Systems Methodology for the SKA

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WP2 Meeting

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Outline

Presentation Contents:

1. Systems approach
2. Goals
3. Requirements
4. Use-Cases
5. Requirements Model
6. Requirement Structure
7. System Hierarchy
8. System Modelling

What is systems Engineering ?

- A structured development process from Concept through to Operational phase
- Includes both the technical and economic factors required to meet the User's needs?
- Breaks down complexity through the use of hierarchies

Is systems engineering needed ?

- SKA is a large and complex project with a long life-span
- Multiple disciplines involved
- Consequently misunderstandings and conflicts are pre-programmed
- Need a holistic approach to resolve this: System Engineering

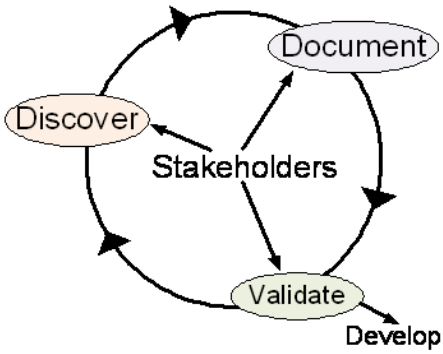
Is systems engineering wanted ?

- Increases documentation?
- Increases bureaucratic procedures?
- Isn't widely adopted in the Radio Astronomy community?

Goals

What is a Goal ?

•A Goal is something a Stakeholder wants to achieve
•Goals are allowed to be neither fully achievable nor measurable
•Goals are agnostic of technology
•Goals can be prioritised



Who elicits and documents Goals ?

• System Engineering Design Group working with stakeholders
•Process is continuous

Who owns the Goals ?

• The stakeholders or their representative

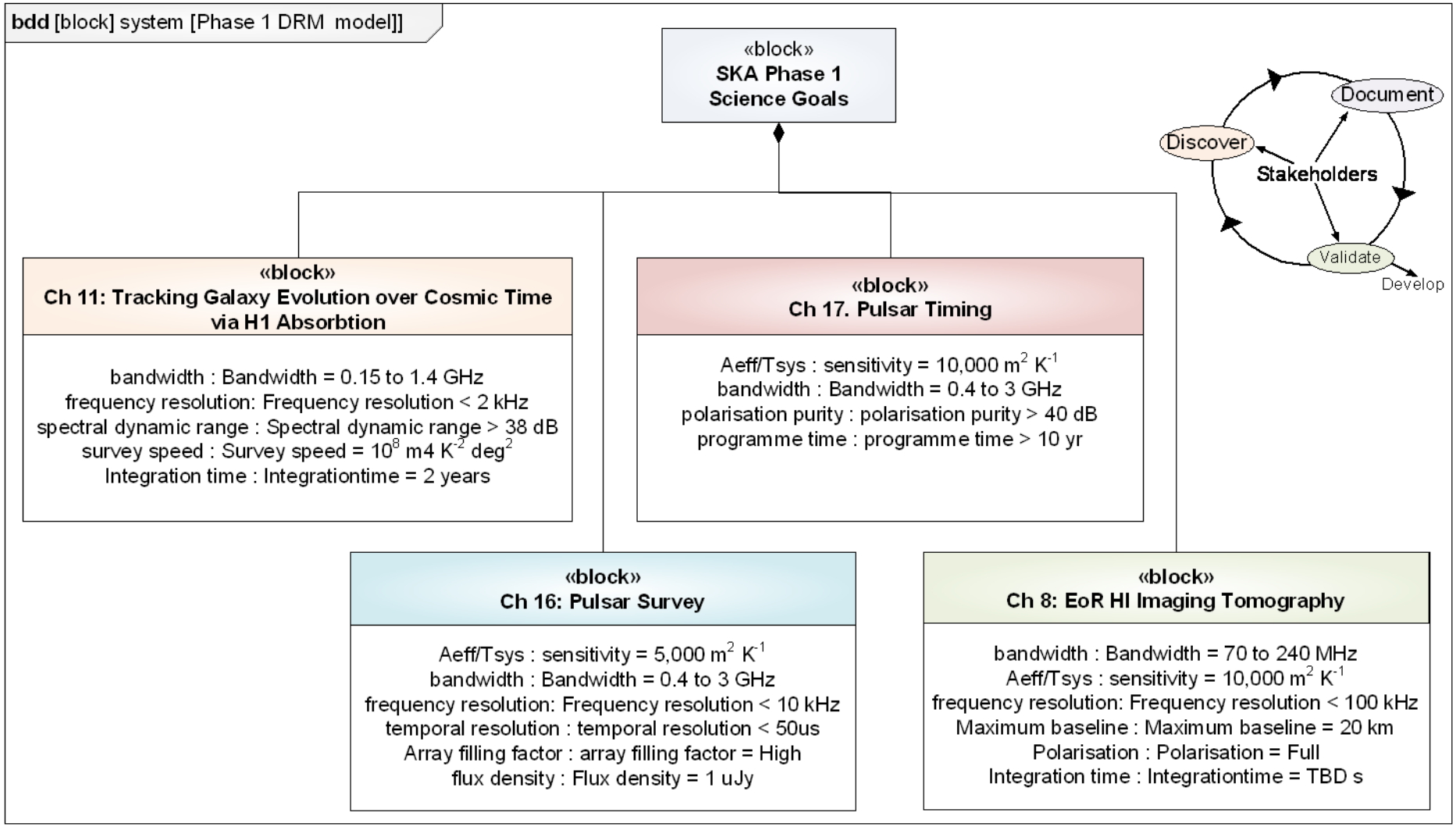
How are Goals used?

• The System Engineering group refine them into realistic, non-conflicting measurable targets: User Requirements

Science

•Scientists are one group of Stakeholders
•The Science Case defines the Science Goals
•The DRM analyses and selects performance envelope of the Science Goals

DRM v 1.0



Technical Goals extracted directly from Tables 8.2, 11.2, 16.2 & 17.2 of DRM v1.0

Epoch of Reionization H I Imaging Tomography

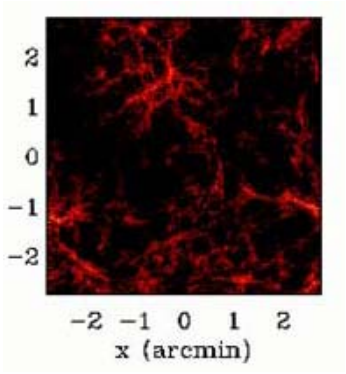
Some DRM Goals are embedded in the DRM v1.0 text.
For example: directly extract some EoR goal statements then ask some questions:

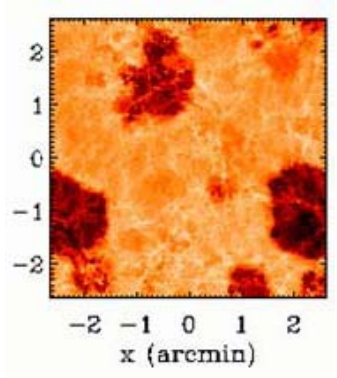
- signal expected is of a few μJy/beam in a 2' beam at 140 MHz
  - What are the spectral characteristics and strength of signal in comparison with the thermal and foreground 'noise'?
  - What is the time variable aspects of the foregrounds (ionosphere for example)?

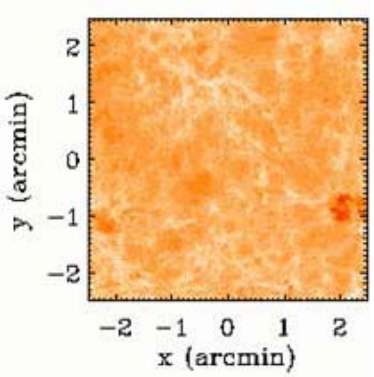
- initial shallow but large-sky survey to start a search for the best Galactic EoR window
  - Is a shallow survey likely to have been implemented by the MWA in the time frame of the SKA?

- calibrated to better than 0.1%, the resulting residuals would be 40 mK
  - Would it be better to say: the residuals in the image cube should be at least 3 dB (and preferably 10 dB) lower than the thermal noise?

These are just a few examples - there will be more!







Requirements

Is requirement engineering needed ?

- 60% of errors originate from inadequate requirement engineering[1]
- The cost of requirements gathering and systems analysis is minor compared to the cost of not doing it

User requirements drive the rest of the project - need to get them right

- All models and information derive from the User requirements
- User requirements are the baseline against which all acceptance tests are defined and executed.
- Requirements are necessary to achieve and demonstrate quality

Requirements Review

- Requirements can be prone to ambiguities, incompleteness, and inconsistencies
- Need to detect these at the requirements phase of the project through review

Requirements may change with time

- Once defined and approved, requirements should fall under change control.

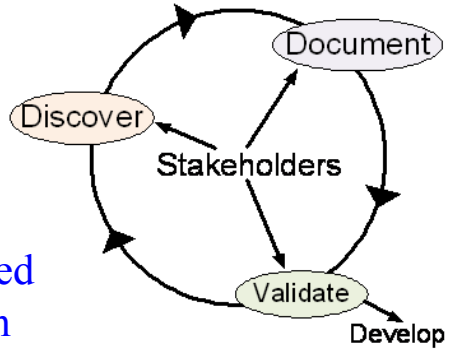
Requirements Tools

- Doors http://www-01.ibm.com/software/awdtools/doors/productline/
- Core http://www.vitechcorp.com/ (MeerKat)
- JAMA Contour http://www.jamasoftware.com/contour/ (ASKAP)

1. S McConnell, Code Complete Microsoft Press 2004

What is a Use-case?

•A Use-Case captures the behavioural requirements of the stakeholders for a system.



Pulsar Observation Use Case

Primary actor: Pulsar Scientist

Goal in Context: Pulsars as probes for fundamental physics

Scope: Non Imaging Processing

Level: Summary

Stakeholders and Interests:

Pulsar Scientist:

- Survey observation of pre specified region of sky and pulsar parameter space.
- Conduct precision timing observations of pulsars relevant to the goals

SKA Operator:

- Manages the SKA operation

Preconditions:

•Fully commissioned SKA Core and associated processing facilities

•Observation time available

Minimal guarantees

Increased number of MSPs timed

Increased MSP timing precision

Success Guarantees

time sufficiently large number of pulsars to sufficiently high precision to be able to detect and characterise gravitational waves

Trigger

Pulsar Scientist submits observation plan

Main Success Scenario:

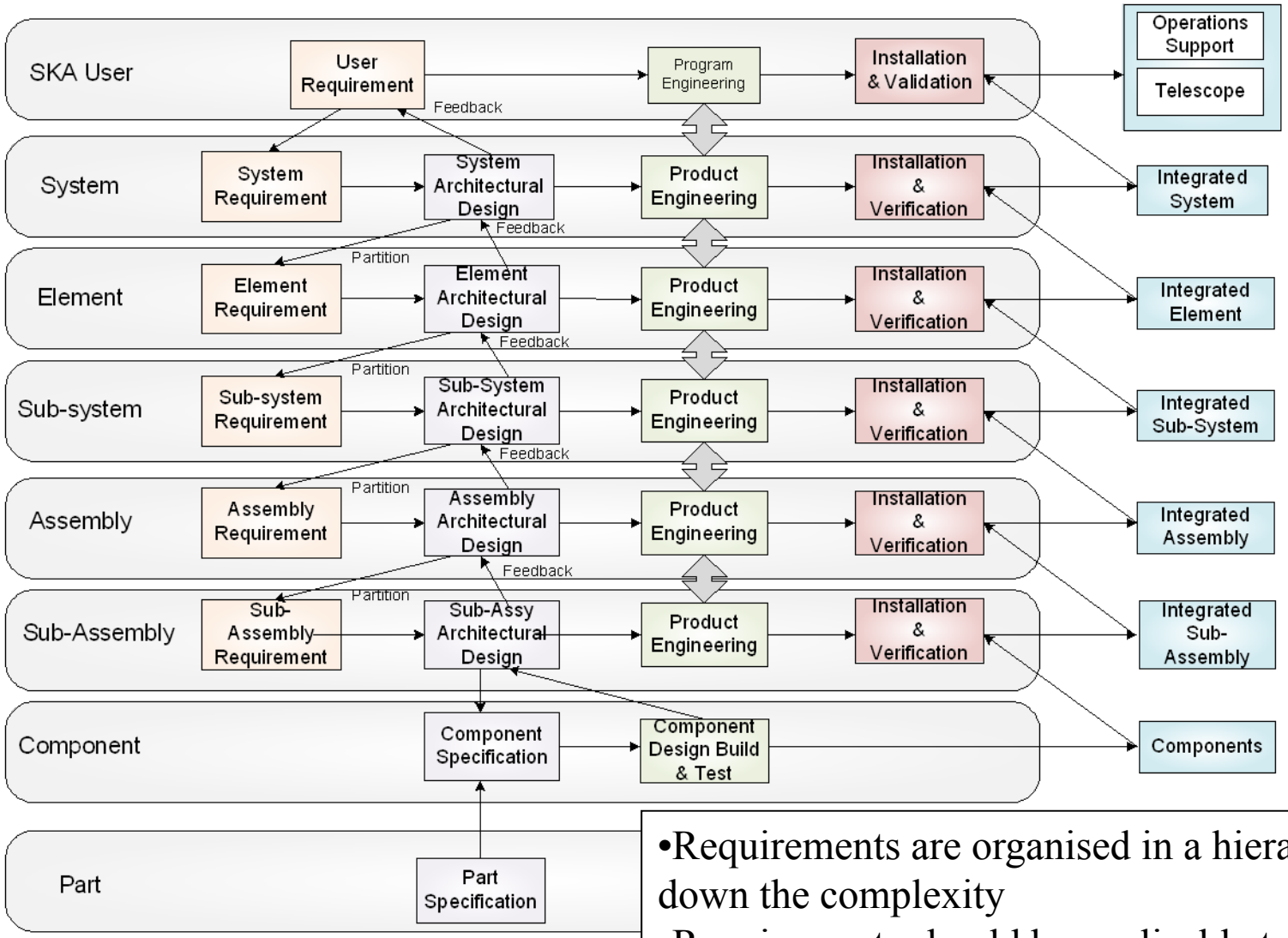
1. Calibrate Telescope
2. Implement all-sky survey
3. Analyse survey for timing candidates
4. Calibrate Telescope
5. Time candidates

Extensions (exceptios to the main success scenario):

2a, 5a Insufficient sensitivity, observation time

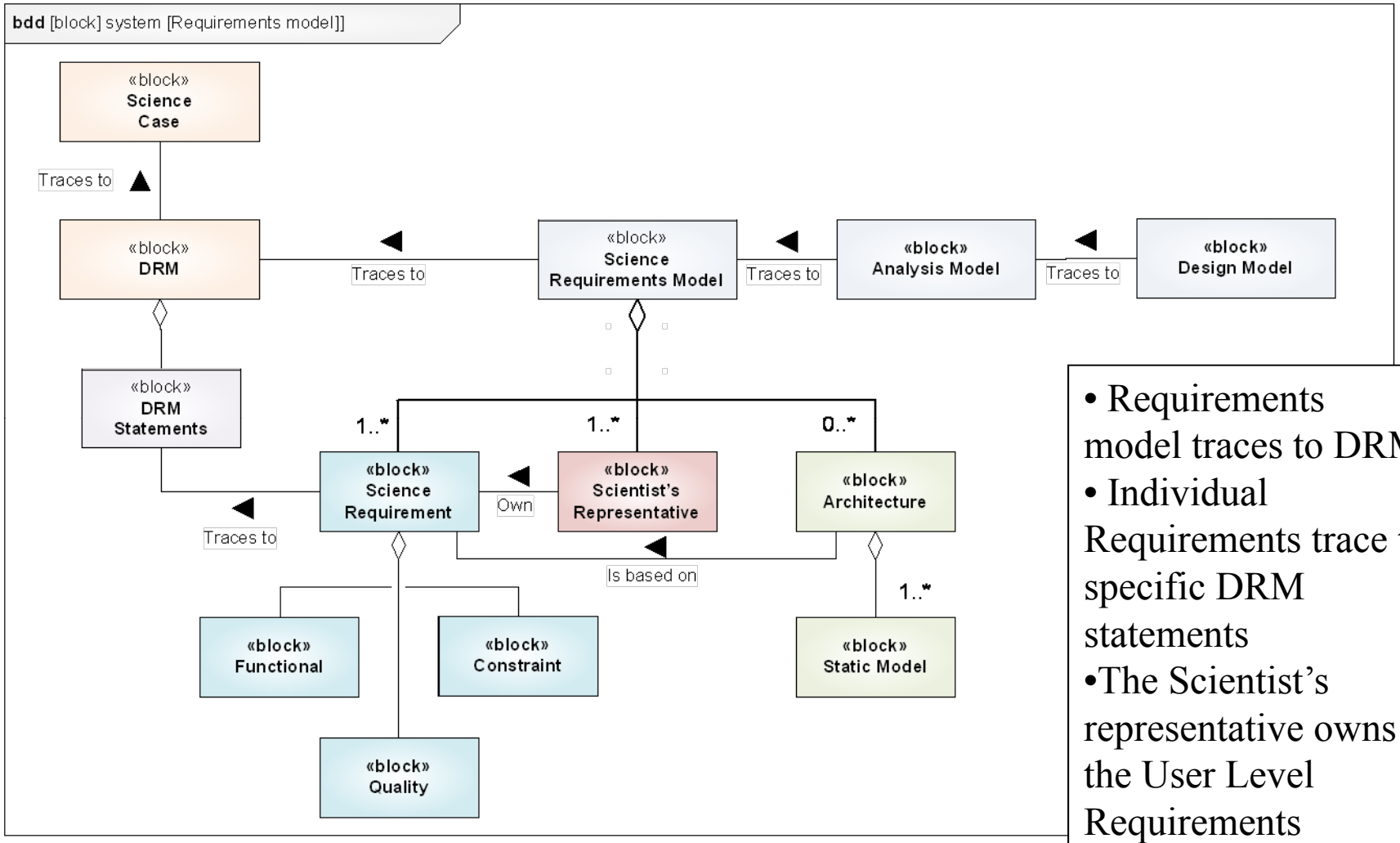
4a. Systematic errors too high to calibrate adequately

Requirements Hierarchy



- Requirements are organised in a hierarchy to break down the complexity
- Requirements should be applicable to their hierarchical level

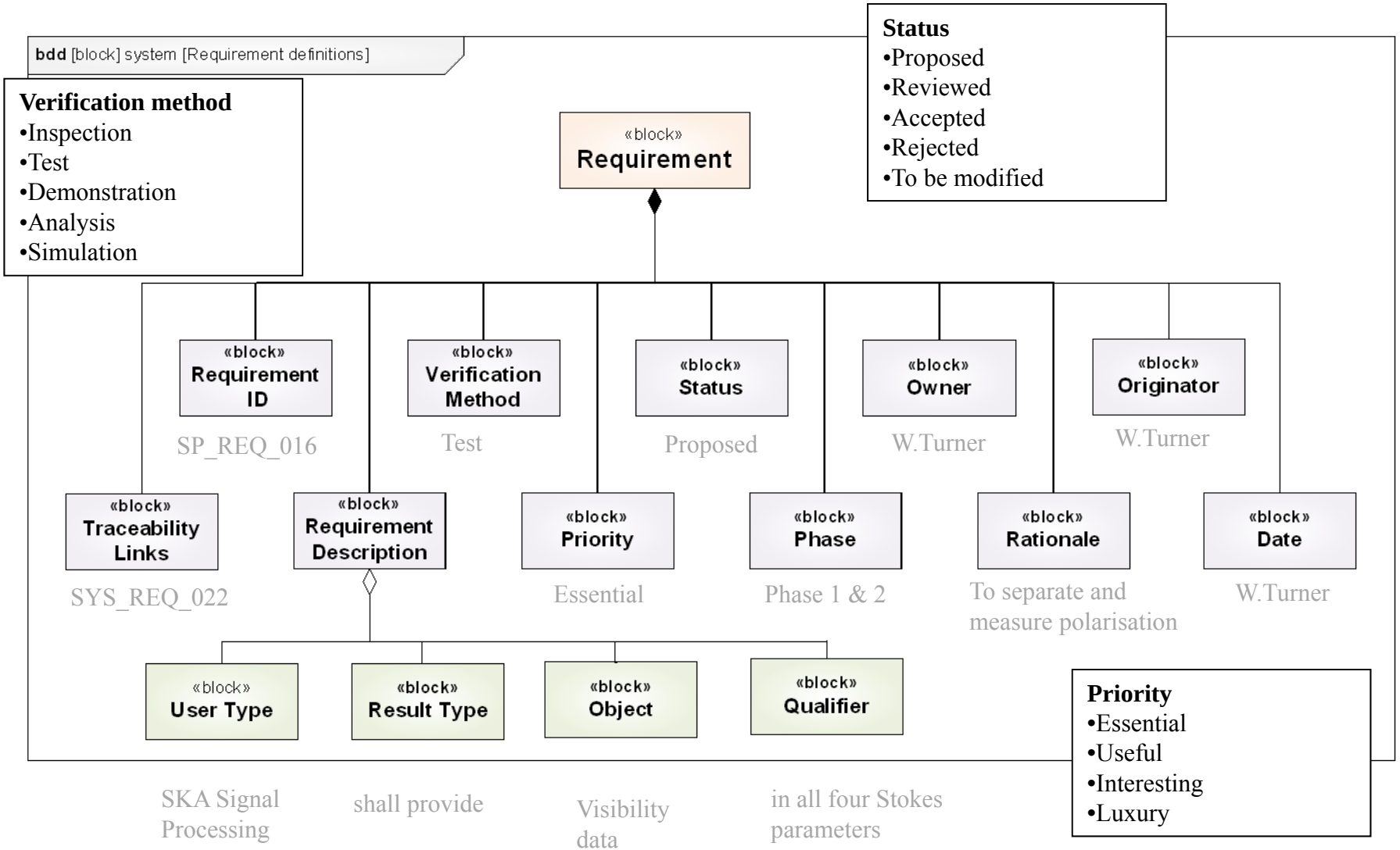
Requirements Model (User Requirements.Science View)



- Requirements model traces to DRM
- Individual Requirements trace to specific DRM statements
- The Scientist's representative owns the User Level Requirements

Note: there are a lot more requirement sources than the Science

Requirement Structure



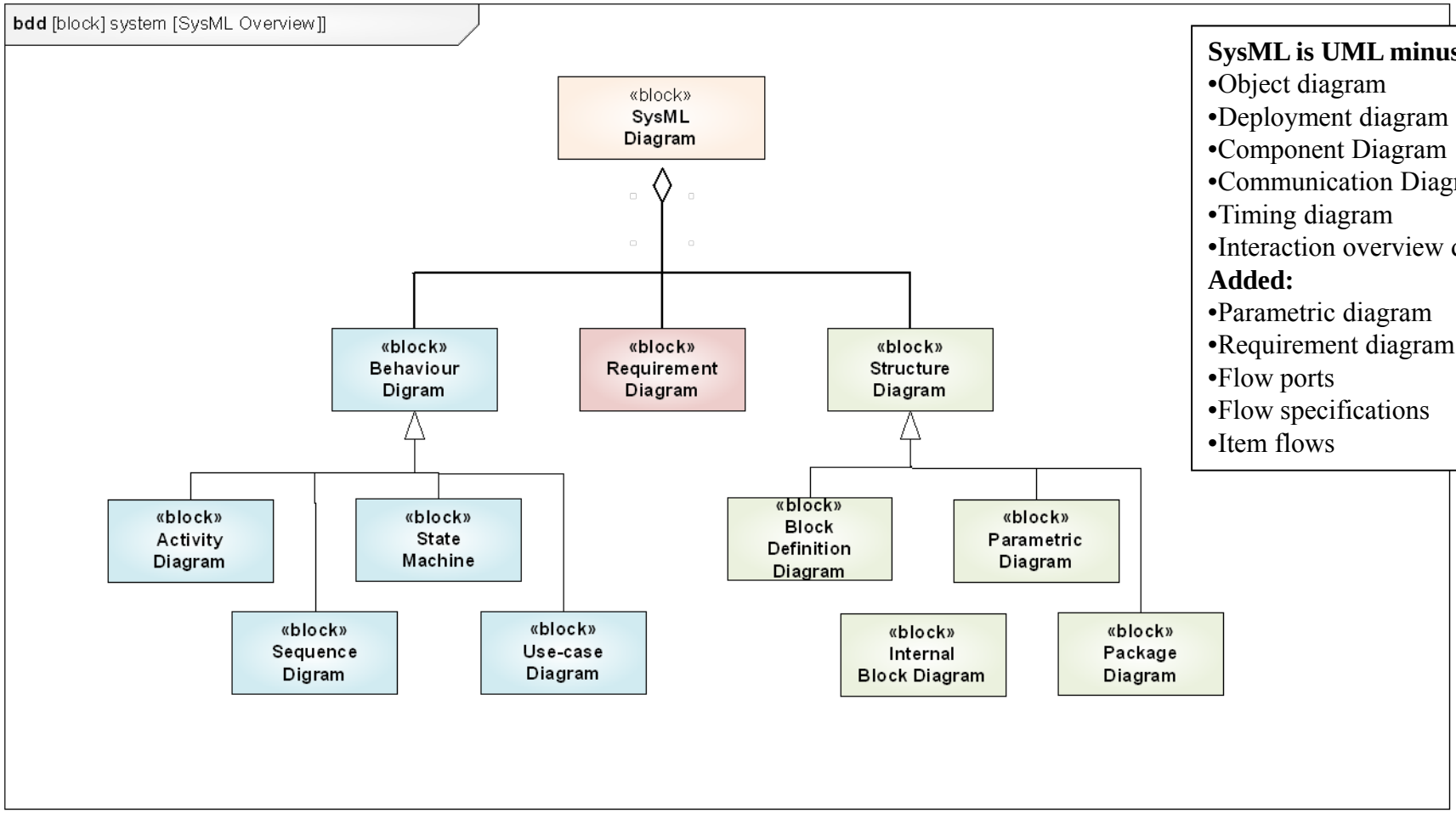
System Modelling

SysML

Graphic Modelling Language http://www.omgsysml.org/

Developed from UML

Many tool vendors including : Enterprise Architect http://www.sparxsystems.com.au/



SysML is UML minus

- Object diagram
- Deployment diagram
- Component Diagram
- Communication Diagram
- Timing diagram
- Interaction overview diagram

Added:

- Parametric diagram
- Requirement diagram
- Flow ports
- Flow specifications
- Item flows

SysML Package Diagram

SysML Package Diagrams

•Typically a package diagram is used to show model elements organised into packages.

•Packages can be organised in hierarchies

•Can include Model Libraries to facilitate reuse

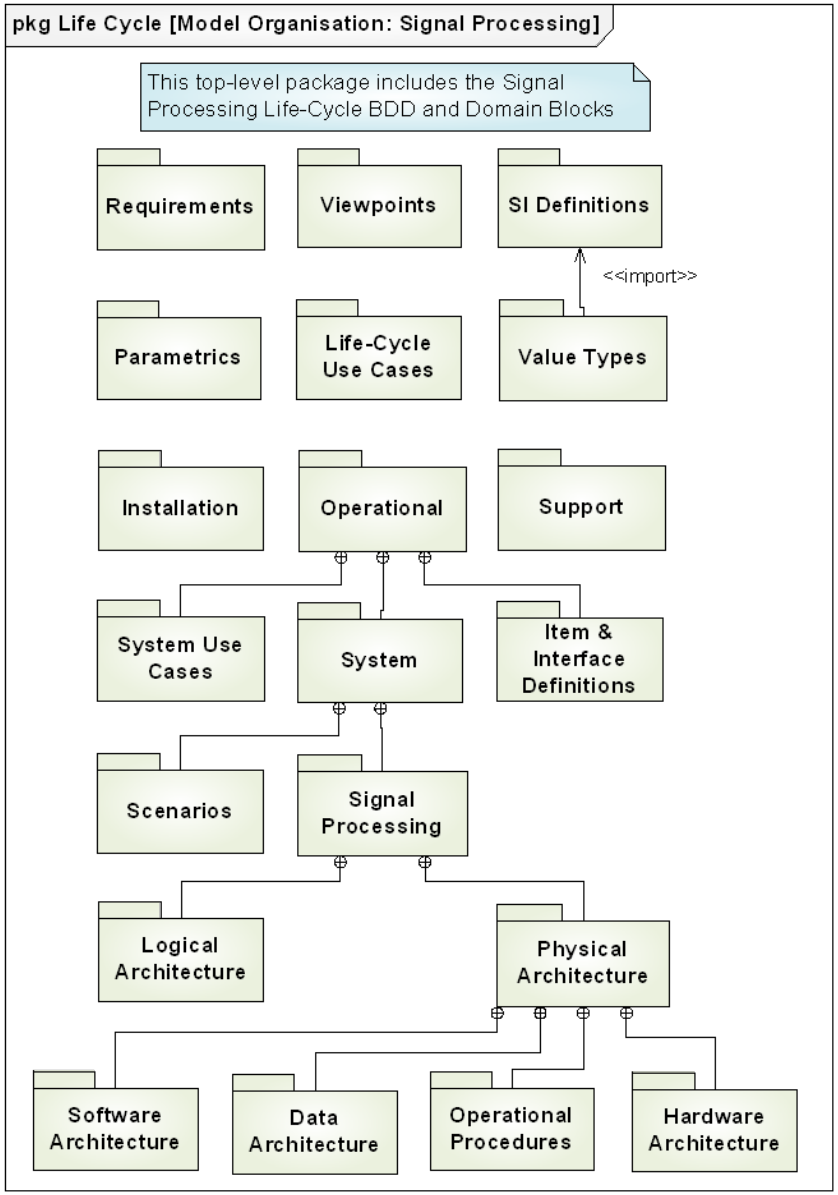
Package Diagram from the perspective of SKA Signal Processing

•Includes Structural, Behavioural and Requirement Packages

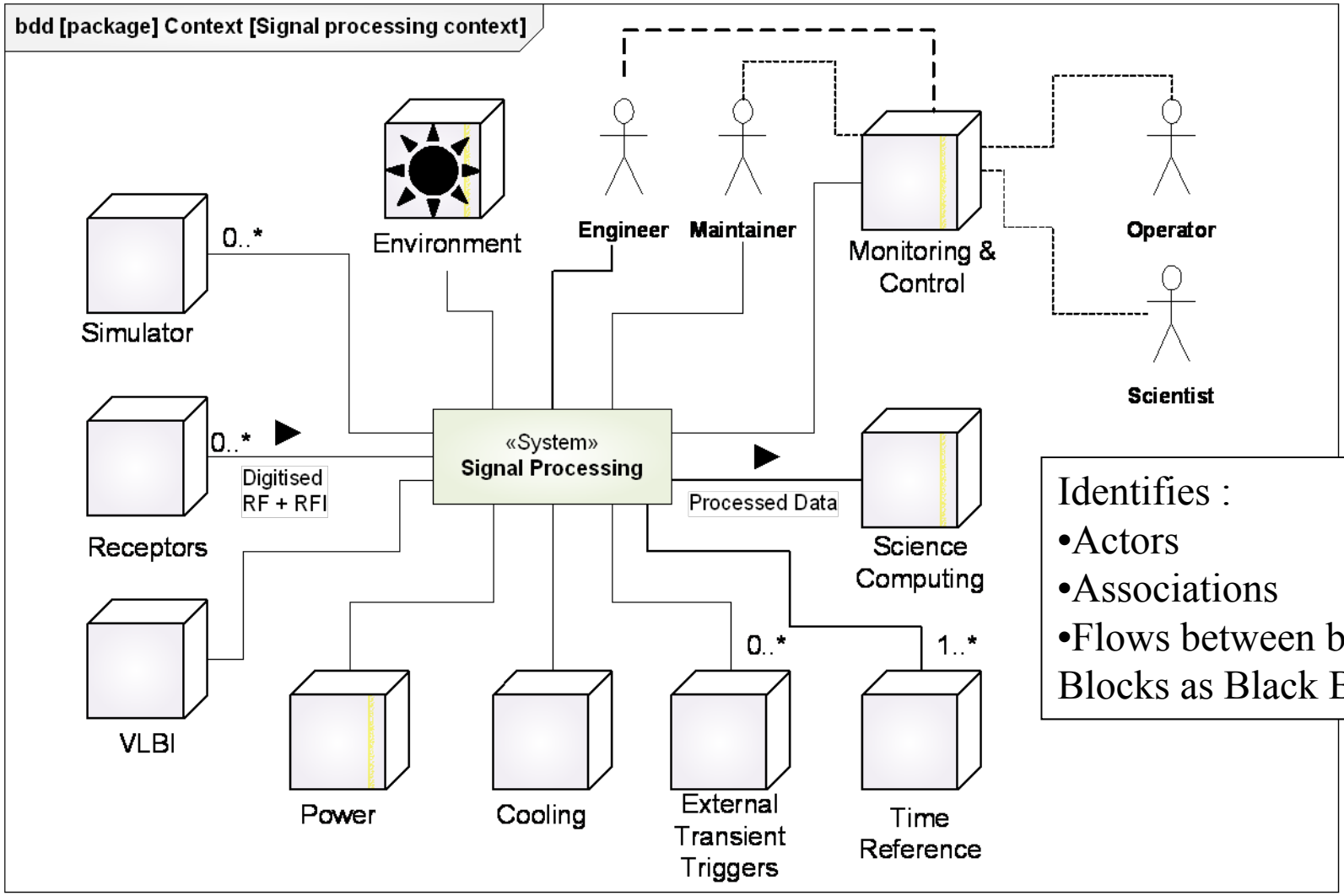
•Libraries such as SI Unit definitions included

•Viewpoints allow system model to be presented from different stakeholder's perspectives

•Physical architecture partitions into software, and hardware but also contains operational procedures and data architecture aspects



System Modelling

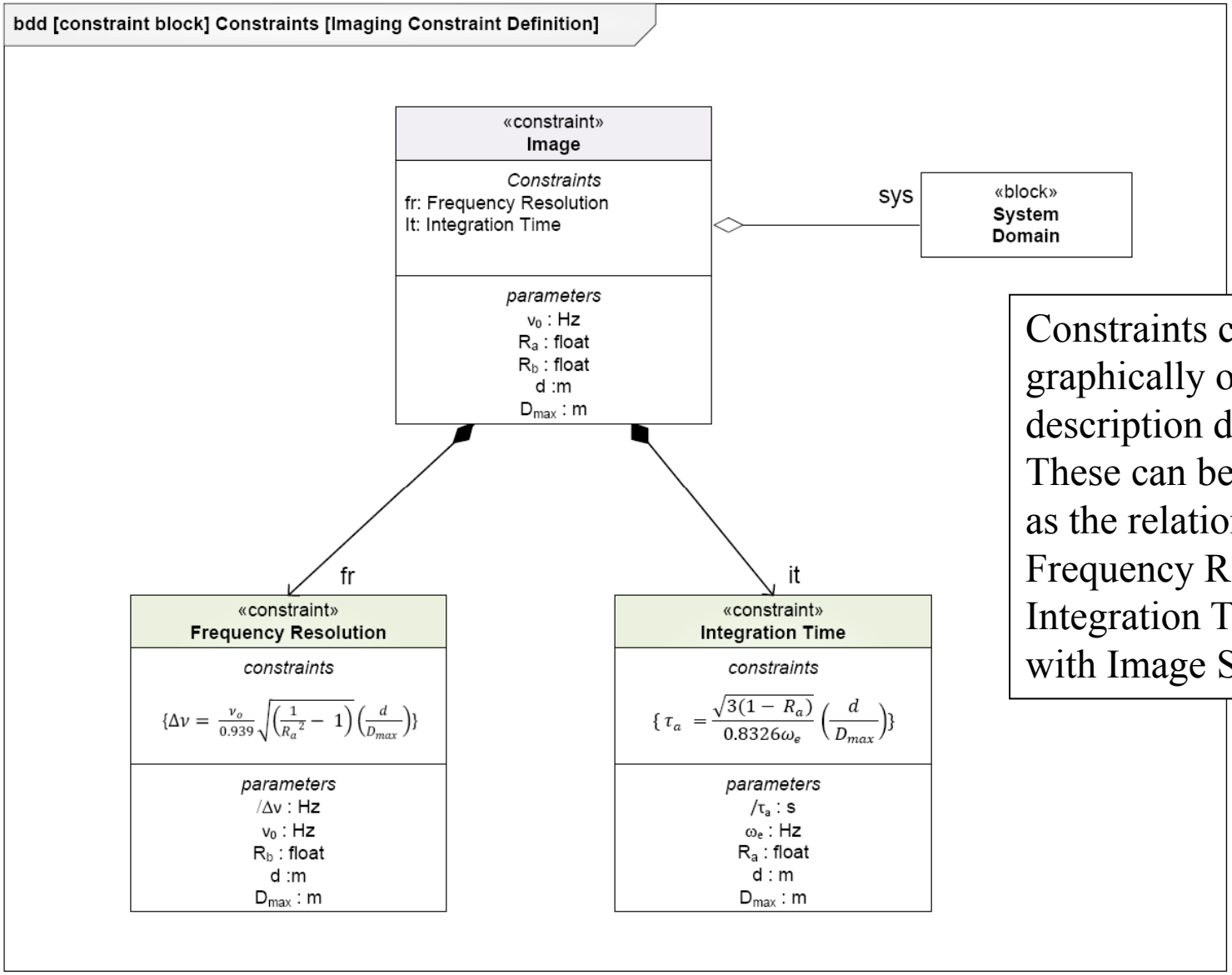


Identifies :

- Actors
- Associations
- Flows between blocks

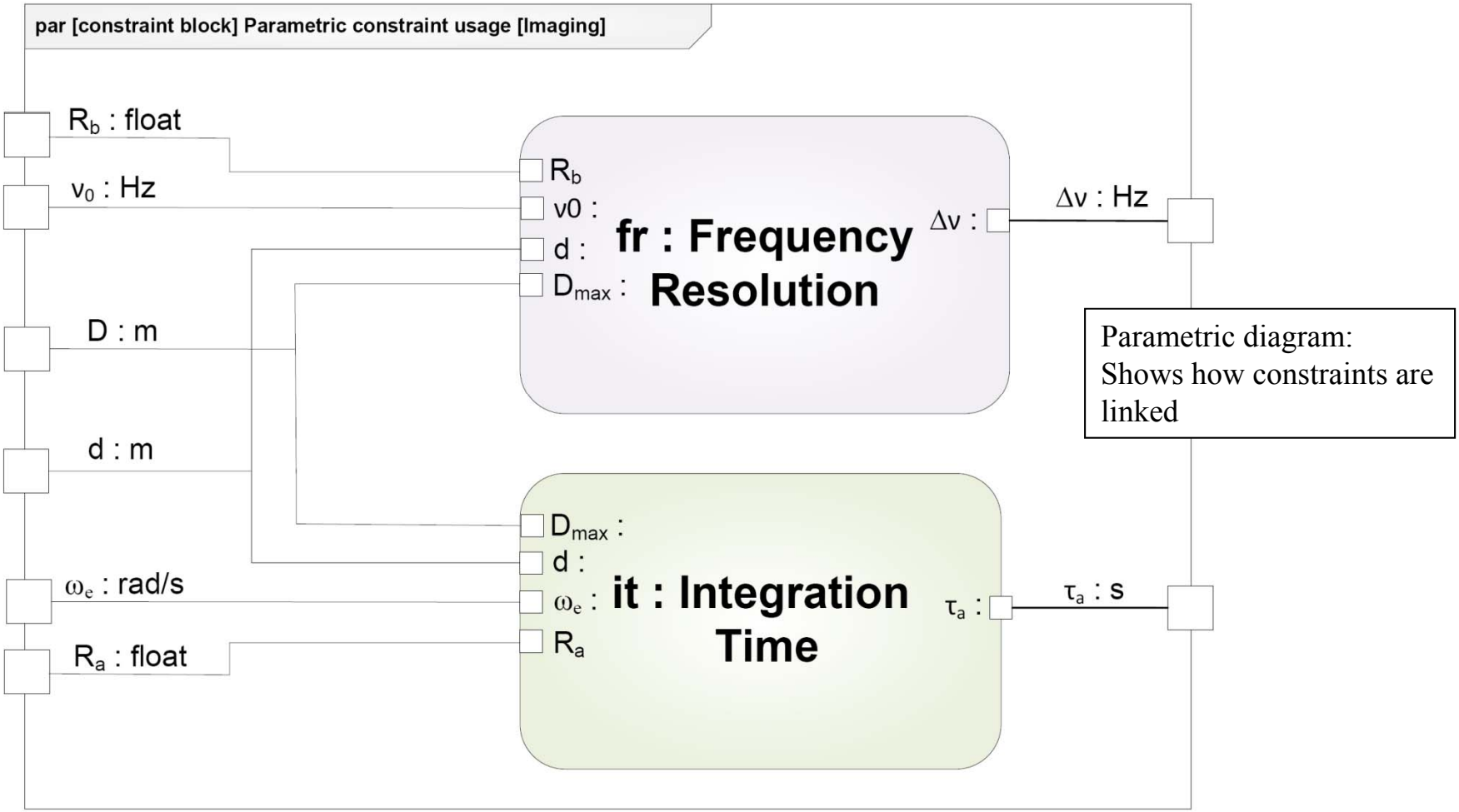
Blocks as Black Boxes

Constraint Block Diagrams



Constraints can be shown graphically on block description diagrams.
These can be equations such as the relationships for Frequency Resolution and Integration Time associated with Image Smearing

Parametric Diagrams



Summary

Systems approach

- Manages complexity
- Isn't widely adopted in the Radio Astronomy community

User Goals

- Source for requirements
- allowed to be neither fully achievable nor measurable

Requirements

- the baseline against which all verification/validation tests are defined and executed
- Need to be traceable
- Use-Cases define the behavioural requirements

System Modelling

- SysML provides a Graphical Language for Modelling Systems
- Potentially reduces the amount of documentation

1. S McConnell, Code Complete Microsoft Press 2004