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Modeling mechanics: maybe wrong; but useful

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National Nuclear Security Administration

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Quality

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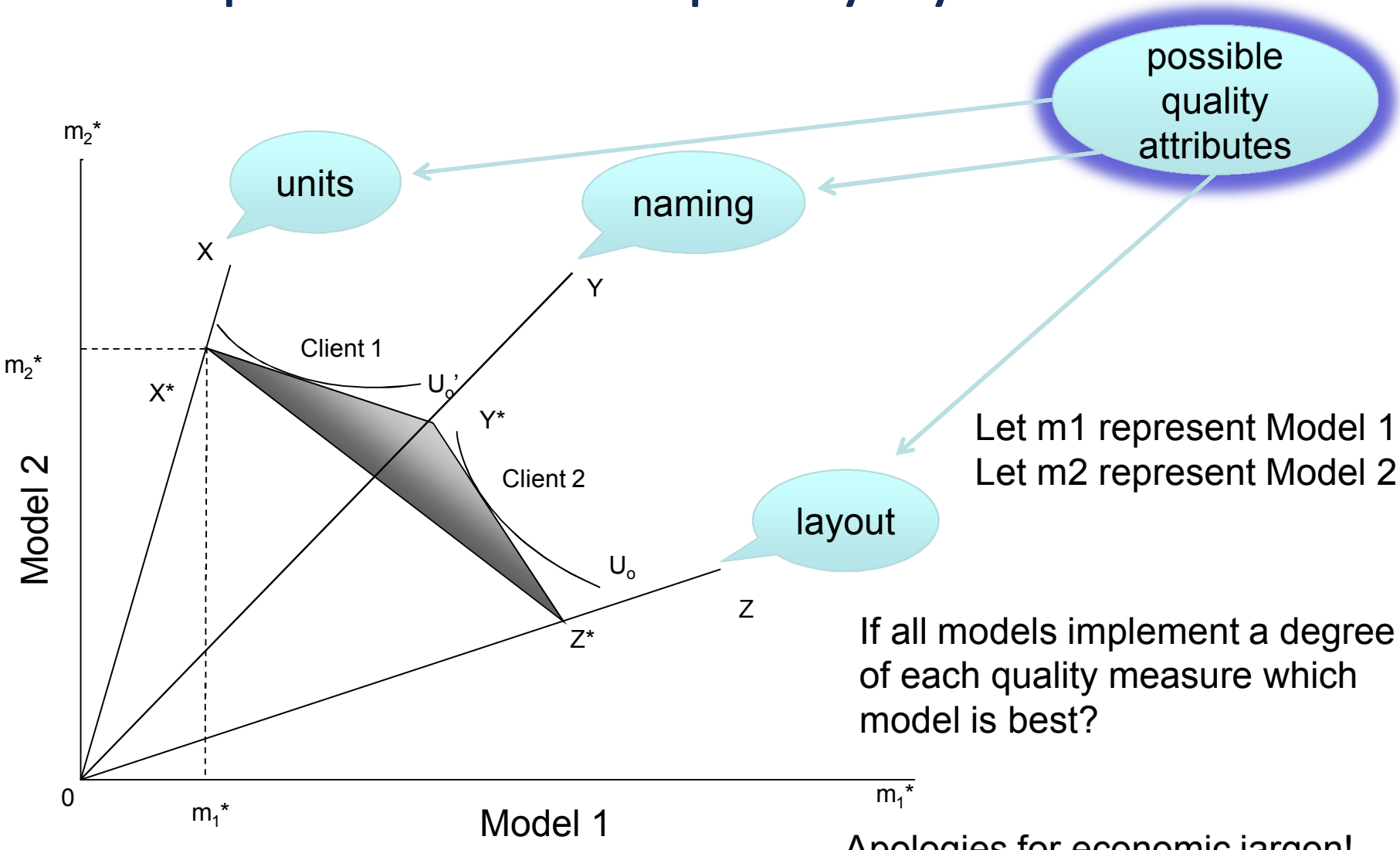
- What is it?
  - A state of being free from defects, deficiencies and significant variations
- Why strive for quality?
  - Reduction in the costs of modeling
  - Protects reputation, develops trust, leads to further work aka employment
  - Promotes the system dynamics methodology
- What is it in the context of system dynamics models?
  - What are its metrics? More on that later.
- What are the processes of assuring quality models?
  - Many articles exist on the modeling process – little on mechanics
  - What are model builders explicitly and subconsciously doing?
- What are the standards?
  - No universal agreed upon set of standards
  - D-Memo (D-4851, 01/15/2001) exists for Vensim
  - Some tools have an informal set - Powersim Studio

Example: A model's quality by attribute

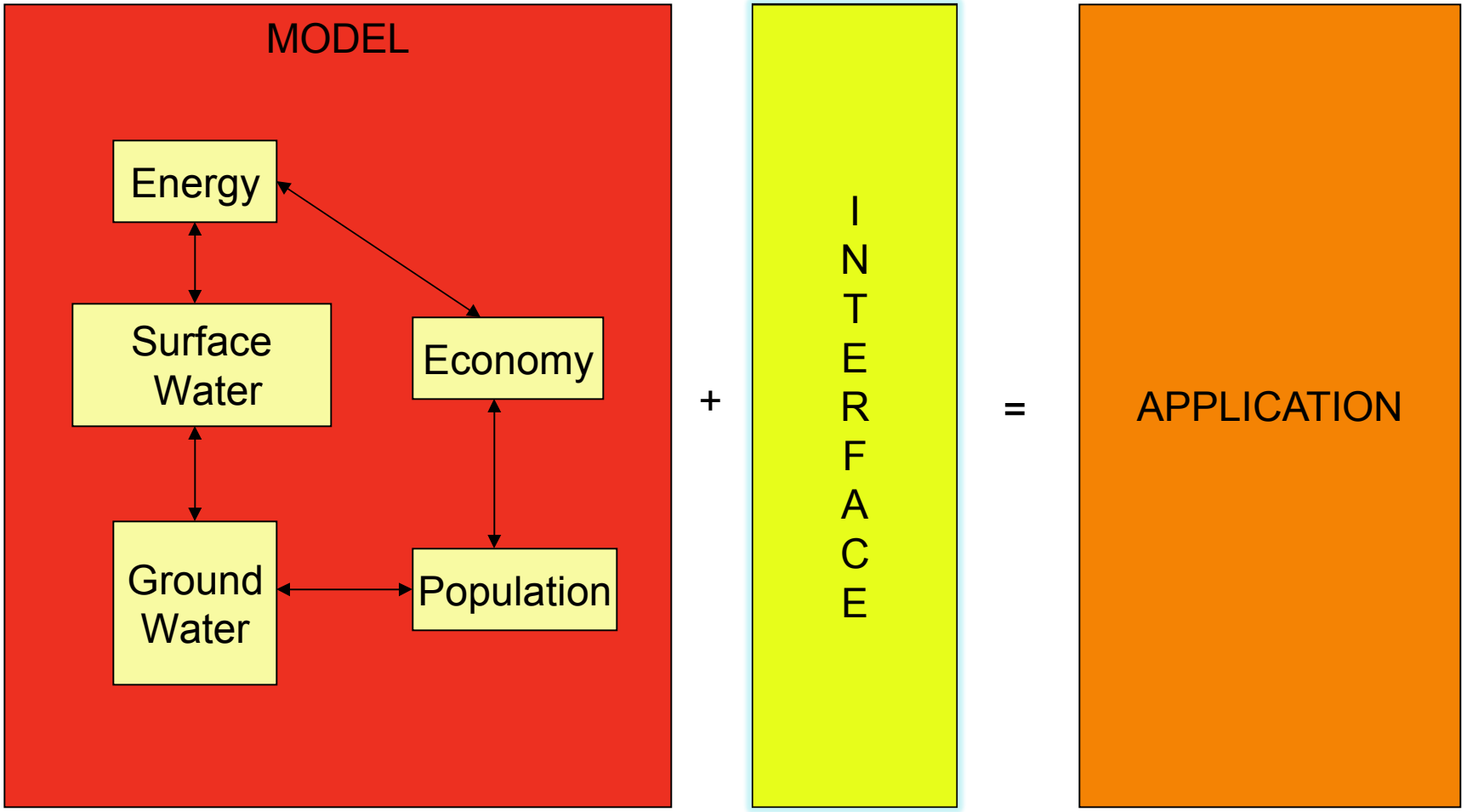


Let m1 represent Model 1
Let m2 represent Model 2

If all models implement a degree of each quality measure which model is best?

Apologies for economic jargon!

Terminology:
Module, model, interface, application

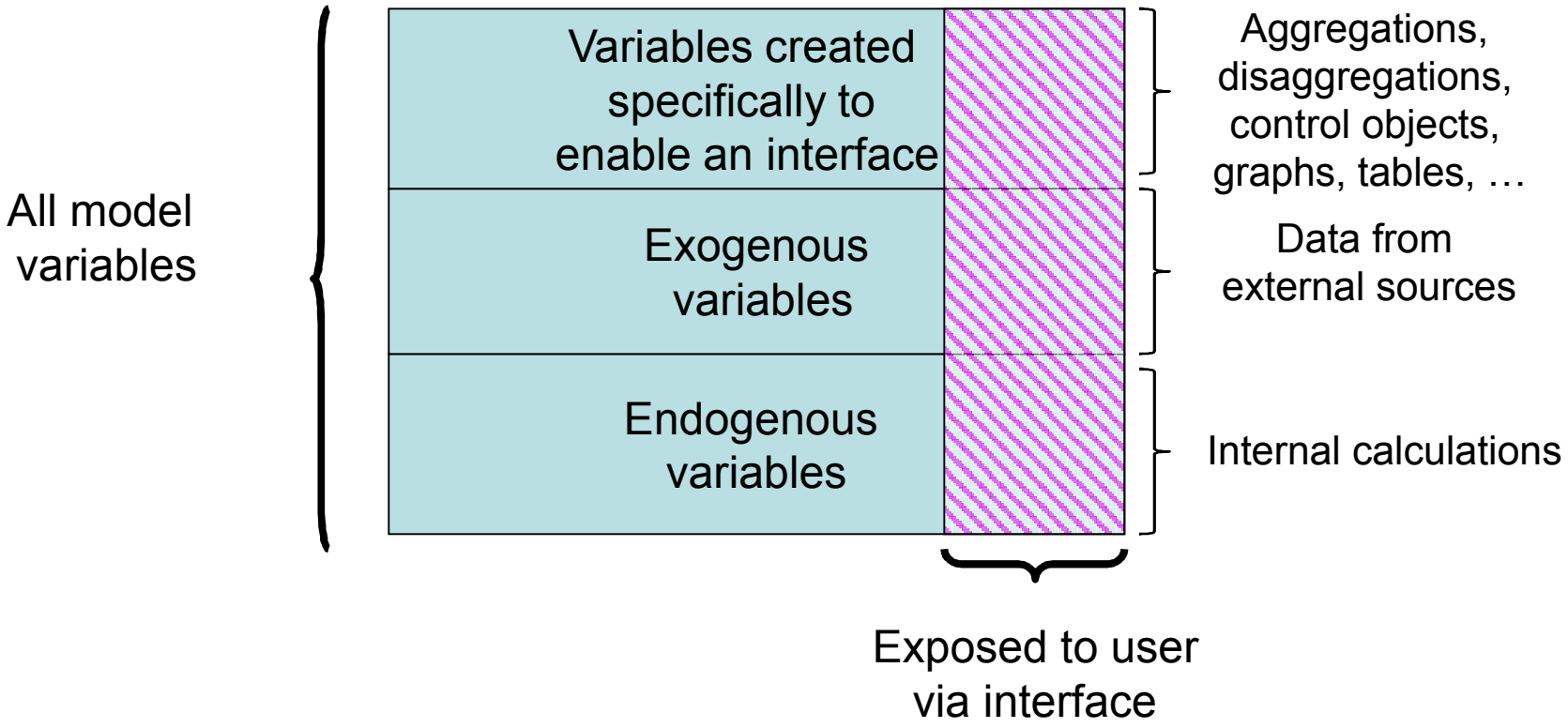


Models and Modules

Working definitions

- Module = a separate part of a model, a piece that can stand alone with little exchange of variables
- Model = All code required to represent a problem
- Interface = Access to model for customers/clients
- Application = Model + Interface

Typical system dynamics application variable classes



Some basic guidelines

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- Units / dimensionality ★
- Naming ★
- Layout
- Complexity: coupling and cohesion
- Color
- Coding style
- …

★ We will take a quick look at these when we build a model

Units / dimensionality

- "... A model might, however, pass many tests but fail one that is absolutely essential, such as, in system dynamics, dimensional consistency. Such a model would be invalid as one would not know how much confidence could be placed in its outputs." [Coyle and Exelby, 2000]

Process tip: make a template and reuse it.

Naming

- The names of variables should be clear and unambiguous.
- Resist using uncommon abbreviations, e.g. ‘fltp’ when you mean ‘fuel type’.
- Use acronyms sparsely and only if they are generally accepted in your field, e.g. kWh instead of kilowatt hours.
- Resist using digits, e.g. 1, when you mean one. Occasionally digits can be used if your client uses them to name objects, e.g. ‘Power plant 1’.
- Resist using special characters, e.g. !, #, $, &, ~, -.
- Constants should be in uppercase, e.g. INITIAL POPULATION.
- Auxiliaries, including flow rates, should be lowercase, e.g. population growth rate.
- Stock[illegible] Corn St[illegible]

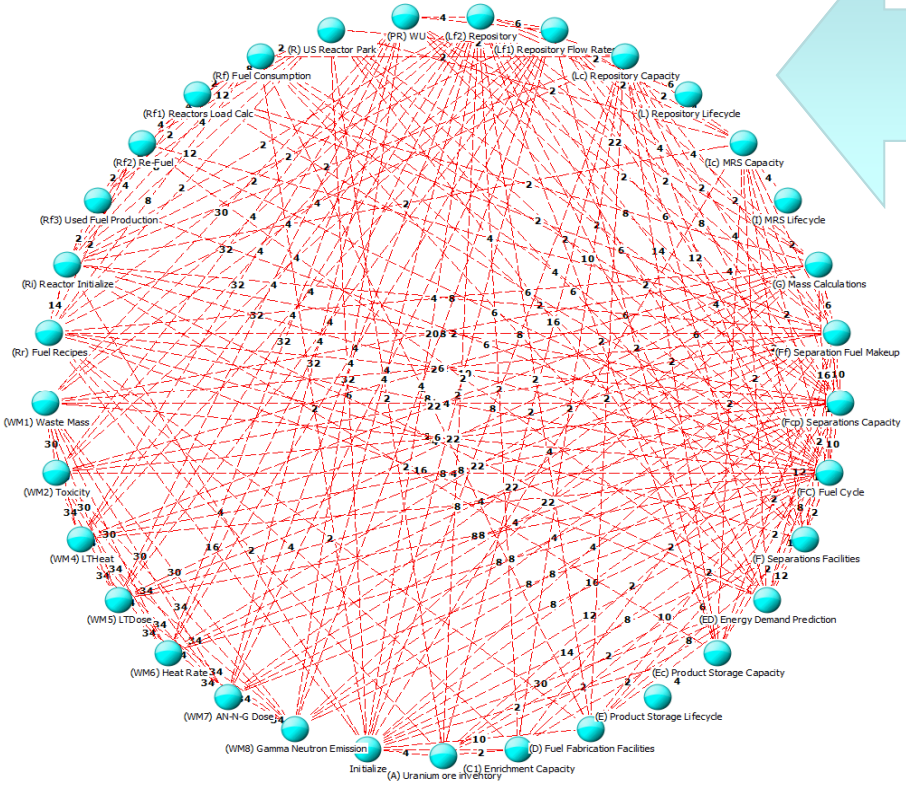
Process tip: Gone are the days of DYNAMO when names were constrained to be 4-6 characters long, make use of new technology!

Layout

- Diagram layout
  - Partition your model (views, tabs, sheets, sector, etc.)
- Variable definition
  - Leave no blank lines at the top of the definition box.
  - Do not make the first line of a definition a comment. If you want to embed comments, place them below the first line of the definition.
  - Do not leave commented, unused (i.e. old) code at the top of the definition. Put it at the bottom of the definition.

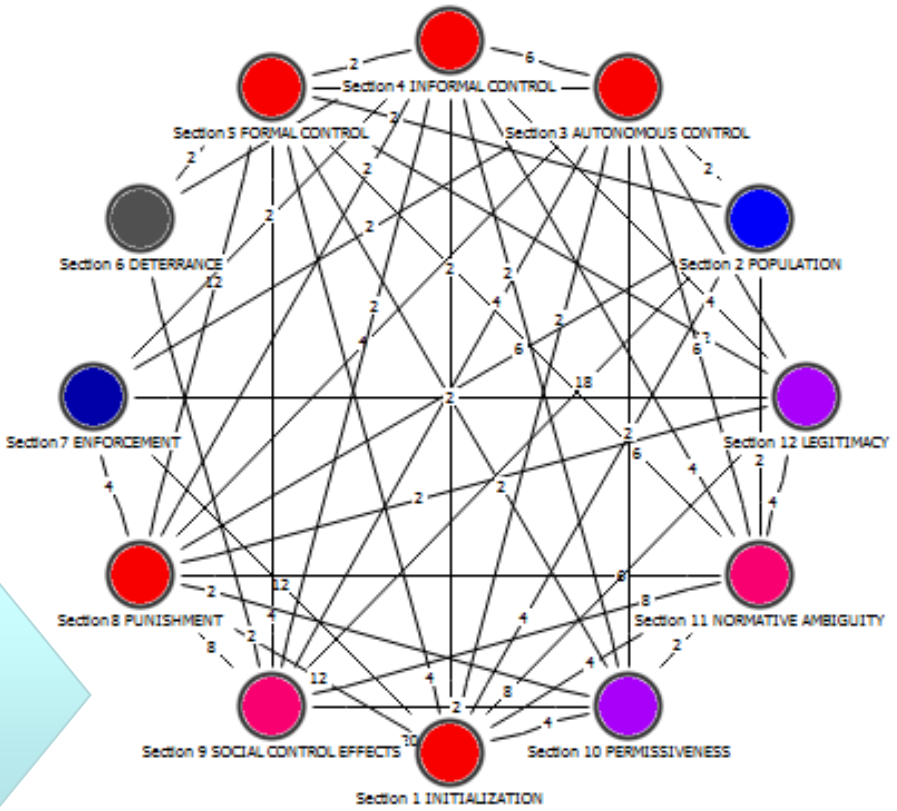
Process tip: this is related to coupling and cohesion.

Complexity: coupling and cohesion



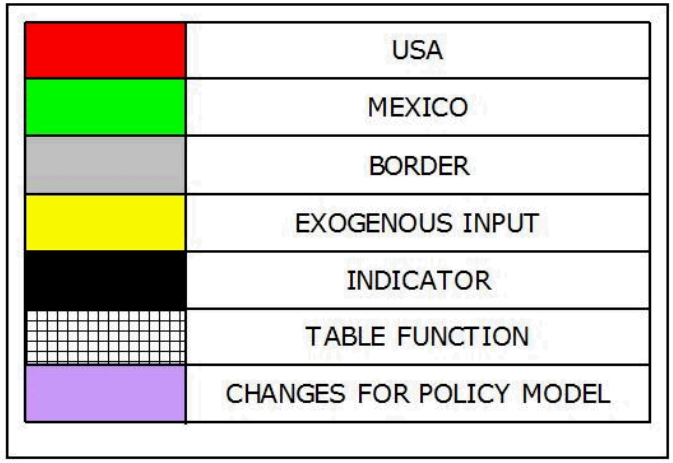
Units: 15
Variables: 168
Variable value elements: 556

Units: 45
Variables: 2918
Variable value elements: 8257858



Color

- The use of color draws the eye to certain variables.
- Set up a color scheme for you or your team, publish it and stick with it.
- Avoid hiding detail that will occur when coloring objects the same color as the diagram background.
- Avoid adding color to model elements to make them ‘look pretty’. Have a purpose for color.



Coding style

Example 1

```
FOR(i='Sun hour band‘ | IF('Open Pond Plants Under
Construction'[i]=0<<plant>>, 'Open Pond Nameplate Capacity in
Construction'[i]/1<<plant>>, 'Open Pond Nameplate Capacity in
Construction'[i]/'Open Pond Plants Under Construction'[i]))
```

Example 2

```
FOR(i='Sun hour band'|
     IF('Open Pond Plants Under Construction'[i]=0<<plant>>,
        'Open Pond Nameplate Capacity in Construction'[i],
        'Open Pond Nameplate Capacity in Construction'[i]/'Open Pond
Plants Under Construction'[i]
       )
     )
```

Process tip: styles can be found in good programming language texts.

*Extracted from: Best Practices for System Dynamics Model Design and Construction with Powersim Studio SAND2011-4108 Unlimited Release Printed June 2011, page 10.

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Let's build a model!

A simple population model

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- Stocks/Levels
  - People
- Flows/Rates
  - Increase in people
  - Decrease in people
- Auxiliaries/Constants
  - Variables that affect increase
  - Variables that effect decrease

How do we get there?

- Strict and consistent commitment to standards both pre- and post- model building
  - Checklists
  - Manual tests: model checks, units checks, spelling, etc.
  - External testing e.g. SDM-Doc
  - Peer review

When do we get there?

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- Today
  - That real land where 100% of our contributions to the field of system dynamics are satisfying and rewarded.

Process tip: THANK YOU!

Model Construction Checklist		
Model name:		
Model date:		
Model team:		
Model reviewer(s)		
Model review date:		
General comments:		
Prior to model construction		
	Yes/No/Exceptions	Notes
Has a set of units been established for the model?		
Has a time unit and time step been established for the model?		
Has a preliminary set of array/range/subscripts been established and created?		
During model construction		
	Yes/No/Exceptions	Notes
The names of variables are clear and unambiguous.		
No uncommon abbreviations		
Acronyms used sparsely and only if they are generally accepted in your field		
Special characters are avoided, e.g. !, #, $, &, ~, -.		
Constants in uppercase, e.g. INITIAL POPULATION		
Auxiliaries, including flow rates, in lowercase, e.g. population growth rate.		
Stocks have the first letter of major words in uppercase, e.g. Corn Stock		
Supporting documents		