Contract-based design, model checking, and model-based safety assessment

An integrated view

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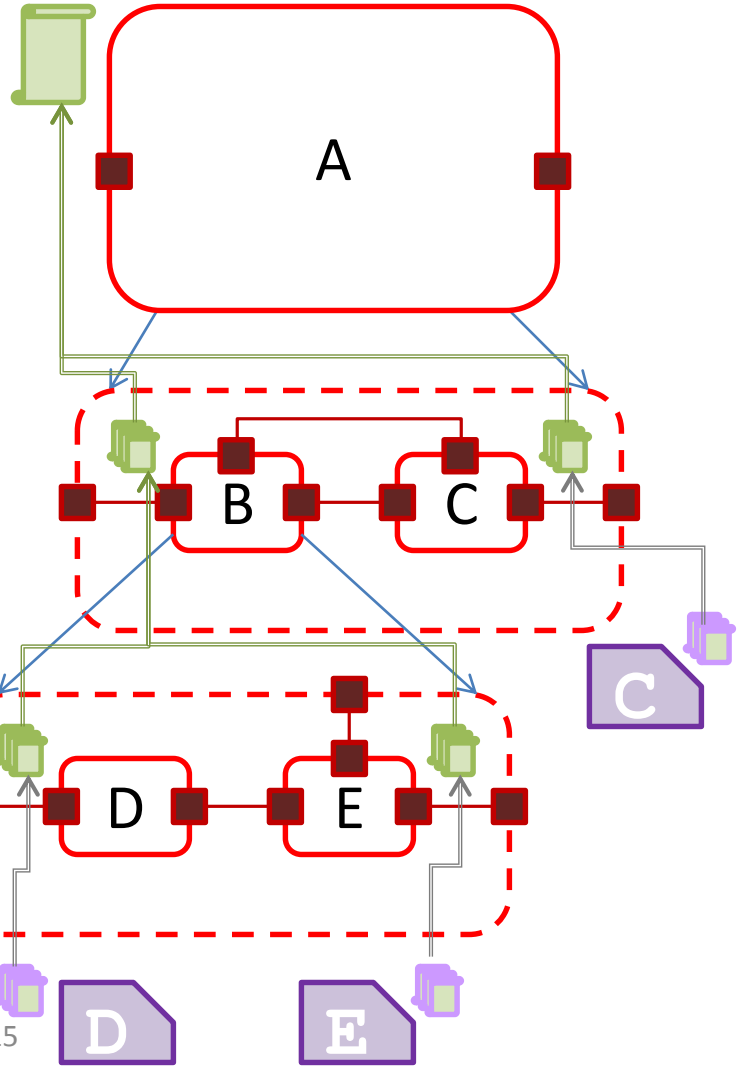
Take away message

- Beyond model checking: new generation of verification techniques
- Tools integrated into structured flow
- May provide integrated backend support for assurance by producing relevant artifacts from unique model

- From model checking to …
  - Contract-based design
    - architectural decomposition + refinement of requirements
  - Safety analysis
    - Extend nominal model to include faulty behaviours
    - Fault Tree construction: detect all fault combinations causing loss of desirable property

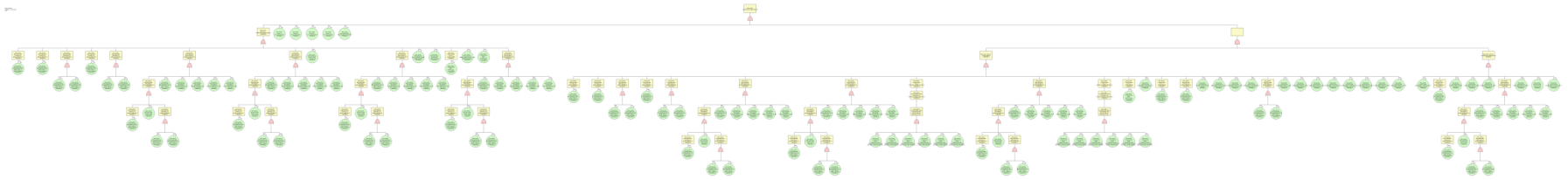
From architectural decomposition to contract-based design

- Hierarchical decomposition
  - Component to subcomponents
  - Implementation of leaf components
- Component associated with contracts
  - Assumptions / guarantees
  - Temporal logic
- Contracts refinement
  - Contract ensured by contract of subcomponents
- Correct implementations ensure correctness of composition



Model-based safety assessment

- Safety assessment
  - Analyze behaviour of system under faults
  - Artifacts: Fault Trees, FMEA tables
  - Qualitative and quantitative arguments



- Model-based Safety Assessment
  - Extend nominal model with faults
    - Symbolic fault injection
    - Valve stuck open, stuck closed, …
  - Analyze extended model
    - Automated production of FT

Formal Verification, Validation, and Safety Assessment

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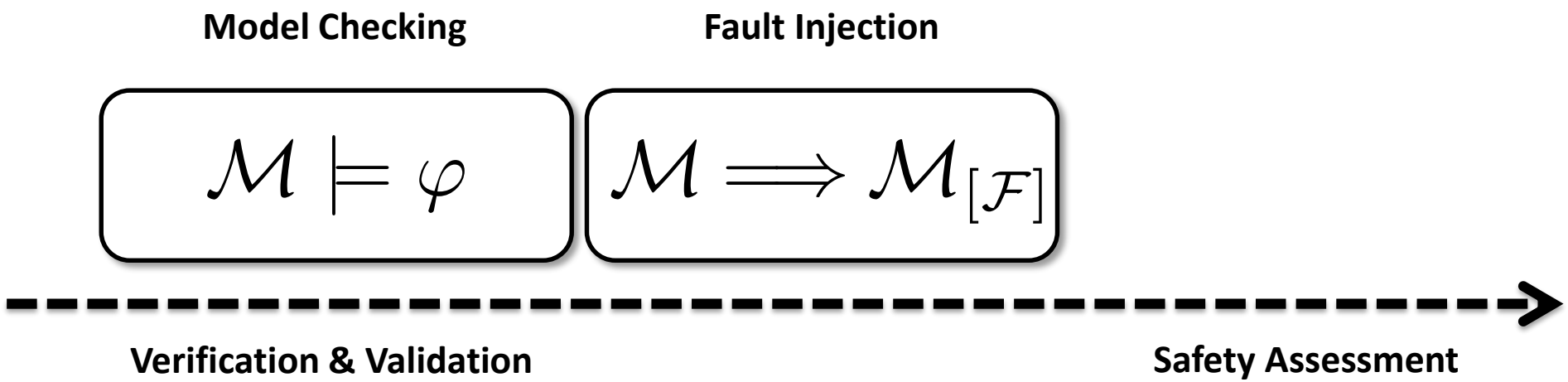

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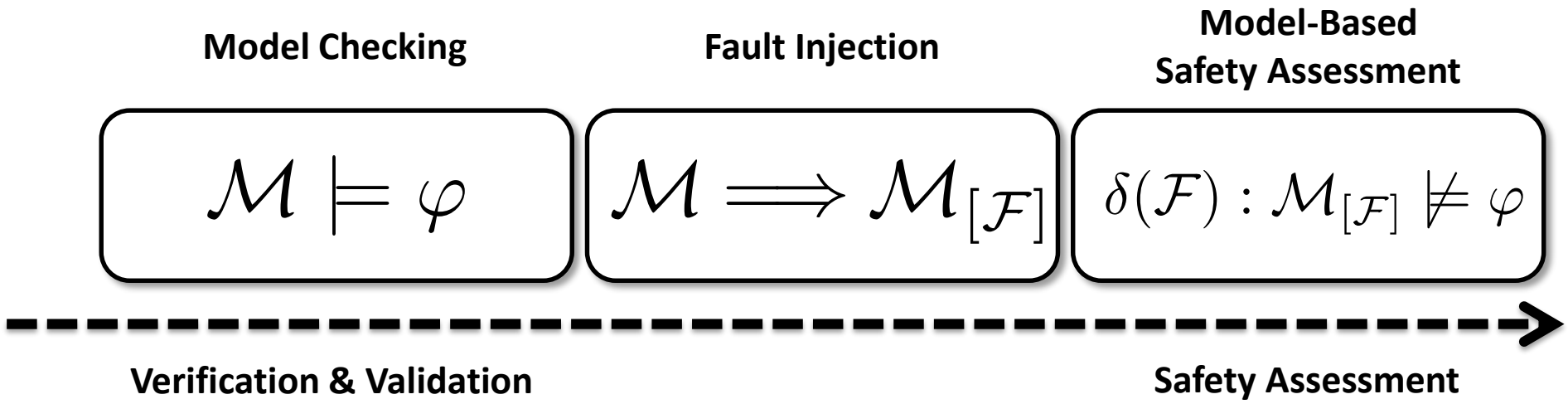

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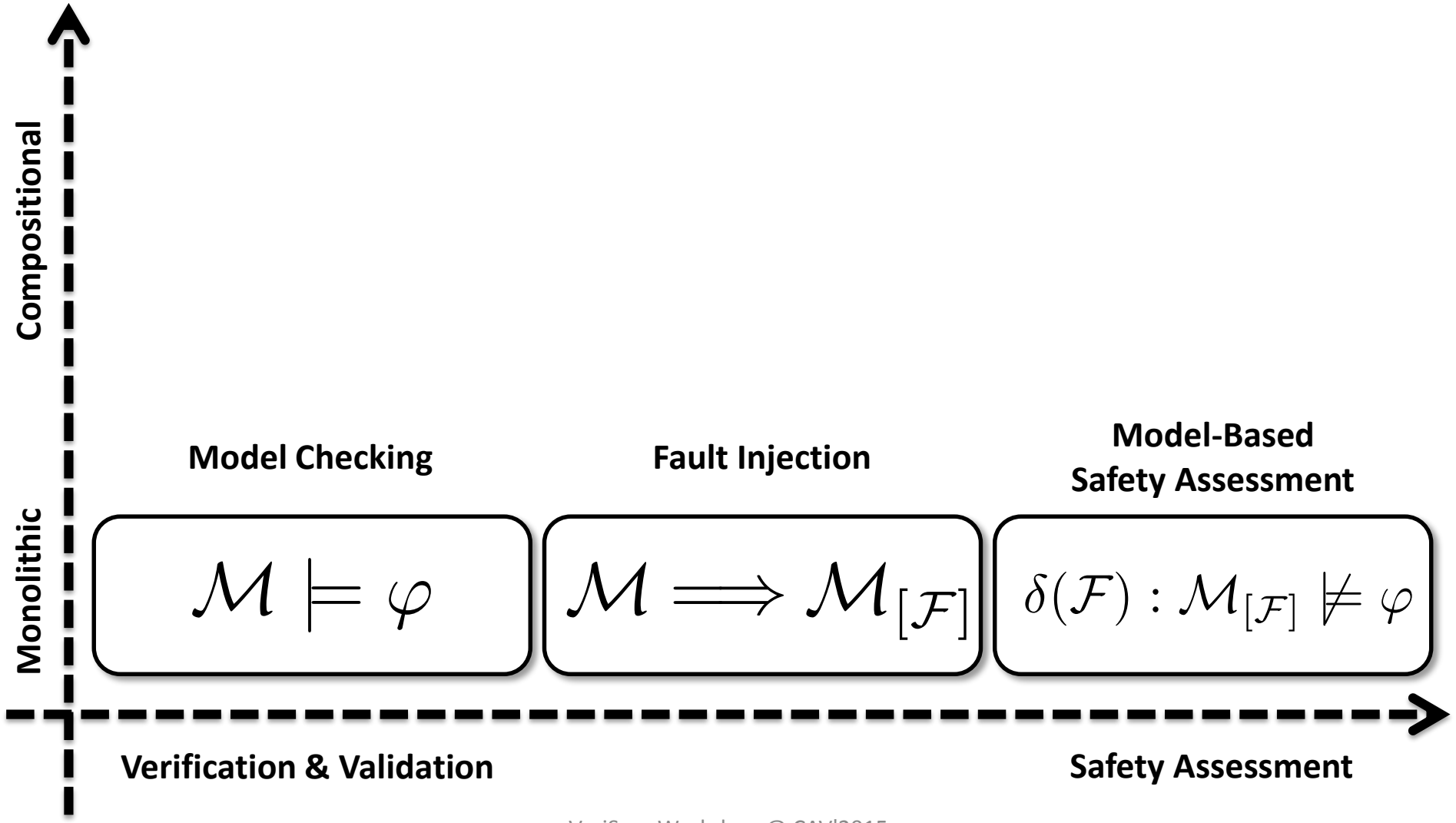

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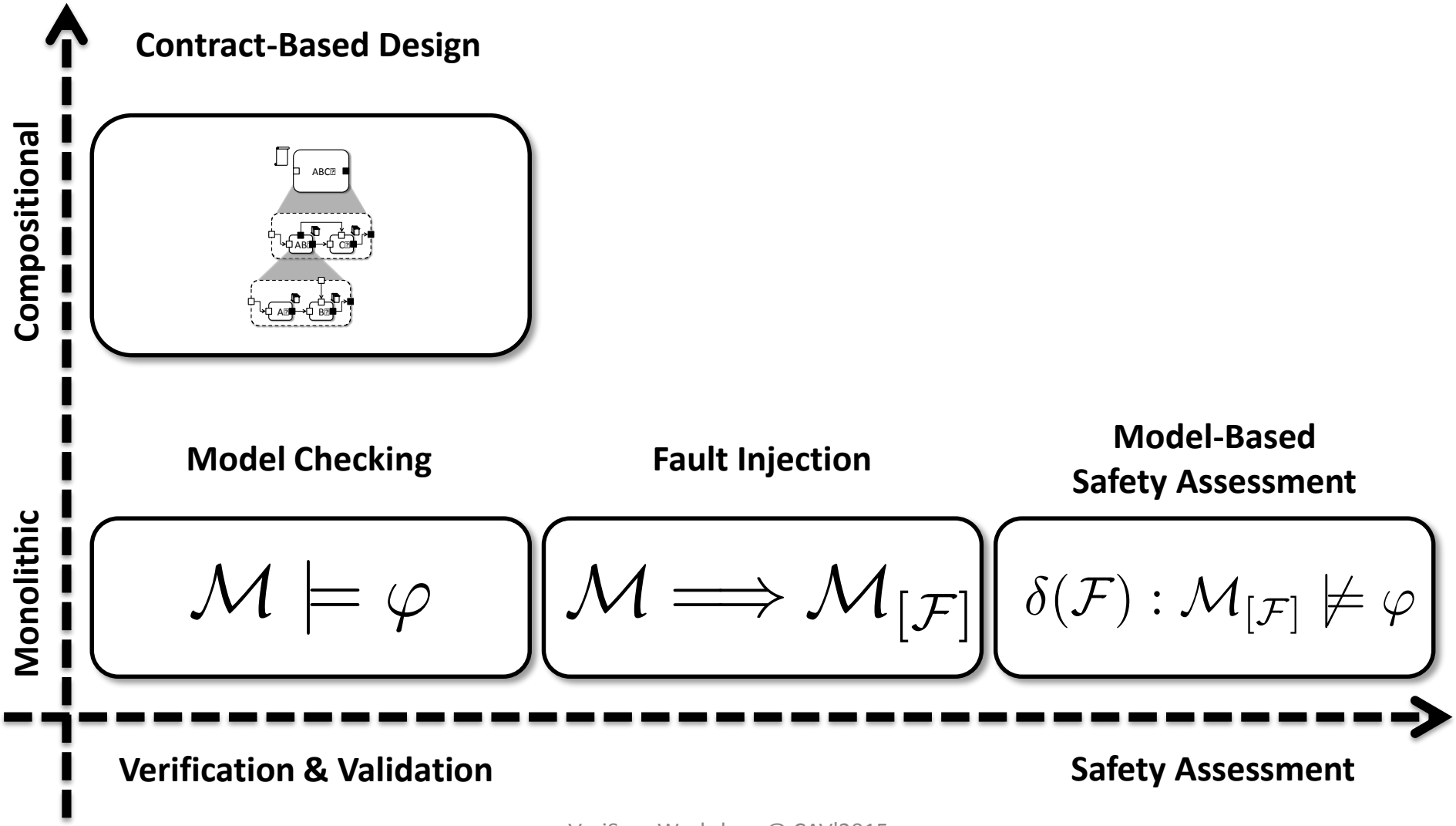

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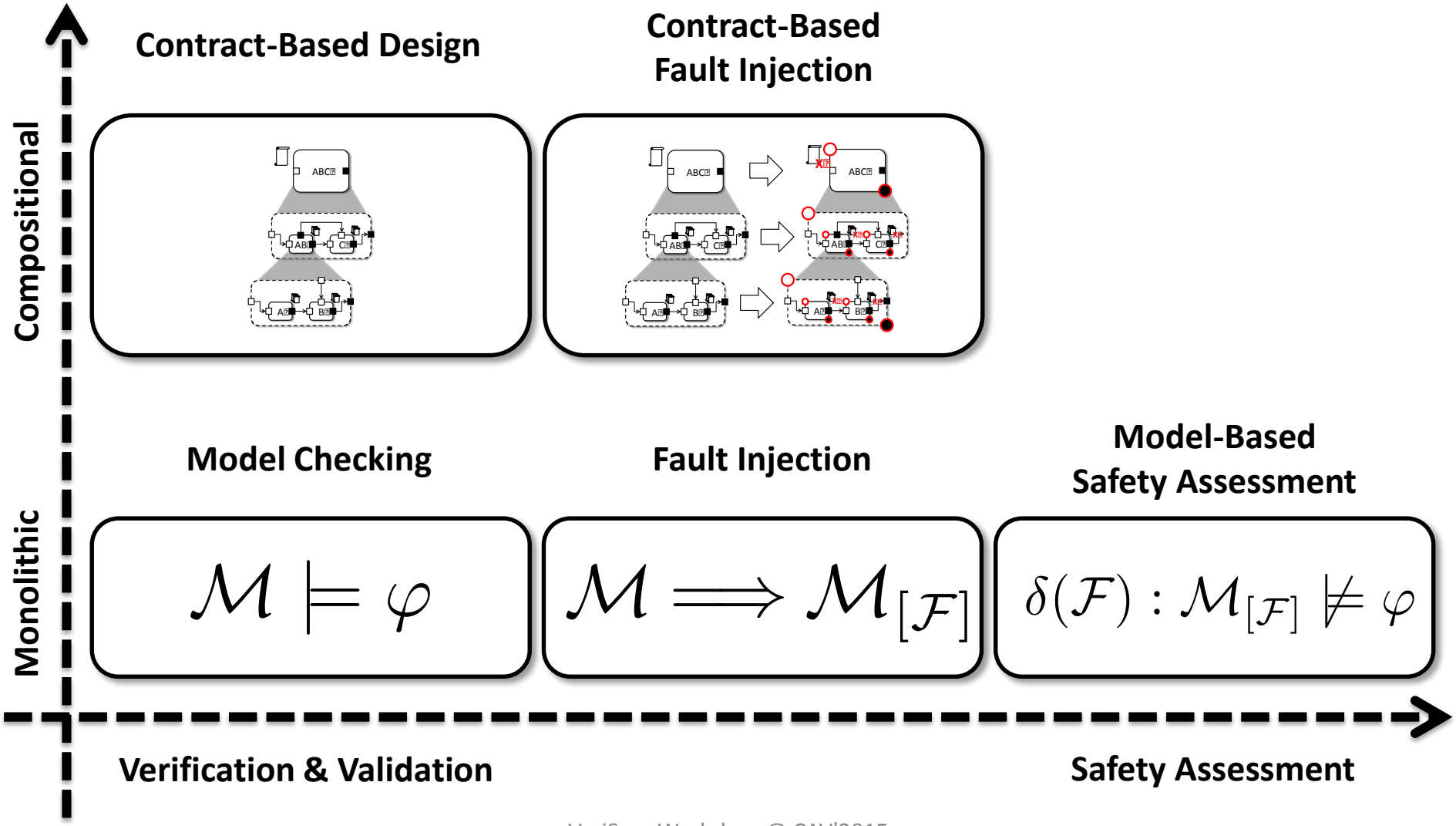

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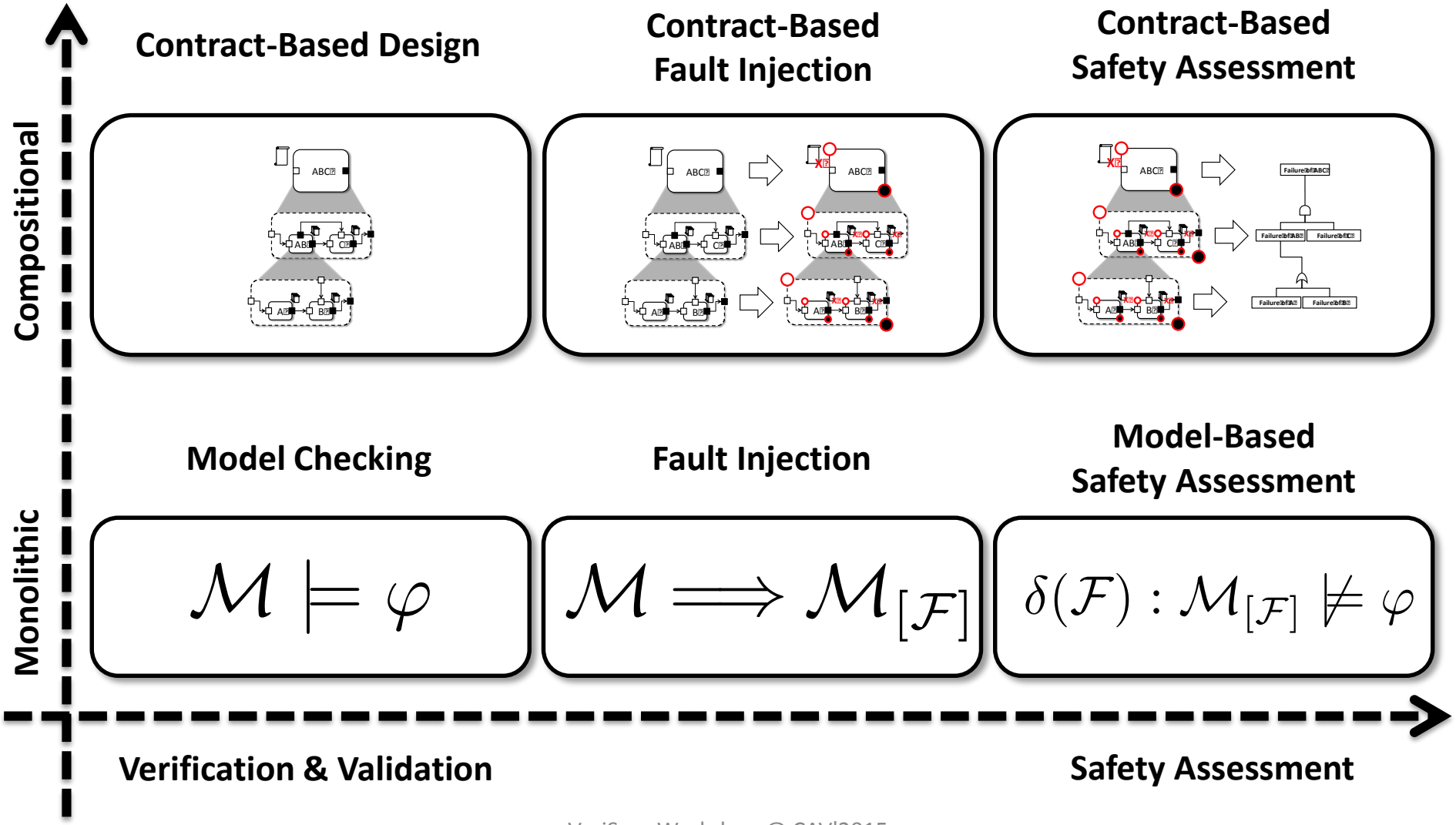

Tool chain

- Infinite-state transition systems
  - The **OCRA** tool for contract-based design
    - http://ocra.fbk.eu/
  - The **nuXmv** model checker
    - http://nuxmv.fbk.eu/
  - The **xSAP** platform for safety analysis
    - http://nuxmv.fbk.eu/

- Hybrid systems
  - **HyCOMP** as a model checker
    - http://hycomp.fbk.eu/

Applications

- Joint project with Boeing on MBSA
  - Formal Design and Safety Analysis of AIR6110 Wheel Brake System [CAV'15]
- Adopted in NASA project on analysis of NextGen
  - Comparing Different Functional Allocations in Automated Air Traffic Control Design [FMCAD'15]
- The COMPASS tool chain
  - AADL modeling language
  - Several projects funded by the European Space Agency

Conclusions and Perspective

- Conclusions
  - New generation of verification techniques
  - Tools integrated into comprehensive process
  - Production of interesting artifacts from unique model

- Integration with assurance? Relevant issues:
  - Tool qualification non trivial
    - One tool vs multiple tools? Tool-to-tool transitions?
  - High level proof production
  - Support to reuse