Passive Network Synthesis:
Camelot in our Grasp

Prepared by

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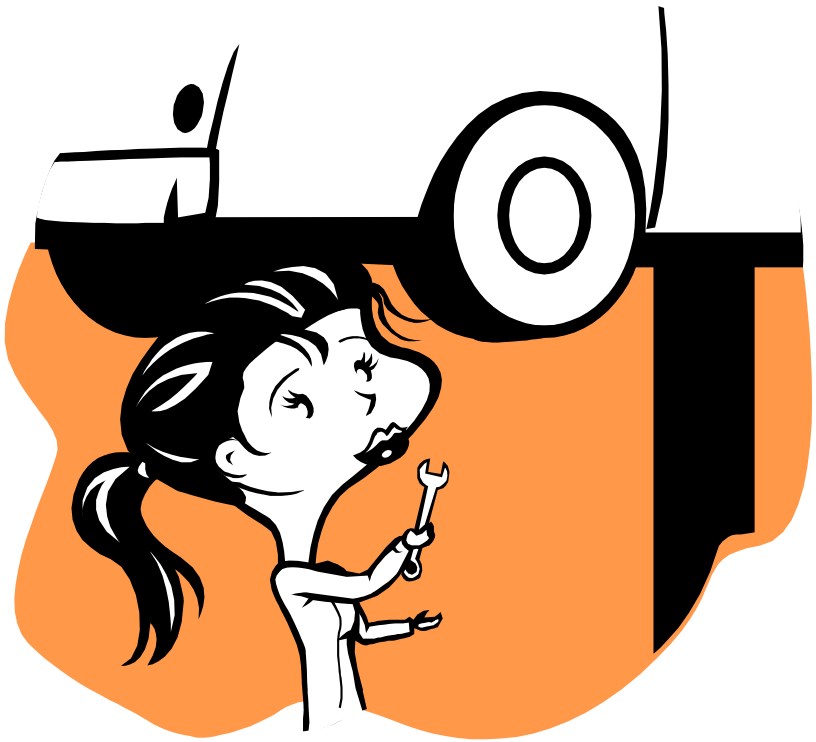


King of the Engineering Art:

the What?

- The Art of the Artificial!! What about Natural Philosophy?
- Synthesis!! What about Analysis?
- Prognostic!! What about Diagnostic?

Oh! Like in **Passive Network Synthesis**

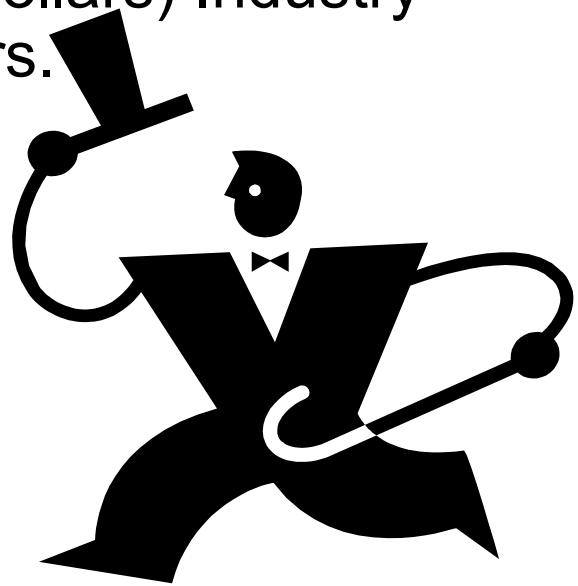
Design: Dummy

Passive Network Synthesis

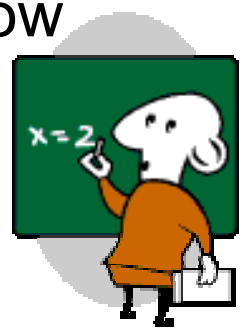
Aha! To Algorithmatize the Design Process! The Epitome of the Engineering Art!!
Off with Your head.

What We Did!

- **1910s and 20s**
  - Developed Explicit Algorithms for Designing Passive LC Filters.
  - Established a Billion Dollar (in 1930s Dollars) Industry Designing Passive LC Telephone Filters.
  - Made Modern Telefony Possible!



- **1930s**
  - Passive Network Synthesis
  - Academic but it Taught us how to Handle Resistive Loads.



What Else We Did – Not Much

- **1940s**
  - Developed Explicit Algorithms for Designing Passive n-Ports
  - Done Independently in 4 Countries During WWII
  - **Absolutely Beautiful – Totally Worthless**

- **1950s – The Golden Age of Circuit Theory**
  - Didn't do Anything Much, unless you count the **Resistive n-port Problem – The Worlds Greatest Career Destroyer**

- **1960s - Goodbye**

What Happened?

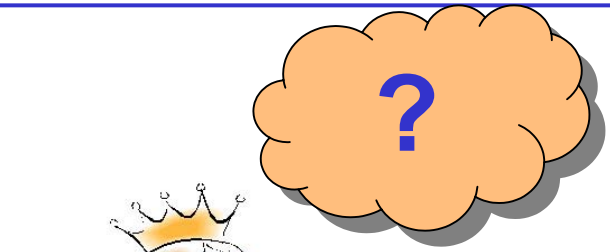
- **Cheap Transistors: When the price of a CK722 went from $99 to 99¢ in 6 Months**
  - The Passivity Constraint Disappeared, and since ***Design with Constraints is What Engineering is All About***, the **Fun Disappeared Too!**
  - Of Course, We hadn't Discovered **Sensitivity and Noise Floors** Yet!
  - Since Our Company is at **WAR with Raytheon**, I Shouldn't Admit that, as a High School Hobbyist, I Bought my First CK722 at **Allied Radio** when it Passed the **$25** Threshold.

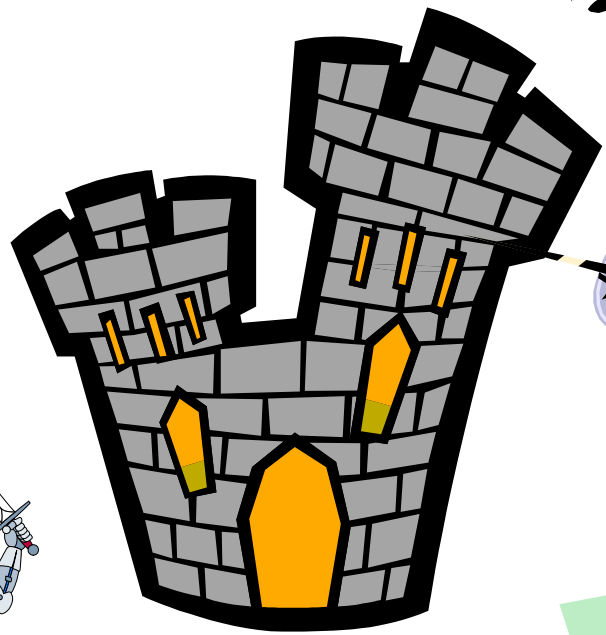
What Else Happened?

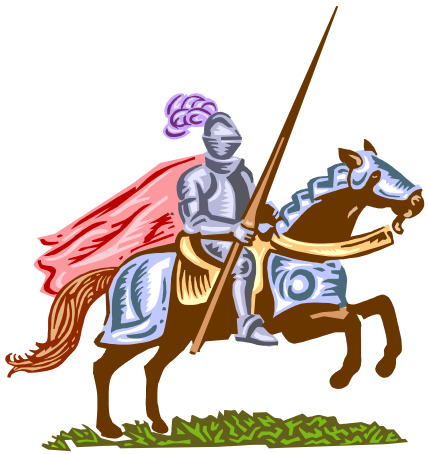
- **Expensive Computers**: When the Mainframe Replaced a Roomful of Graduate Students with Mechanical Calculators **Engineering Art** was Replaced by Brute Force.

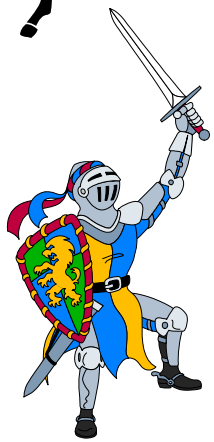
- **Passive Network Synthesis: RIP**

What's This Have to do with Camelot?









Diaspora

And What Do You Think You Guys are Going to Do Out There?

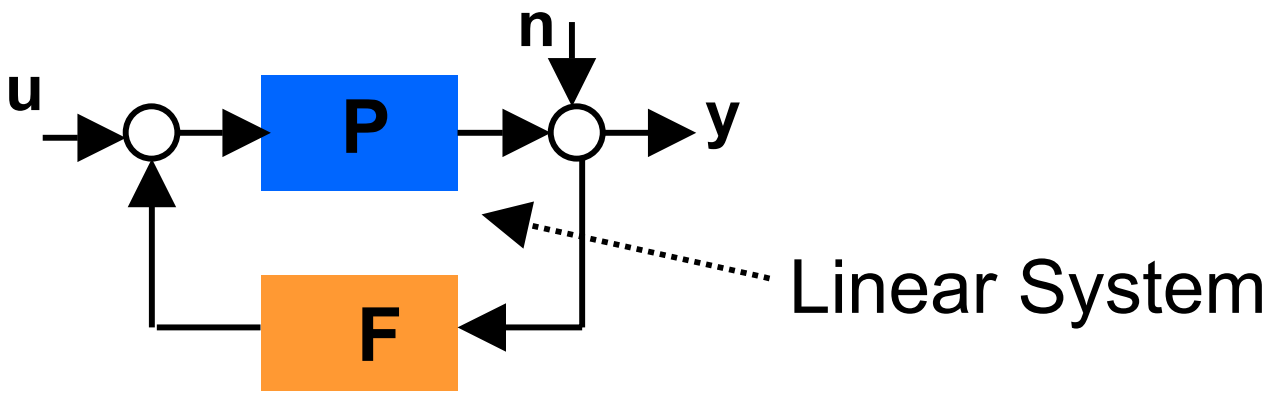
H_∞ Control

Adaptive Control

Active Synthesis?

Youla Parameterization

Youla Parameterization

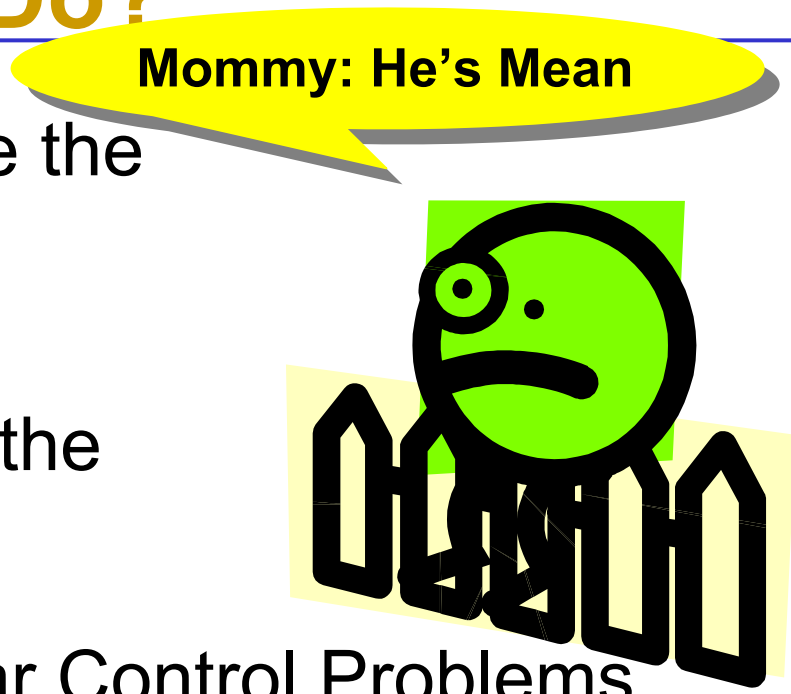


- Let $\mathbf{P = ND^{-1}}$, where **N** and **D** are Stable and Coprime, i.e., there exist Stable **U** and **V** such that; $\mathbf{UN + VD = 1}$.
- Then the set of all possible Stabilizing Feedback Gains may be Parameterized by

$$\mathbf{F = [DW+U][NW+V]^{-1}}$$

where **W** is Stable

What Did Dan Do?



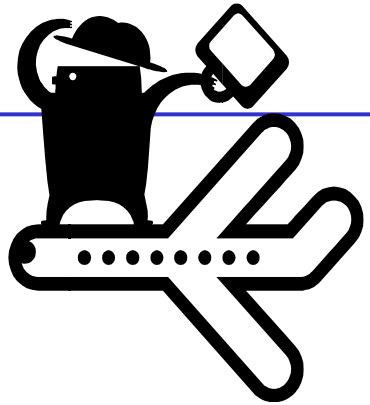
- **NO**, He didn't Algorithmatize the Solution of All Linear Control Problems
- **BUT**, He Did Parameterize the Constraint Set
- The Solution of "Most" Linear Control Problems Follows From the Youla Parameterization.
  - H_2 and H_∞ Optimal Control,
  - Tracking and Disturbance Rejection
  - Pole and Zero Placement
  - Robust Control and Simultaneous Design

Why not Learn the Design?

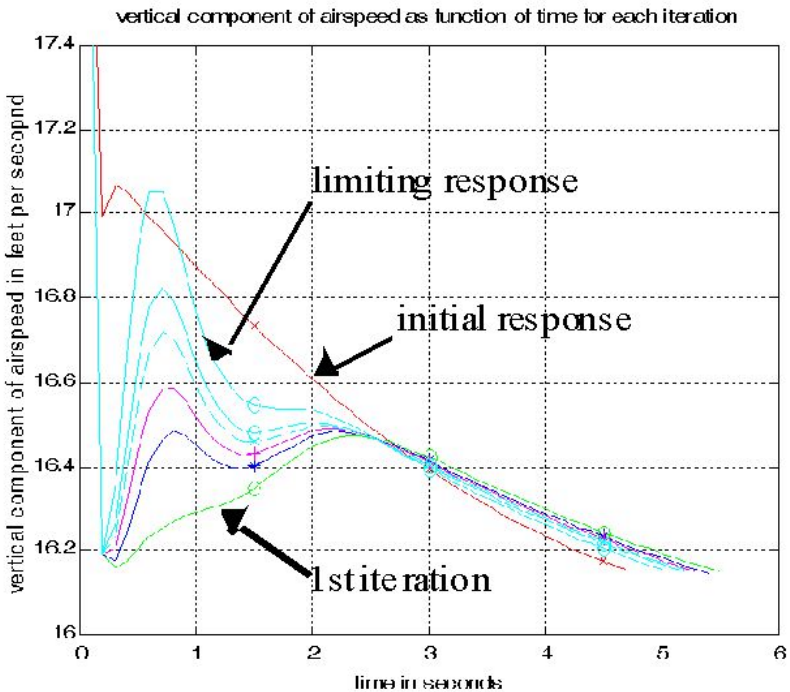
- Just Design a **Generic Control Architecture** or Two and let it **Learn the Design in Real Time**
- The Trick is to use **Measurements of the Actual System** in Operation Instead of a Model of the System
- This Algorithmatizes the Design Process and Yields an **Adaptive Controller** which Compensates for
  - **System Failures** and **Environmental Changes**

Two Adaptive Control Algorithms

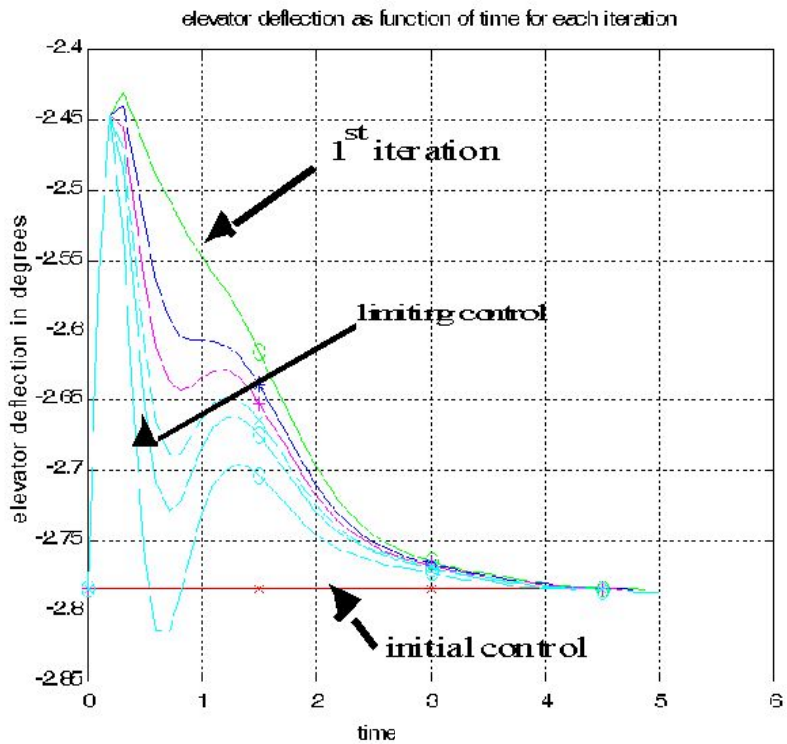
- **Neural Adaptive (Tracking) Controller**
- **Adaptive Dynamic Programming (Optimal) Controller**
- **Both Algorithms are:**
  - **Nonlinear**
  - **MIMO**
  - **Require "Minimal" *a priori* Knowledge About Plant#**
  - **Characterized by a Full Stability Theory**



LoFLYTE® Adaptive Dynamic Programming

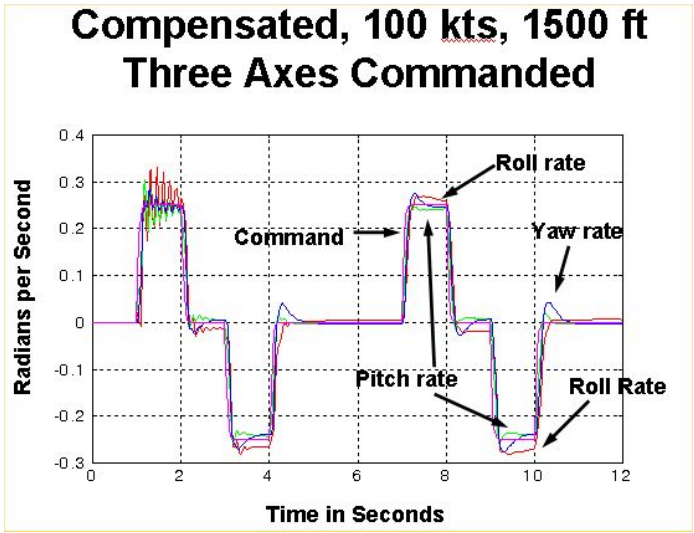


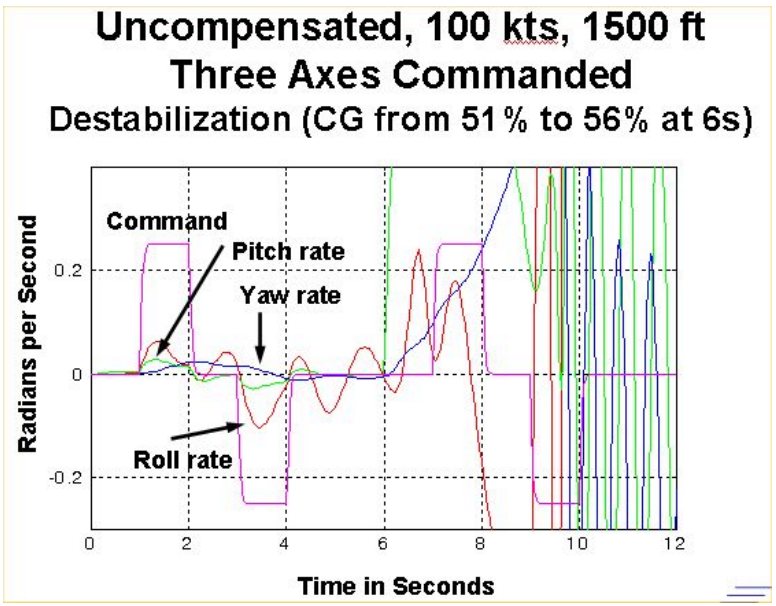
Vertical Component

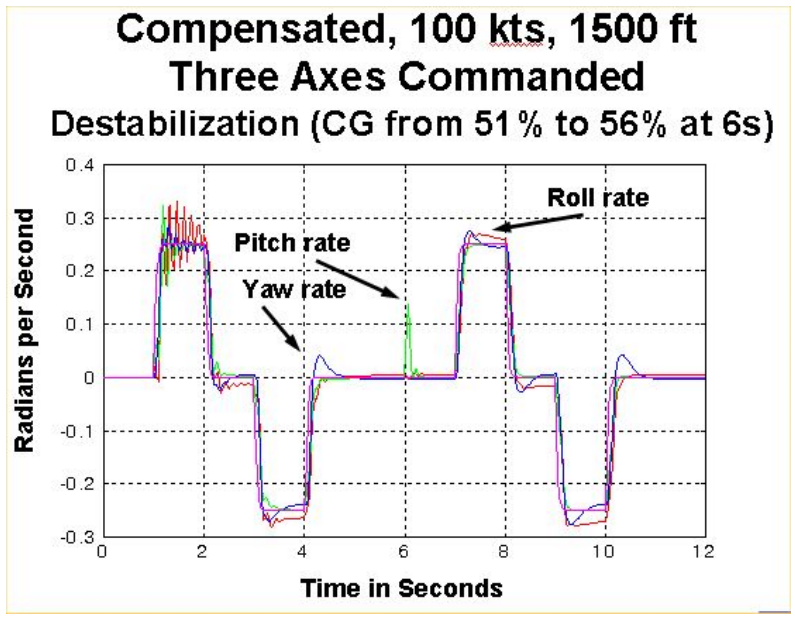


Elevator Deflection

LoFLYTE® Neural Adaptive Control



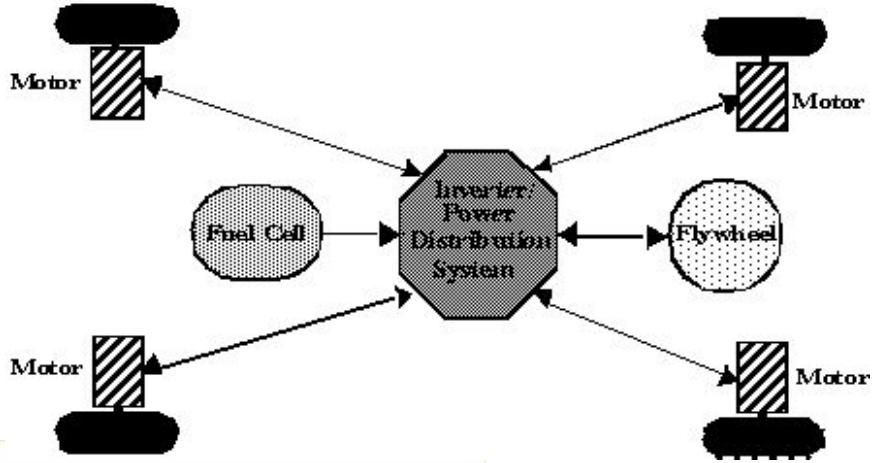


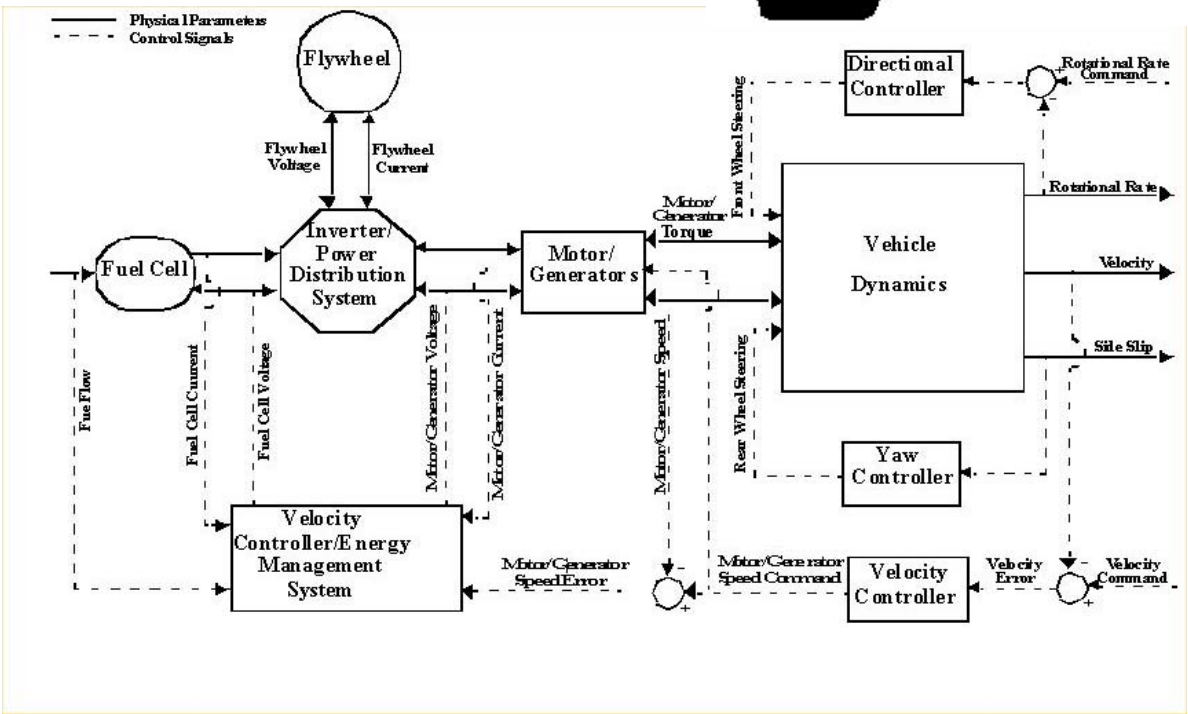


The Real Thing!!

LoFLYTE® at Edwards AFB

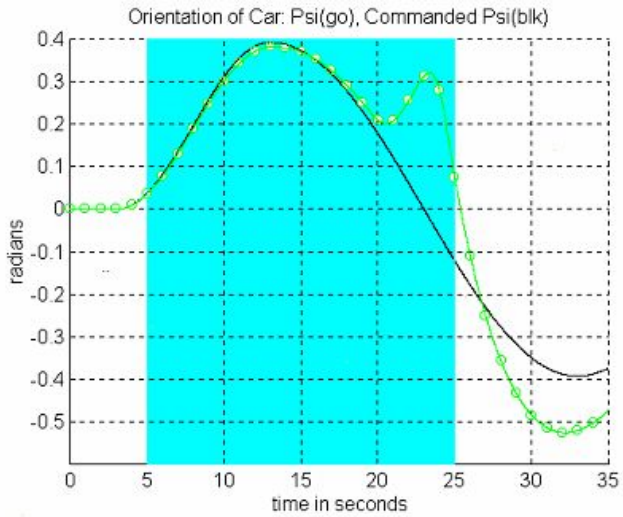
Electric Vehicle Control

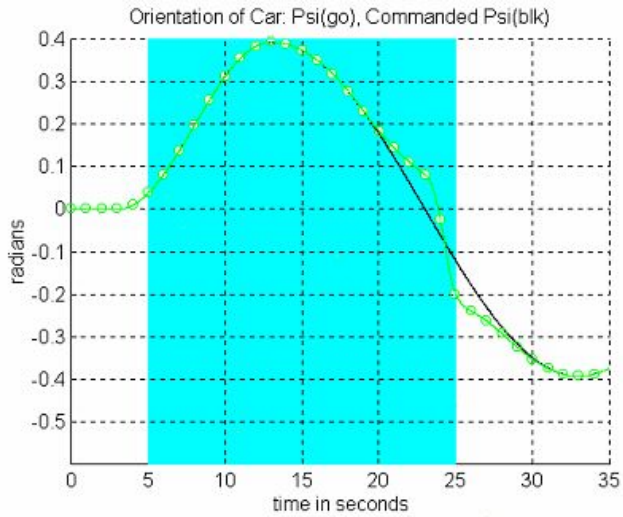




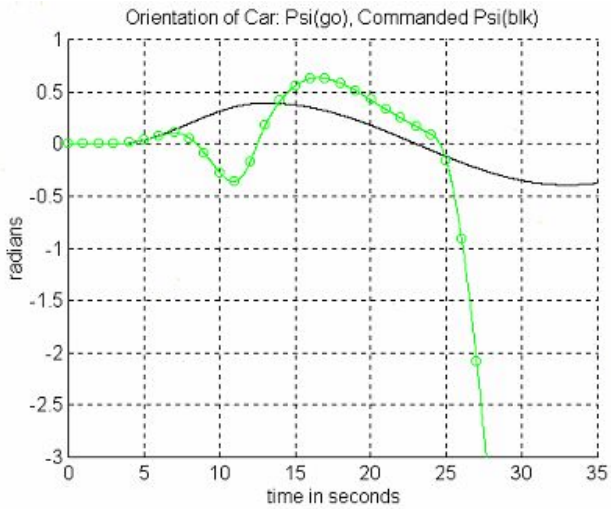
HEV Performance

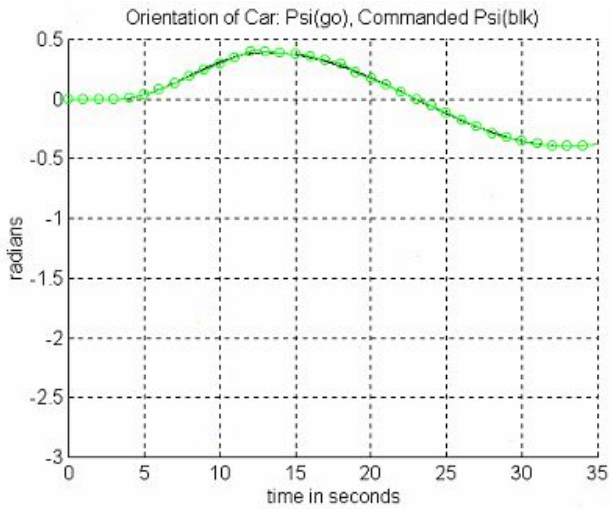
Lightly Loaded HEV On Icy Patch



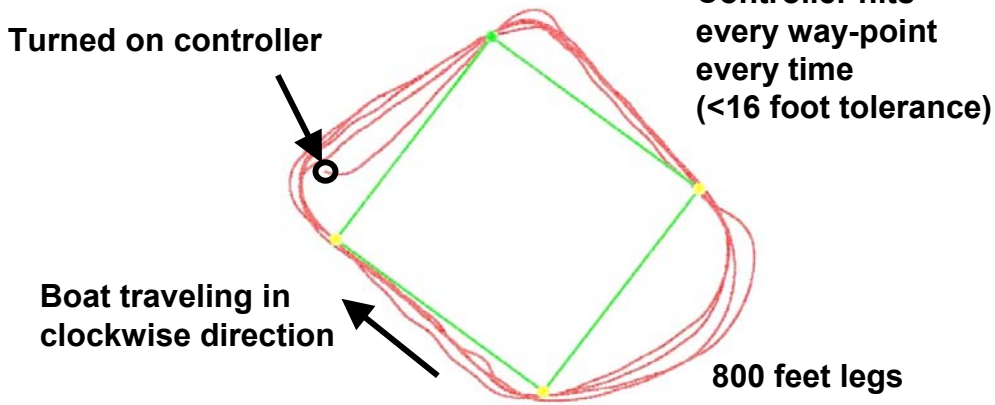


Heavily Loaded HEV On Dry Road





Unmanned Surface Vessel



Why Not Launch a UAV from a USV?

Off with His Head!!