ENGR 599: Emerging Technologies for National Security

Units: 2
Spring 2023—Friday 1-2:50pm

Location: GFS 222

Instructor: Michelle L. Povinelli
Office: PHE 614
Office Hours: TBD
Contact Info: povinell@usc.edu, 213-740-8682
Email will be returned within 48 hours.

Course Description

This course will survey emerging science and engineering technologies relevant to national security. This course is suitable for graduate students in engineering or physics with an interest in examining the relationship of their discipline to national security, defense, and intelligence. Successful completion of the course will allow students to knowledgeably discuss the relationship of science and technology (S&T) development to strategic competitiveness and emerging issues in national defense policy.

Learning Objectives

By the end of the course, students should be familiar with the role of science and technology within the national security strategy of selected countries, the organization of science and technology R&D, and current issues of importance to technological strategic competitiveness. Students will be further introduced to the potential impact and basic operating principles underlying key, emerging S&T areas. At the completion of this course, students will be able to knowledgeably select further courses from the USC curriculum to provide depth in both technical and policy-related areas.

Prerequisite(s): none
Co-Requisite(s): none
Concurrent Enrollment: Students must currently hold graduate status in Viterbi or Physics to register; other students may enroll only with permission of instructor.
Recommended Preparation: undergraduate degree in engineering, science, or mathematics discipline.

Course Notes

Letter grade. Course is Web-Enhanced using Blackboard. Course modality is in-Person. Copies of lecture slides, assignments, and other class information will be posted on Blackboard.

Technological Proficiency and Hardware/Software Required

Basic proficiency with Excel, plotting/graphing software, and MATLAB are recommended prior to starting this course.

Required Readings and Supplementary Materials

There is no required textbook for the course; all required readings will be provided either as a link to freely available material on the Web or as a handout posted to Blackboard.

Description and Assessment of Assignments

The assignments include weekly written assignments and a final project presentation. The written assignments will require students to answer analytical prompts related to the lecture material, incorporating appropriate quantitative analyses, figures, and graphs. Sample assignments are given below the course schedule.

Final

The final exam will be written. It will be given at the standard slot listed in the Schedule of Courses. It will consist of two writing prompts. In response to these prompts, the students will write concise, logical, and well-reasoned opinion pieces (each in 500 words or less) based on the material learned in the class. The final will be closed book, without using notes or the Internet.

Grading Breakdown

Assessment Tool (assignments)	% of Grade
Weekly written assignments	70
Final	30
TOTAL	100

Assignment Submission Policy

All assignments will be submitted via Blackboard prior to start of class on the date due.

Grading Timeline

Assignments will be graded and feedback provided within one week of submission.

Additional Policies

Late assignments will be penalized by deducting 5% of the total number of points per day.

Attendance

Active participation and attendance is essential for the course. Non-attendance may result in lowering of the grade by one letter (e.g. B+ to B, etc.) for each 3 unexcused absences. The instructor will make reasonable accommodations for any students who give advance notice of religious observation, military duties, or other professional obligations (such as attendance of professional conferences).

Classroom norms

This class will involve active discussion of sometimes controversial issues; respectful and active listening is requested from all students.

Zoom etiquette

Zoom use will be minimal but may occasionally be used for office hours or in the event that the instructor has unavoidable travel obligations; students are not required to turn cameras on.

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the USC Student Handbook. All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work

prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

The assignments involve individual writing. All material should be written in the student's own words. Any phrases or sentence fragments taken from reference sources should be placed in quotes and cited appropriately. Students are encouraged to discuss their ideas with others, but all written assignments should be completed independently by the student without editing by a third party.

If found responsible for an academic violation, students may be assigned university outcomes, such as suspension or expulsion from the university, and grade penalties, such as an "F" grade on the assignment, exam, and/or in the course.

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. (Living our Unifying Values: The USC Student Handbook, page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the class, whether obtained in class, via email, on the internet, or via any other media. (Living our Unifying Values: The USC Student Handbook, page 13).

Course Evaluations

Course evaluation occurs at the end of the semester. It is an important review of students' experience in the class and will be used to make future adaptations.

Course Schedule: A Weekly Breakdown

Sample Readings and Deliverables are indicated by the numbers in brackets and are given below the table.

	Topics/Daily Activities	Readings/Preparation (see References, below)	Deliverables (see Assignments, below)
Week 1	**Key technological issues in national security strategy** • Comparison of national security strategies	[1] web links	[1] written assignment
Week 2	**Technology development paradigms** • NASA Technological readiness level (TRL) paradigm • DoD categorization of basic vs. applied research • Technology "Valley of Death"	[2] web links	[2] written assignment
Week 3	**Export Controls and Restrictions** • ITAR Regulations • Export restrictions (EAR) and the Commerce Control List • Classification Schemes	[3] web links	[3] written assignment
Week 4	**The Science and Technology R&D Ecosystem** • Roles of academia, government, national labs, FFRDCs, corporations, and small businesses	[4] web links	[4] written assignment
Week 5	**Artificial intelligence and machine learning I** • Basic principles of artificial intelligence and machine learning	[5] web links	[5] written assignment
Week 6	**Artificial intelligence and machine learning II** • Importance of AI/ML to emerging defense and intelligence issues • Limitations and challenges of machine learning: interpretability, human-in-the-loop, ethics of AI	[6] web links	[6] written assignment
Week 7	**Quantum information science** • Motivation and importance of quantum information science: encryption and decryption, quantum algorithms	web links	written assignment
Week 8	**Quantum information science II** • Basic principles of quantum communication schemes • Emerging physical implementations	web links	written assignment
Week 9	**Semiconductors** • Importance of semiconductor technology to national security concerns • Basics of fabrication technologies; Types of circuits and their uses	web links	written assignment

	• Supply-chain security issues and global tensions; US government models for trusted manufacturing, zero trust		
Week 10	**Cybersecurity I** • High-profile historical breaches • Role of cyberattacks in grey warfare	web links	written assignment
Week 11	**Cybersecurity II** • Basic principles of device and network security • Emerging strategies	web links	written assignment
Week 12	**Hypersonics** • Types of hypersonic systems • Issues for security and defense	[12] web links	[12] written assignment
Week 13	**Remote sensing** • Basic principles of remote sensing • Applications of remote sensing	web links	written assignment
Week 14	**Geospatial intelligence** • Role of spatial data sets in situational awareness and threat assessment • Basic technologies for organization and display of spatial data	web links	written assignment
Week 15	**Ethics** • Theoretical frameworks for ethics in defense; “just war” theory • Historical examples: the atomic bomb, unmanned drone strikes, chemical/biological weapons	Web links	written assignment
FINAL	**Written final exam**		

Sample Readings and Assignments

A partial list of readings and assignments is provided here; a full list will be released to registered students. Note: All assignments should contain citations to your references at the botom. You should typically have between 5 and 10 references for each assignment. You are encouraged to use the assigned readings as references along with additional references you find through your research.

[1] Key technological issues in national security strategy

Readings:

- The White House, *Interim National Security Strategic Guidance*, March 2021. https://www.whitehouse.gov/wp-content/uploads/2021/03/NSC-1v2.pdf
- Daniel R. Coats, *Worldwide Threat Assessment of the US Intelligence Community*, January 2019. https://www.dni.gov/files/ODNI/documents/2019-ATA-SFR---SSCI.pdf
- NATO Defense College, "Russia's updated National Security Strategy," February 2021. https://www.ndc.nato.int/research/research.php?icode=704
- Xi Jinping, Full text of Xi Jinping's report at 19th CPC National Congress. November 2017. http://www.xinhuanet.com/english/special/2017-11/03/c_136725942.htm

Assignment:

Write a concise, 1-page report consisting of the following elements. Be prepared to discuss your findings in the next class.

- *Similarities in national security strategy* (1 paragraph): Select one non-US country to analyze. Begin with a 1-sentence statement of the most important similarities in national security strategy between the US and the selected country with respect to technology. Use the remainder of the paragraph to support your assertion with specific details. List all references as in-text citation numbers with references given at the bottom of the page.
- *Differences in national security strategy* (1 paragraph): for the same choice of non-US country, begin with a 1-sentence statement on the most important differences in national security strategy between the US and the selected country with respect to technology. Use the remainder of the paragraph to support your assertion, as above.
- *Technological analysis* (1 paragraph + figure, table, or graph): Choose one quantitative metric of interest to you, relevant to your precedeeding paragraphs, for analysis. Compare and contrast the two countries with respect to this metric. Incorporate a figure, table, or graph to supplement your written paragraph. (Examples: spending on technological R&D, number and composition of military forces, investment in a particular emerging area, etc.)

[2] Technology development paradigms

Readings:

- NASA, "Technology Readiness Level," https://www.nasa.gov/directorates/heo/scan/engineering/technology/technology_readiness_level
- NASA, "Technology Readiness Level Definitions," https://www.nasa.gov/directorates/heo/scan/engineering/technology/technology_readiness_level
- Congressional Research Structure, *Department of Defense Research, Development, Test, and Evaluation (RDT&E): Appropriations Structure*, https://sgp.fas.org/crs/natsec/R44711.pdf

Assignment:
Choose a hypothetical device, technology, or product that does not yet exist. Turn in a written report covering the following:

- *Describe the technology* (1 paragraph): What does it do, and what is it for?
- *TRL Chart:* Using the NASA TRL Definitions, imagine that you are a researcher / developer working on this technology. For each TRL level, write 1 task you might have to complete to successfully move to the next TRL level.

[3] Export Controls and Restrictions

Readings:

- U.S. Department of State International Traffic in Arms Regulations (ITAR) https://www.pmddtc.state.gov/?id=ddtc_kb_article_page&sys_id=%2024d528fddbfc930044f9ff621f961987
- U.S. Department of Commerce, Bureau of Industry and Security, *Commerce Control List* https://www.bis.doc.gov/index.php/regulations/commerce-control-list-ccl
- Export Solutions, "ITAR vs. EAR: What's the Difference?" https://www.exportsolutionsinc.com/resources/blog/itar-vs-ear-difference/
- Export Compliance Training Institute, "The Export Compliance Basics of ITAR and EAR – Understanding Key Terms, Issues, Similarities, and Differences," https://www.learnexportcompliance.com/the-export-compliance-basics-of-itar-and-ear-understanding-key-terms-issues-similarities-and-differences/
- Beth Daley, "What is classified information, and who gets to decide?," The Conversation, https://theconversation.com/what-is-classified-information-and-who-gets-to-decide-77832

Assignment:
Choose an actual or potential commercial product related to your technical interests / graduate study. Write 3 paragraphs with references:

- *Describe the product* (1 paragraph). What is it and what does it do?
- *Does it fall under the ITAR regulations?* Find the relevant section of the ITAR regulations and read it. Make your best determination as to why or why not ITAR regulations will apply.
- *Does it fall under the EAR regulations?* Find the relevant section of the EAR regulations and make your best determination.

[4] The Science and Technology R&D Ecosystem

Readings:

- PJ Bentley et al, "The relationship between basic and applied research in universities," Higher Education 70: 689-709 (2015). https://link.springer.com/article/10.1007/s10734-015-9861-2
- NSF, Master Government List of Federally Funded R&D Centers, https://www.nsf.gov/statistics/ffrdclist/
- Congressional Research Service, Federally Funded Research and Development Centers (FFRDCs): Background and Issues for Congress, April 2020, https://crsreports.congress.gov/product/pdf/R/R44629/6
- "What is SBIR?" https://www.sbir.gov

Assignment:
Find a news release on a scientific or technological advance that interests you. Read both the news release and the corresponding journal article. Your written assignment should contain the following:

- *Describe the work* (1 paragraph): What was achieved? Who did it (what types of entities?) Why is it important? What can it be used for?
- *Assign a TRL to the work* (1 paragraph): Identify the TRL and explain your reasoning.
- *Describe a potential development pathway (1 paragraph):* for this work to become a commercial product, describe a possible development pathway. What types of further work are required, and what entities might carry them out (give specific examples).

[5] Artificial intelligence and machine learning I

Readings:

- Ayush Pant, "Introduction to Machine Learning for Beginners," towards data science, Jan. 2019. https://towardsdatascience.com/introduction-to-machine-learning-for-beginners-eed6024fdb08
- A. Smola and S.V.N. Vishwanathan, An Introduction to Machine Learning, Cambridge University Press 2008, Chapter 1. https://alex.smola.org/drafts/thebook.pdf

Assignment:

Choose an example of machine learning or AI from real life.

- *Describe* (1 paragraph): describe the application area and how machine learning / AI is used in this application.
- *Algorithm* (1 paragraph): Based on the readings, identify the type of machine learning and algorithm that are likely being used. Explain your reasoning.

[6] Artificial intelligence and machine learning II

Readings:

- Congressional Research Service, Artificial Intelligence and National Security, Nov. 2020. https://sgp.fas.org/crs/natsec/R45178.pdf

Assignment:

Based on your reading of the above reference and your own research, write your analysis of:

- *Threats* (1 paragraph): what is the biggest threats posed by AI/machine learning to national security?
- *Comparative analysis (1 paragraph + charts / figures):* Pick 2 countries to compare and contrast. Choose at least 3 quantitative metrics to compare, related to AI and machine learning. Make a chart comparing the two countries' performance on these metrics. Write a 1-paragraph description comparing and contrasting the two countries chosen.

[12] Hypersonics

Readings:

- R. Jeffrey Smith, "Hypersonic Missiles are Unstoppable. And They're Starting a Global Arms Race," The New York Times Magazine, June 2019. https://www.nytimes.com/2019/06/19/magazine/hypersonic-missiles.html

- Stephen Chen, "What are hypersonic weapons, and why is there a race between China, the US, and others to develop them?" Jan. 2022. https://www.scmp.com/news/china/science/article/3164444/what-are-hypersonic-weapons-and-why-there-race-between-china-us

Assignment:

Write 1 page or less:

- *Challenge* (1 paragraph): Based on the readings, what is the main challenge that hypersonic weapons pose to global security, and why?
- *Risk mitigation* (1 paragraph): Choose a country and imagine you were the head of defense strategy for that country. What possible solutions / strategies would you investigate to counter the threat posed by these weapons systems?

Statement on Academic Conduct and Support Systems

Academic Integrity:
The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the student handbook or the Office of Academic Integrity's website, and university policies on Research and Scholarship Misconduct.

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

988 Suicide and Crisis Lifeline - 988 for both calls and text messages – 24/7 on call
The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services

(though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL) – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

Office for Equity, Equal Opportunity, and Title IX (EEO-TIX) - (213) 740-5086
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

The Office of Student Accessibility Services (OSAS) - (213) 740-0776
OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

USC Campus Support and Intervention - (213) 740-0411
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity, Equity and Inclusion - (213) 740-2101
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call
Non-emergency assistance or information.

Office of the Ombuds - (213) 821-9556 (UPC) / (323-442-0382 (HSC)
A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

Occupational Therapy Faculty Practice - (323) 442-2850 or otfp@med.usc.edu
Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.