THALES

Hardware Software Co-Design and Testing Using Simulink® Real-Time™

Paul Berry and Brian Steenson

Overview

Process Development

- Introduction to THALES
- Overview of design process
- Development of autocode capability

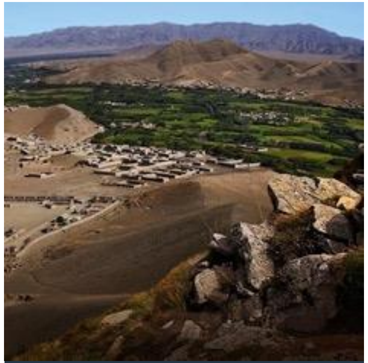
Real Time Testing for the Lightweight Multirole Missile

- Guidance and control algorithm design
- Guidance and control algorithm implementation
- Guidance and control algorithm testing

THALES in the UK

Aerospace

- Avionics Systems
- Air Traffic Management
- In-Flight Entertainment
- Electrical Systems
- Training and Simulation



Defence

- Radar
- Watchkeeper
- Command and Control
- Cameras and Sensors
- Sonar Systems
- Threat Warning
- Short Range Defence

Ground Transportation

- Signalling Systems
- Integrated Comms & Supervision Systems
- Revenue Collection Systems

Security

- Secure Communication
- Network & Infrastructure Systems
- Protection Systems
- Critical Information Systems & Cybersecurity

Space

- Telecoms
- Observation
- Infrastructure
- Navigation

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THALES in Belfast


1962
SEACAT


1967
TIGERCAT


1975
BLOWPIPE


1984
JAVELIN


1989
STARBURST


1997
STARSTREAK (HVM)


1996 - 2002
HELLFIRE


2001
VT1


2002
NLAW


2008
Stormer SP


2008
RAPIDRanger


2009
FASGW


2011
LMM


2014
ForceSHIELD


2015
LML NG

THALES in Belfast

Effectors





Platforms






Space

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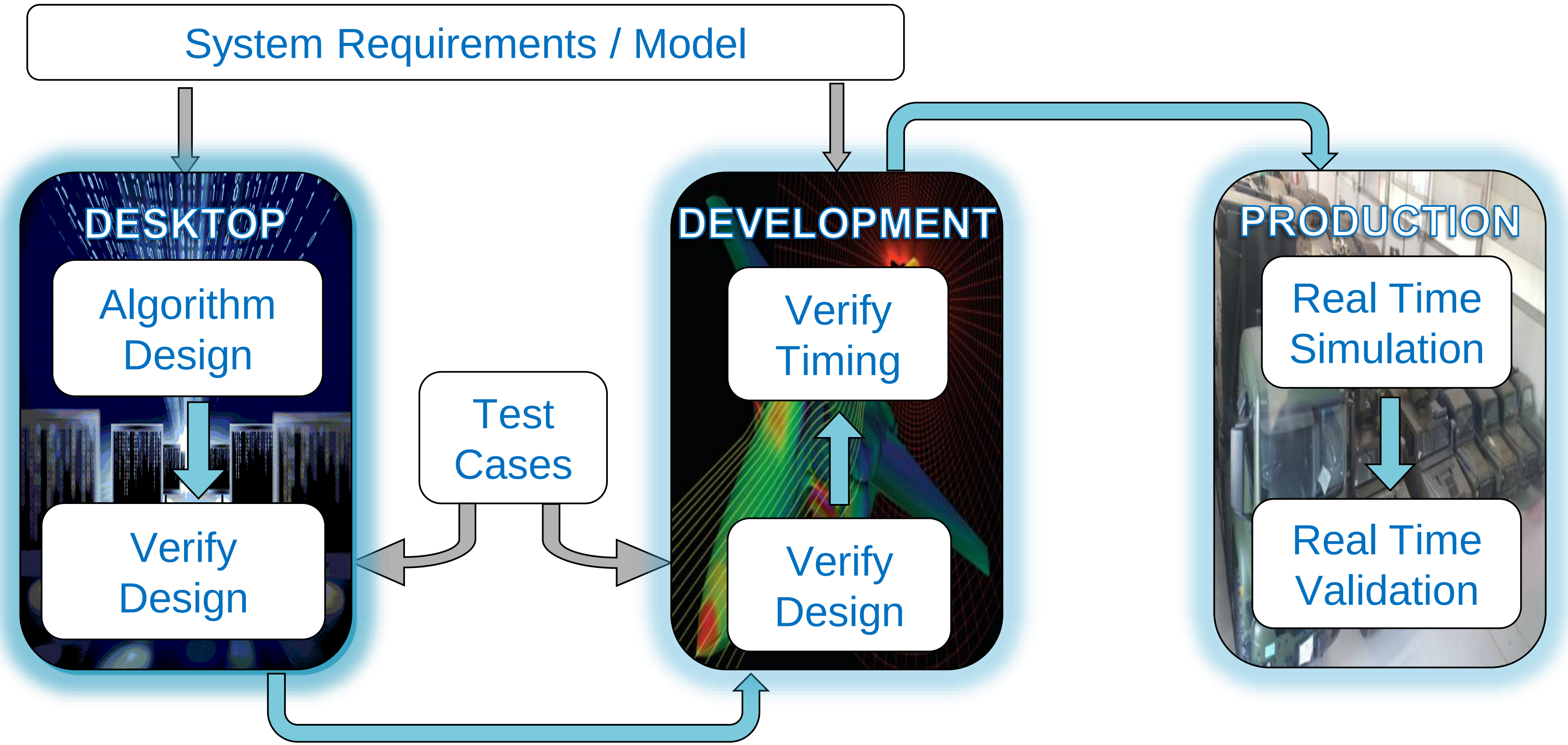
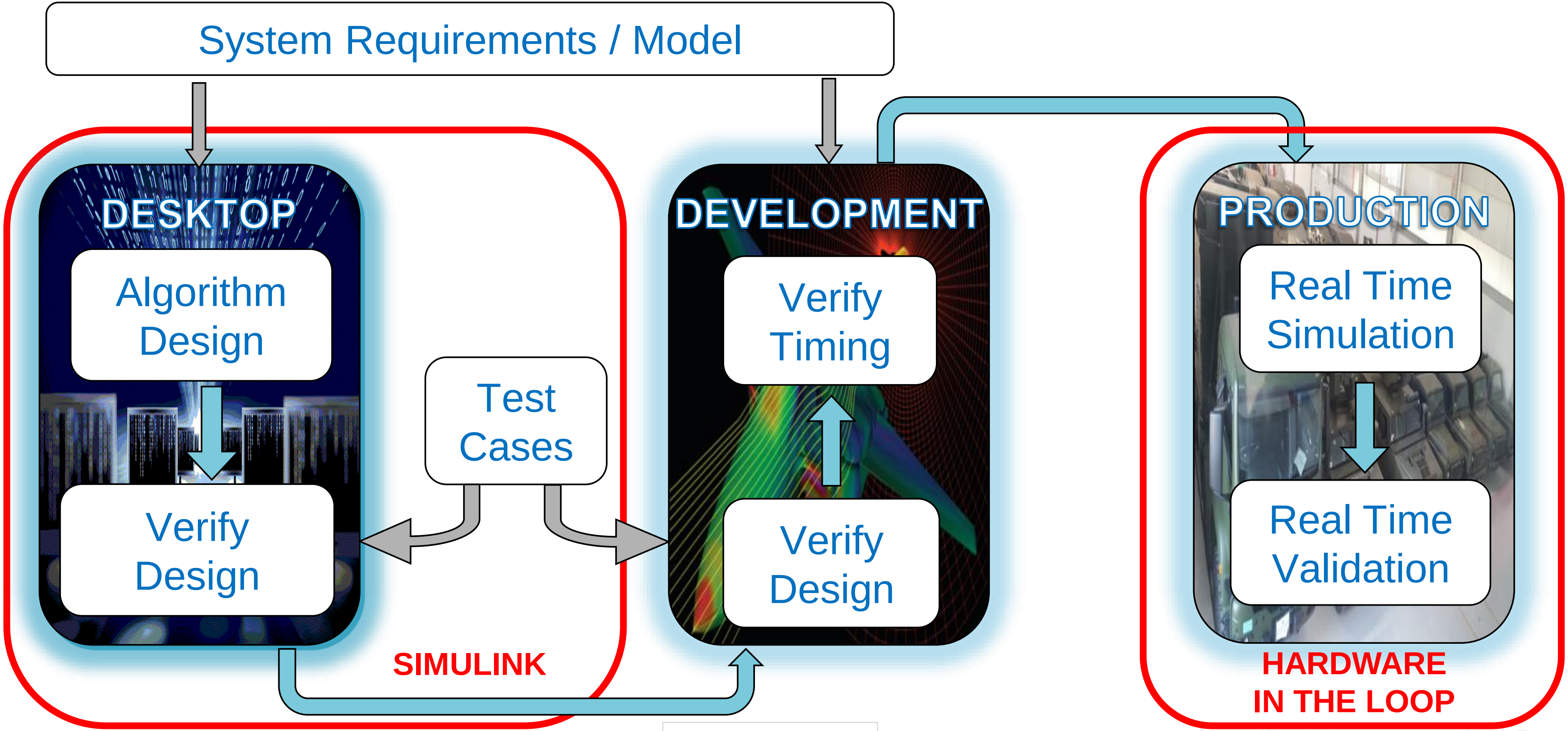
Model Based Algorithm Development



Model Based Algorithm Development



Goals and Objectives

- Remove human error
- Reduced code development time
- Early prototype on hardware
- Improved efficiency
- Fast turn around between iterations
- Common test environment
- Improved traceability

Evolution of Autocoding Capability

2005: Land Based Systems

- Algorithm development for target tracking algorithm
- Implemented in C from Simulink
- Floating point C code

2007: Missile Systems

- Guidance algorithm implemented in C from Simulink
- Target-specific libraries used to optimise speed
- Fixed point C code

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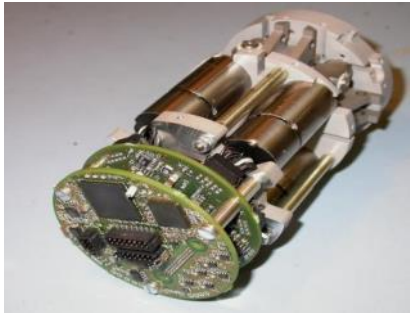
Evolution of Autocoding Capability

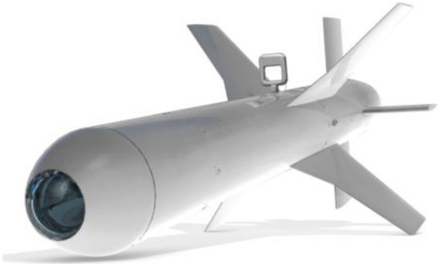
2009: Hardware/Software Partitioning

- Motor control algorithms developed in Simulink
- Autogenerated C code used to quickly prove concept
- Final solution partitioned between C and HDL



2013: FreeFall-LMM rapid development

- Rapid prototyping of guidance and control algorithms
- Autogenerated C code
- 6 months development from concept to flight trials



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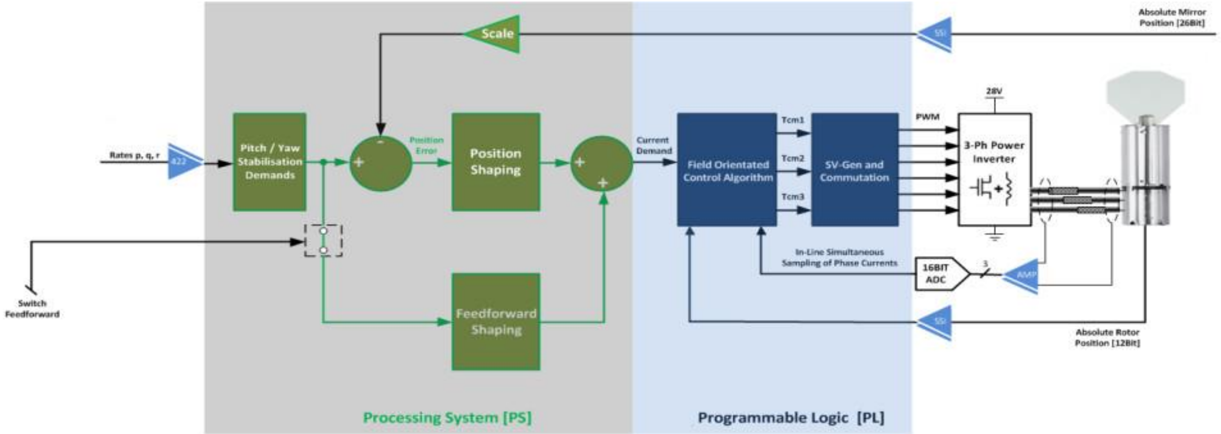
Evolution of Autocoding Capability

2017: Next Generation Beam Steering

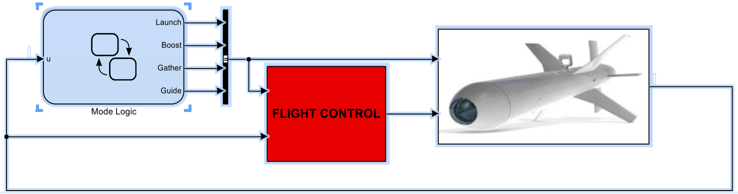
- Updated algorithms developed for new guidance unit
- µrad positional accuracy and stabilisation error
- Autocoded algorithms ported to System on Chip
- Improved linkages between model and implementation



Evolution of Autocoding Capability – Future?

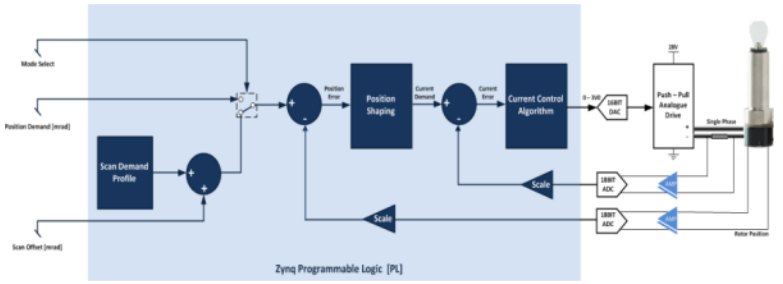
Missile state machines

- Currently using legacy state machine layer
- Bring this logic within MBD process as complexity increases



Digital laser scanning

- Very high rate (ns), high precision control
- High fidelity simulation crucial to understanding
- MBD approach essential for rapid prototyping and implementation



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Real Time Testing for the Lightweight Multirole Missile

www.thalesgroup.com

LMM launch

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Overview

Guidance and control algorithm design

- (Sub)system model development
- Algorithm development
- Performance verification in non-real time Simulink 6DOF simulation
- Generate algorithm autocode (C or HDL)

Guidance and control algorithm testing

- Real time simulator development
  - Real time 6DOF simulation
  - Hardware emulators
- Hardware in the Loop testing
- Verification and Validation

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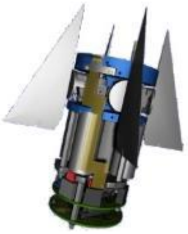
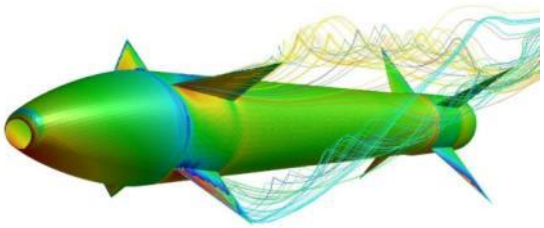
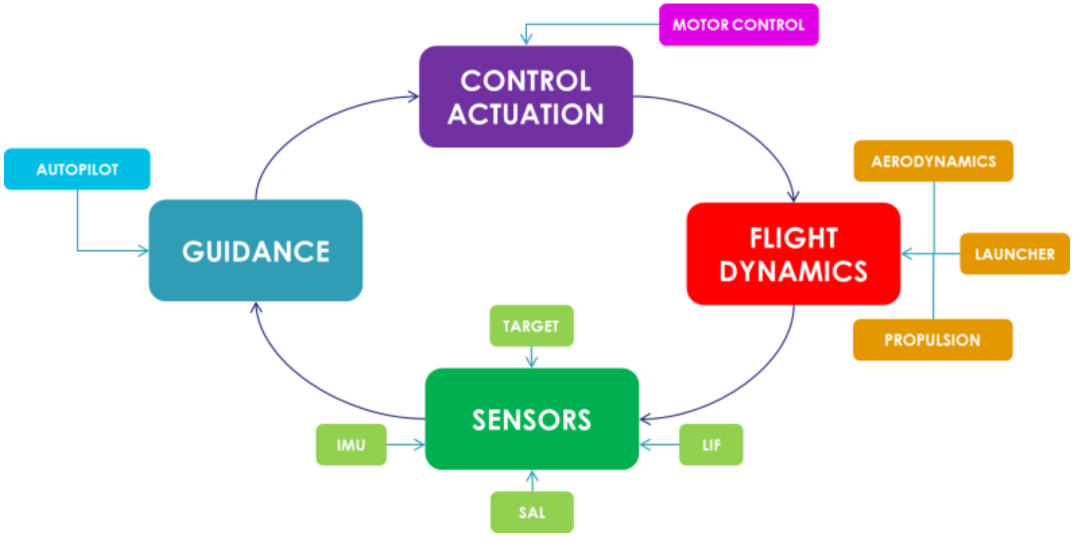
Model Development

Develop subsystem models:

- Aerodynamics
- Structural bending
- Inertial Measurement Unit (IMU)
- Laser Information Field (LIF)
- Semi-Active laser (SAL)
- Control Actuation System (CAS)
- Rocket motor(s)
- Missile dynamics
- Canister exit model
- Launch platform
- Guidance algorithms







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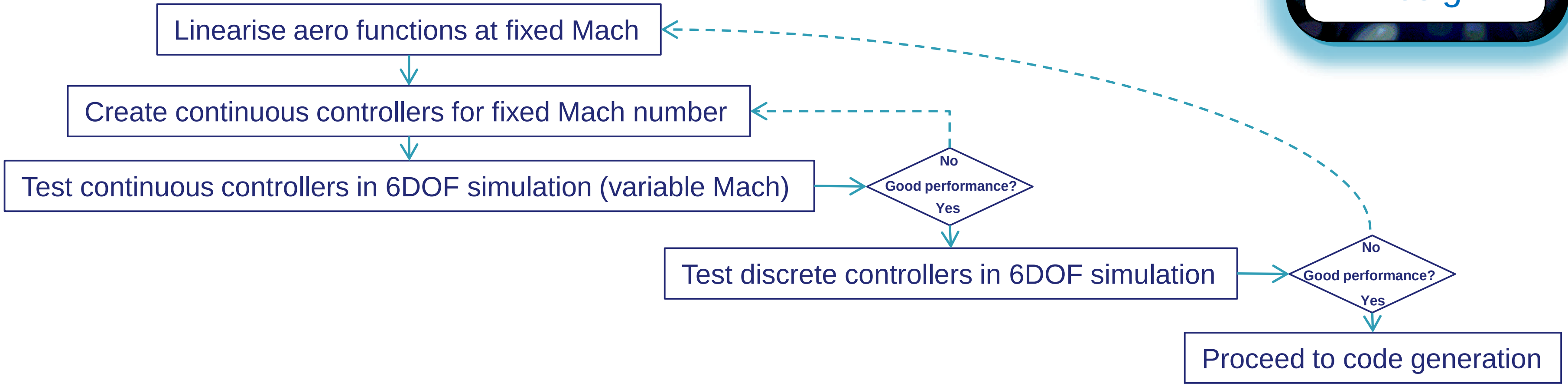
Guidance algorithm design

- Controllers developed at key operating points
- Based on a continuous linearised/idealised model
- Algorithm design iteration may be required
- Discrete versions of algorithms created
- Performance quantified in 6DOF simulation
- Iteration may be needed



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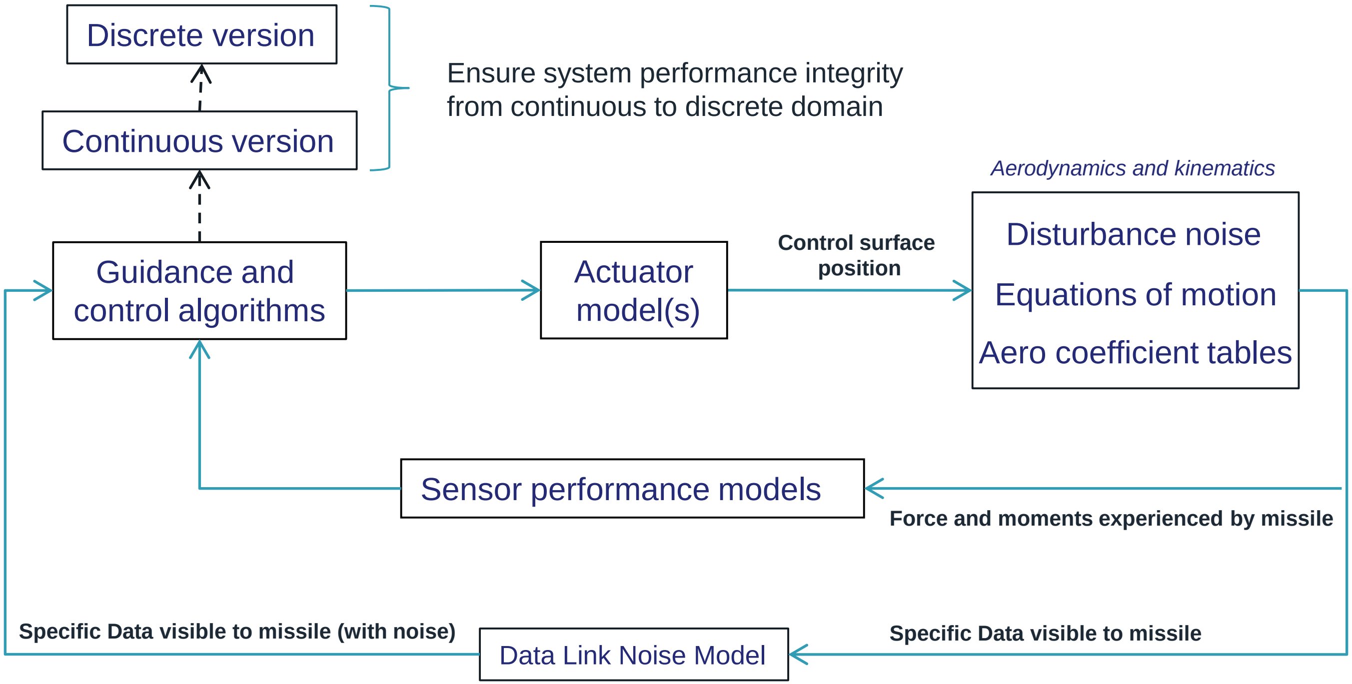
Testing in non-real time - Simulink 6DOF Simulation



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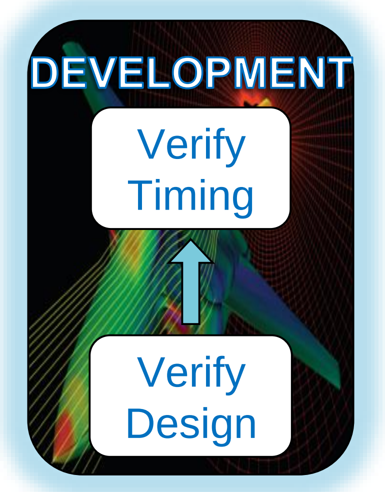
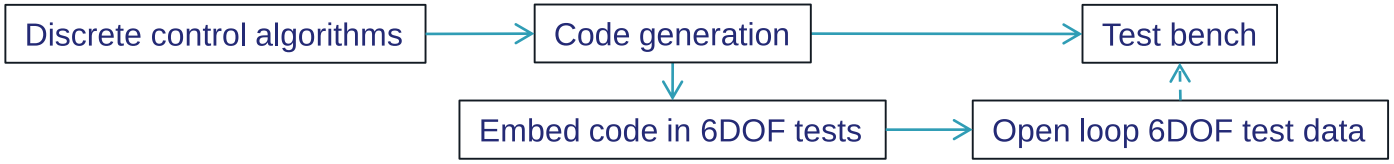
Autocode algorithms onto target - C

- Common autocode configuration settings across projects for code standard consistency
- Run Monte Carlo simulations replacing algorithms with autogenerated code
- Open loop tests using 6DOF generated test vectors performed on target hardware
- Verify executable code integrity and assess coverage





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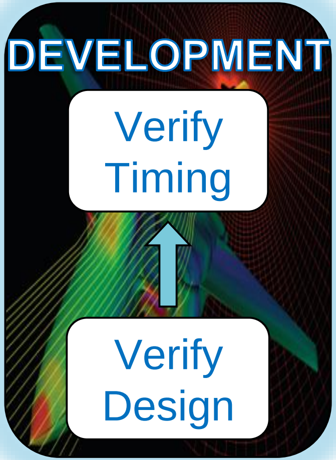
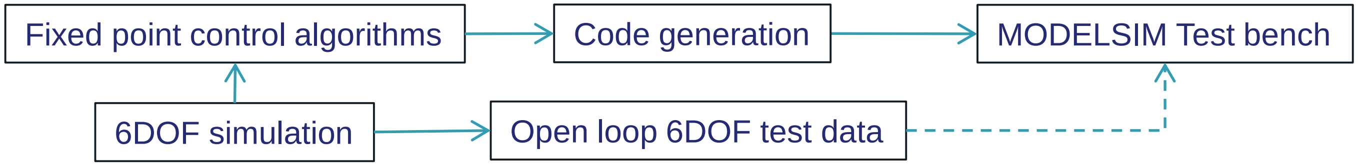
Autocode algorithms onto target - HDL

- Common autocode configuration settings across projects for code standard consistency
- Fixed point model required
- Open loop tests using 6DOF generated test vectors performed on target hardware
- Check executable code integrity and assess coverage





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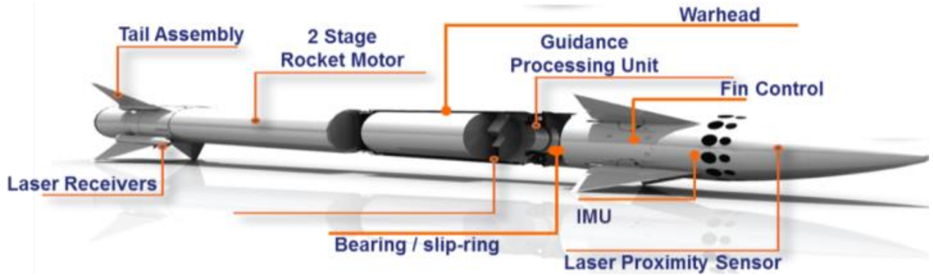
LMM Laser Beam Riding (LBR) HIL key components

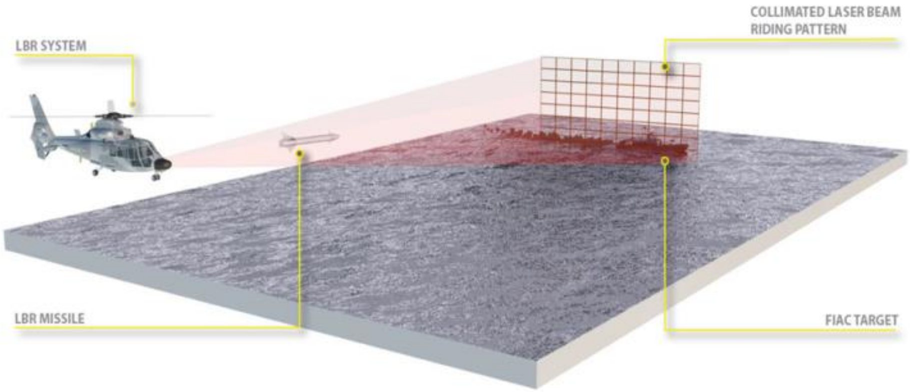
Missile Electronics

- Guidance Processing Unit
  - Generate elevator angle demands
  - Simultaneously roll stabilise missile nose
- Fin Control Actuation System
  - Implement fin control algorithms

System Emulators

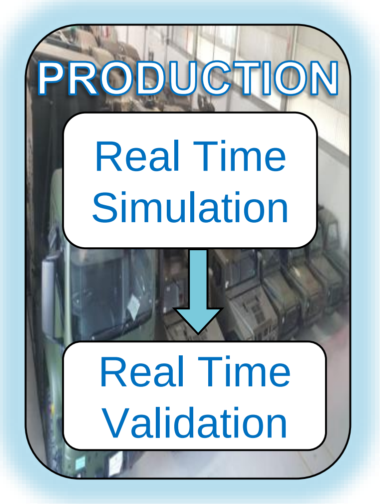
- Laser Information Field emulator
  - Provides missile with its position
- Inertial Measurement Unit emulator
  - Provides missile with rates and accelerations for inertial reference calculations





Hardware in the Loop (HIL) testing

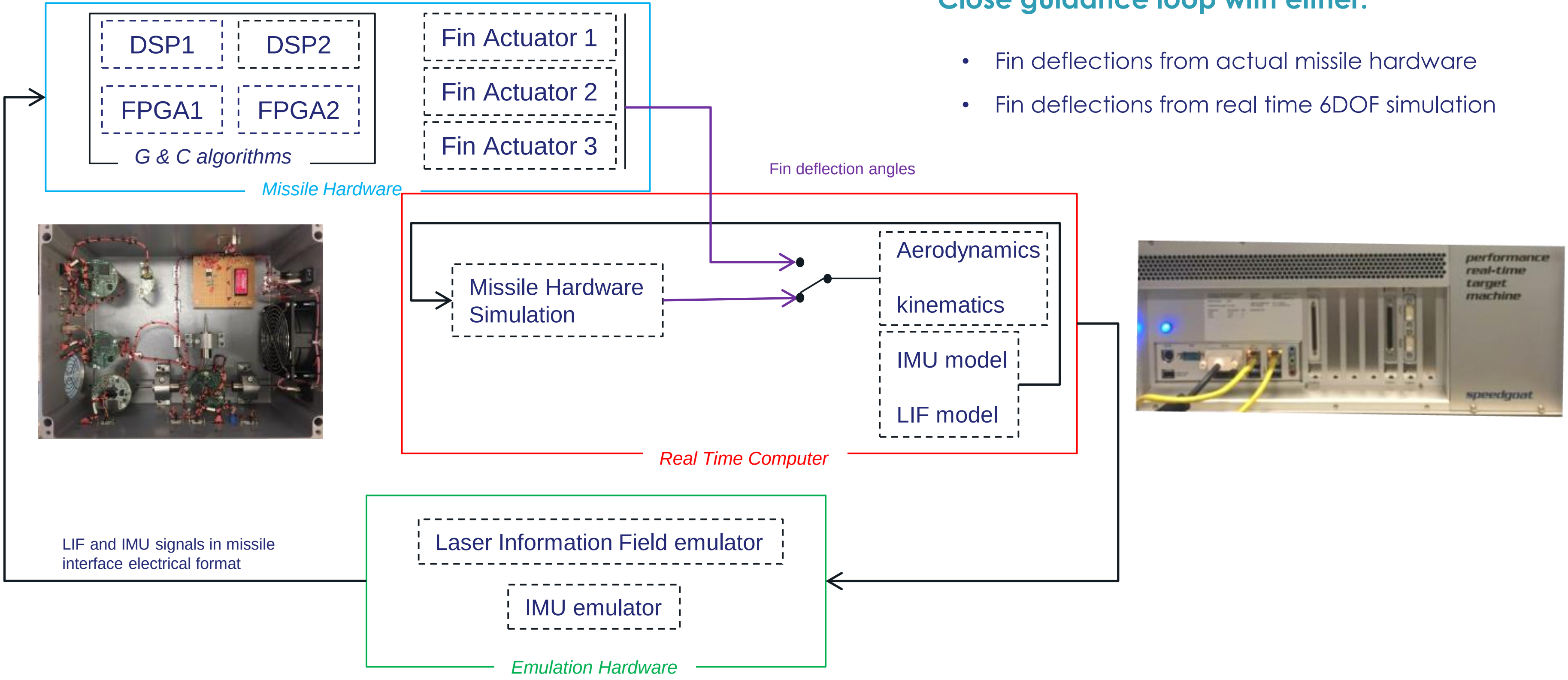
- Autocoded algorithms implemented on hardware
- Simulink Real Time version of 6DOF simulation created
  - May require simplification - Larger step-size, remove high frequency dynamics, limit real time comms
- Model subsystems can be gradually removed from the 6DOF simulation and replaced with hardware or hardware emulators
- Run Monte-Carlo real time simulations on real time target
- Simulation version of algorithms can run on real time target in parallel to permit debugging



LMM Laser Beam Riding (LBR) HIL simulation

Close guidance loop with either:

- Fin deflections from actual missile hardware
- Fin deflections from real time 6DOF simulation



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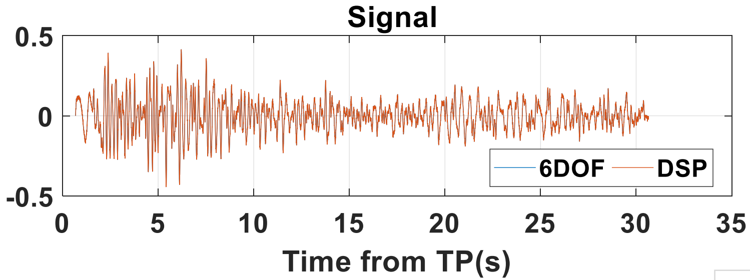
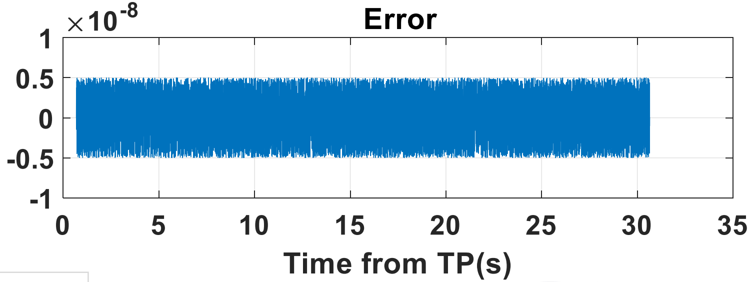
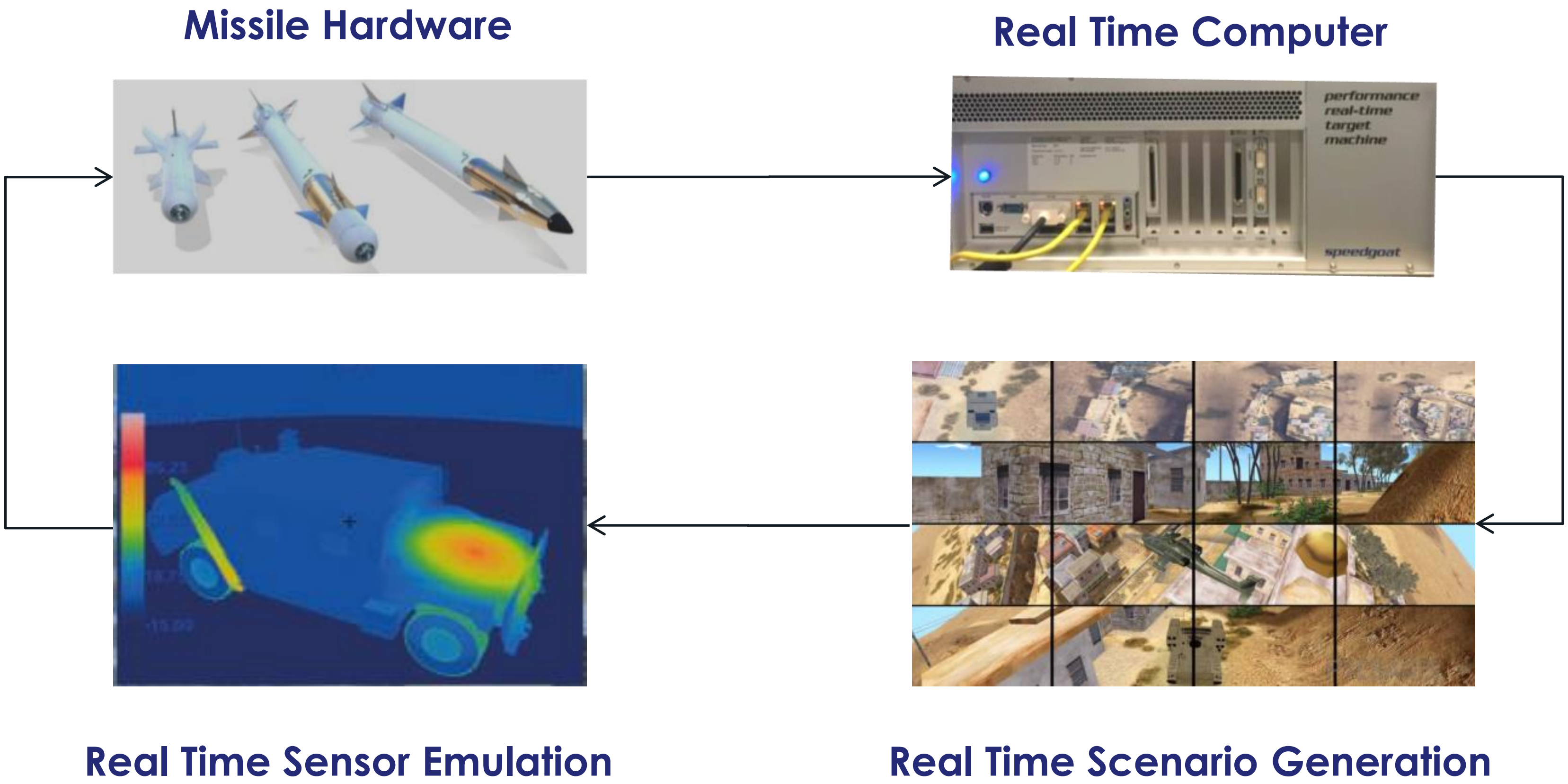
Verification and validation

- HIL simulation is a key part of pre-flight tests
- Hardware stimulated closed-loop with realistic flight data
- Failure mode testing
- Iterative development – 6DOF (both non-real time and real time) validated against flight telemetry data
- Linkage from algorithm design model to hardware implementation tests accelerates rapid prototyping development and testing





Next steps



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LMM in action

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