# From catalogues to models:
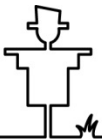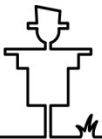
## Transitioning from existing requirements techniques to MBSE

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INCOSE UK ASEC
17th November 2015

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# Introduction

- Organisations with a mature document-centric requirements approach often have a significant investment in both existing tools and processes.

- The move to MBSE raises several questions about how these tools and processes 'fit' in the new world.

- Often the conclusion is a hybrid approach which attempts to get the maximum benefit from existing assets while attempting to 'cherry pick' the best bits of MBSE.

- This may introduce some new problems and can prevent an organisation from realising the full potential of MBSE - such as full automated model checking.
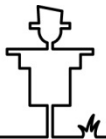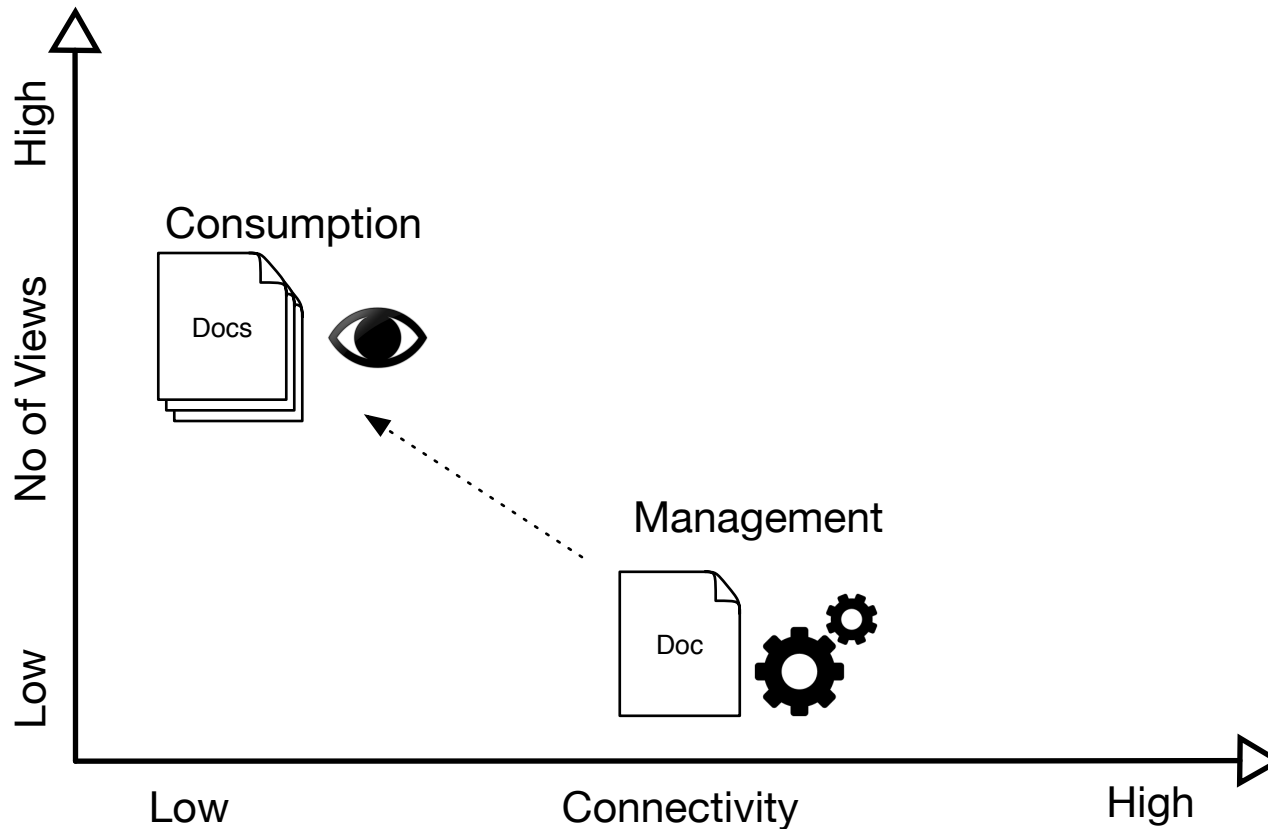
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# Basic document-centric approaches

- Basic document centric approaches are ones which:
  - Predominately use natural language e.g. English.
    - Which can lead to inconsistency and ambiguity.
  - Use general purpose office tools e.g. Word, Excel, PowerPoint as both editors and repositories.
    - Which are focused on presentation rather than the quality of the content and which can be unproductive.
  - Are less likely to use a formally defined requirements ontology or language pattern (i.e. boilerplates).
    - Which can lead to inconsistency and incompleteness.
  - Use a limited set of Views.
    - Most commonly employing functional breakdowns displayed as trees and/or simple tables.
  - Have no or implied linkage between and within documents.
    - This makes it impossible to query information in large sets or to check automatically.
  - By definition are focused around the production of a document for communication, verification and validation.
  - Are completely reliant on manual inspection for completeness and consistency.
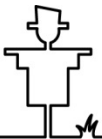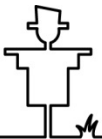
# Number of views vs connectivity for basic document-centric approaches

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# Mature document-centric approaches

- Mature document-centric approaches are ones which are more likely to:
  - Still predominately use natural language e.g. English, but may supplement this with 'pictures' and other representations.
    - Thus presenting a richer view of the requirements than basic approaches.
  - Use specialist requirements management tools.
    - Often with some integration with generic office tools.
  - May use formally defined requirements ontologies.
    - Whether proprietary or standards based such as ISO/IEC 15288.
  - May use requirements boilerplates
    - E.g. the 'Easy Approach to Requirements Syntax (EARS)'.
  - Still use a limited set of Views
    - Although this set is often larger than the 'basic' approach to include things like traceability matrices.
    - However the base topology is still usually either a tree or tabular 'catalogue'.
  - Have some linkage (traceability) in the underlying repository between the elements
    - But still no or only implied linkage between or within the published documents.
  - Still be focused around the production of printable documents for communication, verification and validation.
  - Less reliant on manual inspection for completeness and consistency.
    - Although this is bounded by the scope of the ontology i.e. it doesn't extend to the system design.

# Example of a requirement using EARS

- The pattern for an event-driven functional requirement is as follows:
  - When [Trigger] [Precondition] Actor Action [Object]
  - e.g. *"When an Order is shipped and Order Terms are not 'prepaid', the System shall create an Invoice."*
    - Trigger: an Order is shipped
    - Precondition: Order Terms are not 'prepaid'
    - Actor: the System
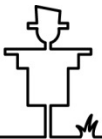    - Action: create
    - Object: an Invoice

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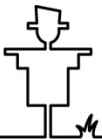
# Number of views vs connectivity for mature document-centric approaches
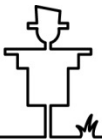
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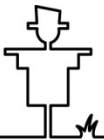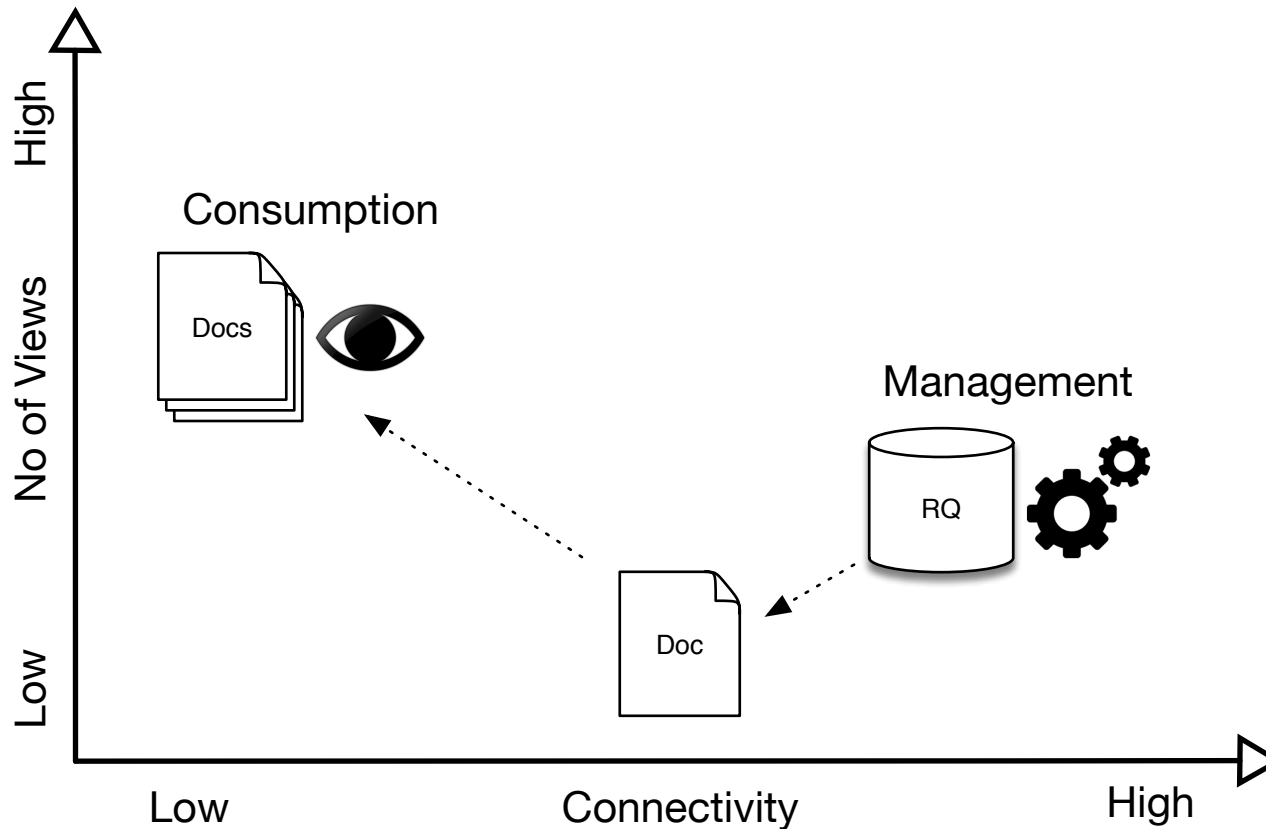
# Why MBSE?

- The properties of a good system model according to Long & Scott (2011):
  1. Provides order, which allows the design team to attack the problem in a coherent and consistent manner.
  2. Has the power to demonstrate and persuade,
  3. Provides greater integrity and consistency, and
  4. Provides greater insight into both the problem and the solution.

- Allows automated model checking in support of manual inspection.
  - is quicker, cheaper, and results in a model of greater quality than when relying on manual inspection alone.
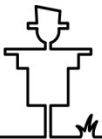
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# Reluctance to do less document-centric requirements management

1. The risk in moving away from what is considered to be an established 'proven' technique to a newer 'less used' technique is perceived to be too high.

2. There may be resistance from external stakeholders.

3. There is a perceived lack of functionality for the management of requirements within current MBSE tools compared to specialist requirements management ones.

4. An unfamiliarity with model-based requirement techniques results in what appears to be an overwhelming set of potential issues. It just looks too hard.

5. They have already made a significant investment in tools and process from which they wish to maximise return, and

6. The authority for the use of the two techniques may be different i.e. a corporate requirements process may be mandated across all projects while MBSE may only be being used on a subset. (It is assumed that the organisation is unaware or doesn't believe this to be an issue.)

# Hybrid approach

- The solution to this tension is often seen as a hybrid approach where requirements are 'authored' within the existing toolset and in accordance with any existing process before being 'exported' to an MBSE tool where they are 'consumed' in a system-model.

- This approach introduces a number of questions:

    1. At what point(s) in the system lifecycle and under what circumstances should requirements be exported from the requirements-catalogue to the system-model?
    2. What form should 'requirements' take in the system-model?
    3. How are requirements edited, particularly if the required edits are identified while being 'consumed' within the system-model?
    4. Which tool should be used for which systems engineering task?
    5. What is the extra effort and cost required by this approach?
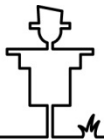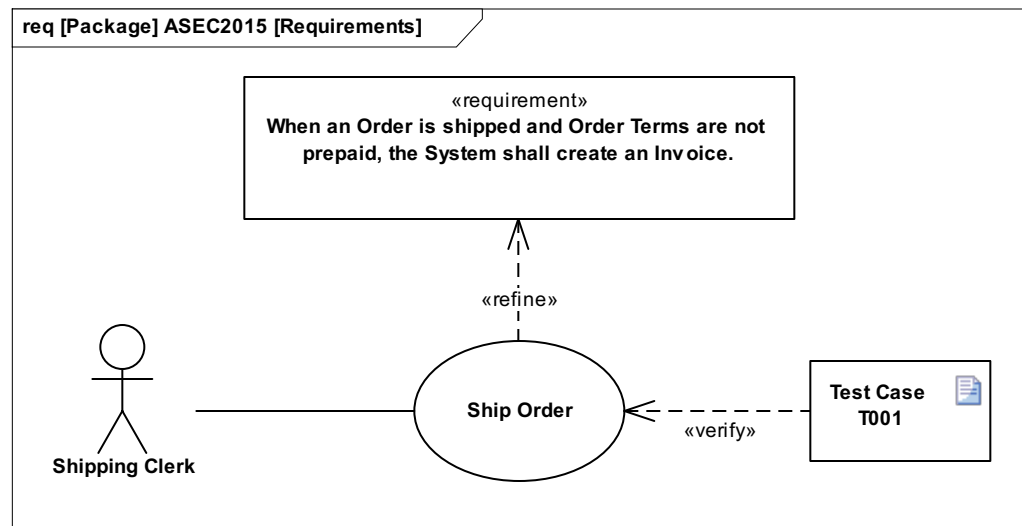
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# Synchronisation point

- RQs are exported from the catalogue to the model when 'ready'.
- 'System Model' is wrongly equated with 'Solution Model'.
- Fails to maximise advantages of MBSE (such as automatic model checking) to model and analyse the problem space.
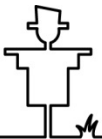
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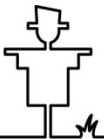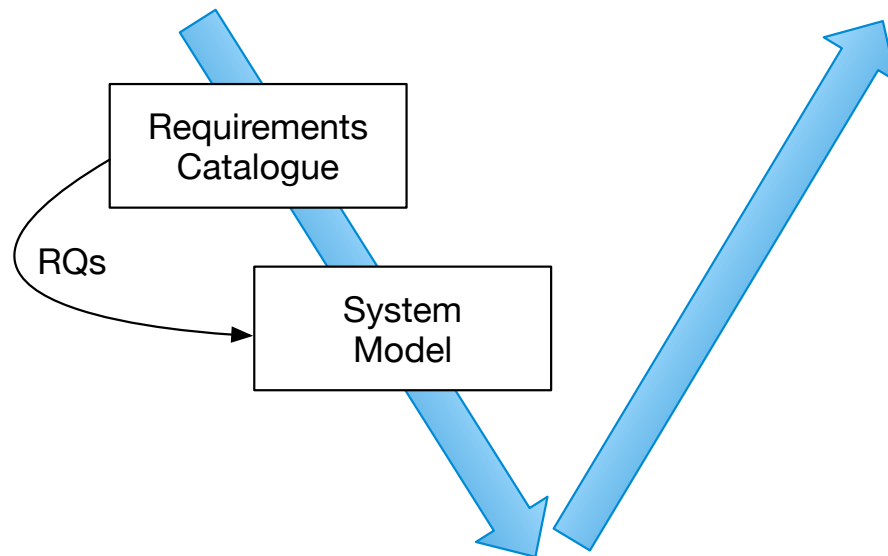
# SysML requirements symbols

- Essentially just a placeholder in the model which serves a link to the original RQ within the catalogue.

- Allows you to argue about the RQ and it's relationship with other elements in the model but not about the subject matter of the RQ itself or it's relationship with other types of RQs only in the catalogue.
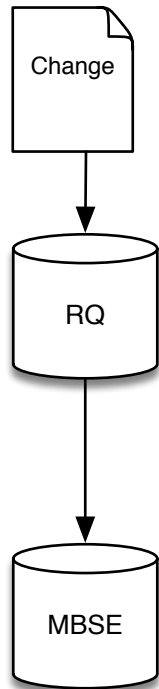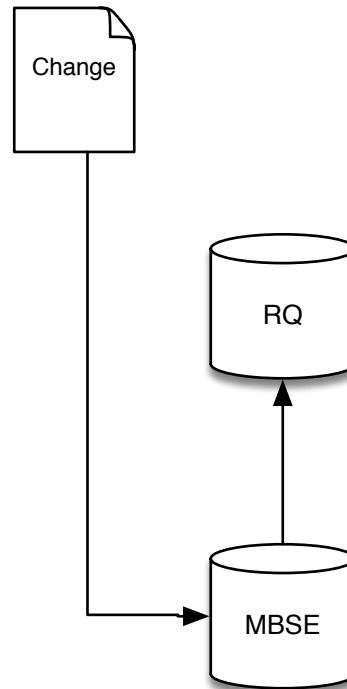
req [Package] ASEC2015 [Requirements]

«requirement»
When an Order is shipped and Order Terms are not prepaid, the System shall create an Invoice.

«refine»

Shipping Clerk

Ship Order

«verify»

Test Case
T001

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# SysML requirements table

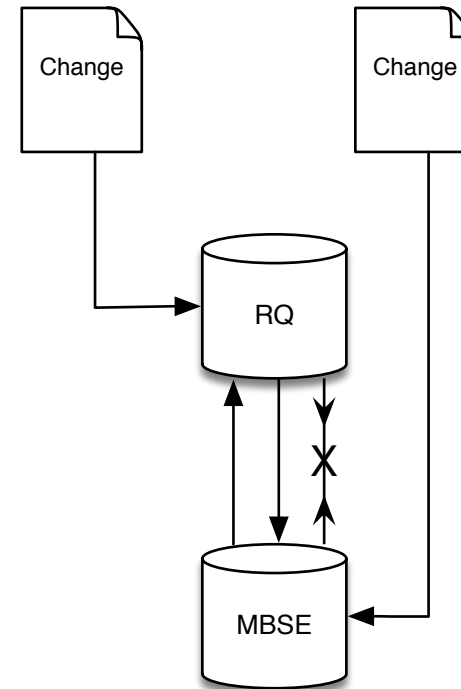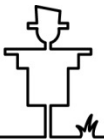| # | ID | Name | Text | Requirement Type | Owner | Source | Risk | Verify Method |
|---|---|---|---|---|---|---|---|---|
| 1 | d.4 | Power | | Requirement [Class] | HSUV Requirements | | | |
| 2 | d.2 | Range | | Requirement [Class] | HSUV Requirements | | | |
| 3 | d.1 | RegenerativeBi | | Requirement [Class] | HSUV Requirements | | | |
| 4 | R1.2.1 | Emissions | The vehicle | Requirement [Class] | " " Eco-Friendliness | | | |
| 5 | 4.2 | FuelCapacity | | Requirement [Class] | " " Capacity | | | |
| 6 | 4.1 | CargoCapacity | | Requirement [Class] | " " Capacity | | | |
| 7 | 2.4 | Acceleration | The Hybrid | Requirement [Class] | 2 Performance | | | |
| 8 | 2.3 | OffRoadCapab | The Hybrid | Requirement [Class] | 2 Performance | | | |
| 9 | 2.2 | FuelEconomy | The Hybrid | Requirement [Class] | 2 Performance | | | |
| 10 | 2.1 | Braking | The Hybrid | Requirement [Class] | 2 Performance | | | |
| 11 | 2 | Performance | The Hybrid | Requirement [Class] | HSUV Requirements | | | |
| 12 | | SafetyTest | | Requirement [Class] | " " Qualification | | | |
| 13 | | Qualification | | Requirement [Class] | HSUV Specification | | | |
| 14 | | PowerSourceM | | Requirement [Class] | HSUV Requirements | | | |
| 15 | | PassengerCapa | | Requirement [Class] | " " Capacity | | | |
| 16 | | Ergonomics | | Requirement [Class] | HSUV Specification | | | |
| 17 | | Eco-Friendiness | | Requirement [Class] | HSUV Specification | | | |

Start — HSUV Requirement Table ×
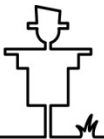
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# Managing Change



Forward       Push Back       Wild West
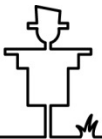
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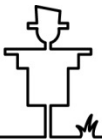
# Which tool?

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# Increased effort and cost

- Having two tools rather than one may mean:
  - Increased licencing costs,
  - Increased resources (storage and processing),
  - Increased administration,
  - New cost of implementing and maintaining tool integration, and
    - Harder than the tool vendors will tell you,
    - Probably not your core business.
  - Increased complexity of process.
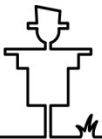    - You'll need a Sheriff for Dodge City.

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# Consequence of this approach

- Assertion:
  - In our experience (yours may very) production of a system-model from a catalogue of text-based requirements will results in the discovery of omissions and inconsistencies not previously identified i.e.
    - *"The system-model will be a more complete and consistent representation than the original requirements-catalogue"*

# Therefore….

- If this assertion is true:
  - we are effectively delaying the production of a higher-quality representation in favour of a lower-quality one, something that contradicts the SE principle of 'left shift'.

- If this assertion is false:
  - the question becomes "why bother with the system-model at all?"

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# Number of views vs connectivity for hybrid approach

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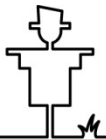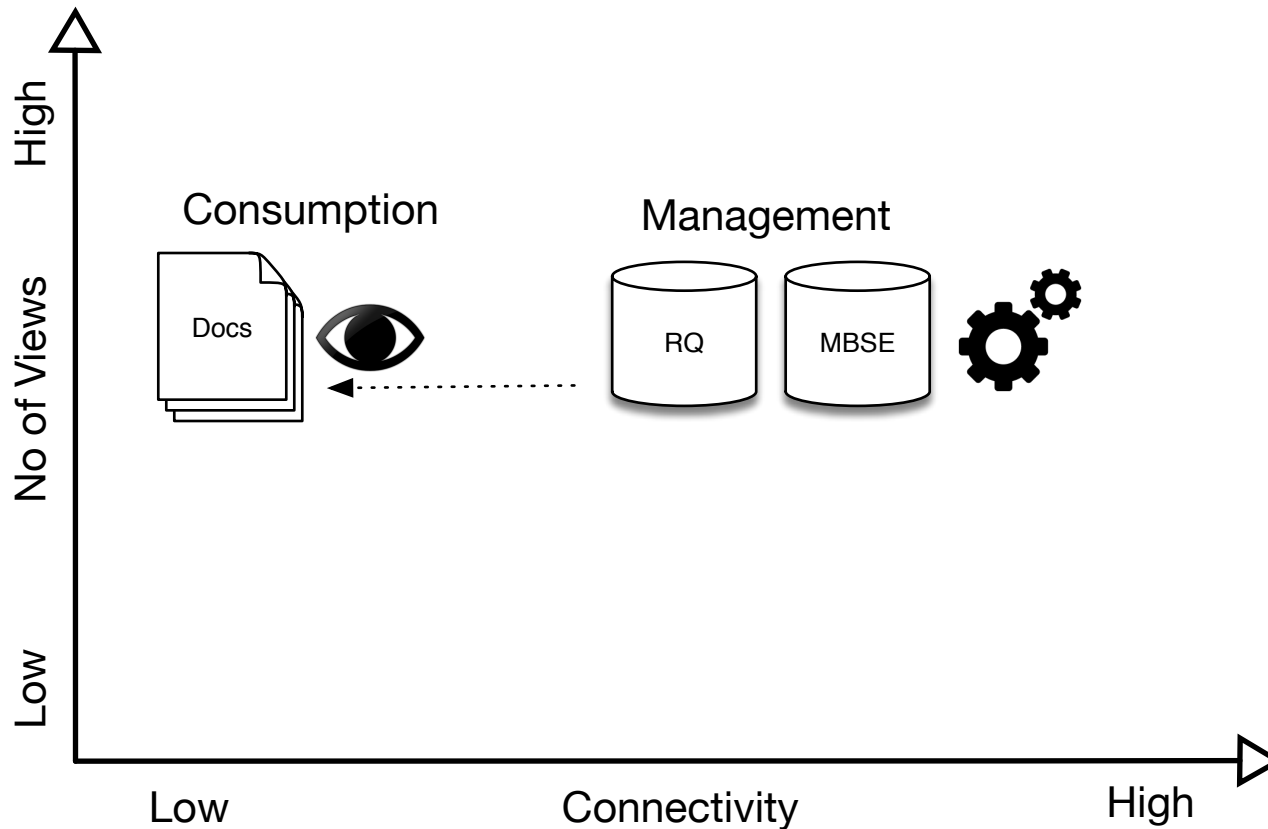
# The Alternative:

Model-Based Requirements Engineering
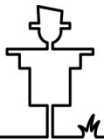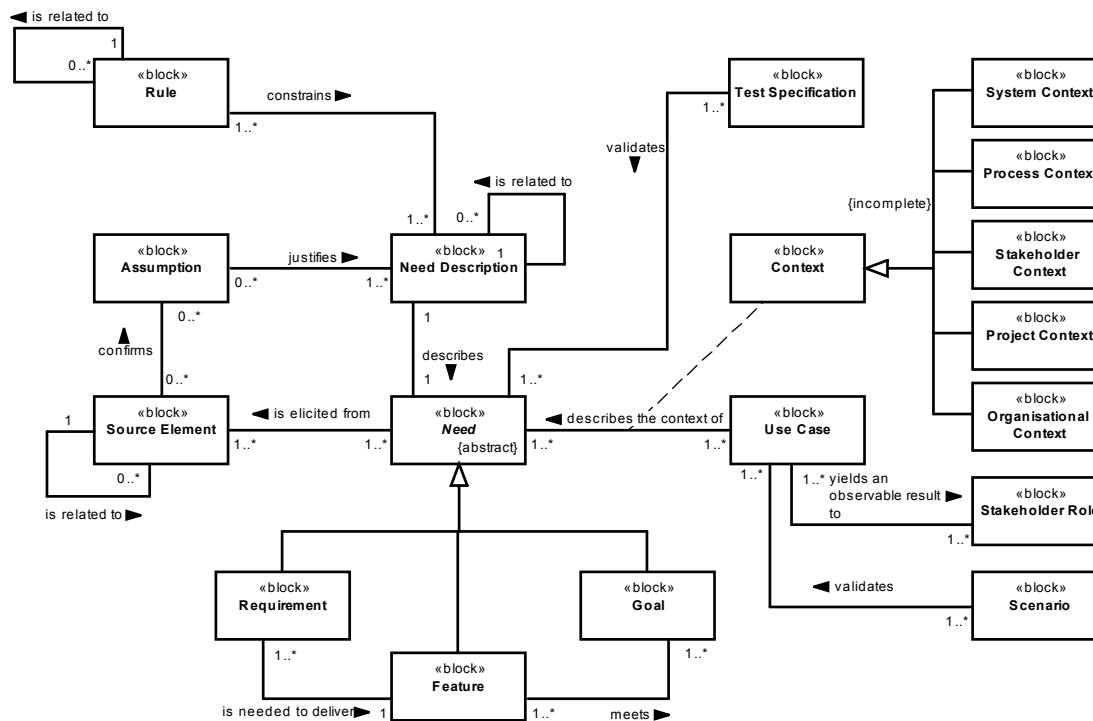i.e. Do everything in your MBSE tool

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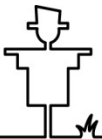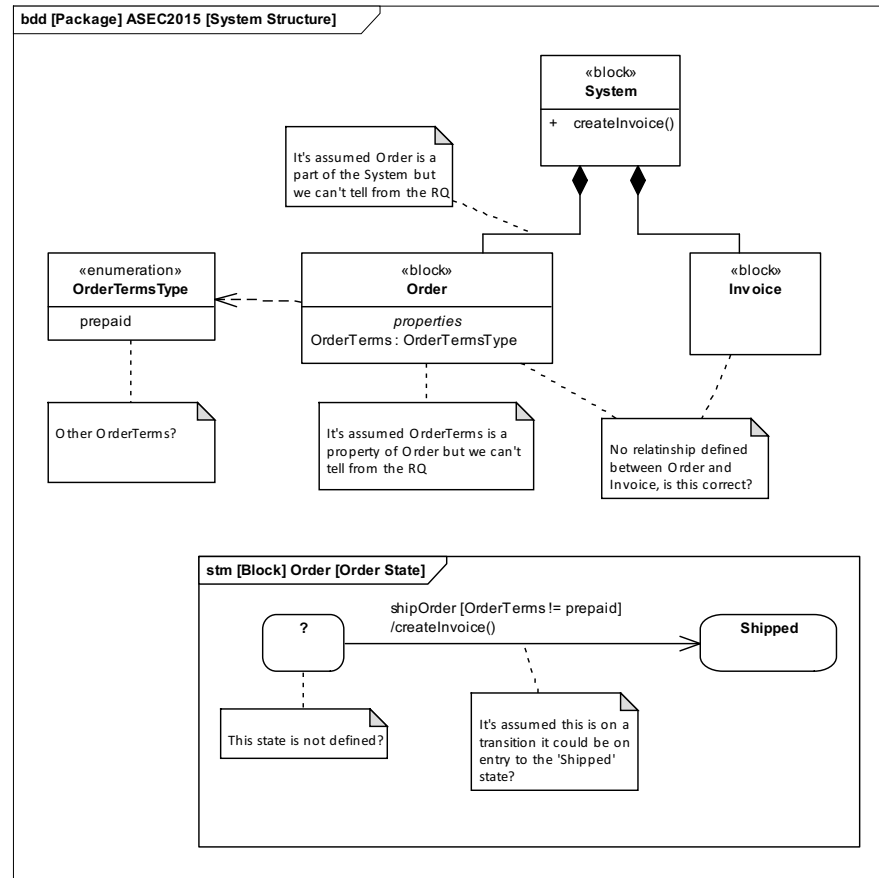# ACRE – Approach to Context-based Requirements Engineering
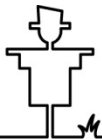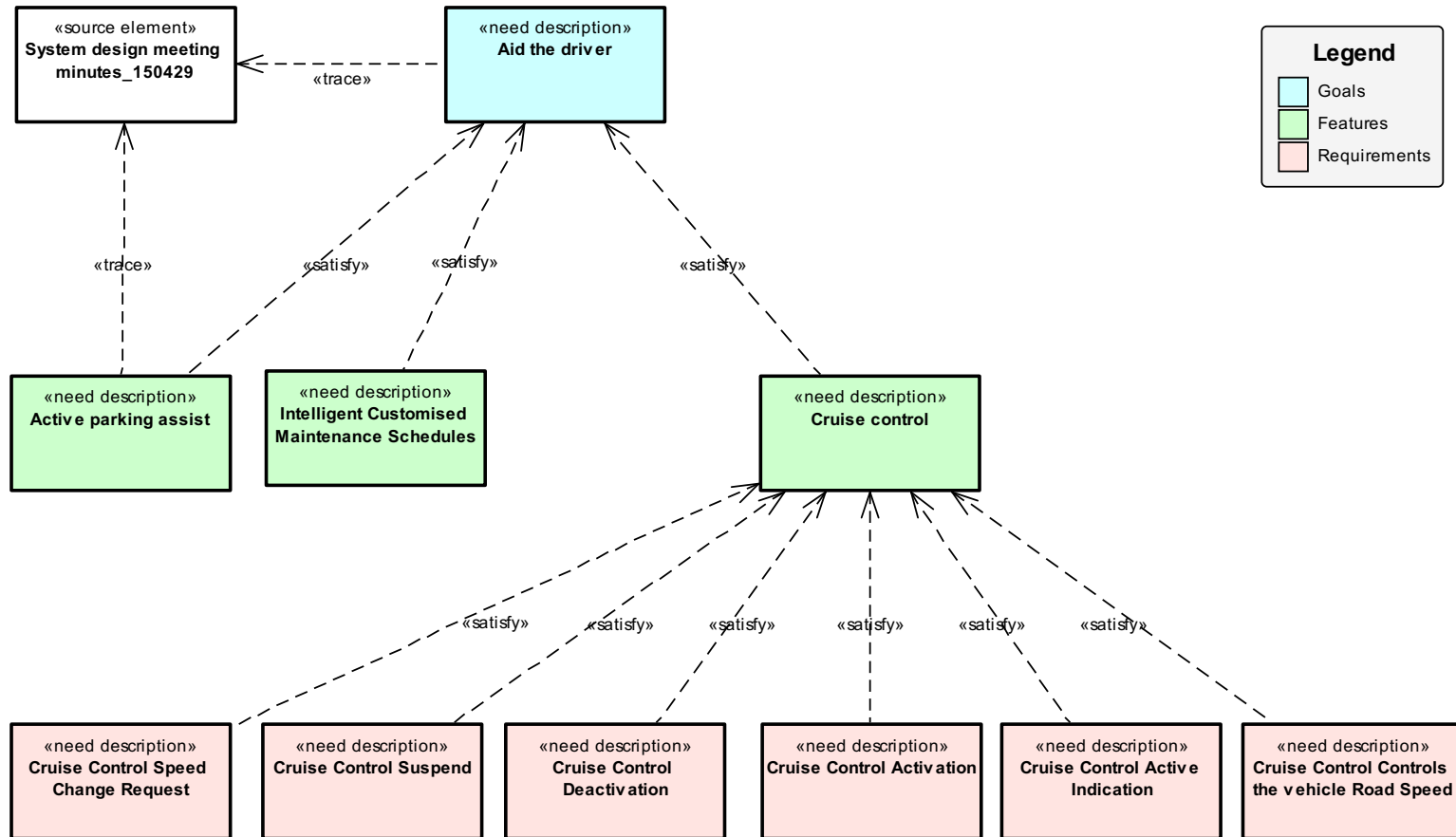
# ACRE cont....

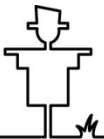See: Holt, Perry & Brownsword "Model-based Requirements Engineering", 2011
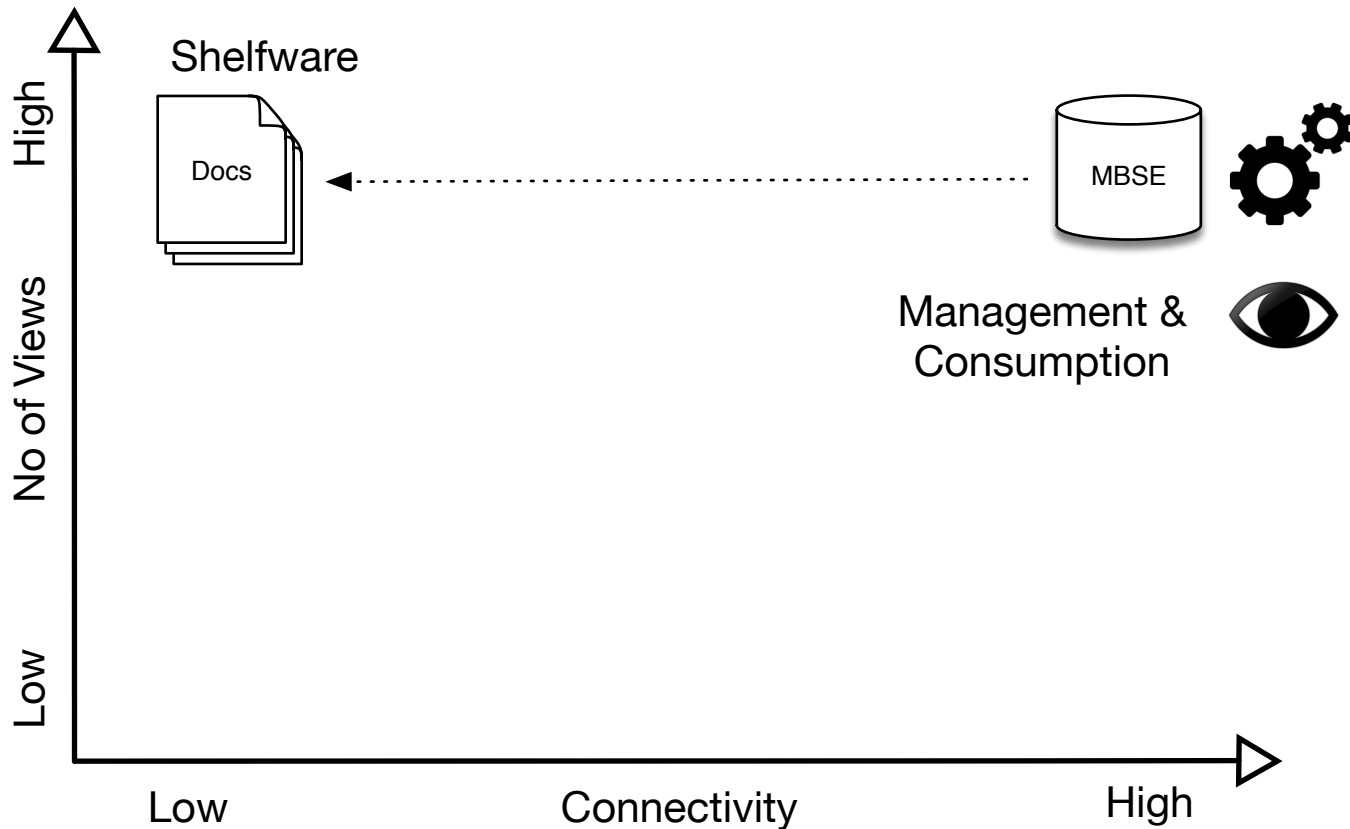
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# Other SysML concepts

*"When an Order is shipped and Order Terms are not 'prepaid', the System shall create an Invoice."*

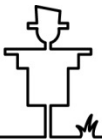# Number of views vs connectivity for MBSE (including MBRE)

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# Conclusions

1. There are limited advantages to 'authoring' text-based requirements outside of your MBSE tool and subsequently importing them.
   - You can write them directly into your MBSE tool, and
   - Model-based requirements allow for greater automated model checking.
2. Given the increase in effort, cost and complexity required to use both a RQ-management and MBSE tool you need to think carefully about this approach.
3. If you are currently using basic document-centric requirements then it is easier to progress directly to a full MBSE/MBRE approach rather than first going to a hybrid approach.
   - This gives you a competitive advantage.

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# Any questions?

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