amounts of data generated by IoT technology deeply integrated into the manufacturing process.

[1] Cyber-physical systems are integrations of computation, networking, and physical processes with feedback loops, where physical processes affect computations and vice versa.

[2] A digital twin is a virtual model of a process, product, service or system across its lifecycle using real-time data to enable analysis, learning and reasoning.

1) Proposed credential to be awarded

Master of Engineering (M.Eng.) in Smart Manufacturing and Systems.

2) Location of program

The Smart Manufacturing and Systems (SMS) program will be hosted in the SFU Surrey campus. Its close proximity to Surrey City Hall and the developing Industry 4.0 industry clusters within the South Fraser region will allow for enhanced collaboration in building a sector-specific graduate engineering program that leads the change in manufacturing and operations in British Columbia.

3) Academic unit(s) offering proposed program

The new program will be offered by the School of Mechatronic Systems Engineering in the Faculty of Applied Sciences, in collaboration with the School of Computing Science.

4) Anticipated program start date

Fall 2021.

5) Anticipated completion time

It is anticipated that the program will typically be completed in four to five terms (16 or 20 months). The duration depends on whether the students take a four or eight-month internship during their study.

6) Contact information

Dr. Edward Park, Professor and Director (*Interim*), 778-239-0196, ed_park@sfu.ca

Dr. Uwe Glässer, Professor, 778-782-6775, glaesser@sfu.ca

PROGRAM DETAILS

7) Aims, goals and/or objectives of the proposed program

The primary goal of the proposed Smart Manufacturing and Systems (SMS) program is to help British Columbia and Canada to become more competitive in the race to implement innovative manufacturing technologies and systems. Canada's manufacturing industries employ 1.7 million people—10% of the Canadian workforce—and generate 42% of all private-sector research and development activity. Canada's strategic economic objective for advanced manufacturing is to increase both manufacturing sales and also exports by 50% each by 2030, to $1 trillion and $540 billion respectively.[3] However, because of fierce global competition and fast paced changes in the manufacturing sector, Canada has serious skill gaps and labour shortages in manufacturing: "skilled and digitally skilled labour are in short supply,"[1] which will greatly weaken Canada's competitiveness. The international market is embracing Industry 4.0, which rapidly alters traditional manufacturing, "providing a huge competitive advantage to economies such as China, U.S.A., Germany, and Japan that are investing strategically in technology and innovation in this sphere."[4] According to the latest labour market development strategy study by the City of Surrey, the skills gap for advanced manufacturing directly affects economic development in Surrey.[5]

The leading-edge professional graduate degree program in SMS offers unique hands-on training in Industry 4.0 technologies, paired with real-world experience from an industrial internship program of at least four months; this way, it prepares graduates for working in the manufacturing sector related to Industry 4.0 and expedites their absorption into the job market. The existing Siemens Mechatronic Certification Program (SMCP) and industrial training equipment already available in the School of Mechatronic Systems Engineering (MSE) offers additional hands-on qualifications that will position SMS among the elite professional engineering programs in Canada. Graduates from the SMS program will be predestined to become leaders (engineering managers and entrepreneurs) in technology innovation shaping our future. While Siemens is a partner for SMCP, the company will not directly be involved in the design or delivery of the SMS program. However, it may serve in an advisory role and, through the already established Siemens Canada Engineering and Technology Academy model, contribute in further advancing the program to be in line with future Industry 4.0 needs of Canada's manufacturing economy.

Given the projected economic growth in advanced manufacturing, the increasing domestic and international demand for skilled labour in this sector, and the profound experience with

3 The Innovation and Competitiveness Imperative: Seizing Opportunities for Growth. Report of Canada's Economic Strategy Tables: Advanced Manufacturing. ISEDC, Government of Canada, 2018. https://www.ic.gc.ca/eic/site/098.nsf/eng/00021.html.

4 Western Canada Advanced Manufacturing Conference, Seeding the Revolution: The Dialogue for Advancing Manufacturing Innovation & Transformation in Canada, Surrey, BC, 2017.

5 Surrey Advanced Manufacturing and Innovation Economy: Labour Market Development Strategy, 2018. https://investsurrey.ca/sites/default/files/docs/amie_labour_market_development_strategy_final.pdf

professional training in mechatronic systems engineering, one can expect strong demand for the proposed program. This also means a steady revenue stream for MSE, FAS and SFU.

8) How does the proposed program fit within the mandate of the institution?

The proposed program in SMS builds upon the Faculty of Applied Sciences' strong commitment to technology-based innovation and furthers SFU's interest in supporting the development of vibrant and technologically innovative communities. Through partnerships with the City of Surrey and industry leaders (such as Siemens, FESTO, KUKA Robotics) and by offering a cutting edge curriculum, this program is positioned to advance Faculty and University level goals in several key areas such as expanding industry collaborations within the South Fraser region, strengthening ties with the City of Surrey and surrounding municipalities, and expanding the talent pool for the manufacturing sector related to Industry 4.0.

9) How does the proposed program support the current academic and strategic plan of the institution?

The proposed SMS program is a direct outcome of the Faculty of Applied Sciences (FAS) Academic Plan 2019-2024[6], which outlines expansion and diversification of professional graduate programs. It also contributes to SFU's strategic interest in capitalizing on opportunities and needs to advance innovation and exciting academic programming in Surrey, especially in creative technologies with special focus on professional degrees at the master's level[7]. The program will have a strong applied orientation on education and hands-on training to prepare graduates for working in the manufacturing sector related to Industry 4.0.

The mission of FAS' "applied sciences" is to address problems in society that are increasingly becoming complex and interdisciplinary. The flexibility of this proposed new graduate initiative allows us to deal with the vast cross-disciplinary nature of this highly innovative sector that spans mechatronic systems engineering, manufacturing engineering, computer science, operations research, and other disciplines. This diversity will be reflected in the composition of the curriculum and the course structure, aiming for a wide range of knowledge and skills to optimally prepare graduates to work in professional environments that require a broad understanding of several key enabling technologies such as Internet of Things (IoT), robotics and automation, predictive maintenance, data analytics and AI.

10) Target Audience

The target audience for the SMS program is domestic students after completing a professionally accredited undergraduate engineering program and engineering professionals who are seeking to enhance their career opportunities in the emerging area of Industry 4.0. The program appeals to this audience for several reasons. First, the significant need of highly qualified personnel for

[6]Faculty of Applied Sciences, Academic Plan 2018-2023, updated June 2018, (Source: https://www.sfu.ca/content/dam/sfu/vpacademic/files/vp_academic_docs/pdfs/AppliedSciences2019-2024.pdf)

[7]Simon Fraser University, Five-Year Academic Plan 2019-2024, updated November 2018, (Source: http://www.sfu.ca/content/dam/sfu/vpacademic/files/academic_planning/SFU-Academic-plan-2019-2024.pdf)

adopting Industry 4.0 standards and technology in smart manufacturing, now and even more so in the future, means attractive employment opportunities. Second, the program offers a distinctive combination of the three key concentrations: hands-on experiential learning and training, specialized academic courses in Industry 4.0, and experiential learning through industrial internships at high-tech firms across Canada. Third, the integration of several transformative technologies such as automation and robotics, AI, predictive analytics, IoT and their fusion in interdisciplinary application fields naturally extends beyond smart factories to other high-tech sectors including but not limited to cyber-physical systems, smart transportation networks, and smart cities.

In addition to the primary target audience, qualified international students can also apply to the program, but only for spots that are not need for domestic students and would be left unfilled otherwise. A higher tuition fee for international students helps subsidizing a lower tuition fee for domestic students and also pay for the professional Industry 4.0 training equipment.

The ongoing SMSCP certificate program has graduated 120 students over the past two years, which is strong evidence of its demand and success. It is a comprehensive industry skills certification program offered in collaboration with Siemens, one of the world's largest high-tech manufacturers. Through its hands-on training focusses on automated assembly lines, SMSCP creates highly talented professionals who can easily meet essential challenges of high-tech automation industries. Applicants mostly consisted of existing upper-level undergraduate engineering students from SFU. These students were interested in enhancing their theoretical knowledge with highly sought hands-on industry skills prior to their graduation for the purpose of expediting their absorption into the job market. The proposed "for credit" SMS program is a natural extension of the non-credit SMSCP for those students striving for much more advanced and deeper graduate-level industry skills education and training in Industry 4.0.

11) Related programs in the institution or other British Columbia post-secondary institutions and outside of British Columbia

SMS will be uniquely positioned as the only master's level professional degree program for training in Industry 4.0 in Western Canada. In B.C., there are no M.Eng. degrees offered in this area but several course-based M.Eng. programs in other areas of specialization:

- SFU offers a regular M.Eng. program (CIP: 14.13) through the School of Engineering Science (ENSC) that allows students to take a prescribed set of graduate and advanced engineering courses from ENSC, MSE, Computing Science, or the Faculty of Science in order to advance their skills and upgrade their training.
- UBC offers a M.Eng. program and a Master of Engineering Leadership (MEL). The former is a regular degree program focused in the areas of mechatronics design (CIP: 14.42), mechanical engineering (CIP: 14.19), etc. The MEL is a hybrid professional degree program that combines graduate-level engineering courses with business courses. The focus is on cross-disciplinary technical instruction and personal leadership development in advanced materials manufacturing (CIP: 14.18), sustainable process engineering (CIP: 14.07), etc.

- UNBC only offers a regular M.Eng. in Integrated Wood Design that focuses on modern wood engineering (CIP: 14.33).
- UVic also offers regular M.Eng. programs in the Departments of Mechanical Engineering (CIP: 14.19) and Electrical & Computer Engineering (CIP: 14.10).

UBC offers the only B.A.Sc. degree in Manufacturing Engineering (CIP: 14.36) in B.C. The graduates of this program, as well as the graduates of SFU's own B.A.Sc. programs in MSE and ENSC, would be strongly qualified for admission into the SMS program.

Related programs outside of British Columbia

With respect to MSc programs in Manufacturing Engineering outside of British Columbia, the following programs stand out.

- McMaster University offers a Master of Engineering in Systems & Technology that delivers specialized training in digital manufacturing, automotive, automation, and smart, connected systems. This program has two pathways toward the degree: (i) Accelerated course & project based option, which requires completion of 7 courses plus a major project and takes 16 months to complete, and (ii) Accelerated course-based option, which requires completion of 10 courses and takes 12 months to complete. Co-op and experiential learning are optional components of this program.

- University of Toronto offers a Master of Engineering in Advanced Manufacturing with two streams: Manufacturing Management that is suitable for students who seek to move into positions of leadership in industry, and Manufacturing Engineering that provides students with advanced manufacturing technologies and skills that can be deployed to increase the efficiency, productivity and profitability of the modern manufacturing industry.

- Queen's University and Western University jointly offer a Master of Engineering in Design and Manufacturing which is designed for working engineering graduates. This part-time program is designed to give practicing engineers the technical knowledge and business and management skills necessary for them to advance to the forefront of their profession.

With respect to master's degree programs focusing specifically on Industry 4.0,

- National University of Singapore offers a Master of Science in Industry 4.0, an interdisciplinary program that trains students about the changing nature of industries by focusing on how to enhance productivity in the workplace. This program takes between 12 and 18 months for full-time students and between 18 and 36 months for part-time students. Students in this program take four core courses and five elective courses and do an industry and consulting application project at the final year of their education. The program curriculum is specifically designed in accordance with the Singapore Smart Industry Readiness Index to help companies in transforming their capabilities through

their human capital, and support Singapore's drive towards becoming a Smart Nation.

- Rutgers University offers a Master of Science Degree in Industrial and Systems Engineering that provides advanced training in critical areas that span three degree options in industrial and systems engineering, production and manufacturing systems engineering, and quality reliability engineering. The program is designed to integrate theory with applied training and skills and students will combine diversified coursework with hands-on learning and research. In this program students take three core and five elective courses.

- University of Wisconsin–Madison offers a fully online master's program in Manufacturing Systems Engineering consisting. This 30-credits program is specifically designed for working professionals to provide them with cross-functional expertise needed to drive creative product and process development, efficient production, and timely delivery to the customer through a systematic approach to finance, methods, materials and technology across traditional departmental boundaries.

- Esslingen University of Applied Sciences in Germany offers the Smart Factory Master's program that gives students the opportunity to acquire skills in planning, developing, monitoring as well as in supply, production, procurement and sales & marketing. This is a three-semester program and designed in detailed discussion with regional industry to comprehensively include "Industry 4.0" in the program to provide graduates with a solid foundation for their subsequent career.

- Charles III University of Madrid in Spain offers a master's program in Connected Industry 4.0. This is a one-year program structured around five modules: Introduction to the Connected Industry 4.0, Cyber-physical Systems, Intelligent Networks, Industrial Processes and Services and Data Processing and their security. Students will be placed in an internship position and they need to write their master's thesis.

12) What differentiates the proposed program from all other related programs in the province?

Most prominent Canadian universities offer master level Mechanical Engineering programs. Few of them, including University of Toronto, McMaster University, University of Calgary and University of British Columbia, offer customized programs with a focused perspective on Manufacturing Engineering.

All of the above-mentioned programs are similar to the SMS program in terms of providing students with advanced topics of Manufacturing Engineering. SMS will integrate both theoretical and practical education as a part of its curriculum with the aim of delivering education and training based on cutting-edge technologies in production to graduate qualified multidisciplinary students. The proposed program is different from other similar programs in two important aspects: first, it has a predominant and comprehensive focus on Industry 4.0 topics such as smart

factory, big data analytics, industrial IoT and digital twin technology as a complete training package. Second, the proposed program offers unique lab courses that provide students with hands-on experiences qualifying them to work in industry immediately after graduation. As a result, the graduates of the program will be equipped to handle the type and scale of data generated by Industry 4.0's digital systems, dubbed a "digital twin," which is a near-real-time digital image of physical manufacturing process that help optimize manufacturing performance.

Moreover, unlike the SMS program the reviewed programs do not have a compulsory industrial internship education component.

In the proposed program, students will gather practical work experience and skills through a mandatory industrial internship, working for either four or eight months (one or two terms) with industrial employers in the advanced manufacturing sector regionally and across Canada. Industrial internships form a key component of the program to provide students with a realistic understanding of challenges and opportunities in advanced manufacturing and the practical side of adopting Industry 4.0 technologies. MSE has a strong track record for their internship programs and many years of experience from internship collaborations with a broad range of industrial employers in the Canadian advanced manufacturing market. The option of either four or eight months of internship provides additional flexibility to accommodate the preference of students and also meet expectations of industry partners for accepting interns. Students from this program can expect to be paid well during their internship.

13) An overview of the level of support and recognition from other post-secondary institutions, and relevant regulatory or professional bodies

The program was conceived after consultation with the following organizations and groups: City of Surrey, Faculty of Applied Science External Advisory Board, MSE External Advisory Board, Engineers and Geoscientists British Columbia (EGBC), Canadian Manufacturers and Exporters (CME), Siemens Canada, and FESTO. Responding to the proposed SMS program, letters from the University of British Columbia, the University of Victoria, City of Surrey, Surrey Board of Trade, and 15 commercial enterprises, including global leaders in high-tech industrial sectors such as KUKA Robotics Canada, FESTO and Siemens Canada, Digital Industries are all strongly positive in their support of the program. In total, MSE received 19 support letters, copied in Appendix 3.

The opinions expressed confirm that engineering professional degree programs are in high demand in Canada. With few successful professional master's programs established in B.C. and across Canada, SMS will fill a specific niche market in B.C. The letters leave no doubt that immediate action for producing more Industry 4.0 talent is imperative for Canada's advanced manufacturing sector and that MSE is well recognized as a competent academic leader to offer such a program at SFU in Surrey: "This program is the first of its kind in Western Canada and aligns with Siemens' goal to invest in Canadian education and in students."[8]; "Given the current global economic landscape and industry's growing demand for high-tech solutions, there is great clarity to the value of establishing British Columbia and Canada as leaders and competitors in

[8] K. Malleret, Director of Industrial Services Siemens Canada Ltd.

relation to Industry 4.0."[9]; "This is a cutting-edge curriculum and the program is well-positioned to advance the Faculty and University level goals in several key areas." (UVic)[10]

MSE is developing the SMS program in consultation with the respective engineering units at the University of British Columbia and the University of Victoria to ensure the program allows for collaborations across post-secondary institutions. Both institutions recognize the need for such a program and have expressed their intention to collaborate with MSE/SFU. Further details are provided in the respective support letters from UBC and UVic (Appendix 3).

14) What added value will the proposed program offer graduates in terms of employment opportunities?

The only other program in the same field offered at SFU is the Siemens Mechatronic Certification Program in the School of Mechatronic Systems Engineering. This non-degree program focuses on automated assembly lines using state-of-the-art industrial training equipment and creates highly talented professionals (mainly targeting undergraduate students) who can easily meet the challenges of **traditional** high-tech automation industries. The training does not, however, include knowledge and skills for the deep integration of Industry 4.0 technologies, the sophisticated interplay between automation and robotics, *IoT devices*[11], big data analytics and AI, taking dynamic optimization of production lines and predictive maintenance[12] to a new level. Likewise, the virtual realization of physical production processes for analytic purposes, a.k.a. digital twins, is becoming the backbone of the manufacturing industry.

The Siemens certification program and the SMS program complement each other in meaningful ways, and students in the SMS program will have the option of taking the external Siemens exams to receive the certification, if wanted. However, the latter can by no means substitute the unique knowledge, training and skills offered by the professional graduate degree program, which greatly improves the opportunity for employment in highly paid engineering/managerial jobs. Besides, the curriculum content and learning outcomes of the certificate program are exclusively driven by Siemens, while the SMS program is wide open to partner with any advanced manufacturing technology companies, as is evident from the range of industry partners who provided letters of support expressing their interest in the program, including FESTO, KUKA, Fanuc, etc. The specific and specialized highly sought-after occupations (e.g., digital twin engineers, industry IoT system developers, Industry 4.0 engineers/managers) that SMS graduates will compete for in the job market are not available to the non-degree Siemens certification graduates.

[9] J. Olson, Dean, Faculty of Applied Science, UBC
[10] C. Bradley, Associate Dean Research, Faculty of Engineering, U. of Victoria
[11] IoT devices, or any of the many things in the internet of things, are nonstandard computing devices that connect wirelessly to a network and have the ability to transmit data.
[12] Predictive maintenance is a proactive strategy for continuously monitoring the condition of machine components to forecast their future failure point and replace parts, based on a plan, in time before they fail.

15) Do potential employers require a degree for graduates to gain employment in the field?

Industry 4.0 is more than technological advancement; it also has to prioritise human resource development, which involves developing the skills that will be required in the future [11, 12]. New qualifications and a new skill-mix demanded by Industry 4.0 will need to be changed educational profiles, as well as education and training policies [10]. In the emerging Industry 4.0 era, the future of work in manufacturing will require graduates with advanced professional degrees such as the proposed SMS program. Fast computing power, a proliferation of IoT sensors, and an exponential growth in the ability to capture data in manufacturing and products are presenting new opportunities that require new talent. The SMS program will produce such talent, e.g., highly specialized digital twin engineers who can help manufactures gain an understanding of their product and manufacturing process, thereby enabling better performance thorough enhanced design and predictive maintenance.

The number of engineers trained in handling the type and scale of data generated by digital twins in Industry 4.0 is increasing, but still falls far short of anticipated demand (refer to the support letter from Global Automakers of Canada).

16) Potential areas/sectors of employment for graduates and/or opportunities for further study in the field

The main technologies that comprise Industry 4.0 include digital manufacturing, IoT, robotics and automation, cyber-physical systems, predictive maintenance and big data analytics. Engineering skills across all disciplines will be needed to design, build, troubleshoot and maintain Industry 4.0 technologies. Students completing the proposed SMS program will be able to pursue additional education and training through graduate studies (e.g., Ph.D., MBA) across a wide variety of interest areas including mechatronics, information technology, data science, manufacturing, and business administration and management.

17) Does the proposal lead to a specific occupation?

1. Digital twin engineers: create virtual representations of products and manufacturing processes, integrate these with the necessary digital elements (including software, data, and chips) into a single design to produce the highest-quality product and help to optimize its design, monitor its performance, predict its maintenance and improve the overall consumer experience.

2. Advanced manufacturing and mechatronics engineers: coordinate and manage manufacturing processes in plant. Maintain broad knowledge of product design, manufacture and assembly techniques. Develop and implement product quality standards. Evaluate and improve manufacturing methods for maximum efficiency.

3. Industry IoT solution architects and system developers: mapping the manufacturers needs to system requirements and technical requirements; producing the technical

specifications, integrating different technologies and platforms such as such as remote operation centers, predictive maintenance, or assisted operations through augmented reality.

18) What labour market needs would the proposed program meet for the province? (Please include no more than 5 applicable National Occupational Classification (NOC) codes.)

The currently available National Occupational Classification (NOC) codes do not fully capture mechatronic and manufacturing engineering qualifications relevant to Industry 4.0 technologies and, as such, do not show the full picture of the labour market needs. Likewise, for the codes listed below the job openings to job seekers ratio does not reflect effectively the job market situation for advanced manufacturing nationally and regionally, as discussed in detail, for instance, in the report by Canada's Advanced Manufacturing Economic Strategy Table [10]. The recent survey on the advanced manufacturing and innovation economy labour market development for the City of Surrey speaks of the same issue [1]. When including in this equation the rapidly growing demand for a digitally skilled workforce critical for transforming Canada's advanced manufacturing sector to adopt smart manufacturing technologies, the picture of actual labour market needs looks very different. In fact, "skilled and digitally skilled labour are in short supply" [1], which is considered a key barrier standing in the way of achieving our manufacturing production goals and growth rates. This situation prompted the creation of a national skills and talent initiative to train and recruit the Industry 4.0 workforce needed to ensure Canada's competitiveness in a global manufacturing market—as associated with the vision #MadeBETTERinCANADA.

2232 Mechanical engineering technologists and technicians

Projected Job Openings:8,400

Projected Job Seekers: 9,500

http://occupations.esdc.gc.ca/sppc-cops/occupationsummarydetail.jsp?&tid=90

2233 Industrial engineering and manufacturing technologists and technicians

Projected Job Openings:8,000

Projected Job Seekers: 8,400

http://occupations.esdc.gc.ca/sppc-cops/occupationsummarydetail.jsp?&tid=91

2141 Industrial and manufacturing engineers

Projected Job Openings:5,000

Projected Job Seekers: 6,600

http://occupations.esdc.gc.ca/sppc-cops/occupationsummarydetail.jsp?&tid=73

Table 1. B.C. Labour Market Outlook 2019

NOC	Employment 2019	Job Openings 2019-2029	Average Annual Replacement Rate	Median Wage ($)	Low Wage ($)	High Wage ($)
2232	2,064	636	2.0%	23.00	33.00	52.82
2233	1,777	490	2.4%	17.88	28.00	46.85
2141	1,340	470	2.5%	20.21	33.61	48.23

https://www.workbc.ca/Labour-Market-Industry/Labour-Market-Outlook.aspx

19) Plans for admissions and transfer within the British Columbia post-secondary education system

Any graduate from the B.C. post-secondary education system holding a B.A.Sc. with a cumulative grade point average (GPA) of 3.0 (on a scale of 0.0 - 4.33) or equivalent will be eligible to apply for the program. Engineering graduates from UBC and UVic, along with qualified graduates from other B.C. post-secondary institutions, are in the core group of the student population targeted by the program. Transfer within the B.C. post-secondary education system would not be possible though due to the highly specialized nature of the program, as well as the lack of a similar program within B.C.

Graduates from this program will be eligible to apply for other graduate programs (e.g. Ph.D. or MBA programs) anywhere in Canada.

20) Enrolment Plan

The anticipated student enrollment for the SMS program over the first three years focuses on **full-time students only** as the program will not offer a part-time option during this time period. The projected enrollment numbers are partly based on the actual enrollment for the professional graduate program in Big Data over its first three years and also on the actual enrollment for the Siemens Mechatronic Certification Program over its first two years. For the targeted starting date of September 2021, the following table summarizes the anticipated (and minimum viable) enrollments for the academic years 2021-2023. Based on the past trend for the existing professional programs in the Faculty of Applied Sciences, we anticipate a further increase in the number of applications but intend to keep the enrollment number at the 2022 and 2023 level of approximately 36~48 students as steady-state enrollment, since it matches our delivery capacity.

Table 2. Expected number of applications and enrollment, SMS program 2021-2023

Start Year	2021	2022	2023
Students enrolled	24 (18)	36 (24)	48 (30)
Applications	100	150	200

Our enrolment plan includes a commitment to ensure increased participation of women in Mechatronic Systems Engineering. The broad vision of how Industry 4.0 technology will transform manufacturing with far reaching implications for the future workforce and the ecosystem surrounding the fourth industrial revolution should make this interdisciplinary field appealing to female graduate students. We will focus on representation of female role models in the images we use on social media and in our advertising. The current number of female students enrolled in the Siemens Mechatronic Certification Program is 20%, up from 10% in the previous year. Currently, 25% of all graduate students in Mechatronics System Engineering are female.

The number of credentials awarded each year at steady-state enrollment in the SMS program is anticipated to range between 44 and 48, not including any credentials from the Siemens Mechatronic Certification Program awarded to SMS students.

21) Delivery methods

The program will be delivered in a traditional in-person classroom-based setting integrated with hands-on lab settings. Students will complete at least 30 units of graduate work divided into three sections: 12 units of specialized hands-on lab courses, two courses with 6 credits each, 12 units of required core courses, 3 units of electives, and either 3 or 6 units for internship, typically working for at least four months with an industry partner in the advanced manufacturing sector anywhere in Canada. The program does not have a capstone. It will be delivered using a **cohort model**; this is required to manage the logistics around the highly specialized lab courses, which heavily rely on cutting-edge industrial assembly line equipment, including industrial robots and manufacturing stations. Further, it will allow to streamline organizational efforts for placing interns at industry partners, normally during summer terms, and fall terms for students who take an 8-months internship.

22) Eligibility for scholarships, awards, and financial aid

Students admitted to the program will not be able to apply for awards associated with the University's operating budget. However, they will be eligible to apply for private awards, and MSE will be approaching external entities for funding for such awards. Additionally, we will also seek industry sponsored scholarships from our industry partners. This portion of SMS student

funding is expected to increase through building a strong reputation of the program over the first three years and beyond. Note that active SMS students will still be eligible to utilize the University's financial aid program.

23) Does the proposed program offer an alternative exit, if appropriate?

Striving for excellence in graduate student education, admission to the SMS program will be highly competitive. This is not just to build a strong reputation of the program but also to ensure that admitted students will successfully graduate from the program in time. However, in the rare case that a student cannot complete the degree program for unforeseeable reasons, MSE still offers an alternative exit through the existing Siemens Mechatronic Certification Program. This way, students will still be able to acquire a professional qualification that greatly enhances their chances of employment in a high-tech manufacturing sector. All active SMS students will also have the opportunity to take advantage of the Siemens Mechatronic Certification Program, which is complementary in nature to the SMS degree program. The additional qualification would complement their education and training in a meaningful way. Still, this will be an optional choice rather than a formal requirement for graduating from the SMS program.

24) Resources required and/or available to implement the program

The proposed specialized hands-on lab courses, Smart Factory I and II, will focus on hands-on learning of various Industry 4.0 technologies, both hardware and software. These labs will be run by a new laboratory instructor (or University Research Associate) who are knowledgeable in the lab content. The lab courses will be run in a dedicated lab space in Galleria 4 of SRYC. This lab space already houses the recently acquired state-of-the-art robotic and automation hardware and software from Siemens and Festo, as well as premium workstations and monitors. The plan is to add additional equipment to develop a unique "Cyber-Physical Lab," which will be a professional and compact Industry 4.0 learning system that integrates key components from various vendors (Siemens, Festo, KUKA, etc.). It will include all the technologies and components needed for communicating and training an in-depth knowledge of Industry 4.0. It will have a modular, flexible and scalable design to accommodate various learning scenarios and cohort sizes. Building on lessons learned from the Siemens Mechatronics Certification offerings, we will limit enrollment in each lab section to 24 spots and have the instructors spending the time in the lab with the students. This will ensure that we can offer a truly premium lab experience by ensuring we have a high-quality lab for students admitted into this program.

Overall, the program will use current faculty and when demand grows in 2 years additional faculty will be hired to add to the complement (see also Appendix 7) to teach its specifically designed SMS courses. As some of the key courses are laboratory heavy, they require participation of technical staff and teaching assistants who will be paid through the funds generated by the SMS tuition fees. A full-time program coordinator will be hired from the funds as well. Finally, additional state-of-the-art laboratory equipment for hands-on Industry 4.0 training will be needed to increase the existing lab capacity.

25) Program evaluation and academic/administrative oversight

The steering committee for the SMS program consists of the program director (currently Dr. Ed Park), the program advisor (currently Dr. Uwe Glässer), the MSE graduate program chair (currently Dr. Patrick Palmer), the director of MSE (currently Dr. Ed Park), one instructor in the program (currently Dr. Amr Marzouk), and MSE academic and administrative services manager Julibeth Fernandez.

MSE will also establish an external advisory board for the SMS program. The committee will consist of five members on three-year terms and will be invited from those who provided the letters of support. Please see Appendix 5 for further details.

The SMS program will be reviewed internally using the same mechanisms that are used to review the other graduate programs in MSE. Program changes will be administered through the existing MSE Graduate Program Committee.

26) Faculty member's teaching/supervision

The specifically designed new SMS courses will be taught by new faculty members to reduce the impact on teaching loads in the existing programs within MSE. However, MSE and CS together have the expertise to cover for these courses if the teaching loads were not of a concern. Below is a list of existing faculty members who can teach the above courses as a team (so that their involvement in this program does not significantly affect their responsibilities in other programs) in the first year, until the new faculty members are hired.

1. **Woo Soo Kim**, Associate Professor (teaching 10%)
   Area: Additive Manufacturing and 3D Printing
2. **Mehrdad Moallem**, Professor (teaching 10%)
   Area: Mechatronics, Control and Automation, Cyber-Physical Systems
3. **Edward Park**, Professor (administration and teaching, 20%)
   Area: Mechatronics, Robotics and Automation, IoT
4. **Gary Wang**, Professor (teaching 10%)
   Area: Product Design and Optimization
5. **Amr Marzouk**, Lecturer (teaching 10%)
   Area: Mechatronics, Industrial Control, IoT
6. **Farid Golnaraghi**, Professor (teaching 10%)
   Area: Mechatronics, Intelligent Systems
7. **Mohammad Narimani,** Lecturer (teaching 10%)
   Area: Mechatronics, Industrial Control
8. **Flavio Firmani**, Lecturer (teaching 10%)
   Area: Design of Mechanisms, Robotics

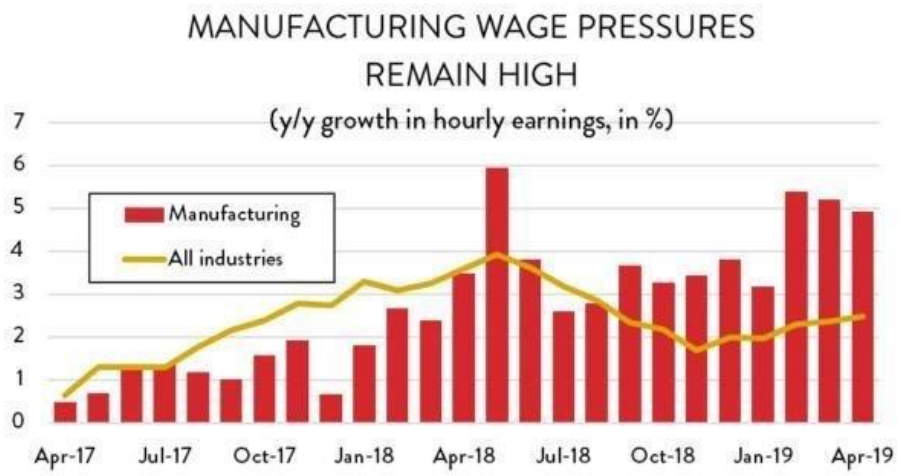
9. **Ramtin Rakhsha**, Lecturer (teaching 10%)
   Area: Robotics and Control
10. **Ahmad Rad**, Professor (teaching 10%)
    Area: Robotics, Intelligent Systems
11. **Taha Al-Khudairi**, Laboratory Engineer and Instructor (teaching 10%)
    Area: Mechatronics, Industrial Control, Robotics
12. **Behraad Bahreyni**, Associate Professor (teaching 10%)
    Area: MEMS, IoT
13. **Mohammad Tayebi**, University Research Associate (Computing Science) (teaching 10%) Area: Data Mining, Machine Learning
14. **Uwe Glässer,** Professor (Computing Science) (administration and teaching, 10%)
    Area: Big Data Intelligence, Cybersecurity

New faculty candidates must hold a PhD degree and should have: (a) a strong background in quantitative methods relevant to the smart manufacturing (Industry 4.0) domain such as industrial IoT, digital twin, machine learning, data science and data analytics and/or operations research, (b) a strong interest in teaching and supervision of topics related to the area of smart manufacturing and operations management, (c) a demonstrated ability and desire to publish in international high-impact journals, and (d) a strong ability to work effectively within and across groups, and (e) fluency in English, both spoken and written.

27) Is the program focus primarily on meeting social benefit(s) or economic benefit(s)?

The program offers graduates socioeconomic benefits from well paid jobs in a highly attractive and growing job market. Because of the inevitable need for the advanced manufacturing sector to enhance their competitiveness in a global market through the adoption of Industry 4.0 technology, the prospects for compensation and job security will also remain competitive for the foreseeable future. This aspect is illustrated in the following diagram[13]:

[13] Sam Charles, Why Manufacturing Engineering is the right fit for you, School of Engineering, The University of British Colombia, 2019.
(Source: https://engineering.ok.ubc.ca/2019/05/24/why-manufacturing-engineering-is-the-right-fit-for-you/)



Employment growth and wages in Canada's manufacturing sector continue to grow. The sector accounts for 7% of the provincial GDP, and 11% of Canada's GDP. Manufacturing is the largest goods producing sector in the country providing value-added goods production such as aerospace, automotive, machinery, electronics. It sits comfortably ahead of mining, oil & gas (8.6%) and the other traditional sector of the economy, agriculture, forestry and fisheries (1.6%).

BC is #3 in Canada in terms of manufacturing employment, more than Alberta and roughly 3x the levels of people employed in, Saskatchewan and Manitoba. Stats Canada data indicates that 178,300 manufacturing jobs exist in BC, a 2.2% growth from December 2017 to January 2018 and an overall 4.6% growth from January 2017 to January 2018.

28) How would the proposed program advance social goods or government priorities?

Canada's Advanced Manufacturing Economic Strategy Table concludes that the adoption of Industry 4.0 technologies is absolutely critical for succeeding in the increasingly competitive international market for advanced manufacturing [10]: "With the right technologies in place—robotics, additive manufacturing and big data analytics—Canadian manufacturers can spur innovation and transform the efficiency of their operations. We have developed a roadmap to achieve this vision by creating a stronger investment-friendly framework, shifting Canada's manufacturing culture to accelerate technology adoption, and growing an inclusive and digitally skilled workforce." Responding to the shortage of a much needed digitally skilled workforce, the Economic Strategy Table pushes for a Skills & Talent Initiative [10].

The program aligns with the B.C. Government's strategy to invest in growing technology and innovation in the province and its vision to promote the City of Surrey as a second Lower Mainland downtown and to build an innovation corridor that will drive economic growth and create good jobs and opportunity for people in Surrey and the Fraser Valley. "Creating an

innovation corridor in Surrey and up the Fraser Valley will create good jobs, attract talent, reduce commute times and raise the standard of living." [18]

Industry 4.0 can open the door to new revenue opportunities and business models by offering solutions to challenges such as lack of resources and rising operational costs. According to the 2018 Management Issues Survey by the Canadian Manufacturers & Exporters (CME) [14], 80% of respondents plan to invest in training and 53% of them plan to invest in advanced manufacturing technologies in the next three years.

29) What social, cultural, regional, community, environmental, institutional and/or intellectual benefit would the proposed program provide?

Social innovations are new strategies, concepts and solutions that aim to meet challenges of the society in a better way than existing practices. Industry 4.0 is closely connected with innovation which can accelerate the society toward an innovation-based economy with knowledge, data, and the IoT as its pillars. This new economic paradigm will affect the current markets and business processes and pave the path to a new age of digitization. This move will result in smart and resource-efficient production models creating value for people and societies. The deployment of robots in manufacturing not only increases productivity but also means humans can avoid tasks that are tiring, dangerous or unhealthy. The concept of smart factories allows to shift the focus of human labour from working in production lines to more creative tasks like monitoring, supervision and maintenance.

30) How would the proposed program support economic growth and/or government economic priorities?

IoT (Internet of Things) applications in manufacturing and factory settings will generate $1.2–$3.7 trillion of global economic value annually by 2025. Industry 4.0 technologies have the potential to boost the productivity of the world's factories by 10–25%, adding 1–1.5% to Canada's annual productivity growth [9]. In their 2018 report on "The Innovation and Competitiveness Imperative: Seizing Opportunities for Growth," Canada's Advanced Manufacturing Economic Strategy Table lays out the imperative for meeting Canada's strategic objectives to increase both manufacturing sales as well as exports by 50% each by 2030, to $1 trillion and $540 billion respectively [10]. Growing the manufacturing sector requires Canada to diversify its export markets, since the national market is comparatively small. "The success of the manufacturing sector is shaped by Canada's relationship with the world. Canada needs to be more competitive if it is to become a leading manufacturing nation front and centre on the world stage." Decisive adoption of transformative technologies associated with Industry 4.0 is absolutely critical for succeeding in the increasingly competitive international market for advanced manufacturing [10]:

> "With the right technologies in place—robotics, additive manufacturing and big data analytics—Canadian manufacturers can spur innovation and transform the efficiency of their operations. We have developed a roadmap to achieve this vision by creating a stronger investment-friendly framework, shifting Canada's manufacturing culture to

> accelerate technology adoption, and **growing an inclusive and digitally skilled workforce**."

Failing to do so is not an option: "Canadian manufacturers will either adopt technology or die." The strategic vision considers the fact that **s**killed and digitally skilled labour are in short supply as one of the five barriers that stand in the way of achieving our manufacturing goals and realizing our ambitions [10]: "Lack of knowledge distribution is what limits the speed of growth. If we can learn best practices and disseminate knowledge faster than others, then we will succeed. We will have the leading edge."

To address this challenge, the Economic Strategy Table pushes for a Skills & Talent Initiative comprising: i) a talent pipeline, ii) a programs and skills network, and iii) job grants, skills curriculum, and lifelong learning. Responding to this national strategic initiative for education and training of a digitally skilled workforce, the primary goal of the Smart Manufacturing and Systems program is to help Canada's manufacturing sector to become more competitive in the race to implement innovative manufacturing technologies and systems. Graduates from this elite program will be leaders in shaping the future of advanced manufacturing.

31) What direct and/or indirect economic, industrial or labour market benefits would the program offer the student, community, region or province?

The program aligns with the B.C. Government's decision to invest in growing technology and innovation in the province and its vision to promote the City of Surrey as a second Lower Mainland downtown and to build an innovation corridor that will drive economic growth and create good jobs and opportunity for people in Surrey and the Fraser Valley. "Creating an innovation corridor in Surrey and up the Fraser Valley will create good jobs, attract talent, reduce commute times and raise the standard of living … Working with our partners, we will create an innovation hub where companies and talent will cluster, supporting our goal of a strong, sustainable economy that benefits the entire province." [18]

A recent study on an advanced manufacturing and innovation economy labour market development strategy for the City of Surrey [1] concluded that employment in the advanced manufacturing and innovation sector in Surrey is estimated to be 18,090 in 2016, divided between advanced manufacturing at about 9,800 (54%) and the innovation economy at about 8,300 (46%). Based on the most conservative growth scenario, **hiring requirements for the advanced manufacturing and innovation sector** in Surrey over the next decade are projected to be about 5,470, which is 30% of current employment. Most of this hiring (55%) is expected to occur with advanced manufacturers and the remainder (45%) with innovation economy employers. In the "high growth" scenario, employment would grow to about 36,200 over ten years, doubling employment in Surrey's advanced manufacturing and innovation sector. The following table shows the types of manufacturing companies in Surrey [1]:

Table 3. Different types of manufacturing companies in Surrey

SUB-SECTOR	# OF COMPANIES	% OF TOTAL
Fabricated metal products and machinery	468	52%
Wood products and furniture	127	14%
Food and beverage	52	6%
Printing	48	5%
Computer and electronic products	33	4%
Clothing and textiles	33	4%
Non-metallic mineral products	29	3%
Transportation equipment	19	2%
Plastics and rubber products	17	2%
Other	68	8%
Total	894	100%

Very few manufacturers have automated systems that move and monitor materials from one manufacturing station to another or have automated systems that supply the raw materials required for manufacturing purposes. The majority of the manufacturing workforce consists primarily of unskilled workers on the production floor with on-the-job training provided by the company. Generally, there is limited use of technologists and technicians. Semi-skilled and trades personnel are used for the operation of some manufacturing equipment and other production activities as well as equipment maintenance, repair and servicing [1]. Engineers are used by a few companies primarily for product design and development.

Because most companies are focusing on today's business, they are not investing in Industry 4.0 skills. Most companies rely primarily on on-the-job training for existing workers, particularly with unskilled production workers. There is limited use of short-term training courses provided by external trainers (e.g. boot camps to learn Industry 4.0 skills) and limited use is made of the Canada Job Grant for the upskilling of existing employees.

In response to the skills gap for advanced manufacturing in Surrey the study proposes as part of an action plan that the City of Surrey in conjunction with industry, SFU and KPU should design and implement a program to interest local high school students in a career in manufacturing [1].

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APPENDICES

Appendix 1 Calendar entry

Smart Manufacturing and Systems

MASTER OF ENGINEERING

The leading-edge professional graduate degree program in Smart Manufacturing and Systems offers unique hands-on learning and training in new Industry 4.0 technologies (artificial intelligence, the Internet of Things, and digital twins combined with industrial automation and robotic systems), which are driving digital transformation in the manufacturing industry. The program is paired with real-world experience from an industrial internship program of at least four months; this way, it prepares graduates for working in the new digital manufacturing sector related to Industry 4.0 and expedites their absorption into the job market and their impact on the future of manufacturing.

Admission Requirements

Applicants must satisfy the University admission requirements as stated in Graduate General Regulation 1.3 in the SFU calendar, and hold a bachelor's degree, or equivalent in mechatronic engineering, computer science, or a related field.

The School's Graduate Admissions Committee may recommend, at its discretion, admission to the Professional Master's program to exceptional students without an undergraduate degree in mechatronic engineering, mechanical engineering, manufacturing engineering or a related field. Students who do not meet the minimum university requirements may be recommended as conditional or qualifying students as per Graduate General Regulation (GGR) 1.3.8 or 1.3.9. For further information on conditional or qualifying admission requirements, please contact the Program Coordinator.

Program Requirements

This program consists of course work and an industrial internship for a minimum of 30 units.

Students must complete all of

MSE 910 - Industrial Internet of Things (3)
MSE 923 - Smart Factory I (6)
MSE 924 - Smart Factory II (6)
MSE 980 - Industry 4.0 (3)

and one of

CMPT 706 - Design and Analysis of Algorithms for Big Data (3)

CMPT 741 - Data Mining (3)
CMPT 780 - Machine Learning (3)
MSE 981 - Industrial Big Data Analytics (3)

and one of

MSE 780 - Manufacturing Systems (3)
MSE 812 - Advanced 3D Printing (3)
MSE 995 - Advanced Modeling and Prototyping (3)

and a minimum of 3 units chosen in consultation with the graduate program chair

and a minimum of one industrial internship

MSE 795 – Industrial Internship (3)

Program Length

Students are expected to complete the program requirements within four terms.

Academic Requirements within the Graduate General Regulations

All graduate students must satisfy the academic requirements that are specified in the Graduate General Regulations, as well as the specific requirements for the program in which they are enrolled.

Appendix 2 New courses

OFFICE OF THE DEAN
Faculty of Applied Sciences
Simon Fraser University

MEMORANDUM

Attention	Dr. Jeff Derksen Dean, Graduate Studies	Date	June 29, 2020
From	Dr. Parvaneh Saeedi Faculty of Applied Science, Graduate Studies Committee		psaeedi@sfu.ca

Re: FAS- MSE ~~Course change and~~ new course proposals

Following the Pre-SGSC's meeting and the committee's feedback on our new program proposal the following items are forwarded to you by the faculty of Applied Sciences Graduate Studies Committee for approval. Please let me know if there is any additional info is required.

~~Course Change:~~

1. ~~MSE 995 - Advanced Modeling and Prototyping~~

New courses:

1. MSE 910 - Industrial IoT
2. MSE 923 - Smart Factory I
3. MSE 924 - Smart Factory II
4. MSE 980 - Industry 4.0
5. MSE 981 - Big Data Analytics

The new course overlap review is requested from all ADRs and the library resource check requests will be done by the school today.

Best Regards,

Parvaneh Saeedi,
Faculty of Applied Science, Graduate Studies Committee

FACULTY OF APPLIED SCIENCES
School of Mechatronic Systems Engineering

Edward J. Park, PhD, PEng
Professor & Director (*Interim*)
Associate Member, Faculty of Health Sciences

Central City Galleria 4, 4388
250-13450 102 Avenue,
Surrey, BC Canada V3T 0A3

TEL: 778.782.8662
FAX: 778.782.7514
EMAIL: ed_park@sfu.ca

MEMORANDUM

Date: June 26, 2020
To: Dr. Parvaneh Saeedi, Associate Dean, Research & Graduate Studies, Faculty of Applied Sciences
From: Dr. Ed Park, Acting Director, School of Mechatronic Systems Engineering
Re: New course proposals and ~~course modifications~~

The School of Mechatronic Systems Engineering has approved the following new courses and ~~course modifications~~:

1. New courses
   - MSE 910
   - MSE 923
   - MSE 924
   - MSE 980
   - MSE 981

2. ~~Course modifications~~
   - ~~MSE 995~~

Best regards,

Ed Park

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) MSE	Number (eg. 810) 910	Units (eg. 4) 3

Course title (max. 100 characters)

Industrial Internet of Things

Short title (for enrollment/transcript - max. 30 characters) **Industrial IoT**

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description)

The Internet of Things (IoT) looks at its application to industrial systems and digital transformation technologies. Study of data collection, visualizaton, analysis, security, privacy, and optimization in IoT and Industrial IoT (IIoT). Implementation aspects of IoT devices in Industry 4.0 and digital twin technologies.

Rationale for introduction of this course

This course provides students enrolled in the new Master of Engineering program in Smart Manufacturing and Systems (a.k.a. Industry 4.0) with fundamentals and cutting-edge engineering perspectives on IoT technologies and their applications.

Term of initial offering (eg. Fall 2019) Fall 2021	Course delivery (eg. 3 hrs/week for 13 weeks) 3 hrs/week for 13 weeks
Frequency of offerings/year 1 time/year	Estimated enrollment per offering 48

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

None

Prerequisite and/or Corequisite: Recommended prerequisite: MSE 310 or equivalent

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☐ Burnaby ☑ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☑ Lecture ☐ Seminar ☐ Lab ☐ Independent ☐ Capstone ☐ _____

Grading Basis ☑ Letter grades ☐ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No

Total repeats allowed? _____

Repeat within a term? ☐ Yes ☑ No

Required course? ☑ Yes ☐ No

Final exam required? ☑ Yes ☐ No

Capstone course? ☐ Yes ☑ No

Combined with a undergrad course? ☐ Yes ☑ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

* See important definitions on the curriculum website.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
A new faculty/instructor will be hired to teach this course.
Additional faculty members, space, and/or specialized equipment required in order to offer this course
Mehrdad Moallem, Behraad Bahreyni, and/or Ed Park may design and offer it as an exception if the new faculty/instructor is unavailable prior to the first offering.

CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
MSE	Ed Park	ed_park@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee	Signature	Date
Department Chair Ed Park	Signature	Date June 26, 2020

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

Overlap check done? ☑ YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee	Signature	Date
Parvaneh Saeedi		June 29, 2020

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee	Signature	Date
Jeff Derksen		August 28, 2020

ADMINISTRATIVE SECTION (for DGS office only)
Library Check: _____
Course Attribute: _____
Course Attribute Value: _____
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

Mechatronic Systems Engineering

MSE 910 (3) Industrial Internet of Things

Course Description
This course provides a comprehensive coverage of the Internet of Things (IoT), exploring the 'things' that make up the IoT. Students will learn IoT uses-cases and the interaction between the industrial IoT (IIoT) devices and digital transformation of industries. The course will also examine the IoT data analysis, security, privacy and optimization of the IIoT scenarios. Implementation of IoT devices into Industry 4.0 processes such as digital twin will also be covered. In the final project completed in small groups of 2-3 students, students will apply the skills they have learned, by designing, building, controlling and testing in a controlled experimentation environment (IIoT testbed), as well as by collecting, storing, analyzing and visualizing the IIoT data.

Pre-requisites
Recommended: MSE 310 or equivalent

Resources / References
Reading materials and online resources given by instructor

Subjects & Topics
1. Introduction to the Internet of Things (IoT) (2 weeks)
2. Industrial Internet of Things (IIoT) systems (2 weeks)
3. IoT in Industry 4.0 and digital twin (3 weeks)
4. IoT data analysis, security, privacy and optimization (3 weeks)
5. Final project (3 weeks)

Course Format
- 3 hours/week of lectures
- Assignments
- Real-world project
- Midterm exam
- Final exam

Grading
- Assignments (15%)
- Project (20%)
- Midterm (25%)
- Final exam (40%)

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) MSE	Number (eg. 810) 923	Units (eg. 4) 6

Course title (max. 100 characters)

Smart Factory I

Short title (for enrollment/transcript - max. 30 characters) **Smart Factory I**

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description)

The smart factory is integral to Industry 4.0. Students will be provided with hands-on experience in main components of smart factory workcells. Students learn to design, install, maintain and troubleshoot key digital transformation components and automation equipment used in modern industrial production processes. A major component of the course is lab-based training using state-of-the-art industrial training equipment including programmable logic controllers, electro-pneumatics, and industrial robots.

Rationale for introduction of this course

This course provides students enrolled in the new Master of Engineering program in Smart Manufacturing and Systems (a.k.a. Industry 4.0) with fundamentals and cutting-edge engineering perspectives on smart factory technologies and components.

Term of initial offering (eg. Fall 2019) Fall 2021	Course delivery (eg. 3 hrs/week for 13 weeks) 6 hrs/week for 13 weeks (3hrs lecture, 3 hrs lab)
Frequency of offerings/year 1 time/year	Estimated enrollment per offering 48

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

None

Prerequisite and/or Corequisite Recommended prerequisite: MSE 310, MSE 250, and MSE 352 (or equivalent)

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☐ Burnaby ☑ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☑ Lecture ☐ Seminar ☑ Lab ☐ Independent ☐ Capstone ☐ _____

Grading Basis ☑ Letter grades ☐ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No	Total repeats allowed? _____	Repeat within a term? ☐ Yes ☑ No
Required course? ☑ Yes ☐ No	Final exam required? ☑ Yes ☐ No	Capstone course? ☐ Yes ☑ No

Combined with a undergrad course? ☐ Yes ☑ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

* See important definitions on the curriculum website.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
A new faculty/instructor will be hired to teach this course.
Additional faculty members, space, and/or specialized equipment required in order to offer this course
Smart Factory (a.k.a. Industry 4.0) Laboratory facility. Amr Marzouk and Taha A-Khudairi may design and offer it as an exception if the new faculty/instructor is unavailable prior to the first offering.

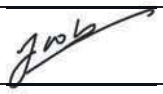
CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
MSE	Ed Park	ed_park@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee	Signature	Date
Department Chair Ed Park	Signature 	Date June 26, 2020

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

Overlap check done? ☑ YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee	Signature	Date
Parvaneh Saeedi		June 29, 2020

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee	Signature	Date
Jeff Derksen		August 28, 2020

ADMINISTRATIVE SECTION (for DGS office only)

Library Check: _____
Course Attribute: _____
Course Attribute Value: _____
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

Mechatronic Systems Engineering

MSE 923 (6) Smart Factory I

Course Description
The smart factory is integral to Industry 4.0. This course aims to provide students with hands-on experience in main components of smart factory workcells. Students learn to design, install, maintain and troubleshoot key digital transformation components and automation equipment used in modern industrial production processes. A major component of the course is lab-based training using state-of-the-art industrial training equipment including programmable logic controllers, electro-pneumatics, and industrial robots.

Pre-requisites
Recommended: MSE310, MSE250, and MSE352 (or their equivalent)

Resources / References
Reading materials and online resources given by instructor

Subjects & Topics
1. Fundamentals of pneumatics, electro-pneumatics and hydraulics (3 weeks)
2. Industrial robotics (2 weeks)
3. Digital factory fundamentals (2 weeks)
4. Programmable logic controllers (4 weeks)
5. Process control technologies (2 weeks)

Course Format
- 6 hours/week of hands-on training (lectures and labs)
- Assignments
- Real-world projects
- Midterm exam
- Final exam

Grading
- Assignments (15%)
- Projects (20%)
- Midterm (25%)
- Final exam (40%)

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) MSE	Number (eg. 810) 924	Units (eg. 4) 6

Course title (max. 100 characters)

Smart Factory II

Short title (for enrollment/transcript - max. 30 characters) **Smart Factory II**

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description)

Smart automation takes industrial automation to the next level. Smart automation components and their integration for the application and implementation of automation tasks in Industry 4.0 production systems are introduced. Students analyze and simulate a smart manufacturing facility in terms of production time, cycle time, scheduling tasks, materials, cost, quality, labour, etc. A major component of this course is lab-based training using state-of-the-art industrial equipment.

Rationale for introduction of this course

This course provides students enrolled in the new Master of Engineering program in Smart Manufacturing and Systems (a.k.a. Industry 4.0) with fundamentals and cutting-edge engineering perspectives on smart automation and its application to design an Industry 4.0 production system.

Term of initial offering (eg. Fall 2019) Fall 2021	Course delivery (eg. 3 hrs/week for 13 weeks) 6 hrs/week for 13 weeks (3hrs lecture, 3hrs lab)
Frequency of offerings/year 1 time/year	Estimated enrollment per offering 48

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

None

Prerequisite and/or Corequisite Prerequisite: MSE 923; recommended prerequisite: MSE 353 (or equivalent)

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☐ Burnaby ☑ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☑ Lecture ☐ Seminar ☑ Lab ☐ Independent ☐ Capstone ☐ _____

Grading Basis ☑ Letter grades ☐ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No	Total repeats allowed? _____	Repeat within a term? ☐ Yes ☑ No
Required course? ☑ Yes ☐ No	Final exam required? ☑ Yes ☐ No	Capstone course? ☐ Yes ☑ No

Combined with a undergrad course? ☐ Yes ☑ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

* See important definitions on the curriculum website.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
A new faculty/instructor will be hired to teach this course.
Additional faculty members, space, and/or specialized equipment required in order to offer this course
Smart Factory (a.k.a. Industry 4.0) Laboratory facility. Amr Marzouk and Taha A-Khudairi may design and offer it as an exception if the new faculty/instructor is unavailable prior to the first offering.

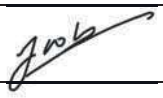
CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
MSE	Ed Park	ed_park@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee	Signature	Date
Department Chair Ed Park	Signature 	Date June 26, 2020

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

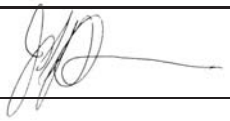
Overlap check done? ☑ YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee	Signature	Date
Parvaneh Saeedi		June 29, 2020

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee	Signature	Date
Jeff Derksen		August 28, 2020

ADMINISTRATIVE SECTION (for DGS office only)

Library Check: _____
Course Attribute: _____
Course Attribute Value: _____
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

Mechatronic Systems Engineering

MSE 924 (6) Smart Factory II

Course Description
Smart automation takes industrial automation to the next level. Smart automation components and their integration for the application and implementation of automation tasks in Industry 4.0 production systems are introduced. Students analyze and simulate a smart manufacturing facility in terms of production time, cycle time, scheduling tasks, materials, cost, quality, labour, etc. A major component of this course is lab-based training using state-of-the-art industrial equipment.

Pre-requisites
Required: MSE 923; recommended: MSE 353 (or equivalent)

Resources / References
Reading materials and online resources given by instructor

Subjects & Topics
1. Electric machines (3 weeks)
2. Industrial motor control (2 weeks)
3. Automation systems and microcontrollers (3 weeks)
4. Industry 4.0 production processes (3 weeks)
5. Digital twin (2 weeks)

Course Format
- 6 hours/week of hands-on training (lectures and labs)
- Assignments
- Real-world projects
- Midterm exam
- Final exam

Grading
- Assignments (15%)
- Projects (20%)
- Midterm (25%)
- Final exam (40%)

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) MSE	Number (eg. 810) 980	Units (eg. 4) 3

Course title (max. 100 characters)

Industry 4.0

Short title (for enrollment/transcript - max. 30 characters) Industry 4.0

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description)

Industry 4.0 is the future of manufacturing which is driven by artificial intelligence, the Internet of Things, and the resulting digital transformation technologies such as digital twins. A digital twin is a virtual model of an industrial process, product, service or system across its life-cycle using real-time data to enable analysis, learning and reasoning. In the Industry 4.0 future, smart factories using additive manufacturing such as 3D printing and other computer-aided manufacturing systems are able to adaptively manufacture parts on demand, direct from digital twin designs. This course provides a comprehensive coverage on, among others, the role of data, manufacturing systems, various Industry 4.0 technologies, applications and case studies.

Rationale for introduction of this course

This course provides students enrolled in the new Master of Engineering program in Smart Manufacturing and Systems (a.k.a. Industry 4.0) with fundamentals and cutting-edge engineering perspectives on Industry 4.0 technologies and their applications.

Term of initial offering (eg. Fall 2019) Fall 2021	Course delivery (eg. 3 hrs/week for 13 weeks) 3 hrs/week for 13 weeks
Frequency of offerings/year 1 time/year	Estimated enrollment per offering 24

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

None

Prerequisite and/or Corequisite Recommended prerequisite: MSE 380 or equivalent

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☐ Burnaby ☑ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☑ Lecture ☐ Seminar ☐ Lab ☐ Independent ☐ Capstone ☐ _____

Grading Basis ☑ Letter grades ☐ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No

Total repeats allowed? _____

Repeat within a term? ☐ Yes ☑ No

Required course? ☐ Yes ☑ No

Final exam required? ☑ Yes ☐ No

Capstone course? ☐ Yes ☑ No

Combined with a undergrad course? ☐ Yes ☑ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

* See important definitions on the curriculum website.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
A new faculty/instructor will be hired to teach this course.
Additional faculty members, space, and/or specialized equipment required in order to offer this course
Woo Soo Kim, Gary Wang, and/or Ed Park may design and offer it as an exception if the new faculty/instructor is unavailable prior to the first offering.

CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
MSE	Ed Park	ed_park@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee	Signature	Date
Department Chair Ed Park	Signature	Date June 26, 2020

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

Overlap check done? ☑ YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee	Signature	Date
Parvaneh Saeedi		June 29, 2020

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee	Signature	Date
Jeff Derksen		August 28, 2020

ADMINISTRATIVE SECTION (for DGS office only)
Library Check: _____
Course Attribute: _____
Course Attribute Value: _____
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

Mechatronic Systems Engineering

MSE 980 (3) Industry 4.0

Course Description
Industry 4.0 is the future of manufacturing which is driven by artificial intelligence, the Internet of Things, and the resulting digital transformation technologies such as digital twins. A digital twin is a virtual model of an industrial process, product, service or system across its lifecycle using real-time data to enable analysis, learning and reasoning. In the Industry 4.0 future, smart factories using additive manufacturing such as 3D printing and other computer-aided manufacturing systems are able to adaptively manufacture parts on demand, direct from digital twin designs. This course provides a comprehensive coverage on, among others, the role of data, manufacturing systems, various Industry 4.0 technologies, applications and case studies.

Pre-requisites
Recommended: MSE 380 or equivalent

Resources / References
Reading materials and online resources given by instructor

Subjects & Topics
- Week 1: Introduction to Industry 4.0
- Week 2: Comparison between smart Industry 4.0 factory and today's factory
- Week 3: Innovative Industrial Internet of Things (IIoT) solutions
- Week 4-5: Smart manufacturing digitization, digital twins, and predictive maintenance
- Week 6-7: Robotic automation and collaborative robotic cyber-physical systems
- Week 8-9: Big data analytics, cyber security, and cloud computing for Industry 4.0
- Week 10-11: Industry 4.0 case studies 1: Manufacturing factories and assembly lines, food and agritech industry, inventory management and quality control, plant safety and security
- Week 12-13: Strategies for competing in an Industry 4.0 world

Course Format
- 3 hours/week of lectures
- Case study assignments and project
- Midterm exam
- Final exam

Grading
- Assignments/project (30%)
- Midterm (30%)
- Final exam (40%)

SFU GRADUATE AND POSTDOCTORAL STUDIES

New Graduate Course Proposal

Course Subject (eg. PSYC) MSE	Number (eg. 810) 981	Units (eg. 4) 3

Course title (max. 100 characters)

Industrial Big Data Analytics

Short title (for enrollment/transcript - max. 30 characters) **Industrial Big Data**

Course description for SFU Calendar (course descriptions should be brief and should never begin with phrases such as "This course will..." or "The purpose of this course is..." If the grading basis is satisfactory/unsatisfactory include this in the description)

Data is the lifeblood of the smart factory. Provides students with hands-on experience in big data analytics. Students in this course learn about life cycle of big data analytics for Industry 4.0 from data collection to data preparation to data mining. As a result, they are empowered with the skill of handling massive, heterogeneous manufacturing data in highly distributed environments of Industry 4.0.

Rationale for introduction of this course

This course provides students enrolled in the new Master of Engineering program in Smart Manufacturing and Systems (a.k.a. Industry 4.0) with hands-on experience in industrial big data analytics and their applications to Industry 4.0.

Term of initial offering (eg. Fall 2019) Fall 2021	Course delivery (eg. 3 hrs/week for 13 weeks) 3 hrs/week for 13 weeks
Frequency of offerings/year 1 time/year	Estimated enrollment per offering 48

Equivalent courses (courses that replicates the content of this course to such an extent that students should not receive credit for both courses)

None

Prerequisite and/or Corequisite None

Criminal record check required? ☐ Yes if yes is selected, add this as prerequisite

Additional course fees? ☐ Yes ☑ No

Campus where course will be taught ☐ Burnaby ☑ Surrey ☐ Vancouver ☐ Great Northern Way ☐ Off campus

Course Components * ☑ Lecture ☐ Seminar ☐ Lab ☐ Independent ☐ Capstone ☐ _____

Grading Basis ☑ Letter grades ☐ Satisfactory/ Unsatisfactory ☐ In Progress / Complete

Repeat for credit? ☐ Yes ☑ No

Total repeats allowed? _____

Repeat within a term? ☐ Yes ☑ No

Required course? ☐ Yes ☑ No

Final exam required? ☑ Yes ☐ No

Capstone course? ☐ Yes ☑ No

Combined with a undergrad course? ☐ Yes ☑ No If yes, identify which undergraduate course and the additional course requirements for graduate students:

* See important definitions on the curriculum website.

RESOURCES

If additional resources are required to offer this course, provide information on the source(s) of those additional resources.

Faculty member(s) who will normally teach this course
A new faculty/instructor will be hired to teach this course.
Additional faculty members, space, and/or specialized equipment required in order to offer this course

CONTACT PERSON

Academic Unit / Program	Name (typically, Graduate Program Chair)	Email
MSE	Ed Park	ed_park@sfu.ca

ACADEMIC UNIT APPROVAL

A course outline must be included.

Non-departmentalized faculties need not sign

Graduate Program Committee	Signature	Date
Department Chair Ed Park	Signature	Date June 26, 2020

FACULTY APPROVAL

The course form and outline must be sent by FGSC to the chairs of each FGSC (fgsc-list@sfu.ca) to check for an overlap in content

Overlap check done? ☑ YES

This approval indicates that all the necessary course content and overlap concerns have been resolved. The Faculty/Academic Unit commits to providing the necessary resources.

Faculty Graduate Studies Committee	Signature	Date
Parvaneh Saeedi		June 29, 2020

A library review will be conducted. If additional funds are necessary, DGS will contact the academic unit prior to SGSC.

SENATE GRADUATE STUDIES COMMITTEE APPROVAL

Senate Graduate Studies Committee	Signature	Date
Jeff Derksen		August 28, 2020

ADMINISTRATIVE SECTION (for DGS office only)
Library Check: _____
Course Attribute: _____
Course Attribute Value: _____
Instruction Mode: _____
Attendance Type: _____

If different from regular units:
Academic Progress Units: _____
Financial Aid Progress Units: _____

Mechatronic Systems Engineering

MSE 981 (3) Industrial Big Data Analytics

Course Description

This course provides students with skills to turn big industrial data into actionable information by using predictive analytics. In this process students learn to answer four questions related to a smart factory using the right tools and techniques: what happened, why it happened, what will happen and what actions to follow. With this goal, the course covers three modules: Industrial Big Data Management, Industrial Big Data Predictive Analytics, and industry-specific challenges and solutions. In the data management module, data gathering, storage, selection, transformation, preparation and cleaning approaches are presented. The predictive analytics module covers a broad range of methods in unsupervised learning, supervised learning and semi-supervised learning focusing on deep learning methods. The last module discusses challenges and solutions in predictive analytics for industrial data with a focus on cloud-based solutions. Examples are: heterogeneous data integration, missing data imputation, learning from imbalanced data, and anomaly detection. Students will work with real-word industrial data during the semester and are assigned weekly practical assignments to gain hands-on experience. A course project lets students work in teams to enhance their skills in addressing immediate real-world problems and improve interpersonal skills through experiential learning.

Pre-requisites

None

Resources / References

Reading materials and online resources to be provided by instructor

Subjects & Topics

- Big data management (2 weeks), unsupervised learning (2 weeks), supervised learning (2 weeks), semi-supervised learning (1 week), deep learning (3 weeks), Industry-specific challenges and solutions (3 weeks)

Course Format

- 3 hours/week of lectures
- Weekly hands-on assignments to apply techniques learned in the class
- Quizzes to evaluate students' theoretical knowledge
- Final project addressing a real-world smart factory problem

Grading

- Assignments (40%)
- Project (40%)
- Quizzes (20%)

Appendix 3 Letters of support

Support Letters from City of Surrey / Surrey Board of Trade

CITY OF SURREY

the future lives here.

June 8, 2020

Mr. Andrew Petter, President and Vice-Chancellor
Simon Fraser University, 8888 University Drive
Burnaby, BC V5A 1S6

Dear Mr. Petter:

I am pleased to provide this letter of support for Simon Fraser University's (SFU) new Smart Manufacturing and Systems Professional Masters Program. This program, as the first Master's level professional Industry 4.0 program in BC, has strong alignment with the City's focus on Industry 4.0 by supporting our manufacturing sector in integrating core capabilities such as robotics and automation, IoT, digital manufacturing, and big data analytics.

Surrey has long been Metro Vancouver's industrial hub and will continue to be the region's strategic industrial base for generations to come. With 1,000 manufacturers, our manufacturing sector employs over 23,000 Surrey employees. In the City's 2018 Labour Market Study for Surrey's Advanced Manufacturing and Innovation Economy, skilled technologists, technicians, and engineers trained in advanced manufacturing were identified as a skills gap in bringing this sector to fully adopt Industry 4.0. This Masters program aligns with the findings from discussions between industry, government, and academia from that study and will train the critical talent needed to increase global competitiveness not only of Surrey companies, but manufacturers across the region and province.

As you well know, our region's competitive advantage is with our talent. Now more than ever, we need skilled talent that will help us build local capacity to support more domestic production capabilities in the midst of global trade uncertainty.

SFU and the City of Surrey have a long-standing history of partnership in identifying city-wide and regional strategic growth opportunities, and working together to develop and execute initiatives to capture those opportunities. Recent SFU Surrey initiatives that the City has been proud to support are the 2019 opening of the Sustainable Environmental Engineering building and program, as well as the announcement of the upcoming SFU Quantum Algorithms Institute. The new Smart Manufacturing and Systems Professional Masters Program complements these Provincial investments in developing Surrey as an innovation precinct and metropolitan centre South of the Fraser.

The City of Surrey is extremely supportive of Simon Fraser University's Smart Manufacturing and Systems Professional Masters Program as a critical initiative that will strengthen the region's manufacturing competitiveness, create high-value jobs, grow our innovation ecosystem, and attract investment.

Sincerely,

Stephen Wu, Manager, Economic Development

Investment & Intergovernmental Relations Department 13450 - 104 Avenue Surrey BC Canada V3T 1V8
T 604.591.4128 F 604.594.3055 www.surrey.ca

SURREY BOARD OF TRADE

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Dr. Ed Park, PhD, PEng
Professor and Director (*Interim*), School of Mechatronic Systems Engineering
Associate Dean, Academic, Faculty of Applied Sciences
Simon Fraser University

Re: Letter of Support – Master of Engineering (M.Eng.) in Smart Manufacturing and Systems

Dear Dr. Park:

Simon Fraser University is Canada's leading engaged university, defined by its dynamic integration of innovative education, cutting-edge research, and far-reaching community engagement. Their campuses in Surrey, Vancouver, and Burnaby are within one-hour commute of fifty percent of BC's population.

Simon Fraser University's proposed Master of Engineering (M.Eng.) in Smart Manufacturing and Systems program offers a unique opportunity for Surrey and our members. Key among this region is the advanced manufacturing sector: nearly 24,000 of Surrey's labour force work here; and the manufacturing sector is incredibly important in providing the city's population with well-paying jobs. Additionally, Surrey has 8,000 commercial and industrial businesses that play a vital role as suppliers of raw materials, goods and services in the ecosystem for local manufacturing companies.

Surrey is home to a wide range of manufacturing businesses, spanning from robotics and technology companies to machinery and furniture producers. Graduates of this program will have a direct impact in supporting local companies through the complete spectrum of automation. Further, this new program builds upon the success and expertise within the School of Mechatronic Systems Engineering and will provide applied learning labs that will benefit industry through hands on training. Members of the Faculty work closely with industry and their track record of industrial research grants is among the largest at SFU. A focus in Industry 4.0 and advanced manufacturing will enhance industrial research and services activities in the Fraser Valley region and build upon our competitive advantage in global markets.

The Surrey Board of Trade, alongside City of Surrey, recognizes that SFU's infrastructure and program breadth continues to have a positive impact in revitalizing the new Surrey

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SURREY BOARD OF TRADE

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City Centre and in fueling the local economy. Advanced manufacturing remains a key priority for the City's economic development strategy.

The SBOT represents 3,000 members and has over 6,000 business contacts with over 60,000 employees. The purpose of the organization, on behalf of its members, is to advocate at all levels of government, facilitate networking opportunities, and provide cost-saving benefits and marketing opportunities. We are a not-for-profit organization with a common goal of furthering the interests of businesses in our region. We have demonstrated, through our projects and initiatives, a commitment to enhancing the local economy.

Other benefits directly related to the program launch would include:

- The need to meet the increasing enrollment demand from the fast-growing university-aged population in the south Fraser Valley and for engineers. BC has the highest labour market demand for engineers in Canada but seriously lags behind peer provinces in the percentage of engineering graduates per capita. The technology sector growth has been suppressed due to a lack of engineering talent according to the BC Technology Industries Association;
- This program will accommodate growth and labour market demand driven capacity created by the need for advanced manufacturing solutions in industries;
- SFU Surrey is the only research university in the South Fraser region. The program provides the opportunity for industry-based collaborations for which SFU and SFU Surrey have a strong reputation. The program offered will provide the training and education required to meet BC's labour market needs and maintain a competitive economy;
- The expansion of Surrey based academic programming will support the institution's vision for the integration of innovative education, leading edge research and far-reaching community engagement through applied learning. SFU Surrey has been a living example of what it means to be an "engaged university";
- A new program will expand opportunities for community partnerships through research, student projects and industrial internships.

Thanks to vast forests and rich mineral deposits, a highly educated workforce, and a province-wide focus on research and innovation, BC's manufacturing companies are making the planet and its people healthier and more productive with a vast array of manufactured products. The SBOT acknowledges the importance of SFU's work to make

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a difference in the community and supports their application for a new graduate program in Smart Manufacturing and Systems. By focusing on advanced manufacturing, agri-innovation, and Industry 4.0, the proposed program will create a prosperous and resilient economy that supports a healthy community for Surrey's future.

Sincerely,

H. Captain (Navy) Anita Huberman CEO, Surrey Board of Trade

101-14439 104 Avenue, Surrey, BC V3R 1M1 | 604.581.7130 | info@businessinsurrey.com | **businessinsurrey.com**

Support Letters from Academic Intuitions

THE UNIVERSITY OF BRITISH COLUMBIA

Faculty of Applied Science
Office of the Dean
5000 – 2332 Main Mall
Vancouver, BC Canada V6T 1A4

Phone 604 822 6413
Fax 604 822 7006
www.apsc.ubc.ca

June 8, 2020

Professor Eugene Fiume
Dean, Faculty of Applied Science
Simon Fraser University
8888 University Drive
Burnaby, BC V5A 1S6

Dear Eugene,

Given the current global economic landscape and industry's growing demand for high-tech solutions, there is great clarity to the value of establishing British Columbia and Canada as leaders and competitors in relation to Industry 4.0. Additionally, British Columbia currently graduates less than half the number of Masters- and PhD-level engineers as compared to our peer provinces, Ontario and Quebec. The opportunity to increase the number of graduate students in engineering programs (which has been a shared goal amongst all higher education institutions in British Columbia), coupled with increased focused, hands-on training in the advanced manufacturing sector is critical to the future of the Province. Thus, I am writing to express my support for the proposed Master of Engineering program in Smart Manufacturing and Systems (M.Eng. SMS) at Simon Fraser University.

By building on SFU's existing collaborations with industry and local government, and by leveraging SFU's strengths in mechatronic systems engineering, computer science and operations research, the proposed M.Eng. SMS program will provide students with research and employment opportunities in across a in manufacturing, production management. Graduates of the program will have specialized knowledge of Internet of Things, robotics and automation, predictive maintenance, data analytics gained through cross-disciplinary applied education, and will enrich the talent pool for one of the most valuable and growing sectors in the B.C. economy. Our Faculty has also recognized the need for investment in this area by developing our own programs at both the undergraduate (BASc in Manufacturing Engineering) and graduate level (MEng in Mechatronics and MEL in Advanced Materials and Manufacturing).

On behalf of the University of British Columbia's Faculty of Applied Science, I look forward to welcoming the proposed M.Eng. SMS program into the engineering educational landscape, and to even greater collaboration between our institutions. Indeed, it is only by working together that we can help B.C. realize its potential to be a global leader in advanced manufacturing innovation.

Once again, I enthusiastically support the proposed graduate program in Smart Manufacturing and Systems at Simon Fraser University, and wish you success in its implementation.

Sincerely,

James Olson, PhD, P.Eng, FCAE
Dean, Faculty of Applied Science

University of Victoria Engineering

Faculty of Engineering
Office of the Dean

University of Victoria
Engineering Office Wing
RM 248

PO Box 1700 STN CSC
Victoria British Columbia
V8W 2Y2 Canada

Tel (250) 721-8677
Fax (250) 721 8676
www.uvic.ca/engineering

June 3, 2020

Professor E. Park
Director (Interim), School of Mechatronic Systems Engineering
Simon Fraser University
8888 University Drive
Burnaby, BC V5A 1S6

Re. Letter of support for Proposed Smart Manufacturing and Systems Master of Engineering Program

Dear Dr. Park:

The proposed graduate program in Smart Manufacturing and Systems (SMS) is a much-needed addition to the training and education of highly qualified personnel for the Province of British Columbia and Canada. This program will educate and train engineers with the advanced knowledge critical to the region's high technology sector, such as digital: manufacturing, Internet of Things (IoT), robotics and automation, cyber-physical systems, predictive maintenance and big data analytics. The proposed education and training in these fields will develop graduate skills that are in high demand and are transferrable across a wide spectrum of companies in the technology field. On leaving the SMS program, students will be well prepared for the work force and I feel confident that there will be no shortage of employment opportunities.

The proposed SMS program will continue to build on SFU's existing collaborations with industry and also further the Faculty of Applied Sciences' strong commitment to the development of vibrant and technologically innovative communities. These communities will be further developed through partnerships with City of Surrey and relevant industry leaders. This a cutting-edge curriculum and the program is well-positioned to advance the Faculty and University level goals in several key areas. For example, expanding industry collaborations within the South Fraser Region, strengthening ties with all levels of government, and expanding the talent pool for the manufacturing sector.

I enthusiastically endorse the proposed program in Smart Manufacturing and Systems at SFU and wish you success in implementing the program.

Sincerely,

Colin Bradley, Ph.D., P.Eng.
Professor and Associate Dean Research
Faculty of Engineering, University of Victoria

Support Letters from Industrial Companies

SIEMENS

Date June 9th 2020

Mr. Christopher Duffin
Senior Associate Director of Advancement
Office of the Dean, Faculty of Applied Sciences
Simon Fraser University
Burnaby B.C.

Dear Christopher,

Subject: Master of Engineering in Smart Manufacturing and Systems – Industry 4.0

On behalf of Siemens Canada, Digital Industries, I am pleased to provide this letter of support to Simon Fraser University (SFU) for their new Master of Engineering Degree in Smart Manufacturing and Systems. This program is the first of its kind in Western Canada and aligns with Siemens' goal to invest in Canadian Education and in students.

Being part of the manufacturing ecosystem in Canada, as a technology partner and manufacturer, we strive to make our contribution by enhancing manufacturing landscape in Canada. This can be done with a synchronous approach towards Industry 4.0 and smart manufacturing systems by means of technology and people leadership.

People Leadership is about the best coaching, training, simulations and demonstrations being available for our human capital to be able to leverage the technological aspects and bring Canadian manufacturers at the same or better positioning than the typical industrial manufacturing countries in the world.

This is where we are excited about the collaboration with SFU, to close the loop on skill development and people leadership so that companies such as Siemens, or our Industrial partners and customers can readily embrace technological advancements which lead to higher productivity, better quality, faster time to market for Canadian manufacturers. The Master's degree on Smart Manufacturing and Systems – Industry 4.0 will be a leading course which will help transform the skill development of students from various engineering backgrounds so that we have a workforce of the future ready for advance manufacturing.

SFU and Siemens have previously also collaborated on the Siemens Mechatronics Certification program, bringing electrical, mechanical, and computer technologies in a holistic approach for complex manufacturing systems. SFU will lead the training and coaching for college faculty and students from all around the world. This is a great baseline, and which will be strengthen further with SFU's proposed degree program.

Unrestricted Siemens Canada Limited

1577 North Service Road East
Oakville, ON
Canada L6H 0H6

Tel.: 1 (905) 465-8000
www.siemens.ca

SIEMENS

We firmly believe that our strength as a Canadian company is reinforced when we work together with Education Partners such as Simon Fraser University. The proposed Master of Engineering Degree in Smart Manufacturing and Systems is a way to bring Industry and Education closer together and we fully support this approach.

Sincerely,

MALLERET KAREN

Digitally signed by MALLERET KAREN
Date: 2020.06.09 16:32:52 -04'00'

Karen Malleret
Director of Industrial Services
Siemens Canada Limited, Digital Industries

Unrestricted Siemens Canada Limited

1577 North Service Road East
Oakville, ON
Canada L6H 0H6

Tel.: 1 (905) 465-8000
www.siemens.ca

KUKA

June 8, 2020

Dr. Ed Park, PhD, PEng
Professor and Director (*Interim*), School of Mechatronic Systems Engineering
Associate Dean, Academic, Faculty of Applied Sciences
Simon Fraser University
8888 University Drive
Burnaby, BC, V5A 1S6

Re: Letter of Support for the development of a Professional Master's Program in Smart Manufacturing and Systems (Industry 4.0)

It is our great pleasure to provide this letter of support for the development of a Professional Master's Program in Smart Manufacturing and Systems (a.k.a. Industry 4.0) proposed by Simon Fraser University, in British Columbia, Canada.

KUKA Robotics Canada is a subsidiary of the global automation corporation KUKA AG. KUKA is best known for its wide range of German-engineered and built industrial robots, which are highly desirable for their performance and lowest total-cost-of-ownership. KUKA also offers a wide range of positioners, slides, sensitive and collaborative robots, mobile platforms, mobile robots, simulation software and Industry 4.0 solutions. This complete array of products combined with our engineering and support services help Canadian manufacturers achieve the highest level of productivity and profitability.

The proposed master's program fills an important talent gap that exists in industry today. Graduates of this program will have the skills and competence necessary to help local companies grow through the complete spectrum of automation. They will be able to start by identifying projects with attractive ROI, complete the simulation proof of concept (digital twin), develop a project scope and follow through with the implementation of a successful project. As a company starts on the path of automation and continuous improvement, they become more competitive, win more business and employ more people in higher-skilled, better paying jobs here in Canada! With the right support from the Canadian government they can expand their business into foreign markets and become globally competitive!

KUKA is already deeply involved in the BC area. Our partnership with UBC Center for Wood Processing, UFV and the CNRC provides learning and development systems for students and companies. Additionally, we work with various companies including Daimler, Ballard, BW Structures, Coulson and Delta Controls; and System Integrators like Remtech Systems and Apex Motion Controls. This program will also enable us to support the growth of local system integrators and end user customers in this important Canadian manufacturing market.

KUKA Robotics Canada Ltd. 2865 Argentia Rd. Unit 4-5, Mississauga, ON L5N 8G6 Canada
T: (905) 858-5852 F: (905) 858-5851 E: info.ca@kuka.com W: www.kuka.com

KUKA

As one of the world's leading suppliers of robotics, plant manufacturing automation, system technology and a pioneer in Industry 4.0, KUKA is uniquely positioned to partner with SFU in the development, support and implementation of this innovative program, which would be the first of its kind in Canada in terms of its comprehensiveness and uniqueness. This would be the only true Industry 4.0 graduate training program in Canada that is geared to produce professional graduates with talents who will be ready to immediately contribute to the transformation of the Canadian manufacturing industry for improved productivity and global competitiveness. Our broad product range, leading-edge technology and open-architecture controls system will provide the best learning platform and ecosystem for a program of this importance.

We hope that our endorsement of this program will contribute to your decision to approve this important program that is needed to fuel the manufacturing growth in BC and all the related jobs that will be created. We would be pleased to provide you with more information as required.

Sincerely,

Edward Manera, P.Eng.
President
KUKA Robotics Canada Ltd.

KUKA Robotics Canada Ltd. 2865 Argentia Rd. Unit 4-5, Mississauga, ON L5N 8G6 Canada
T: (905) 858-5852 F: (905) 858-5851 E: info.ca@kuka.com W: www.kuka.com

CONFIRMED AUTOMATION SYSTEMS INC
1651 Welch Street, North Vancouver BC, V7P 3G9

6 June 2020

Mr. Christopher Duffin,
Senior Associate Director of Advancement,
Office of the Dean, Faculty of Applied Sciences, Simon Fraser University
L9006 8888 University Drive
Burnaby, BC
Canada
V5A 1S6

Dear Mr. Duffin:

Our company provides Production Optimization and Production Intelligence solutions for customers across North America in the manufacturing sector. We utilize automation, mechanical improvements and production line data to optimize operations for our customers. These projects all fall within the definition of Industry 4.0, which was established in 2011 by a working group from the German government.

Staff in our firm are all engineers from a variety of disciplines including Computer Science and Mechanical Engineering. When staff join our team we need to provide training on Industry 4.0 to ensure they understand the relationships between the manufacturing equipment and the benefits that can be provided by the computer links between the manufacturing and business processes.

Students that have been provided this training in advance of joining our firm would provide strong value.

We strongly support your initiative to introduce a Smart Manufacturing and Systems Masters of Engineering program at SFU. When you get your first graduates, please let us know.

Sincerely,

Mike Gardiner

President – Confirmed Automation Systems Inc.

FANUC

FANUC Canada Limited
6774 Financial Drive
Mississauga, Ontario, L5N 7J6

Tel: (905) 812-2300
www.fanuccanada.com

June 8, 2020

Dr. Ed Park, PhD, PEng
Professor and Director (Interim), School of Mechatronic Systems Engineering
Associate Dean, Academic, Faculty of Applied Sciences
Simon Fraser University
8888 University Drive
Burnaby, BC V5A 1S6

Re: Letter of Support – Master of Engineering (M.Eng.) in Smart Manufacturing and Systems

Dear Dr. Park,

Please accept this letter of support for your plan to establish a Smart Manufacturing and Systems Professional Masters program at Simon Fraser University. Such a program aligns precisely with current industry needs and global demand for innovation in manufacturing.

FANUC is the market leader in industrial robotics and automation for manufacturing with over 650,000 robots installed globally. Our technology is world renowned for reliability and for helping our customers to be more productive and competitive. The adoption of Industry 4.0 technologies is a very real challenge for the majority of our customers. This includes all aspects of advanced manufacturing, IIoT, robotics, cyber-physical systems, and big data analytics. The challenge becomes even greater to find the skilled people to support such initiatives. This program can help solve these challenges by bringing vital skilled resource to industry.

We believe this program will provide benefit to Surrey and the region by advancing industry and increasing industry collaboration. It will also have great positive impact on British Columbia's and Canada's initiatives for advance manufacturing.

FANUC Canada can also offer support for this program with in-kind contributions for factory automation equipment. These contributions can support building the technical labs necessary to support experiential learning. Our in-kind contribution will consist of significant equipment discounts over and above any standard or educational discounts.

We wish you success in establishing this extremely relevant and important program. If any additional information or further confirmation of our support for this program is required, please feel free to contact us.

Sincerely,

Peter Fitzgerald
General Manager
FANUC Canada Ltd.
905-812-2310

Page 1 of 1

FESTO

Mr. Christopher Duffin
Office of the Dean
Simon Fraser University
8888 University Drive
Burnaby, BC V5A 1S6

Smart Manufacturing and Systems Program
June.8th, 2020

Dear Program Review Committee:

Festo Didactic, Inc. has been fortunate to support the mechatronics program at Simon Fraser University for many years. Through this partnership, Festo has worked in conjunction with SFU faculty and provided learning systems for mechatronics, electrical engineering, pneumatics, and automation technology. The proposed development of a new program for Smart Manufacturing and Systems is a natural continuation of our work together. We feel confident in saying that if approved this program will greatly increase the ability for Simon Fraser University to help meet the needs of local industry for a skilled and qualified workforce for many years into the future.

The Festo group of companies are proud to be innovation leaders in the promotion and implementation of Advanced Mfg and Industry 4.0 worldwide.
Festo Inc, our automation division has aggressively expanded its presence in Western Canada over the past decade by assisting the manufacturing sector with increasing productivity and introducing automation into their manufacturing processes.
The proposed program aims to support these advancements to the manufacturing sector, and we believe it will have a huge impact on many industry sectors in BC.

In parallel, Festo Didactic is the world-leading provider of equipment and solutions for technical education.
Our product and service portfolio provide the education sector with holistic education solutions for all areas of technology in factory automation, mechatronics, electrical engineering and mechanical engineering.
We are currently introducing Industry 4.0 to universities and colleges through our Festo's Cyber Physical (CP) Factory and Labs.

Our Learning Systems combine theoretical knowledge with practical experience in automation and technology. This experience comes from Festo's history of working with over 300,000 customers in more than 200 industries across the globe. Intuitive and fast learning is achieved through practical learning systems, which make the technologies and processes used in industrial production immediately tangible for the students. These systems help students gather the real, practical experience that they need to work independently in industry.

For these reasons, we are hopeful the program review committee will see the same promise in this new program as we do.
The program goals are easily in reach, and we are certain they will increase the productivity and competitiveness of the BC manufacturing sector.
I am available to answer your questions or provide any other insight as needed. Good luck with your review process. Thank you for your time & attention.

Yours Sincerely,

Greg James

Greg James
Regional Sales Manager, Festo Didactic

Festo Didactic Ltd

675 Rue du Carbone
Quebec, Quebec
G2N 2K7

Cell 647-628-6871

www.festo-didactic.com

Wiivv Wearables Inc.
1152 Mainland Street, Suite 400
Vancouver, V6B 4X2
Canada

Dr. Ed Park, PhD, PEng
Professor and Director (Interim), School of Mechatronic Systems Engineering
Associate Dean, Academic, Faculty of Applied Sciences
Simon Fraser University

Dear Dr. Park,

This letter is intended to outline an industry perspective on how and why the new program proposed by SFU, Smart Manufacturing and Systems Professional Masters Program (Industry 4.0), will be a great resource for industry in BC and critical for building an "industry 4.0" smart workforce in BC that will increase domestic production and reduce supply chain complexity.

Wiivv (pronounced weave) is transforming footwear, supportive apparel, and wellness for every human body so that you can move and feel your best. We are a leading consumer technology company based in Vancouver, BC that empowers people and brands with the benefits of custom fit products sold and shipped directly to consumers using Wiivv Fit Technology. Wiivv developed and operates a complete value chain; from scan via smartphone, through to customization, hybrid manufacturing, and delivery.

Wiivv is already applying industry 4.0 methods to the product development, manufacturing, and delivery of our products in the following areas:

- Hybrid manufacturing: on-demand manufacturing, joining custom components to non-custom components
- Custom order tracking during manufacturing and shipping
- Using AI to leverage our novel data set from customers to improve products, educate customers, and flag issues
- Industry leader in the use of 3D printers for manufacturing and intelligent product customization

Wiivv would provide benefit to the Masters program by enhancing curriculum and providing a cutting edge, industry partner for students to apply their knowledge and skills, thus accelerating their learning. Carly Fennell and Colin Lawson, who lead biomechanics and manufacturing collectively have also endorsed this program and are willing to guest lecture in the program as needed. This new Masters program would benefit Wiivv by providing access to highly trained professionals, and by sharing resources, facilities, and experts that might not be available otherwise. This would accelerate Wiivv's technological advantage and continue to position Wiivv as an industry 4.0 leader.

More broadly, we see this program as a platform to build a highly specialized and technical workforce that will naturally grow Industry 4.0 manufacturing here in BC/Canada. This is critical to increase domestic production, reduce the complexity of Canadian supply chains and make Canada far less reliant on international entities for the production of goods.

Sincerely,

Shamil Hargovan, *Founder and CEO*

June 9, 2020

Dr. Ed Park, PhD, PEng
Professor and Director (Interim), School of Mechatronic Systems Engineering
Associate Dean, Academic, Faculty of Applied Sciences
Simon Fraser University

Re: Letter of Support – Master of Engineering (M.Eng.) in Smart Manufacturing and Systems

Dear Dr. Park:

Finning is pleased to provide a letter of support behind SFU's proposed graduate program expansion in Smart Manufacturing and Systems, aimed at meeting an important need in B.C. and Canada – that of developing leaders in Industry 4.0 technologies.

Finning is the world's largest Caterpillar dealer, selling, renting and providing parts and service for equipment and engines to customers across diverse industries, including mining, construction, petroleum, forestry and a wide range of power systems applications. Finning is headquartered in Vancouver, B.C. and operates in three regions: Western Canada, South America (Chile, Argentina, Bolivia, Uruguay) and the United Kingdom (UK) and Ireland, employing over 13,000 employees across 214 locations. We also have a substantial remanufacturing business through our world-class parts and component refurbishing enterprise, OEM, based in Edmonton, Alberta.

Manufacturing continues to be a large component of the diversified Canadian economy. With the growing influence in digital technologies in both manufacturing and resource industries in the form of robotics, additive manufacturing and big data analytics—Canadian manufacturers, like Finning, are spurring innovation and transforming the efficiency of their operations. We believe western Canada is positioned very well to advance the adoption of these technologies and we will need leaders in Industry 4.0 to shift Canada's manufacturing culture to accelerate technology adoption and growing an inclusive and digitally skilled workforce.

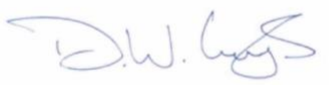
Adoption of these advanced manufacturing technologies requires new digital skills, process-related and business skills. We see tremendous benefit in expanding SFU's graduate programs and introducing a program dedicated to Industry 4.0. This type of innovative program would serve companies, like ours, very well in terms of developing a greater pool of talent to draw upon in the manufacturing/remanufacturing pillar of our business.

FINNING

This growth in SFU's engineering program will support our future needs in the area of skilled and diverse engineering professionals. The proposed program strengths include an emphasis on technical skill development, experiential learning and an interdisciplinary perspective that will allow graduates to make an immediate impact in the manufacturing and remanufacturing sectors. The broad-based learning outcomes are supported with an industry perspective through curriculum, industrial internships, team projects and problem-based learning.

Finning is in full support of this program launch and believes it could bring tremendous benefit to engineering training and help to propel B.C. to a leadership position in Industry 4.0 technologies. At Finning, we operate in a highly competitive sector and need to stay on the leading edge of our market – education and applied training is a key component to this and we believe the direction that SFU is taking with its new program is exactly what is needed at this time and in the future.

Sincerely,



Dave Cummings
Executive Vice President & Chief Digital Officer
Finning International

FINNING

YASKAWA

CANADIAN HEADQUARTERS
YASKAWA CANADA INC.
3530 LAIRD ROAD, UNIT 3
MISSISSAUGA, ONTARIO
L5L 5Z7
TEL: 905/569-MOTO (6686)
FAX: 905/569-2240

Hi Chris,

I would like to say that we at Yaskawa Canada Inc. support the new School of Mechatronic Systems Engineering program that is being proposed. Not only do we support, but we definitely see a need for this program in the province of British Columbia.

As you know we are a worldwide leader in robotics and automation, and the proposed program will bring the teachings of automation within the manufacturing industry. Currently we have customers that have robotics and automation, however they are unable to expand their businesses due to the fact of not having the people with the skill set to hire.

This program will highlight and bring to the forefront opportunities for students to learn the latest in automation manufacturing as well as working with robots. These are industry standards now and for the future, and we support your push for this program.

Our donation of a robot to your facility only further shows our support and excitement in having an opportunity to bring such knowledge to students. We look forward to working alongside Simon Fraser University School of Mechatronic Systems Engineering.

Regards,

Chris Lewis
Regional Technical Manager
Yaskawa Canada, Inc.
Motoman Robotics Division

chris.lewis@motoman.com
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O: 905-813-5934
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seaspan
VANCOUVER SHIPYARDS

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North Vancouver, BC V7P 2R2
Canada

(604) 988-3111
www.seaspan.com

June 5, 2020

Andrew Petter
President and Vice-Chancellor Simon Fraser University
8888 University Drive Burnaby, BC
V5A 1S6

Dear Dr. Petter:

On behalf of Seaspan, I am pleased to provide this letter of support for Simon Fraser University's (SFU) new Smart Manufacturing and Systems Professional Masters Program. This program is an exciting program for Seaspan as we are constantly looking for new talent that can help to drive efficiency and innovation in our design and manufacturing processes.

Seaspan is Canada's Non-Combat Shipbuilding partner with approximately 1400 employees at our Vancouver Shipyards in North Vancouver and a further 1400 employees spread between our Vancouver Drydock, also in North Vancouver, and our Victoria Shipyards in Victoria. Today we are designing and building the next generation of larger Canadian Coast Guard vessels, along with two Joint Support Ships for the Royal Canadian Navy. We continue to expand and require high quality engineering staff to support these complex ship designs and the corresponding production and manufacturing of the ships themselves.

SFU is a leader in innovative programs looking towards the future—in this case to Industry 4.0. Seaspan continues to evolve its digital design and building processes and is introducing technologies such as robotic welding to drive our efficiency. This makes for a great match between SFU's programs and Seaspan's industry talent needs.

I am delighted to support Simon Fraser University's Smart Manufacturing and Systems Professional Masters Program as a unique initiative that will encourage entrepreneurial development, attract investment, and create jobs in the Vancouver area.

Thank you in advance for your thoughtful consideration of this opportunity.

Sincerely,

D. Hargreaves

Dave Hargreaves
Vice President, Strategy and Business Development

Re: Letter of Support – Master of Engineering (M.Eng.) in Smart Manufacturing and Systems.

To Whom It May Concern:

I am pleased to provide this letter of support for Simon Fraser University and their aspirational vision to launch a new Master of Engineering (M.Eng.) in Smart Manufacturing and Systems.

As a member of the tech ecosystem in British Columbia, I am a strong advocate for the important role universities play in supporting industry through applied research, knowledge transfer, learning environments for continuous piloting of new technologies and the development of our next generation of thought leaders and change makers.

Training leaders for Industry 4.0 represents a massive challenge that requires a collective effort. Universities have a major task to support competence development and local industry in its adoption.
Without question, the demand for technical professionals in the space of Industry 4.0 and advanced manufacturing is strong and growing, with the opportunity for the British Columbia labour market to enjoy the benefit of graduates with a unique skillset and an applied learning experience that will be offered through the proposed leading-edge professional graduate degree program.

Look no further than how the COVID-19 pandemic hit manufacturers in an unexpected and unprecedented way. For the first time in modern manufacturing history, demand, supply and workforce availability were affected globally at the same time. Moving forward, advances in automation and robotics will drastically increase productivity across a number of manufacturing processes and reframe our planning in domestic manufacturing. Automated manufacturing will create new jobs and opportunities for digitally-savvy employees who can lead in an unpredictable world.

Industry 4.0 is transforming the production capabilities of all industries, including the agricultural domain. In my roles as Chairman with Terramera and Fraser Valley based CubicFarm Systems Corp, it is easy to recognize how rapid advances in technology have challenged conventional farming. I, along with my colleagues, have a strong interest in the proposed program's success and see key areas of alignment in research, industrial internships, and faculty engagement with a focus on agri-tech and food production.

Simon Fraser University's proposed program offers a unique initiative that will encourage entrepreneurial development, attract investment, and create opportunities for future generations. I look forward to continued collaboration among my various roles in the agri-tech sector. This program represents a novel and valuable addition to the existing engineering programs in our province to support innovation and our economy.

Thank you in advance for your thoughtful consideration of this opportunity.

Sincerely,

Jeff Booth

Chairman, Terramera

Chairman, CubicFarms

11631 Kestrel Drive, Richmond BC V7E 4E3 Canada

Global Automakers of Canada

Members: BMW · Honda · Hyundai · Jaguar Land Rover Kia · Maserati · Mazda · Mercedes-Benz · Mitsubishi · Nissan Porsche · Subaru · Toyota · Volkswagen · Volvo

Associates: Denso · Ferrari · Isuzu · McLaren · SXM CVS

June 8, 2020

Mr. Christopher Duffin
Senior Associate Director of Advancement
Office of the Dean, Faculty of Applied Sciences
Simon Fraser University, Room L9006
8888 University Drive,
Burnaby, BC V5A 1S6

Re: Smart Manufacturing and Systems (SMS) Masters of Engineering Program

On behalf of the 15 members of the Global Automakers of Canada, we wish to acknowledge SFU Faculty of Applied Sciences' commitment to technological innovation through the development of the Smart Manufacturing and Systems (SMS) Masters of Engineering Program.

With a focus on developing the core technologies comprising "Industry 4.0", this program addresses the critical needs of the new economy by focusing on digital manufacturing, the IoT, robotics and automation, cyber-physical systems, predictive maintenance and big data analytics. Automakers face a shortage of talent to plan, implement, execute and maintain new digital systems of Industry 4.0, and the proposed program is a welcome addition. The number of engineers trained in handling the type and scale of data generated by digital twins in Industry 4.0 is increasing, but still falls far short of anticipated demand. Therefore, we strongly support your initiative to train much-needed professional engineering talent via the proposed program.

We believe that another strength of this exciting program will be that it will be found in the experiential learning that it is anticipated to take place via the hands-on learning and training and academic and industrial internships.

Thank you for your leadership.

Yours sincerely,

David C. Adams
President & CEO

Delivering Choice. Driving the Future. 1 Concorde Gate, Suite 701, PO Box 20 Toronto, ON M3C 3N6 **Tel** 416.595.8251 **GlobalAutomakers.ca**

Forestry Innovation Investment

June 9, 2020

Andrew Petter
President and Vice-Chancellor
Simon Fraser University
8888 University Drive
Burnaby, B.C.
V5A 1S6

Dear Dr. Petter:

On behalf of Forestry Innovation Investment (FII), I am pleased to provide this letter of support for the School of Mechatronic Systems Engineering, Faculty of Applied Sciences at Simon Fraser University's (SFU) new Masters of Engineering (M.Eng.) in Smart Manufacturing and Systems program. The program's goal to support British Columbia in implementing new manufacturing technologies and systems aligns with FII's objective to strengthen B.C.'s capability to produce competitive wood-based products and building systems that create and respond to market demand.

As part of our Wood First program, FII makes strategic investments in strengthening the supply chain and improving the competitiveness of the manufacturing sectors by developing sustainable approaches to manufacturing wood-based products and building systems. To achieve this, highly knowledgeable trained professionals are required. The Masters of Engineering in Smart Manufacturing and Systems program will not only train leading-edge professionals but also provides the real-world experience through the industrial internship program that will make for an expeditious and effective entry to the job market.

I am delighted to write this letter of support for Simon Fraser University's Masters of Engineering in Smart Manufacturing and Systems program as we share the common goal of strengthening B.C.'s manufacturing sector. Thank you in advance for your thoughtful consideration of this new opportunity.

Sincerely,

Michael Loseth
CEO
Forestry Innovation Investment

Suite 1200, 1130 West Pender Street, Vancouver, British Columbia, V6E 4A4, Canada | Tel: 604.685.7507 | www.bcfii.ca

BRITISH COLUMBIA

CASCADE aerospace

CASCADE AEROSPACE INC.

An Operating Unit of IMP Aerospace & Defence

1337 Townline Road
Abbotsford, BC,
Canada V2T 6E1
Ph: (604) 850-7372

June 10, 2020

Subject: Proposal for Smart Manufacturing & Systems Professional Masters Program

To Whom it May Concern:

This letter is to provide support to the above noted initiative. As a large scale MRO in a highly competitive industry, we are always looking to provide that extra value add, a part of which is being a dynamic provider of offerings that customers cannot get anywhere else.

To achieve this, we require technology to expand our capabilities. A way of doing this is to create collaborative relationships with schools such as SFU. Cascade currently has a strong relationship with SFU, and have employed Applied Science students and graduates. To have a SMS program would assist with this collaboration; brainstorming industry issues would result in SFU getting the chance to research and apply the technology, and Cascade would have the ability to implement proven solutions and novel methods.

Smart Manufacturing is well known and proven to play an important role in any country's economic development. By supporting this effort, Cascade, as well as other businesses in British Columbia and Canada will benefit in overall expansion of capabilities, and the result will be solutions that will result in technological advancement. In our minds, it's a win for everyone.

Thank you for your time and attention.

Sincerely

Glenda Mohr
Director, Human Resources & Training
Cascade Aerospace

GENESIS ROBOTICS
AND MOTION TECHNOLOGIES

Letter of Support

Simon Fraser University
Faculty of Applied Sciences
8888 University Drive,
Burnaby, BC V5A1S6, Canada

June 10, 2020

To Whom it May Concern,

This letter confirms that Genesis Robotics and Motion Technologies is in support of Simon Fraser University's (SFU) initiative to launch a new Smart Manufacturing and Systems Professional Master's Program.

Genesis currently employs several SFU alumni and actively participates in recruitment of co-op students from SFU's engineering faculties. We value our collaboration with SFU and believe that the new program will further enhance SFU's ability to bring economic value locally, nationally, and internationally.

We look forward to developing a stronger partnership with SFU and to engaging with students and faculty from the Smart Manufacturing & Systems Program.

Sincerely,

Chris Di Lello
Chief Executive Officer
Genesis Robotics and Motion Technologies

www.genesis-robotics.com #1 - 6279 202 Street, Langley, BC, V2Y 1V7 604 800 1907

Rockwell Automation

June 10, 2020

Christopher Duffin
Senior Associate Director of Advancement, Office of the Dean, Faculty of Applied Sciences
Simon Fraser University
8888 University Drive
Burnaby BC V5A 1S6
Canada

Dear Christopher:

I am writing this on behalf of Rockwell Automation in support of Simon Fraser University's intent to launch a new Smart Manufacturing and Systems Program. As an organization which is also working to address the workforce development needs in the industrial space, Rockwell Automation agrees that expertise in smart manufacturing is a key need. The demand for associated skills in this field of study is growing as companies progress with digital transformation, operations & information technologies converge, and assets become more intelligent.

Rockwell Automation, Inc. (NYSE: ROK), headquartered in Milwaukee, WI, is a global leader in industrial automation and digital transformation. We strive to connect the imaginations of people with the potential of technology to expand what is humanly possible, making the world more productive and more sustainable. We have a long history of collaborating with educational institutions and are encouraged to see progressive entities like Simon Fraser University provide students with the skills needed to succeed in smart manufacturing roles.

Sincerely,

Michael Cook
Director, Global Academic
Rockwell Automation

expanding **human possibility**

Allen-Bradley FactoryTalk

Appendix 4 Details of program steering committee (if applicable)

The SMS program will collaborate with a number of external partner organizations from the private sector, government sectors and professional organizations. MSE will establish an external advisory board consisting of five members on three-year terms.

Besides seeking input and feedback on various aspects regarding the design, implementation, operation and evolution of the program, the external advisory board is invaluable for establishing and growing a base of internship partners accepting SMS interns on a regular basis and to further enhance job opportunities for students graduating from this program.

The external advisory board will be composed of five representatives from external organizations in addition to the MSE program director. The program director and one designated external representative will act as co-chairs of the external advisory board.

Potential partner organizations with competence in advanced manufacturing and Industry 4.0 technology, for instance, include the following ones:

- Surrey Board of Trade
- Siemens Canada, Digital Industries
- KUKA Robotics Canada
- Global Automakers of Canada
- FESTO Didactic, Inc.
- Seaspan
- Yaskawa Canada Inc.
- Finning International
- Wiivv
- 5 Booths Consulting Inc.

Appendix 5 Abbreviated curriculum vitae for faculty

Dr. WOO SOO KIM, P.Eng

Associate Professor in the School of Mechatronic Systems Engineering,
Simon Fraser University

Employment History

2016 Sept. - Current	Associate Professor, School of Mechatronic Systems Engineering, Faculty of Applied Sciences, *Simon Fraser University.*
2018 Jan. – 2018 Mar.	Visiting Professor, *EMPA- Swiss Federal Laboratory of Materials Engineering in ETH Domain*, Zurich in Switzerland.
2017 May – 2017 Oct.	Visiting Professor & Brain Pool Fellow, Department of Material Science and Engineering, *Seoul National University* in South Korea.
2010 Sept. – 2016 Aug.	Assistant Professor, School of Mechatronic Systems Engineering, Faculty of Applied Sciences, *Simon Fraser University.*
2009 Jan. - 2010 Aug.	Senior Research Staff Scientist, *Xerox Research Centre of Canada,* Toronto in Canada
2001 Dec. - 2002 Dec.	Visiting Research Staff, *Fraunhofer Institute of Silica Research* at Wuerzburg in Germany.

Educational Background

2009 PostDoc	*Massachusetts Institute of Technology (MIT)*, Department of Materials Science and Engineering, USA "Silver Nanoparticle Self-Assembly for Plasmonic Applications."
2006 Ph.D.	*Korea Advanced Institute of Science and Technology (KAIST)*, Department of Materials Science and Engineering, South Korea "Nano Imprint Lithography with Surface Functionalized Sol-gel Hybrid Polymer toward Mechanically Durable Stamp Applications."
2003 M.Sc.	*Korea Advanced Institute of Science and Technology (KAIST)*, Department of Materials Science and Engineering, South Korea "Soft Lithography of Sol-gel Hybrid Polymers for Photonic Applications."
2001 B.Sc.	*Yonsei University*, Department of Materials Engineering, South Korea

Awards, Honors and Scholarships

2016	**Title:** *International Short Visit Award 2018*, Award: $12,000, **Type:** Research, **Organization:** Swiss National Science Foundation
2010	**Title:** *Brain Pool Fellowship*: $25,000, **Type:** Research, **Organization:** National Research Foundation of South Korea
2016	**Title:** *Hanwha Advanced Material Award 2016*, Award: $13,000, **Type:** Research, **Organization:** Hanwha Corporation's New Faculty Award
2010	**Title:** *Wendy McDonald* Endowed Research Fellow Award: $5,000, **Type:** Research, **Organization:** Simon Fraser University
2009	**Title:** The first prize of *Quadrant Award 2007*: €15,000, **Type:** Research, **Organization:** ETH Zurich, **Details:** International PhD thesis competition in Polymeric and Composite Materials and Manufacturing Field held in ETH Zurich in Switzerland

Research Objectives

Over the past ten years as a Principle Investigator in Simon Fraser University, I have established a strong and flourishing research program in Additive Manufacturing of Printed Electronics. SFU's Additive Manufacturing Laboratory quickly became an interdisciplinary research training platform with a substantial critical mass of research personnel. Additive manufacturing is an emerging field that integrates the aspects of nanotechnology, material science, and mechatronics to design novel materials and manufacturing of energy, sensing robots, and their systems. My laboratory is equipped with the necessary facilities to generate transformative technological advances.

Publications & Patents: 1 book chapter, 57 refereed journal publications, 22 US patents, and 21 refereed conference proceedings have been published as a corresponding author.

Conferences, Workshops and Presentations: 45 invited talks from 2010, and 15 media interviews such as Maclean, New Scientist, ScienceDaily, AAAS EurekAlert!, and YTN broadcasting were given so far.

Research/Project Funding – Received: Total external funding received as PI: $2,330,300 in total (from 2010 September to 2020 May) including NSERC DAS Award, three NSERC CRD, and international collaborative funds from S. Korea etc.

Supervision of Highly Qualified Personnel

Here is a summary for past HQP training in my lab: 1) Supervised one PDF, three PhD students, eleven MSc students, and twelve international visiting students to completion, 2) Currently supervise four PhD students and one MSc student, 3) Supervised 72 research Coop students, and 15 Undergraduate students by Capstone Design Projects, 4) Participated in 57 thesis examination for 37 PhD theses and 20 MSc thesis since 2010.

Active Service to the Academic Community

- **Evaluation Committee of Grant Proposals:** Member of NSERC Discovery Selection Committee in 2019, Engineering RTI Grants Selection Committee in 2017 to 2019.
- **Conference Session Organizer:**
  - Presider of the Next-generation nano-lithography session of PMSE, *ACS 2012 National meeting* in San Diego, USA, March 2012.
  - One of four Symposium BM4 organizers for Material Research Society's Fall Conference in Boston, 2016.
  - General Co-Chair of IEEE International Flexible Electronic Technology Conference in Vancouver, 2019 August.
- **Conference General Co-Chair**: organized and hosted IEEE International Flexible Electronic Technology Conference in Vancouver, 2019 August.
- **Award Committee Member:**

  The 14th IEEE international conference on Nanotechnology in Toronto, August 2014.
- **Journal Editor:** One of the Editor in IEEE Transactions of Electron Devices since 2019.
- **Senior Member of IEEE** since 2020.

G. GARY WANG, PH.D., P. ENG.

Mechatronic System Engineering
Simon Fraser University
250-13450 102 Avenue
Surrey, British Columbia V3T 0A3

Office phone: 778 782-8495
Fax: 778 782-7514
E-mail: gary_wang@sfu.ca

EDUCATION

PhD	Mechanical Engineering, University of Victoria, BC	1999
MSc	School of Mechanical Science and Engineering, Huazhong University of Science and Technology (HUST), Wuhan, China	1995
BSc	School of Mechanical Science and Engineering, HUST, China	1992

PROFESSIONAL EMPLOYMENT

Professor (2011-present), Simon Fraser University (SFU), Mechatronic Systems Engineering

Associate Professor (2008-2011), SFU, Mechatronic Systems Engineering

Associate Professor (2004-2007), The University of Manitoba (UM), Dept. of Mech. and Manuf. Engr.

Assistant Professor (1999-2003), UM, Dept. of Mech. and Manuf. Engr.

AWARDS AND RECOGNITIONS

- Fellow, American Society of Mechanical Engineers (ASME) (2013-present), member since 1998
- Associate Editor, *Engineering Optimization Journal*, geographically representing North America
- Associate Editor, *ASME Transactions, Journal of Mechanical Design*
- Co-chair, Inaugural International Symposium on Frontiers in Engineering Design, National Science Foundation of China, 2016
- Excellence in Teaching, 2014, SFU, one of the three recipients of the year, $2500 cash award
- Rh Award for Outstanding Research, 2007, The University of Manitoba, $10000 cash award, the only one in the Applied Science Category
- I. W. Smith Award for Creating Engineering, 2005, The Canadian Society for Mechanical Engineering
- Leader of the Design Automation Committee in the premier International Design Engineering Technical Conferences (IDETC)

RESEARCH

Recent Journal Articles

1. Wu, D., Wang, G. G., "Knowledge Assisted Optimization for Large-scale Design Problems: A Review and Proposition," *ASME Transactions, Journal of Mechanical Design*, Jan 2020, Vol. 42, pp. 010800 (10 pages), DOI: 10.1115/1.4044525.
2. Abram, D., Wikarna, A., Wang, G. G., Golnaraghi, F. A., "Modular Impact Diverting Mechanism for Football Helmet," *Journal of Biomechanics,* 2019. https://doi.org/10.1016/j.jbiomech.2019.109502
3. Shi, R. Liu. L., Long, T., Wu, Y., and Wang, G. G., "Multi-fidelity Modeling and Adaptive Co-Kriging Based Optimization for All-electric GEO Satellite Systems," *ASME Transactions, Journal of Mechanical Design*, doi:10.1115/1.4044321. June 29, 2019.
4. Singh, Y., Khorasany R.M.H., Kim W. H .J., Alavijeh, A. S., Kjeang, E., Rajapakse. RKND, Wang, G. G., "Ex situ Characterization and Modelling of Fatigue Crack Propagation in Catalyst Coated Membrane Composites for Fuel Cell Applications," *International Journal of Hydrogen Energy*, 44(2019) 12057-12072.
5. Wu, D., Coatanea, E., and Wang, G. G., "Employing Knowledge on Causal Relationship to Assist Multidisciplinary Design, Optimization," *ASME Transactions,* Journal of Mechanical Design. 141(4),

041402 (Jan 11, 2019) doi: 10.1115/1.4042342
6. Wang, X., Song, B., Wang. G. G., and Wang, P., "A Novel Evolutionary Sampling Assisted Optimization Method for High Dimensional Expensive Problems," *IEEE Transactions on Evolutionary Computation*, 2018, 10.1109/TEVC.2019.2890818, Jan 9, 2019. https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8603839
7. Nagarajan, H. P. N., Mokhtarian, H., Coatanea, E., Wang, G. & Haapala, K. R., "Knowledge-Based Optimization of ANN Topology for Additive Manufacturing Process Modeling: A Case Study for Fused Deposition Modeling," *ASME Transactions, Journal of Mechanical Design,* Feb 2019, Vol. 141, 021705:1-12.
8. Woldermariam, E. T., Coatanea, E., Wang, G. G., Lemu, H. G., and Wu, D., "Customized Dimensional Analysis Conceptual Modeling Framework for Design Optimization – A Case Study on the Cross-flow Micro Turbine Model," *Engineering Optimization*, Oct 11, 2018, *https://doi.org/10.1080/0305215X.2018.1519556*
9. Shi, R., Liu, L., Long, T., Wu, Y., and Wang, G. G., "Multidisciplinary modeling and surrogate assisted optimization for satellite constellation systems," *Structural and Multidisciplinary Optimization*, July 25, 2018, *https://doi.org/10.1007/s00158-018-2032-1*
10. Cheng, G. H., Gjernes, T., Wang, G. G., "An Adaptive Aggregation-based Approach for Expensively Constrained Black-box Optimization Problems," *ASME Transactions, Journal of Mechanical Design*, Vol. 140, No. 9, 091402, June 2018.
11. Meselhy, K. T., Wang, G. G., "Reliability Based Design Optimization on Qualitative Objective with Limited Information," *ASME Transactions, Journal of Mechanical Design*, August 17, 2018. doi:10.1115/1.4041172.
12. Woldermariam, E. T., Lemu, H. G., Wang, G. G., "CFD-Driven Valve Shape Optimization for Performance Improvement of a Micro Cross-Flow Turbine," *Energies*, 2018, Vol. 11, No. 248, doi:10.3390/en11010248.
13. Wu, D., Haji Hajikolaei, K., Wang, G.G., "Employing Partial Metamodels for Optimization with Scarce Samples," *Structural and Multidisciplinary Optimization,* Sept 30, 2017, Vol. 57, No. 3, pp. 1329-1343. https://link.springer.com/article/10.1007/s00158-017-1815-0.
14. Singh, Y., Khorasany, R.M.H., Sadeghi Alavijeh, A., Kjeang, E., Wang, G.G., Rajapakse, R.K.N.D., "Ex situ Measurement and Modelling of Crack Propagation in Fuel Cell Membranes under Mechanical Fatigue Loading," *International Journal of Hydrogen Energy*, Vol. 42, No. 30, 2017, pp. 19257-19271. https://doi.org/10.1016/j.ijhydene.2017.06.151
15. Zhang, G., Wang, G.G., Farhangi, H., Palizban, A., "Data Mining of Smart Meters for Load Category based Disaggregation of Residential Power Consumption," *Journal: Sustainable Energy, Grids and Networks*, 10 (2017), pp. 92-103.

Recently Completed Industry Projects

General Motor Company (GM), Auto-body Assembly Process Optimization
Toyo Pumps, New Pump Design, Modeling, and Optimization
Innovata Labs, Helmet Impact Diversion Mechanism Development
Rapid Electrical Vehicles, Electrification of F-150 Pick-up Truck
Aurel Systems Inc., Knowledge Assisted Large-scale Production Optimization for Chemical Plants
Exro Technologies, Modeling and Optimization of Racing Electrical Cars Using Reconfigurable Motors
St. Paul's Hospital, Emergency Department Modeling and Process Optimization for Wait Time Reduction
Manitoba Hydro, System Planning Optimization for Maximum Profit
Westland Helicopters, Engine Air Intake Shape Optimization
Monarch Industries, Incorporating Rapid Prototyping into Mold Making Process
Vansco Electronics, Production Cost Minimization for Instrument Display Panel
Philips and Temro, Design Automation of Industry Silencers
Winnipeg Region Health Authorities, Healthcare System Modeling and Efficiency Optimization
30 other companies and organizations, Additive Manufacturing services and research since year 2001

CURRICULUM VITAE

Mehrdad Moallem, Ph.D., P.Eng.
School of Mechatronic Systems Engineering
Faculty of Applied Sciences
Simon Fraser University, BC, Canada

Date: June 2020
Email: mmoallem@sfu.ca
Phone: 778.782.8156

Field(s) of Specialization: Electrical Engineering, Mechatronics, Control of Dynamic Systems, Robotics and Automation

Current Research Areas/Topics: Control and Automation for Energy Systems; Mechatronics and Robotics; Control of Power Electronics Systems; Intelligent Control and Machine Learning.

Career History: Dr. Moallem has more than twenty years of experience in Canada and USA in multi-disciplinary areas related to control systems, embedded computing, energy systems, and mechatronics. He has collaborated in the form of R&D and technology transfer activities with several companies, universities, and research institutions. He has been on the editorial boards of major conferences and journals including the *American Control Conference*, *IEEE/ASME Transactions on Mechatronics*, *IFAC journal of Mechatronics, and International Journal of Intelligent Robotics and Applications, Springer*. During his career he has attracted multi-million research funds (industry/government) from different companies and government funding agencies including NSERC and MITACS.

Dates	Rank and Position	Department	Institution
09/2012-onward	Professor	School of Engineering Science, Mechatronic Systems Engineering	Simon Fraser University, Surrey, BC, Canada
06/2007-09/2012	Associate Professor	School of Engineering Science, Mechatronic Systems Engineering	Simon Fraser University, Surrey, BC, Canada
09/2007-09/2009	Adjunct Research Professor	Electrical & Computer Engineering	The University of Western Ontario, London, ON, Canada
07/2006-06/2007	Associate Professor	Electrical & Computer Engineering	The University of Western Ontario, London, ON, Canada
08/1999-06/2005	Assistant Professor	Electrical & Computer Engineering	The University of Western Ontario
2002-2007	Associate Scientist (affiliation)	Canadian Surgical Technologies and Advanced Robotics (CSTAR) group	Lawson Health Research Institute (UWO Hospital)
1998-1999	R&D Engineer	Free-Electron Laser Laboratory	Duke University, NC, USA
1997-1998	Postdoctoral fellow	Electrical & Computer Engineering	Concordia University, Montreal, Canada

Academic Qualifications

B.Sc.	Shiraz University, Shiraz, Iran	Electrical & Electronic Engineering	1986
M.Sc.	Sharif University of Technology, Tehran, Iran	Electronic Engineering	1988
Ph.D.	Concordia University, Montreal, QC, Canada	Electrical & Computer Engineering	1997

Number of Postgraduate Students Supervised

Program	Status	Senior Supervisor	Joint Supervision
Ph.D.	Graduated	27	17
	Ongoing	10	5
Master of Applied Science	Graduated	26	15
	Ongoing	4	4

Publications

Publications	Quantity
Journals	94
Books	4
Referred Conferences	130
Patents	3
Book Chapters	7
h-index	41
i10-index	104
Google Scholar Citations (April 2020)	5582

Sample Publications

(1) J. Jiang, A. Mohagheghi, M. Moallem, "Energy-efficient Supplemental LED Lighting Control for a Proof-of-Concept Greenhouse System," *IEEE Trans. on Industrial Electronics,* vol. 67, no. 4, pp. 3033-3042, 2020.

(2) S. H. Kamali, M. Miri, M. Moallem, S. Arzanpour, "Cylindrical Cam Electromagnetic Vibration Damper utilizing Negative Shunt Resistance," *IEEE/ASME Transactions on Mechatronics*, in press, 2019.

(3) S. F. Toloue, S. H. Kamali, M. Moallem, "Torque Ripple Minimization and Control of a Permanent Magnet Synchronous Motor using Multi-objective Extremum Seeking," *IEEE/ASME Trans. on Mechatronics,* vol. 24, no. 5, pp. 2151-2160, 2019.

(4) A. Mohagheghi, M. Moallem, "Intelligent Spectrum Controlled Supplemental Lighting for Daylight Harvesting," *IEEE Transactions on Industrial Informatics,* in press, 2020.

(5) S. H. Kamali, M. Miri, M. Moallem, S. Arzanpour, "Cylindrical Cam Electromagnetic Vibration Damper utilizing Negative Shunt Resistance," *IEEE/ASME Transactions on Mechatronics*, in press, 2019.

(6) S. F. Toloue, S. H. Kamali, M. Moallem, "Torque Ripple Minimization and Control of a Permanent Magnet Synchronous Motor using Multi-objective Extremum Seeking," *IEEE/ASME Trans. on Mechatronics*, vol. 24, no. 5, pp. 2151-2160, 2019.

(7) K. Seifi, M. Moallem, "An Adaptive PR Controller for Synchronizing Grid-connected Inverters," *IEEE Transactions on Industrial Electronics,* Vol. 66, No. 3, pp. 2034-2043, 2019.

(8) S.H. Kamali, M. Moallem, S. Arzanpour, "Realization of an Energy-efficient Adjustable Mechatronic Spring," *IEEE/ASME Transactions on Mechatronics*, Vol. 23, No. 4, pp. 1877-1885, 2018.

(9) M. Naserimojarad, M. Moallem, S. Arzanpour, "A Comprehensive Approach for Optimal Design of MR Dampers," *J. of Intelligent Material Sys. and Structures,* Vol. 29, Issue 18, pp. 3648-3655, 2018.

(10) R. Leewe, Z. Shahriari, K. Fong, M. Moallem, "Resonance Frequency Tuning of an RF Cavity through Sliding Mode Extremum Seeking," *Nuclear Inst. and Meth, in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equip.,* Elsevier, Vol. 902, pp. 70–75, 2018.

(11) S.H. Kamali, M. Moallem, S. Arzanpour, "A Self-tuning Vibration Energy Harvester with Variable Loads and Maximum Allowable Displacement," *Smart Mat. and Structures,* Vol. 25, No. 10, 2018.

(12) S. F. Toloue, M. Moallem, "Multivariable Sliding-mode Extremum Seeking Control with Application to MPPT of an Alternator-based Energy Conversion System," *IEEE Tran. on Industrial Electronics,* Vol. 64, No. 8, pp. 6383 – 639, 2017.

(13) Z. Shariari, R. Leewe, M. Moallem, K. Fong, "Automated Tuning of Resonance Frequency in an RF Cavity Resonator," *IEEE/ASME Transactions on Mechatronics*, Vol. 23, No. 1, pp. 311-320, 2018.

(14) G. Boscarino, M. Moallem, "Daylighting Control and Simulation for LED-based Energy-efficient Lighting Systems," IEEE Trans. on Industrial Informatics, Vol 12, No. 1, pp. 301-309, 2016.

(15) J. Amini, M. Moallem, "A Fault-Diagnosis and Fault-Tolerant Control Scheme for Flying Capacitor Multilevel Inverters," *IEEE Transactions on Industrial Electronics,* Vol. 64, No. 3, pp. 1818-1826, 2017.

(16) A. Shagerdmootaab, M. Moallem, "A Double-Loop Primary-Side Control Structure for HB-LED Power Regulation," IEEE Tran. on Power Electronics, Vol. 31, No. 3, 2015.

OMB No. 0925-0001 and 0925-0002 (Rev. 09/17 Approved Through 03/31/2020)

BIOGRAPHICAL SKETCH

NAME: **PARK, EDWARD J.W.**

POSITION TITLE: Full Professor of Mechatronic Systems Engineering, Simon Fraser University

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
University of British Columbia, Vancouver, Canada	BASc	06/1996	Mechanical Engineering
University of Toronto, Toronto, Canada	MASc	06/1999	Mechanical Engineering
University of Toronto, Toronto, Canada	PhD	06/2003	Mechanical Engineering

A. Personal Statement

My lab has been a world leader in the development and application of portable and wearable ambulatory monitoring systems using wearable sensors. The potential impact of such ambulatory monitoring systems is significant for the practice of physical medicine/rehabilitation, as well as for the wearable smart devices market. For example, it opens the possibility of continuous monitoring for early diagnosis of a chronic condition, an acute event such as stroke or falling in older adults or during rehabilitation from a surgical procedure. In addition to publishing over 50 papers in this field, my lab has been highly successful in generating and transferring IP for industry partners such as Intel Corporation and other consumer wearable device companies. Furthermore, my lab has spun off two University startups: Bigmotion Technologies Inc., which develops intelligent wearable health Internet of Things solutions, and, more recently, Human in Motion Robotics Inc., based on the granted patents.

Research Interests: mechatronics and biomechatronics, robotics and automation, IoT and wearable technology

B. Positions

Positions and Employment

2003-2008	Assistant Professor, Mechanical Engineering, University of Victoria
2008-2014	Adjunct Professor, Mechanical Engineering, University of Victoria
2008-2014	Associate Professor, Mechatronic Systems Engineering, Simon Fraser University
2013-2016	Associate Dean, Academic, Faculty of Applied Sciences, Simon Fraser University
2013-present	Associate Member, Faculty of Health Sciences, Simon Fraser University
2014-present	Full Professor, Mechatronic Systems Engineering, Simon Fraser University
2017-2018	Associate Dean, Graduate & Postdoctoral Studies, Simon Fraser University
2019-present	Director (*Interim*), Mechatronic Systems Engineering, Simon Fraser University
2020-present	Associate Dean, Academic, Faculty of Applied Sciences, Simon Fraser University

C. Selected Refereed Publications (last six years)

Journal Papers

J1. K. Merry, M. MacPherson, E. Macdonald, M. Ryan, E.J. Park, and C. Sparrey, "Differentiating Sitting, Standing and Walking Through Regional Plantar Pressure Characteristics", *Journal of Biomechanical Engineering*, 142(4), 041004, 2020

J2. T.J. Lee, S. Zobayed, F. Firmani, and E.J. Park, "A Novel Automated Transplanting System for Plant Tissue Culture", *Biosystems Engineering*, 181, pp. 63-72, 2019.

J3. H. Esmaeilsabzali, R.T.M. Payer, Y. Guo, M.E. Cox, A.M. Parameswaran, T.V. Beischlag, and E.J. Park, "Development of a Microfluidic Platform for Size-based Hydrodynamic Enrichment and PSMA-targeted Immunomagnetic Isolation of Circulating Tumour Cells in Prostate Cancer", *Biomicrofluidics*, 13, 014110, 2019.

J4. S. Khakshour, M. Labrecque, H. Esmaeilsabzali, F.J.S. Lee, M.E. Cox, E.J. Park*, and T.V. Beischlag*, "Retinoblastoma Protein (Rb) Links Hypoxia to Altered Mechanical Properties in Cancer Cells as Measured by an Optical Tweezer", *Nature Scientific Reports*, 7: 7833, 2017. (* co-corresponding authors).
J5. Aziz, J. Klenk, L. Schwickert, L. Chiari, C. Becker, E.J. Park, G. Mori, and S.N. Robinovitch, "Validation of Accuracy of SVM-based Fall Detection System Using Real-world Fall and Non-fall Datasets", *PLOS ONE*, 12(7): e0180318, 2017.
J6. S. Sadeqi, S. Bourgeois, E.J. Park, and S. Arzanpour, "Design and Performance Analysis of a 3-RRR Spherical Parallel Manipulator for Hip Exoskeleton Applications", *Journal of Rehabilitation and Assistive Technologies Engineering*, 4, pp. 1-11, 2017.
J7. Y. Roshan, R. Hoskinson, and E.J. Park, "Design Approach for a Wireless Power Transfer System for Wristband Wearable Devices, *IET Power Electronics*, 10(8), pp. 931-937, 2017.
J8. P.K. Yoon, S. Zihajehzadeh, B.S. Kang, and E.J. Park, "Robust Biomechanical Model-based Motion Tracking of Lower Body Using UWB and IMU *IEEE Sensors Journal*, 17(4), pp. 1084-1096, 2017.
J9. S. Zihajehzadeh and E.J. Park, "A Novel Biomechanical Model-aided IMU/UWB Fusion for Magnetometer-free Lower Body Motion Capture", *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 47(6), pp. 927-938, 2017.
J10. Aziz, M. Musngi, E.J. Park, G. Mori, and S.N. Robinovitch, "A Comparison of Fall Detection Algorithms (Threshold-based vs. Machine Learning) Using Waist Mounted Tri-axial Accelerometer Signals from a Comprehensive Set of Falls and Non-falls Trials", *Medical & Biological Engineering & Computing*, 55(1), pp. 45-55, 2017.
J11. S. Zihajehzadeh and E.J. Park, "Regression Model–based Walking Speed Estimation Using Wrist-Worn Inertial Sensors", *PLOS ONE*, 11(10): e0165211, 2016.
J12. D. Loh, S. Zihajehzadeh, R. Hoskinson, H. Abdollahi, and E.J. Park, "Pedestrian Dead Reckoning with Smartglasses and Smartwatch", *IEEE Sensors Journal*, 16(22), pp. 8132-8141, 2016.
J13. H. Esmaeilsabzali, T.V. Beischlag, M. Cox, A. Parameswaran, N. Dechev and E.J. Park, "An Integrated Microfluidic System for Immunomagnetic Detection and Isolation of Rare Prostate Cancer Cells from Blood", *Biomedical Microdevices*, 18(1): 22, 2016.
J14. K. Karakoc, A. Suleman, and E.J. Park, "Analytical Modeling of Eddy Current Brakes with the Application of Time Varying Magnetic Fields", *Applied Mathematical Modelling*, 40(2), pp. 1168-1179, 2016.
J15. S. Zihajehzadeh, P. Yoon, B.S. Kang, and E.J. Park, "UWB-Aided Inertial Motion Capture for Lower Body 3-D Dynamic Activity and Trajectory Tracking", *IEEE Transactions on Instrumentation and Measurement*, 64(12), pp. 3577-3587, 2015.
J16. T.J. Lee, S. Zihajehzadeh, D. Loh, R. Hoskinson, and E.J. Park, "Automatic Jump Detection in Skiing/Snowboarding Using Head-mounted MEMS Inertial and Pressure Sensors", *Proceedings of IMechE, Part P: Journal of Sports Engineering and Technology*, 229(4), pp. 278-287, 2015.
J17. B. Ulutas, A. Suleman, and E.J. Park, "LMI-Based Distributed H∞ Control of the Thirty Meter Telescope's Primary Mirror", *Mechatronics*, 28, pp. 55-66, 2015.
J18. S. Zihajehzadeh, D. Loh, M. Lee, R. Hoskinson, and E.J. Park, "A Cascaded Kalman Filter-Based GPS/MEMS-IMU Integration for Sports Applications", *Measurement*, 73, pp. 200-210, 2015.
J19. S. Khakshour, T.V. Beischlag, C. Sparrey, and E.J. Park, "Probing Mechanical Properties of Jurkat Cells under the Effect of ART Using Oscillating Optical Tweezers", *PLOS ONE*, 10(4), e0126548, 2015.
J20. S. Zihajehzadeh, M. Lee, J.K. Lee, R. Hoskinson, and E.J. Park, "Integration of MEMS Inertial and Pressure Sensors for Vertical Trajectory Determination", *IEEE Transactions on Instrumentation and Measurement*, 64(3), pp. 804-814, 2015.
J21. J.K. Lee, S.R. Robinovitch, and E.J. Park, "Inertial Sensing-based Pre-impact Detection of Falls Involving Near-Fall Scenarios", *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 23(2), pp. 258-266, 2015.
J22. F. Firmani, S.R. Robinovitch, and E.J. Park, "Biometric System for Measuring Gait and Fall Characteristics Captured on Video", *ASME Journal of Biomechanical Engineering*, 136(7), 071005, 2014.
J23. K. Karakoc, A. Suleman, and E.J. Park, "Optimized Braking Torque Generation Capacity of an Eddy Current Brake with the Application of Time Varying Magnetic Fields", *IEEE Transactions on Vehicular Technology*, 63(4), pp. 1530-1538, 2014.
J24. Aziz, E.J. Park, G. Mori, and S.N. Robinovitch, "Distinguishing the Causes of Falls in Humans Using an Array of Wearable Tri-axial Accelerometers", *Gait & Posture*, 39(1), pp. 506-512, 2014.

Behraad Bahreyni, PhD, PEng

Associate professor, School of Mechatronic Systems Engineering, Simon Fraser University
MSE 4176, 250–13450 102nd Ave, Surrey, BC, Canada V3T 0A3
Tel: +1 (778) 782–8694 Email: bba19@sfu.ca Web: http://sense.fas.sfu.ca

RESEARCH INTERESTS

Micro- and nano-sensors; Sensor signal processing (machine learning, sensor fusion); MicroElectroMechanical Systems (MEMS); Analog circuit design; Advanced materials.

TEACHING CONTRIBUTIONS

Expertise: Sensors and Actuators; Microsystems; Analog electronics; Nanosystems; Machine learning.
Course development:

- *SFU*: 3 core undergraduate courses (MSE 210, 251, 311), 1 elective course (MSE 490), and one graduate course (MSE 811) for the School of Mechatronic Systems Engineering since 2009. All undergraduate courses included hands-on laboratory experiments developed from grounds up for the MSE curriculum.
- *University of Manitoba*: Taught (3×) and updated 2 core undergraduate courses (ECE 24216 and 24367).

PROFESSIONAL EXPERIENCE

Associate Professor, Sep 2014–present, *Mechatronic Systems Engineering*, *SFU*, Surrey, Canada.
Assistant Professor, Sep 2008–Aug 2014, *Mechatronic Systems Engineering*, *SFU*, Surrey, Canada.
Senior MEMS Design Engineer, Oct 2007–Aug 2008, *Sand 9 Inc.*, Boston, USA.
Research Associate, Oct 2006–Sep 2007, *University of Cambridge*, Cambridge, UK.

AWARDS AND DISTINCTIONS

- *Best Paper Award*, IEEE Sensors Applications Symposium, Malaysia, 2020.
- *Visiting Fellow*, Swinburne University of Technology, Melbourne, Australia, 2017.
- *Accelerator Supplements for NSERC Discovery Grants Program*, NSERC, Canada, 2014.
- *Endowed Research Fellowship Award*, Simon Fraser University, Canada, 2008.
- *The Douglas R. Colton Medal for Research Excellence*, CMC Microsystems, Canada, 2007.
- *Micralyne Microsystem Design Award*, Ottawa, Canada, 2005.
- *Edward Toporeck Graduate Fellowship in Engineering*, University of Manitoba, Canada, 2003.

EDUCATION

Post-doctoral researcher, Nanoscience Centre, 2006–2007, University of Cambridge, UK
PhD in Electrical Engineering, 2002–2006, University of Manitoba, Canada
MSc in Electrical Engineering, 2000–2001, University of Manitoba, Canada
BSc in Electronics Engineering, 1994–1999, Sharif University of Technology, Iran

RESEARCH CONTRIBUTIONS

- **Research funding:** $8.9M since 2009
- **Supervision:** 8 PDF, 9 PhD, 17 MASc, 4 MEng, 48 BSc
- **Co-supervision:** 2 PDF, 4 PhD, 3 MASc
- **Industrial collaborations:** >15 Canadian and international companies
- **International projects:** With teams in Australia, The Netherlands, Russia, USA, Italy, and Hong Kong.

PATENTS (TOTAL 7)

P1. **B. Bahreyni**, "Accelerometer sensor", *US/WO/CA patent US20190271717A1*, Issued 2019.
P2. **B. Bahreyni** et al, "Vibratory gyroscope utilizing nonlinear modal interaction", *US/WO/JP/EP/CA/CN patent 2016179698 A1*, Issued 2018.
P3. **B. Bahreyni**, "Vector light sensor and array thereof", *US patent US10084001B2*, Filed Nov 2015, Issued 2018.
P4. **B. Bahreyni** et al, "Mechanical resonating structure and methods", *US patent US8446078 B2*, Issued 2013.
P5. **B. Bahreyni** and C. Shafai, "System and method for measuring magnetic field strength using a mechanical resonator", *WO/2007/128096*, *US patent US20110050214 A1*, Issued 2011.

SELECTED REFEREED JOURNAL PAPERS (TOTAL 44)

J1. T. Nguyen, **B. Bahreyni**, *et al*, "Self-powered monolithic accelerometer using photonic gate", **In Press**, *Nano Energy*, Apr 2020.

J2. M. Kanygin, A.P. Joy, and **B. Bahreyni**, "Localized mechanical actuation using *pn* junctions", *Nature Scientific Reports*, vol. 9:14885, no. 1, pp. 1–9, Oct. 2019.

J3. A. Sarrafan, S. Azimi, F. Golnaraghi, and **B. Bahreyni**, "A nonlinear rate microsensor utilising internal resonance", *Nature Scientific Reports*, vol. 9:8648, no. 1, pp. 1–9, Jun. 2019.

J4. A.P. Joy, M. Kanygin, and **B. Bahreyni**, "Measurement of mechanical strain based on piezo-avalanche effect", *Applied Physics Letters*, vol. 114, no. 19, p. 192101, May 2019.

J5. F. Edalatfar, B. Yaghootkar, A.Q. Ahsan Qureshi, S. Azimi, A. Leung, and **B. Bahreyni**, "Development of a micromachined accelerometer for particle acceleration detection", *Journal of Sensors and Actuators A: Physical*, vol. 280, pp. 359–367, Sep. 2018.

J6. A. Sarrafan, **B. Bahreyni**, and F. Golnaraghi, "Analytical modeling and experimental verification of nonlinear mode coupling in a decoupled tuning fork microresonator," in *Journal of Microelectromechanical Systems*, vol. 27, no. 3, pp. 398–406, Jun 2018.

J7. F. Xia, F. Campi, and **B. Bahreyni**, "Tri-mode capacitive proximity detection towards improved safety in industrial robotics," in *IEEE Sensors Journal*, vol. 18, no. 12, pp. 5058–5066, Jun 2018.

J8. F. Edalatfar, S. Azimi, A.Q. Ahsan Qureshi, B. Yaghootkar, A. Keast, W. Friedrich, A. Leung, and **B. Bahreyni**, "A wideband, low-noise accelerometer for sonar wave detection", *IEEE Sensors Journal*, vol. 18, no. 2, pp 508–516, Jan 2018.

J9. A. Sarrafan, **B. Bahreyni**, and F. Golnaraghi, "Development and characterization of an H-shaped microresonator exhibiting 2:1 internal resonance", *IEEE Journal of MicroElectroMechanical Systems*, vol 26, no 5, pp 993–1001, Oct 2017.

J10. S.V. Grayli, A. Ferrone, L. Maiolo, A. De Iacovo, A.Pecora, L.Colace, G.W. Leach, and **B. Bahreyni**, "Infrared photo-resistors based on recrystallized amorphous germanium films on flexible substrates", *Journal of Sensors and Actuators A: Physical*, vol 263, pp 341–348, Aug 2017.

J11. M. Shafiei, I. El-Chami, L. Rintoul, and **B. Bahreyni**, "Morphology of electrospun poly(ethylene oxide) ultra-fine fibres with incorporated MoO_3 nanoparticles", *Journal of Materials & Design*, vol 113, pp 76–83, Jan 2017.

J12. M.A. Rasouli and **B. Bahreyni**, "Viability of piezojunction effect for microresonator applications", *IEEE Transactions on Electron Devices*, vol 63, no 11, pp. 4452–4458, Nov 2016.

J13. J. Lee, F. Nabki, R. Abdolvand, and **B. Bahreyni**, "Micromachined resonators: A review", *Micromachines*, 7, 160, Aug 2016. (**invited**)

J14. M. S. Hajhashemi, A. Rasouli, and **B. Bahreyni**, "Improving sensitivity of resonant sensor systems through strong mechanical coupling," *IEEE/ASME Journal of MicroElectroMechanical Systems*, vol 25, no 1, pp 52–59, Feb 2016.

J15. F. Aezinia and **B. Bahreyni**, "An interface circuit with wide dynamic range for differential capacitive sensing applications", *IEEE Transactions on Circuits and Systems II*, vol 60, pp 766–770, Nov 2013.

J16. T. Rai, P. Dantes, **B. Bahreyni**, and W.S. Kim, "Stretchable RF antenna with silver nanowires", *IEEE Electron Device Letters*, vol 34, no 4, pp 544–546, Apr 2013.

J17. F. Aezinia, Y.F. Wang, and **B. Bahreyni**, "Three dimensional touchless tracking of objects using integrated capacitive sensors", *IEEE Transactions on Consumer Electronics*, vol 58, no 3, pp 886–890, Aug 2012.

J18. A.H. Khoshaman and **B. Bahreyni**, "Measurement of volatile organic vapours using electrosprayed thin films of metal organic frameworks", *Journal of Sensors and Actuators B: Chemical*, vol 162, no 2, pp 114–115, Feb 2012.

ADDITIONAL CONTRIBUTIONS TO DISSEMINATION OF KNOWLEDGE

1 book; 2 book chapters; 61 papers in Conference Proceedings; 24 Conference Presentations; 26 Invited talks

PROFESSIONAL AFFILIATIONS

- Institute of Electrical and Electronics Engineers, IEEE (Senior Member)
- Engineers and Geoscientists British Columbia, EGBC (PEng)

VOLUNTEER SERVICE

- Chair of IEEE Sensor Chapter in Vancouver;
- Guest Editor for technical journals;
- Membership in organization committees for technical conferences.

Resume

Taha Al-Khudairi, M.Sc, P.Eng.
SFU - School of Mechatronics Systems Engineering
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Current Teaching and Professional Practice

8/2017 – Present SFU – School of Mechatronic Systems Engineering BC, CANADA

Instructor, SIEMENS Mechatronics Systems Certification Program

- Teaching Level-1 courses including Pneumatic and Hydraulic Systems, Digital Systems and PLCs
- Teaching Level-2 courses including Process Control, Microcontrollers, and Adv. PLC programming
- Prepared course materials and hands-on tasks (experiments) using FESTO/SIEMENS lab equipment
- Installed and configured Modular Production System Festo MPS-200 and SMC Pneumatic setups

3/2013 – Present SFU – School of Mechatronic Systems Engineering BC, CANADA

Manager, Instructional and Research Labs

- Managing instructional laboratories and supervising installation of lab equipment
- Collaborating with faculty members in the development and operation of instructional laboratories
- Developing and maintaining lab policies in consultation with MSE Director
- Evaluating requirements for acquisition and maintenance of laboratory equipment
- Planning space allocation of assets, renovations, and alterations to facilities
- Preparing layout integration of instructional labs to faculty, and contractors
- Contributing to the annual budget for lab equipment, computing platforms, and project expenses
- Supervising technical staff members by evaluating job descriptions and provide training
- Acting as a manager for safety requirements of instructional and research labs
- Installed PCB facility that uses CNC milling, drilling, though-hole plating and assembly machines
- Member of Executive, Budget, Space, and Safety Committees at Surrey Campus

Education

- **Ph.D.** Mechatronic Systems Engineering, ***In Progress***, (CGPA = 4.0/4.3)
  Simon Fraser University
- **M.Sc.** Engineering Systems Management, (CGPA = 3.97/4.0)
  American University of Sharjah
- **M.Sc.** Electrical Engineering (with major in Computer Engineering), (82.3%)
  University of Baghdad
- **B.Sc. with honors,** (ranked 2nd in a class of 115) Electrical Engineering,
  University of Baghdad

Certification

- SIEMENS Certified Instructor Level 3, SIEMENS Mechatronics Certification Program, Germany
- SIEMENS Certified Instructor Level 2, SIEMENS Mechatronics Certification Program, Germany
- SIEMENS Certified Instructor Level 1, SIEMENS Mechatronics Certification Program, Germany
- SIEMENS Certified Mechatronics Associate, SIEMENS Mechatronics Certification Program, Canada
- SIEMENS Certified Mechatronics Assistant, SIEMENS Mechatronics Certification Program, Canada
- Registered as a Professional Engineer (P.Eng.) in the Province of BC, Canada
- Certified Profibus Installer, Procentec, UAE

Teaching Awards	▪ **Best Lab Instructor Award** in the School of Engineering, American University of Sharjah ▪ **Engineering Student Council Award** as being the best lab instructor in the Department of Computer Engineering, American University of Sharjah
Industrial Teaching Experience	▪ *Using PLCs to Control Real-time Industrial Applications*, TUV Akademie M.E., UAE ▪ *PLC Commissioning, Programming, and Troubleshooting*, TUV Akademie M.E., UAE ▪ *Programmable Logic Controllers*, Khalidiya Palace Hotel, Abu Dhabi, UAE
Industrial Experience	1/2008 – 2/2013 SFU – Mechatronic Systems Engineering Program BC, CANADA **Lab Engineer** 2/2001 – 12/2007 American University of Sharjah – Dept. of Computer Eng. Sharjah, UAE **Lab Instructor** 12/1999 – 1/2001 Dubai Ports and Customs – IT Department Dubai, UAE **System Developer** 10/1998 – 8/1999 MANTIQ Inc. – R&D Section Baghdad, IRAQ **Sr. Electrical Engineer** 10/1996 – 10/1998 Electronic Design Center – Automation Section Baghdad, IRAQ **Control Engineer** 10/1993 – 9/1996 MANTIQ Inc. – R&D Section Baghdad, IRAQ **Electrical Engineer (Part-time)** 9/1992 – 9/1993 Al-Fairouz for Computer Services Baghdad, IRAQ **Maintenance Engineer (Electrical)**
Professional Membership	▪ Engineers and Geoscientists BC, Membership ID 41104 ▪ International Society of Automation (ISA), Membership ID 33708815 ▪ Project Management Institute (PMI), Membership ID 963367 ▪ IEEE Member, Membership ID 41380891

Amr Marzouk, Ph.D., P.Eng.

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Office: (778) 782-8149

EDUCATION

- **Ph.D., Mechatronic Systems Engineering**
  Simon Fraser University (Fall 2009 – Fall 2014)
- **M.A.Sc., Mechatronic Systems Engineering**
  Simon Fraser University (Fall 2007 - Summer 2009)
- **B.Sc. (honors), Electronics and Communications Engineering**
  Arab Academy for Science and Technology and Maritime Transport (Fall 2002 - Summer 2007)

ACADEMIC TEACHING EXPERIENCE

- **Lecturer,** *Mechatronic Systems Engineering (2015-Present)*
- **Sessional Instructor**, *Mechatronic Systems Engineering (2014-2015)*
- **Limited-Term Lecturer,** *Mechatronic Systems Engineering (2012-2014)*
- **Sessional Instructor**, *Mechatronic Systems Engineering (2010-2012)*

INDUSTRIAL EXPERIENCE

- Siemens Mechatronic Systems Certification Program (SMSCP)[1] at Simon Fraser University
  - **Program Coordinator** *(2017-Present)*
  - **Siemens certified Instructor**
    - Level-1: Mechatronic Systems Assistant
    - Level-2: Mechatronic Systems Associate
    - Level-3: Mechatronic Systems Professional
    - Level-3: Train-the-Trainer
- **Research and Development Engineer**
  ASSESSX, *Simon Fraser University (May 2008 - August 2008)*
- **Embedded Systems Engineer**
  GMS Petroleum, Abu Dhabi, UAE (January 2006 - July 2006)
- **Automation and Instrumentation Engineer**
  SUMED, Alexandria, Egypt (August 2005 - September 2005)

[1] SMSCP focuses on hands-on industrial training with a duration of approximately 60 hours/course taught on weekends or during SFU term breaks. Level-1 is four courses, Level-2 is six courses, and Level-3 is two courses.

Amr Marzouk, Ph.D., P.Eng.

SCHOLARSHIPS AND AWARDS

- NavTech Marine Services full scholarship during M.A.Sc. in Mechatronic Systems in Engineering. *Simon Fraser University (Fall 2007 - Summer 2009)*

CERTIFICATIONS

- Professional Engineer, Engineers and Geoscientists of British Columbia.
- Siemens Certified Mechatronic Systems Instructor (Level-1, Level-2, and Level-3).

SERVICE HISTORY

- Capstone project senior supervisor for over 30 capstone projects to date.
- Held multiple positions in graduate supervisory and examining committees.
- Faculty Advisor for the SFU Satellite Design Team and SFU Rocketry.
- Co-Champion for Technology Entrepreneurship at SFU, a joint effort between the School of Mechatronic Systems Engineering and Beedie School of Business.
- Member of the School's Diversity Committee.
- Member of the FAS cross-faculty competition administrative team.
- Instructor for the Spectrum program in collaboration with Steveston-London Secondary school intended to introduce highly motivated students to mechatronics.
- Instructor for the Sticks and Stars program, a joint program between SFU FAS and Surrey Schools District aimed at helping at-risk grade nine children.
- Invited speaker for TA marking and feedback organized by SFU Learning Commons.
- Invited speaker for Surrey School teachers on using LEGO Mindstorms for educational purposes.
- Instructor, workshops on robotics for SFU's Summer Camps.

Mohammad Ali Tayebi

CONTACT INFORMATION

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WORK EXPERIENCE

- **University Research Associate**, School of Computing Science, Simon Fraser University, 2019 - Present
- **Postdoctoral Research Fellow**, School of Computing Science, Simon Fraser University, 2016 - 2019
- **Software Engineer and Algorithm Designer**, Sepanta R&D Foundation, Tehran, Iran, 2005 - 2007

EDUCATION

Simon Fraser University, Burnaby, British Columbia, Canada
Ph.D. Computing Science, 2008 - 2015
- Thesis Title: "Predictive Models for Public Safety Using Social Network Analysis"

Amirkabir University of Technology, Tehran, Iran
M.Sc. Computer Science, 2005 - 2008
- Thesis Title: "Knowledge Extraction from Social Media Using Link Analysis"

University of Tabriz, Tabriz, Iran
B.Sc. Computer Science, 2000 - 2005

PUBLICATIONS

Peer-reviewed Books and Book Chapters

- **Mohammad A. Tayebi**, Uwe Glässer, David B. Skillicorn, Editors. Open Source Intelligence and Cyber Crime - Social Media Analytics. Lecture Notes in Social Networks (LNSN), Springer, 2020 (in print).
- **M. A. Tayebi** and U. Glässer. Social Network Analysis in Predictive Policing Concepts, Models and Methods. Lecture Notes in Social Networks (LNSN), Springer, 2016.
- P. L. Brantingham, M. Easter, R. Frank, U. Glässer, and **M. A. Tayebi**. Co-offending Network Mining. in *U. Kock Wiil (ed.), Counterterrorism and Open Source Intelligence*, Lecture Notes in Social Networks, Vol. 2, Springer, pp. 73 102, 2011.
- U. Glässer, **M. A. Taybei**, P. L. Brantingham, and P. J. Brantingham. Estimating Possible Criminal Organizations from Co-offending Data, *Public Safety Canada*, Ottawa, Canada, 2012. (Resulted in invited keynote of *Organized Crime Summit* in Vancouver, November 2012)

Peer-reviewed Journal and Conference Publications

- Amir Yaghoubi Shahir, **Mohammad A. Tayebi**, Uwe Glässer, Tilemachos Charalampous, Zahra Zohrevand, and Hans Wehn, Mining Vessel Trajectories for Illegal Fishing Detection. In *Proceedings of the 2019 IEEE International Conference on Big Data (BigData'19)*, Los Angeles, USA, 2019.
- Z. Zohrevand, U. Glässer, **M. A. Tayebi**, H. Y. Shahir, M. Shirmaleki and A. Y. Shahir. Deep Learning Based Forecasting of Critical Infrastructure Data. In *Proceedings of the*

26th Conference on Information and Knowledge Management (CIKM'17), pp. 1129–1138, Singapore, 2017.

- **M. A. Tayebi**, U. Glässer, P. L. Brantingham, and H. Y. Shahir. SINAS: Suspect Investigation Using Offenders' Activity Space. In *Proceedings of European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases (ECML-PKDD'17)*, pp. 253–265, Skopje, Macedonia, 2017.
- Z. Zohrevand, U. Glässer, H. Y. Shahir, **M. A. Tayebi**, and R. Costanz. Hidden Markov Based Anomaly Detection for Water Supply Systems. In *Proceedings of the 2016 IEEE International Conference on Big Data (BigData'16)*, pp. 1551-1560, Washington D.C., USA, 2016.
- **M. A. Tayebi**, U. Glässer, M. Ester, and P. L. Brantingham. Personalized crime location prediction. *European Journal of Applied Mathematics*, vol. 27, pp. 422–450, Cambridge University Press, 2016.
- **M. A. Tayebi**, M. Ester, U. Glässer and P. L. Brantingham. Spatially Embedded Co-offence Prediction Using Supervised Learning. In *Proceedings of 20th Knowledge Discovery and Data Mining (KDD'14)*, pp. 1789–1798, New York City, USA, 2014.
- **M. A. Tayebi**, R. Frank and U. Glässer. Understanding the Link Between Social and Spatial Distance in the Crime World. In *Proceedings of ACM SIGSPATIAL Conference on Advanced in Geographic Information Systems (SIGSPATIAL'12)*, pp. 550–553, Redondo Beach, USA, 2012.
- **M. A. Tayebi**, M. Jamali, M. Ester, U. Glässer, and R. Frank. CrimeWalker: A Recommendation Model for Suspect Investigation. In *Proceedings of ACM Conference on Recommender Systems (RECSYS'11)*, pp. 173-180, Chicago, USA, 2011.
- **M. A. Tayebi**, L. Bakker, U. Glässer and V. Dabbaghian. Locating Central Actors in Co-offending Networks. In *Proceedings of Conference on Advances in Social Network Analysis and Mining (ASONAM'11)*, Kaohsiung, Taiwan, pp. 171–179, 2011.
- **M. A. Tayebi**, S. M. Hashemi and A. Mohades, B2Rank: An Algorithm for Ranking Blogs Based on Behavioral Features. In *Proceedings of International Conference on Web Intelligence*, pp. 104-107, Silicon Valley, USA, 2007.

Academic Experience

Service

- Program Co-chair, International Symposium on Foundations of Open Source Intelligence and Security Informatics (FOSINT-SI), 2016 (San Francisco), 2017 (Sydney), 2018 (Barcelona), 2019 (Vancouver), 2020 (The Hague)
- Sudent Volunteer Co-Chair, ACM Conference on Recommender Systems, Vancouver, 2018

Reviewer for Journals

- Social Network Analysis and Mining (SNAM), Journal of Information Science, IEEE Intelligent Systems, International Journal of Information Technology and Decision Making (IJITDM), Knowledge and Information Systems (KAIS)

Instructor

- Security Testing and Evaluation, Simon Fraser University, Canada, Fall Semesrter, 2019
- Database Systems II , Simon Fraser University, Canada, Summer Semesrter, 2018
- Introduction to Data Mining, Ontario Provincial Police, Canada, 2017
- Programming principles, Tabriz Azad University, Iran, 2005

Appendix 6 Budget for the proposed program (financial and personnel)

The program will initially be taught by existing faculty members, with a team teaching approach. As demand grows, the program will require three new faculty to teach its specifically designed SMS courses. As some of the courses are laboratory heavy, they require participation of technical staff and teaching assistants who will be paid through the funds generated by the SMS tuition fees. A full-time program coordinator will be hired from the funds as well, with an additional $100,000/yr devoted to the investment on state-of-the-art laboratory equipment for hands-on Industry 4.0 training.

Proposed tuition and other program fees including a justification

Tuition for the SMS program will be charged on a program basis: tentatively $8,700 per term for domestic students and $12,400 for international students effective September 1, 2021. Students will normally complete the program in 4 terms, hence the total program cost for domestic students will be $34,800, and for international students $49,600. There will be a continuing fee per term, 50% of the regular fee, for those students who take longer than 4 terms. The tuition fees are summarized in the following table. Not all students will need to take a continuing term; only those who have an extended internship placement.

	Term 1	Term 2	Term 3	Term 4	**Total Tuition**	Continuing Term (50%)	Total with Continuing Term
Domestic	$8,700	$8,700	$8,700	$8,700	**$34,800**	$4,350	$39,150
International	$12,400	$12,400	$12,400	$12,400	**$49,600**	$6,200	$55,800

The tuition is sufficient to cover the costs of the program. Space is being reconfigured within the Faculty and School, therefore no additional space is required to accommodate the new program at this time. The current faculty complement will team teach the new program for the first year.

As demand grows for the program, space and faculty resources will be addressed. The Dean acknowledges that tuition and revenues will meet the necessary resources to mount the program.