Making Information Flow
DSM, Overlapping Framework, Design Principle 2

4013.315 Architectural Engineering System Design

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Her dilemma...how to order activities?

Sookja, the chief schedule planner of the SNU IT Center project, is looking at the design schedule that 'Y' design company recently reported to her.

Since 'Y' company knows well about the design process she expected their design schedule would be one that represents the company's experience and knowledge. However, their schedule does not seem to be optimized in terms of having a lot of design iteration cycles and lead time in the design process.
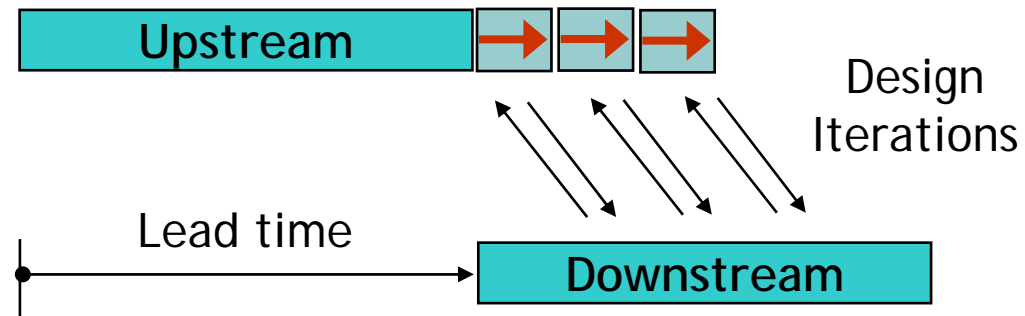
As you are taking 4013.315...

she asked you to help to find the activity order that minimize design lead time and change iterations.

How can you help her?

Lead time and iterations

Information Dependency Table

Activity	Dependent on the information given by
a	
b	c, i
c	d, h
d	g, h
e	a
f	e
g	f, h
h	e, g
i	b
j	i

* All activity have the <u>same</u> duration and you do not have to consider other conditions like resource requirements. Also, note that even in the optimum activity order there <u>still exist some coupled activities</u>, which means you cannot achieve zero lead time.

This may be helpful...

		a	b	c	d	e	f	g	h	i	j
Activity	a	▉									
Activity	b		▉	x						x	
Activity	c			▉	x				x		
Activity	d				▉			x	x		
Activity	e	x				▉					
Activity	f					x	▉				
Activity	g						x	▉	x		
Activity	h					x		x	▉		
Activity	i		x							▉	
Activity	j									x	▉

"Focusing on information flow among project functions and development phases"
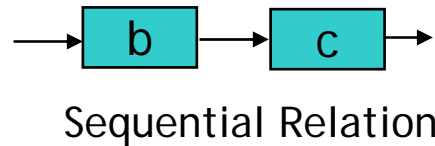
Lecture Outline

➢ Design Activity Ordering

➢ Design Activity Overlapping

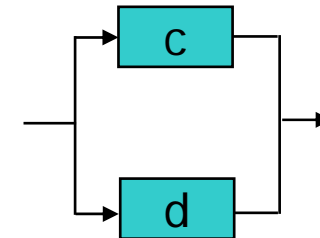➢ Fragmentation of Construction Value Chain

Activity Ordering

➢ In a way to minimize:

  ▪ Activity lead time that is required as a result of <u>not</u> having the necessary information.

  ▪ Possible iterations in between design activities, when changes or errors are made in <u>succeeding</u> activities.

➢ DSM: Design (Dependency) Structure Matrix, Steward (1965), Eppinger
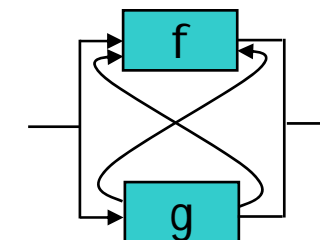
Different sequences for two design activities

Sequential Relation

Parallel (independent) Relation

Coupled (interdependent) Relation

		a	b	c	d	e	f	g	h	i	j
Activity	a										
Activity	b	x									
Activity	c		x								
Activity	d		x								
Activity	e	x									
Activity	f		x					x			
Activity	g						x				
Activity	h					x		x			
Activity	i		x								
Activity	j									x	

[Eppinger, 1992]

DSM Principle I

Try to reduce the information dependency relationships located above the diagonal line by reordering activities so that the number of coupled activities and possible iterations can be minimized.

Sookja's case

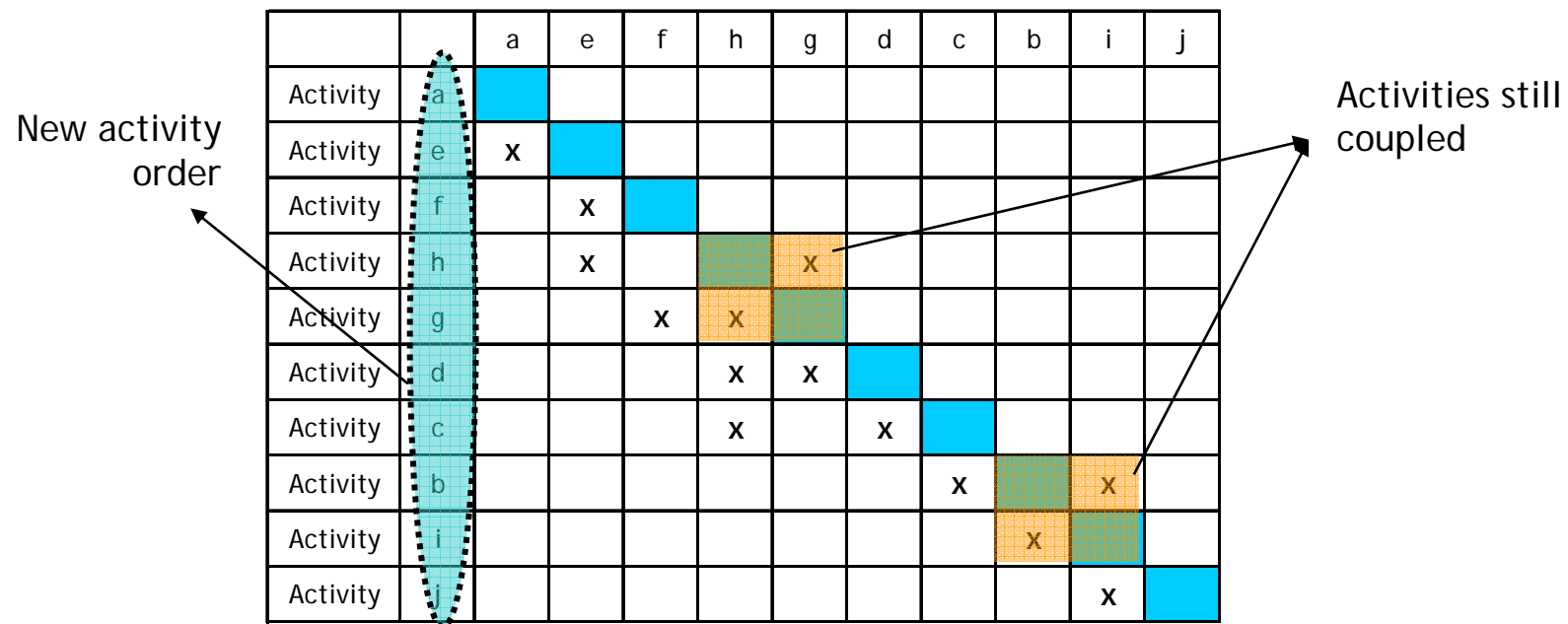|		a	b	c	d	e	f	g	h	i	j
Activity	a										
Activity	b			x						x	
Activity	c				x				x		
Activity	d							x	x		
Activity	e	x									
Activity	f					x					
Activity	g						x		x		
Activity	h					x		x			
Activity	i		x								
Activity	j									x	

DSM Principle II

Try to reduce the path of iteration cycles by reordering activities so that <u>associated efforts</u> can be minimized.

DSM Principle III

If having inevitable 'coupled' activities, pay special managerial attentions to those activities (Breaking interdependency can be also tried).

		a	e	f	h	g	d	c	b	i	j
Activity	a	█									
Activity	e	x	█								
Activity	f		x	█							
Activity	h		x		▓	x					
Activity	g			x	x	▓					
Activity	d				x	x	█				
Activity	c				x		x	█			
Activity	b							x	▓	x	
Activity	i								x	▓	
Activity	j									x	█

New activity order

Activities still coupled

Optimized Activity Order for the Case

DSM Practice

Please optimize the below DSM and Reorder the activity order.

		a	b	c	d	e	f	g	h	i
Activity	a									
Activity	b			x			x			
Activity	c					x				
Activity	d			x						
Activity	e	x								
Activity	f		x		x					
Activity	g						x		x	
Activity	h						x			
Activity	i							x		

DSM Practice

		a	e	c	d	b	f	h	g	i
Activity	a	▮								
Activity	e	x	▮							
Activity	c		x	▮						
Activity	d			x	▮					
Activity	b			x		▮	x			
Activity	f				x	x	▮			
Activity	h						x	▮		
Activity	g						x	x	▮	
Activity	i								x	▮

Smart Cells

Probability of realizing this dependency relationship

Precedence Relationships (FF,FS,SS,SF) or Reprocess Iterations (RI)

Lag or Lead Time associated with this dependency relationship

To be used to break down activities into smaller segments. In this case, 20% of downstream work can start independent of its upstream, because that portion of work is classified as general, administrative work, which is not dependent on upstream work.

Unique to the set of UP and DN. ie. Sensitivity of 'C' to 'A' can be different from sensitivity of 'C' to 'B'

* Impact of Reprocess Iterations: function of Dependency Probability, Upstream Sensitivity, and Downstream Reliability

ADePT™* : a commercial application

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Lecture Outline

✓ Design Activity Ordering

➤ Design Activity Overlapping

➤ Fragmentation of Construction Value Chain

Activity Overlapping

➢ Concurrent engineering has been developed to cope with competitive business environments that require the industries to <u>develop and market products faster</u> [Eppinger et al., 1992].

➢ Concurrent engineering aims principally at reducing the duration of engineering time and costs.

➢ One of the major challenges facing concurrent engineering lies in an overlapping practice.

Activity Overlapping

➢ Properly overlapped tasks can facilitate development progress, while <u>overlapping practice without careful management may increase the development cost and worsen the product quality</u> [Eppinger et al., 1992].

Discussions: effectiveness of design activity overlapping

➢ What if the upstream activity transfers immature data that still requires a substantial amount of rework and time to finalize to the downstream activity?

The downstream activity becomes inefficient by producing problematic results based on inaccurate upstream data [Li, 1999], which results in rework iterations between two activities.

Discussions: effectiveness of design activity overlapping

➢ What would be a solution to achieve effective overlapping?

An effective overlapping practice can be achieved by freezing upstream parameters before transferring information to the downstream activity so that the downstream crew can begin their work based on the frozen parameters [Li, 1999].

Discussions: effectiveness of design activity overlapping

➢ What would be a pitfall of this solution?

If the <u>finalized</u> information released by the upstream crew actually contains a substantial amount of undiscovered rework, the downstream work based on this unreliable information might need additional rework [Li, 1999].
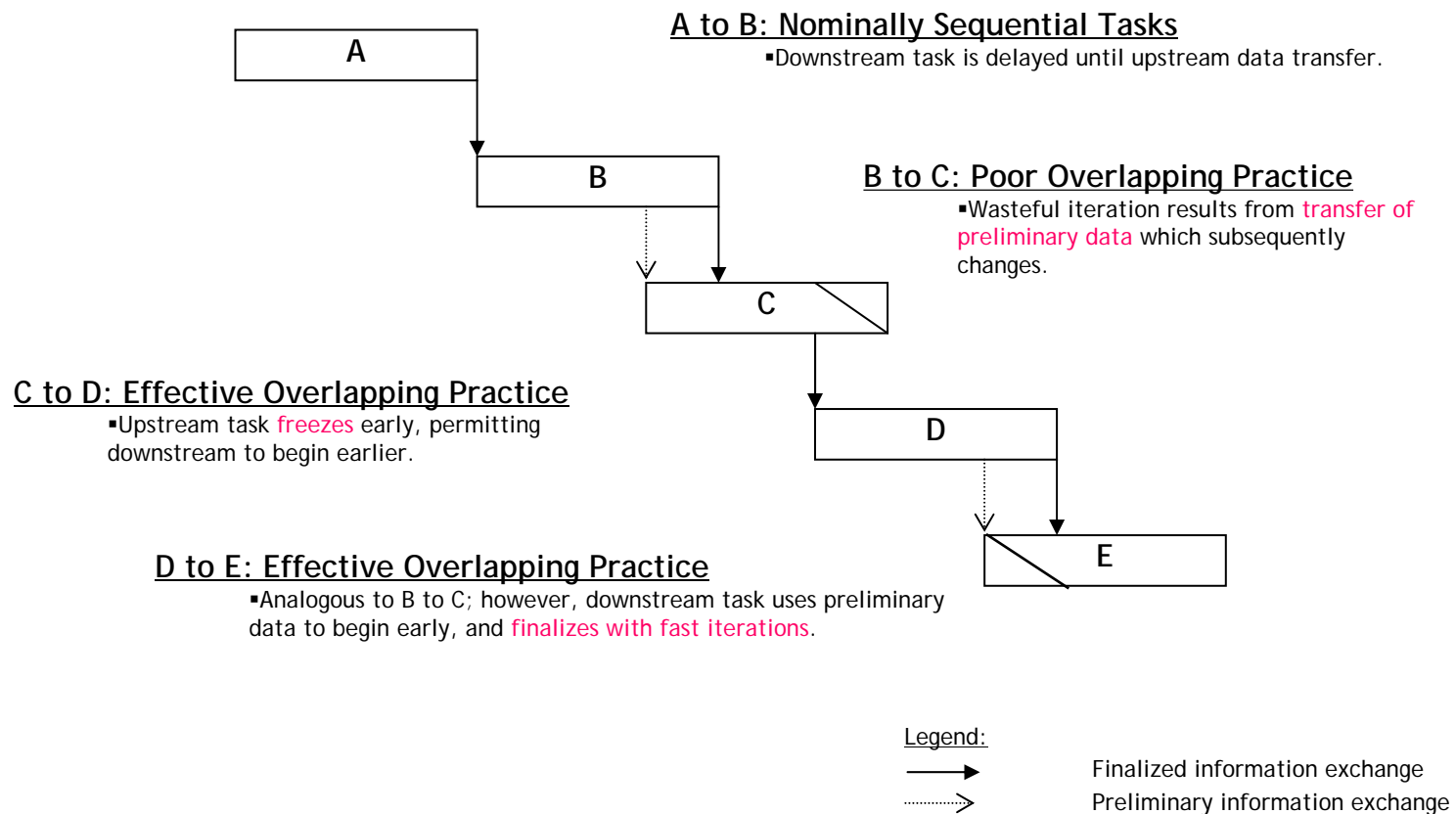
Discussions: effectiveness of design activity overlapping

➢ What else would be an alternative to achieve effective overlapping?

Using <u>preliminary data</u> from upstream, generate work units that are flexible and have high tolerances for errors and changes. In this strategy, the upstream parameters are not necessarily frozen when transferred. The important thing is that the downstream activity must be flexible enough for fast iterations as upstream data finalizes. [Li, 1999].

Overlapping practices

A to B: Nominally Sequential Tasks
▪Downstream task is delayed until upstream data transfer.

B to C: Poor Overlapping Practice
▪Wasteful iteration results from transfer of preliminary data which subsequently changes.

C to D: Effective Overlapping Practice
▪Upstream task freezes early, permitting downstream to begin earlier.

D to E: Effective Overlapping Practice
▪Analogous to B to C; however, downstream task uses preliminary data to begin early, and finalizes with fast iterations.

A
B
C
D
E

Legend:
⟶ Finalized information exchange
⤳ Preliminary information exchange

Versions of overlapping practices [adapted from Eppinger, 1992]

Discussions: how to evaluate effectiveness of overlapping?

➢ Which characteristics in design work can influence a decision of overlapping degrees between design activities?

➢ And, how to evaluate the effectiveness of design activity overlapping?
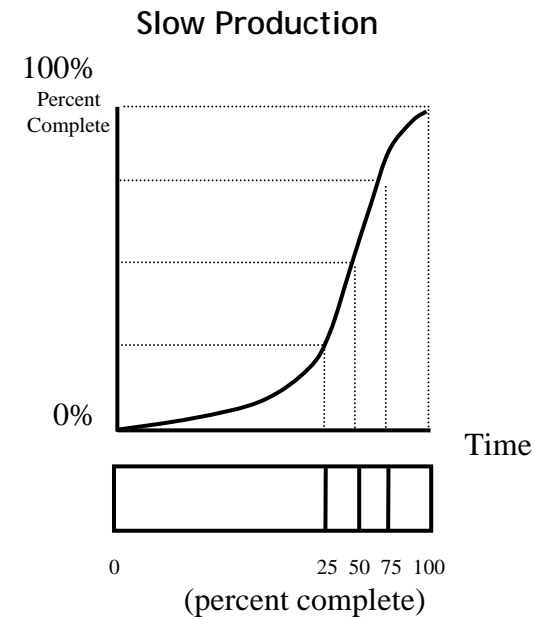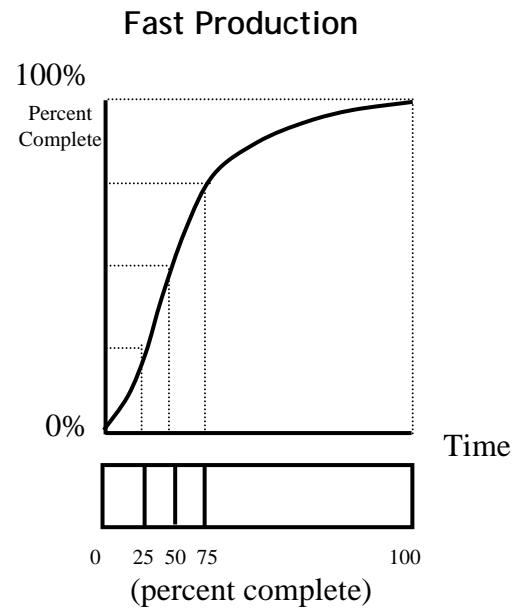
Eppinger's Overlapping Framework

➢ Eppinger [1992] classifies overlapping practices in terms of upstream evolution and downstream sensitivity, focusing on transferring information that is derived from design parameters.

➢ Upstream evolution describes the ability of the upstream to provide finalized information, with which a downstream task can proceed.

➢ Downstream sensitivity describes the sensitivity of the downstream to changes in an upstream task.

Expanding the framework

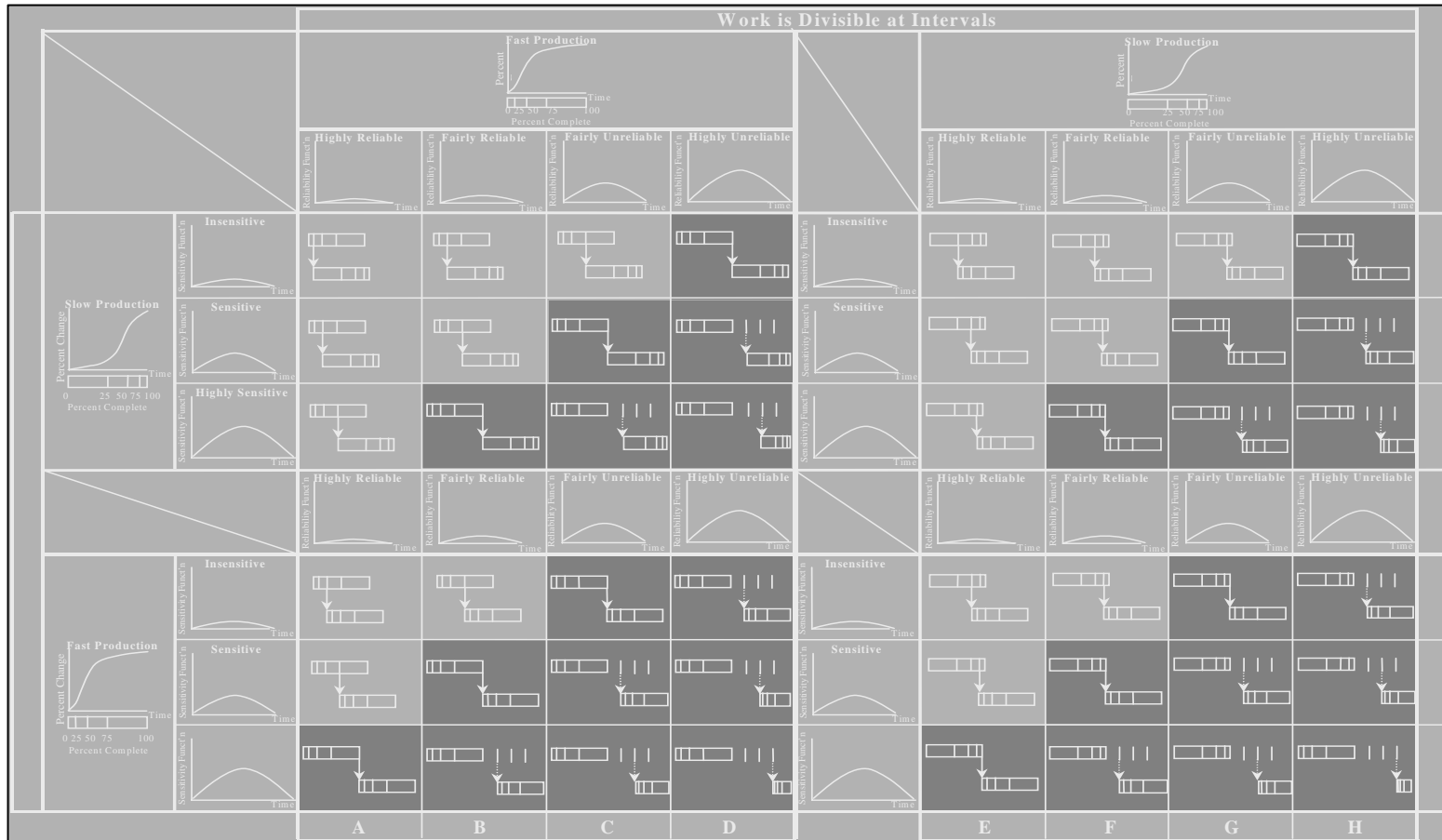| Activities	Eppinger's	Expanded
Upstream	Information evolution (Fast/Slow)	Production rate (Fast/Slow)
	NA	Reliability (Reliable/Unreliable)
Downstream	Sensitivity (Sensitive/Insensitive)	Sensitivity (Sensitive/Insensitive)

Production Rate

Production Rate [Li, 1999]

Discussions: how to determine an appropriate overlapping degree?

➤ If the upstream has a fast production rate, the required overlapping degree would be 1) increase or 2) decreased?

➤ If the upstream is reliable, the required overlapping degree would be 1) increase or 2) decreased?

➤ If the downstream is sensitive to upstream errors and changes, the required overlapping degree would be 1) increase or 2) decreased?

An example

Overlapping Framework [Pena-Mora & Li, 2001]

Lecture Outline

✓ Design Activity Ordering

✓ Design Activity Overlapping

➢ Fragmentation of Construction Value Chain

Fragmentation of construction value chain

➢ Customers and competition has led, in dynamic markets, to increasing the performance at reduced cost.

➢ In construction, the added pressure of volatile and erratic demand, and increased complexity have led to increased specialisation and fragmentation of construction value chain.

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Project organisations getting complex

- ➢ The process of construction procurement involves a series of different specialists in contributing to the work at different times.

- ➢ The level of understanding between them is often less than would be desirable.

- ➢ The need to build an effective project team, in which information flow is streamlined and decision-making is responsive to changing environment.

The Wheel of Leadership

➢ All designers and technologists should be able to manage themselves.

➢ However, there is a need for a coordinating effort of the whole project.

➢ Although every team will have their own "Project Manager", there is a need for one to take the responsibility for the overall coordination.

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➢ Li, M.(1999), *A Robust Planning and Control Methodology for Design-Build Fast-Track Civil Engineering and Architectural Projects*, Thesis (M.S.), Dept. of Civil and Environmental Engineering, MIT