Basics of Design Structure Matrices

Eindhoven University of Technology
Department of Mechanical Engineering
Systems Engineering

L.F.P. Etman, J. (Koos) E. Rooda
AIM2015 Vienna

September 16, 2015

Contents

The design structure matrix DSM

	a	b	c	d	e
a	-		x		x
b		-		x	
c	x		-		x
d		x		-	
e	x		x		-

	q	r	s	t	u
q	-	x			
r		-			
s		x	-		x
t				-	x
u	x		x		-

- A DSM is an $N \times N$ matrix with identical row and column labels.
- A mark (x) at position (i, j) indicates: element i depends on element j.
- Directed and undirected DSMs may be distinguished.
- Different types and strengths of dependencies may be indicated.

Clustering a DSM

	a	*b*	*c*	*d*	*e*
a	-		x		x
b		-		x	
c	x		-		x
d		x		-	
e	x		x		-

	d	*b*	*e*	*a*	*c*
d	-	x			
b	x	-			
e			-	x	x
a			x	-	x
c			x	x	-

By permuting the rows and columns of the DSM, using a clustering algorithm, the underlying structure can be revealed.

Building a DSM

Questions:

- Which row and column elements should be used, e.g. components, activities, subsystems, people, etc.
- What type of dependencies should be modeled, e.g. spatial, energy, information, etc.

Methods to build a DSM:

- *Directly* from:
  - technical drawings,
  - technical documentation, and
  - expert interviews.
- *Indirectly* from a design matrix DM by:
  1. documents that specify the mapping, of e.g. functions to components, in a DM, and
  2. use the DM, to calculate the function DSM and the component DSM.

The design matrix DM

	k	l	m	n
a		x		x
b	x		x	
c		x	x	

- A design matrix is a $M \times N$ matrix that maps M elements of one domain to N elements of another domain, e.g. rows represent components and columns represent functions.
- Function l is fulfilled by components a and c.

DM to DSM conversion

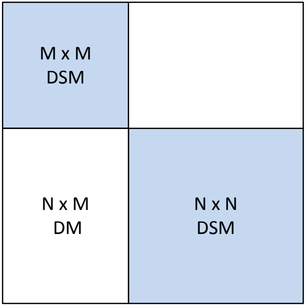
	k	l	m	n
a		x		x
b	x		x	
c		x	x	

	k	l	m	n
k	-		x	
l		-	x	x
m	x	x	-	
n		x		-

	a	b	c
a	-		x
b		-	x
c	x	x	-

- If two functions share a common component, then they are dependent, e.g. l and n share component a.
- If two components contribute to the same function, then they are dependent, e.g. a and c both contribute to l.

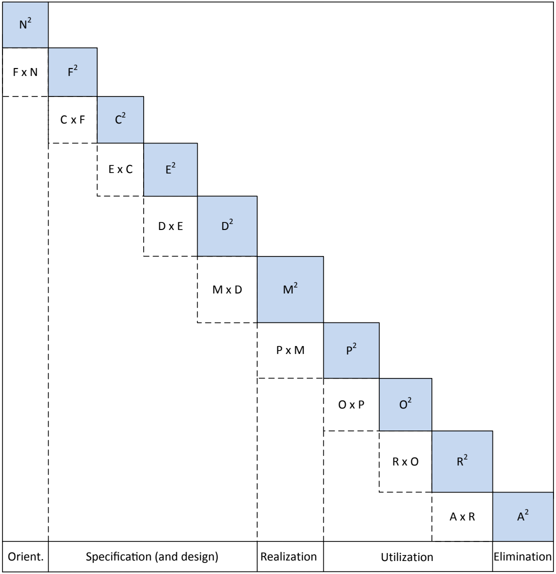
The multi-domain matrix MDM



	k	*l*	*m*	*n*	*a*	*b*	*c*
k	-		x				
l		-	x	x			
m	x	x	-				
n		x		-			
a		x		x	-		x
b	x		x			-	x
c		x	x		x	x	-

- Multiple DSMs and DMs are combined in one matrix.
- Matrices on the diagonal are single domain DSMs, e.g. function DSMs; component DSMs.
- Off-diagonal matrices are DMs mapping the dependencies between two domains, e.g. function-component DM.

The life cycle matrix LCM



An LCM is an MDM:

$$X == Y \quad : \; DSM(X,X),$$
$$X \;/\!= Y \quad : \; DM(X,Y),$$

where X, Y:

N	-	Needs,
F	-	Functional,
C	-	Conceptual,
E	-	Embodiment,
D	-	Detailed,
M	-	Manufacturing,
P	-	Physical,
O	-	Operational,
R	-	Revision,
A	-	Annihilation.