



CFD Validation Experiments: Toward a Broader Perspective

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AIAA SciTech January 2020

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- **Context: What is a CFD Validation Experiment?**
- **A Case for a Broader Interpretation**
 - Validation Dialog
 - Technique Verification
- **A CFD Validation Experiment Lifecycle**
 - Initiation
 - Design
 - Implementation
 - Analysis
- **Closing Remarks**



What is a CFD Validation Experiment?

- **AGARD CP-437 (CFD Validation Conference) 1988: [1]**
 - *“an experiment that is designed to provide detailed building block data for developing CFD codes. This objective requires that the data be taken in the form and detail consistent with CFD modelling requirements and that the accuracy and limitations of the experimental data be thoroughly understood and documented”*
- **More recently:**
 - AIAA 2014-0205: *“A validation experiment is conducted for the primary goal of determining the predictive capability of a mathematical model of a physical process,”*
 - AIAA 2016-3811: *“A validation experiment is a physical realization of a properly posed applied mathematics problem with initial conditions, boundary conditions, material properties, and external forces” and “Validation experiments are performed to generate data for assessing the accuracy of the mathematical model via simulation outcomes produced by the verified computational model.”*
- **Considered synonymous with a particular type of wind tunnel (WT) test & compared to “traditional experiments” that either:**
 - improve understanding of some physical process;
 - construct, improve or determine parameters in mathematical models of moderately well-represented physical processes; or
 - determine the reliability, performance or safety of components, subsystems or complete systems



A Case for a Broader Interpretation

- **Our proposed definition:**

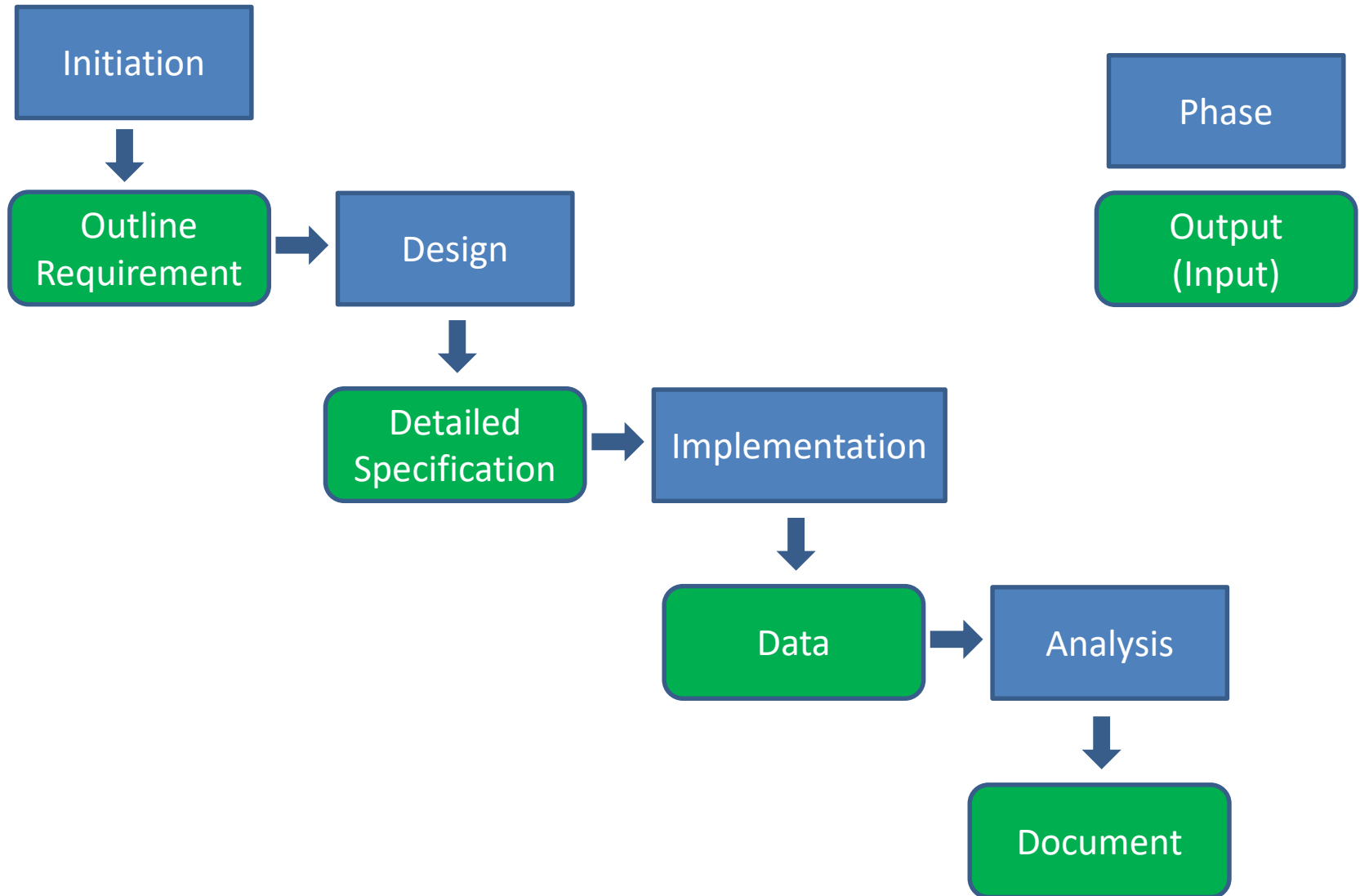
- *“A CFD validation experiment is the process followed from the point at which physical phenomena of interest are first identified, through to that at which the results of CFD computations are compared with physical measurements in a manner that is designed specifically to assess CFD predictive capability.”*
- Not constrained solely to the reference WT tests
- Also covers preliminary CFD and physical testing activities ...
 - and experimentation associated with both
- ... and the conduct of the reference CFD computations

- **Two Key Enablers**

- Validation Dialog:
 - Balanced and synergistic use of physical testing & computational studies
 - Involves:
 - active participation of & communication between all stakeholders;
 - techniques “speaking for themselves”
- Technique Verification:
 - Understanding of underlying principles and practicalities
 - Translation between physical testing and computational modelling
 - Decision making and prioritization guided by Validation Dialog

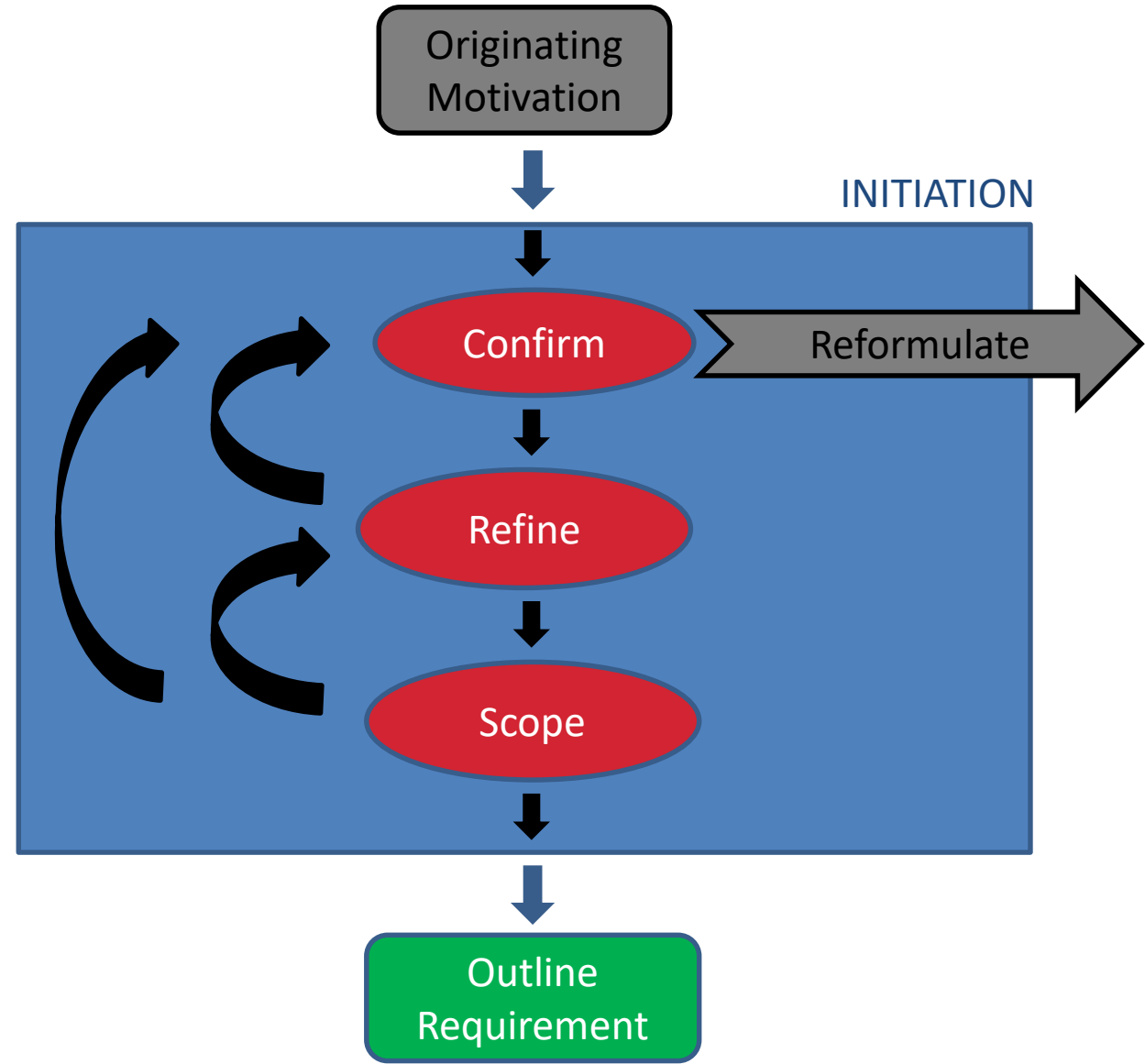
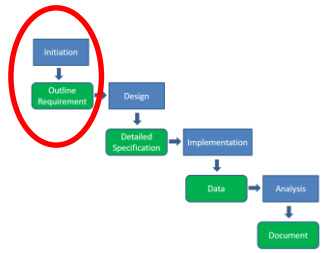


Schematic of a CFD Validation Experiment Lifecycle



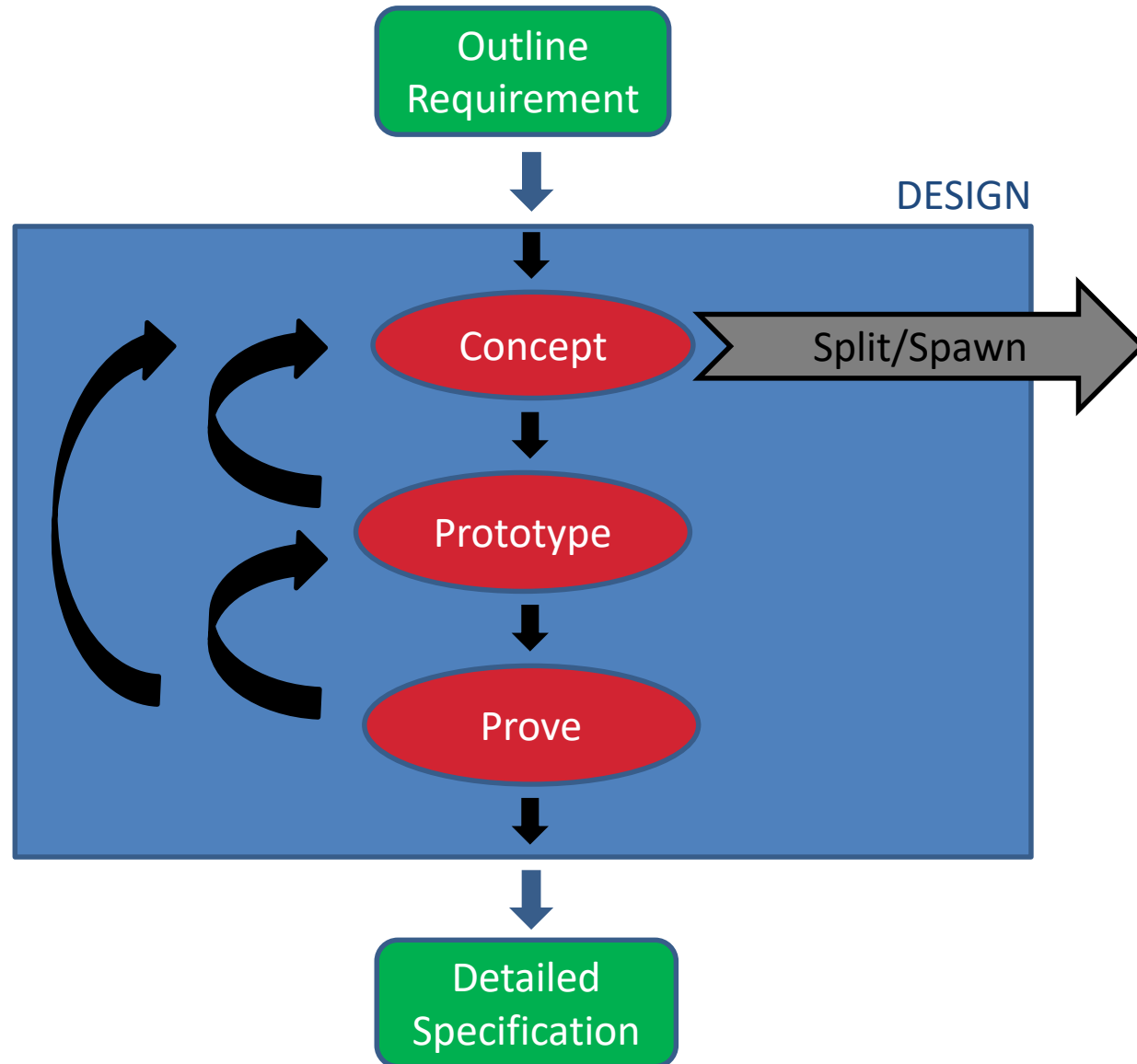
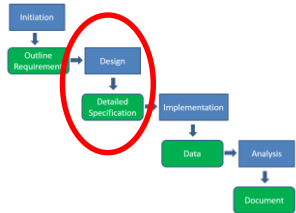


Initiation Phase



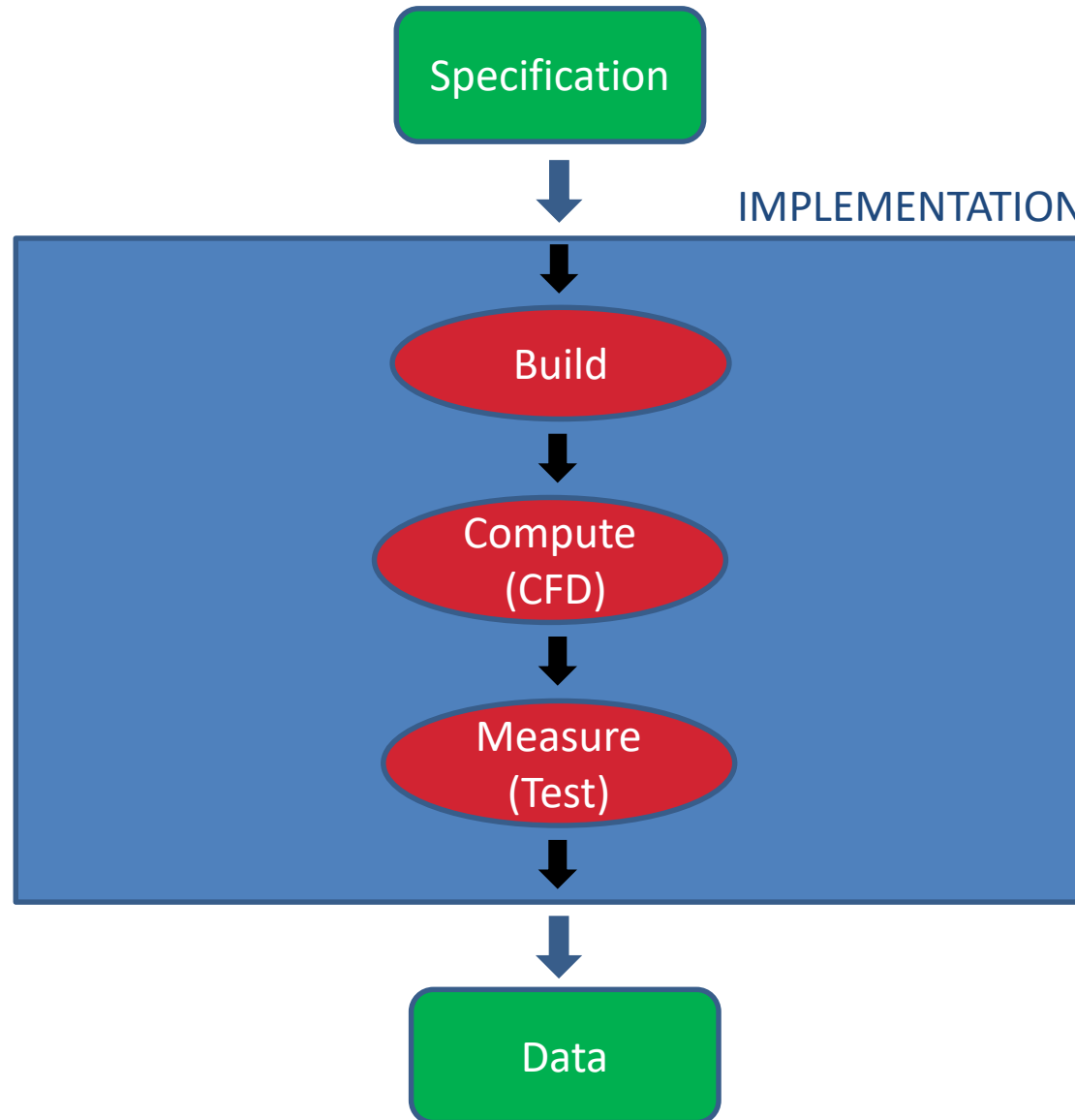
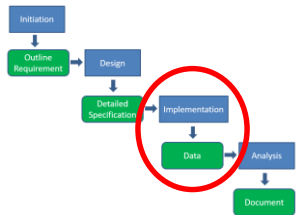


Design Phase



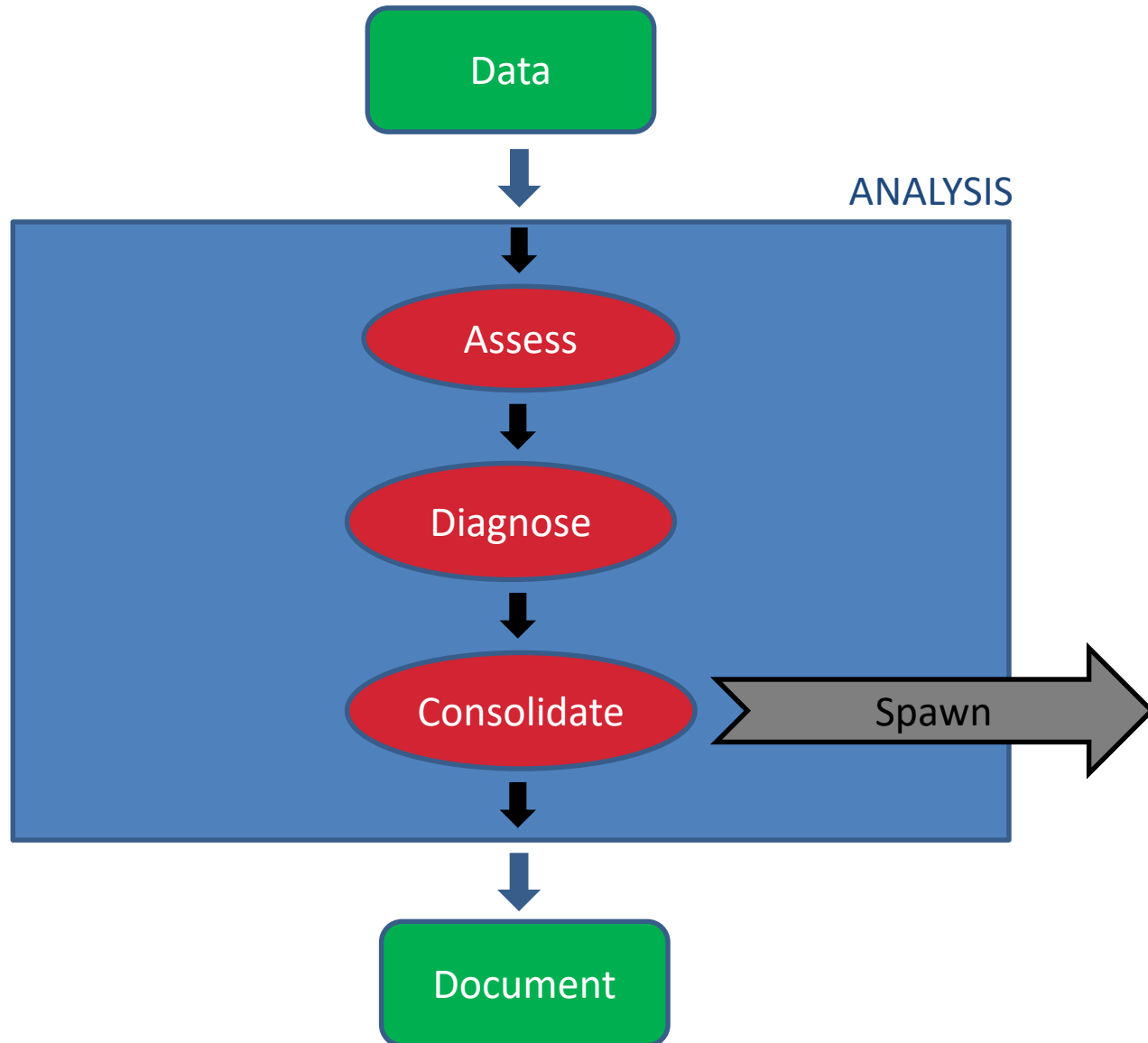
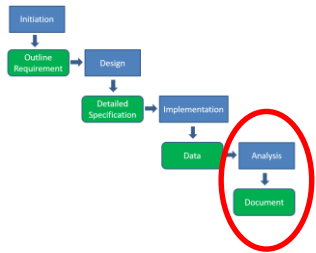


Implementation Phase





Analysis Phase





- **We have proposed a broader definition of a CFD Validation Experiment that:**
 - More directly acknowledges the importance of exploiting the capabilities of CFD and physical testing techniques in balanced, synergistic ways
 - Encourages wider recognition of the value of what might otherwise be considered studies of lesser importance
 - Preliminary computational studies and ground tests driving developments in related technologies – metrology, for instance
 - Broadens the stakeholder community
- **In turn, this is expected to encourage the adoption of more systematic approaches to complex problems**
 - such that they are more readily broken-down into smaller, more focused endeavors,
 - while at the same time making them easier to fund
- **It is hoped that this will help further the development of predictive CFD capabilities and support the realization of Certification by Analysis**



Thank You For Your Attention

Any Questions?