



VAASAN YLIOPISTO

## COMPLEXITY IN PRODUCT DEVELOPMENT PROJECTS

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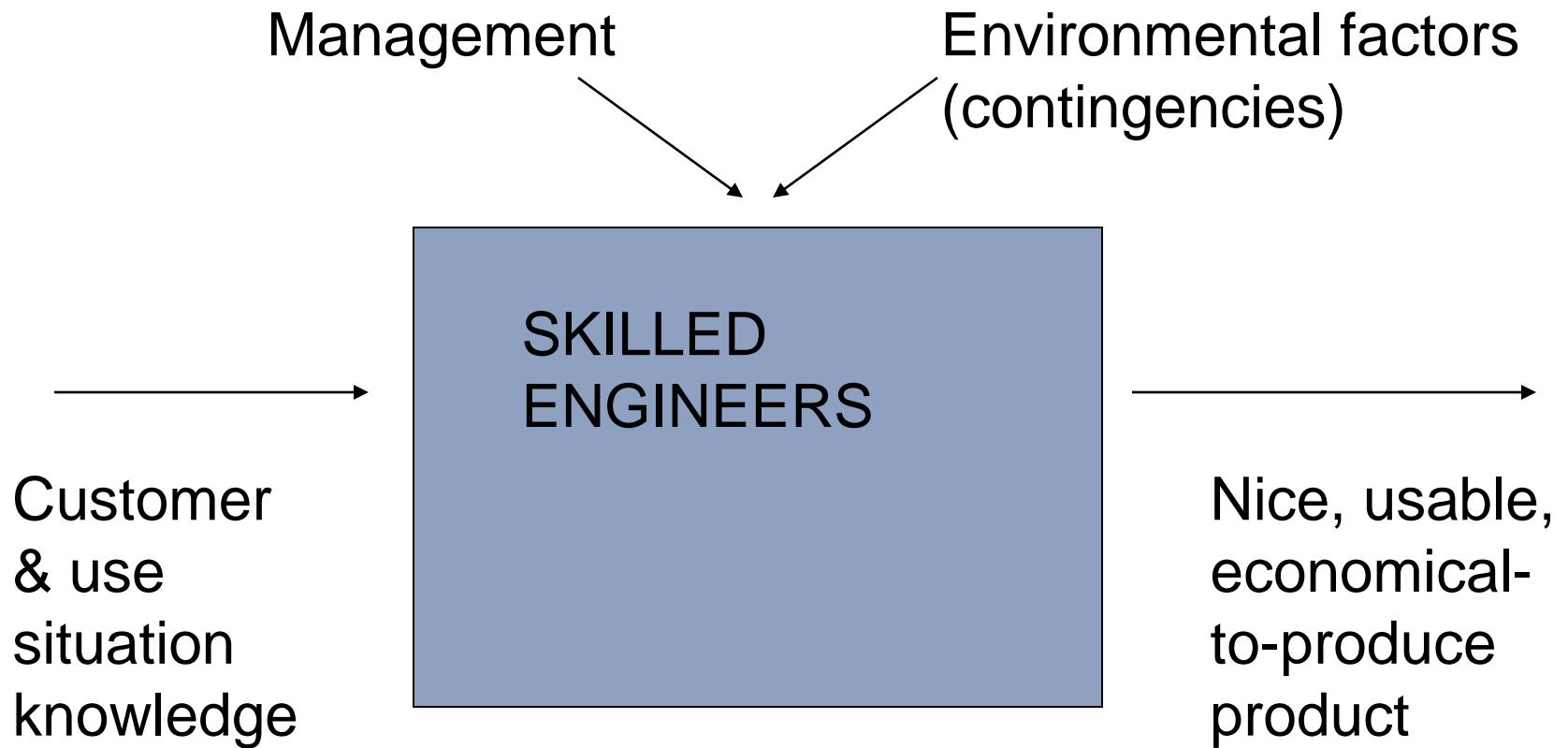
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More detailed information: transactive memory and communication patterns [knata@uwasa.fi](mailto:knata@uwasa.fi)

DSM, TOC, Bullwhip effect [phelo@uwasa.fi](mailto:phelo@uwasa.fi)

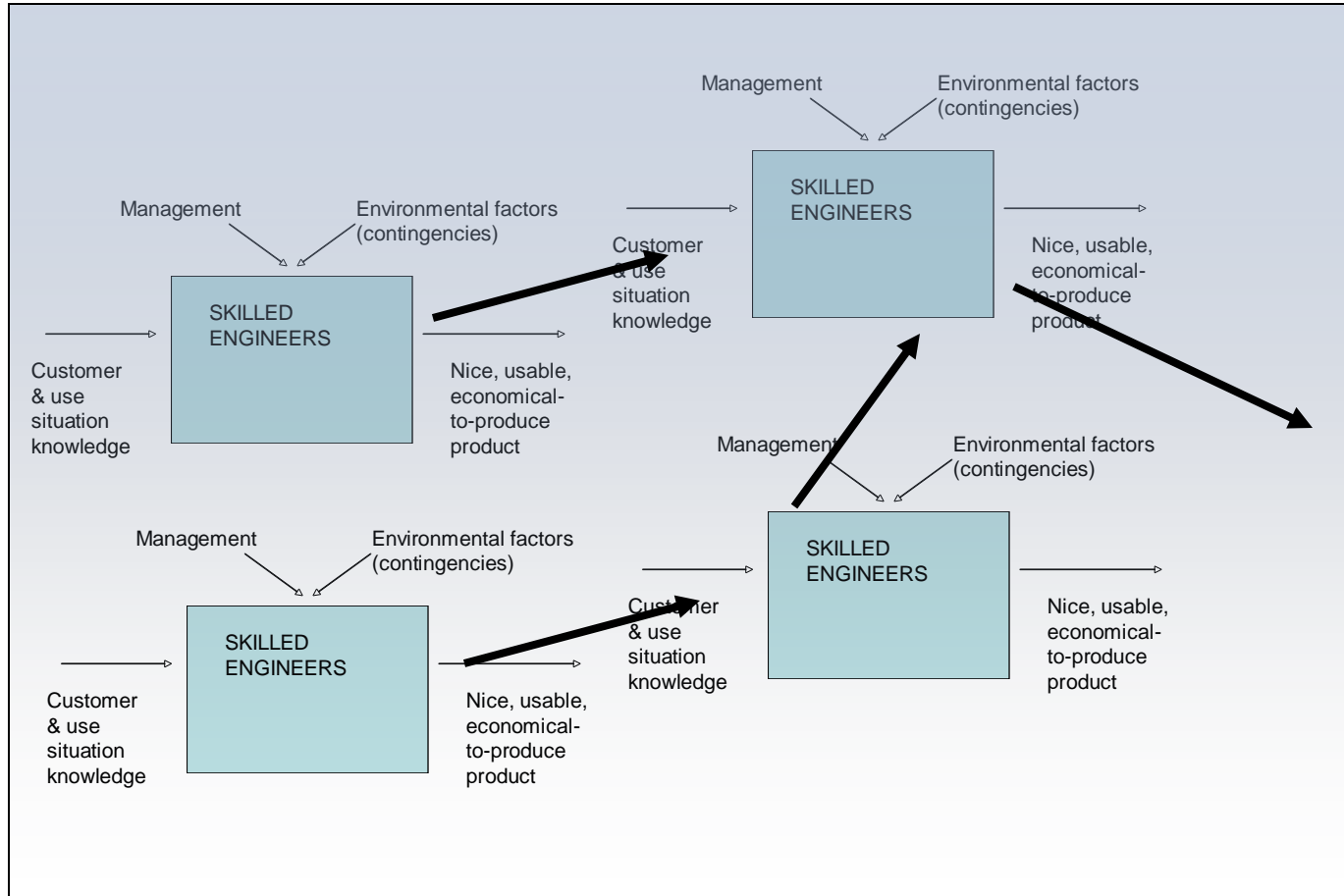


# In the beginning there was a simple model.....





# CoPS ? (Complex Product Systems, Brady 1994)



**SYSTEM**  
that the  
customers  
use for  
complex  
processes



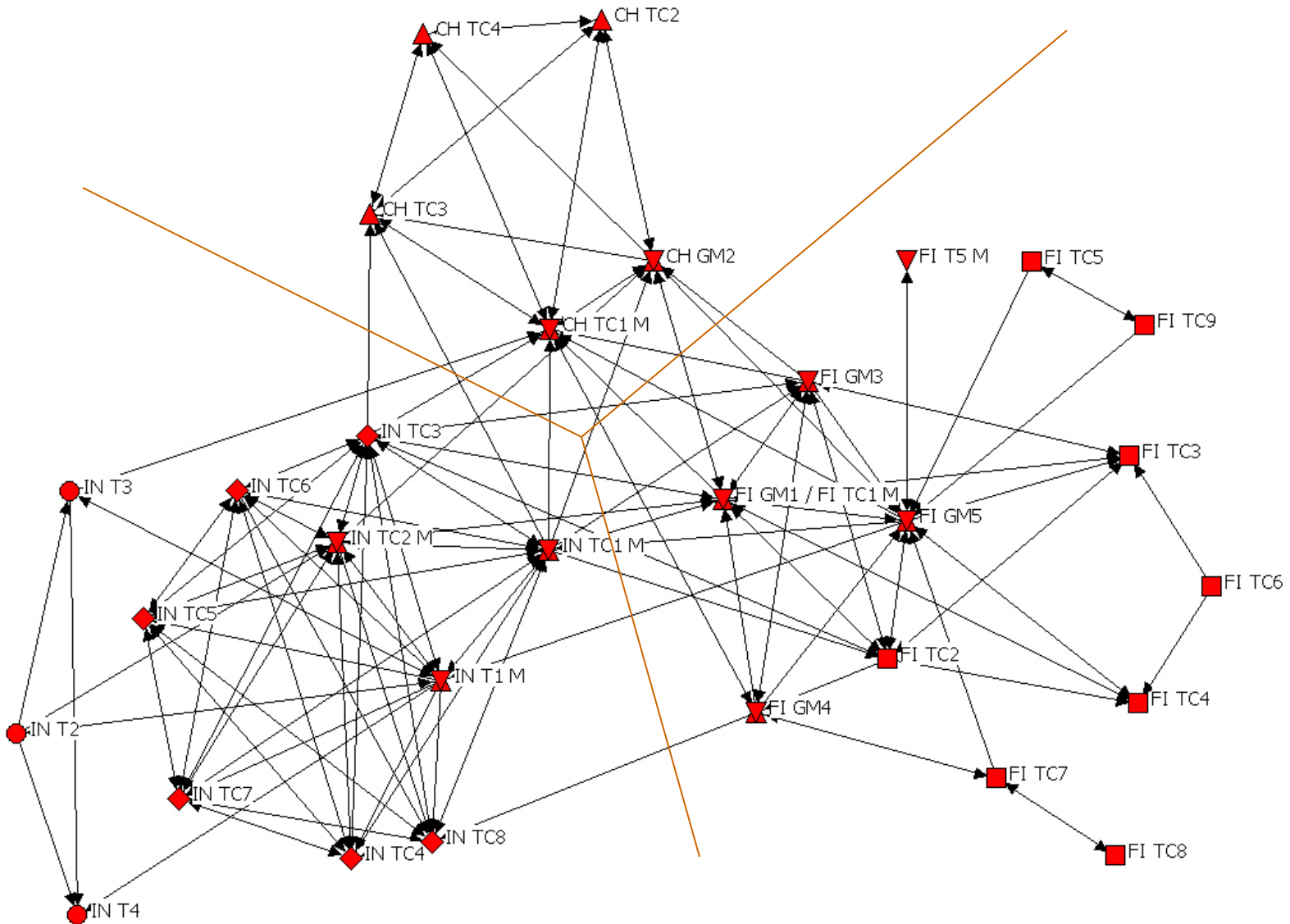


# COMPLEXITY AND PRODUCT DEVELOPMENT

1. Products are developed through multiple-nature relations between and among stakeholders (Porter's "copter")
2. Project goals and requirements are difficult to explain in a way that is nice, clear and open to everybody
3. Changes, randomness, environmental events and emergence take place during long-duration projects



# An international project group (Kitaygorodskaya 2007)





# PROBLEMS of culture ?

- time zone (night / day)
  - language
- culture (power distance)
  - vicinity / structure
- knowledge of each other's task and knowledge (transactive memory)
- crudeness of technical equipment used in communication
  - perceived importance of things & events
- “whom would we think needs to be contacted in a situation like this ?”
  - “why would I contact anybody?”
    - “who will get shit for this ?”



# C-C-C-CHANGES....

- Meanings of words change: “management representative” vs. “johdon edustaja” (ISO 9001/1984)
- Most of what we see is not visible to us (“Remember that big tree outside Your office?”)
- Most of customer/consumer/use case data comes to the persons who need it second-hand (“iso näyttö”/”large display” or “24 degree roof”)
- Most of the customers indeed will live their life further during our planning.... and while they live, their definition of “good enough” develops....



## “Action in cockpit”

- Two types of changes:

Planned, caused by testing and improvements

- possible to know where iterations occur, but not the magnitude
- good design methods, tools and coordination: Requirements mgmt., DSM, CMMi, ...

Unplanned, caused by “events” and errors

- impossible to know when they occur and what problems they cause
- risk management methods (documentation, doubling, FMEA...) and improvisation by staff



# PROBLEMS of communication ?

- “Oh, You have winter there ?”
- “What the @\*?&œ√ioe\_l, this hood will not shut ?”
- “The new technologically superior product surprisingly failed at the market”
- Need for update packages and other support services (that are difficult to price according to the real costs)

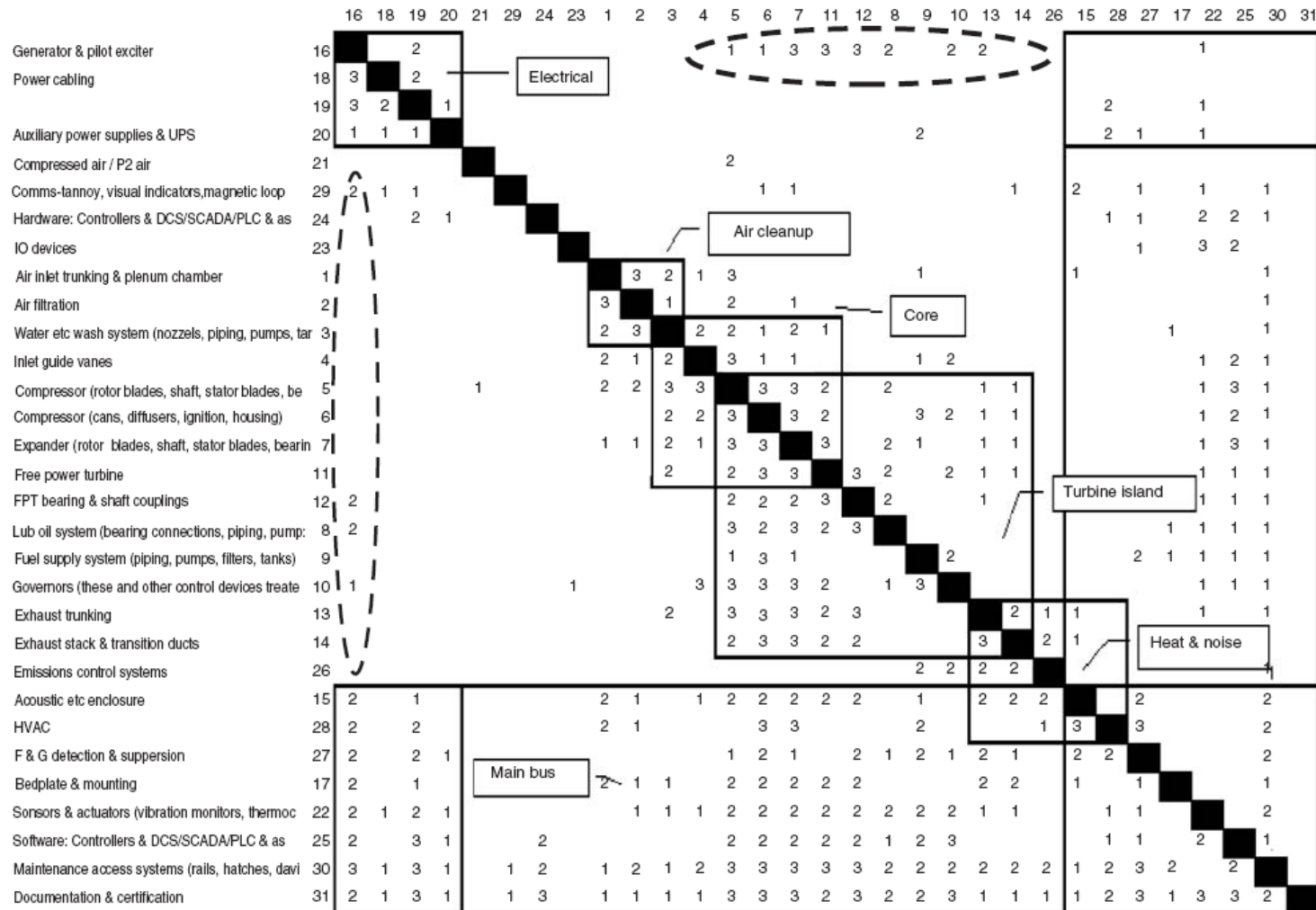


# Original DSM of a Gas Turbine (Sharman & Yeassine 2007)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Air inlet trunking & plenum chamber			3	2	1	3				1				1																	1	
Air filtration	1	3		1		2		1																							1	
Water etc wash system	2	2	3		2	2	1	2			1					1															1	
Inlet guide vanes	3	2	1	2		3	1	1		1	2											1			2						1	
Compressor	4	2	2	3	3		3	3	2			2		1	1							1	1			3					1	
Combustor	5			2	2	3		3		3	2	2		1	1								1			2					1	
Expander or Turbine	6	1	1	2	1	3	3		2	1		3		1	1						1					3					1	
Lub oil system	7				3	2	3					2	3				2	1					1			1					1	
Fuel supply system	8				1	3	1			2								1					1		1		2				1	
Governors	9				3	3	3	3	1	3		2					1						1	1		1					1	
Free power turbine	10			2		2	3	3	2		2		3	1	1								1		1						1	
FPT bearings & coupling	11				2	2	2	2				3		1			2					1									1	
Exhaust trunking	12			2		2	3	3				3	3		2	1							1				1				1	
Exhaust stack & transition ducts	13				2	3	3					2	2	3		1					1						2					
Acoustic etc enclosure	14	2	1		1	2	2	2		1		2	2	2	2		2							2			2				2	
Generator & pilot exciter	15					1	1	3	2		2	3	3	2							2		1								1	
Bedplate & mounting	16	2	1	1		2	2	2				2	2	2	2	1	2							1							1	
Power cabling	17																3				2										1	
Switchgear	18																				3	2									1	
Auxiliary power supplies & UPS	19								2					1							1	1				1			2	1	1	
Compressed air	20				2																										1	
Sensors & actuators	21		1	1	1	2	2	2	2	2	2	2	2	1	1		2				1	2	1					1	1		2	
IO devices	22																						3			2		1				
Hardware: Controllers	23																				2	1		2		2		1	1		1	
Software: Controllers	24				2	2	2	1	2	3	2	2				1					2	1	2		2		2	1	1		1	
Emissions control systems	25								2	2			2	2																	1	
F&G detection & suppression	26				1	2	1	1	2	1		2	2	1	2	2					2	1		1		2			2		2	
HVAC	27	2	1			3	3		2					3		2					2					1	1	3			2	
Comms-tannoy, visuals, mag. loop,	28					1	1							1	2	2						1		1				1			1	
Maintenance access systems	29	1	2	1	2	3	3	3	2	2	2	3	3	2	2	3	3	2	1	3	1				2	2	2	3	2	1		
Documentation & certification	30	1	1	1	1	3	3	3	2	2	2	2	3	1	1	1	2	1	1	3	1		3		3	3	2	3	2	1	2	



# Clustered DSM of a Gas Turbine (Sharman & Yeassine 2007)





# EMERGENCE, AT RANDOM ?

- Theory of emergence means that while an event is going on, it is impossible to know what the end state will be; the result is not the sum of all of the ingredients....
- ....and not all the project ingredients are known (randomness, complexity, theory of “satisficing” - Simon 1985)
- So, all project tasks should be considered probabilities ???????

=> TOC-based management ?



# Emergence emerges

- Ericsson Twente: project was killed the same week when the final (successful) prototype was due (strategic decision)
- The bullwhip effect (Forrester effect) in multi-layered systems
- “Environmental” factors: Tsunami ? Bird flu ? 9/11 ? Collapse of Soviet Union ? (and other minor issues);

are they increasing ?

Are they increasing

world-wide.....

or just in places

where we work ?





# Work culture of projects and other Polya processes (Helo & Kekäle 2006)

QuickTime™ and a  
TIFF (LZW) decompressor  
are needed to see this picture.



# PROBLEMS of inaccuracies & built-in delays: the Bullwhip effect

QuickTime™ and a  
TIFF (LZW) decompressor  
are needed to see this picture.

- Countermeasures to project forecast inaccuracies: Lack of project phase visibility can be addressed by providing direct access to hot-spot data (moving pictures ?).
- Instant action: Long lead times should be reduced wherever economically advantageous (and nearly everywhere else)



# Communication patterns

<b>research project</b> (task is complex, universally defined and aims at creation of new knowledge)	all team members
<b>technical service project</b> (task is less complex, locally defined, technologies involved are stable and well known)	supervisors
<b>development project</b> (task complexity stays in between those of research and technical service projects, it is locally defined, but technologies involved are not well understood )	all team members (from inside team/other departments), gatekeepers (from outside the organization)



# The product is a part of the solution: DESIGN FOR “X”

- Design for complexity:

- robustness
- scalability
- culture-tolerance
- outsourceability
- profitability
- life-cycle view/service business view
- technologic development platform/”renewability”

⇒ the simpler the product/project, the less parts and phases where something can go wrong AND less interfaces where information and responsibility disappears

⇒ standard parts, standard procedures



# How to (eventually) win over complexity ?

- The many subsystems must be understood
- Overall system solution by integrating the subsystems
- Integration in complex world by information dependence
- Organization solutions based on this structure; immediate, correct information to all
- Follow the scene; assess risks all the time; learn over project borders
- Pray & stay awake (even a disappearingly small probability is probable..... )