33rd Annual INCOSE international symposium

hybrid event

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Integration of Technical Management and System Architectures

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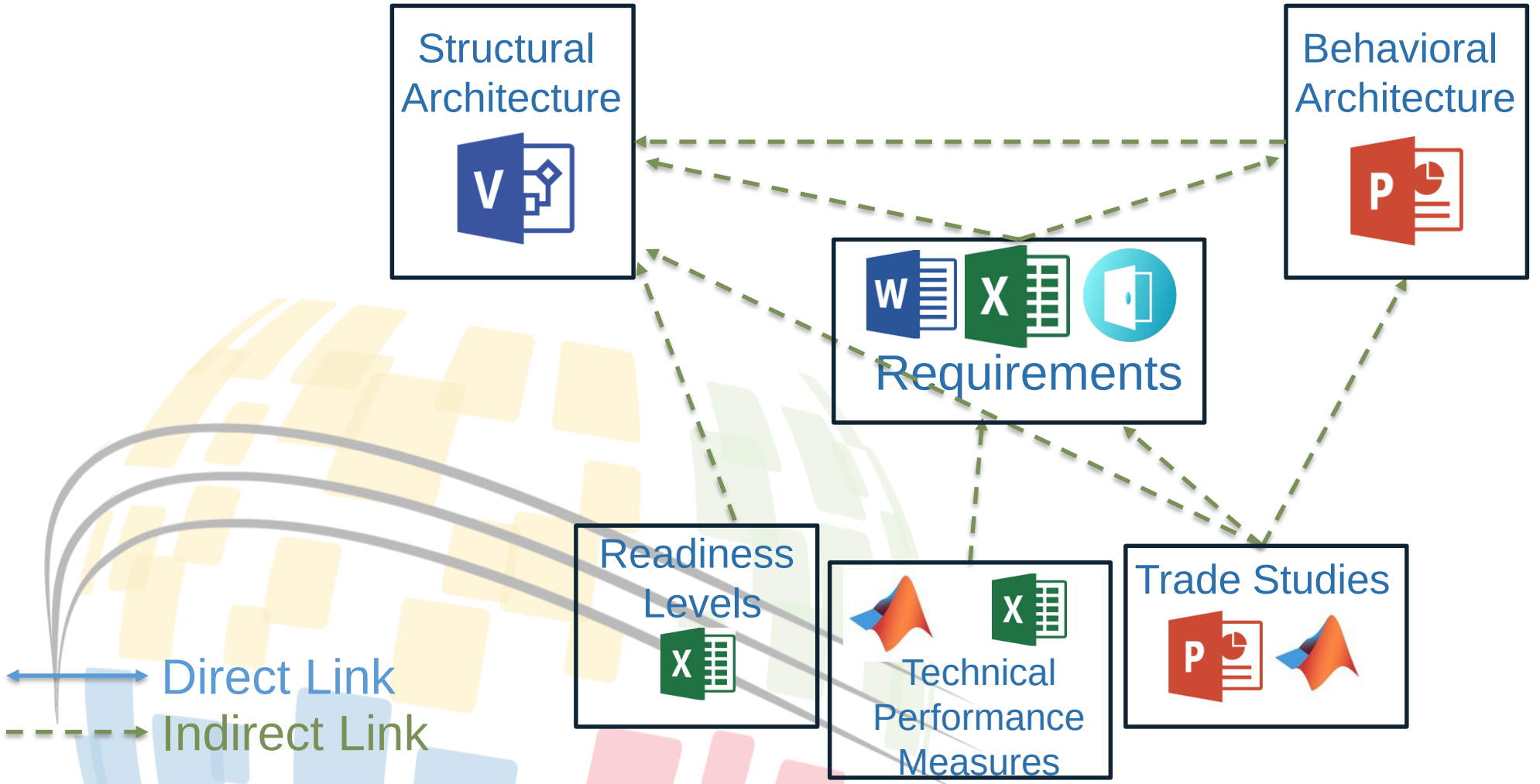
Problem Statement

- Problem
  - Technical Management and System Architecture development have been traditionally treated as separate efforts
  - The process is forced rather than actively monitoring the sources of truth
  - Updates were requested periodically, so delayed
- Solution
  - Integrate the System Architecture and Technical Management Processes into common tools
  - On demand monitoring of source of truth

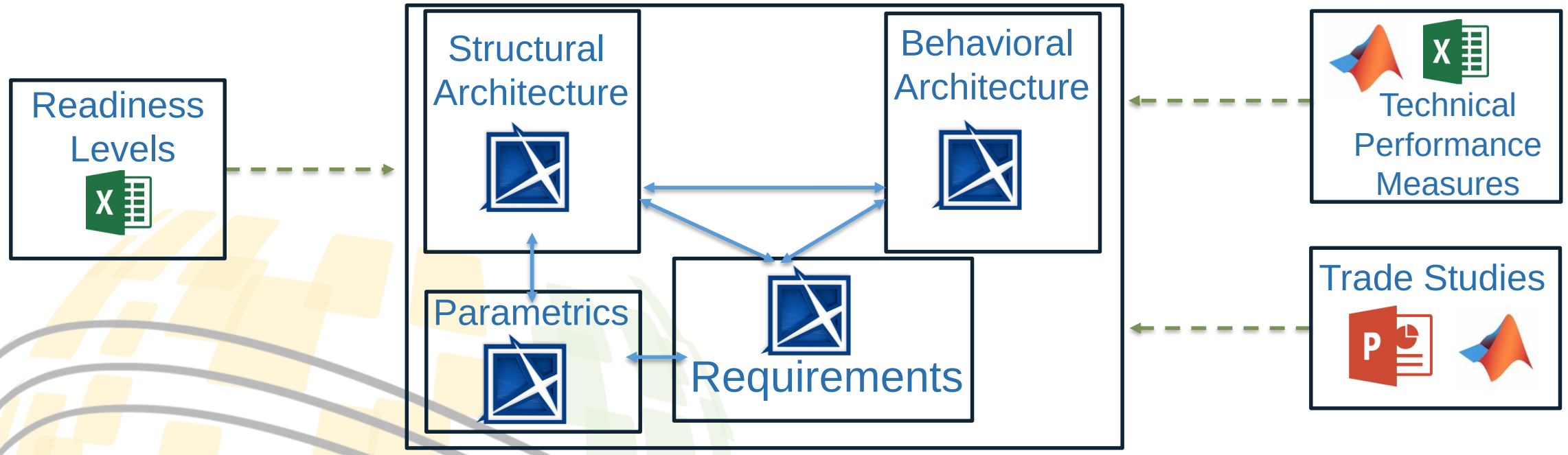
Technical Management =	System Architecture =
Technical Performance Measures (TPMs) Readiness Level Assessment Trade Study Management	Requirements Structure (Includes Interfaces) Behavior Parametrics

Technical Management – Traditional



All Separate Tools With Indirect Links

Technical Management with MBSE



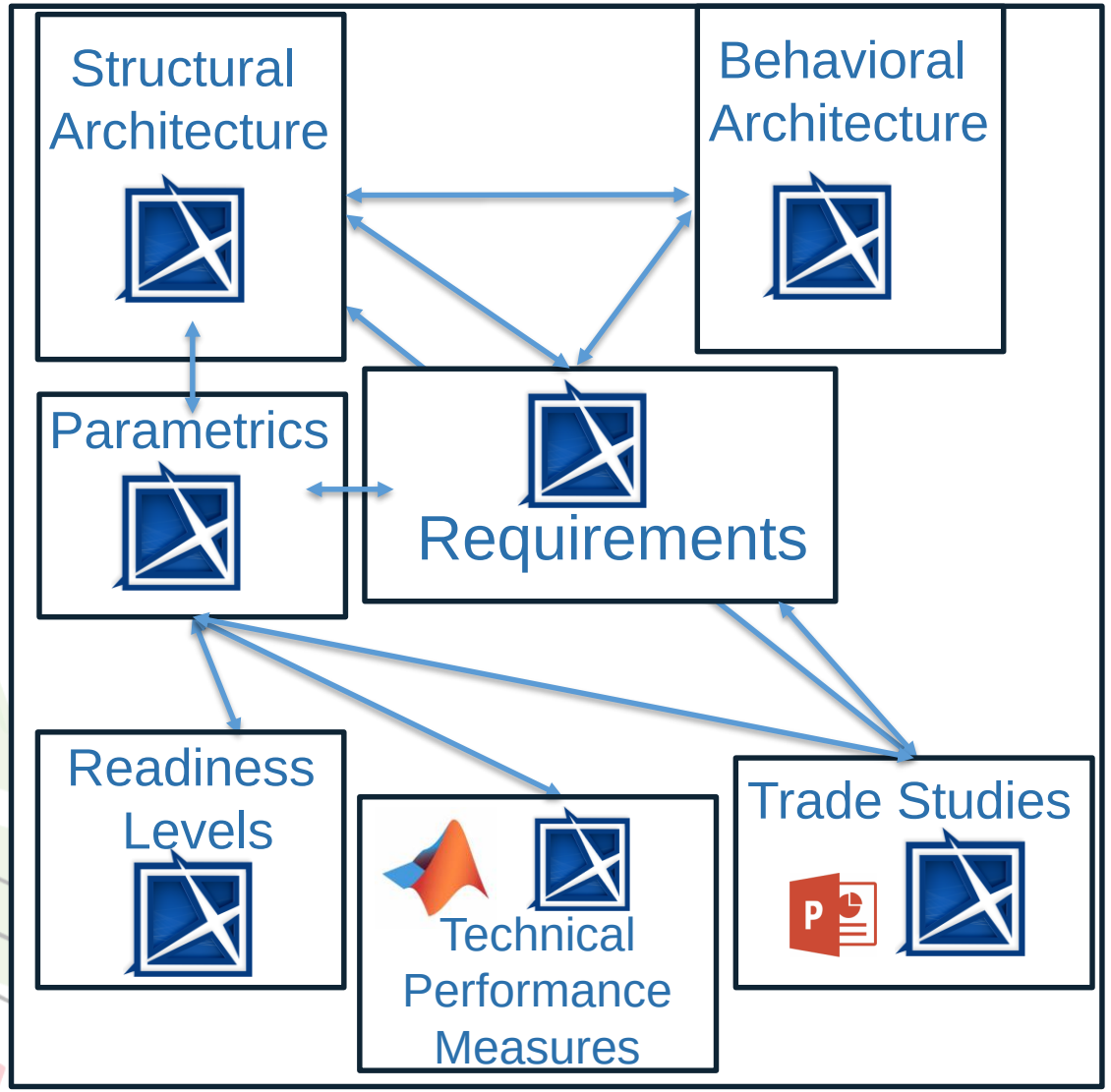
Rise of Model Based Systems Engineering

Direct Link

Indirect Link

Integrated Technical Management

- Direct linkage between monitoring tools and the source of truth data
- Singular tool implementation presented today



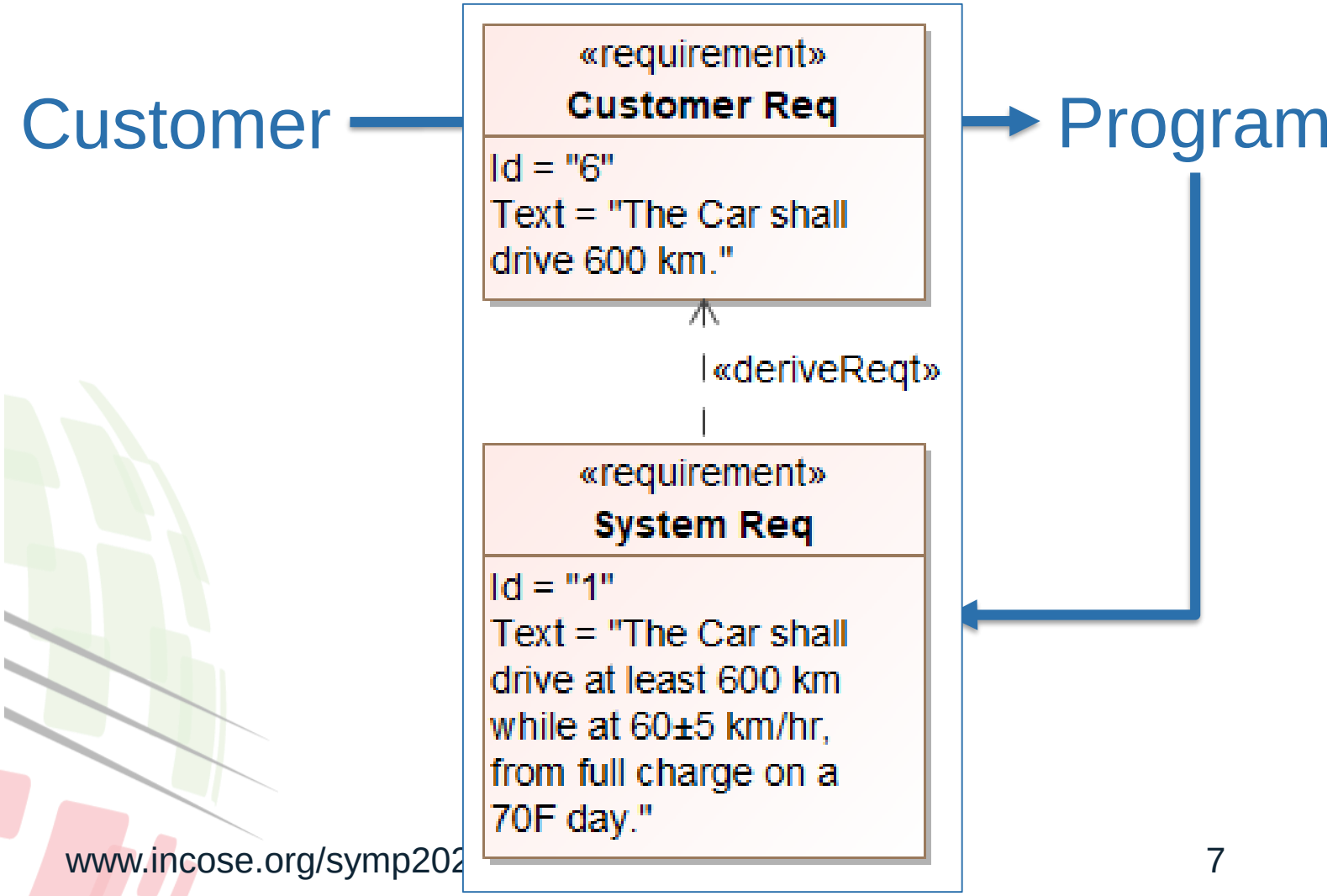
Example Situation - Walkthrough of the Process

New Program - Car

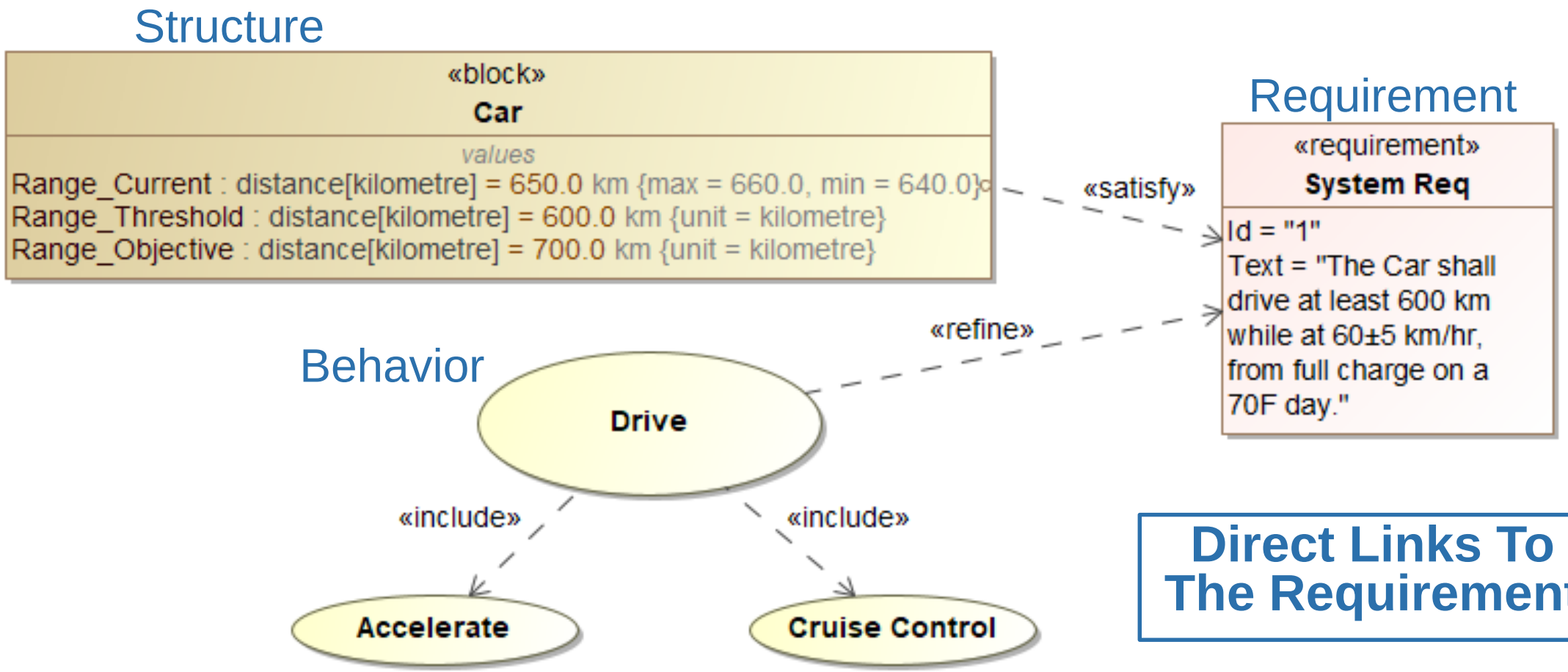
1. Receive Requirements and Capture in Architecture
2. Integrate Requirements With Structure and Behavior
3. Establish TPM and Initiate Status Tracking
4. Decompose System and Initiate Trade Studies
5. Execute System Trades
6. Capture Results of System Trade
7. Monitor TRLs
8. Monitor TPMs
9. Create TPM Output Reports

1. Receive Requirements For A New Car And Capture Them In Requirements Architecture

- Ensure Requirement is SMART
  - Add Conditions
- Ask Customer Questions
- Capture Customer Agreement

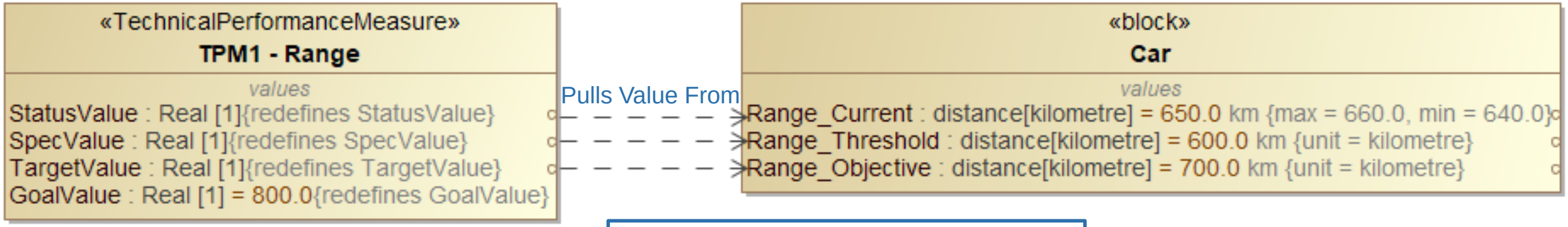


2. Integrate Requirements With Structure and Behavioral Architecture



Direct Links To The Requirement

3. Establish A System TPM And Initiate Status Tracking

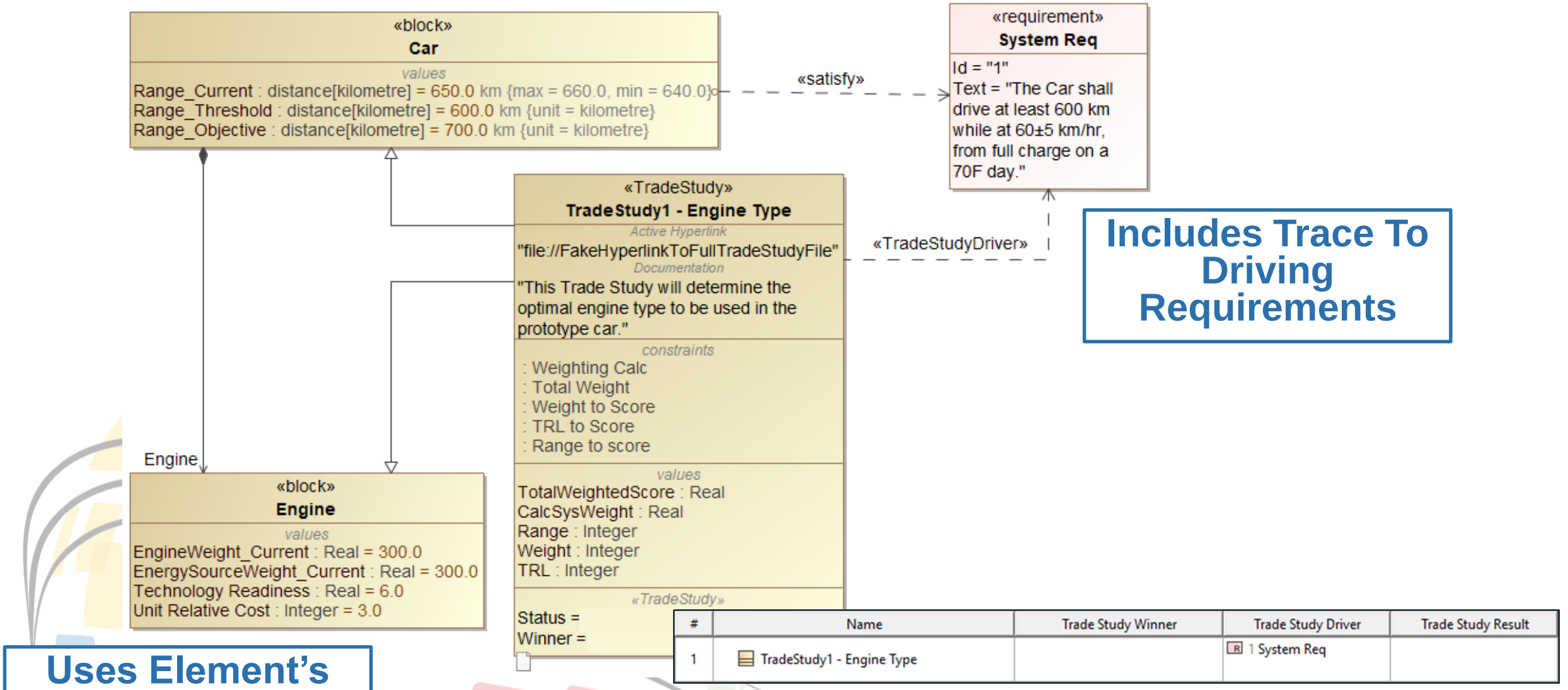


TPM pulls from the Car Block for on demand trending

Table To Update TPM Current Status

#	Name	Type	Default Value	Max	Min	Measurement Type	Source Location
1	Range_Current	distance[kilometre]	650	640	660	Estimated	file://HyperlinkToSourceFile

4. Decompose System and Initiate Trade Studies

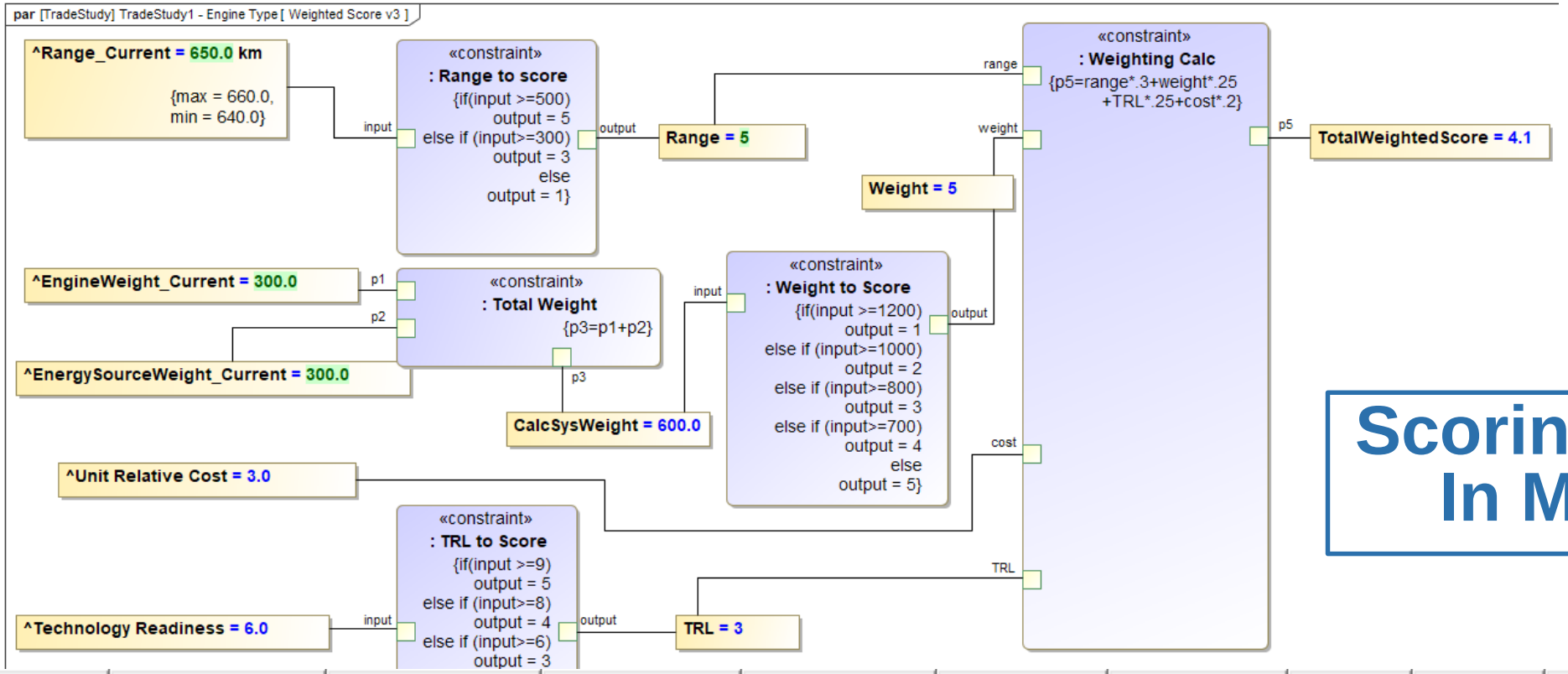


Includes Trace To Driving Requirements

Uses Element's TRL and values in the trade

5. Execute System Trades

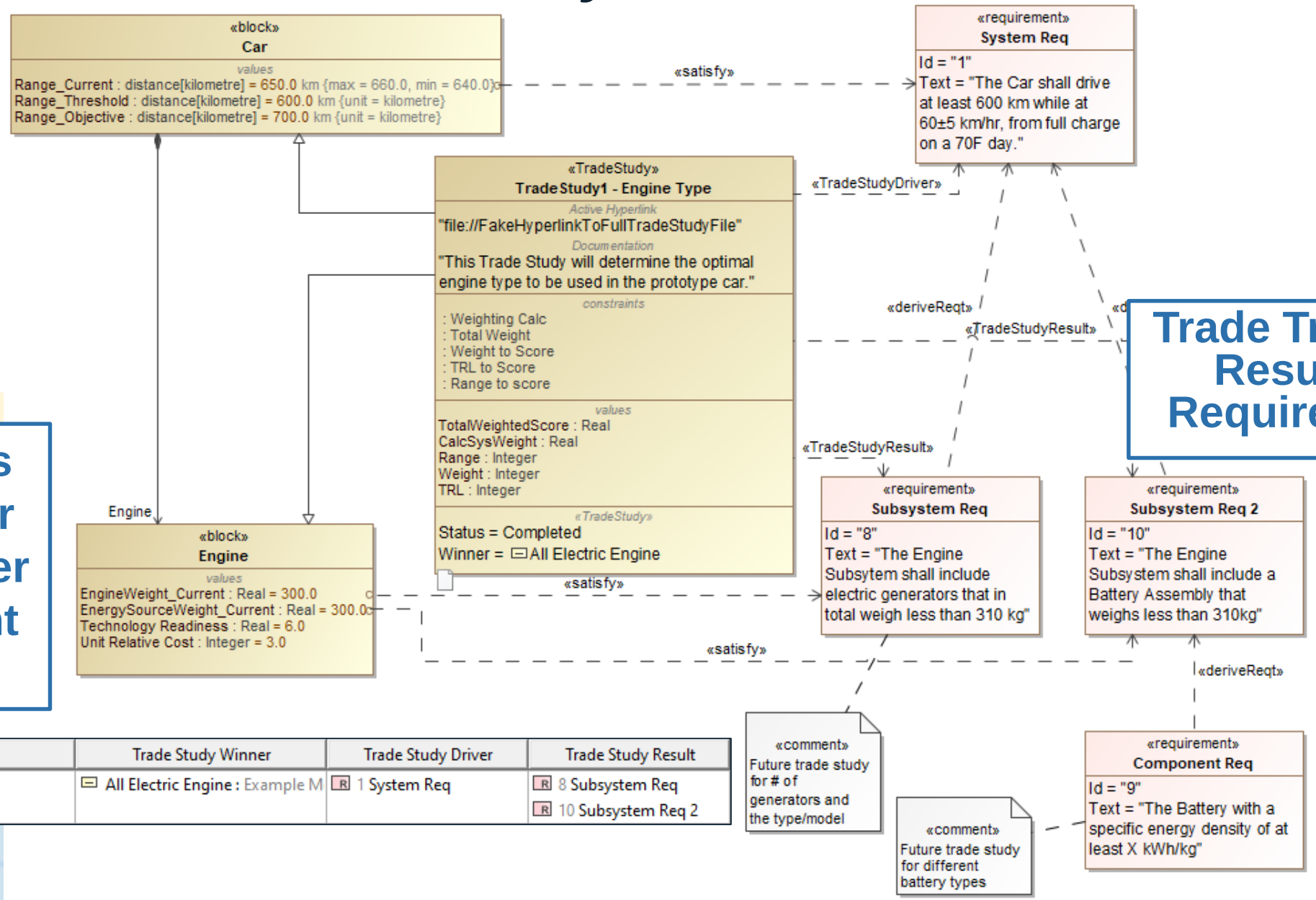
- Engine options are different Instances
  - TRL is part of scoring criteria in this example
- Linked to physics based / external analysis tools as needed



Scoring Done In Model

#	Name	EngineWeight_Curr : Real	EnergySourceWeigh : Real	Range_Current : distance[kilometr	Technology Readiness : Real	Unit Relative Cost : Integer	CalcSysWeight : Real	Range : Integer	Weight : Integer	TRL : Integer	TotalWeightedScore : Real
1	All Electric Engine	300	300	650 km	6	3	600	5	5	3	4.1
2	Hybrid Engine	600	400	450 km	9	4	1000	3	2	5	3.45
3	Combustion Engine	700	80	500 km	9	1	780	5	4	5	3.95

6. Capture Results Of System Trade



Trade Traces to Resulting Requirements

Engine values changing over time can trigger re-assessment of trade

#	Name	Trade Study Winner	Trade Study Driver	Trade Study Result
1	TradeStudy1 - Engine Type	All Electric Engine : Example M	1 System Req	8 Subsystem Req 10 Subsystem Req 2

7. Monitor TRLs

Table To Update RL Current Status As They Change

#	Name	CTE	CME	TRL	MRL	IRL	TRL Rational	MRL Rational	IRL Rational
1	Engine	Yes	Yes	TRL8	MRL6	N/A	Testing of xx has been finished	We can manufature the batteries	

"Update table" updates the architecture elements directly

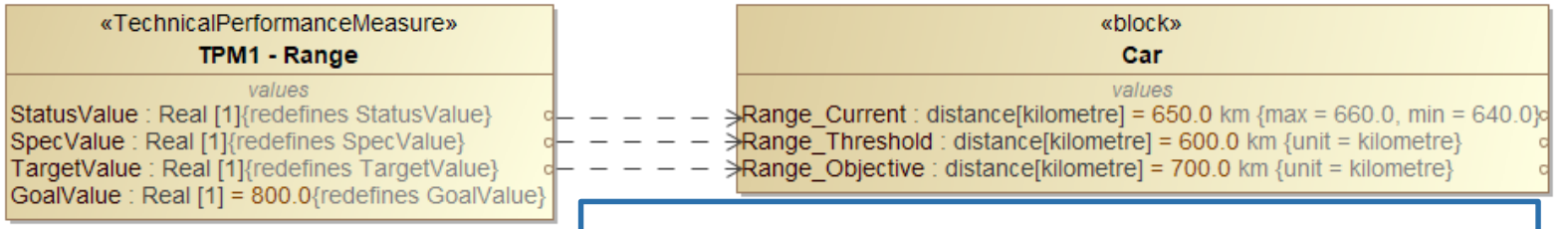
RL Metric Table – Run As Needed

#	Date	Scope	CTE	CME	TRL	MRL	IRL	TRL Rationale	MRL Rationale	IRL Rationale
1	2023.03.08 21.30	Engine			TRL4					
2	2023.03.08 21.43	Engine	Yes	Yes	TRL7	MRL6	N/A	This has been proven in prototype vehicles, but not in this application	We can manufature the batteries	
3	2023.03.08 21.43	Engine	Yes	Yes	TRL8	MRL6	N/A	Testing of xx has been finished	We can manufature the batteries	

Can Track/Store Historical Data Directly in Model

RLs updated from ASoT when needed

8. Monitor TPMs



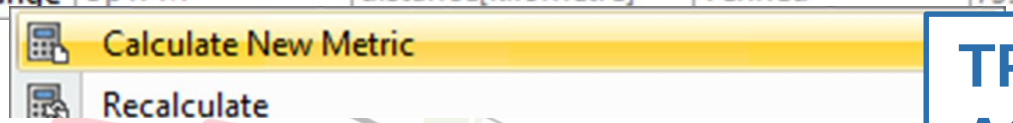
"Update table" updates the architecture elements directly

Table To Update TPM Current Status As They Change

#	Name	Type	Default Value	Max	Min	Measurement Type	Source Location
1	Range_Current	distance[kilometre]	650	640	660	Estimated	file://HyperlinkToSourceFile

TPM Metric Table – Run Monthly

#	Date	Scope	Direction Indicator	Units	Measurement Type	Status Value	Spec Value	Target Value
1	2023.01.01 07.04	TPM1 - Range	UpTPM	distance[kilometre]	Estimated	550	600	700
2	2023.02.01 07.07	TPM1 - Range	UpTPM	distance[kilometre]	Calculated	650	600	700
3	2023.03.01 07.08	TPM1 - Range	UpTPM	distance[kilometre]	Simulation	710	600	700
4	2023.04.01 07.09	TPM1 - Range	UpTPM	distance[kilometre]	InitialActuals	730	600	700
5	2023.05.01 07.10	TPM1 - Range	UpTPM	distance[kilometre]	Verified	735	600	700



Can Track/Store Historical Data Directly in Model

TPMs updated from ASoT when needed

9. Create TPM Output Reports For Leadership

#	Date	Scope	Direction Indicator	Units	Measurement Type	Status Value	Spec Value	Target Value	Goal Value
1	2023.01.01 07.04	TPM1 - Range	UpTPM	distance[kilometre]	Estimated	550	600	700	800
2	2023.02.01 07.07	TPM1 - Range	UpTPM	distance[kilometre]	Calculated	650	600	700	800
3	2023.03.01 07.08	TPM1 - Range	UpTPM	distance[kilometre]	Simulation	710	600	700	800
4	2023.04.01 07.09	TPM1 - Range	UpTPM	distance[kilometre]	InitialActuals	730	600	700	800
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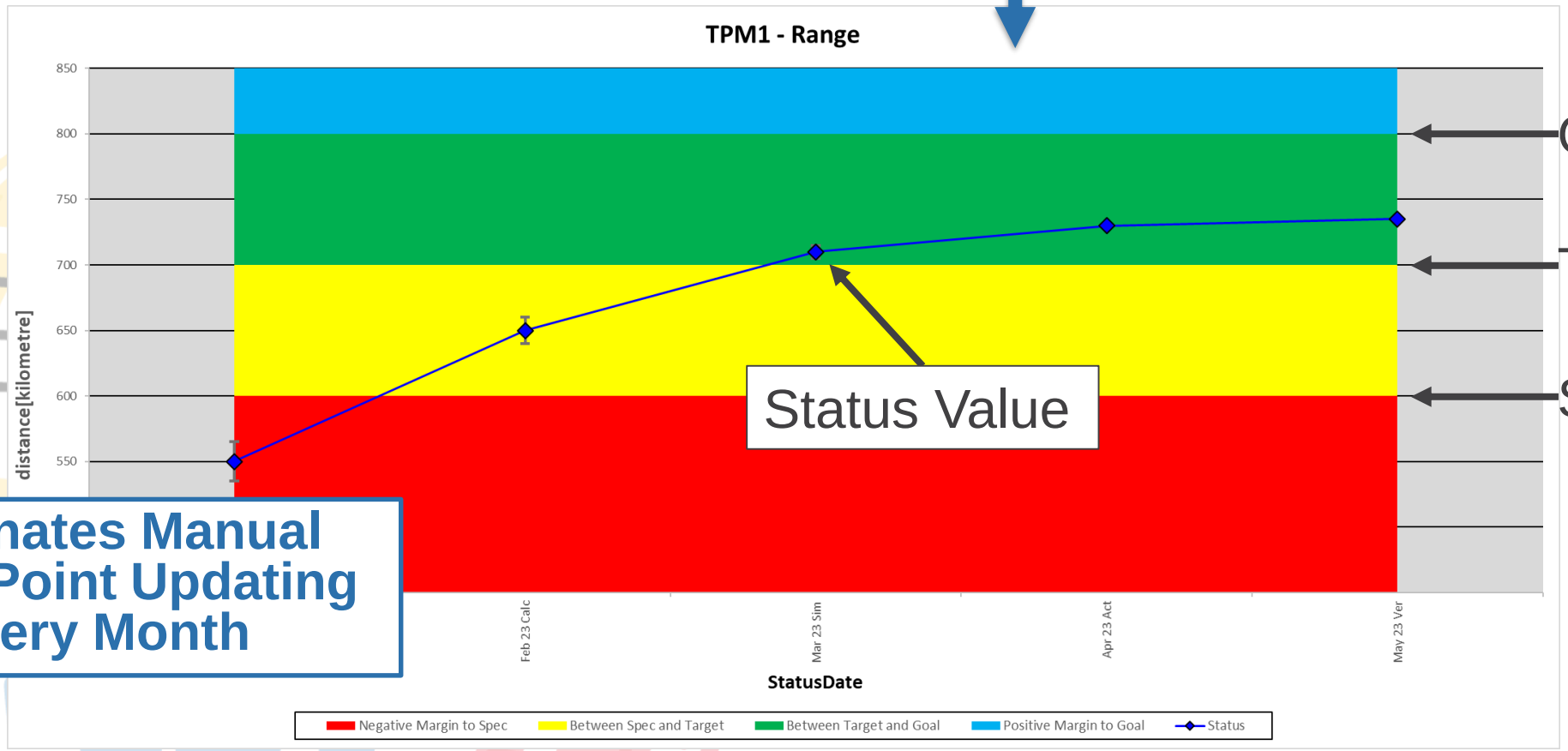

Goal Value

Target Value

Spec Value

Eliminates Manual PowerPoint Updating Every Month

Conclusion / Benefits

- Technical Management Data co-located with System Architecture in Cameo
  - Technical metrics directly use ASoT data
  - Reports can be done on-demand
- Ability to perform an Integrated Impact Assessment
  - As TRLs evolve, have direct traceability to trade studies and requirements to ensure assumptions still valid
  - As TPMs evolve, can identify impacts to architecture and trades directly
  - If Requirements change, can identify impacts to architecture, trades, and TPMs immediately
- Integrating these processes with the architecture development in a common tool enables systems engineering to more holistically manage the development

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www.incose.org/symp2023