Astrosat 250 Core Avionics Demonstrator

ESA Workshop on Avionics Data, Control and Software Systems (ADCSS 2010)

New Approaches for Verification and Validation of Avionics (NAVVA)

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Avionics Functional Validation – ASTRIUM Toulouse - France

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Agenda

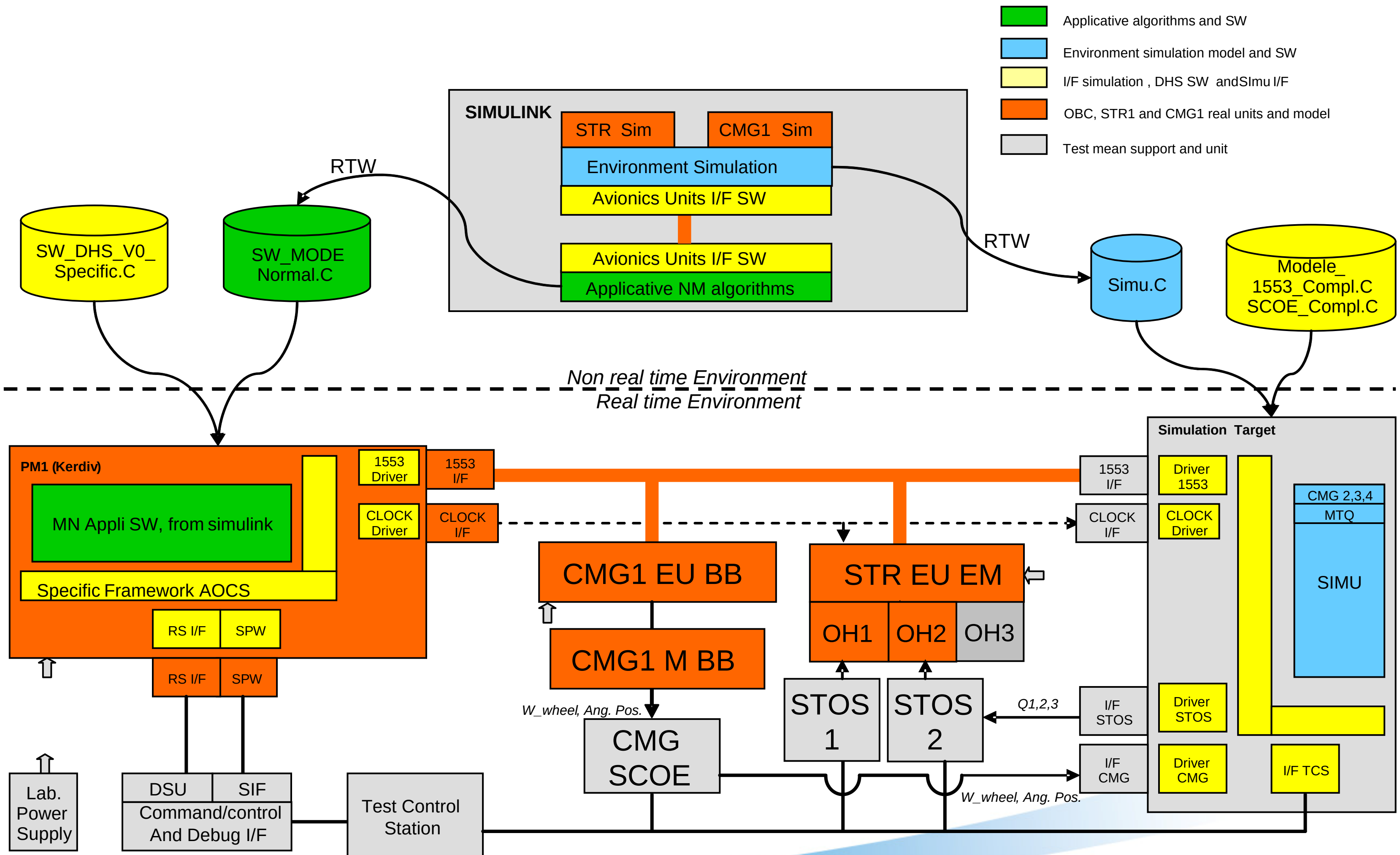
- Introduction / Main objectives
- Test configuration architecture / Key features
- AOCS SW RTS development / Functional validation
- Results
- Conclusion / Feedback / Forecast

Introduction / Main objectives

- **In 2008, ASTRIUM Satellites decided to start the development of a new platform for LEO missions called AstroSat 250**
- **AstroSat 250 is based on LEON3-based new computer, on a new generation star tracker from EADS SODERN and on a new gyroless AOCS mode based on STR sensor and CMG actuators**
- **During phase B, ASTRIUM decided to demonstrate early new AOCS mode and new avionics features with HIL (Hardware In the Loop) tests**
- **Development of a specific in-house process to generate the test configuration based on the Matlab-Simulink-RTW-Embedded Coder components chain**
- **Rapid prototyping/Mini-development approach to connect specific software components and Real Time simulator (RTS) components to existing elements**
- **Co-engineering between the four skills of the development team (AOCS Studies, RTS, On-board Software, Functional Validation)**

➔ Core Avionics Demonstrator (CAD)

Test configuration architecture overview



AOCS SW development (1/2)

- **New gyroless AOCS mode, based on STR and CMG:**
  - From Phase B prototype up to a detailed mode implemented for real-time tests
- **AOCS Matlab/Simulink model derived from Phase B simulator to ensure auto-coding:**
  - Need for strict rules regarding overall architecture (e.g. separation between FSM part and rest of the world) and with clear/explicit interfaces
  - Completion of the model, including detailed core functional models for STR and CMG
  - Additional requirements linked to real-test bench configuration (e.g. to include initialisation part, to add idle/stand-by modes, to add minimum TM/TC management)

AOCS SW development (2/2)

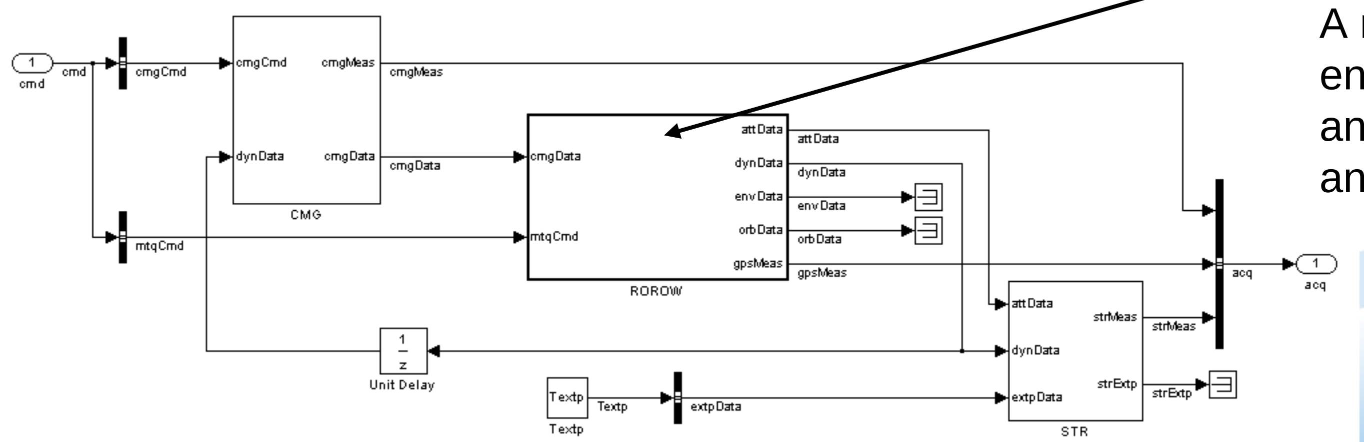
- **Reinforced co-engineering between AOCS / SW / RTS / FV teams:**
  - Agreed conventions & interfaces
  - Define early constraints in Matlab-Simulink model to cope with EC autocoded component to be plugged on existing flight-standard V0 code (using the result of in-house survey of autocoding techniques and benefits)
  - Need for quick iterations on the AOCS Matlab/Simulink model, managed by AOCS team, to ensure effective process at SW and RTS levels

- **Reference test cases produced on the basis of AOCS Matlab/Simulink model:**
  - Used for comparison/validation on the CAD test configuration

RTS development

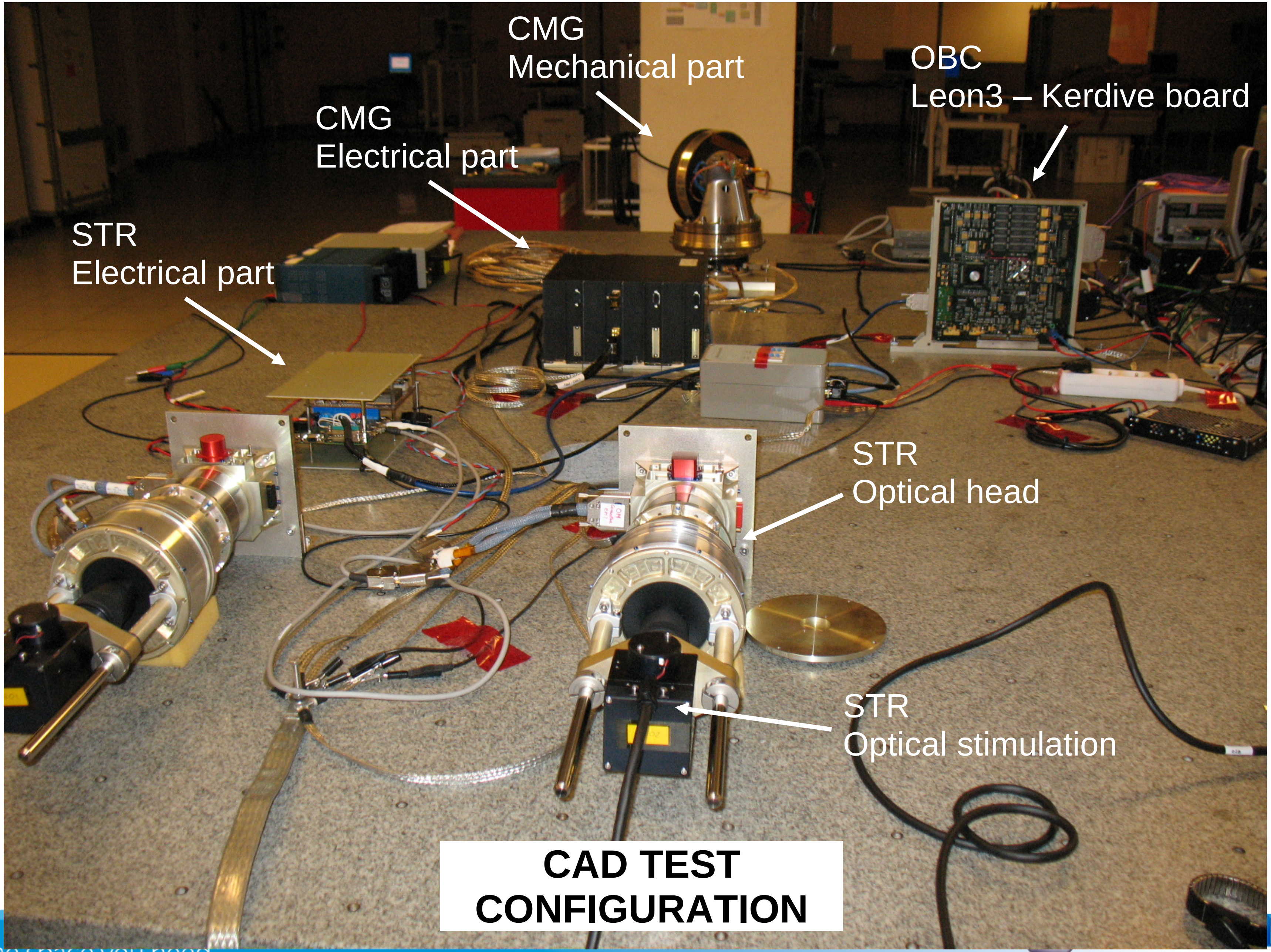
- **Similar to commercial solution with the ability to reuse and integrate easily in-house SCOEs, real OBC and 1553 spacecraft bus interfaces (models and specimen)**
- **Minimize the number of HW or SW components between the simulink autocoded models and the spacecraft equipments**
  - One single real time SW infrastructure, the SimTG simulation kernel and a real time linux operating system
  - One single HW, a PC with direct interfaces to spacecraft HW units and SCOEs
- **One single simulink model (.mdl) generates three C++ simulations models**

ROROW model : rest of the world
A model with spacecraft environment, dynamic and core models for GPS and MTQ equipments



Functional validation

- **General knowledge and use of new OBC and STR units : interfaces, electrical and functional constraints**
- **Integration of the units**
- **Interface verification:**
  - 1553 avionics bus protocol verification for STR and CMG
  - Synchronization clock
  - Stimulation interface verification
    - Electrical acquisition for CMG
    - Optical stimulation for STR
- **Open and closed loop AOCS functional tests defined at study level**


CMG
Mechanical part
OBC
Leon3 – Kerdive board
CMG
Electrical part
STR
Electrical part
STR
Optical head
STR
Optical stimulation
CAD TEST
CONFIGURATION

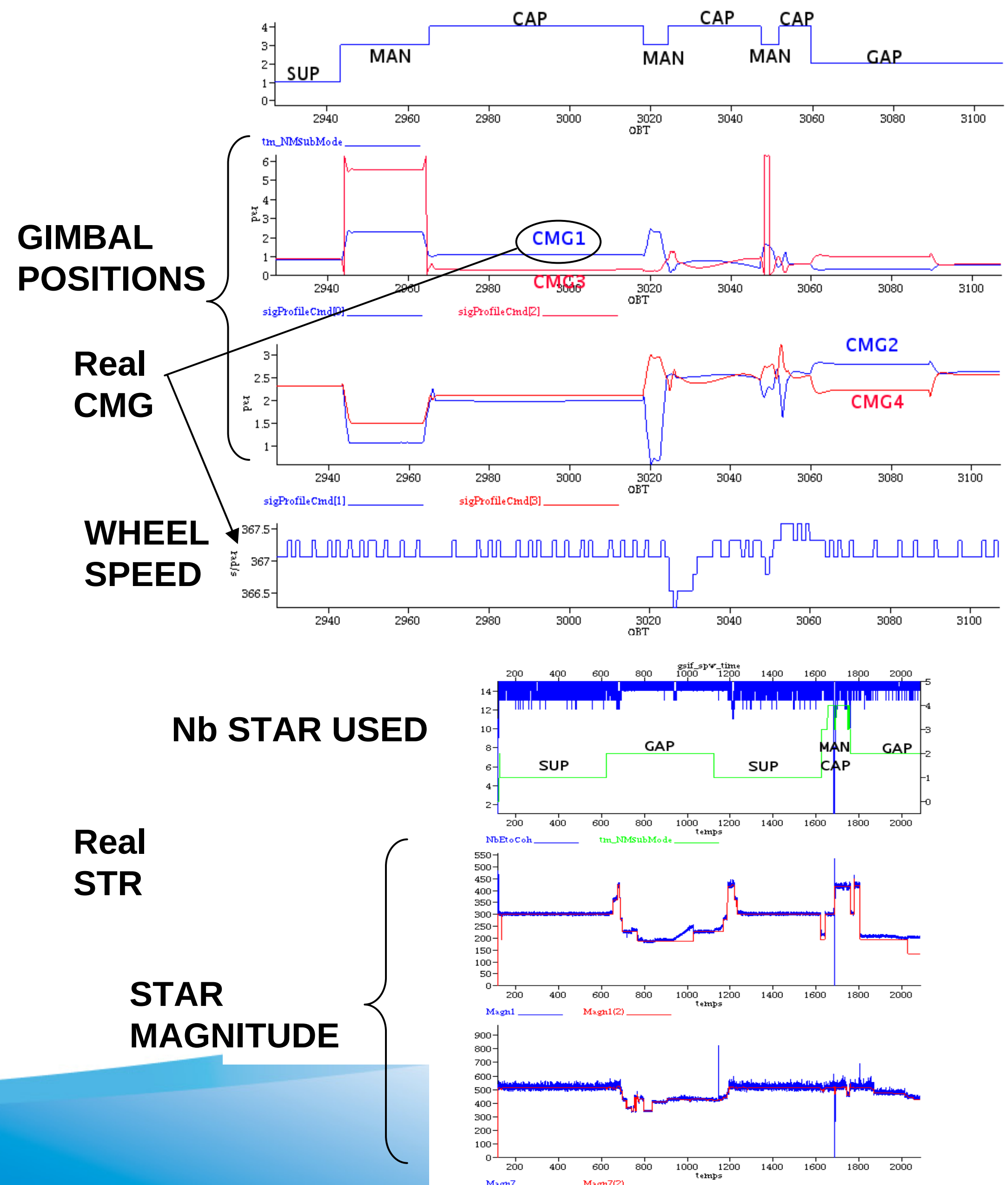
Results (1/2)

- **Astrosat 250 CAD campaign has been concluded successfully with closed loop HIL tests**
- **Very challenging objectives have been met:**
  - Successful integration of auto-coded AOCS SW&RTS part:
    - Reactive & flexible loop to iterate on the model (functional design, parameter tuning) in case of evolution (less than a day between simulink model modification and bench update including non regression tests)
    - Successful integration of the auto-coded AOCS SW with the flight-standard DHS software on the AS250 computer board
  - RTS Bench:
    - Demonstration of a low cost bench set-up competitive toward a ‘D-Space solution type’ (Planning/Cost efficiency/Very ‘robust’ solution)
    - Validation of the RT linux solution vs traditional VME approach
  - Rapid prototyping successful: a few months to get the bench operational, rapid generation of updates of OBSW and of RTS, efficient transmission of Simulink reference case down to Real Time bench procedure
  - Open and closed loop HIL tests carried out with same results as on reference Simulink test case -> validation of the new AOCS mode in HIL environment

Results (2/2)

HIL Closed Loop Tests (Mission Profile in Normal Mode) :

- SUn Pointing (SUP submode)
- Attitude MANeuver (MAN submode)
- Imaging (Custom Accurate Pointing or CAP submode)
- Earth Pointing (Geocentric Attitude Pointing or GAP submode)



Same results as on reference Simulink test case

Conclusion / Feedback / Forecast (1/2)

- **Innovative approach:**
  - Allows faster development process for AOCS SW part, compared to classical process (SSS/SRS/DDD/code/validation). In this simplified process applied for prototyping approach, gain on schedule is estimated about 60/70% reduction.
  - Easier detailed design phase with Matlab/Simulink (e.g. modification & analysis capabilities, observability, debugging) than on reference operational means
  - Capability on the CAD bench to use / plug existing in-house elements (SCOE, AS250 computer board)
  - Development skills organization kept thanks to strong multi-disciplinary co-engineering
- **Efficient reuse:**
  - Drivers, architecture, models, electrical interfaces, SCOEs, test sequences, … for next Astrosat 250 benches and simulator family

Conclusion / Feedback / Forecast (2/2)

- **The Astrosat 250 CAD test configuration is today a back-up solution to investigate anomalies found on development bench**
- **It could be used for further potential evolutions of our generic platform Astrosat 250**
- **The Core Avionics Demonstrator is a new bench concept to demonstrate new avionics features early in a project (phase B)**
- **Advantages of the auto-coding on board software concept are studied for future projects in Astrium to move from prototype environment to C/D phase development**