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A Model Based Systems Engineering Approach to Communicating and Verifying Dynamic Requirements in Contracted System Development

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26 October 2018

The views expressed in this presentation are the work of the author and do not necessarily represent the views of DoD or the United States Government

- **Motivation**
- **Problem Exploration**
- **Proposed Solution**
- **Next Steps**
- **Questions**

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Motivation

*"Mission complexity is **growing faster than our ability to manage it** . . . increasing mission risk from inadequate specifications and incomplete verification."* INCOSE SE Vision 2025

> *"Often the acquisition engineering processes are **document-intensive** and stove-piped, leading to **extended cycle times** with systems that are **cumbersome to change and sustain**… Current acquisition processes and engineering methods **hinder meeting the demands** of exponential technology, growth and access to information."* DoD Digital Engineering Strategy

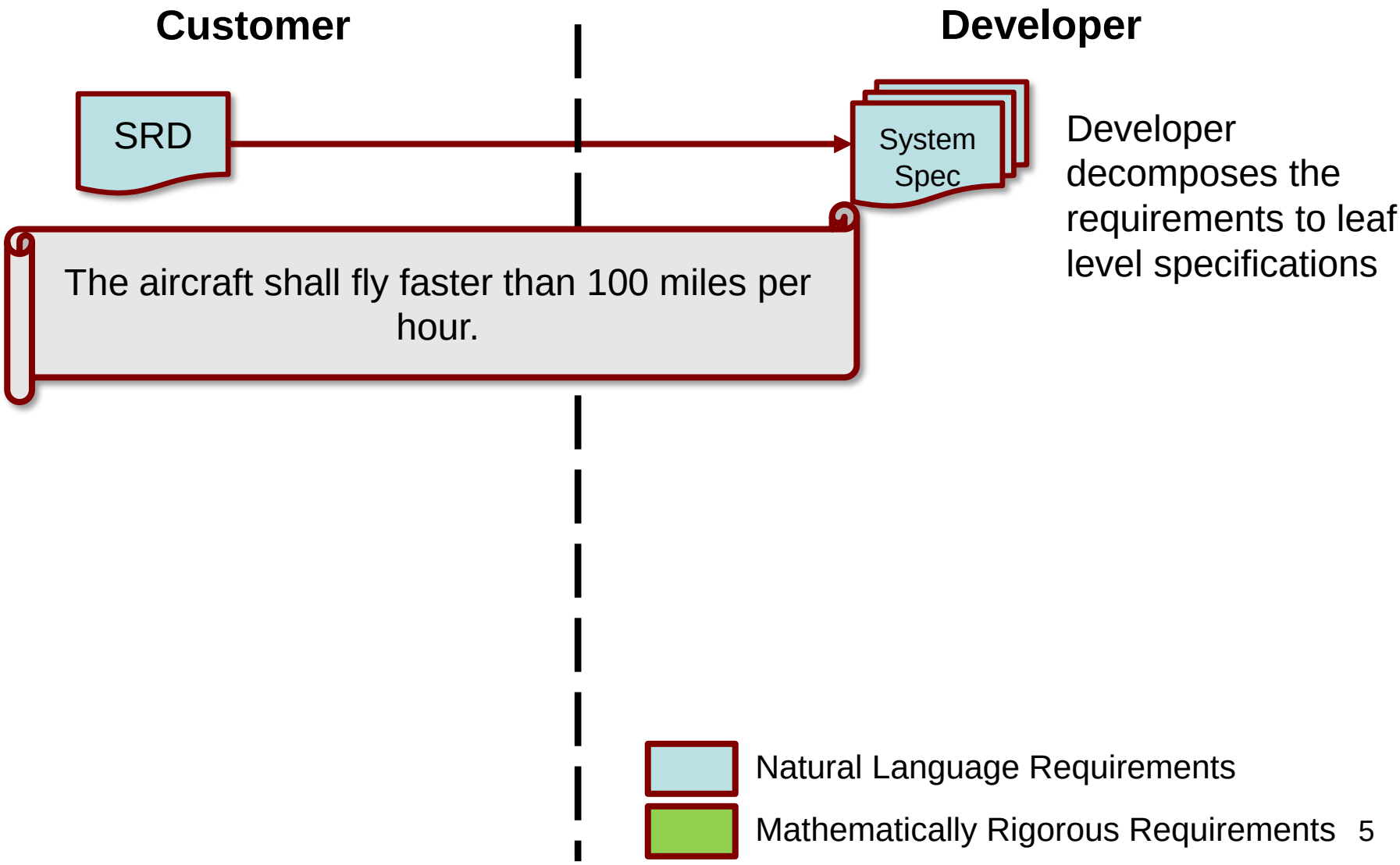
"Model-based approaches will move engineering and management from paper documentation as a communications medium to a paperless environment, by permitting the capture and review of systems design and performance in digital form." INCOSE SE Vision 2025

DoD Digital Engineering Strategy, Office of the Deputy Assistant Secretary of Defense for Systems Engineering, Washington DC, June 2018
INCOSE Systems Engineering Vision 2025, INCOSE SE Vision Team, 2014

PROBLEM

How is contracted system development different and why isn't it experiencing the benefits of MBSE?

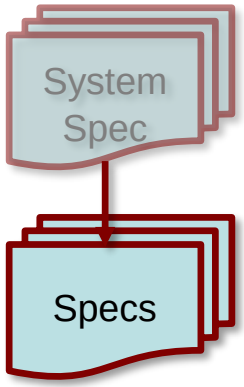
Problem – SE in Contracted System Development Today



Problem – SE in Contracted System Development Today

Customer

Developer



Developer allocates leaf-level specifications to system components

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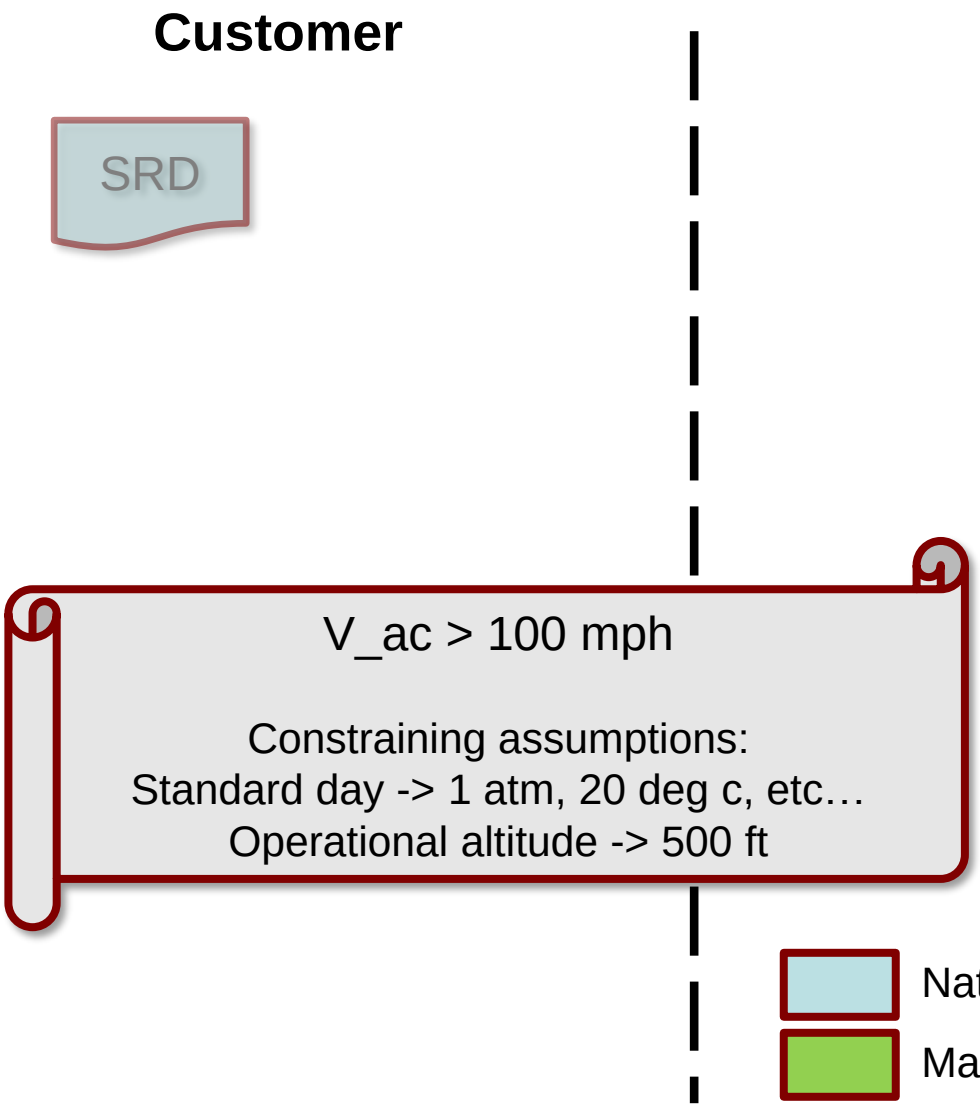
Problem – SE in Contracted System Development Today



Developer translates natural language component specifications into quantitative design constraints

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Problem – SE in Contracted System Development Today

Customer

SRD

Developer

System Spec

Specs

Design Constraints

Developer designs and implements system IAW constraints

System Design

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Problem – SE in Contracted System Development Today

Customer

SRD

V_ac_demonstrated = 100 mph

Test conditions:
Standard day -> 1.01 atm, 22 deg c, etc…
Operational altitude -> 499 ft

Developer

System Spec

Specs

Design Constraints

System Design

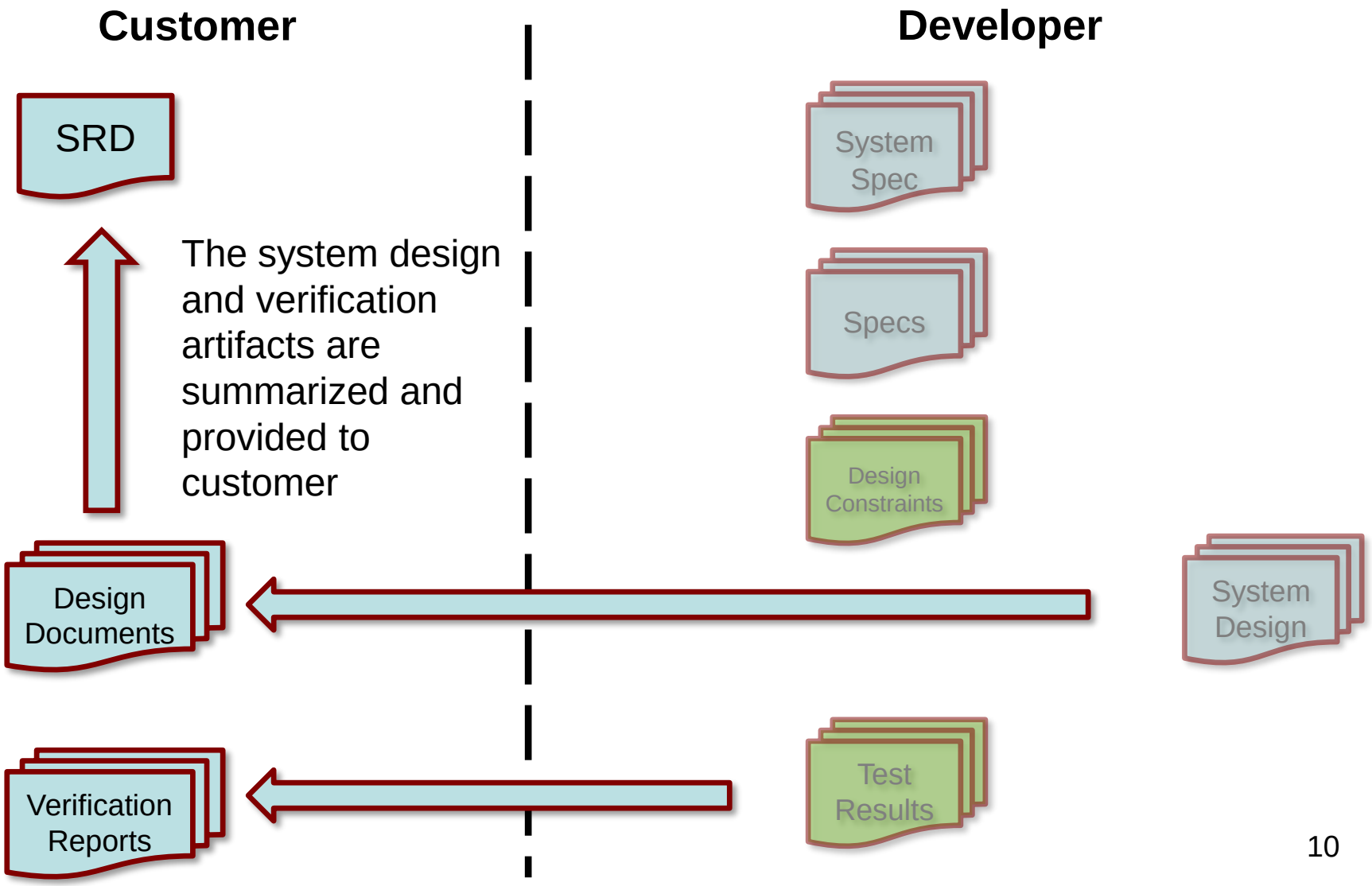
Test Results

The system is evaluated against the design constraints to create verification artifacts

Artifacts will vary based on stage of design…

- Predictions
- Analysis/M&S results
- Test results

Problem – SE in Contracted System Development Today



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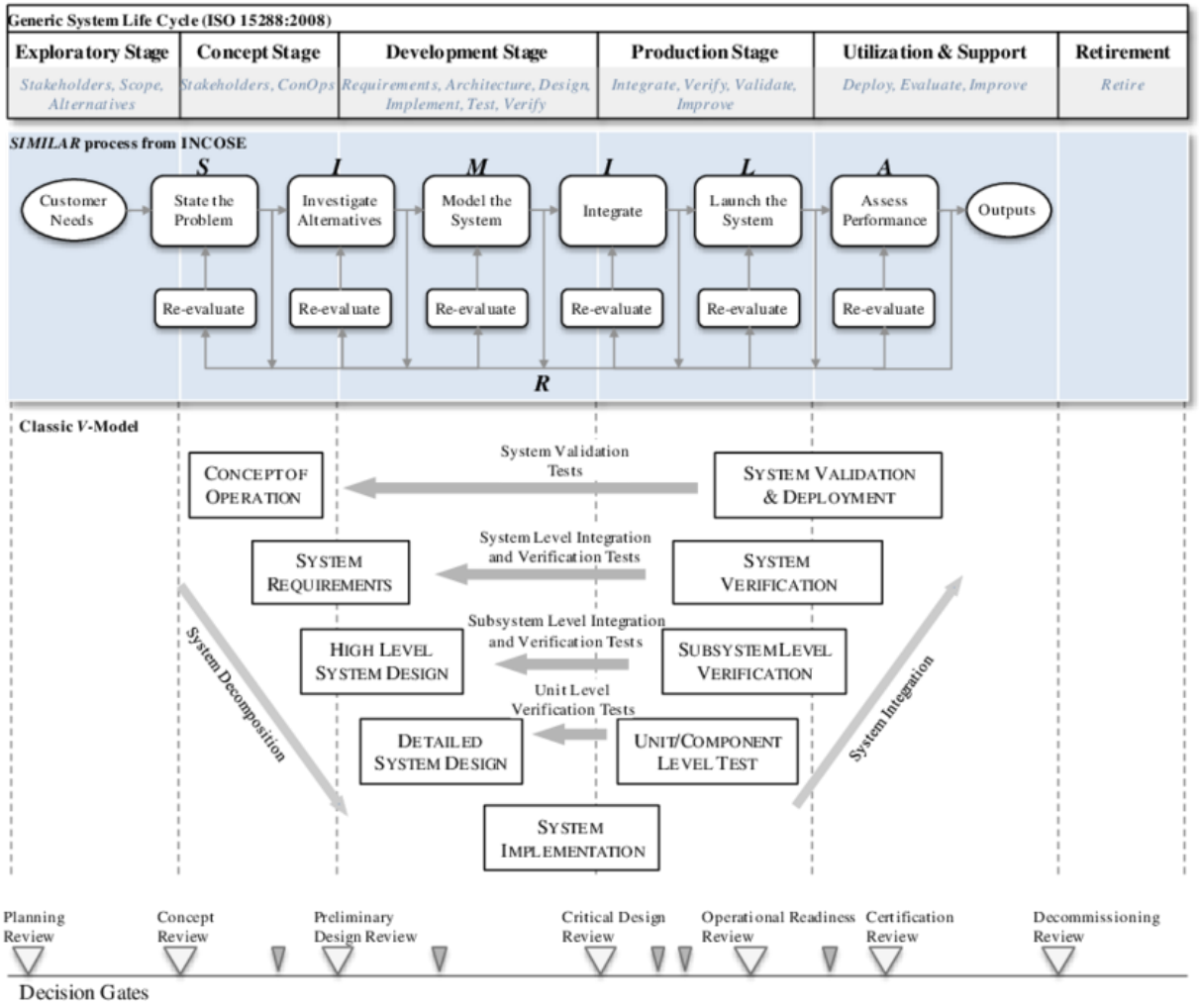

How is consistency and traceability maintained over time??

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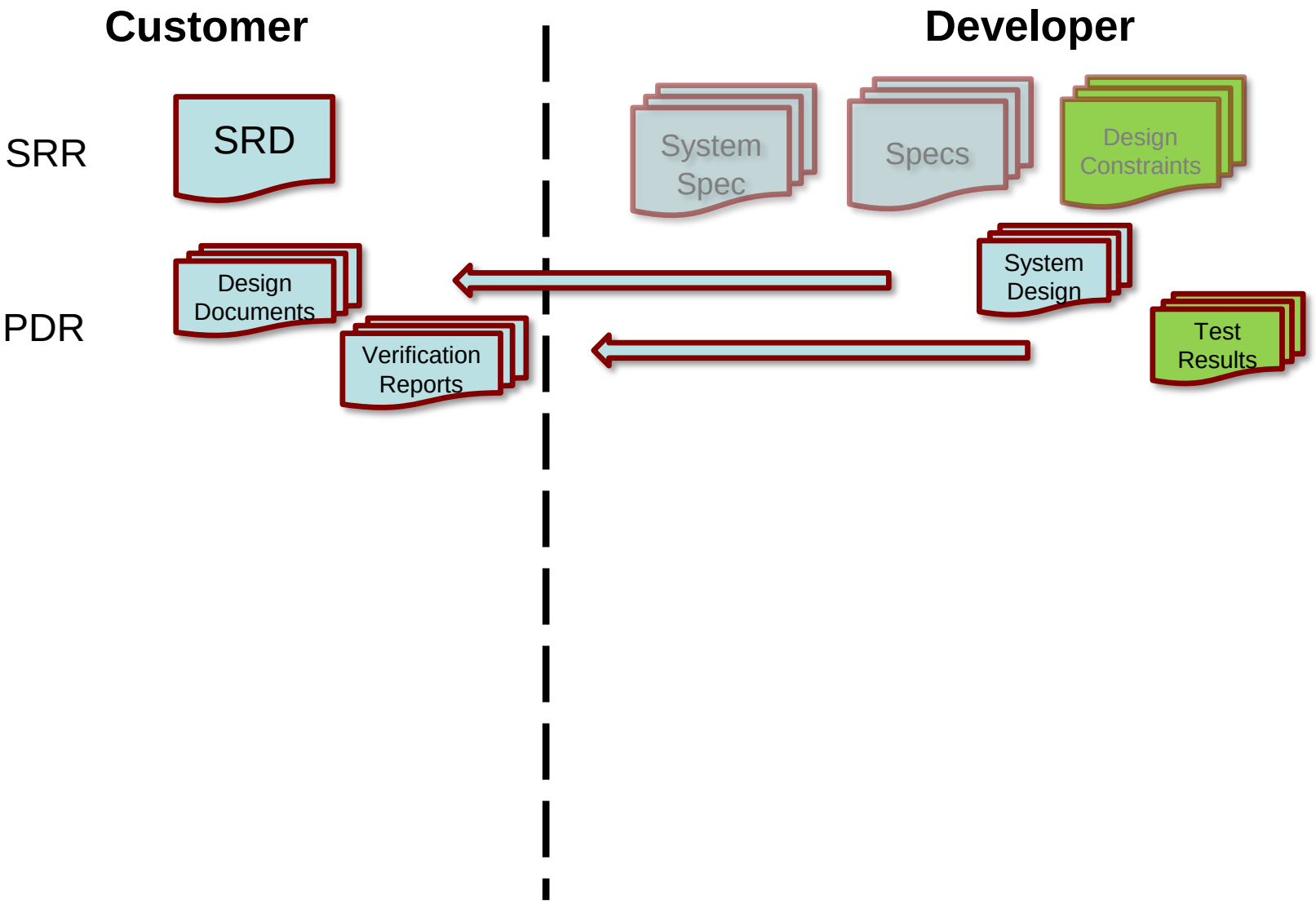
Problem – SE in Contracted System Development Today

Customer

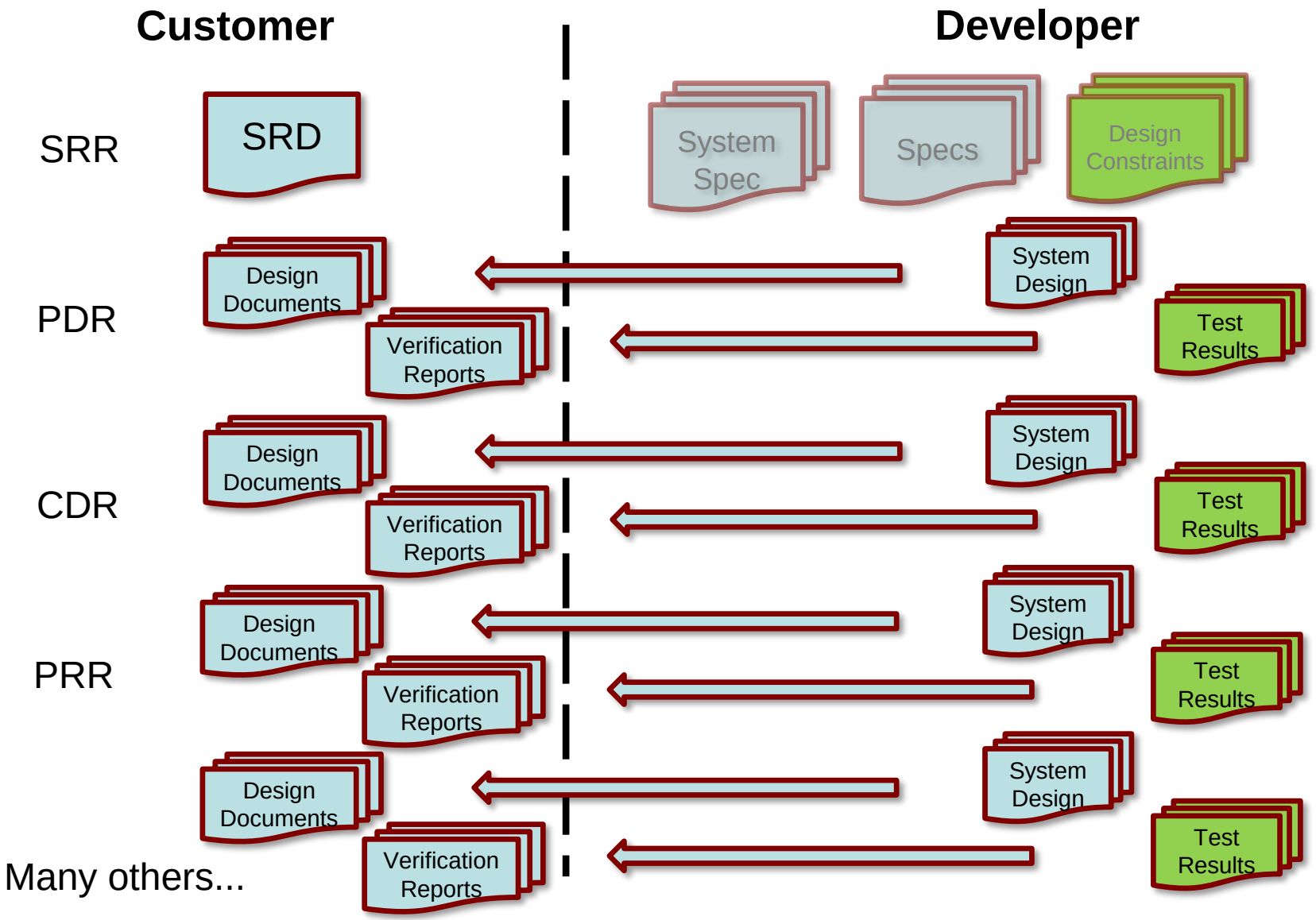
SRR

Developer

Problem – SE in Contracted System Development Today



Problem – SE in Contracted System Development Today



Many others...

Problem – Developer Traceability

Customer

SRR

PDR

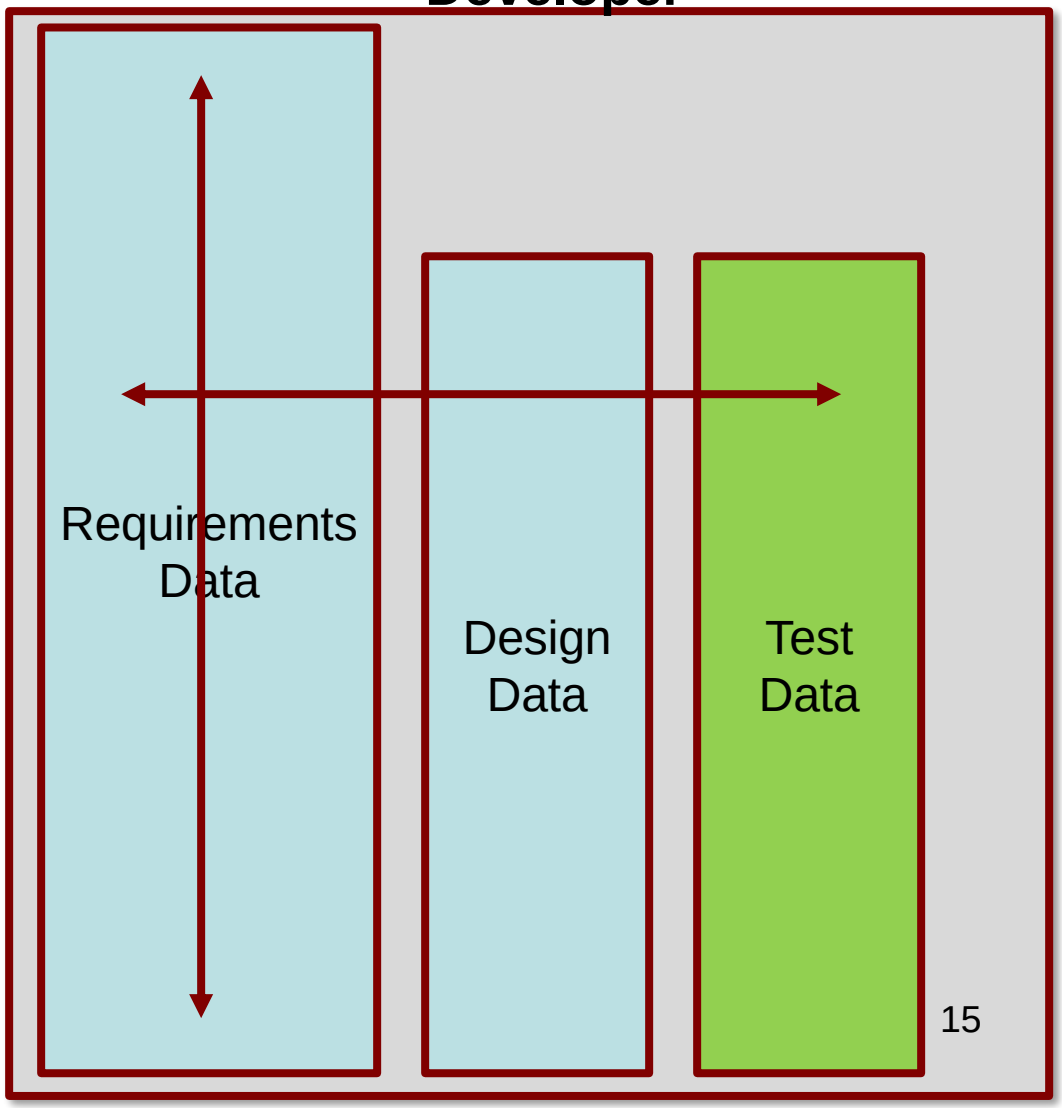
CDR

PRR

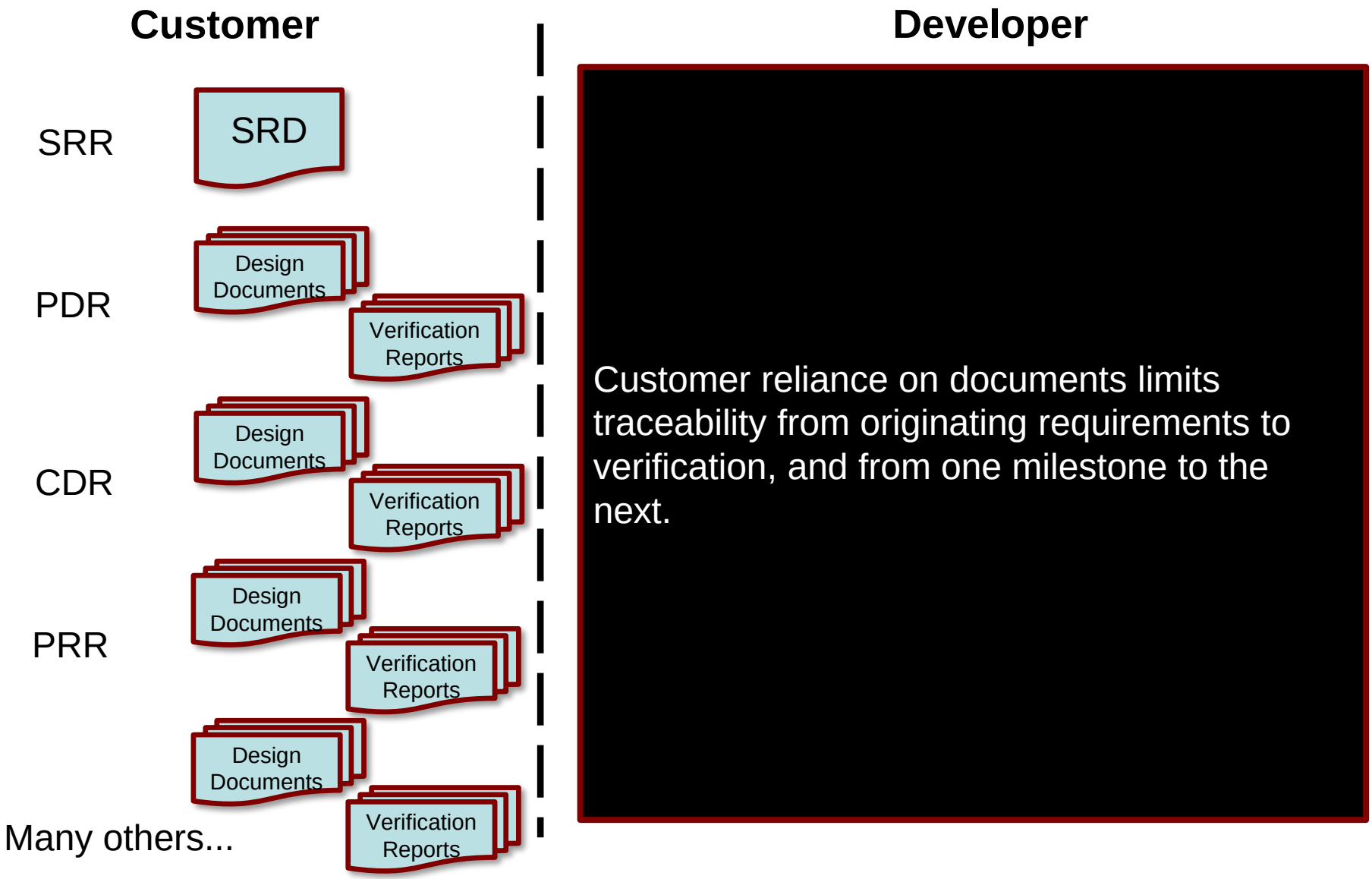
Many others...

Models enable traceability from requirements to verification AND from project initiation to completion

Developer



Problem – Customer Traceability



What is the Problem?

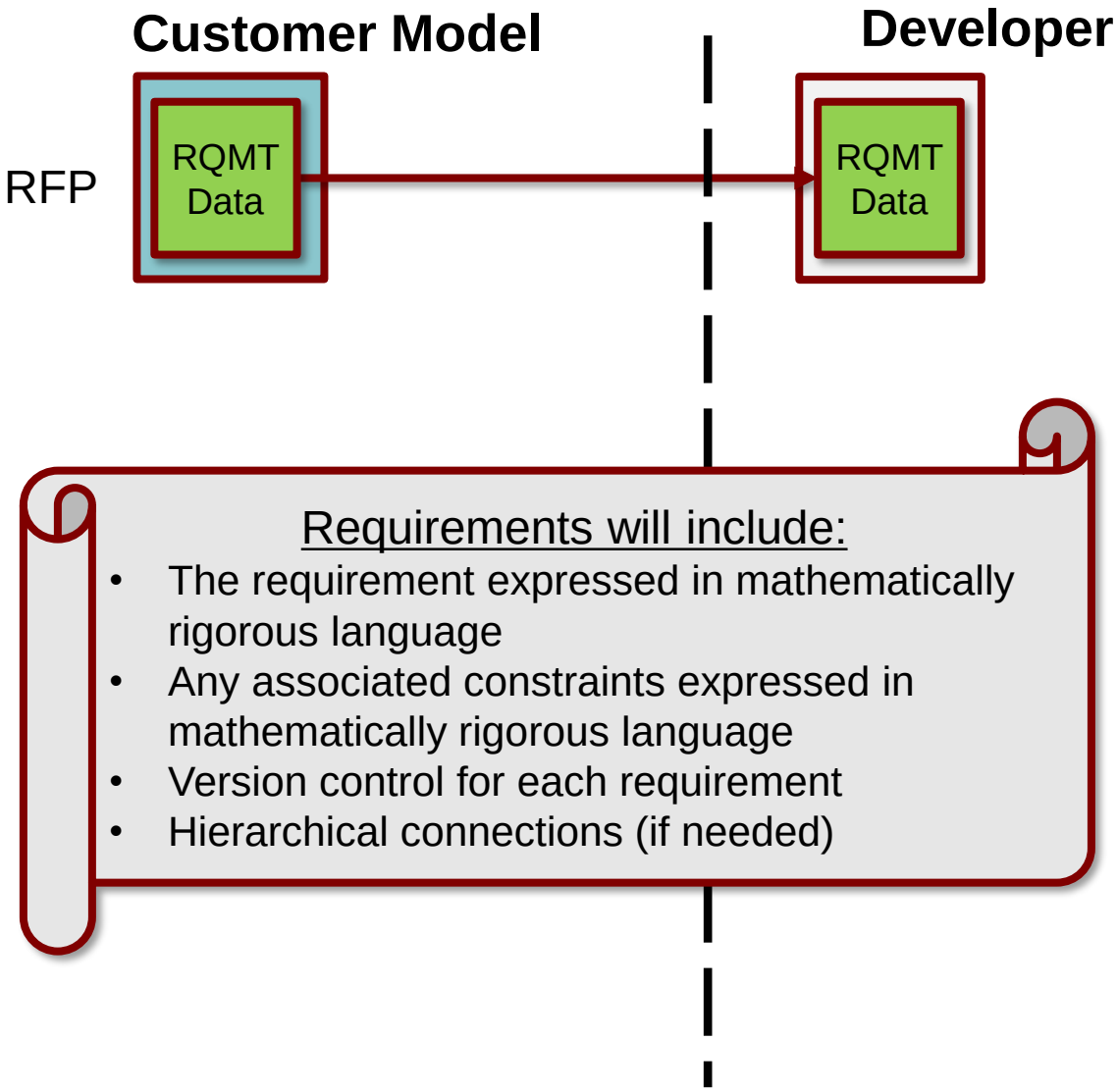
- **At each design review, the customer verifies that the developer will meet each requirement.**
  - Starts with the requirement and trace through contractor design review package to positively assert that the requirement will be satisfied
  - Document based traceability usually flows the opposite direction:
    - Example: The test results reference the requirement document, but the requirement document does not reference the test results that satisfy it
- **Document based verification requires cross referencing across multiple documents, created at different points of the program.**
- **Use of documents rather than models limits the ability to use tools to assist this process**

PROPOSED SOLUTION

Solution – What is needed?

- **A method that provides explicit bi-directional traceability from originating requirements to verification artifacts**
- **Supports rapid and accurate verification throughout program lifecycle**
  - **From early design reviews throughout delivery until disposal**
  - **Minimized requirement ambiguity**
- **Other goals**
  - **Respects data right concerns: Developers consider their model based approaches proprietary**
  - **Portability: Not a tool specific approach**

Solution – Model Based Requirement Verification



Customer provides requirements in model form as part of RFP

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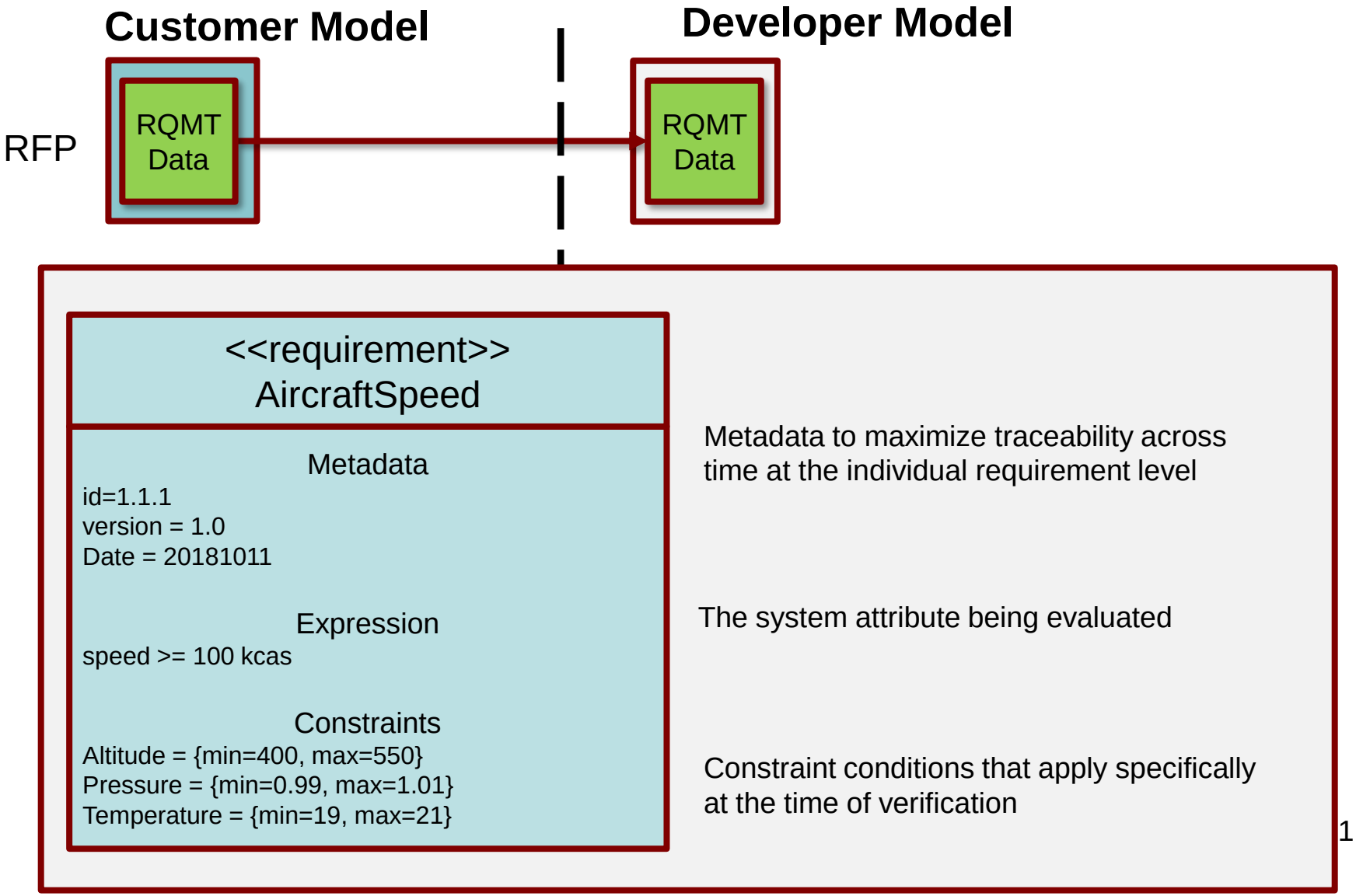
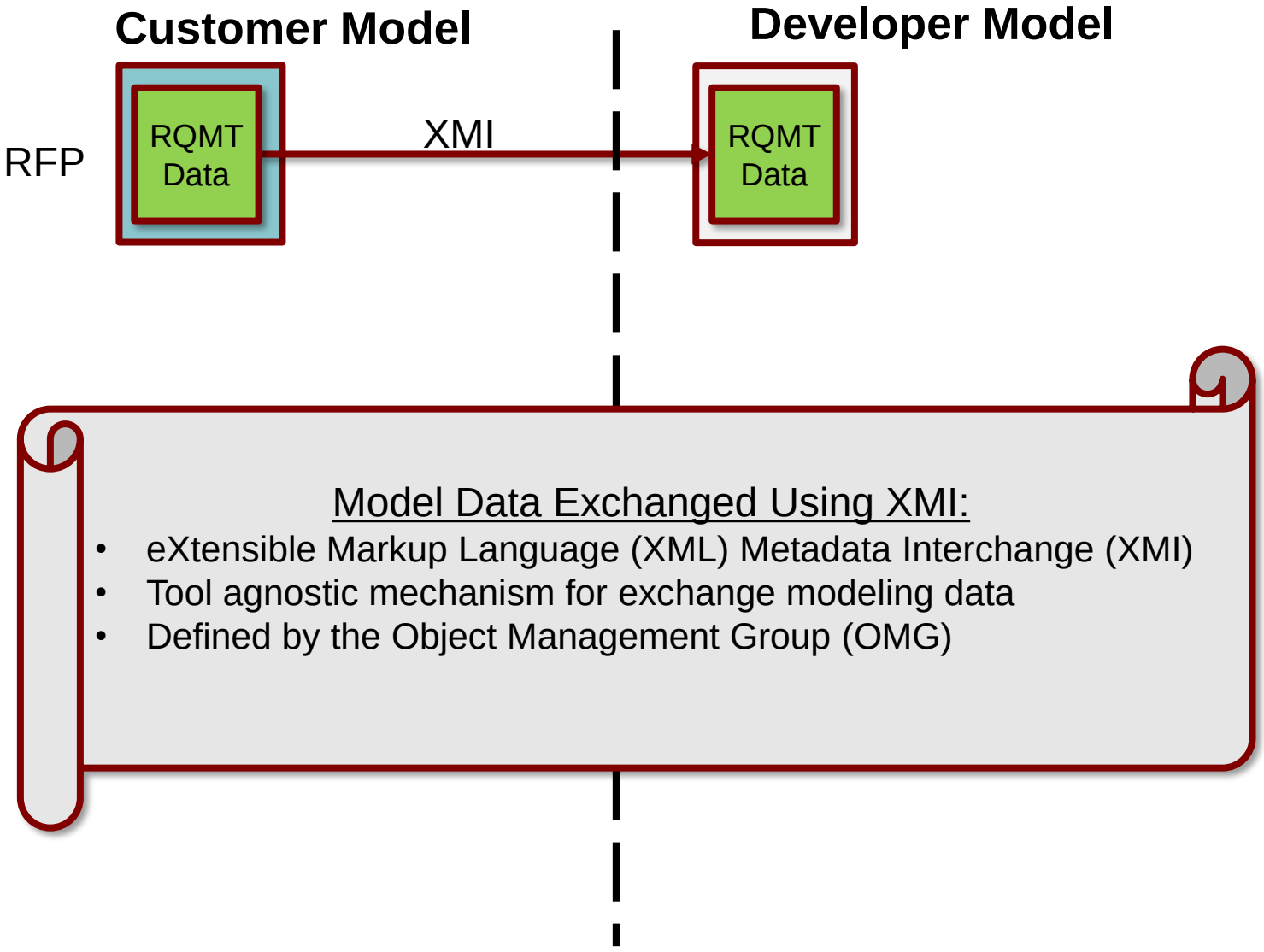
Solution – Model Based Requirement Verification



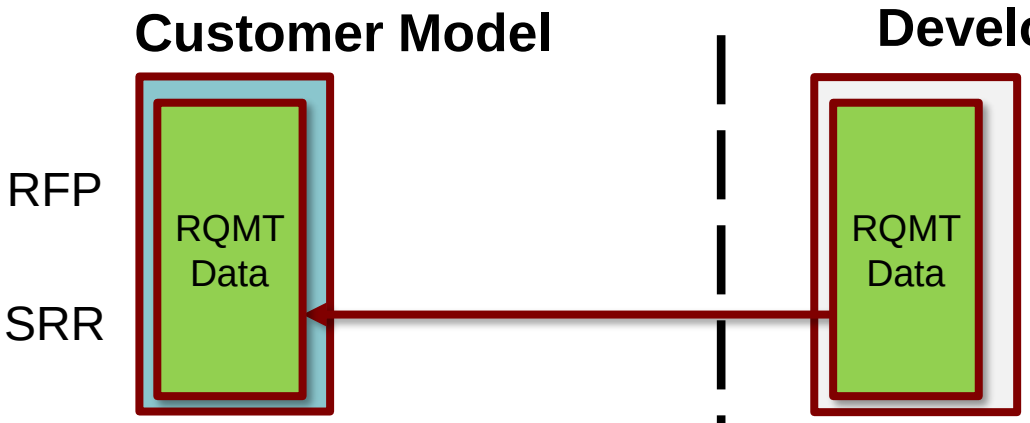
Solution – Model Based Requirement Verification



Model Data Exchanged Using XMI:

- eXtensible Markup Language (XML) Metadata Interchange (XMI)
- Tool agnostic mechanism for exchange modeling data
- Defined by the Object Management Group (OMG)

Solution – Model Based Requirement Verification



Developer allocates leaf-level specifications to system components and provides customer update model data using model interchange format

Data would include:

- Any decomposition required to show verification of the requirement
- Any updated constraints needed to refine requirement

Data would not include:

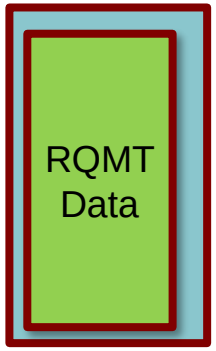
- Detailed component design constraints not directly related to system requirements

Solution – Model Based Requirement Verification

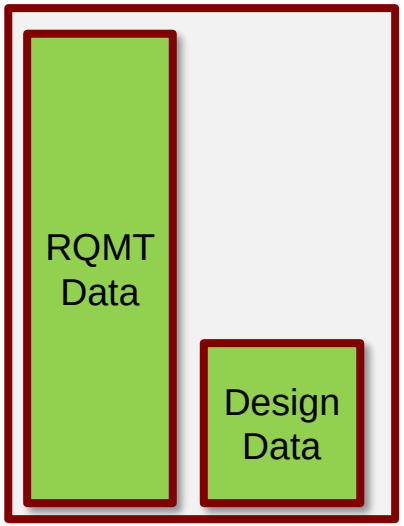
Customer Model

RFP

SRR

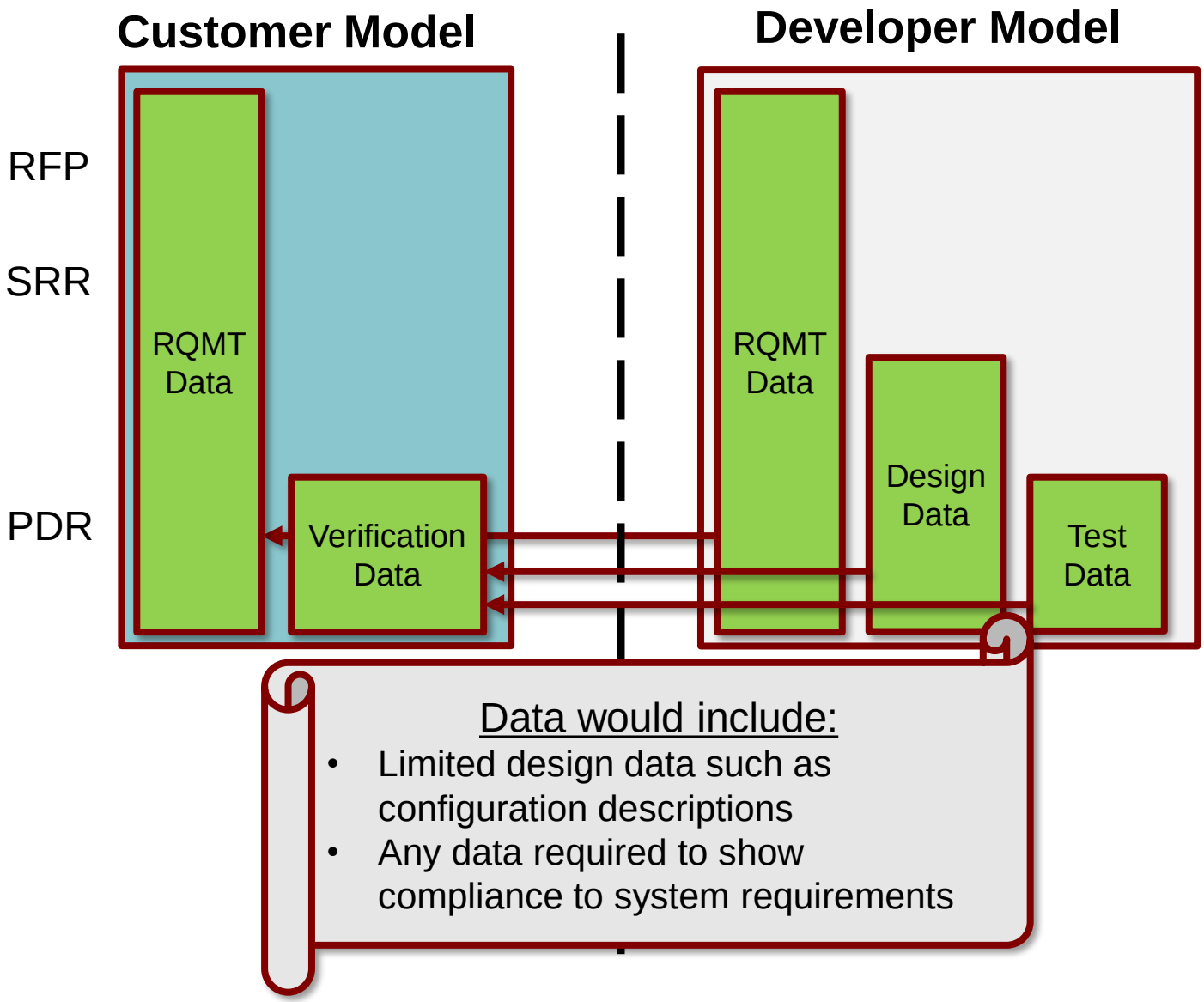


Developer Model



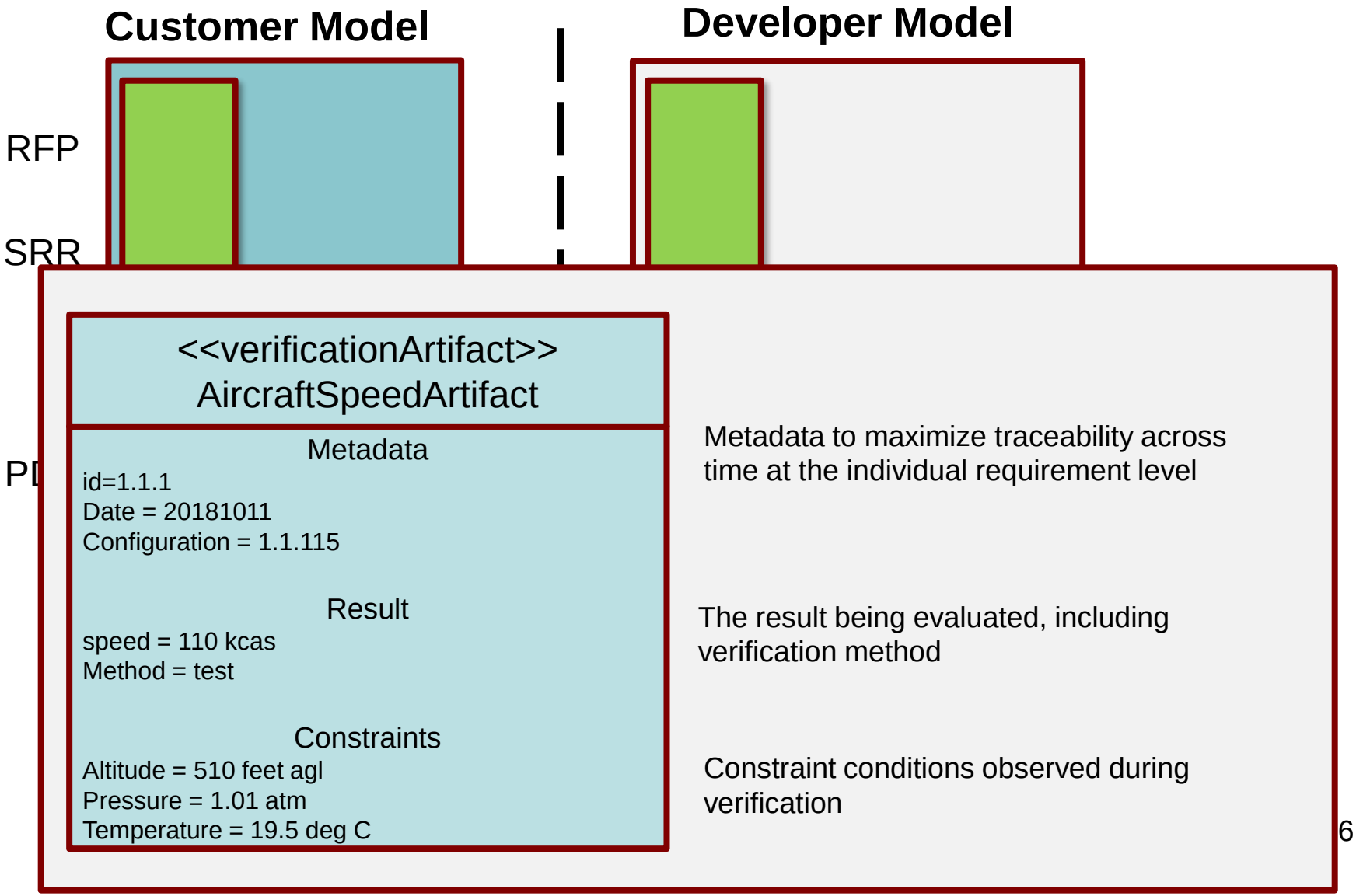
Developer designs and implements system

Solution – Model Based Requirement Verification

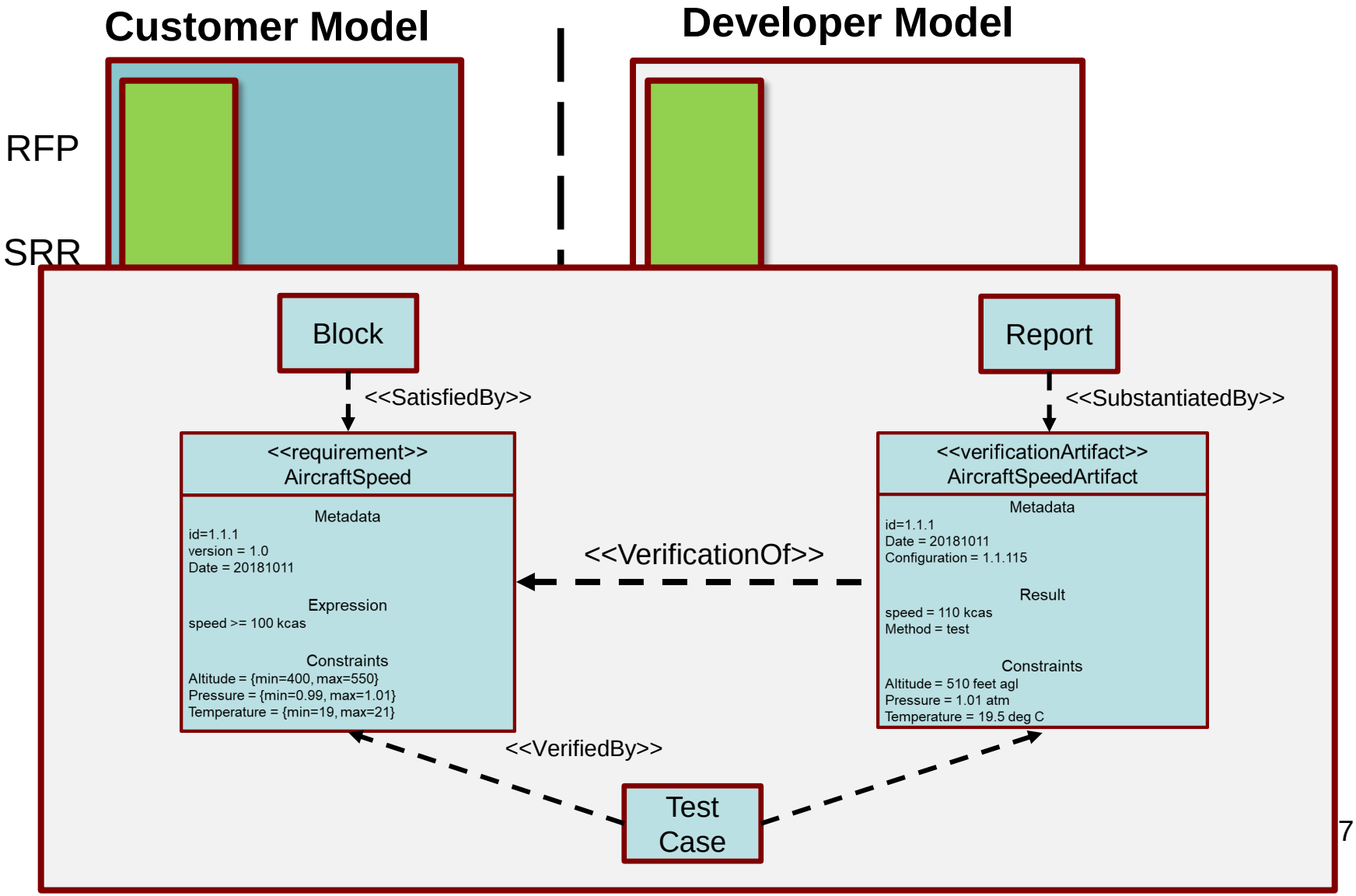


Developer performs early analysis to predict system performance. Developer provides data to customer in model interchange format

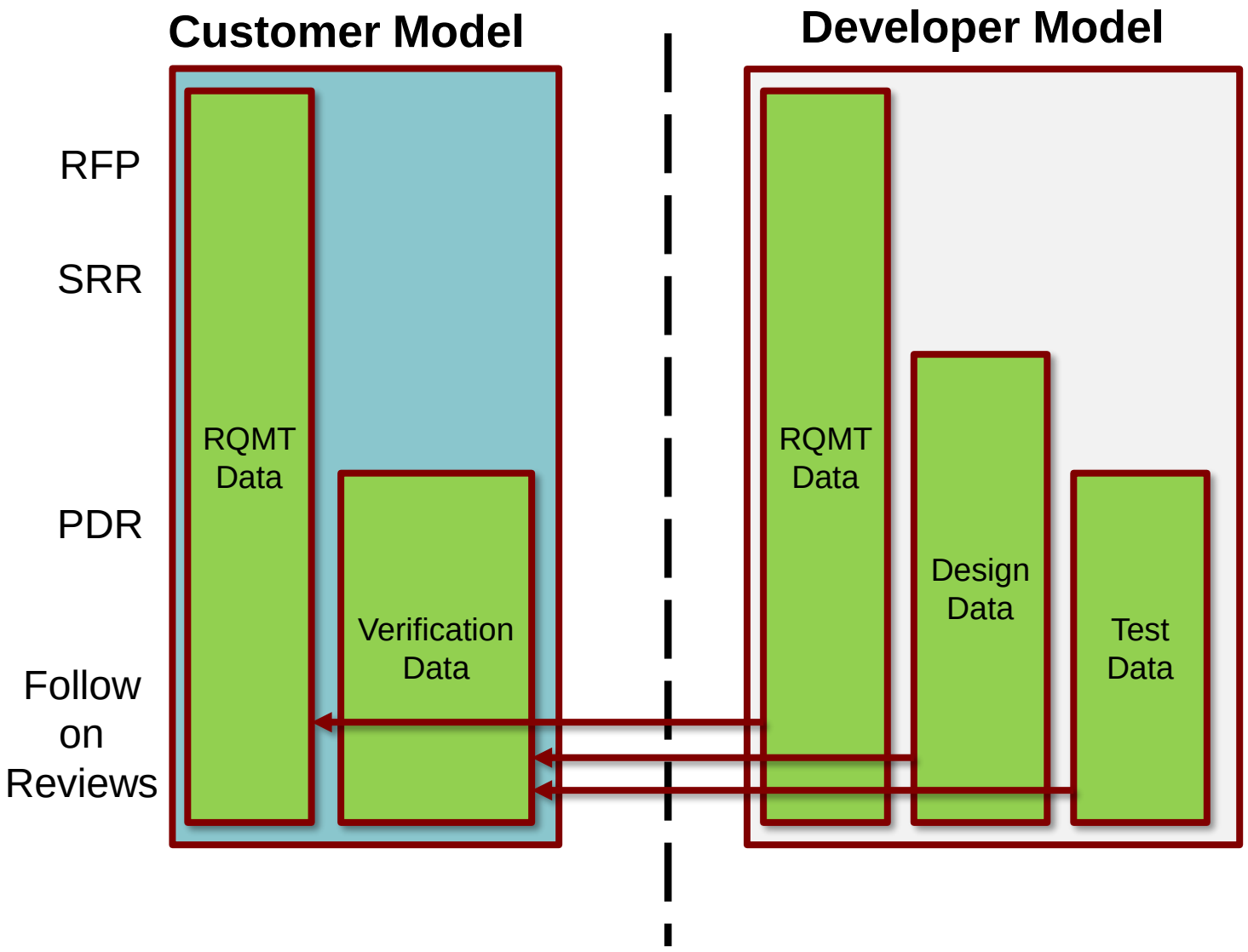
Solution – Model Based Requirement Verification



Solution – Model Based Requirement Verification



Solution – Model Based Requirement Verification



Developer updates models as system design and verification progresses.

NEXT STEPS

Next Steps

- **Phase 1: Development of SysML profile**
  - Requirements model requires updates for automated evaluation
    - Support for quantitative requirements
    - Constraints evaluated for each requirement
    - Additional requirement metadata (ex: configuration)
  - SysML currently does not support capturing performance data at the system level
- **Phase 2: Toy problem development**
  - Utilize example of a small UAS
  - Explore utilization of SysML profile to prepare it for next phase
- **Phase 3: Experimentation**
  - Build a challenge problem using existing system data
  - Have reviewers evaluate the system using both the original method and the new method to determine whether it shows improvement

Questions

Questions?

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