Systems Engineering Requires a Paradigm Shift

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SYSTEMS ENGINEERING

A peep into history
The whole is more than the sum of its parts

Aristotle – Metaphysica 330 BC
PONT DU GARD IN FRANCE (19 BC)
THE TERM SYSTEMS ENGINEERING CAN BE TRACED TO BELL TELEPHONE LABORATORIES

“today's systems may embed themselves in history” - Ludwig von Bertalanffy

▸ First attempt to teach systems engineering as we know it today came in 1950 at MIT by Mr. Gilman, Director of Systems Engineering at Bell.

Ludwig von Bertalanffy

GENERAL SYSTEM THEORY

Revised Edition

[Image of a book cover]
SAGE - Semi Automatic Ground Environment air-defense system was defined and managed by MIT (1951 –1980)
The earlier Northrop XB-35 of the 1940s had mechanical controls. The B-2 of today has fly-by-wire controls a combination of mechanical electronics and software.
FAILURES HAVE HAPPENED

Systems Engineering has failed us for some time now
AS THE SYSTEMS HAVE BECOME COMPLICATED, ACCIDENTS HAVE INCREASED.

The first error in 1962
US aviation authority: Boeing 787 bug could cause 'loss of control'

More trouble for Dreamliner as Federal Aviation Administration warns glitch in control unit causes generators to shut down if left powered on for 248 days.

SUMMARY: We are adopting a new airworthiness directive (AD) for all Boeing Company Model 787 airplanes. This AD requires a repetitive maintenance task for electrical power deactivation on Model 787 airplanes. This AD was prompted by the determination that a Model 787 airplane that has been powered continuously for 248 days can lose all alternating current (AC) electrical power due to the generator control units (GCUs) simultaneously going into failsafe mode. This condition is caused by a software counter internal to the GCUs that will overflow after 248 days of continuous power. We are issuing this AD to prevent loss of all AC electrical power, which could result in loss of control of the airplane.
AIRBUS A400M CRASHES DUE TO ENGINE FAILURE

Glitch found in engine software requires immediate checks after issue-plagued fleet is grounded.

The Airbus A400M has been plagued by technical faults and now software glitches that reportedly caused a crash. Photograph: Julio Munoz/EPA

Airbus has issued a critical alert calling for immediate checks on all its A400M aircraft after a report identified a software bug as having caused a fatal crash in Spain earlier this month.

Four crew dead!!

In a statement Airbus said it was "devastated to confirm" the loss of four crew members, adding that another two are in hospital in a serious condition.

The plane crashed in a rural area near Seville airport (Pic: Airlive.net)
F-35 LIST OF BUGS PUBLISHED IN REPORT
"There's no brakes... hold on and pray": Last words of man before he and his family died in Toyota Lexus crash.

THERE HAVE BEEN FAILURES IN OTHER FIELDS TOO
WE REQUIRE
SOMETHING
Different
“The world as we have created it is a process of our thinking. It cannot be changed without changing our thinking

-Albert Einstein”
EFFORT DISTRIBUTION IN SYSTEM DEVELOPMENT
V model today
AN INTERESTING METRIC ON THE PROCESS TODAY

1. Cost of Fixing
2. Type Errors Found
3. Effort Spent/Where errors found
WE REQUIRE A PARADIGM SHIFT!
MATHEMATIZE THE LEFT AND AUTOMATE THE RIGHT

– IS THE MANTRA
- Model based representation
- Property based requirements
- Formal proof of correctness of behavior
- Validated control system in the presence of noise, modeling inaccuracy, data ambiguity, faults
- Model based testing
- Generate random test cases
- Generate test cases using Orthogonal arrays
- Generate test cases using formal methods
- Generate test cases from Mutants
- Always measure coverage
Requirements

Make use of Simulink Blocks

Models

Requirement based tests

Use autocode

Structural Autotests

C/Ada

There is a little bit of test case automation here.

There is a big confusion here on how to write requirements!!

Remember: Models ARE NOT requirements!!
THIS IS WHAT WE NEED TO DO NOW

Properties

Models

C/Ada

Bring in Property Based Requirements

Bring in Property Based Testing

Use Simulink blocks or any other models

Property Based Autotests

Definitely use autocode

Structural Autotests

Continue with your automated testing
Thank you

Any questions?
You can find me at
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Our system is only as good as the test cases we have designed to prove it correct