

A Summary of SAE 550:

Systems Architecting and the Political Process



**University of Southern California
Viterbi School of Engineering
Systems Architecture & Engineering (SAE)**



**Mr. Ken Cureton & Dr. Edwin Ordoukhanian
August 2025**

SAE-550-Summary.pptx



- Instructor of many Systems Architecting & Engineering (SAE) classes since Fall of 1996
- Senior Systems Engineer (Retired) for The Boeing Company Huntington Beach CA-- Boeing Defense, Space, & Security: Phantom Works
 - Manned Space, Launch Systems, Satellite Systems, Networked Systems, Cyber Security, and Defense Conversion
- Was employed as a Computer Hardware/Software and Systems Engineer for 46 years: Government, Small Business, & Aerospace Sectors
- Professional Societies (Senior Member): AIAA, INCOSE, IEEE
 - IEEE SMC former co-chair MBSE Working Group
 - INCOSE Resilient Systems Working Group (RSWG) chair
 - AIAA Space Settlement Technical Committee Member
 - Network-Centric Operations Industry Consortium (NCOIC) Technical Council Chair Emeritus
- Formal Education:
 - BS in High-Energy & Nuclear Physics
 - MS in Systems Architecting & Engineering



- Experience:
 - Systems Engineer at Crane Aerospace and Electronics (MBSE, Brake Control System Development, Modeling and Simulation)
 - Former Teaching Assistant at USC (SAE 549, SAE 541, SAE 548, SAE 550, SAE 551, SAE 560)
 - Former Research Assistant at USC (Self-Driving Cars, UAV Swarms)
- Education:
 - Ph.D., Astronautical Engineering, USC
Specializing in Systems Architecting and Engineering
 - M.S. Aerospace Engineering, USC
 - B.Eng., Automation and Control, National Polytechnic University of Armenia
- Societies
 - INCOSE and INCOSE TLI, AIAA, IEEE
- Research Interest:
 - MBSE, Autonomous Systems and SoS, Engineered Resilient Systems, Complex Engineered Systems, Human-System Integration

SAE 550 Objective

❑ Part of Systems Architecting & Engineering (SAE) Series

- **Objective:**

Analysis of risks inherent in managing high-tech/high-cost government-funded or corporate-funded engineering programs; tools and techniques for coping with the impacts of politically-driven budgets on the engineering design process.

- **Elective Course in University of Southern California's Masters Program in Systems Architecting & Engineering**

- **Class originated by Dr. Brenda Forman in the early 1990s**
- **Class restarted in the Fall of 1996 to Fall 2014 by Ken Cureton, then Dr. Elliot Axelband for 2015-2016, Ken Cureton resuming in Spring of 2017**

- **About 1,000 Students have completed the class**

- **Student Demographics:**

- **About 1/2 are employed by aerospace/defense companies**
- **About 1 out of 20 are Air Force, Space Force, Navy, or Army officers**
- **Remainder are foreign students or those with more of a commercial background**

SAE 550 Value to Students

☐ **Not a Political Science Course!**

- **Provides Political Risk Analysis and Mitigation Techniques**
 - **Supplements Classic Cost, Schedule, Performance & Programmatic Risk Management Systems Engineering Techniques**
- **Demonstrates the need for Organizational Resilience**

☐ **Unique Class Emphasis: Impact on Systems Architecture**

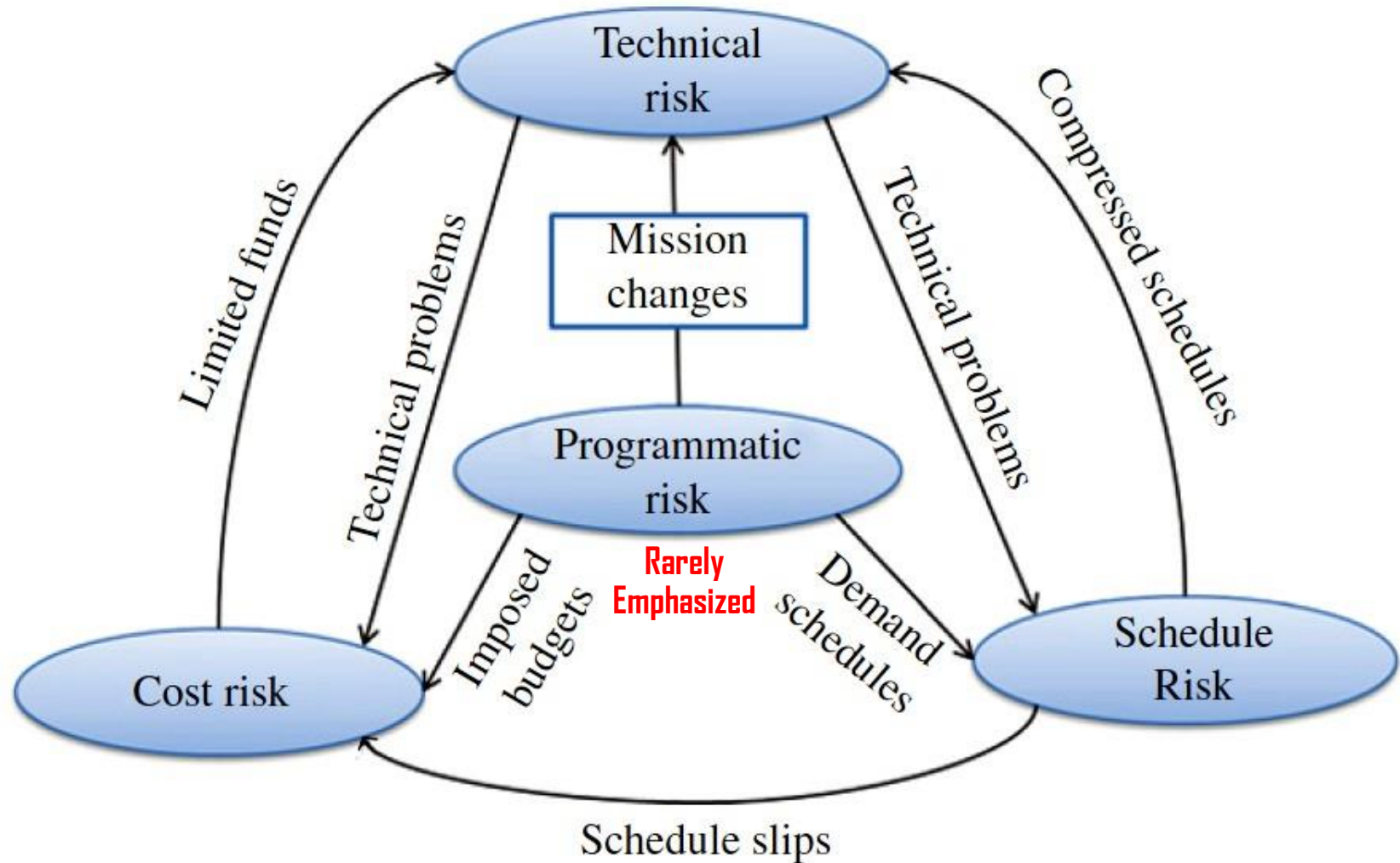
- **Other Courses Focus on Political Impact on Technologies**

☐ **On Completion of the Course, Students:**

- **Grasp the Real-World Processes for Project Approvals, Funding, Budget Scheduling, and Regulatory Control**
- **Understand the Necessity for Strong, Coherent Constituency and “Keeping the Program Sold”**
- **Demonstrate Agility in Political Reasoning (Negotiation, Compromise & Appearance) to Supplement Engineering Logic**

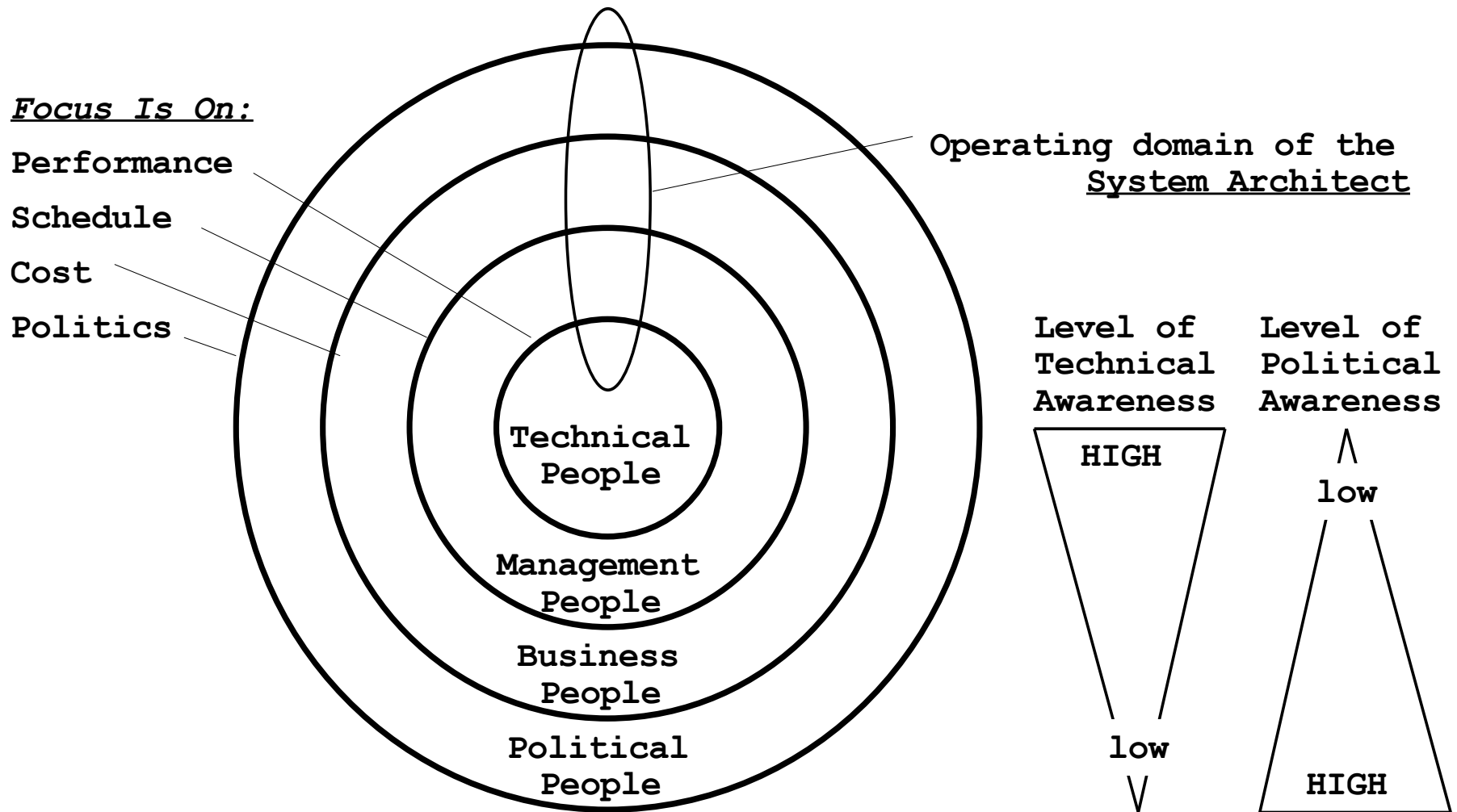
☐ **Typical Student Feedback: *“I am now far more effective in project management and real-world systems architecting!”***

Emphasizes *Programmatic* Risk Management



Source: INCOSE Systems Engineering Handbook, v4, INCOSE-TP-2003-002-04 2015

Visualization of the Socio-Political Situation



Source: K. Cureton "Assured Crew Return Vehicle" Case Study, USC SAE 599, Fall 1993

SAE 550 Class Format

- ❑ Semester Class, 15 Weeks, One night/week**
 - Weekly Lectures, 2 hours 40 minutes each**
 - 1 Final Exam week (scheduled but not used)**
- ❑ Distance Learning Format via Distance Education Network (DEN)**
 - Typically only a few students in the TV Studio, majority of students are scattered across the US**
 - Class content webcasted for online/offline viewing**
 - Class presentations hosted on DEN System for student preview**
 - Class content in weekly reading materials (including 9 Case Studies), hosted on DEN Software**
 - DEN System provides for Chat or Voice Interaction online, Discussion Boards offline**
 - Simultaneous Webex for real-time interaction**

SAE 550 Class Grading

- ❑ **One Research Paper required of each student**
 - **In place of a Final Exam, 50% of class grade**
 - **Papers are typically 20 single-spaced pages, suitably formatted for publication in a technical journal**
 - **Student materials on “How to Write a Research Paper”**
 - **Students choose research topic**
 - **Submit abstract for approval by Instructor**
- ❑ **9 Case Studies in lectures, 5 other Case Studies for Homework**
 - **Homework analysis is 25% of class grade**
- ❑ **One Take-Home Midterm Exam, 25% of class grade**
- ❑ **Structured analysis required for paper, midterm, homework**
 - **Specific analyses required in each case to demonstrate student’s ability to apply the class fundamentals:
Political Risk Mitigation Factors**
 - **Also known as the Political “Facts Of Life” or FOLs**

SAE 550 “Political Facts of Life”

(Heuristics as envisioned by Dr. Brenda Forman)

1. Politics, Not Technology, Controls What Technology Is Allowed To Achieve

- **Budget Limitations (Amount of Money, Color-Of-Money)**
- **Regulatory Constraints (Export/ITAR, “Fencing”, Laws)**
- **Schedule Deadlines (Not enough time to do it “Right”)**

2. Cost Rules

- **Usually have to Overstate the Benefits and Understate the Costs just to get a Program Started**
- **Program Funding has to be Re-Won each Year**
- **Government Rarely Provides an Optimal Funding Profile (prefers reduced & level-loaded funding over a longer time)**

3. A Strong, Coherent Constituency Is Essential

- **Every Successful Program Must Serve Multiple Agendas**
- **Government Loves to Dictate Multiple-Mission Systems**

Source: Maier, M. W., & Rechtin, E. (2002). The Art of Systems Architecting (2nd ed.). Boca Raton, FL: CRC Press. ISBN: 0-8493-0440-7
Chapter 12 (contributed by Dr. Brenda Forman)

SAE 550 “Political Facts of Life”

(Heuristics as envisioned by Dr. Brenda Forman)

4. Technical Problems Become Political Problems

- **All Big-Budget High-Tech Government-Funded (or Corporate-Funded) Programs Operate in a Political Fishbowl**
 - **Ever-present Foes Looking For Excuses To Seize Funding**
 - **Valid Scientific Reports Will Be Misused for Political Purposes**

5. The Best Engineering Solutions Are Not Necessarily The Best Political Solutions

- **For Technical People: the Illogic of Negotiation, Compromise and Appearance in Politics**
 - **Programs That Create Jobs Are More Likely To Be Funded Than Programs With Theoretical Goals (Like Basic Research)**
- **For Political People: the Naiveté of Scientific Reasoning and Logical Choices in Engineering and Science**
 - **Most Politicians Have neither the Technical Background nor the Time to Understand Technical Implications of Their Choices**

Source: Maier, M. W., & Rechtin, E. (2002). The Art of Systems Architecting (2nd ed.). Boca Raton, FL: CRC Press. ISBN: 0-8493-0440-7
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SAE 550 Other “Political Facts of Life”

- 6. Timing Is Everything**
- 7. Political Problems Become Technical Problems (or Opportunities)**
- 8. Politics Prefers Immediate, Near-Term Gratification**
 - **Political Process Constantly Striving to Satisfy Immediate, Urgent Needs With Insufficient Resources (Money, Time) (*This Year* is More Important Than Out-Years)**
 - **Election “Event Horizon” Also Encourages Near-Term Focus (in USA: 2 Years for House, 4 Years for President, 6 Years for Senate)**
- 9. Politics Believes In Gurus And Heroes**
 - **And Once Tarnished, Forever Untrustworthy (Stink Sticks)**
- 10. A Catchy Slogan Is Essential To Getting Attention**
- 11. Perception Is Often More Important Than The Truth**
- 12. Staffers Shape Decision-Making**
- 13. Mental Bias Due To Risk Denial**

SAE 550 Introductory Lecture #1

❑ Syllabus

- Homework Assignments
- Research Paper

❑ Definitions

- “The Political System”
- Coping Skills for the Modern Design Engineer
- Role of the System Architect in the Political Process

❑ Introduction to the Political Facts Of Life

- Parallels in Our Personal Lives
- Show Intimate Relationship Between Engineering Design Process And Pressures Of Political Process
- Help Students To Understand That Political Process
 - To Give Confidence & Effectiveness In Future
- Emphasis on Engineering and not on Political Science!

SAE 550 Lecture #2: Budget Processes

❑ Description of the U.S. Federal Budget Process

- **Brief Overview of PPBE Process (including POM & FYDP)**
- **President's Budget Request**
- **Generation of the Congressional Budget Bills**
- **Signing Into Law by President (or Threats of Veto)**
- **Continuing Resolutions, Rescissions, Plus-Ups, Earmarks**
- **PAYGO, Nunn-McCurdy Act, Clinger-Cohen Act**
- **Mandatory (Entitlements) vs. Discretionary Funding**
- **Efforts to Balance the Federal Budget**
- **Deficit Spending, Line-Item Veto, "Pork Barrel" Politics, Acquisition Reform, Budgetary Reform, Interest on the National Debt**

❑ Investigation of Difficulty in Reducing Governmental Budgets and Complexity

SAE 550 Lecture #3: FOL Characteristics and Defense

- ❑ In-Depth Characteristics of the Political Facts Of Life (FOL)**
 - Analyzes WHY things happen according to the Political FOLs**
 - Identify root causes and potential impacts on programs**
 - Discuss “lessons learned” and potential defenses**
- ❑ The Need for Political Risk Mitigation**
 - Coping Skills and Defensive Engineering
(Similar to Need for Performance/Cost/Schedule Risk Mitigation)**

SAE 550 Lecture #4: Case Study #1

❑ Launch Systems:

- The Original Space Shuttle vs. Eventual Space Shuttle
- Impact on Expendable Launch Vehicles (e.g. CELV)
- Contrast of American vs. Russian Approaches

❑ Space Transportation Infrastructure Constituency

- The Space Race: Sputnik - Apollo, recent resurgence
 - A View Into the Future: China, Japan, India, Europe, etc.
- Intro to Struggle Between NASA and the DoD for Control of Space Funding
 - The Great Bureaucratic Space War
- Impact of Challenger & Columbia Disasters
 - Augustine Committee, Rogers Report

❑ Investigation of Difficulty in Funding Big-Budget, Long-Term, High-Tech Space Infrastructure Programs

- Hard to Predict Specific Practical Applications

SAE 550 Lecture #5: Case Study #2

❑ The V-22 Tiltrotor “Osprey”

- **Example of the Development of a Mission System**
 - **Caught in Cross-Fire of Politics! (Congress vs. White House)**
 - **Political Impact of Technical Problems**
- **Fixed-Wing vs. Helicopter: Which Is It? Both? Neither?**
 - **The Technical Challenges of a Convertiplane**
 - **The Challenge of FAA Certification for Civil Uses**

❑ Department of Defense Constituency

- **Intro to Funding War Between the Forces: Air Force vs. Army vs. Navy (and Plight of Marine Corps Funding)**
- **Multi-Role, Multi-Service, Multi-Mission Systems**
 - **Political Pressures to Develop; Resistance from the Forces**

❑ Investigation of Difficulty in Funding Big-Budget, Long-Term, High-Tech Mission Systems Development & Construction

SAE 550 Lecture #6: Case Study #3

❑ Joint Strike Fighter / F-35

- Continues to investigate how Political Processes apply to Global, Multiple Use / Multiple Country Systems
- Examines the difficulty in replacing aging but very popular and still-functional Legacy systems
 - Choose between develop individual replacement systems, or designing a high-commonality platform that can be tailored to meet specific needs?
- Demonstrates program survival when experiencing technological, programmatic, and political challenges
 - Program faced multiple cost overruns, technical challenges, and project cancellation hurdles during development

❑ Emphasizes the Critical Role of Constituency:

- Program emphasized affordability but it turned out to be extremely costly– a challenge to constituency budgets!
 - Building every new fighter costs *much* more than its predecessors
- JSF program played a key role in bringing *Jobs* to countries participating in the development process

SAE 550 Lecture #7: Case Study #4

- ❑ **Ground Transportation Infrastructure
(Roads, Autos, Trucks, Trains, etc.)**
 - **How Political Processes influence funding and approval of Public Infrastructures**
 - **Using the U.S. Ground Transportation Infrastructure as an example by examining the Historical Perspective of:**
 - The Erie Canal Inland Waterways
 - The Transcontinental Railroad
 - U.S. Interstate Highway System
- ❑ **Such Infrastructure Systems Suffer A Common Set Of Problems:**
 - **Require significant up-front investment & yield uncertain payback on that investment in the far future**
 - **The Key Any New Infrastructure is CONSTITUENCY**
 - **Everybody evaluates what the Political Process calls WIIFM:
*What's In It For Me***
- ❑ **Investigation of Difficulty in Obtaining Funding and Approval for the Creation, Maintenance, and Upgrades of Infrastructures**

SAE 550 Lecture #8: Systems Engineering Concepts and Programmatic Risk Management

❑ Review of:

- **Systems Engineering and Architecting Fundamentals**
- **Risk Management**
- **Technical Leadership**

❑ Applied to SAE 550 Class Content:

- **Systems Architecting and Engineering Activities**
- **Systems Architecting Principles**
- **Constraints Impact on System Architecture**
- **Real Options in Systems Architecting**
- **Trade-off Analysis & Steps**
- **Risk and Risk Types, Identification, Management, Mitigation**
- **Modeling Risks and Dealing with Uncertainties**
- **Technical Leadership and Styles**
- **Cognitive Biases & Mitigation Strategies**

SAE 550 Lecture #9: Case Study #5

- ❑ **Superconducting Supercollider (basic research)**
 - **Examines how Political Processes apply to *Basic Research Systems***
- ❑ **Covers a Basic Research System that is:**
 - **Supposedly a Development Project**
 - **Intended for eventual Operation & Use**
 - **An example of *critical* need to develop & nurture Constituency**
 - ***Extremely* difficult to explain the Practical applications to the Political System**
 - **How does one guarantee the Political Benefits of such a project, when (by definition) one doesn't know for sure what the Technical Benefits might be?**
 - **There might not be any Technical Benefits, other than lessons-learned from failed experimentation!**

SAE 550 Lecture #10: Case Study #6

❑ Precision Navigation Systems

(GPS, GLONASS, Galileo, BeiDou, IRNSS, QZSS)

- Examines how Political Processes apply to Global, Multiple Use Systems (Both Military and Civilian, and of Multiple Countries!)
- Focuses on how the FOLs apply to Services (and not just to their Systems)
- Investigates if the 5 Primary Political FOLs always apply, or are there Counter-Examples
- Demonstrates how to discuss technical aspects of a Case Study

❑ Covers Global Services that are:

- ***Extremely*** difficult to explain the potential applications to the Political System before first available for Use
 - How does one guarantee the Political Benefits of such a project, when one doesn't know for sure what *all* potential uses might be?
 - Many Global Services (e.g. Telecommunications) typically cause disruption of (and eventual replacement of) Legacy Systems and ***radically*** change Operations and Use via new/improved capabilities

SAE 550 New Case Studies & Homework Case Studies

❑ Lecture #11: New Case Study #7: California High-Speed Rail

- **Content still in development**

❑ Lecture #12: New Case Study #8: Hoover Dam

- **Content still in development**

❑ Lecture #13: New Case Study #9: Future Combat System (FCS)

- **Content still in development**

❑ Homework Case Studies

(from lectures used in previous semesters)

- **HW1: Superconducting Materials & Application**
- **HW2: Space Station Freedom (SSF)**
- **HW3: Assured Crew Return Vehicle (ACRV)**
- **HW4: Federal Fire-Fighting Process**
- **HW5: National AeroSpace Plane**

SAE 550 Summary

- ❑ **Students Exposed to a Broad Range of Political Impacts on Actual Case Study System Architecture and Design**
 - **Research, Design & Development of Mission Systems**
 - **Operation & Use of Mission Systems**
 - **Mission Processes: Operations, Logistics, Sustainment**
 - **Infrastructure Systems**
 - **Non-US Systems**
- ❑ **Students Required to Demonstrate (for their chosen topic and for 5 Homework Case Studies):**
 - **Political Impacts on System Architecture and Design**
- ❑ **Emphasis: Training Systems Architects & Systems Engineers in the Understanding and Application of Political Risk Mitigation Factors**
 - **Dr. Brenda Forman's "Political Facts Of Life"**