PROPOSAL TO ESTABLISH A NEW MASTER'S DEGREE PROGRAM

This template is to be used only by programs that have received specific written approval from the Provost's office to proceed with internal proposal development and review. The proposal template should be completed in full and submitted to the University Provost's Office [mailto: curriculumplanning@asu.edu]. It must undergo all internal university review and approval steps including those at the unit, college, and university levels. A program **may not** be implemented until the Provost's Office notifies the academic unit that the program may be offered.

MASTER'S DEGREE PROGRAM

College/School: College of Global Futures

Note: Program ownership is coded at the College/School level first and may not be a center, department or division apart from it.

Department/Division/School: School of Complex Adaptive Systems (CSCAS)

Proposing faculty group (if applicable)**:**

Name of proposed degree program: Master of Science (MS) in Complex Systems Science

Proposed title of major: Complex Systems Science

Master's degree type: MS - Master of Science

If Degree Type is "Other", provide degree type and proposed abbreviation: N/A

Is a program fee required? Yes, a program fee is required.

Note: for more information about program fee requests, visit https://provost.asu.edu/curriculum-development/changemaker/form-instructions#fees

Is the unit willing and able to implement the program if the fee is denied? No, we are not able to implement the program.

Requested effective term and year: Fall 2021

(The first semester and year for which students may begin applying to the program)

Delivery method and campus or location options: *select all locations that apply*

☐ Downtown Phoenix ☐ Polytechnic ☒ Tempe ☐ West ☐ Other: _____

☒ **Both** on-campus **and** ☒ ASU Online*** -** (check applicable campus(es) from options listed above)

☐ ASU Online only (all courses online and managed by ASU Online)

Note: Once students elect a campus or Online option, students will not be able to move between the on-campus and the ASU Online options. Approval from the Office of the University Provost and Philip Regier (Executive Vice Provost and Dean) is required to offer programs through ASU Online. Please complete the ASU Online Offering form in Curriculum ChangeMaker to begin this request. Prior to completing the online Curriculum ChangeMaker form, please contact EdPlus at asuonline@asu.edu who can provide you with additional information regarding the online request process.

Do Not Fill in this information: Office Use Only **Plan Code:**	**CIP Code:**

PROPOSAL CONTACT

Name:	Manfred Laubichler	**Title:**	President's Professor
Phone number:	965 6214	**Email:**	manfred.laubichler@asu.edu

DEAN APPROVAL(S)

This proposal has been approved by all necessary unit and college/school levels of review, and the college/school(s) has the resources to offer this degree program. I recommend implementation of the proposed degree program.

Note: An electronic signature, an email from the dean or dean's designee, or a PDF of the signed signature page is acceptable.

College/School/Division Dean name:	Christopher Boone		
Signature:	DocuSigned by: Christopher Boone 758040605B584C3...	**Date:**	December 3, 2020

Please note: Proposals for new degrees also require the review and recommendation of approval from the University Graduate Council, Curriculum and Academic Programs Committee (CAPC), the Academic Senate (2 readings), and the Office of the Provost before they can be put into operation.

The final approval notification will come from the Office of the Provost.

1. PURPOSE AND NATURE OF PROGRAM

A. Provide a brief program description:

The interdisciplinary Master of Science in Complex Systems Science program will assist students in developing skills in theoretical foundations, modeling, problem solving, critical thinking, and the importance of direct experience through research or related activities in the context of complex systems science. Complex Adaptive systems science focuses on the behavior and consequences of highly interactive and networked systems by investigating the common principles underlying these diverse systems. The program will focus on the general theoretical foundations, modeling methods and a broad overview of application domains. Complex systems are at the core of all real-world challenges ranging from health, sustainability, engineering, economics, urban and social systems and basic sciences. Expertise in complex systems science will allow graduates to contribute to practical and theoretical solutions in a vast number of areas thus fitting with ASU's mission to advance research and discovery of public value; and assuming fundamental responsibility for the economic, social, cultural and overall health of the communities it serves. Students will be introduced to the theoretical foundations, methods of inquiry and a range of applications. They will engage in different learning modalities including practical exercises and guided research projects.

B. Will concentrations be established under this degree program? ☐ Yes ☒ No

(Please provide additional concentration information in the curricular structure section – number 7.)

2. PROGRAM NEED

Explain why the university should offer this program (include data and discussion of the target audience and market).

The School of Complex Adaptive Systems in the College of Global Futures, the Global Biosocial Complexity Initiative and its 100+participating ASU faculty across more than 10 academic units, and our partner institution, the Santa Fe Institute (SFI) with its resident and external faculty, represent the world's leading concentration of researchers in complex systems science. Leveraging ASU's pioneering role in online education, this group of faculty is able to offer a cutting-edge online degree program that is unique in both its scope and level of expertise. By offering the degree through the EdPlus platform students world-wide can take advantage of the expertise of this large group of researchers and are provided with a unique combination of theoretical foundations and practical applications in complex systems science. Offering a degree in collaboration with SFI is also an innovative approach to master's level education that builds on ASU's innovation expertise and reflects the realities of an interconnected world that requires the ability to be highly dynamic and adaptive. The campus immersion model will cover the same ground as the online degree and include additional options for students to become involved in the labs of participating faculty.

Gradutes of this degree will have multiple career opportunities. Complex systems science is an important part of solutions in such areas as sustainability, finance, a large number of the social sciences, the biomedical sciences and computer science. It is foundational for all attempts to understand risk and security. Career options include, but are not limited to: 15-0000 *Computer and Mathematical Occupations*; project growth rate in employment 2018 to 2028 is

12.7%; and 19-0000 *Life, Physical and Social Science Occupations*; projected growth rate in employment 2018 to 2028 is 7.4% (source Bureau of Labor Statistics (www.bls.gov). Furthermore, the report "The New Foundational Skills for the Digital Economy: Developing the Professionals of the Future" by BurningGlass Technologies (https://www.burning-glass.com/wp-content/uploads/New_Foundational_Skills.pdf) identifies many of the skills developed as part of this degree as foundational to a large number of employment opportunities.

The career options for graduates of this degree are therefore manifold: (1) it better qualifies students for a number of PhD programs at ASU. As there are no complex systems undergraduate degrees, it provides necessary qualifications for more advanced studies; (2) it is an added qualification for a huge number of jobs in the private and public sectors in all the areas listed above (see the BurningGlass report). Given these options and trends and the tremendous growth in these sectors of the economy, we project outstanding career options for graduates.

This degree serves a number of market needs. The need to better understand complexity is widely recognized. The Economist in an editorial in 2004 (28th October) and in many articles afterwards called for the need to "keep it simple" in light of ever-increasing complexity and identified complexity science as the way to advance that vision. Similarly, *JAMA* called for the urgent need to understand healthcare as a complex system (doi:10.1001/jama.2012.7551). *Science* identified expertise in networks, especially complex networks, as a major career option (https://www.sciencemag.org/careers/2009/07/tangled-webs-careers-network-science). Yet globally, only a handful of complex systems degree programs or concentrations exist, mostly at the PhD level and are more narrowly focused. At ASU we have avoided this narrow specialization by offering a concentration in a number of PhD degrees. Both our experience and the experience of our colleagues highlight the need for a broad, interdisciplinary MS program ahead of the PhD. There are no comparable degrees offered at any universities in Arizona.

3. IMPACT ON OTHER PROGRAMS

Attach any letters of collaboration or support from impacted programs (see checklist sheet). Please submit as a separate document.

This is a new degree that does not negatively impact any existing ones. It is part of ASU's institutional collaboration with the Santa Fe Institute and is covered by these agreements. The agreement about the degree allows newly and jointly developed materials to be incorporated into any other ASU courses, which represents another a positive impact. Furthermore, it complements existing PhD concentrations in Complex Adaptive Systems Science offered by Graduate Faculty in Complex Adaptive Systems Science as a transdicplinary concentration in Anthropology, Applied Mathematics in the Social and Life Sciences, Biology, Environmental Social Science, Global Health and Sustainability PhD programs. The degree will be offered by the newly established School of Complex Adaptive Systems in the College of Global Futures.

4. PROJECTED ENROLLMENT

How many new students do you anticipate enrolling in this program each year for the next five years?

Note: The Arizona Board of Regents (ABOR) requires that nine master's degrees be awarded every three years. Thus, the projected enrollment numbers must account for this ABOR requirement.

5-YEAR PROJECTED ANNUAL ENROLLMENT					
Please utilize the following tabular format	**1st Year**	**2nd Year** (Yr. 1 continuing + new entering)	**3rd Year** (Yr. 1 & 2 continuing + new entering)	**4th Year** (Yrs. 1, 2, 3 continuing + new entering)	**5th Year** (Yrs. 1, 2, 3, 4 continuing + new entering)
Number of Students Majoring (Headcount)	20	50	80	100	120

5. ACCREDITATION OR LICENSING REQUIREMENTS (if applicable)

Provide the names of the external agencies for accreditation, professional licensing, etc. that guide your curriculum for this program, if any. Describe any requirements for accreditation or licensing.

N/A

6. STUDENT LEARNING OUTCOMES AND ASSESMENT

Attach a PDF copy of the assessment plan printed from the University Office of Evaluation and Educational Effectiveness assessment portal demonstrating UOEEE's approval of your assessment plan for this program. Visit the assessment portal at https://uoeee.asu.edu/assessment-portal or contact uoeee@asu.edu with any questions.

See Appendix II: Assessment Plan

7. CURRICULAR STRUCTURE

A. Curriculum Listing

Required Core Courses for the Degree			
Prefix and Number	**Course Title**	**New Course?**	**Credit Hours**
CAS 501	Fundamentals of Complex Systems Science: Evolution	Yes	3
CAS 502	Fundamentals of Complex Systems Science: Computation	Yes	3
CAS 503	Fundamentals of Complex Systems Science: Collectives	Yes	3
Choose two courses from the following:			
CAS 520	Methods for Complex Systems Science: Agent Based Modeling	Yes	3
CAS 521	Methods for Complex Systems Science: Network Analysis	Yes	3
CAS 522	Methods for Complex Systems Science: Dynamical Systems	Yes	3
CAS 523	Methods for Complex Systems Science: Statistics and Dimensionality Reduction	Yes	3
		Section sub-total:	15
Electives **Students take three elective courses for a total of 9 credit hours**			
Prefix and Number	**Course Title**	**New Course?**	**Credit Hours**
Sample List of Electives:			
CAS 540	Socio-Ecological Complex Systems	Yes	3
CAS 541	Complex Urban Systems	Yes	3
CAS 542	Sustainability as a Problem of Complexity	Yes	3
CAS 543	Complexity Economics	Yes	3
CAS 544	Innovation in Complex System	Yes	3
CAS 545	Disease as a Complex System	Yes	3
		Section sub-total:	9
Culminating Experience(s)			**Credit Hours**

E.g. – *Capstone course, portfolio, written comprehensive exam, applied project, thesis (must be 6 credit hours with oral defense)*	
The applied project should be taken over two sessions	
CAS 593 Applied Project (see description below)	6
Section sub-total:	6
Total required credit hours	30

1. List all required core courses and total credit hours for the core (required courses other than internships, thesis, capstone course, etc.).
2. Omnibus numbered courses cannot be used as core courses.
3. Permanent numbers must be requested by submitting a course proposal to Curriculum ChangeMaker for approval.

B. Will concentrations be established under this degree program? ☐ Yes ☒ No

8. COURSES

A. Course Prefix(es): Provide the following information for the proposed graduate program.

i. Will a new course prefix(es) be required for this degree program?

Yes ☒ No ☐

If yes, complete the **Course Prefixes / Subjects Form** for each new prefix and submit it as part of this proposal submission. Form is located under the courses tab.

B. New Courses Required for Proposed Degree Program: Provide course prefix, number, title, credit hours and brief description for any new courses required for this degree program.

New Courses for MS in Complex Systems Science

Foundation Courses

Note on Core Foundation courses: As an innovative part of this degree we have developed three core foundation courses, each representing one fundamental dimension of complex systems. In each of these courses we will discuss one dimension (evolution, computation and information, collectives) in depth and across the whole spectrum of complex systems (social, behavioral and life sciences and engineering). This is a novel approach that differs from a more traditional sequence of theoretical introduction followed by different application areas and allows for a deeper understanding of the core properties of complex systems.

CAS 501: Fundamentals of Complex Systems Science: Evolution 3 Credit Hours

Most systems are complex. Complex systems share a number of critical features across all domains. This includes the fact that all complex systems are historical, path-dependent products of adaptive evolution. Foundations of Complex Systems: Evolution explores the evolutionary and adaptive dimensions, processes and mechanisms, and consequences of complex systems in a systematic way across the social, behavioral and life sciences and engineering.

CAS 502: Fundamentals of Complex Systems Science: Computation 3 Credit Hours

Most systems are complex. Complex systems share a number of critical features across all domains. This includes the fact that all complex systems process information and perform computations in the broadest sense. Foundations of Complex Systems: Computation explores the informational and computational dimensions of complex systems with an emphasis on how complex systems acquire, process, store and transmit information in a systematic way across the social, behavioral and life sciences and engineering.

CAS 503: Fundamentals of Complex Systems Science: Collectives 3 Credit Hours

Most systems are complex. Complex systems share a number of critical features across all domains. This includes the fact that all complex systems are collectives. Foundations of Complex Systems: Collectives explores how complex systems act through collective behavior, decision making and computation in a systematic way across the social, behavioral and life sciences and engineering.

Core Methods Courses

CAS 520: Methods for Complex Systems Science: Agent Based Modeling 3 Credit Hours

The study of complex systems involves a number of analytic methods and modeling approaches. Methods for Complex Systems Science: Agent Based Modeling introduces students to agent-based modeling approaches in a systematic way across the social, behavioral and life sciences and engineering.

CAS 521: Methods for Complex Systems Science: Network Analysis 3 Credit Hours

The study of complex systems involves a number of analytic methods and modeling approaches. Methods for Complex Systems Science: Network Analysis introduces students to the theory and application of network analysis in a systematic way across the social, behavioral and life sciences and engineering.

CAS 522: Methods for Complex Systems Science: Dynamical Systems 3 Credit Hours

The study of complex systems involves a number of analytic methods and modeling approaches. Methods for Complex Systems Science: Dynamical Systems introduces students to theory and application of dynamical systems modeling in a systematic way across the social, behavioral and life sciences and engineering.

CAS 523: Methods for Complex Systems Science: Statistics and Dimensionality Reduction 3 Credit Hours

The study of complex systems involves a number of analytic methods and modeling approaches. Methods for Complex Systems Science: Statistics and Dimensionality Reduction introduces students to necessary statistical techniques and methods in dimensionality reduction required for the analysis of complex systems in a systematic way across the social, behavioral and life sciences and engineering.

Elective Courses

CAS 540: Complex Socio-Ecological Systems 3 Credit Hours

A prime example of complex systems are combined socio-ecological systems representing the multiple ways humans interact with their environment. Complex Socio-Ecological Systems will explore these interactions in past, present and future and across a number of different scales with a special emphasis on how such processes can be modeled.

CAS 541: Complex Urban Systems 3 Credit Hours

The trend of urbanization is accelerating. By 2050 more than 75% of all people are projected to live in urban areas. Urban Systems as Complex Systems explores the patterns and processes of urbanization through the lens of complex systems science with a special focus on how CSS can advance solutions to pressing challenges of urbanization.

CAS 542: Sustainability as a Problem of Complexity 3 Credit Hours

Sustainability Challenges are complex challenges. Sustainability as a Problem of Complexity explores in a systematic way the interconnected nature of sustainability challenges and presents a complex systems science based framework for developing sustainability solutions.

CAS 543: Complexity Economics 3 Credit Hours

The economy is clearly a complex system. Yet both Micro- and Macroeconomics are predicated on abstractions that reduce the inherent complexity of economic interactions. Complexity economics introduces a complementary approach to economic modeling based on a number of complex systems approaches, methods and concepts.

CAS 544: Innovation in Complex System 3 Credit Hours

Innovation is a central property of complex systems. Without innovation there would be no evolution of complex systems. This course will explore the dynamics of innovation in complex systems across a number of different domains. Including biological, social, cultural and technological innovations. It will focus on the common principles and differences guiding innovation dynamics. It will also focus on unintended consequences of innovation, such as cascading effects and innovation traps and investigate why certain systems fail to innovate. Students will be able to identify common features of innovation across complex systems.

CAS 545: Disease as a Complex System 3 Credit Hours

Disease is a complex problem. Disease as a Complex System analyzes multiple interconnected dimensions of disease from the molecular to the socio-economic, from disease causation to treatment and health case solutions from a complex systems science perspective.

Culminating Experience

CAS 593: Applied Project 6 Credit Hours

The applied project in the complex systems science degree involves the synthesis of materials from foundation, methods and elective courses in the form of a literature review-based analysis of a specific real-world problem followed by an applied project. It also involves the creation of a portfolio of student accomplishments. The applied project is a modeling and research project in any of the applied or foundational areas of complex systems science. Students will define this project with a faculty mentor and apply a selection of methods covered in the methods courses to a dataset.

8. FACULTY, STAFF, AND RESOURCE REQUIREMENTS

A. Faculty

i. Current Faculty – Complete the table below for all current faculty members who will teach in the program. If listing faculty from an academic unit outside of the one proposing the degree, please provide a support statement from that unit.

Name	Rank	Highest Degree	Area of Specialization/Expertise	Estimated Level of Involvement
Manfred Laubichler	President's Professor	PH.D.	Evolutionary Theory, Theoretical Biology, Complex Systems	High
Michael Barton	Professor	PH.D.	Anthropology, Modeling	High
Sander van der Leeuw	Professor	PH.D.	Sustainability	Medium
Shade Shutters	Assistant Research professor	PH.D.	Behavioral Biology	Medium
Marco Janssen	Professor	PH.D.	Modeling, Applied Math	Medium
Stephanie Forrest	Professor	PH.D.	Computer Science	Medium

Bryan Daniels	Assistant Research Professor	PH.D.	Physics, Modeling	Medium
Joffa Appelgate	Assistant Research Professor	PH.D.	Economics, Modeling	Medium
Sara Walker	Associate Professor	PH.D.	Physics, Information theory	Medium
Enrico Borriello	Assistant Research Professor	PH.D.	Physics, Statistics	Medium
Deryc Painter	Postdoc	PH.D.	Network Analysis	Medium
Sean Bergin	Assistant Research professor	PH.D.	Anthropology, Modeling	Medium
Jose Lobo	Associate Research Professor	Ph.D.	Sustainability, Innovation	Medium

ii. **New Faculty -** Describe the new faculty hiring needed during the next three years to sustain the program. List the anticipated hiring schedule and financial sources for supporting the addition of these faculty members.

No new faculty are needed to deliver this curriculum. However, as new faculty will be added to the new School of Complex Adaptive Systems, we will be able to offer more courses as electives as all new faculty have the potential to contribute to this program in the future.

iii. **Administration of the program -** Explain how the program will be administered for the purposes of admissions, advising, course offerings, etc. Discuss the available staff support.

The program will be administered by the School of Complex Adaptive Systems (SCAS) with the support of EdPlus for the digital immersion offering, and the College of Global Futures. SCAS is the academic home for the degree. Admission, advising and course offerings will be coordinated by SCAS. SCAS already coordinates the graduate faculty in complex adaptive systems and the existing complex systems concentrations in a number of Ph.D. programs as well as the Complex Adaptive Systems Science graduate certificate. SCAS has experience in managing online degrees as well as coordinating degrees developed in partnership with outside organizations, such as with the MS and graduate certificate programs in Biomimicry.

Michael Barton is the Associate Director for educational programs in SCAS and will be overseeing administration of this degree program.

B. **Resource requirements needed to launch and sustain the program:** Describe any new resources required for this program's success such as new staff, new facilities, new library resources, new technology resources, etc.

The program can be delivered with the proposed program fee, no additional new resources are needed.

APPENDIX I
OPERATIONAL INFORMATION FOR GRADUATE PROGRAMS
(This information is used to populate the Graduate Programs Search/catalog website.)

1. **Proposed title of major:** Complex Systems Science

2. **Marketing description** *(Optional - 50 words maximum. The marketing description should not repeat content found in the program description.)*

   The Master of Science degree in complex systems science is an interdisciplinary program designed for those seeking a broad understanding of complex systems challenges and their potential solutions in a number of contexts ranging from health, sustainability, engineering, economics, urban and social systems and basic sciences.

3. **Provide a brief program description** *(Catalog type (i.e. will appear in Degree Search) – no more than 150 words. Do not include any admission or curriculum information)*

   Most systems are complex. This means that through the interaction between their parts these systems exhibit emergent properties and unintended consequences. The curriculum in complex systems science focuses on developing skills in theoretical foundations, modeling, problem solving, critical thinking, and the importance of direct experience through research or related activities. Complex systems science students will cultivate the ability to approach complex problems through analysis and modeling and by identifying issues, asking questions, and collaborating with others to create effective solutions. Graduates in complex systems science can apply their skills to a large number of areas and in many professions where they can make a difference through innovative and creative methods.

4. **Delivery/Campus Information Options:** Both, On-Campus and ASU Online

5. **Campus(es) where program will be offered:**
   ASU Online curriculum consists of courses that have no face-to-face content. iCourses are online courses for students in on-campus programs. iCourses may be included in a program, but may not comprise the entirety of a program. On-campus programs must have some face-to-face content.
   Note: Office of the Provost approval is needed for ASU Online delivery option.

   ☐ ASU Online only (all courses online and managed by ASU Online)

   All other campus or location options (please select all that apply):

   ☐ Downtown Phoenix ☐ Polytechnic ☒ Tempe ☐ West ☐ Other: _____

   ☒ **Both** on-campus **and** ☒ ASU Online*** -** (check applicable campus(es) from options listed above)

   Note: Once students elect a campus or Online option, students will not be able to move between the on-campus and the ASU Online options. Approval from the Office of the University Provost and Philip Regier (Executive Vice Provost and Dean) is required to offer programs through ASU Online. Please complete the ASU Online Offering form in Curriculum ChangeMaker to begin this request. Prior to completing the online Curriculum ChangeMaker form, please contact EdPlus at asuonline@asu.edu who can provide you with additional information regarding the online request process.

6. **Admission Requirements:**

   Applicants must fulfill the requirements of both the Graduate College and the College of Global Futures.

   Applicants are eligible to apply to the program if they have earned a bachelor's or master's degree in a STEM field, economics, social sciences, humanities or related field, from a regionally accredited institution.

   Applicants must have a minimum cumulative GPA of 3.00 (scale is 4.00 = "A") in the last 60 hours of their first bachelor's degree program, or applicants must have a minimum cumulative GPA of 3.00 (scale is 4.00 = "A") in an applicable master's degree program.

All applicants must submit:

1. graduate admission application and application fee
2. official transcripts
3. two letters of recommendation
4. written statement
5. professional resume
6. proof of English proficiency

Additional Application Information

An applicant whose native language is not English must provide proof of English proficiency regardless of current residency.

7. Application Review Terms (if applicable session):

Indicate the first term and year in which applications will be opened for admission. Applications will be accepted on a rolling basis after that time.
Note: It is the academic unit's responsibility to display program deadline dates on their website.

Terms	Years	University Late Fee Deadline
☒ Fall (regular) ☒ Session B	(year): 2021 (Tempe and Online) (year): 2021 (Online)	July 1st October 1st
☒ Spring (regular) ☒ Session B	(year): 2022 (Tempe and Online) (year): 2022 (Online)	December 1st February 8th
☒ Summer (regular)	(year): 2022 (Tempe and Online)	May 14th
Note: Session B is only available for approved online programs.		

Program admission deadlines website address: https://scas.asu.edu/

8. Curricular Requirements:

Curricular Structure Breakdown for the Academic Catalog:
(To be completed by the Graduate College)

30 credit hours including the applied project course (CAS 593)

Required Core (15 credit hours)
CAS 501 Fundamentals of Complex Systems Science: Evolution (3)
CAS 502 Fundamentals of Complex Systems Science: Computation (3)
CAS 503 Fundamentals of Complex Systems Science: Collectives (3)
Choose two from the following:
CAS 520 Methods for Complex Systems Science: Agent Based Modeling (3)
CAS 521 Methods for Complex Systems Science: Network Analysis (3)
CAS 522 Methods for Complex Systems Science: Dynamical Systems (3)
CAS 523 Methods for Complex Systems Science: Statistics and Dimensionality Reduction (3)

Electives (9 credit hours)

Culminating Experience (6 credit hours)
CAS 593 Applied Project (6)

Additional Curriculum Information

The applied project is a modeling and research project in any of the applied or foundational areas of complex systems science. Students will define this project with a faculty mentor and apply a selection of methods covered in the methods courses to a dataset. The applied project also involves the creation of a portfolio of student accomplishments.

9. Comprehensive Exams:

Master's Comprehensive Exam (when applicable), please select from the appropriate option.

N/A

10. Allow 400-level courses: ☒ **Yes** ☐ **No**

Note: No more than 6 credit hours of 400-level coursework may be included on a graduate student plan of study.

11. Committee:

Required number of thesis committee members (must be at least 3 including chair or co-chairs): N/A

Required number of non-thesis option committee members (must be a minimum of one): 1

12. Keywords: List all keywords that could be used to search for this program. Keywords should be specific to the proposed program – limit 10 keywords.

complex systems, evolution, sustainability, collectives, adaptation, innovation, modeling

13. Area(s) of Interest

A. Select **one (1)** primary area of interest from the list below that applies to this program.

- ☐ Architecture & Construction
- ☐ Arts
- ☐ Business
- ☐ Communication & Media
- ☐ Education & Teaching
- ☐ Engineering & Technology
- ☐ Entrepreneurship
- ☐ Health & Wellness
- ☐ Humanities
- ☐ Interdisciplinary Studies
- ☐ Law & Justice
- ☐ Mathematics
- ☐ Psychology
- ☒ STEM
- ☐ Science
- ☐ Social and Behavioral Sciences
- ☐ Sustainability

B. Select **one (1)** secondary area of interest from the list below that applies to this program.

- ☐ Architecture & Construction
- ☐ Arts
- ☐ Business
- ☐ Communications & Media
- ☐ Education & Teaching
- ☐ Engineering & Technology
- ☐ Entrepreneurship
- ☐ Health & Wellness
- ☐ Humanities
- ☐ Interdisciplinary Studies
- ☐ Law & Justice
- ☐ Mathematics
- ☐ Psychology
- ☐ STEM
- ☐ Science
- ☒ Social and Behavioral Sciences
- ☐ Sustainability

14. Contact and Support Information:

Office Location - Building Code & Room: *(Search ASU map)*	ECA 110
Campus Telephone Number: (may not be an individual's number)	965 6214
Program Email Address: (may not be an individual's email)	GBCI@asu.edu

Program Website Address: (if one is not yet created, use unit website until one can be established)	complexity.asu.edu
Program Director (Name):	Manfred Laubichler
Program Director (ASURITE):	mlaubic
Program Support Staff (Name):	Adam Farni
Program Support Staff (ASURITE):	afarni
Admissions Contact (Name):	Michael Barton
Admissions Contact (ASURITE):	cmbarton

15. Application and iPOS Recommendations: List the Faculty and Staff who will input admission/POS recommendations to Gportal **and** indicate their approval for Admissions and/or POS:

NAME	ASURITE	ADMSN	POS
Manfred Laubichler	mlaubic	x	x
Michael Barton	cmbarton	x	x
Adam Farni	afarni	x	x
Trish Yasolsky	pyasolsk	x	x

APPENDIX II

Assessment Plan

MS in Complex Systems Science (MS1562011527)
MS1562011527 GF-Global
Approved Futures

Learning Outcome 1: Graduates of the program will be able to evaluate the basic principles of complex systems science and apply those to a number or real-world cases from different areas, including environmental sciences, economics, sustainability and health in order to solve problems.

- **Concepts:** Sophisticated understanding and critical application of the main features of complex systems; the ability to analyze real world cases as instances of complex systems; the ability to formulate a research question or a policy question as a complex systems problem; the ability to collect data and information relevant to analyzing real world cases as complex systems problems.

- **Competencies:** Students will demonstrate competence in comprehending and critically evaluating the core principles of complex system science and also show an ability to apply these theoretical concepts to real worlds cases.

- **Process:** The ability to comprehend concept 1 will be tested in all written assignments throughout the degree and it will be the basis for assessment of the final research project, which will be an application of complex systems science approaches to a real-world case taken from any number of application areas and matched to the student's interest and goals. Student work will be assessed as a sequence of program milestones that together will form the basis of a program-long student portfolio. 85% of students will achieve 80% or better on the faculty designed assessment rubrics for the final project and all milestones laid out in the program-long student portfolio. Besides formulating a research question students will also be able to conduct preliminary research towards addressing the problem they identified. This will include a comprehensive literature review as well as data gathering and analysis. They will demonstrate the ability of independent research, critical evaluation of the literature and data analysis. Student work will be assessed as a sequence of program milestones that together will form the basis of a program-long student portfolio. 85% of students will achieve 80% or better on the faculty designed assessment rubrics for the final project and all milestones laid out in the program-long student portfolio.

- **Measures:** The ability to comprehend concept 1 will be tested in all written assignments throughout the degree and it will be the basis for assessment of the final research project, which will be an application of complex systems science approaches to a real-world case taken from any number of application areas and matched to the student's interest and goals. Student work will be assessed as a sequence of program milestones that together will form the basis of a program-long student portfolio. 85% of students will achieve 80% or better on the faculty designed assessment rubrics for the final project and all milestones laid out in the program-long student portfolio. Besides formulating a research question students will also be able to conduct preliminary research towards addressing the problem they identified. This will include a comprehensive literature review as well as data gathering and analysis. They will demonstrate the ability of independent research, critical evaluation of the literature and data analysis. Student work will be assessed as a sequence of program milestones that together will form the basis of a program-long student portfolio. 85% of students will achieve 80% or better on the faculty designed assessment rubrics for the final project and all milestones laid out in the program-long student portfolio.

Learning Outcome 2: Graduates of the program will be familiar with the essential methodological and modeling tools in complex systems science and demonstrate the ability to apply those to novel data sets.

- **Concepts:** Sophisticated understanding of a number of analytical and modeling techniques; the ability to match those techniques with specific complex systems problems; the ability to adapt standard techniques to apply to a specific problem; the ability to critically asses the assumptions involved in applying a specific technique; the ability to see the limitation of each modeling approach.

- **Competencies:** Students will demonstrate competence in understanding and applying core modeling techniques of complex systems science and be able to select which technique is appropriate for particular empirical cases. This includes competency in dynamical systems modeling, agent based modeling and statistics.

- **Process:**

- **Measures:** The ability to comprehend Concepts 2 will be tested in all relevant methods courses within the degree and also in the development of the methodological framework for the final project. Students will have to defend their selection of methods and be able to critically asses the results of their simulations and analysis. Student work will be assessed as a sequence of program milestones that together will form the basis of a program-long student portfolio. 85% of students will receive a B grade or higher and hit 80% on the assessment scales for the final project and in for all milestones laid out in the program-long student portfolio. The portfolio will include a rubric of milestones that will also be used to continuously improve the program and help to identify resources needed for students to succeed.Students will also demonstrate their ability to adapt standard techniques to fit their research question and data structures. This involves basic programming skills allowing students to productively apply methods to real world cases. Student work will be assessed as a sequence of program milestones that together will form the basis of a program-long student portfolio. 85% of students will receive a B grade or higher and hit 80% on the assessment scales for the final project and in for all milestones laid out in the program-long student portfolio. The portfolio will include a rubric of milestones that will also be used to continuously improve the program and help to identify resources needed for students to succeed.

Learning Outcome 3: Graduates of the program will be able to identify and analyze concrete examples of complex systems and compare those to other such examples in order to identify similarities and differences between those systems.

- **Concepts:** How can we detect complex systems? By what criteria are we identifying a system as complex? What data structures are needed to identify complex systems? What questions can be addressed and answered about those examples using complex systems concepts and methods? Independent execution of a research question about a concrete example of a complex system.

- **Competencies:** Students will demonstrate competence in comparing instances of complex systems to each other in order to detect common principles and structures.

- **Process:**

- **Measures:** The ability to comprehend Concepts 3 will be tested in all relevant applied courses within the degree in form of a final project in each of these courses. Students will have to present their research question, defend their selection of methods and be able to critically asses the results of their analysis. Student work will be assessed as a sequence of program milestones that together will form the basis of a program-long student portfolio. 85% of students will receive a B grade or higher and hit 80% on the assessment scales for the final project and in for all milestones laid out in the program-long student portfolio. The portfolio will include a rubric of milestones that will also be used to continuously improve the program and help to identify resources needed for students to succeed.: Students will also demonstrate their ability to compare their analysis of concrete examples with other cases of complex systems discussed within the degree. This way students will develop a comparative perspective in analyzing complex systems and be able to identify similarities and differences across different examples of complex systems. Student work will be assessed as a sequence of program milestones that together will form the

basis of a program-long student portfolio. 85% of students will receive a B grade or higher and hit 80% on the assessment scales for the final project and in for all milestones laid out in the program-long student portfolio. The portfolio will include a rubric of milestones that will also be used to continuously improve the program and help to identify resources needed for students to succeed.

APPENDIX III

Statements of Collaboration and Impact

College of Global Futures – Official Submission

From: Caroline Harrison
To: "curriculumplanning@asu.edu"
Cc: Andrew Maynard; Manfred Laubichler; Christopher Boone; Michael Barton; Amanda Morales-Calderon
Subject: Proposal to establish MS CSS
Date: Friday, December 4, 2020 9:55:35 AM
Attachments: image003.png
Proposal_to_establish_MS_degree_in_Complex_Systems_Science_Final.pdf
CC Request for Digital Imm Approved.pdf
Approval Memo CAS - Complex Adaptive Systems.msg

Attached is the signed proposal to establish a Master of Science degree in Complex Systems Science through the School of Complex Adaptive Systems in the College of Global Futures. It includes the approved assessment plan from UOEEE. I have also attached the approval for Digital Immersion. We have received approval for the new CAS prefix and will begin submitting the requests for new courses associated with this degree.

We are in the process of requesting support statements from The College, WP Carey, and Fulton Schools of Engineering. I will forward those as they are received.

Let me know what other information you will need or if you have any questions.

Thanks.

Caroline J. Harrison, PhD
Director, Curricular and Digital Initiatives
Associate Instructional Professional
Senior Sustainability Scholar

College of Global Futures
Arizona State University
P.O. Box 875502 | Tempe, Arizona | 85287-5502
PH: 480-965-8645 | Main: 480-965-2975

Sent: Friday, February 12, 2021 5:00 PM
To: Christopher Boone <Christopher.G.Boone@asu.edu>
Subject: RE: Letters of Collaboration and Impact for MS Complex Systems Science

This is fine Chris. Thanks, Pat

Patrick J. Kenney
Dean, The College of Liberal Arts and Sciences
Foundation Professor, School of Politics and Global Studies
Arizona State University

From: Christopher Boone
Sent: Friday, February 12, 2021 2:05 PM
To: Patrick Kenney <pkenney@asu.edu>
Subject: Letters of Collaboration and Impact for MS Complex Systems Science

Hi Pat,

In the School of Complex Adaptive Systems, we are proposing a Master of Science in Complex Systems Science (please see attached). I'd appreciate it if you could look this over and let us know if you have any objections.

Thanks,
Chris

Christopher Boone
Dean, College of Global Futures
Professor, School of Sustainability

College of Global Futures
Arizona State University

https://collegeofglobalfutures.asu.edu/
PO Box 875502, Tempe, AZ 85287-5502
Executive Assistant: Lorraine.Protocollo@asu.edu
480-965-2236
The College of Global Futures embraces ASU's mission as being a comprehensive public research university, measured not by whom it excludes, but rather by whom it includes and how they succeed; advancing research and discovery of public value; and assuming fundamental responsibility for the economic, social, cultural and overall health of the communities it serves. We support and foster a culture of inclusiveness, tolerance, and respect that promotes equal opportunity and diversity among faculty, staff, and students and through our engagement with diverse communities within and beyond the University.

From: Manfred Laubichler <Manfred.Laubichler@asu.edu>
Sent: Sunday, February 21, 2021 8:51 AM
To: Christopher Boone <Christopher.G.Boone@asu.edu>
Cc: Caroline Harrison <Caroline.Harrison@asu.edu>
Subject: Re: Letters of Collaboration and Impact for MS Complex Systems Science

There is some overlap, but our courses discuss the topic in the context of CAS, which their course do not. Also, initially ours are designed as 7 week online courses

M

Manfred D. Laubichler, Ph.D.
President's Professor of Theoretical Biology and History of Biology
Director, School of Complex Adaptive Systems
Director, Global Biosocial Complexity Initiative
Director, ASU-SFI Center for Biosocial Complex Systems
Arizona State University
Tempe, AZ 85287-4501

e-mail: Manfred.Laubichler@asu.edu

https://devo-evo.lab.asu.edu

External Professor
Santa Fe Institute
http://www.santafe.edu

External Faculty
Complexity Science Hub Vienna
https://www.csh.ac.at

Visting Scholar
Max Planck Institute for the History of Science
https://mpiwg-berlin.mpg.de

On Feb 21, 2021, at 8:47 AM, Christopher Boone <Christopher.G.Boone@asu.edu> wrote:

Please see the message from Kyle below.

Christopher Boone
Dean, College of Global Futures
Professor, School of Sustainability
<image002.png>
https://collegeofglobalfutures.asu.edu/
P.O. Box 875502 | Tempe, Arizona | 85287-5502
PH: 480-965-2236 | Main: 480-965-2975
Executive Assistant: Lorraine.Protocollo@asu.edu

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From: Kyle Squires <squires@asu.edu>
Sent: Saturday, February 20, 2021 10:10 PM
To: Christopher Boone <Christopher.G.Boone@asu.edu>
Subject: RE: Letters of Collaboration and Impact for MS Complex Systems Science

Hi Chris,

Thanks for the note and degree proposal. FSE does not have any concerns with the proposed degree.

We do ask that you examine two of our courses that are similar to those proposed:

- CAS 541 and CAS 522 are similar to IEE 477
- CAS 502 is similar to IEE 556.

Thanks,

-- Kyle

From: Christopher Boone <Christopher.G.Boone@asu.edu>
Sent: Thursday, February 18, 2021 4:05 PM
To: Kyle Squires <squires@asu.edu>
Subject: FW: Letters of Collaboration and Impact for MS Complex Systems Science

Hi Kyle,

Following up this. Please let me know if you have any questions/objections.

Christopher Boone
Dean, College of Global Futures
Professor, School of Sustainability
<image004.png>
https://collegeofglobalfutures.asu.edu/
PO Box 875502, Tempe, AZ 85287-5502
Executive Assistant: Lorraine.Protocollo@asu.edu
480-965-2236
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<image005.jpg>

Kapucinski, Anne, R., Agrawal, Arun, Boone, Christopher, Bromaghim, Erin, Louis, Garrick E., Taylor, Dorceta E. 2020. *Strengthening Sustainability Programs and Curricula in Higher Education*. Washington. D.C.: The National Academies Press. https://doi.org/10.17226/25821

From: Christopher Boone
Sent: Friday, February 12, 2021 2:04 PM
To: Kyle Squires <squires@asu.edu>
Subject: Letters of Collaboration and Impact for MS Complex Systems Science

Hi Kyle,

In the School of Complex Adaptive Systems, we are proposing a Master of Science in Complex Systems Science (please see attached). I'd appreciate it if you could look this over and let us know if you have any objections.

Thanks,
Chris

Christopher Boone
Dean, College of Global Futures
Professor, School of Sustainability
<image006.png>
https://collegeofglobalfutures.asu.edu/
PO Box 875502, Tempe, AZ 85287-5502
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<image005.jpg>

EdPlus/ASUOnline

MEMORANDUM

To: Manfred Laubichler
From: Carolyn Culley
Date: 1/9/2020
Subject: Complex Systems Science, MS

Dear Manfred,

Congratulations!

The Complex Systems Science, MS, program has received support from Dean Phil Regier to be offered through ASU Online. This program must complete university governance reviews for formal approval. Please include this support memo along with your proposal submission when it is submitted formally to the university (to curriculumplanning@asu.edu) by your dean or their designee.

Please note that in order to proceed with implementation, final approval must be supplied by the university provost.

Once again, congratulations! We are excited to work with you on your new program.

Thank you!

Carolyn Culley
Associate Director, Academic Program Management
EdPlus at ASU
Arizona State University
Phone: (480) 884-0156
Carolyn.Culley@asu.edu

CC: Gemma Garcia
CurriculumPlanning@asu.edu

(NEW GRADUATE INITIATIVES)

PROPOSAL PROCEDURES CHECKLIST

Academic units should adhere to the following procedures when requesting new curricular initiatives (degrees, concentrations or certificates).

☒ **Obtain the required approval from the Office of the Provost to move the initiative forward for internal ASU governance reviews/approvals. Please see the academic strategic plan website at: https://provost.asu.edu/curriculum-development.**

☐ **Submit any new courses that will be required for the new curricular program to the Curriculum ChangeMaker online course approval system for review and approval.**

- Additional information can be found at the Provost's Office Curriculum Development website: Courses link
- For questions regarding proposing new courses, send an email to: courses@asu.edu

☐ **Prepare the applicable proposal template and operational appendix for the proposed initiative.**

☐ **Obtain letters or memos of support or collaboration (if applicable).**

- when resources (faculty or courses) from another academic unit will be utilized
- when other academic units or degree programs may be impacted by the proposed request
- if the program will have an online delivery option support will be required from the Provost's office and ASU Online. (*Please complete the ASU Online Offering form in Curriculum ChangeMaker to begin this request.*)

☒ **Obtain the internal reviews/approvals of the academic unit.**

- internal faculty governance review committee(s)
- academic unit head (e.g. Department Chair or School Director)
- academic unit Dean or their designee (will submit approved proposal to the curriculumplanning@asu.edu email account for further ASU internal governance reviews (as applicable, University Graduate Council, CAPC and Senate)

Additional Recommendations

All new graduate programs require specific processes and procedures to maintain a successful degree program. Below are items that the Graduate College strongly recommends that academic units establish after the program is approved for implementation.

☐ **Establish satisfactory academic progress policies, processes and guidelines** – Check within the proposing academic unit and/or college to see if there are existing academic progress policies and processes in place. If none have been established, please go to http://graduate.asu.edu/faculty_staff/policies and scroll down to the **academic progress review and remediation processes** (for faculty and staff) section to locate the reference tool and samples for establishing these procedures.

☐ **Establish a Graduate Student Handbook for the new degree program** – Students need to know the specific requirements and milestones they must meet throughout their degree program. A Graduate Student Handbook, provided to students when they are admitted to the degree program and published on the website for the new degree, gives students this information. To be included in the handbook are the unit/college satisfactory academic progress policies, current degree program requirements (outlined in the approved proposal) and a link to the Graduate Policies and Procedures website: http://graduate.asu.edu/faculty_staff/policies.