33rd Annual INCOSE international symposium

hybrid event

Honolulu, HI, USA
July 15 - 20, 2023

An Approach to

# Integrated Digital Requirements Engineering



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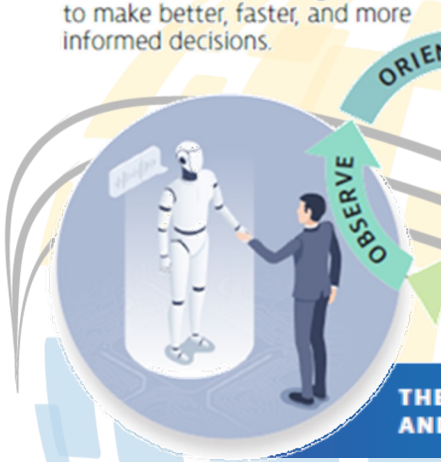
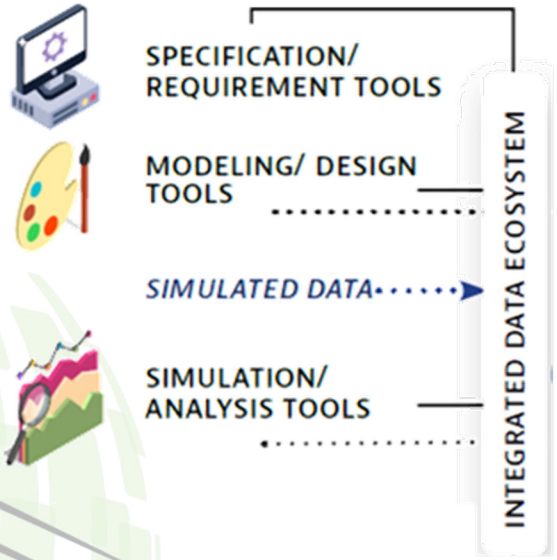
# An Approach to **Integrated Digital Requirements Engineering**

## INCOSE Vision 2035

**HUMAN-MACHINE COLLABORATION**

Human-Machine teams will become increasingly common as the pace of discovery, simulation, observation, and evaluation, allowing the team to make better, faster, and more informed decisions.




**THE NEED FOR TRUST IN MODELS AND DATA WILL REQUIRE NEW VERIFICATION AND VALIDATION METHODS.**



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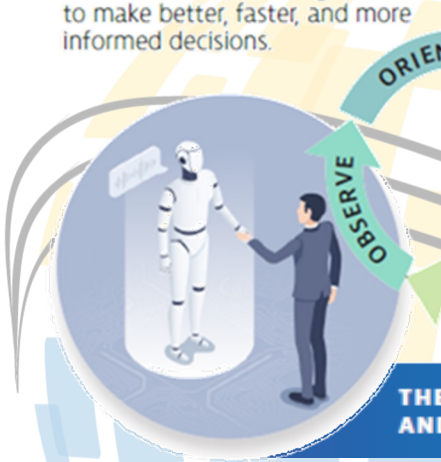
# An Approach to **Integrated Digital Requirements Engineering**

**Deploy Digital Thread through Iterative & Continuous Workflows, fostering Automation of tasks**

and evaluation, allowing the team to make better, faster, and more informed decisions.




SPECIFICATION/ REQUIREMENT TOOLS

MODELING/ DESIGN TOOLS

*SIMULATED DATA*

SIMULATION/ ANALYSIS TOOLS

INTEGRATED DATA ECOSYSTEM

**Set-up an Authoritative Source of Truth (ASoT), Ensuring Consistency of Digital Artifacts**

**Use a shared Semantic reference**

**Provide Advanced V&V capabilities**

**THE NEED FOR TRUST IN MODELS AND DATA WILL REQUIRE NEW VERIFICATION AND VALIDATION METHODS.**



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# State of the art | Requirements Engineering

## Scope of expectations

Capture expectations

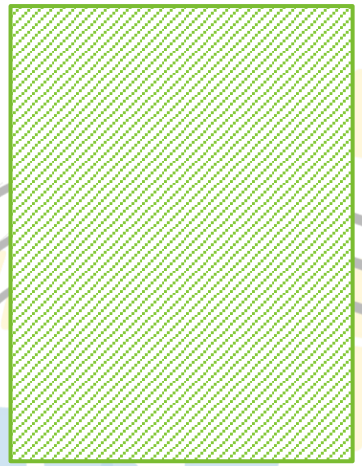
## Requirements

Provide a rigorous reference for V&V

TEST

failed

achieved



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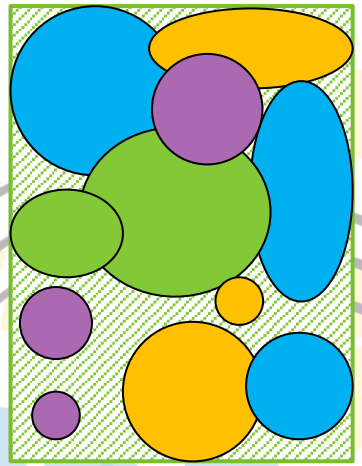
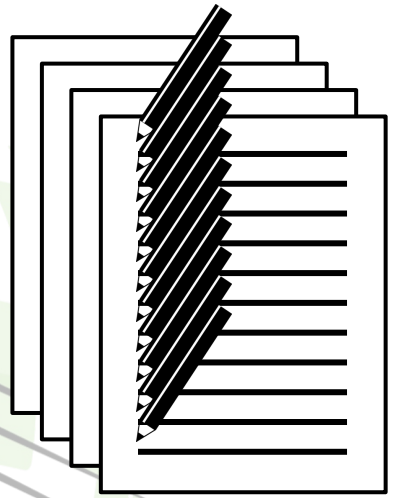
# STATE OF THE ART | REQUIREMENTS ENGINEERING

## SCOPE OF EXPECTATIONS



Capture expectations

## REQUIREMENTS



Provide a rigorous reference for V&V

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# STATE OF THE ART | REQUIREMENTS ENGINEERING

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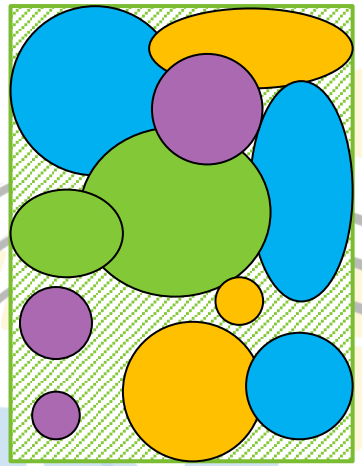

- **DIFFICULT** to get a good, precise and global **UNDERSTANDING**

# STATE OF THE ART | REQUIREMENTS ENGINEERING

SCOPE OF EXPECTATIONS

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REQUIREMENTS

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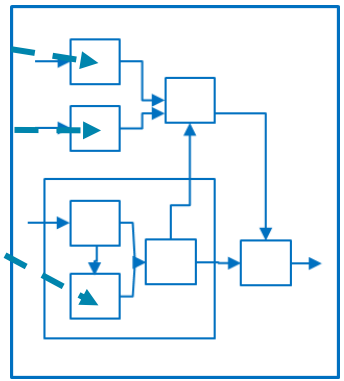

**Improve understanding**:

- **Easing navigation** across the specification
- **Providing more information** & context



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# STATE OF THE ART | REQUIREMENTS ENGINEERING

## SCOPE OF EXPECTATIONS

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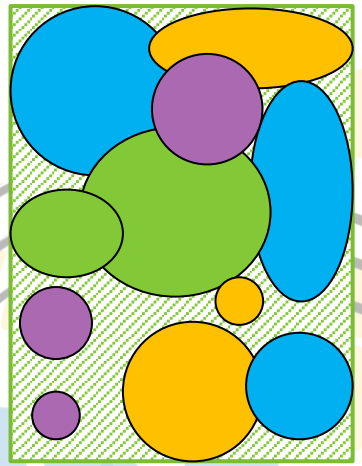
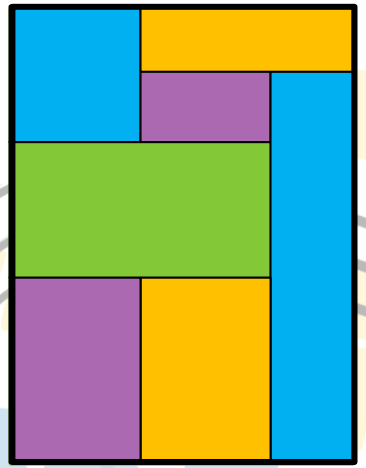


- **GAPS** in coverage
- **OVERLAPPING** & lack of **CONSISTENCY**

# MODEL BASED | REQUIREMENTS ENGINEERING

## SCOPE OF EXPECTATIONS

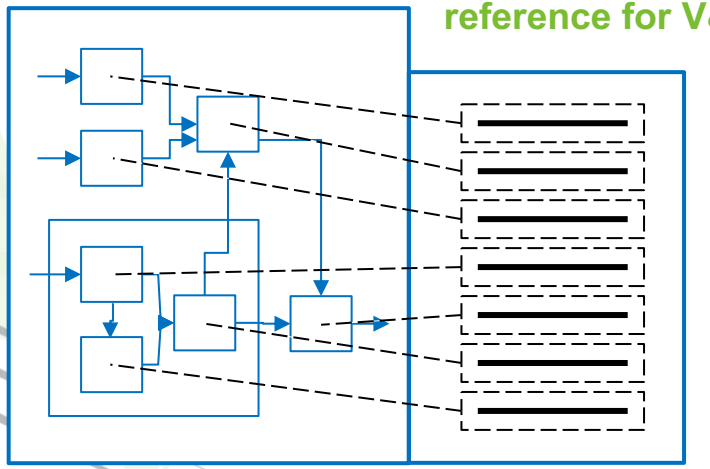


Capture expectations

Model expectations

Structure the capture of expectations

## REQUIREMENTS MODELS



Provide a rigorous reference for V&V

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# MODEL BASED | REQUIREMENTS ENGINEERING

SCOPE OF EXPECTATIONS

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REQUIREMENTS

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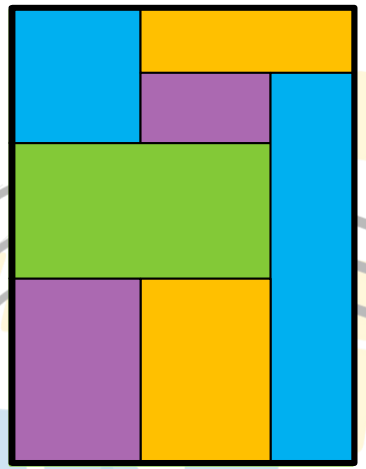
achieved



Model expectations

MODELS

Improve requirements

- CONSISTENCY
- COMPLETENESS
- UNDERSTANDING

Structure the capture of expectations



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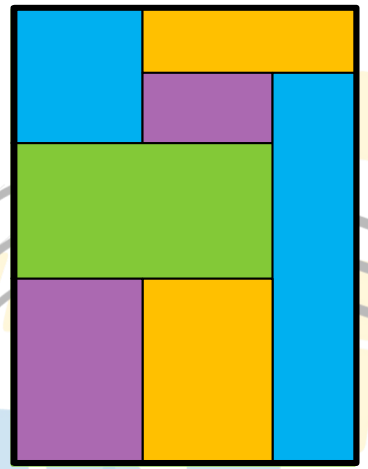
# MODEL BASED | REQUIREMENTS ENGINEERING

## SCOPE OF EXPECTATIONS



Capture expectations

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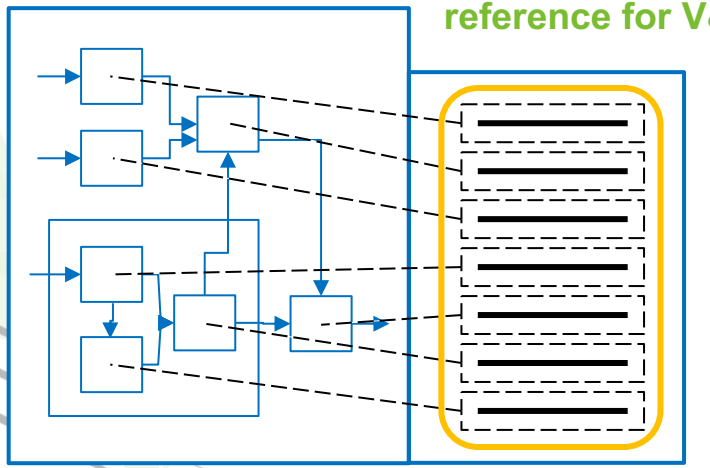
## REQUIREMENTS MODELS



Provide a rigorous reference for V&V


- **AMBIGUITY** of natural language



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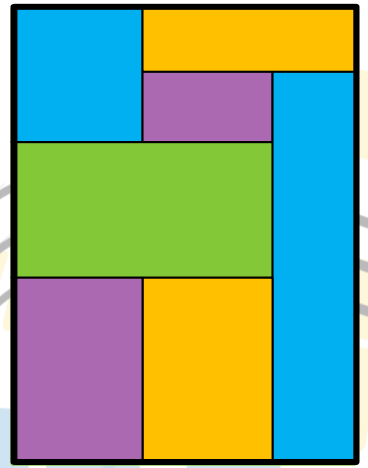
# DIGITAL REQUIREMENTS ENGINEERING

SCOPE OF EXPECTATIONS

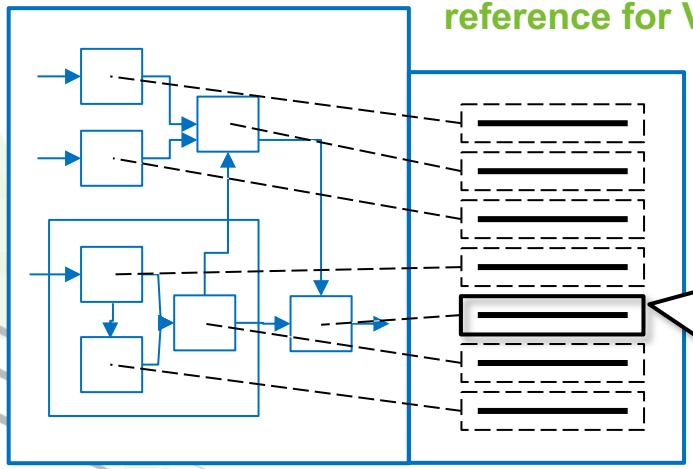


Capture expectations

Model expectations

Structure the capture of expectations

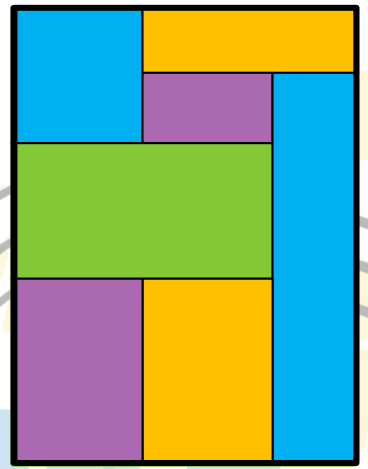
REQUIREMENTS MODELS



Provide a rigorous reference for V&V


Digitalized Requirements

# DIGITAL REQUIREMENTS ENGINEERING



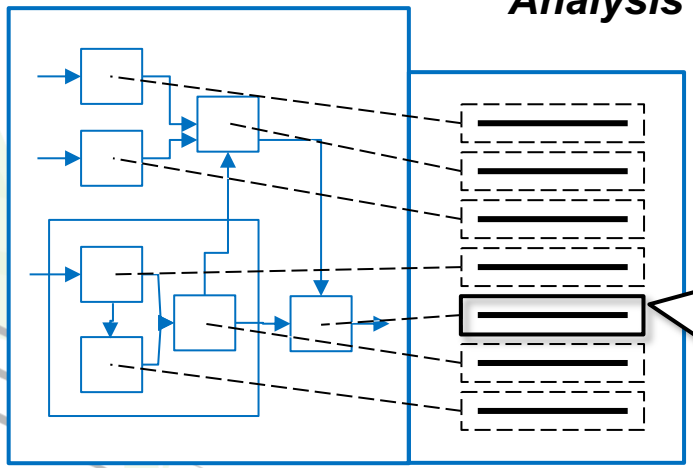
SCOPE OF EXPECTATIONS

Capture expectations

Model expectations

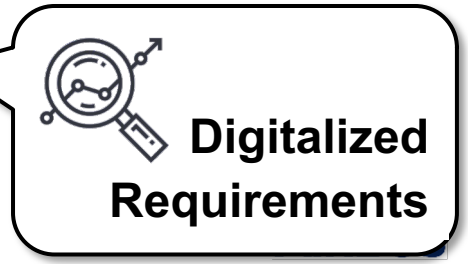
Structure the capture of expectations

REQUIREMENTS MODELS



*Automatic Formal Proof Analysis*


*Automatic Checking of Simulations & Tests*



## Comparison of requirements engineering approaches

# DIGITAL REQUIREMENTS ENGINEERING

| | Benefits | | | | | | | | | Supported requirement types |
|---|---|---|---|---|---|---|---|---|---|---|
| | Editing easiness | Intuitiveness | Context Understanding | Reduced Ambiguity | Consistency | Completeness | Support to V&V | Integration with MBSE | Support abstraction | |
| Requirements in natural language, structured into chapters / modules | +++ | +++ | --- | --- | --- | --- | --- | --- | ++ | All |
| Textual requirements traced to MBSE models | ++ | ++ | - | -- | -- | -- | -- | + | (*) | Technical requirements |
| Textual requirements structured from MBSE models | o | o | o | o | o | o | o | ++ | | Technical requirements |
| Requirements identified using executable design models | -- | + | +++ | ++(1) | ++(2) | ++ | ++ | - | | Expected behavior |

(*) Depends on model abstraction

(1) Difficult to well identify requirement scope from model elements

(2) Risks on requirements atomicity and of over-specification (anticipating implementation)



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## Comparison of requirements engineering approaches

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| PMM | --- | --- | +++ | +++ | +++ | +++ | +++ | -- | -- | Technical requirements |

***Property Model Methodology***

*Micouin P et al., Property Model Methodology: A Landing Gear Operational Use Case, INCOSE IS 2018*



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## Comparison of requirements engineering approaches

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| PMM | --- | --- | +++ | +++ | +++ | +++ | +++ | -- | -- | Technical requirements |

Model requirement as observers ⇩ Provide advaced V&V features

| Target: | | | | | | |
|---|---|---|---|---|---|---|
| Digital Requirements Engineering | +++ | +++ | +++ | +++ | +++ | Technical requirements |



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## Comparison of requirements engineering approaches

# DIGITAL REQUIREMENTS ENGINEERING

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| PMM | --- | --- | +++ | +++ | +++ | +++ | +++ | -- | -- | Technical requirements |

Ensure high level of usabilty

| Target: | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Digital Requirements Engineering | + | + | +++ | +++ | +++ | +++ | +++ | Technical requirements |



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## Comparison of requirements engineering approaches

# DIGITAL REQUIREMENTS ENGINEERING

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| Requirements identified using executable design models | -- | + | +++ | ++(1) | ++(2) | ++ | ++ | - | | Expected behavior |
| PMM | --- | --- | +++ | +++ | +++ | +++ | +++ | -- | -- | Technical requirements |

**Ensure full integration into MBSE workflow**

| Target: | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Digital Requirements Engineering | + | + | +++ | +++ | +++ | +++ | +++ | +++ | Technical requirements |



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## Comparison of requirements engineering approaches

# DIGITAL REQUIREMENTS ENGINEERING

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| Textual requirements structured from MBSE models | o | o | o | o | o | o | o | ++ | | Technical requirements |
| Requirements identified using executable design models | -- | + | +++ | ++(1) | ++(2) | ++ | ++ | - | | Expected behavior |
| PMM | --- | --- | +++ | +++ | +++ | +++ | +++ | -- | -- | Technical requirements |
| Target: | | | | | | | | | Support use at all abtraction levels ⇩ | |
| Digital Requirements Engineering | + | + | +++ | +++ | +++ | +++ | +++ | +++ | +++ | Technical requirements |



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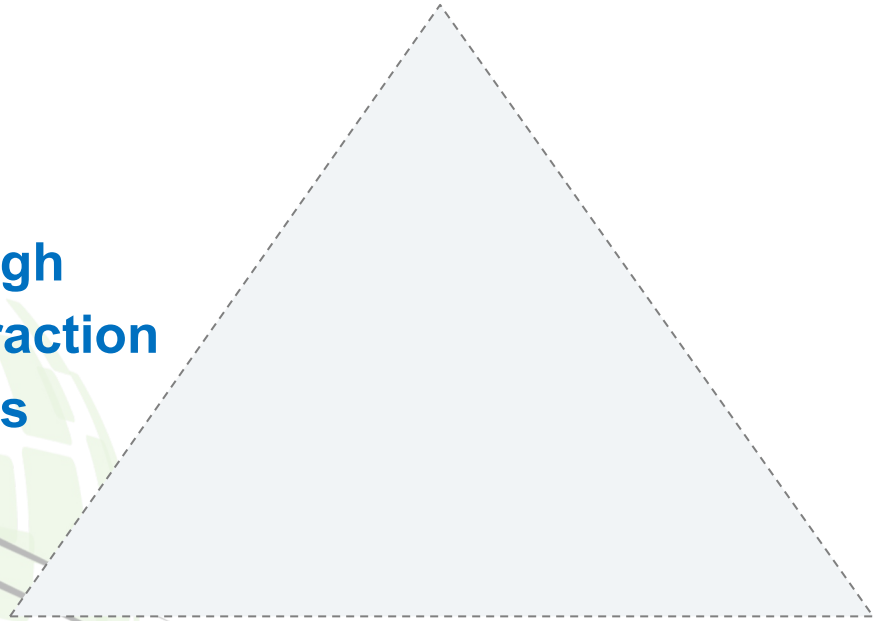
**Support use across several abstraction levels**

# DIGITAL REQUIREMENTS ENGINEERING

Disregard un-useful / un-important information

**Abstraction** — **through Abstraction Levels**

Provide more details





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**Support use across several abstraction levels**

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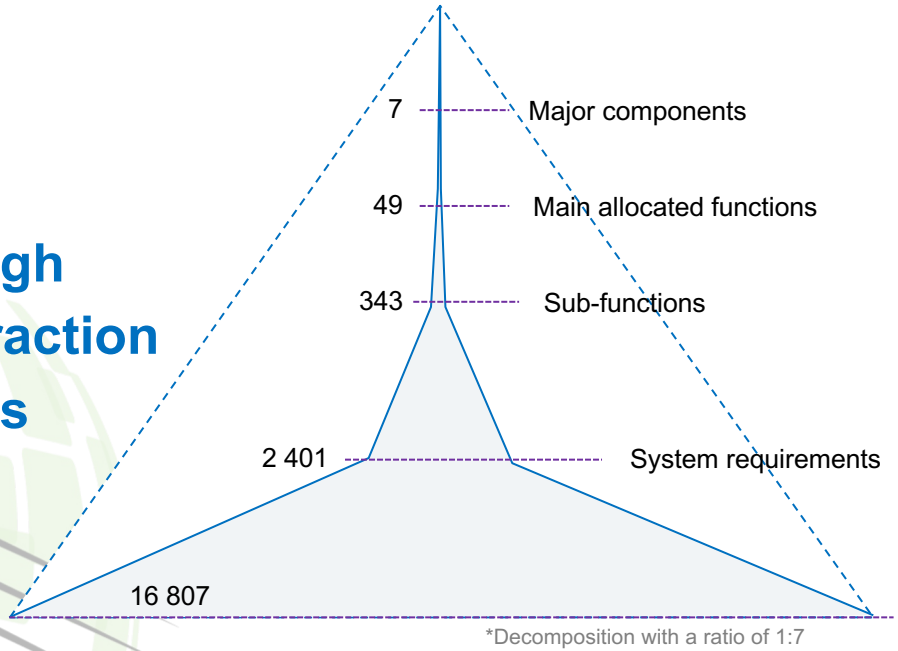


Need to capture consistency relationships between system artifacts at different abstraction levels.



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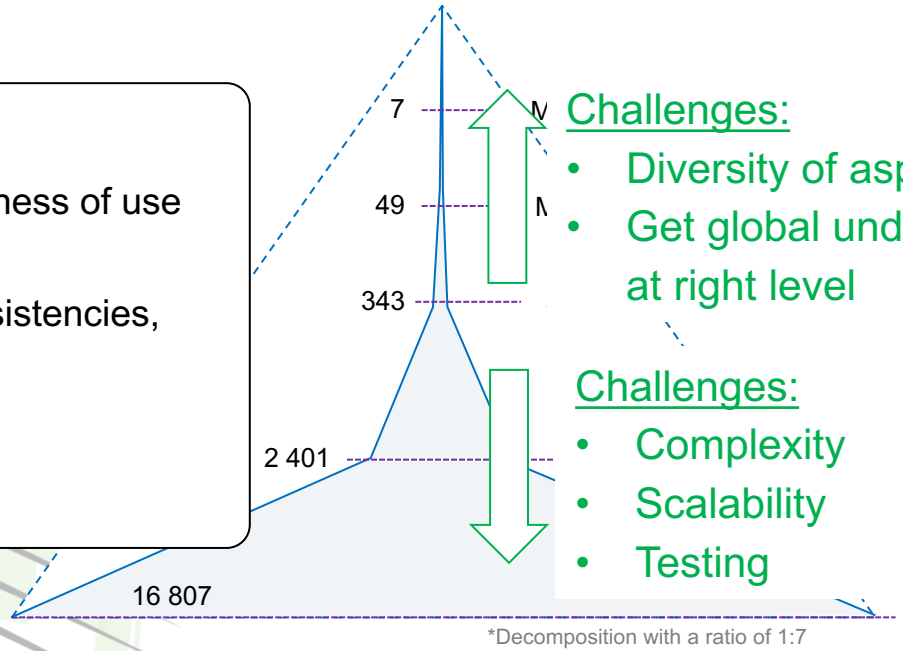
**SUPPORT USE ACROSS SEVERAL ABSTRACTION LEVELS**

# DIGITAL REQUIREMENTS ENGINEERING

- Maximize **Usability**
  - ➢ Efficiency, easiness and intuitiveness of use
- Maximize **Automation**
  - ➢ Reducing risks of errors & inconsistencies,
  - ➢ Reducing modeling effort
- Ensure overall **Consistency** and **Abstraction management**




Challenges:
- Diversity of aspects
- Get global understanding, at right level

Challenges:
- Complexity
- Scalability
- Testing

Refined requirements



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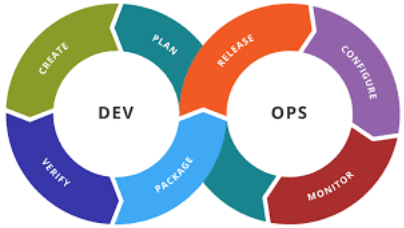
**CONTINUOUS INTEGRATION & DEVELOPMENT**

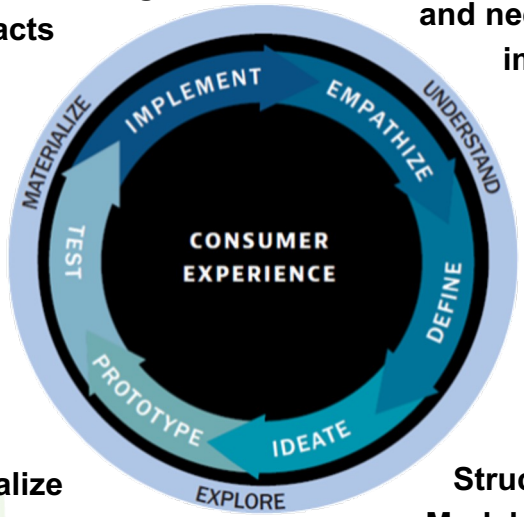
# Integrated Digital Requirements Engineering




- Ensuring full **integration into MBSE workflows** and maximizing **digital continuity** between systems engineering artifacts*

**Baseline the resulting Artifacts**

**Identify needed changes and needed refinements / improvements**




**Verify & Validate produced Digital Artifacts**

**Capture Needs & Expectations**

**Capture & Digitalize Requirements**

**Structure & Model Needs & Expectations**

*INCOSE Vision 2035

*Combination of professional data, information, knowledge, and wisdom (DIKW Pyramid) expressed in digital form and exchanged within a digital ecosystem.



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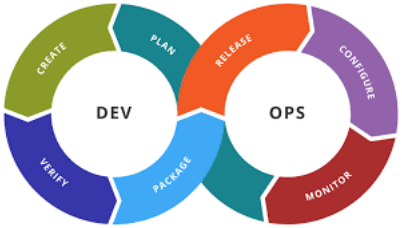
## Continuous Integration & Development

# Integrated Digital Requirements Engineering

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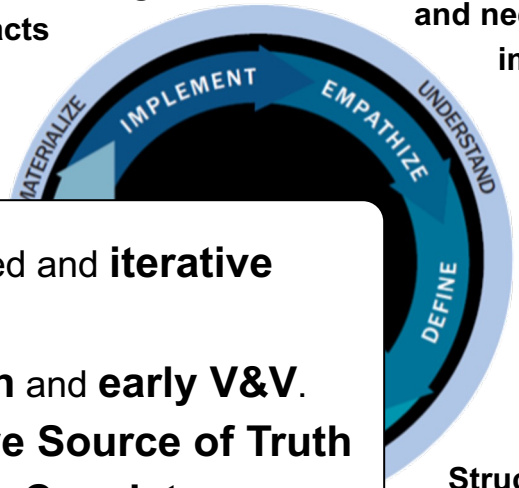


**Capture Needs & Expectations**

**Structure & Model Needs & Expectations**

- Support global integrated and **iterative MBSE workflow**.
- Maximize **Automation** and **early V&V**.
- Maintain **Authoritative Source of Truth** (ASoT), ensuring overall **Consistency**
- At all **Abstraction levels**.

*Combination of professional data, information, knowledge, and wisdom (DIKW Pyramid) expressed in digital form and exchanged within a digital ecosystem.



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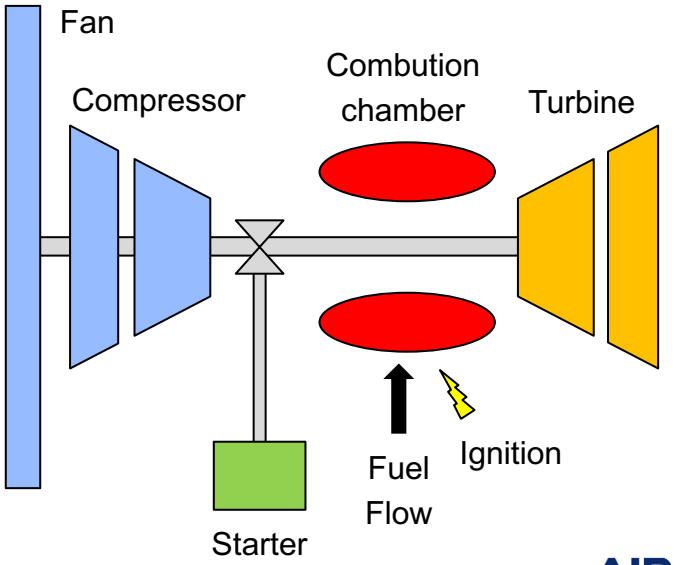
# Engine Architecture

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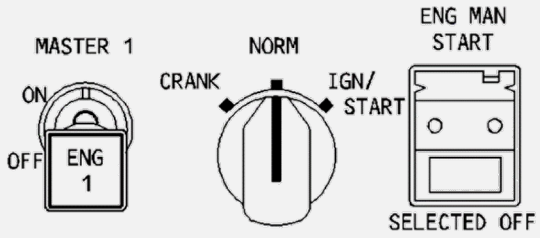
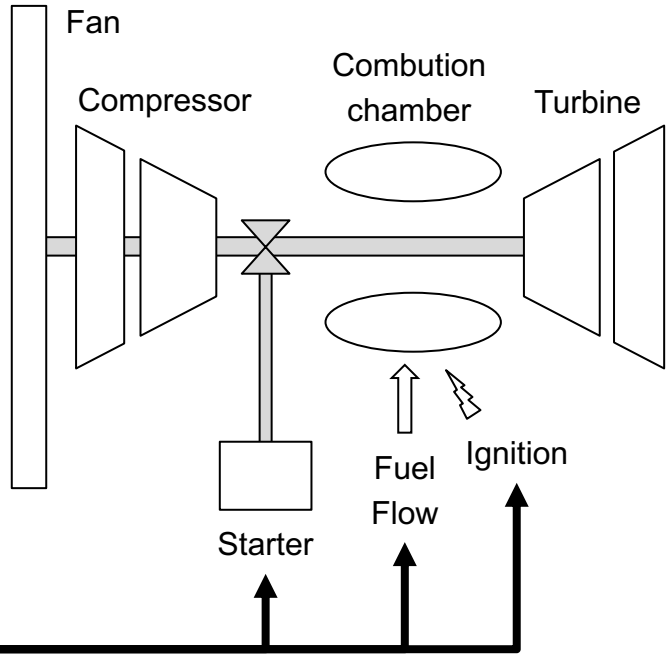
# Engine Architecture

**Cockpit Controls**

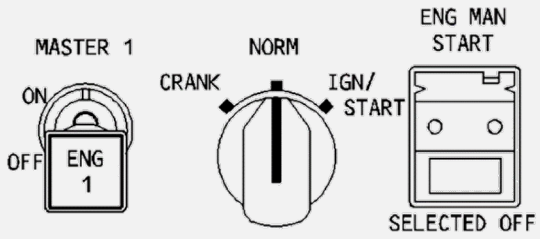



**Engine Control System**



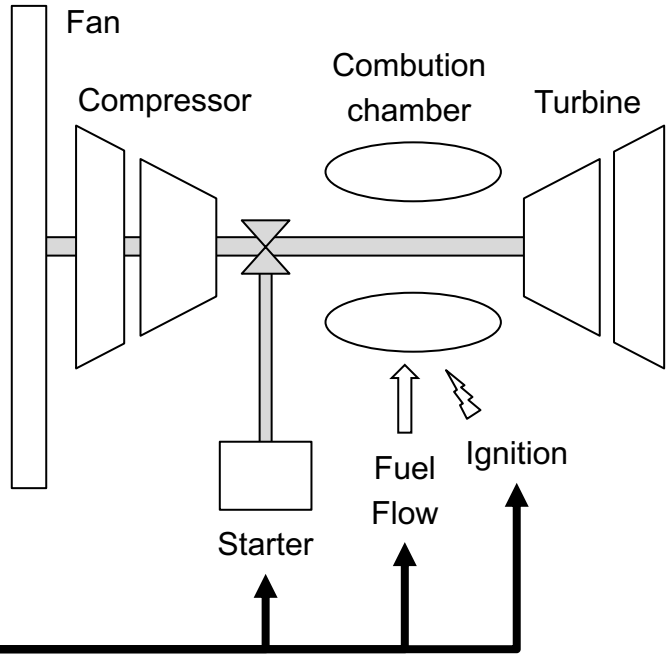
# Engine Start Procedure

**Cockpit Controls**



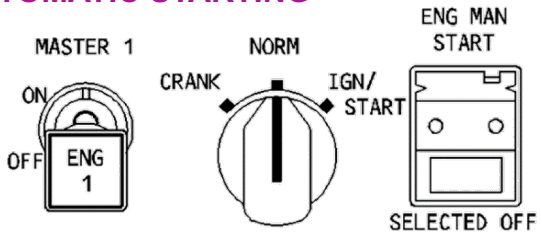

**Engine Control System**

**Motoring** → **Ignition** → **Self sustaining combution**

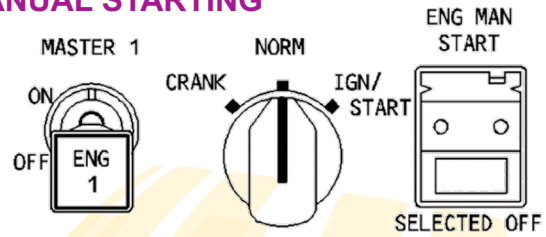


# Engine Start Procedure

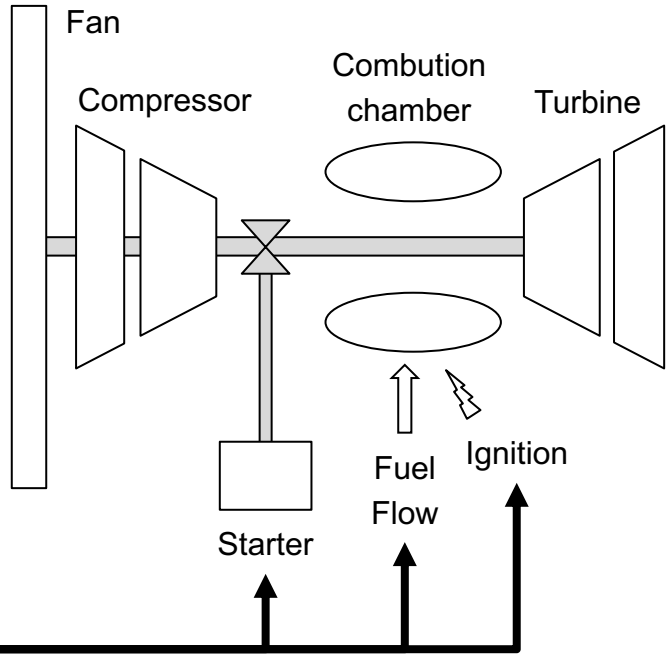
## AUTOMATIC STARTING




## MANUAL STARTING



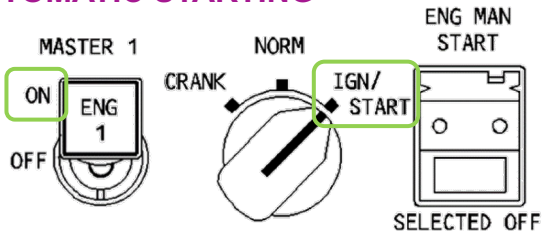




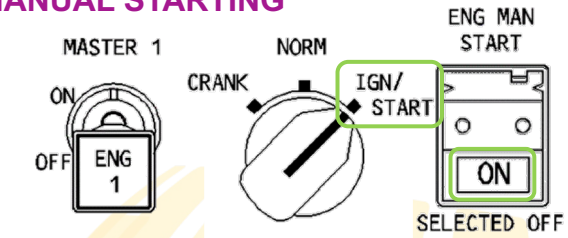

Engine Control System

# Engine Start Procedure

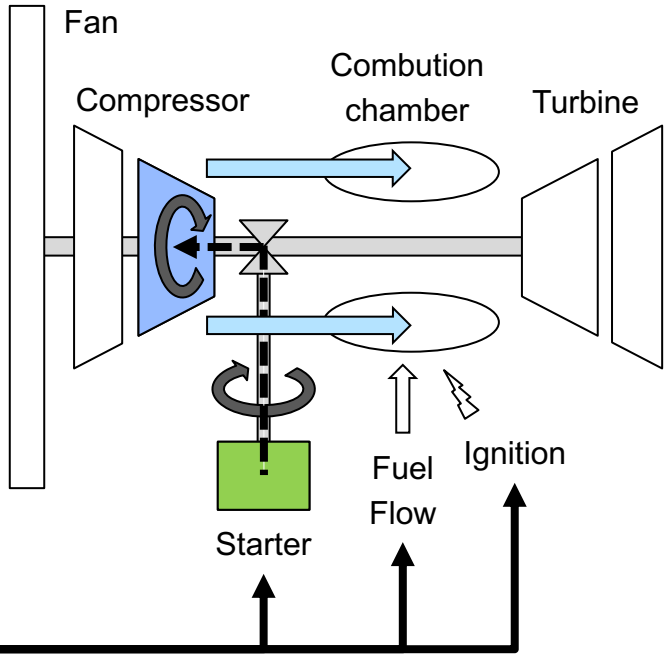
## AUTOMATIC STARTING




## MANUAL STARTING



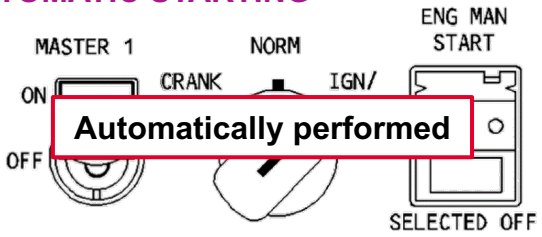

**Motoring** → **Ignition** → **Self sustaining combution**



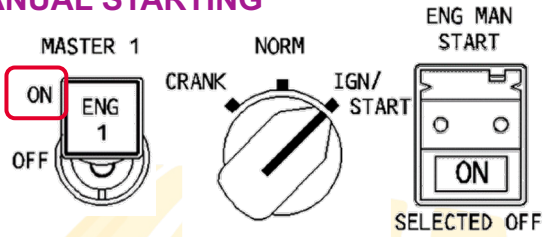

**Engine Control System**

# Engine Start Procedure

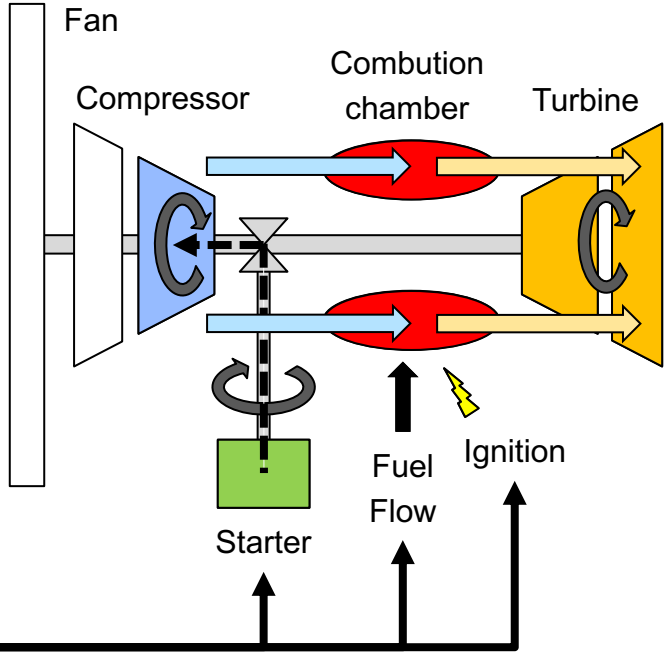
## AUTOMATIC STARTING

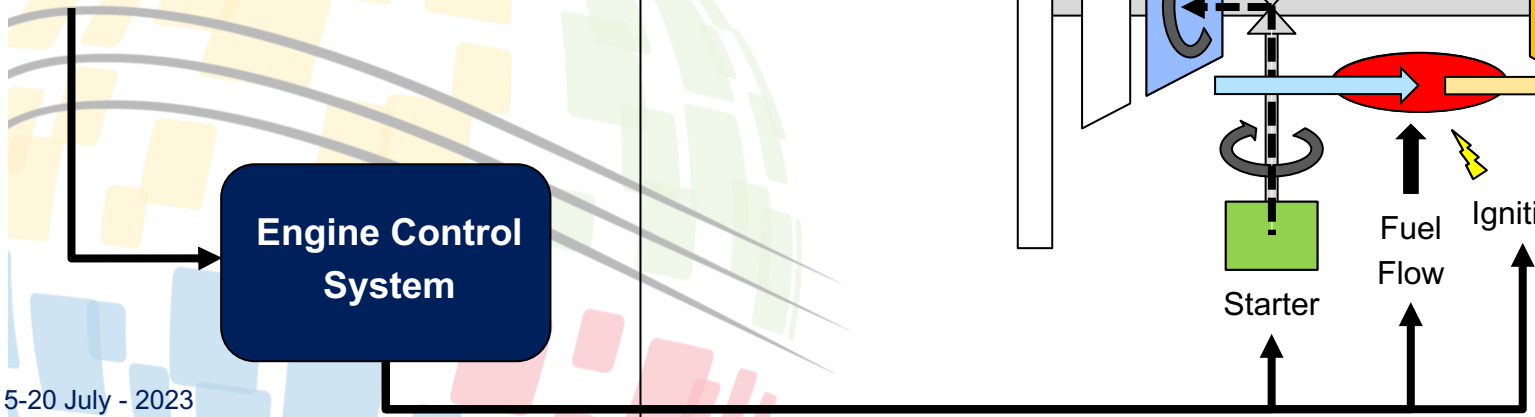



## MANUAL STARTING

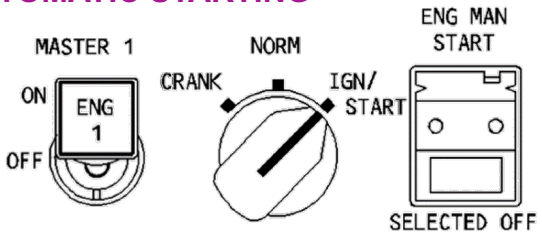




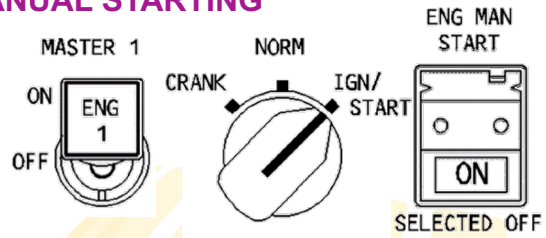


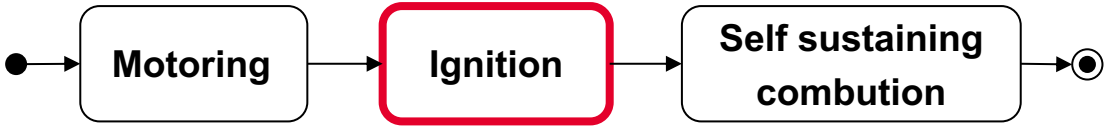
## AUTOMATIC STARTING

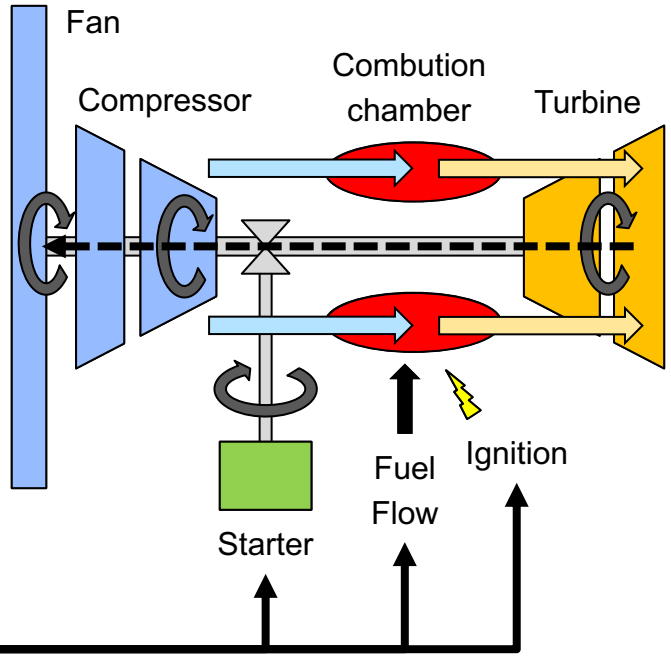



## MANUAL STARTING



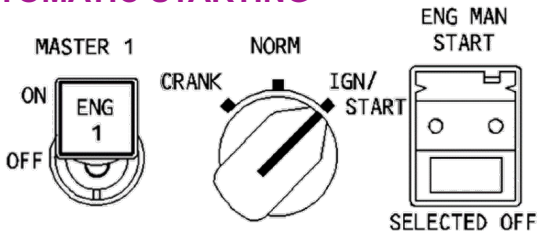

# ENGINE START PROCEDURE



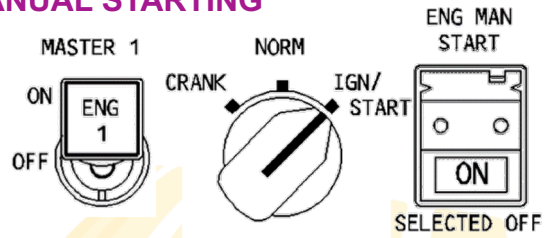




Engine Control System

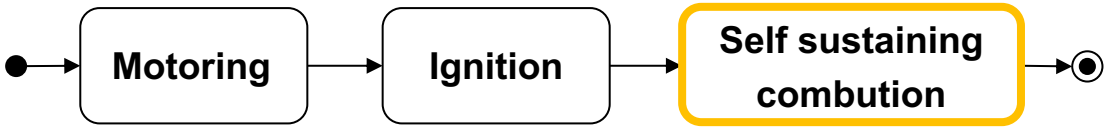
## AUTOMATIC STARTING

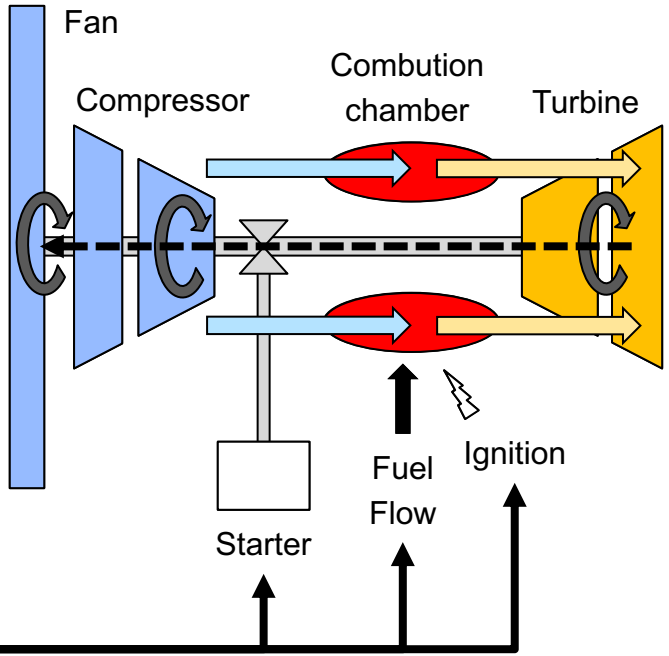



## MANUAL STARTING



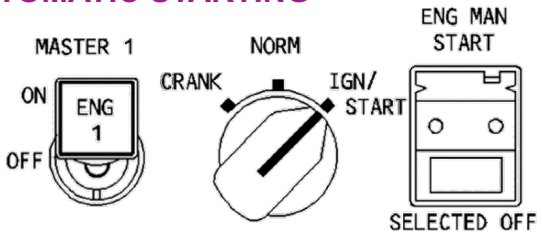

# Engine Start Procedure



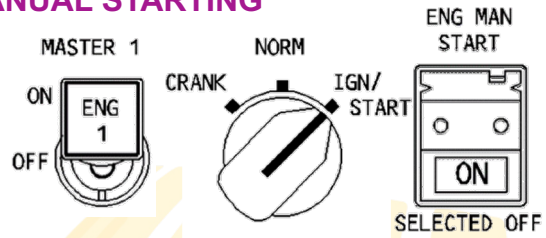




Engine Control System

## AUTOMATIC STARTING

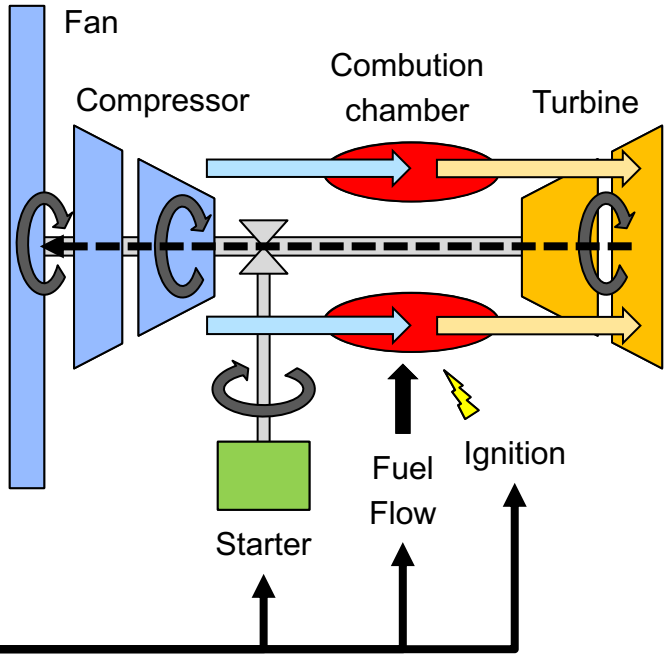


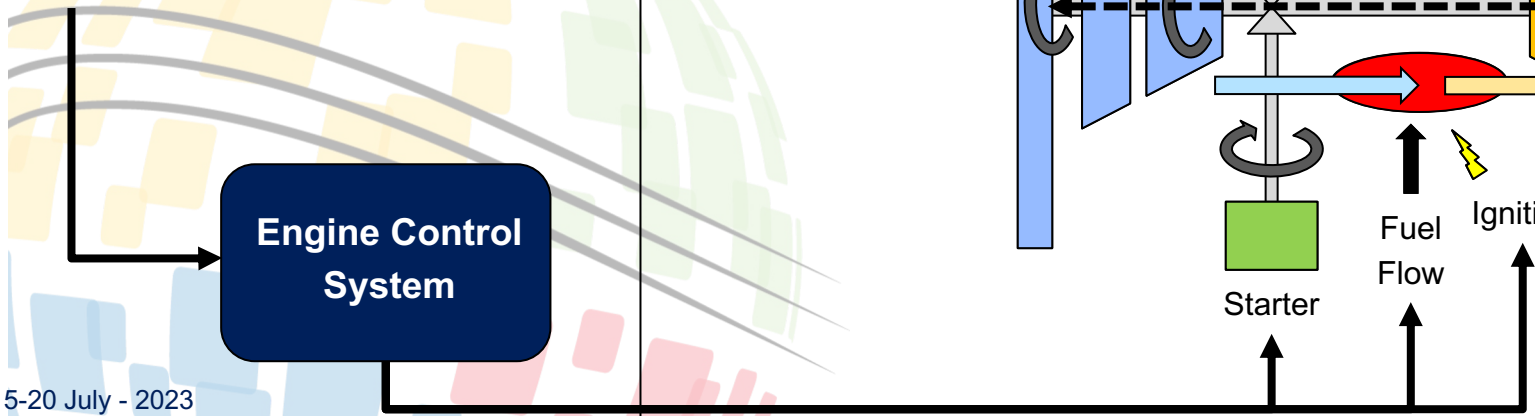

## MANUAL STARTING



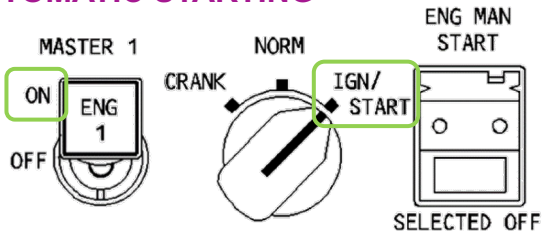

# Engine Start Procedure

Let's specify conditions to enter in motoring phase.

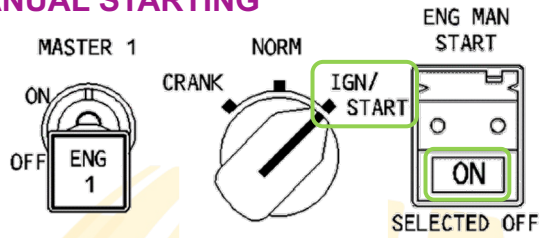



## AUTOMATIC STARTING



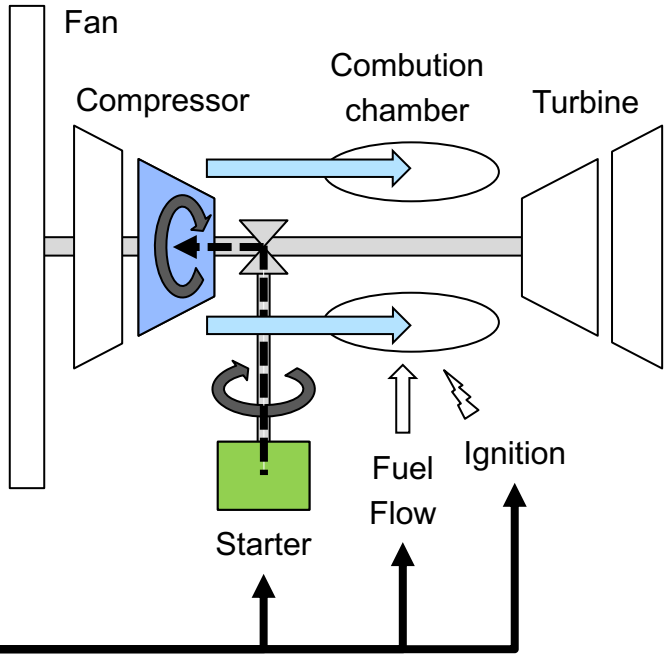

## MANUAL STARTING




# Engine Start Procedure

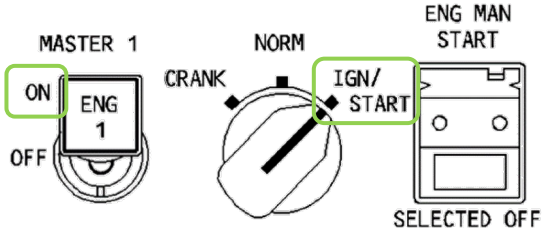
**Motoring**

Let's specify conditions to enter in motoring phase.

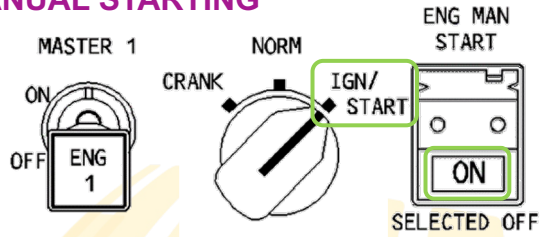



**Engine Control System**

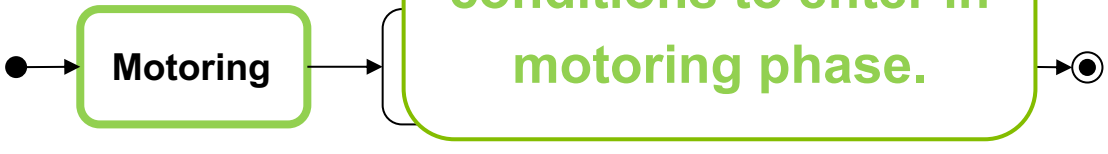
## AUTOMATIC STARTING

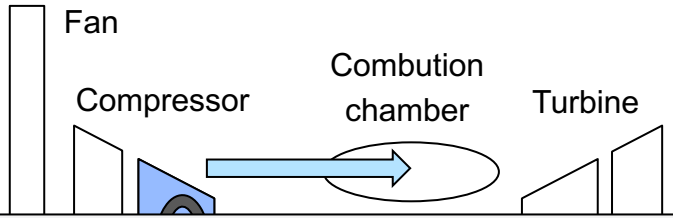



## MANUAL STARTING




# Engine Start Procedure

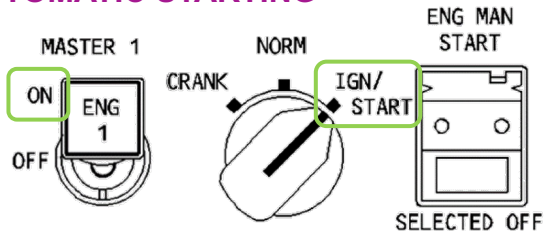



Requirements | Assumptions

| Index | Summary | Precondition | | | | Duration | Postcondition |
|---|---|---|---|---|---|---|---|
| | | Engnie_Start_Selector | Master_Lever | ENG_MAN_START_sw | N2 | | Start_Valve_cmd |
| 1 | Start Valve Openning in Manual Starting Motoring | IGN_START | Off | On | | | Open |
| 2 | Start Valve Openning in Automatic Starting Motoring and Ignition | IGN_START | On | | | | Open |
| 3 | Start Valve Closing | | | | >50 | | Closed |

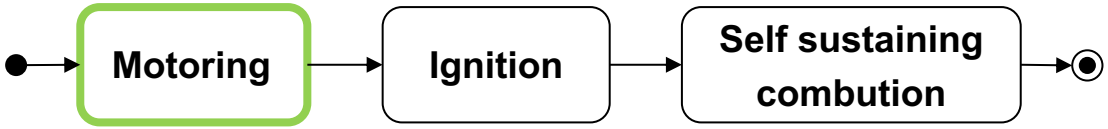
## AUTOMATIC STARTING

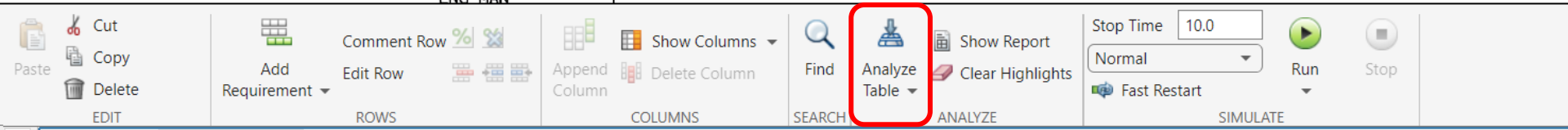



## MANUAL STARTING

ENG MAN

# ENGINE START PROCEDURE




Model Browser

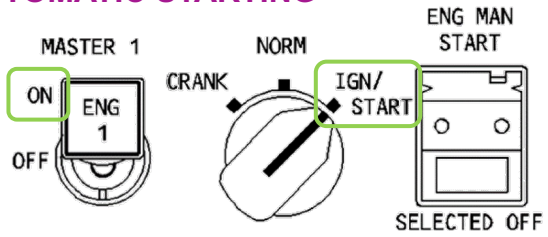
Requirements Table

CmdStartValve_v1 ▸ Requirements Table

Requirements | Assumptions

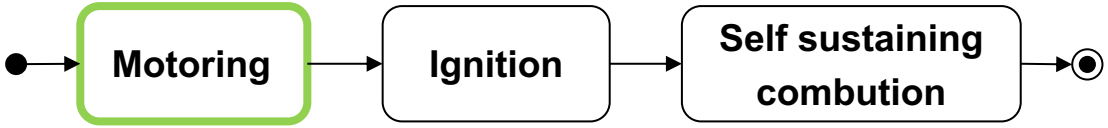
| Index | Summary | Precondition | | | | Duration | Postcondition |
|---|---|---|---|---|---|---|---|
| | | Engnie_Start_Selector | Master_Lever | ENG_MAN_START_sw | N2 | | Start_Valve_cmd |
| 1 | Start Valve Openning in Manual Starting Motoring | IGN_START | Off | On | | | Open |
| 2 | Start Valve Openning in Automatic Starting Motoring and Ignition | IGN_START | On | | | | Open |
| 3 | Start Valve Closing | | | | >50 | | Closed |

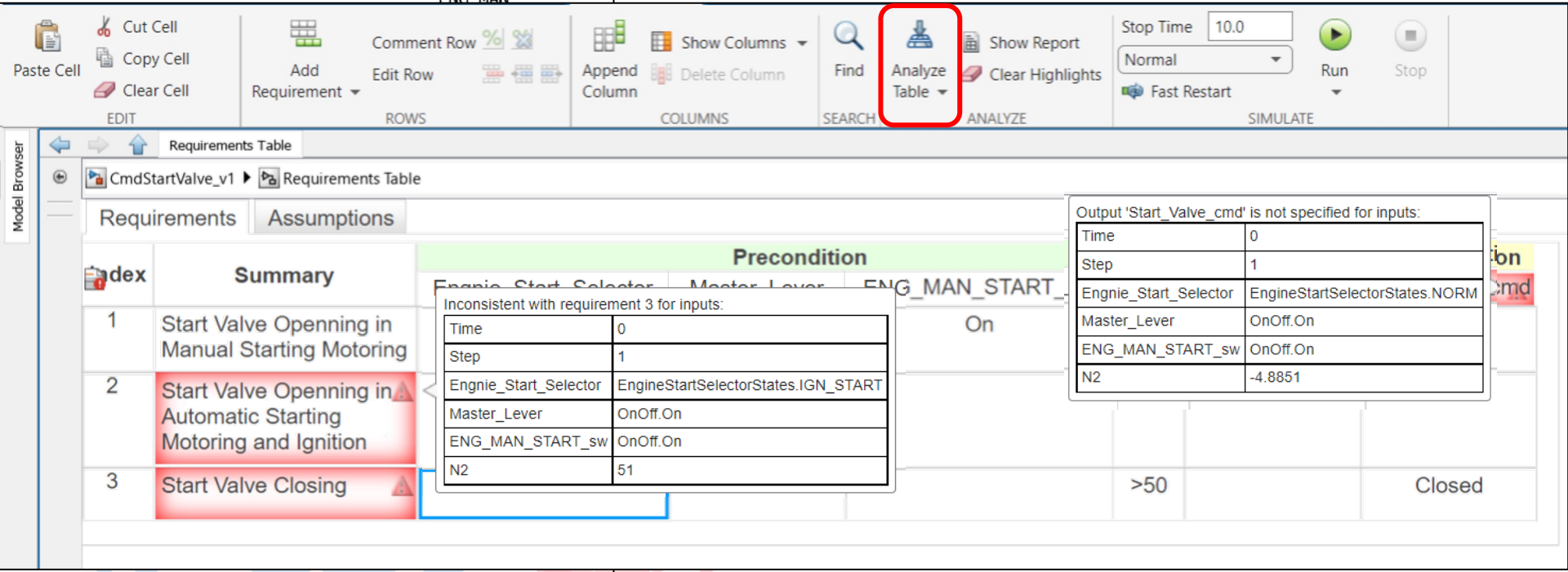
## AUTOMATIC STARTING



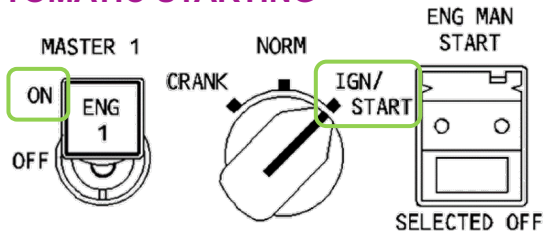

## MANUAL STARTING

# ENGINE START PROCEDURE



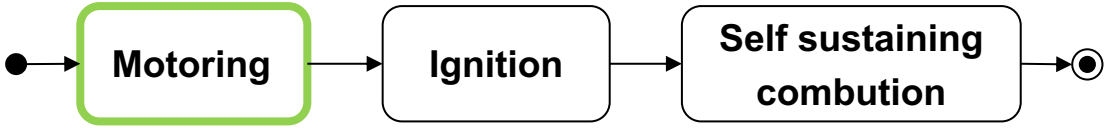



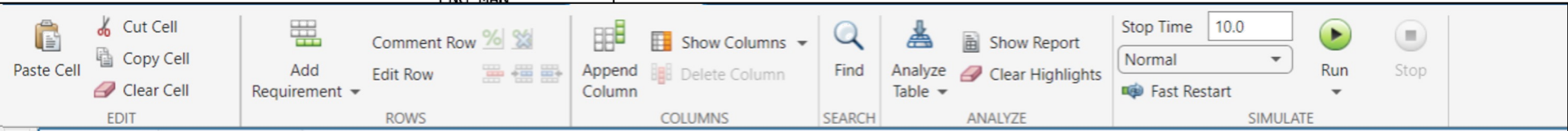
## AUTOMATIC STARTING




## MANUAL STARTING

# ENGINE START PROCEDURE




Model Browser

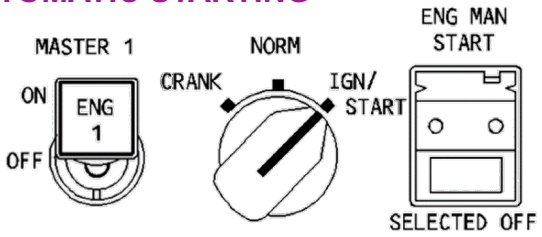
Requirements Table

CmdStartValve_v1 ▸ Requirements Table

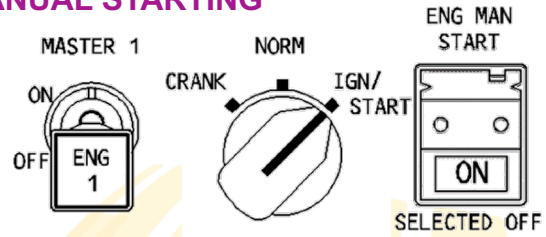
Requirements | Assumptions

| Index | Summary | Precondition | | | | Duration | Postcondition |
|---|---|---|---|---|---|---|---|
| | | Engnie_Start_Selector | Master_Lever | ENG_MAN_START_sw | N2 | | Start_Valve_cmd |
| 1 | Start Valve Openning in Manual Starting | IGN_START | Off | On | <50 | | Open |
| 2 | Start Valve Openning in Automatic Starting Motoring and Ignition | IGN_START | On | | <50 | | Open |
| 3 | Start Valve Closing | | | | >50 | | Closed |
| 4 | Default state | Else | | | | | Closed |

## AUTOMATIC STARTING

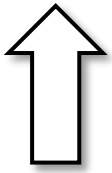


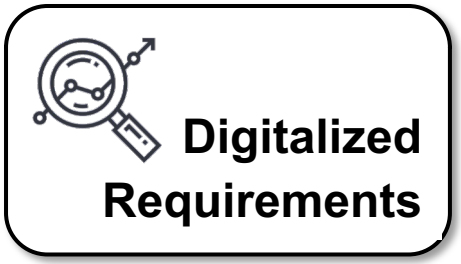

## MANUAL STARTING




# Engine Start Procedure

***Automatic Formal Proof Analysis***

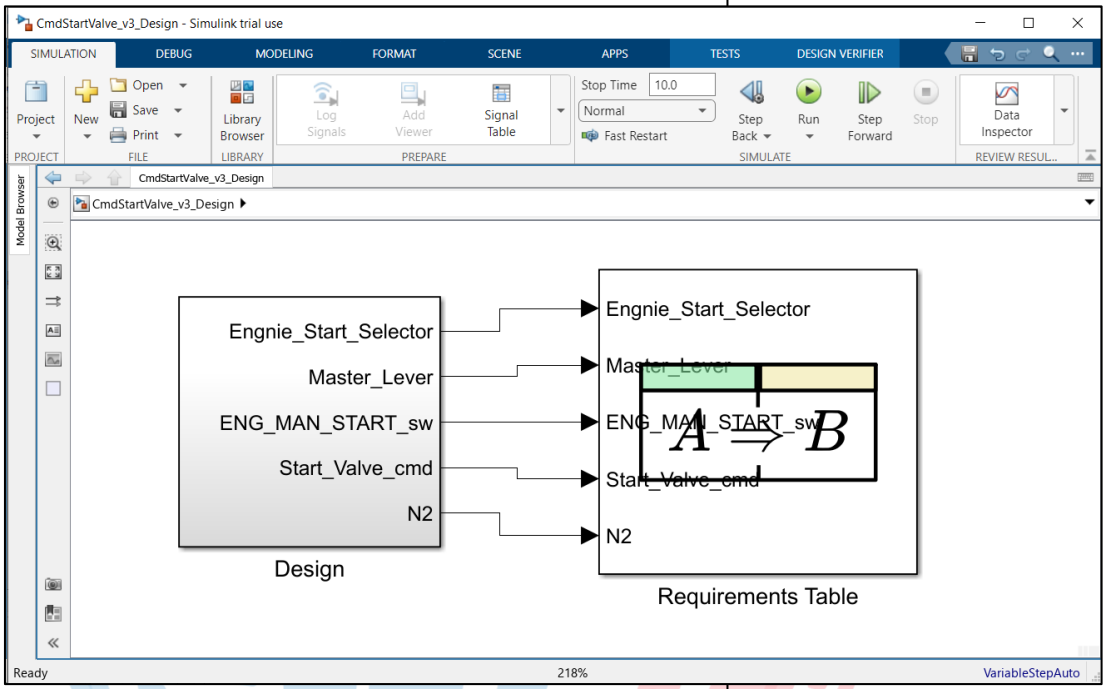





## Allows:

- **Automatic checking** of requirements during simulations
- **Test cases generation** to ensure design coverage objectives
- **Formal Design verification**

# Engine Start Procedure





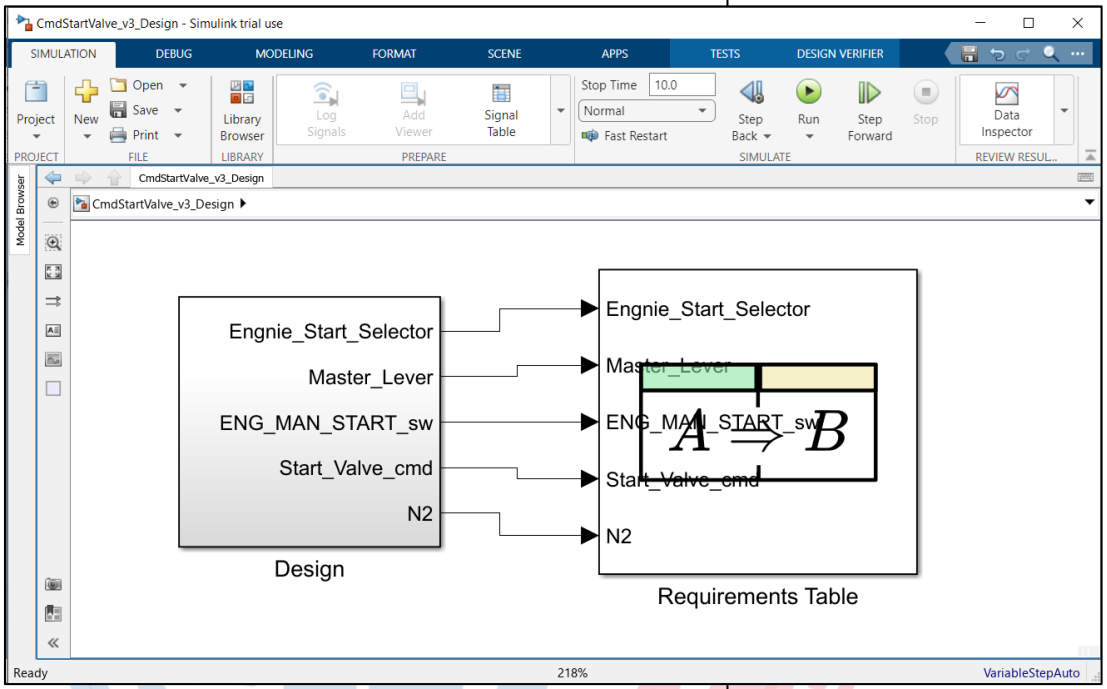
***Automatic Formal Proof Analysis***

***Automatic Checking of Simulations & Tests***

**Digitalized Requirements**

## Allows:

- **Automatic checking** of requirements during simulations
- **Test cases generation** to ensure design coverage targets
- **Formal Design verification**



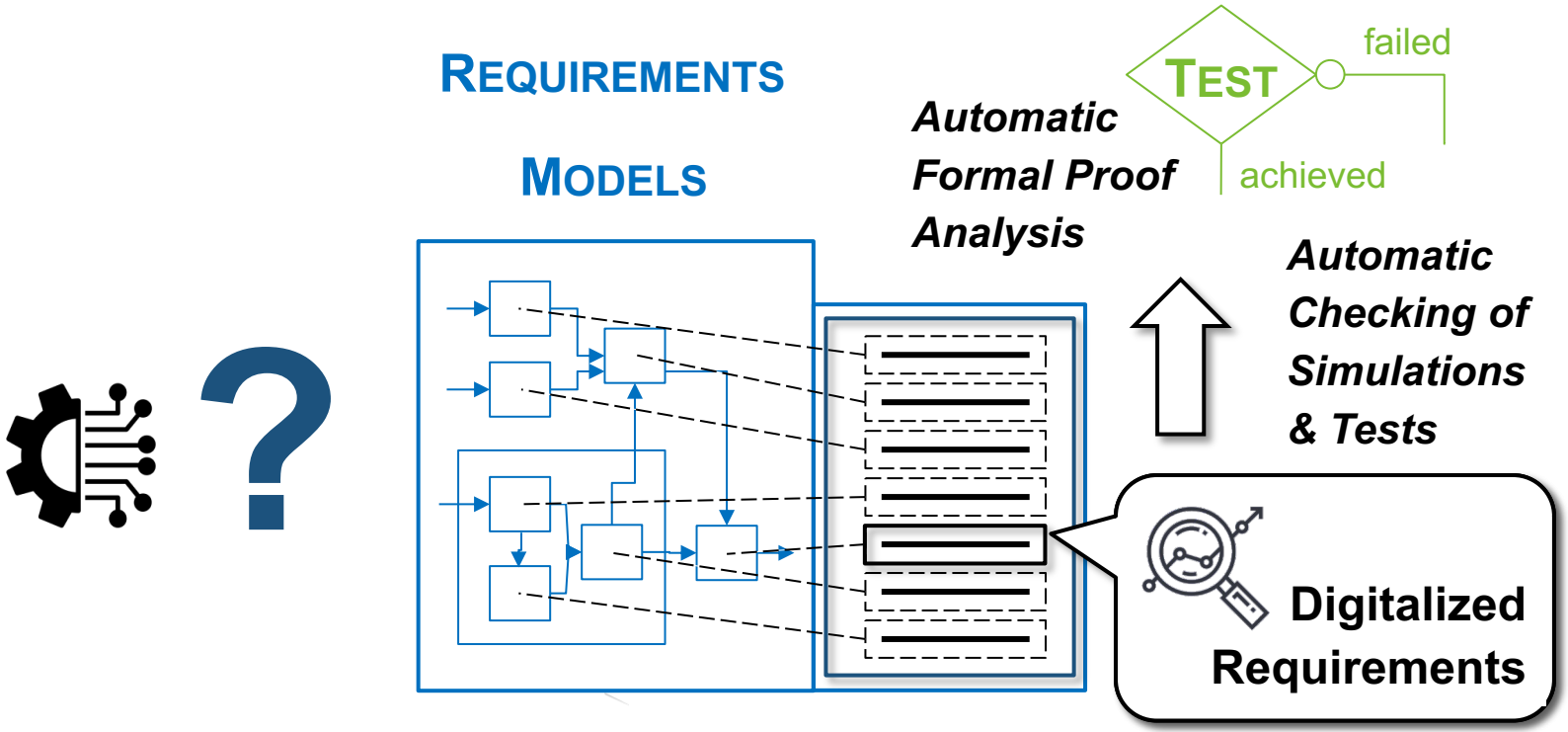

# Integration into MBSE workflows
# Maximizing digital continuity


***Automatic Formal Proof Analysis***

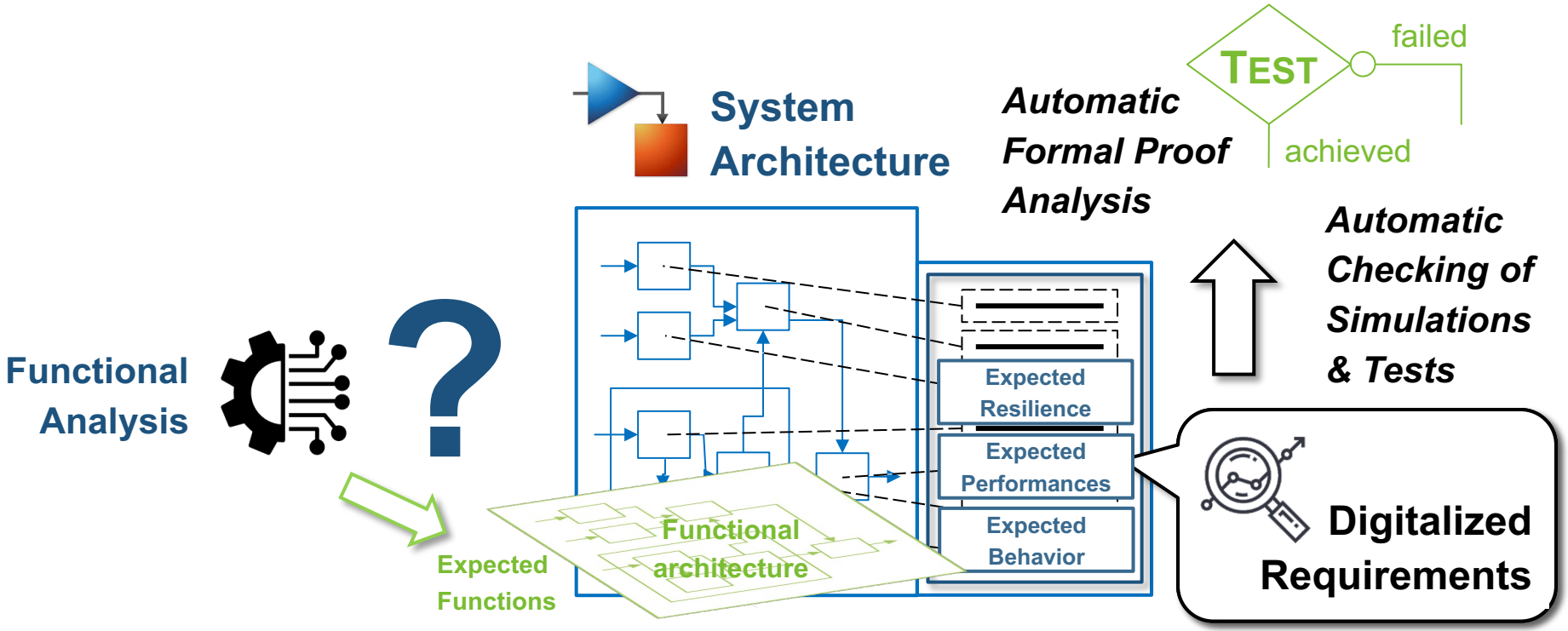
***Automatic Checking of Simulations & Tests***

**Digitalized Requirements**

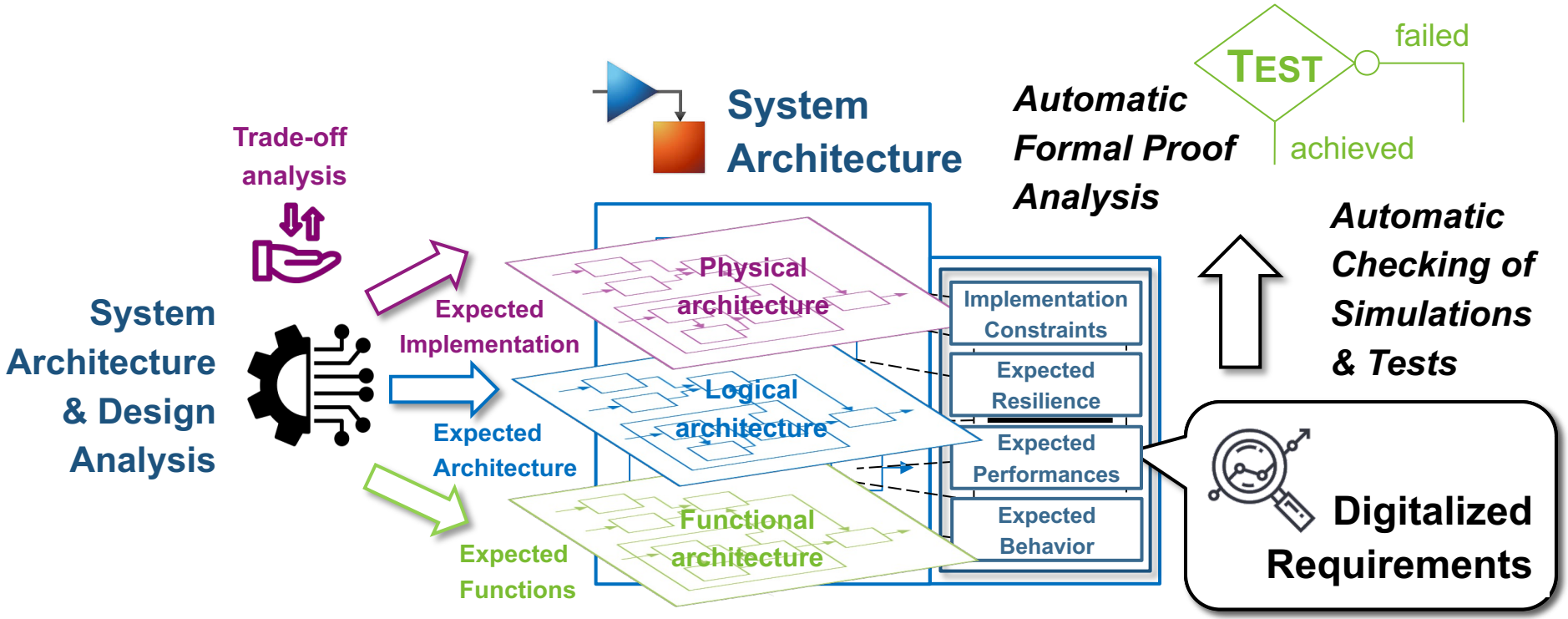
# Integration into MBSE workflows
# Maximizing digital continuity



# Integration into MBSE workflows
# Maximizing digital continuity



# Integration into MBSE workflows
# Maximizing digital continuity

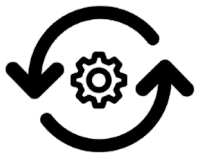


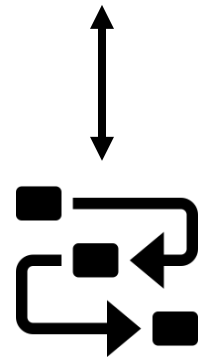
# Integration into MBSE workflows
# Maximizing digital continuity

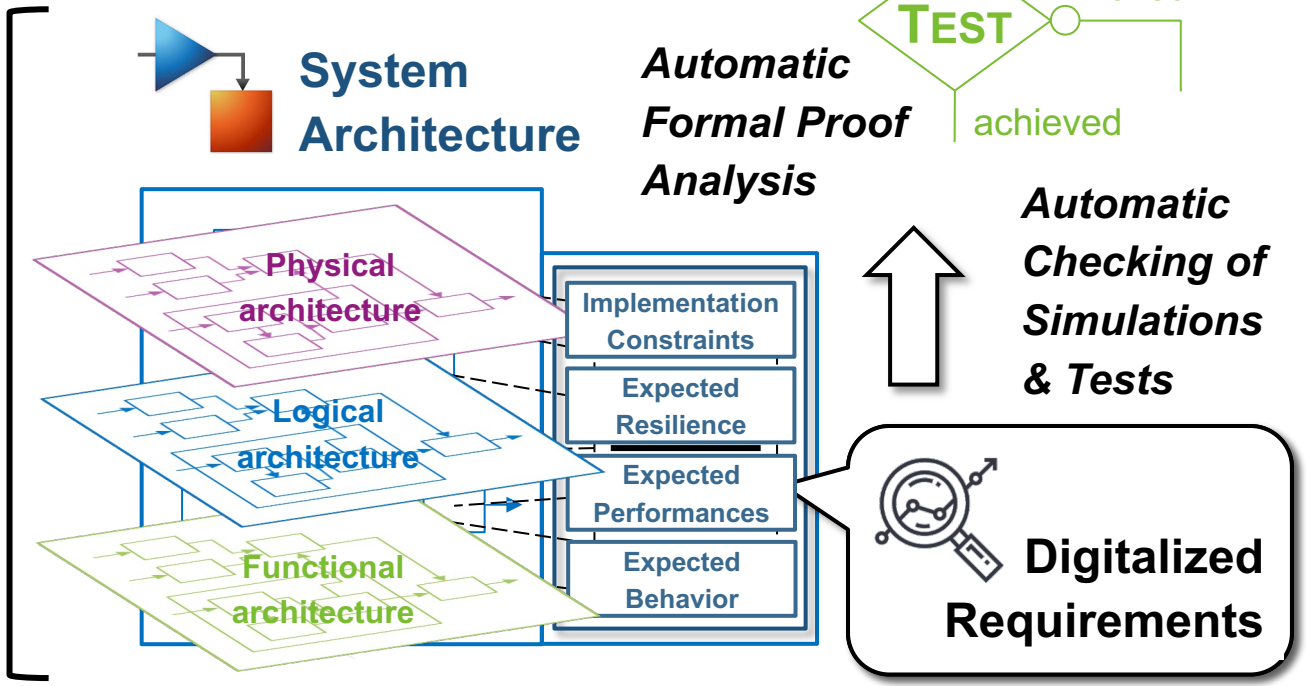
**Re-Engineered & Reuse of System Architecture models**

**Change Management**

**Operational & Functional Scenarios**





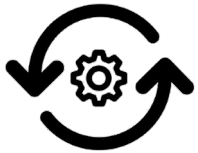


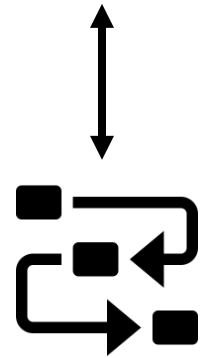
# Integration into MBSE workflows
# Maximizing digital continuity

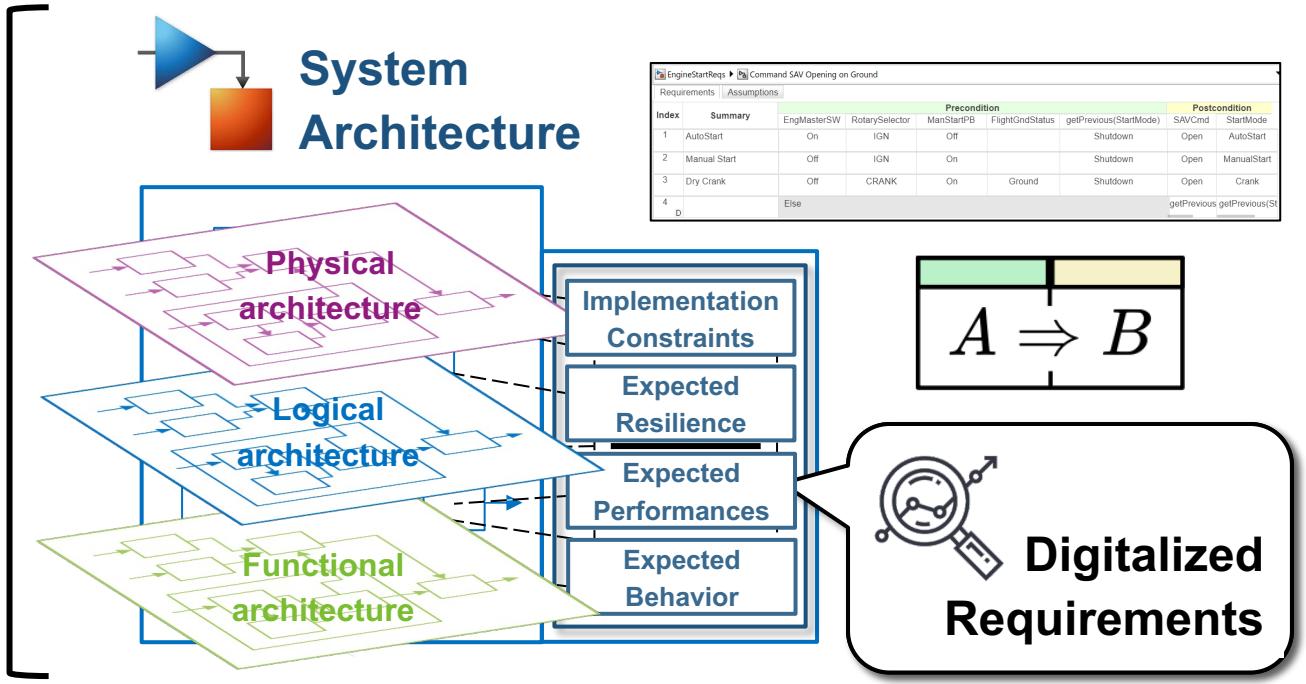
**Re-Engineered & Reuse of System Architecture models**

**Change Management**

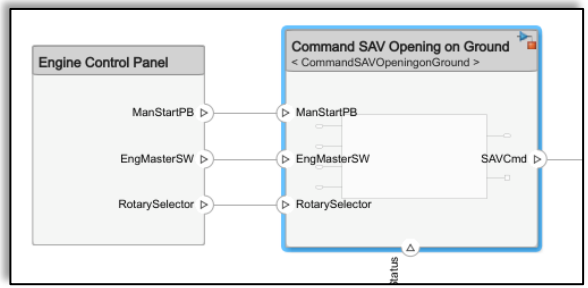
**Operational & Functional Scenarios**



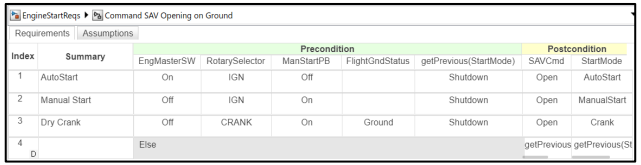




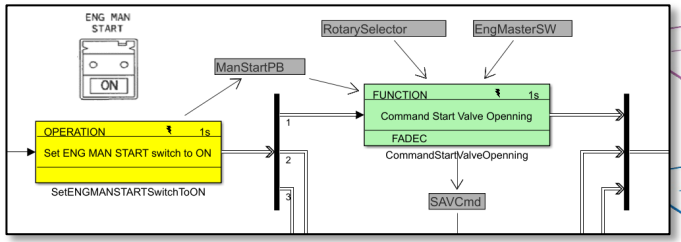
# Integration into MBSE workflows
# Maximizing digital continuity

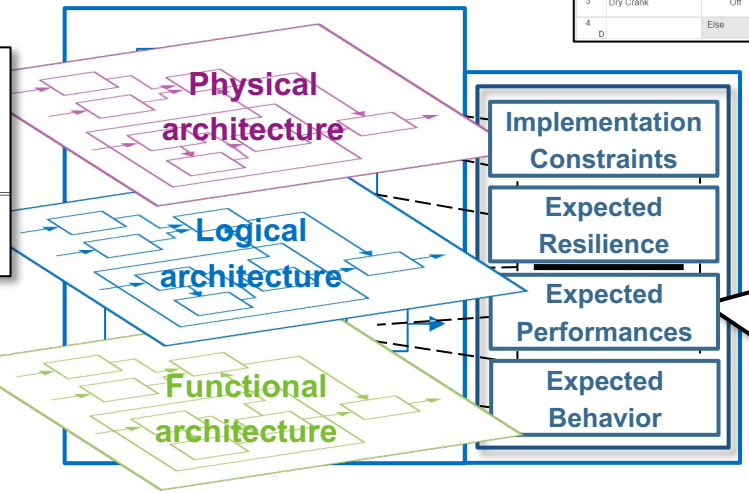


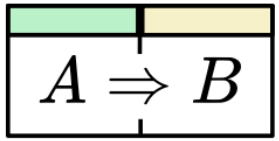

## System Architecture



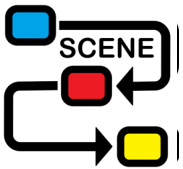
| Index | Summary | Precondition | | | | | Postcondition | |
|---|---|---|---|---|---|---|---|---|
| | | EngMasterSW | RotarySelector | ManStartPB | FlightGndStatus | getPrevious(StartMode) | SAVCmd | StartMode |
| 1 | AutoStart | On | IGN | Off | | Shutdown | Open | AutoStart |
| 2 | Manual Start | Off | IGN | On | | Shutdown | Open | ManualStart |
| 3 | Dry Crank | Off | CRANK | On | Ground | Shutdown | Open | Crank |
| 4 | | Else | | | | | getPrevious | getPrevious(St |



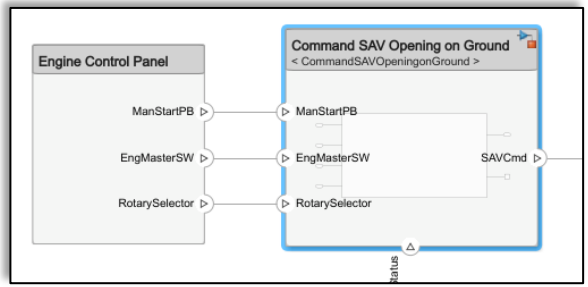




## Operational & Functional Scenarios




## Digitalized Requirements

# Integration into MBSE workflows
# Maximizing digital continuity

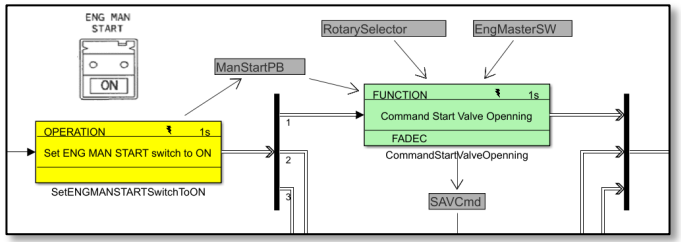



## System Architecture

EngineStartReqs ▸ Command SAV Opening on Ground

Requirements | Assumptions

| Index | Summary | Precondition | | | | | Postcondition | |
|---|---|---|---|---|---|---|---|---|
| | | EngMasterSW | RotarySelector | ManStartPB | FlightGndStatus | getPrevious(StartMode) | SAVCmd | StartMode |
| 1 | AutoStart | On | IGN | Off | | Shutdown | Open | AutoStart |
| 2 | Manual Start | Off | IGN | On | | Shutdown | Open | ManualStart |
| 3 | Dry Crank | Off | CRANK | On | Ground | Shutdown | Open | Crank |
| 4 D | | Else | | | | | getPrevious | getPrevious(St |




## Operational & Functional Scenarios

SCENE

Are different **Perspectives** about the same **Expected** System **Behavior,**

*(with their* **"Pro & Cons"***)*

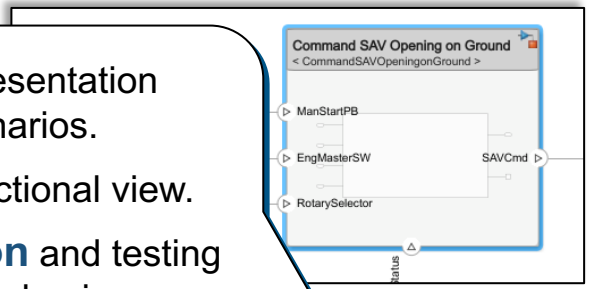
$$A \Rightarrow B$$

## Digitalized Requirements

# Integration into MBSE workflows

Max

- **Complete** representation gathering all scenarios.
- **Structured** functional view.
- Allow **simulation** and testing of the expected behavior.



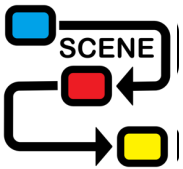

**System Architecture**

- **Atomic, un-ambiguous & testable**.
- Formalizing **constraints**, expected **performances**, **unexpected behavior**.
- **Formal consistency** checking, **achievability** checking, and **completeness** assessment.
- **Automatic** Tests **checking**.

**Story telling:**

- **Intuitive & Easy** way to describe expected behavior.
- **Simple** description as focusing on a cases of use.

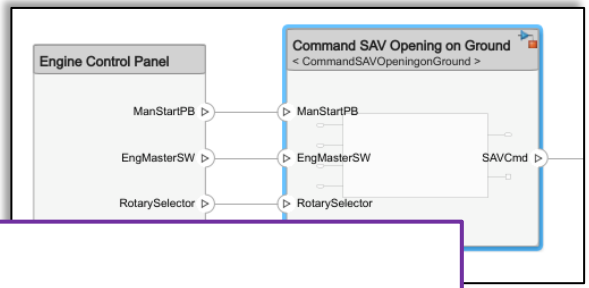
**Operational & Functional Scenarios**




Are different **Perspec**
about the same **Expect**
System **Behavior,**
*(with their* **"Pro & Cons"***)*

**Digitalized Requirements**

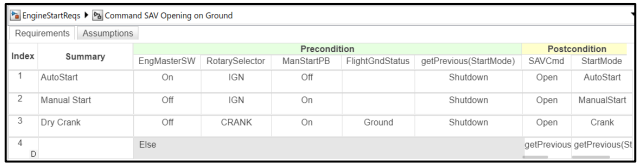
# Integration into MBSE workflows
# Maximizing digital continuity

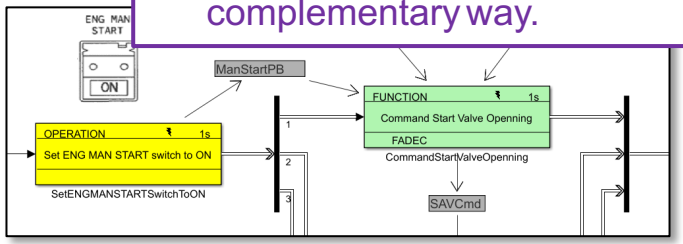


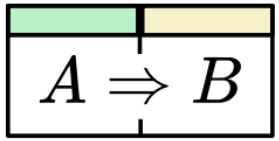

**Goal** is to,

- **model** behavior **only once,**
- to **get the best** from each model,
- using them in a **Consistent** complementary way.

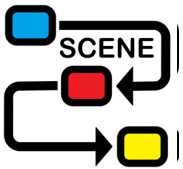
## System Architecture

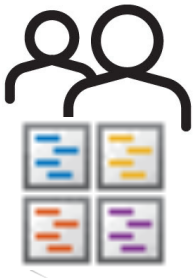


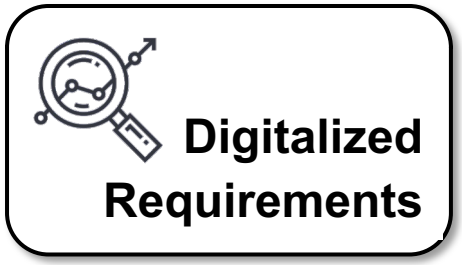



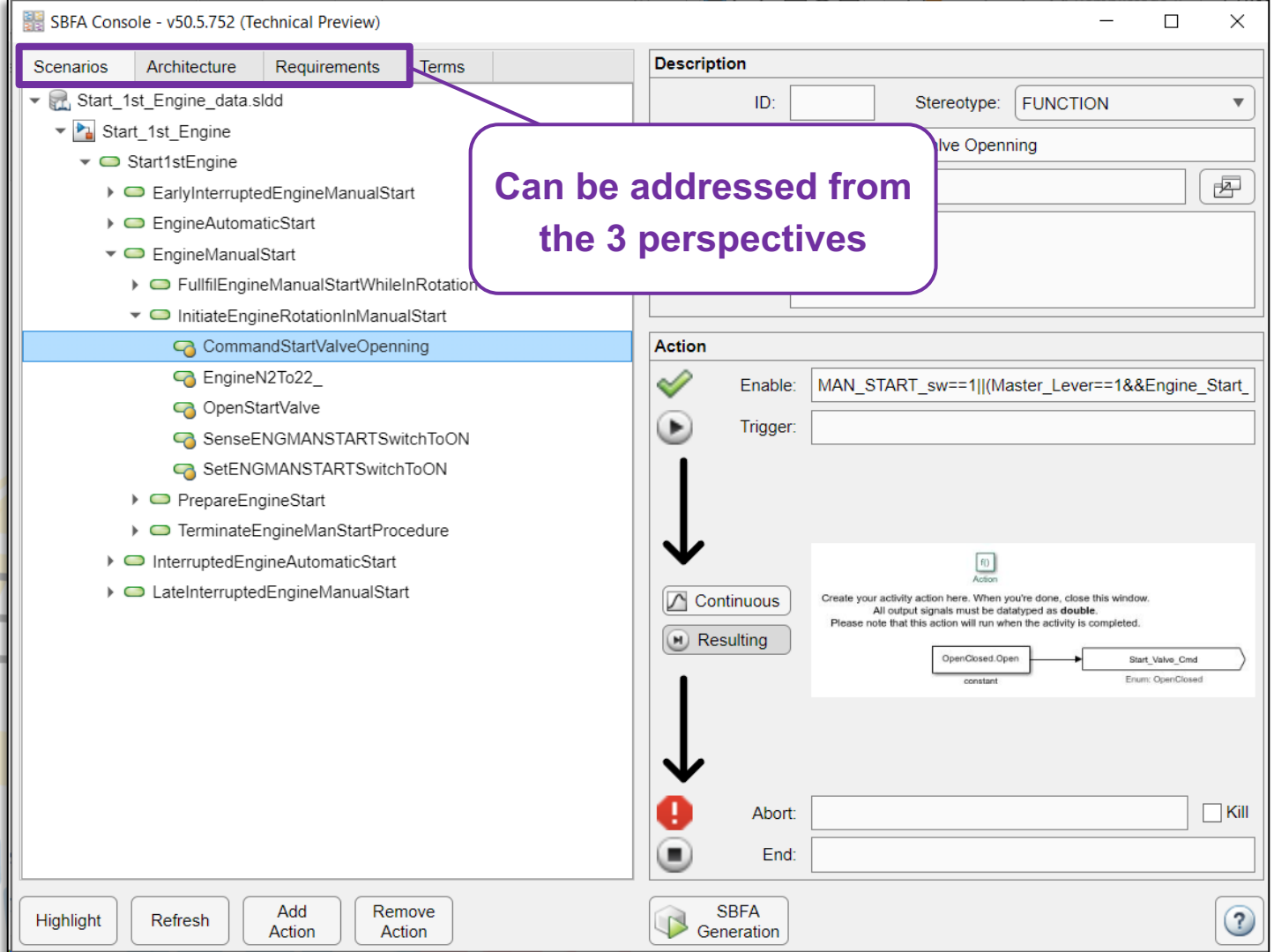



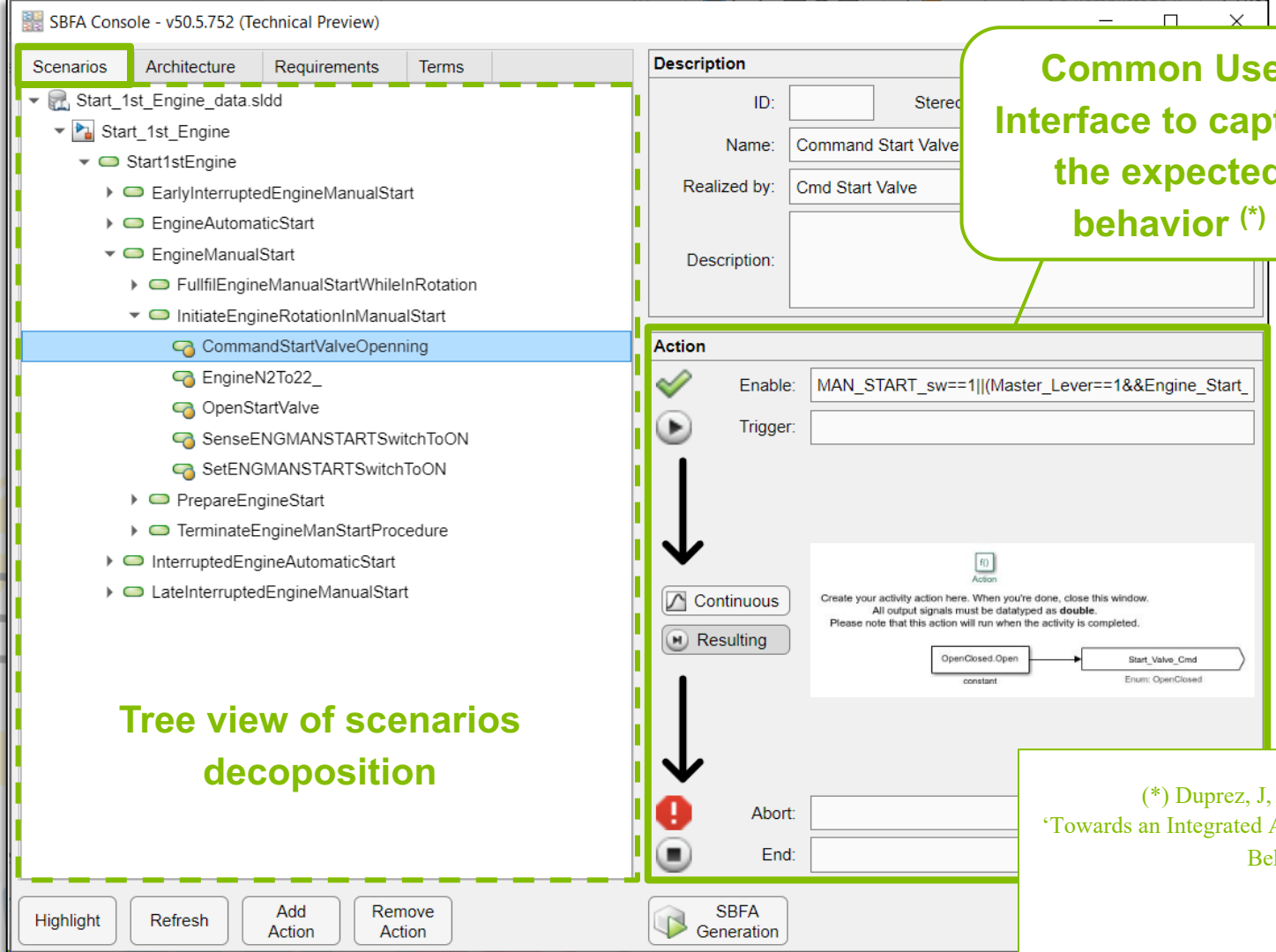

## Operational & Functional Scenarios



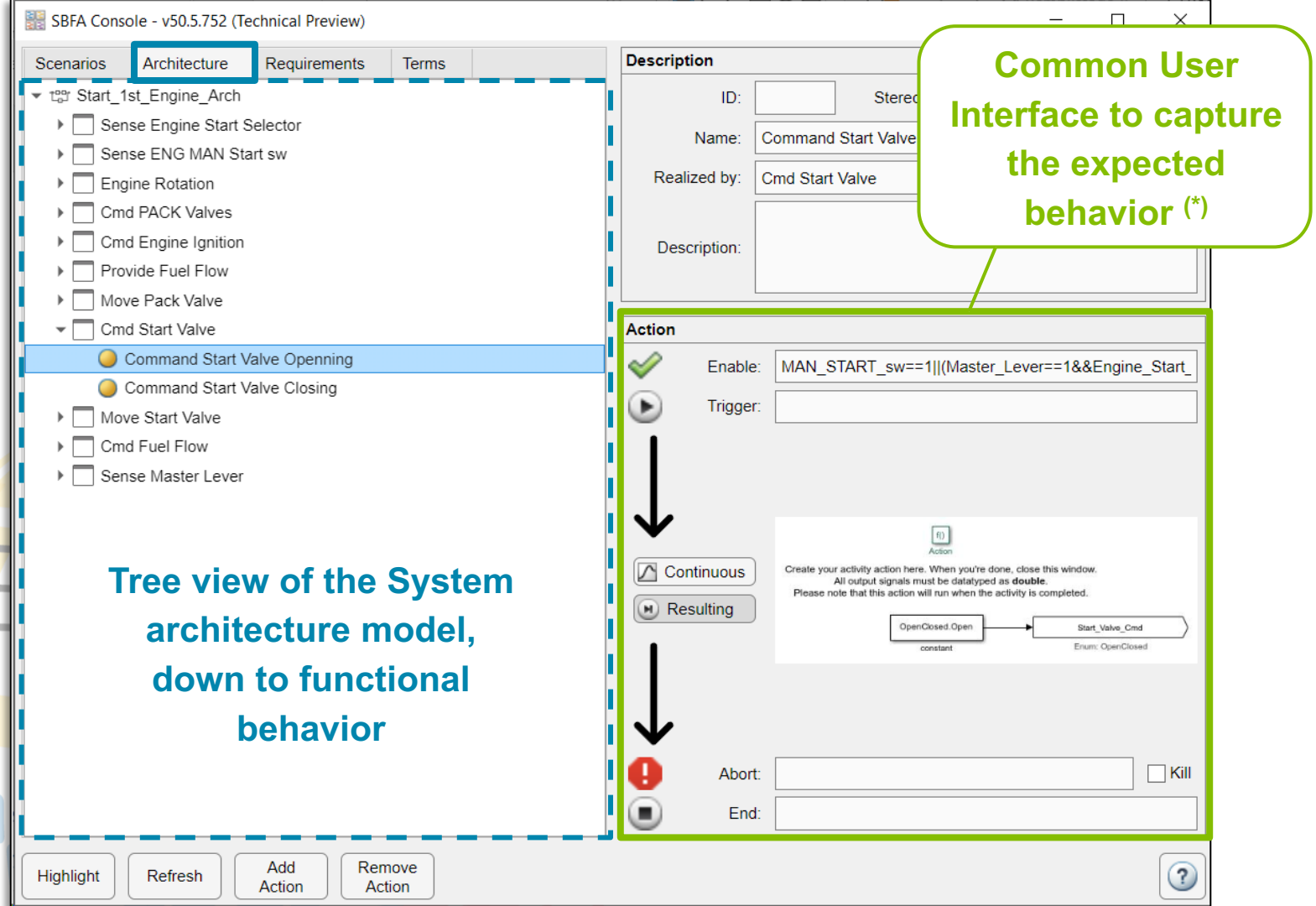



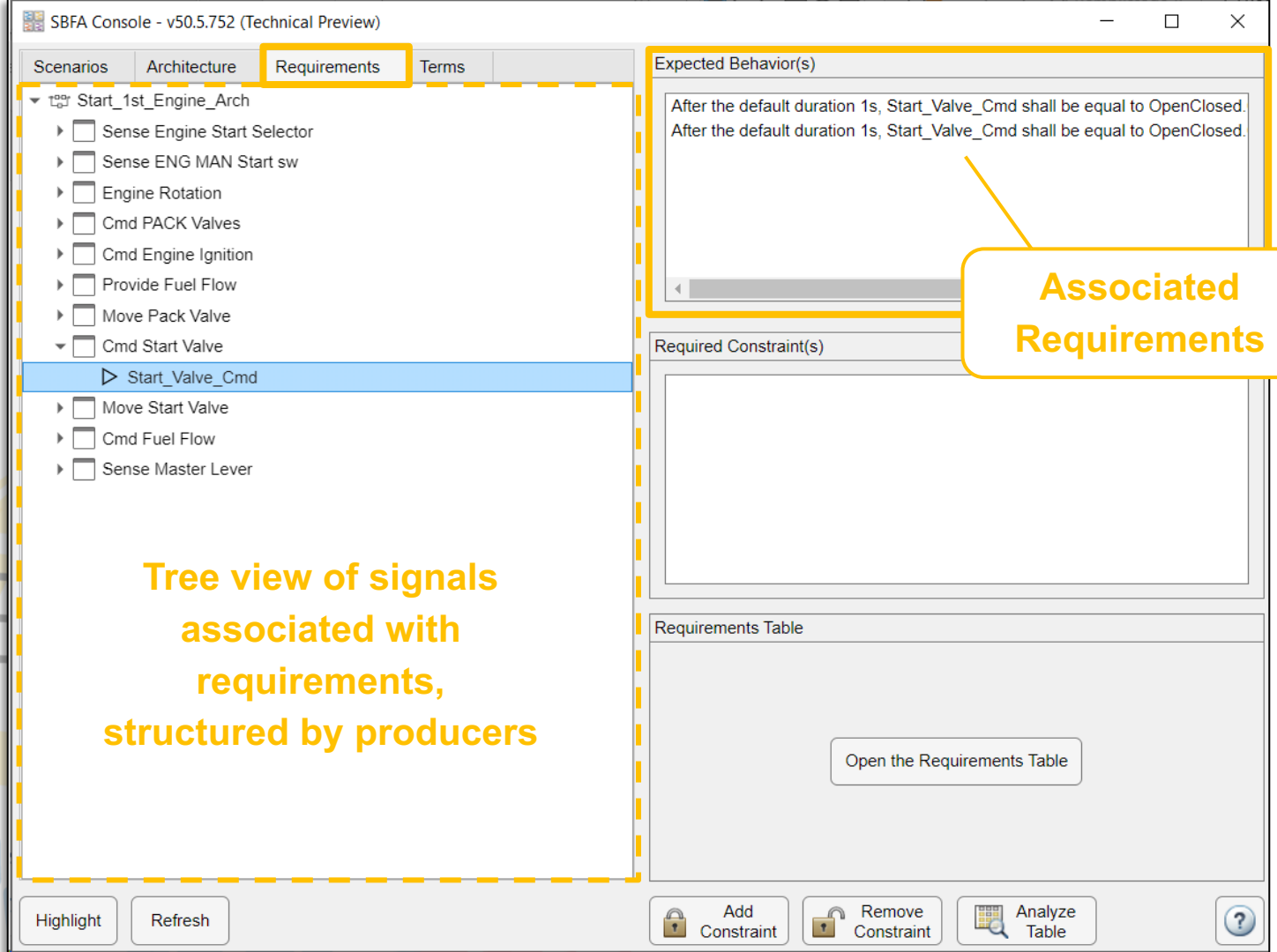


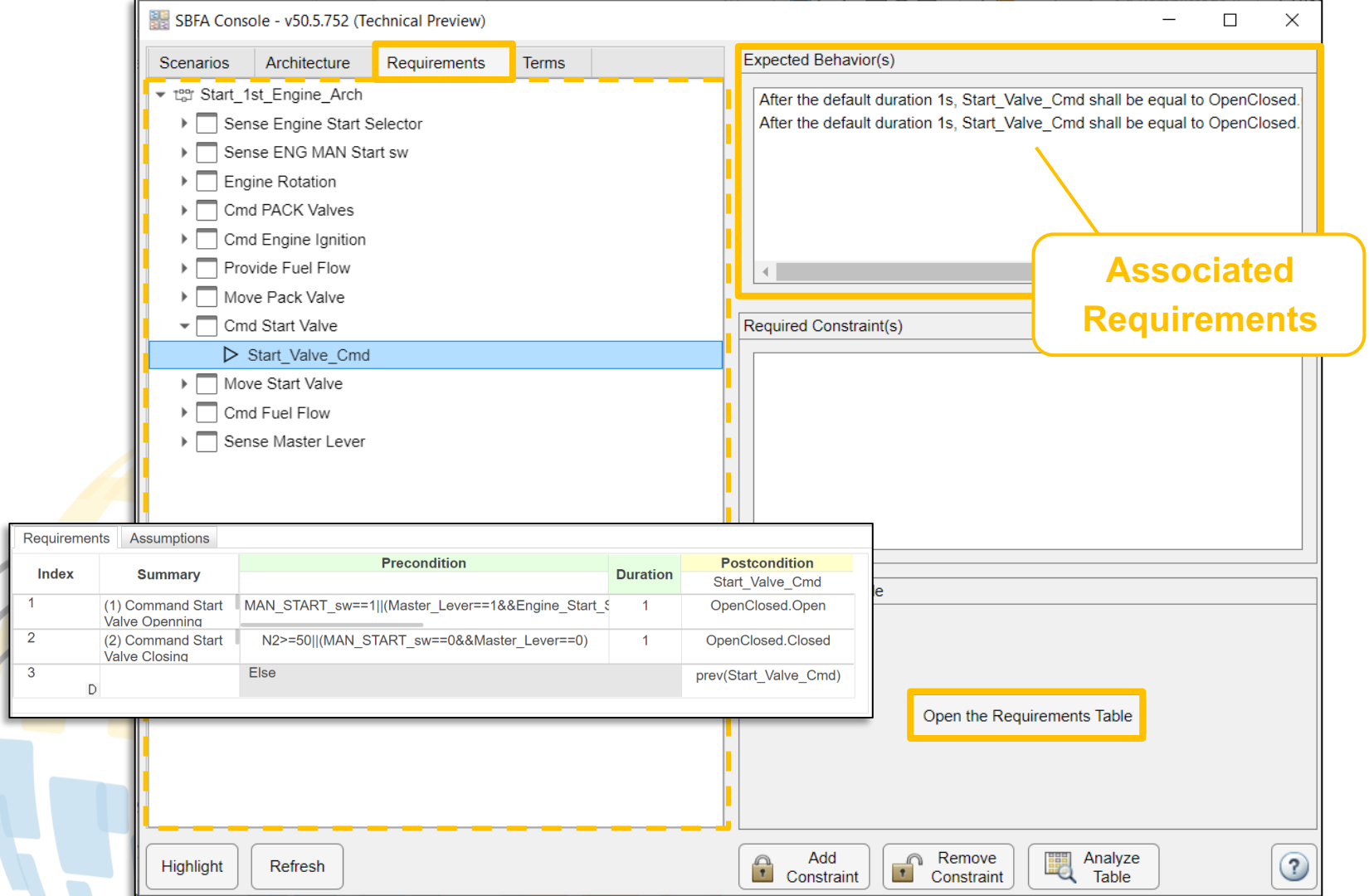

SBFA Console - v50.5.752 (Technical Preview)
Scenarios
Architecture
Requirements
Terms
Start_1st_Engine_data.sldd
Start_1st_Engine
Start1stEngine
EarlyInterruptedEngineManualStart
EngineAutomaticStart
EngineManualStart
FullfilEngineManualStartWhileInRotation
InitiateEngineRotationInManualStart
CommandStartValveOpenning
EngineN2To22_
OpenStartValve
SenseENGMANSTARTSwitchToON
SetENGMANSTARTSwitchToON
PrepareEngineStart
TerminateEngineManStartProcedure
InterruptedEngineAutomaticStart
LateInterruptedEngineManualStart
Can be addressed from the 3 perspectives
Description
ID:
Stereotype:
FUNCTION
lve Openning
Action
Enable:
MAN_START_sw==1||(Master_Lever==1&&Engine_Start_
Trigger:
Continuous
Resulting
Action
Create your activity action here. When you're done, close this window.
All output signals must be datatyped as double.
Please note that this action will run when the activity is completed.
OpenClosed.Open
constant
Start_Valve_Cmd
Enum: OpenClosed
Abort:
Kill
End:
Highlight
Refresh
Add Action
Remove Action
SBFA Generation

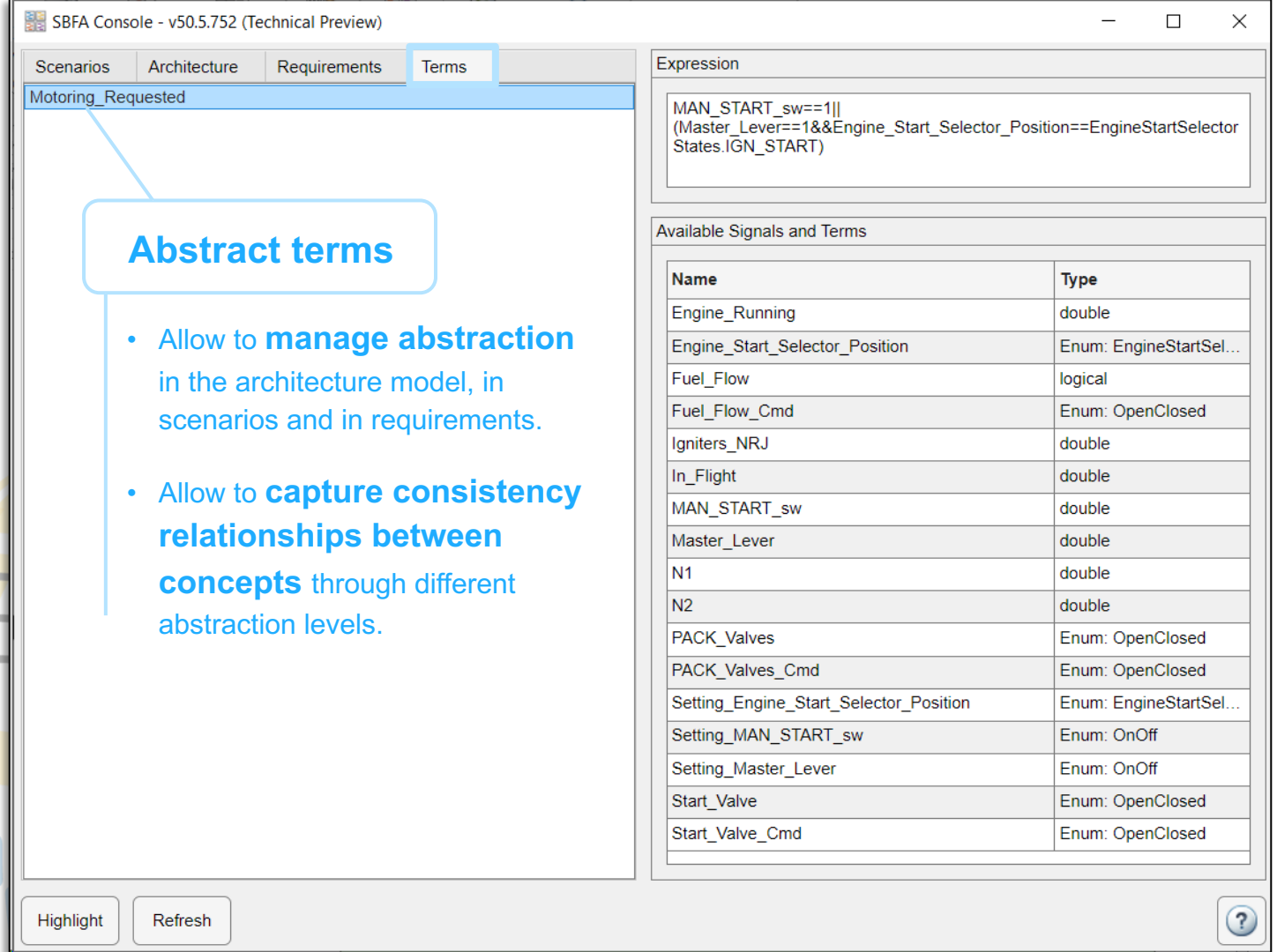



(*) Duprez, J, Royer, L, Faudou, R 'Towards an Integrated Approach of Systems Behavior Modeling and Specification.' INCOSE IS 2021

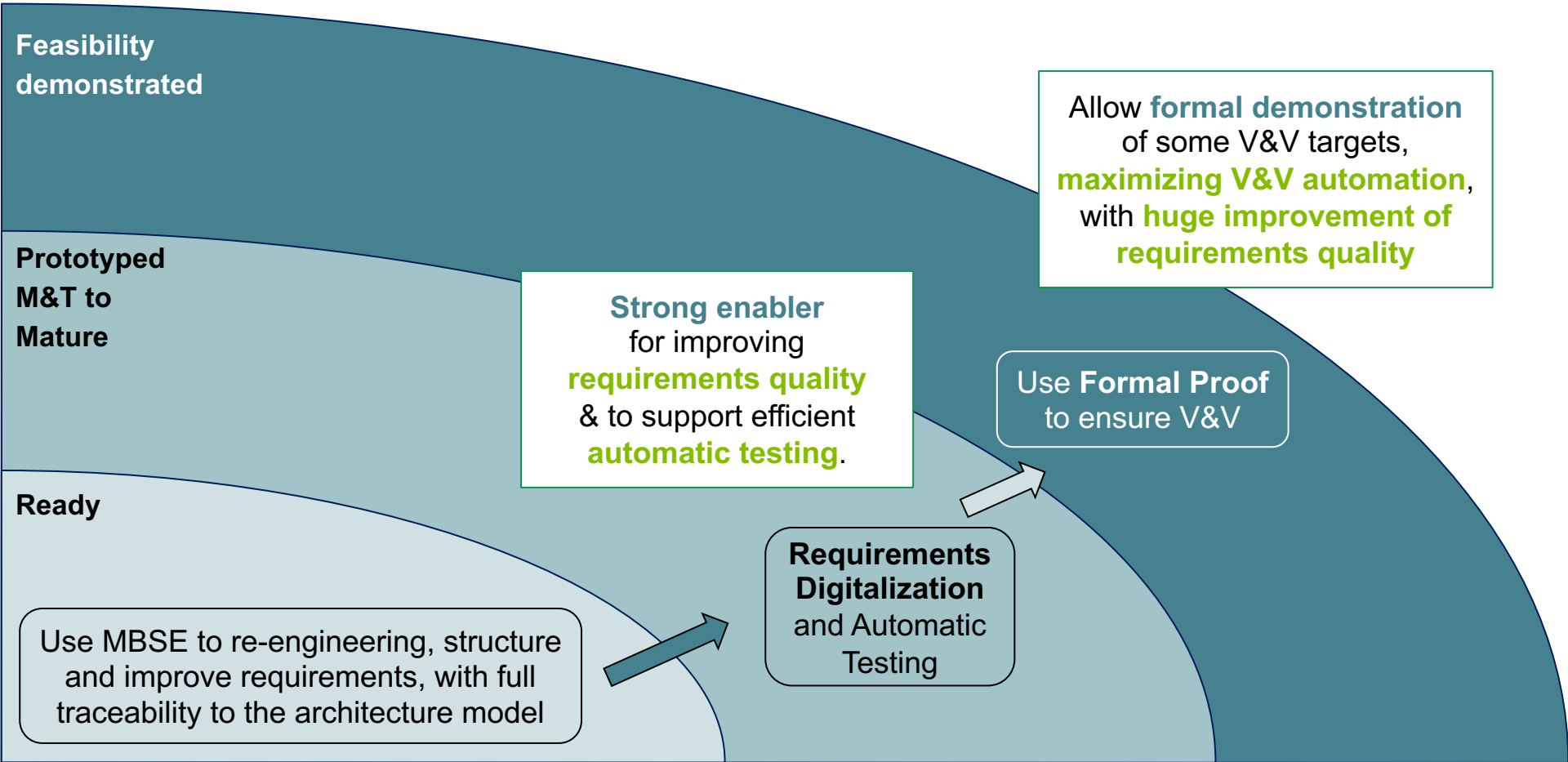

SBFA Console - v50.5.752 (Technical Preview)
Scenarios
Architecture
Requirements
Terms
Start_1st_Engine_Arch
Sense Engine Start Selector
Sense ENG MAN Start sw
Engine Rotation
Cmd PACK Valves
Cmd Engine Ignition
Provide Fuel Flow
Move Pack Valve
Cmd Start Valve
Command Start Valve Openning
Command Start Valve Closing
Move Start Valve
Cmd Fuel Flow
Sense Master Lever
Tree view of the System architecture model, down to functional behavior
Description
ID:
Name:
Command Start Valve
Realized by:
Cmd Start Valve
Description:
Common User Interface to capture the expected behavior (*)
Action
Enable:
MAN_START_sw==1||(Master_Lever==1&&Engine_Start_
Trigger:
Continuous
Resulting
Create your activity action here. When you're done, close this window.
All output signals must be datatyped as double.
Please note that this action will run when the activity is completed.
OpenClosed.Open
constant
Start_Valve_Cmd
Enum: OpenClosed
Abort:
Kill
End:
Highlight
Refresh
Add Action
Remove Action


SBFA Console - v50.5.752 (Technical Preview)
Scenarios
Architecture
Requirements
Terms
Start_1st_Engine_Arch
Sense Engine Start Selector
Sense ENG MAN Start sw
Engine Rotation
Cmd PACK Valves
Cmd Engine Ignition
Provide Fuel Flow
Move Pack Valve
Cmd Start Valve
Start_Valve_Cmd
Move Start Valve
Cmd Fuel Flow
Sense Master Lever
Tree view of signals associated with requirements, structured by producers
Expected Behavior(s)
After the default duration 1s, Start_Valve_Cmd shall be equal to OpenClosed.
After the default duration 1s, Start_Valve_Cmd shall be equal to OpenClosed.
Associated Requirements
Required Constraint(s)
Requirements Table
Open the Requirements Table
Highlight
Refresh
Add Constraint
Remove Constraint
Analyze Table

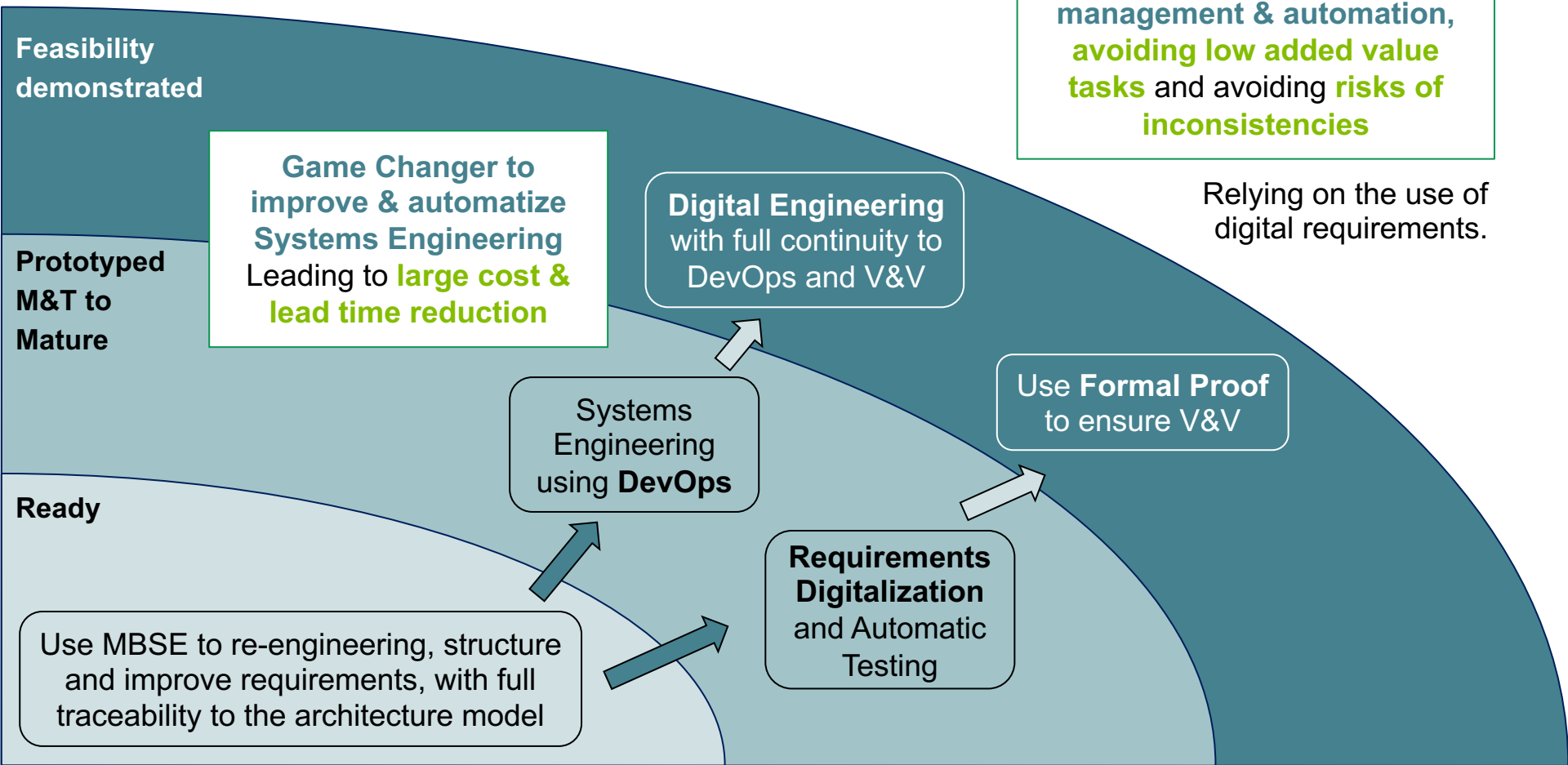

SBFA Console - v50.5.752 (Technical Preview)
Scenarios
Architecture
Requirements
Terms
Start_1st_Engine_Arch
Sense Engine Start Selector
Sense ENG MAN Start sw
Engine Rotation
Cmd PACK Valves
Cmd Engine Ignition
Provide Fuel Flow
Move Pack Valve
Cmd Start Valve
Start_Valve_Cmd
Move Start Valve
Cmd Fuel Flow
Sense Master Lever
Expected Behavior(s)
After the default duration 1s, Start_Valve_Cmd shall be equal to OpenClosed.
After the default duration 1s, Start_Valve_Cmd shall be equal to OpenClosed.
Associated Requirements
Required Constraint(s)
Requirements
Assumptions
Index
Summary
Precondition
Duration
Postcondition
Start_Valve_Cmd
1
(1) Command Start Valve Openning
MAN_START_sw==1||(Master_Lever==1&&Engine_Start_S
1
OpenClosed.Open
2
(2) Command Start Valve Closing
N2>=50||(MAN_START_sw==0&&Master_Lever==0)
1
OpenClosed.Closed
3
D
Else
prev(Start_Valve_Cmd)
Open the Requirements Table
Highlight
Refresh
Add Constraint
Remove Constraint
Analyze Table


SBFA Console - v50.5.752 (Technical Preview)
Scenarios
Architecture
Requirements
Terms
Motoring_Requested
Abstract terms
• Allow to manage abstraction in the architecture model, in scenarios and in requirements.
• Allow to capture consistency relationships between concepts through different abstraction levels.
Expression
MAN_START_sw==1||
(Master_Lever==1&&Engine_Start_Selector_Position==EngineStartSelector
States.IGN_START)
Available Signals and Terms
Name
Type
Engine_Running
double
Engine_Start_Selector_Position
Enum: EngineStartSel...
Fuel_Flow
logical
Fuel_Flow_Cmd
Enum: OpenClosed
Igniters_NRJ
double
In_Flight
double
MAN_START_sw
double
Master_Lever
double
N1
double
N2
double
PACK_Valves
Enum: OpenClosed
PACK_Valves_Cmd
Enum: OpenClosed
Setting_Engine_Start_Selector_Position
Enum: EngineStartSel...
Setting_MAN_START_sw
Enum: OnOff
Setting_Master_Lever
Enum: OnOff
Start_Valve
Enum: OpenClosed
Start_Valve_Cmd
Enum: OpenClosed
Highlight
Refresh

# Conclusion

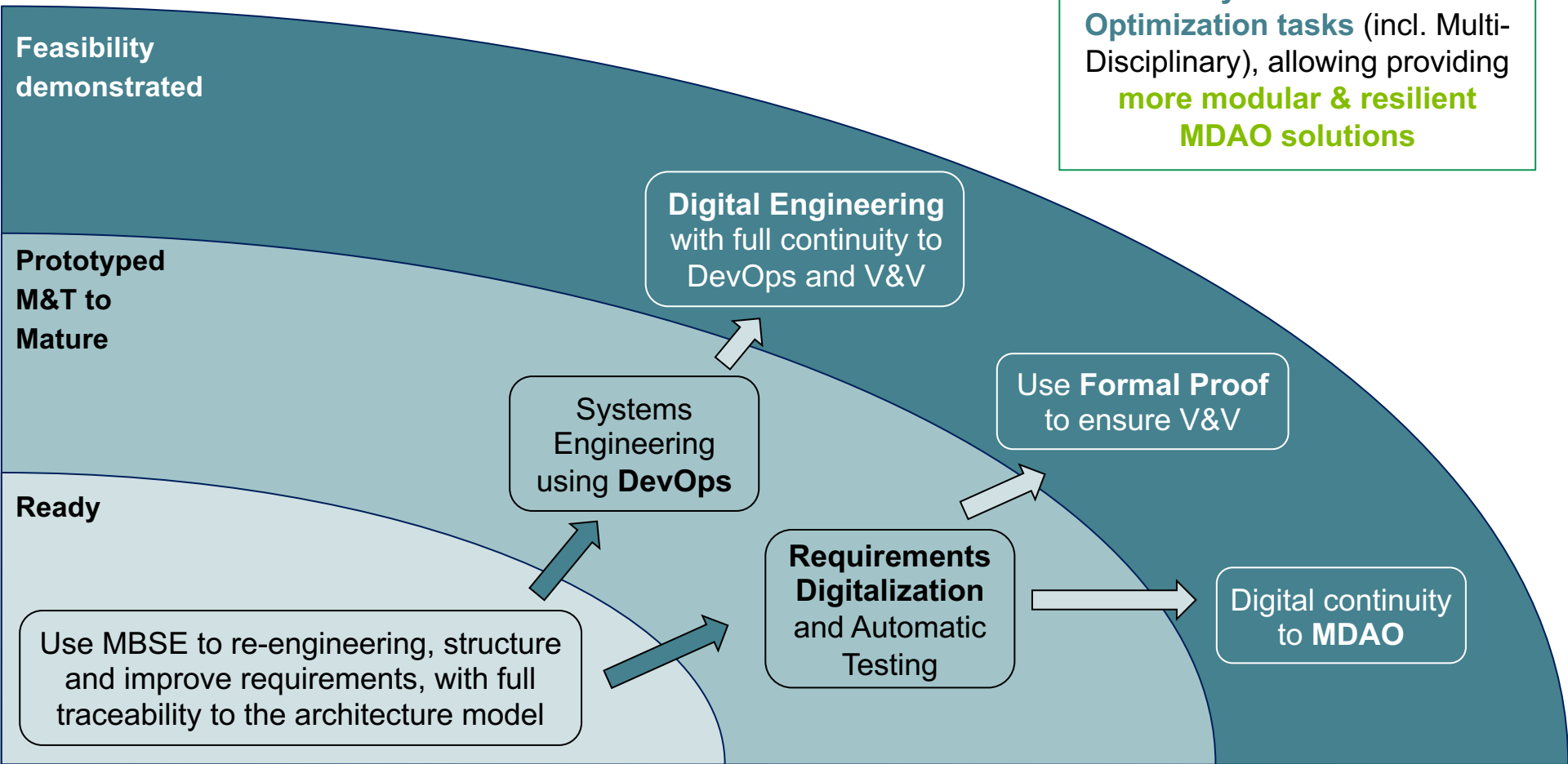

Feasibility demonstrated
Prototyped M&T to Mature
Ready
Use MBSE to re-engineering, structure and improve requirements, with full traceability to the architecture model
Requirements Digitalization and Automatic Testing
Strong enabler for improving requirements quality & to support efficient automatic testing.
Use Formal Proof to ensure V&V
Allow formal demonstration of some V&V targets, maximizing V&V automation, with huge improvement of requirements quality

# Conclusion

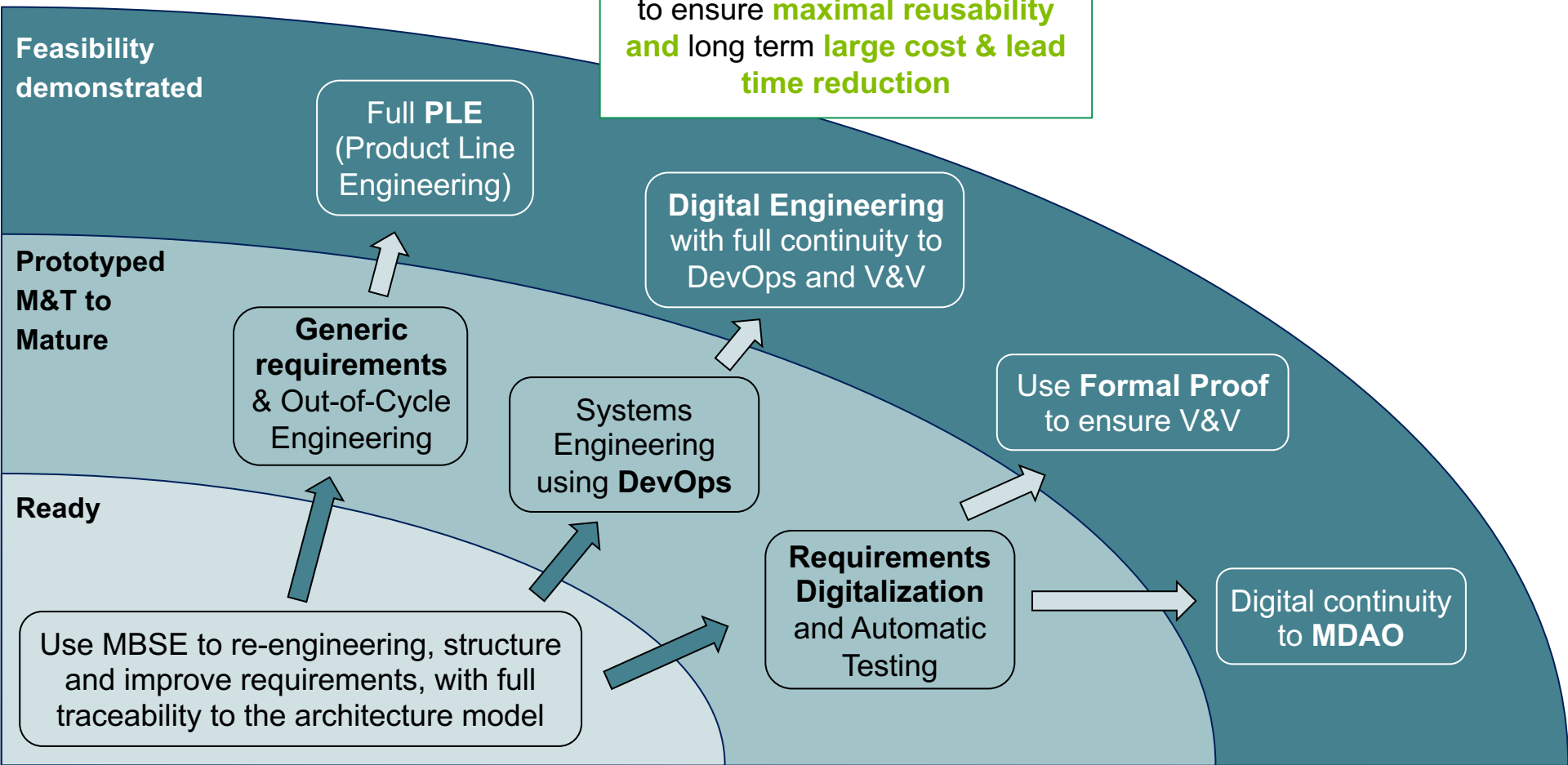

Feasibility demonstrated
Prototyped M&T to Mature
Ready
Use MBSE to re-engineering, structure and improve requirements, with full traceability to the architecture model
Systems Engineering using DevOps
Requirements Digitalization and Automatic Testing
Use Formal Proof to ensure V&V
Digital Engineering with full continuity to DevOps and V&V
Game Changer to improve & automatize Systems Engineering Leading to large cost & lead time reduction
Maximize workflows management & automation, avoiding low added value tasks and avoiding risks of inconsistencies
Relying on the use of digital requirements.

# Conclusion

Allow ensuring full **Digital Continuity with Trade-off and Optimization tasks** (incl. Multi-Disciplinary), allowing providing **more modular & resilient MDAO solutions**



# Conclusion


Game Changer for Engineering to ensure maximal reusability and long term large cost & lead time reduction
Feasibility demonstrated
Full PLE (Product Line Engineering)
Digital Engineering with full continuity to DevOps and V&V
Prototyped M&T to Mature
Generic requirements & Out-of-Cycle Engineering
Systems Engineering using DevOps
Use Formal Proof to ensure V&V
Ready
Use MBSE to re-engineering, structure and improve requirements, with full traceability to the architecture model
Requirements Digitalization and Automatic Testing
Digital continuity to MDAO

# Conclusion ➔ Need to extend the collaboration to a larger community

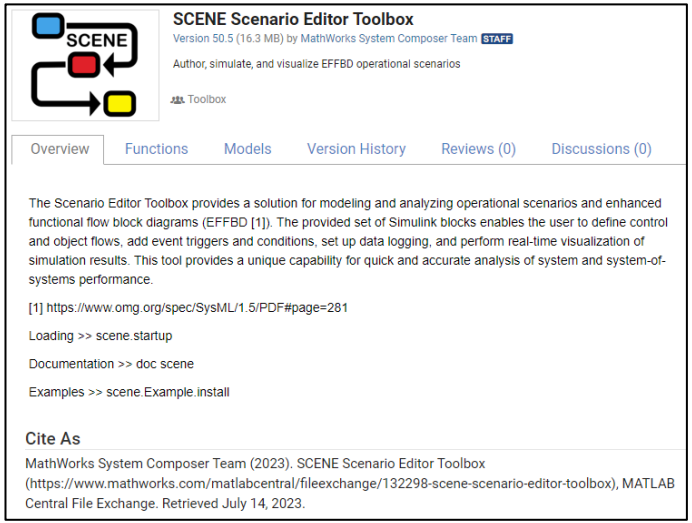
- Approach and Tooling developed through a collaboration between Airbus & MathWorks
- Feasibility & value demonstrated, but still at prototype level

## Goals:

- Address a larger scope of applications, through additional perspectives
- Establish a shared and robust semantics
- Gain in maturity through extended feedbacks

## Tool available in MathWorks File Exchange

https://fr.mathworks.com/matlabcentral/fileexchange/132298-scene-scenario-editor-toolbox



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hybrid event

Honolulu, HI, USA
July 15 - 20, 2023

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