Experience of Applying Rodin in an Industrial Environment

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Context

- AWE has been using Formal Methods (in various forms) for over a decade.
- Our application of formal methods encompasses:
  - analysis of existing electrical/software systems,
  - analysis of Safety Themes,
  - and most recently, in applying mathematical rigour to the design of electrical systems.

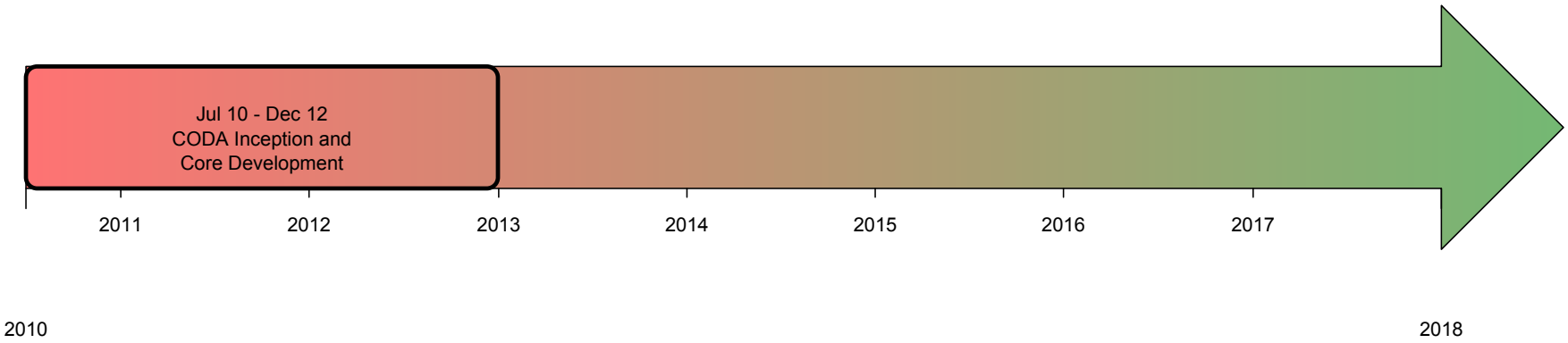
Presentation Aims

- Introduce the Co-Design Architecture (CODA).
- Highlight how Rodin is currently being used within AWE.
- Suggest how to introduce Formal Methods into the systems development process.

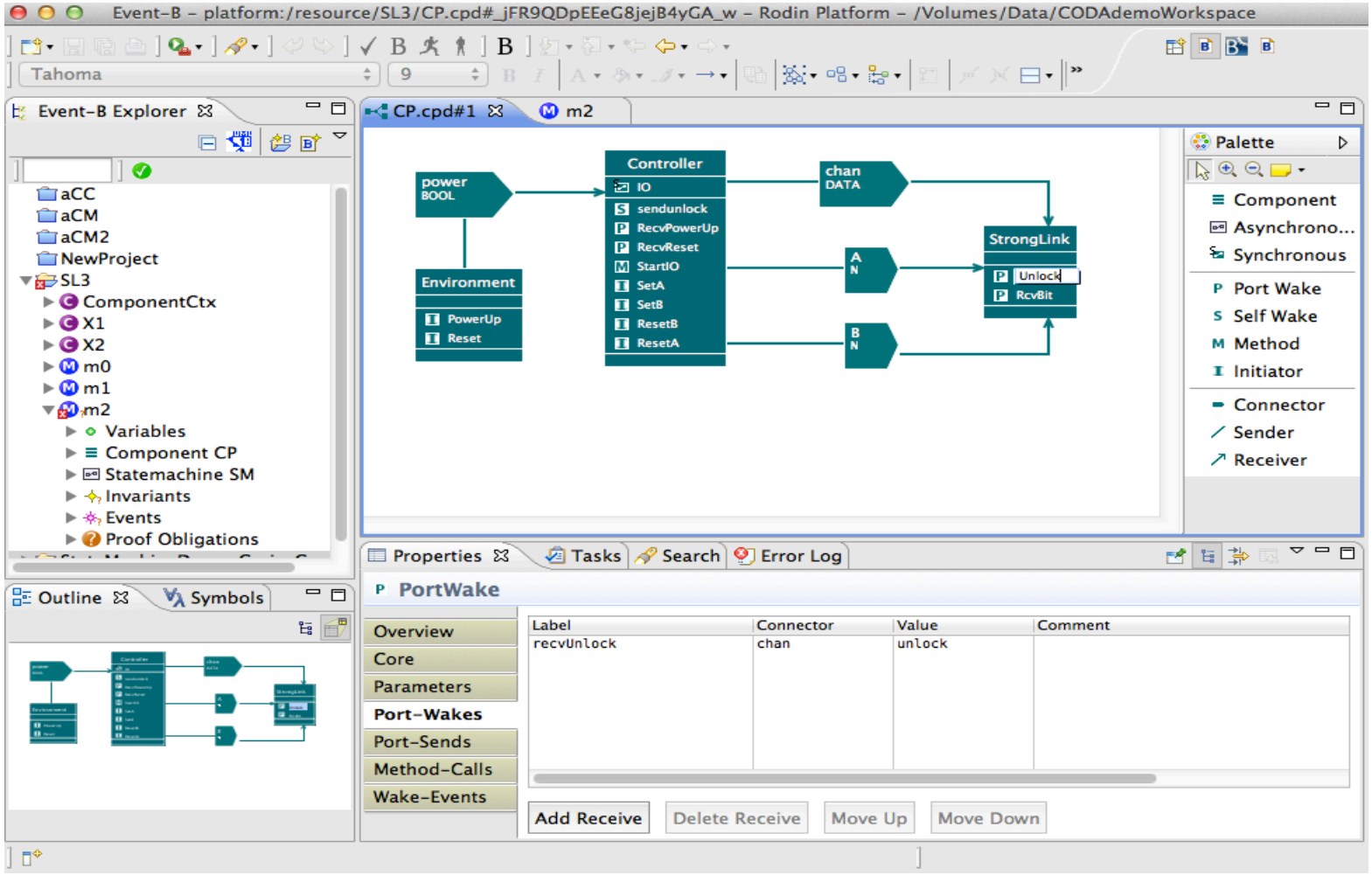
What is CODA?

- CODA provides a graphical interface and methodology to develop, analyse, and formally verify the interactions between, and the behaviour of, the components of systems comprising both software and digital electronic hardware.
- CODA guides the designer to embrace modelling the entire system:
  - This includes modelling the interactions with its environment.
- CODA constrains and specialises Event-B, tailoring it for our specific applications.
  - Refinement in CODA can be targeted at individual components in a clean, visual manner.

CODA Timeline: Past



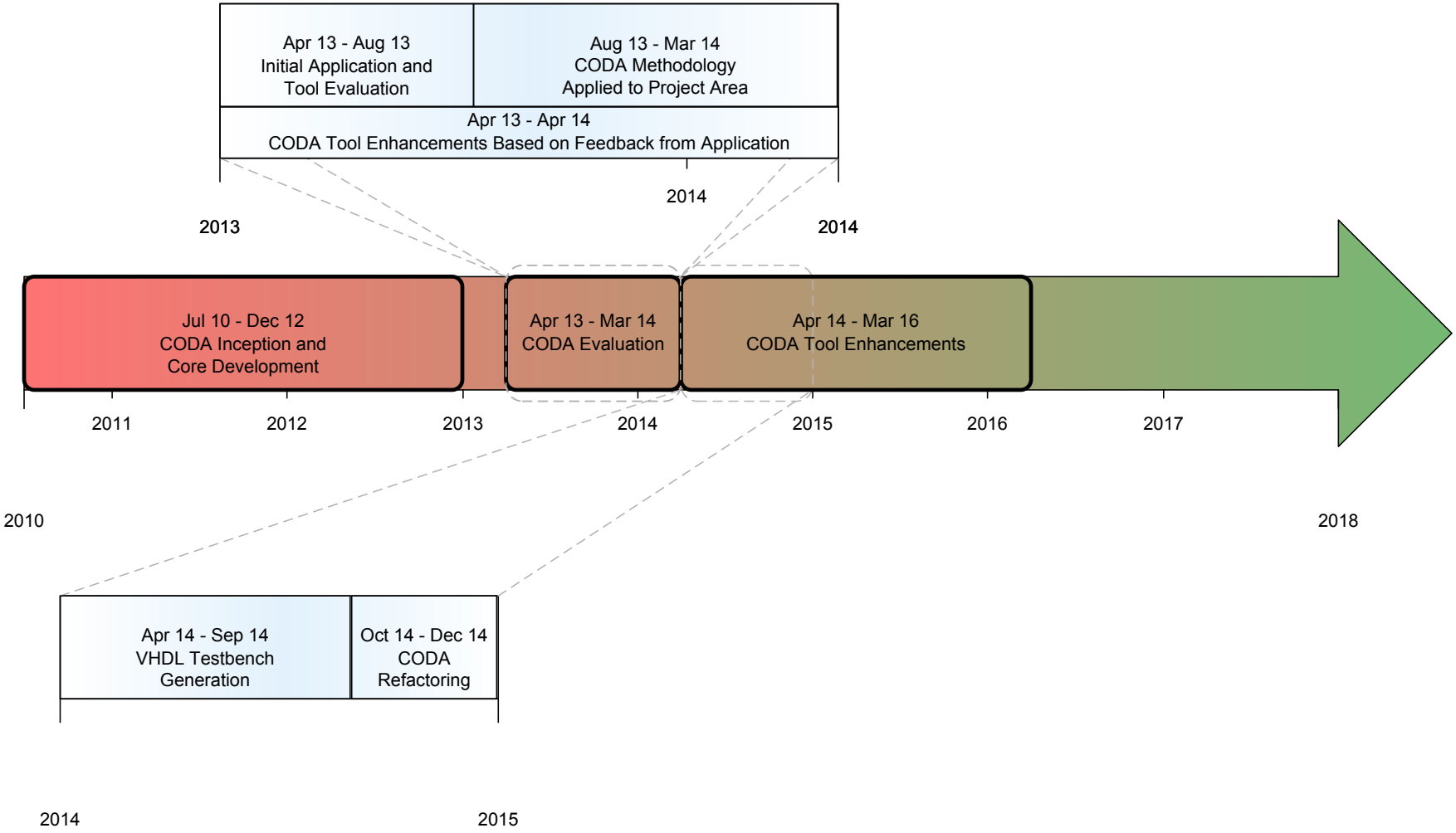
CODA IDE v1



Utilising the Rodin IDE

- Extensive use is made of the underlying Rodin engine and other Rodin plug-ins.
  - iUML-B State machines are used to model behaviour of individual CODA components.
  - ProB is used to model check and animate translated Event-B (from iUML-B and CODA graphical models).
  - The Proof Obligation Generator, SMT and Atelier-B provers are used to prove correctness of the translated Event-B.
- Additional analysis at the CODA-level has been introduced:
  - A CODA validation check prior to translation.
  - The CODA Simulator for CODA-level animation.

CODA Timeline: Past and Present



Recent Application at AWE

- Case Study looking at a complex ‘slice’ of a system’s functional behaviour.
  - 9 month period, with 20 on-site contractor days.
- Applying Event-B refinement within the CODA methodology
  - Looked at correctly capturing the top level requirements: what is the aim of the system?
  - Forced resolution of ambiguities in the informal system definition
  - Highlighted a disconnect between the requirements levels
  - Ensured problem was completely understood

Key Findings of the Methodology

- Refinement chains are not a one *'shot approach'*.
  - Iteration through the refinement chain, sometimes requiring significant refactoring is necessary.
  - Recent application required 6 iterations through various levels of refinement.
- SMT solvers are key:
  - An increase of 31% automatically discharged proofs
  - 98% (with SMT) vs 67% (without SMT) of a total 1173 proofs.
- Analysis performed using Event-B and the CODA methodology is bearing fruit:
  - Prominent in illustrating (lack of) understanding of the problem.
  - Can be used to provide confidence to the customer through animation in ProB.

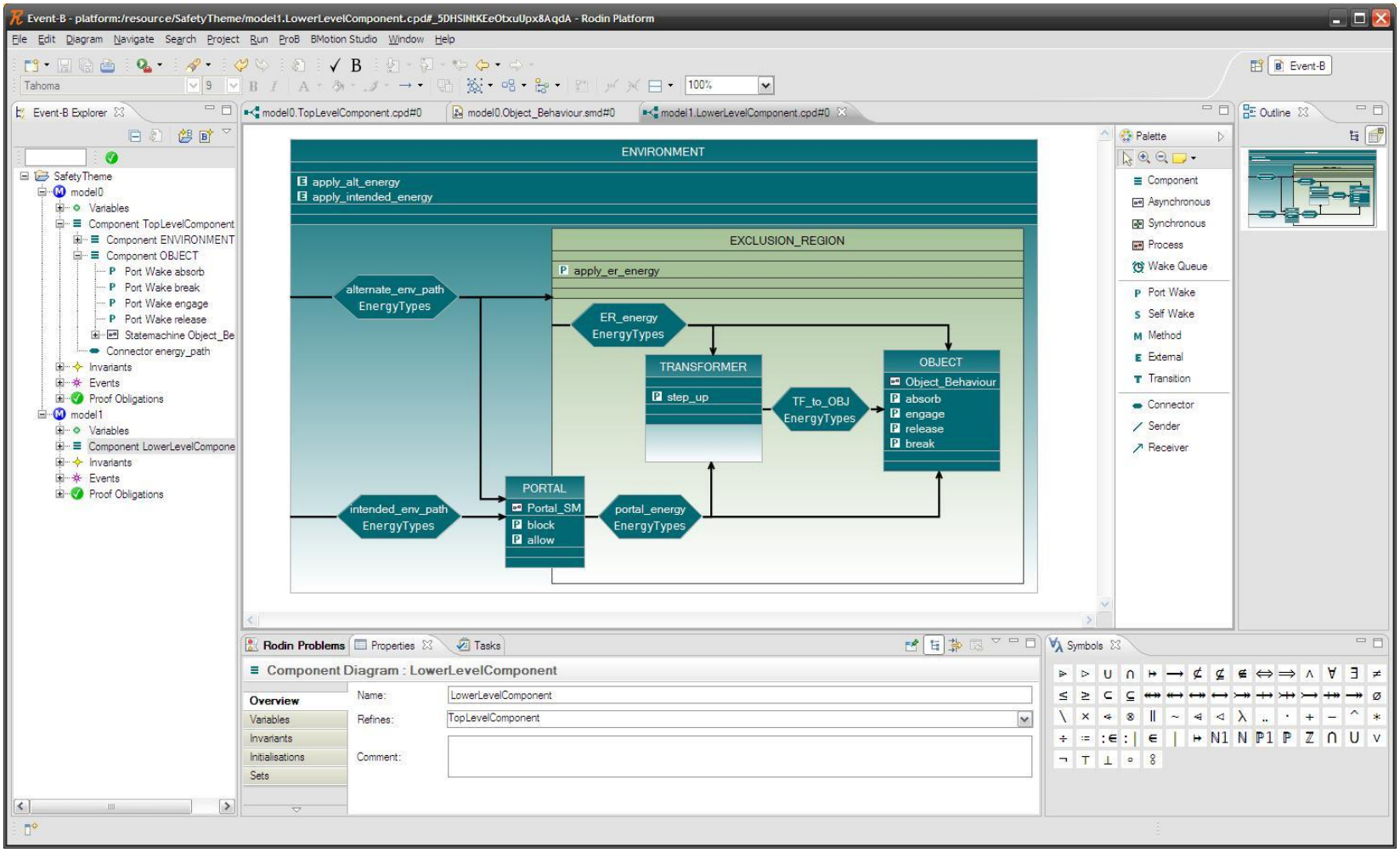
Verification and Validation

- How does Rodin enhance V&V?
- Verification (safety) of the design:
  - Formal proof through the use of Invariants.
  - LTL statements asserted by ProB over the model.
- Validation of the design:
  - Animation in ProB can and has been be used to walk through scenarios at different refinement levels during the development process

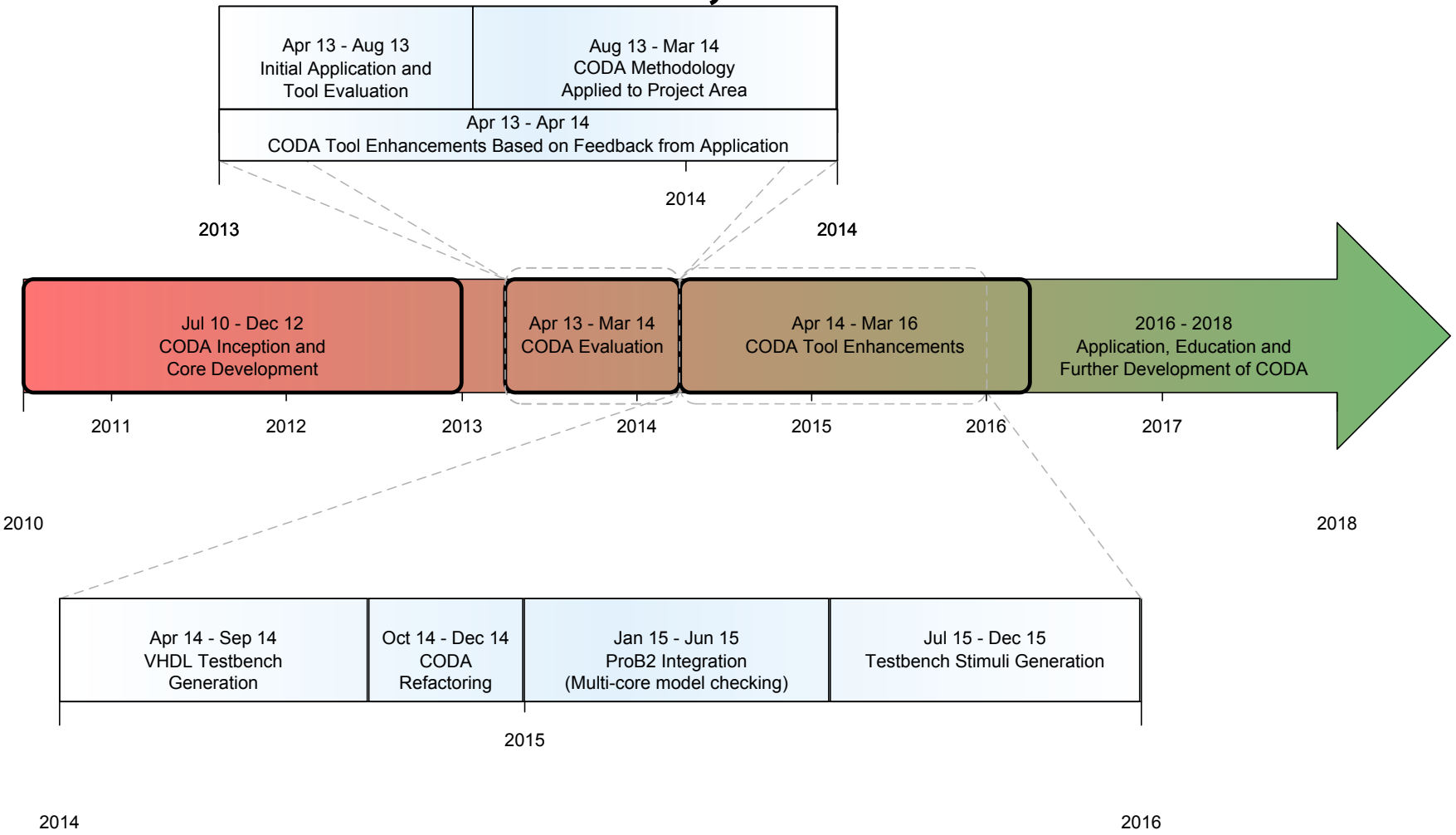
Further V&V: Responsiveness

- We define the responsiveness of a system as *"a system's ability to always respond in the correct and expected way to external stimuli".*
- First attempt used a composite approach from a common specification:
  - Manually identify valid paths through the specification and define invalid path rules.
  - Automated generation (using MALPAS) of **all** paths through the specification.
    - Number of paths then reduced by applying the invalid path rules.
  - Iterative comparison of the results of these two approaches produce a common, complete, set of valid paths of the system.

CODA IDE v4



CODA Timeline: Past, Present and Future



Concluding Remarks

- Enhancement of current engineering practices by adding mathematical rigour.
- Introduction via the V&V route met with less resistance.
  - Not too intrusive
  - But able to illustrate real benefit to the systems development process in an incremental manner
- Scale-up activities over time as they becomes more accepted.
- Continued application is key to reaffirming the benefits.