Systems Concurrent Engineering of a “Green” Car

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Objectives

- Present the systems concurrent engineering approach
  - for the development of complex products

- Illustrate the approach with a hypothetical case:
  - the development of a "Green Car".

The “green” car – mission and concept

- Transports up to two people on a road
- a small ecological vehicle
- congestion in major cities.

- less polluting than the average car,
- can reach speeds of 100 kilometers per hour
- has a movable frame for safety and maneuverability.

- unites the small size and efficiency of a motorcycle with
- comfort and safety of a car, using
- compressed natural gas as fuel.

- cheaper to run,
- quieter and less polluting.
- lots of recyclable parts.

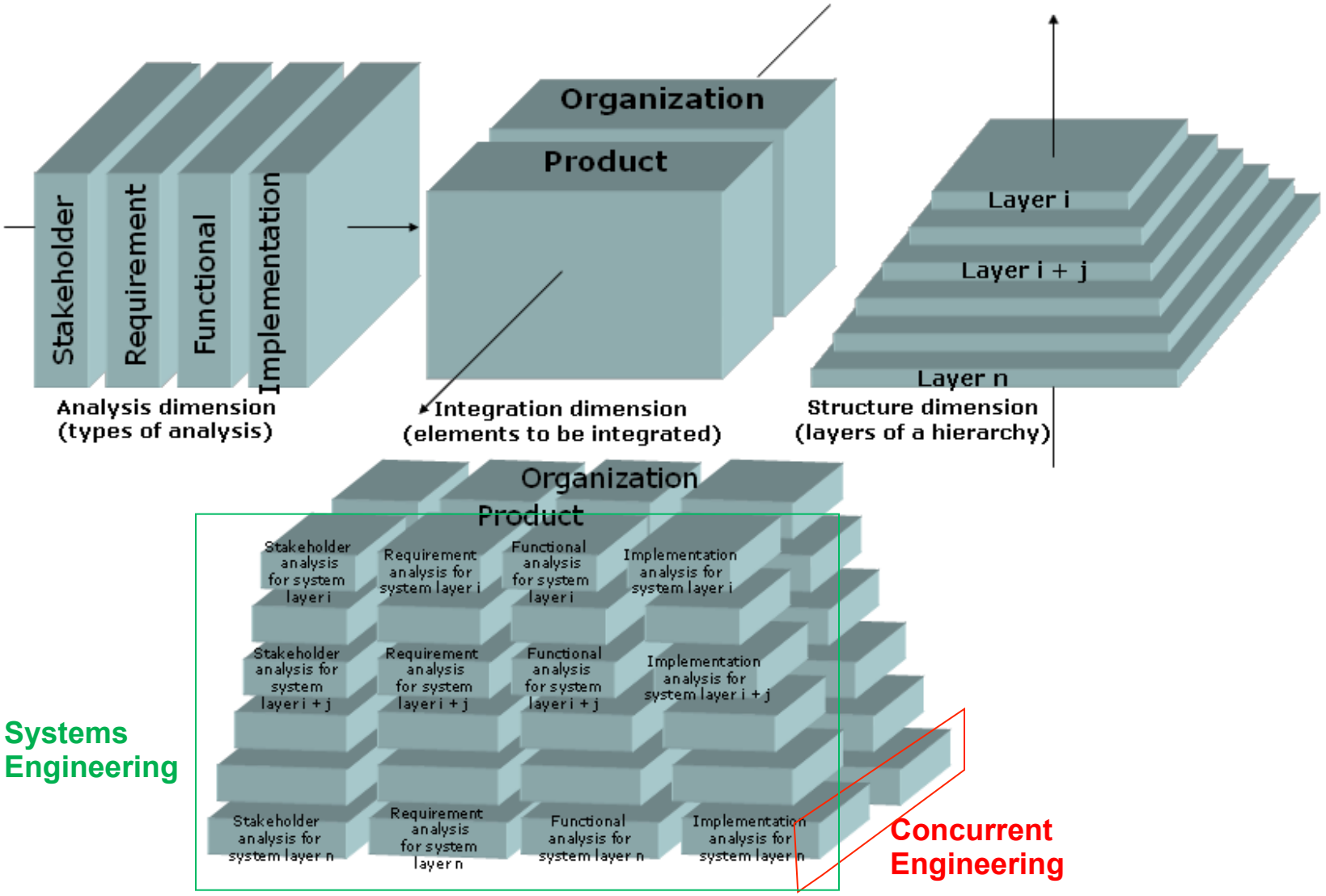
Traditional systems engineering approach

- Automobiles are **complex** products
- The later changes are made along **product life cycle**, the more they will cost
- Need to anticipate life cycle process **requirements** to the early stages of product development
- Traditional **systems engineering** focuses on:
  - Product
  - Development organization
  - Operations
- Traditional **concurrent engineering** focuses on:
  - Parts
  - Part design

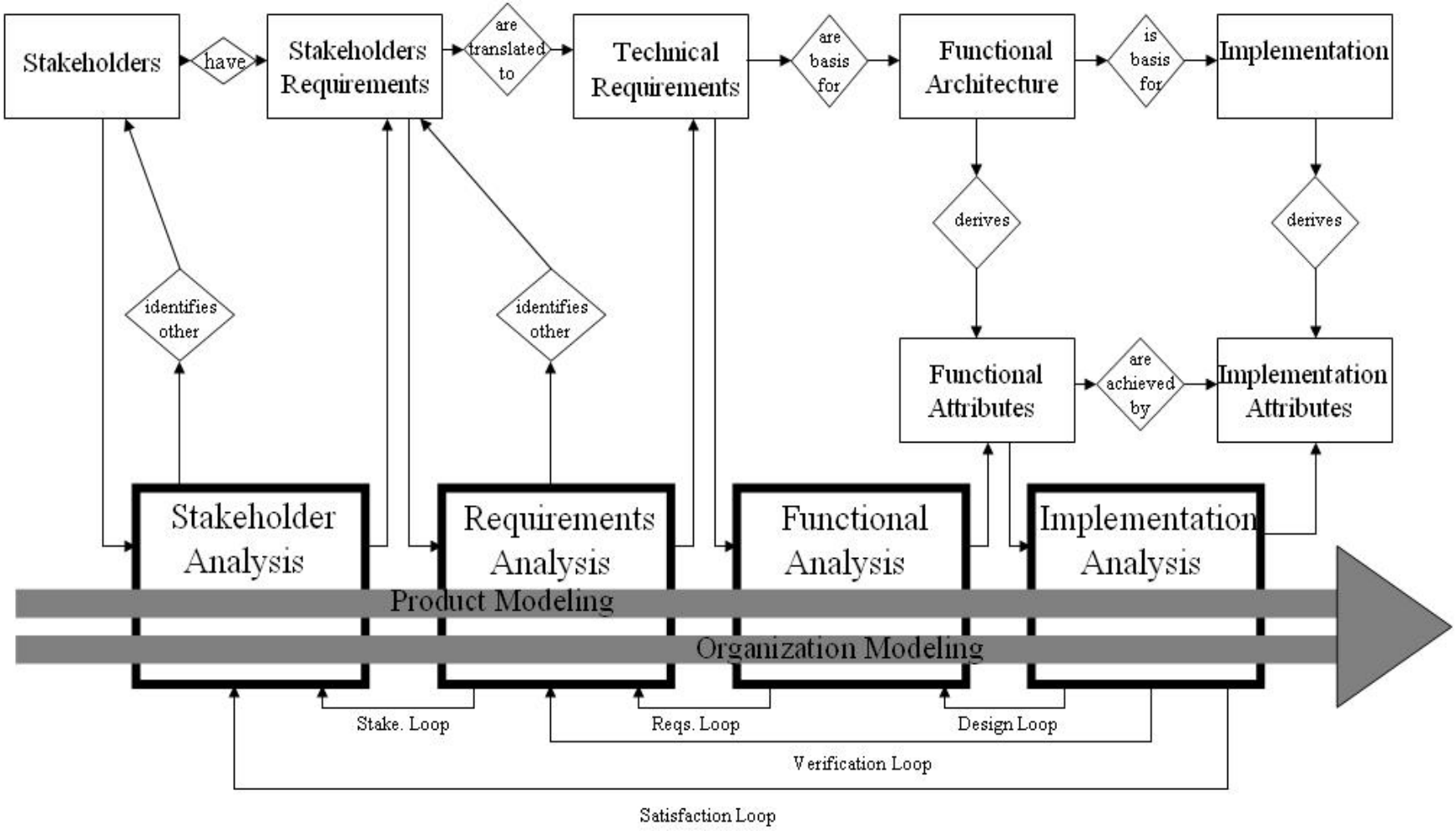
The systems concurrent engineering approach

- applies concurrent engineering along
- the systems engineering subprocesses:
  - stakeholder analysis,
  - requirements analysis,
  - functional analysis and
  - implementation analysis
- anticipates, to the early stages of the systems architecting:
  - the requirements,
  - functions and
  - parts needed along the product life.
- analysis sub-processes are performed, concurrently, for product and organization.
- recursively applicable to each layer of the system breakdown structure.

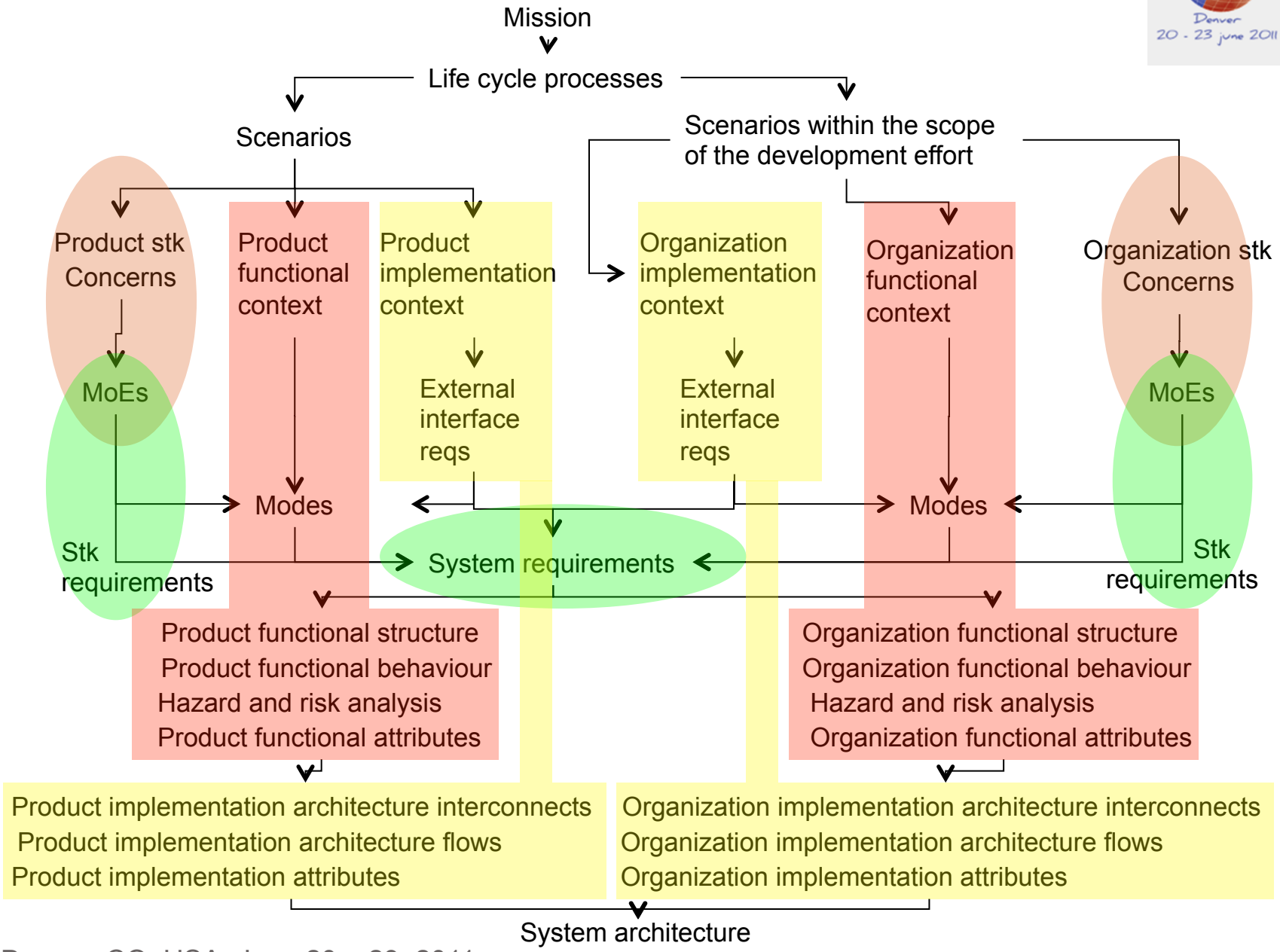
The systems concurrent engineering framework



The systems concurrent engineering method



The systems concurrent engineering method in detail



The “green car” system concurrent engineering

- Stakeholder driven
- Top level is the system life not the system itself
- It starts identifying the product life cycle processes and its scenarios
  - ***development,***
  - ***manufacturing & assembly,***
  - ***test & calibration,***
  - ***distribution*****,**
  - ***sales*****,**
  - **use & service and**
  - **disposal**
- Product is analyzed in all of its life cycle process and scenarios
- Organization is analyzed in the life cycle processes within the ***scope of development effort***

Life cycle scenarios of chosen processes

Organization	**Development**	**Conception**	Advanced Design	Components Design	Tests and adjustment	*Ramp-up* Production
	Sales	Logistic Planning	**Deliveries**	-	-	-
Product	**Operation (Use)**	*Start* Hold	Low speed	**High speed**	Collision	-
	Disposal	**Disassemble**	Specialist analysis	Conditioning	Repair	-

Chosen for further demonstration

Product stakeholders and their concerns

	PRODUCT	
Chosen Processes	**OPERATION**	**DISPOSAL**
Scenario	**High Speed**	**Disassemble**
STAKEHOLDERS and their CONCERNS	Driver – Ease of steering	Owner - Reduced Price
	Passengers - Noise	Government - Vehicles Recycling Policies
	Other Vehicles - Signals	Recycling plant - Ease of disassembly
	Legislators (supervision) - Identification	Community - Traffic Safety
	Population - Polluting Level	

Organization stakeholders and their concerns

	ORGANIZATION	
Chosen Processes	**DEVELOPMENT**	**SALES**
Scenario	**Conception**	**Deliveries**
STAKEHOLDERS and their CONCERNS	Environmental Protection Agency - Do not harm the environment	Vendors - Sales Effort and greater number of cars sold
	Customers - Satisfaction with the product	Distributors - Agility to deliver/ Deadlines
	Suppliers - Fidelity	Competitors – Competitiveness
	Safety Regulators - Reduce accidents	Manufacturer - Orders
	Academy - New researches	Consumer - Contract Compliance
	Scrappers – Retreat units in poor condition	Shareholders - Investment
	Distributors - Product Quality	
	Competitors - Knowledge of technology	
	Standards organisms - Comply with standards	
	Department of Transportation - Cost Reduction	

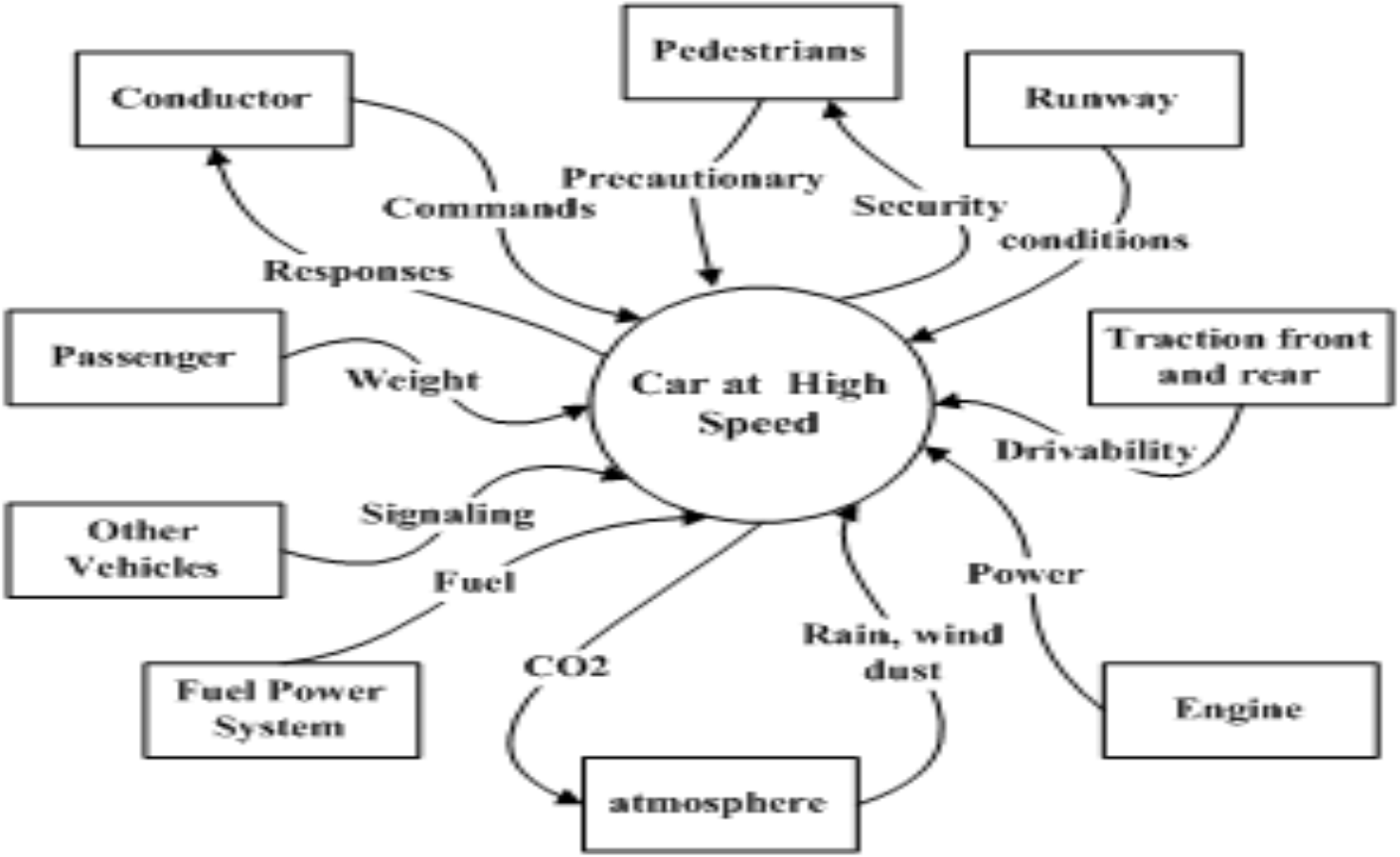
MoEs and stakeholder requirements

STAKEHOLDER		MoE's	REQUIREMENT
Suppliers	Fidelity	Orders made/ Requests per month	Purchase of car components in accordance with the specifications and quality defined.
Vendors	Sales Effort -Increased number of cars sold	Monthly Sales Shares	The monthly production of the product must ensure the commitments made to customers.
Driver	Ease of Steering	Shorter response time to answer the driver commands	The response time to commands made by the driver must be at the forefront of the standards of the industry.
Recycling Plant	Ease of disassembly	Man-hour taken to disassemble the car	The Green-Car design features will provide a simple process of disassembly.

- Product
- Organization

Product functional analysis

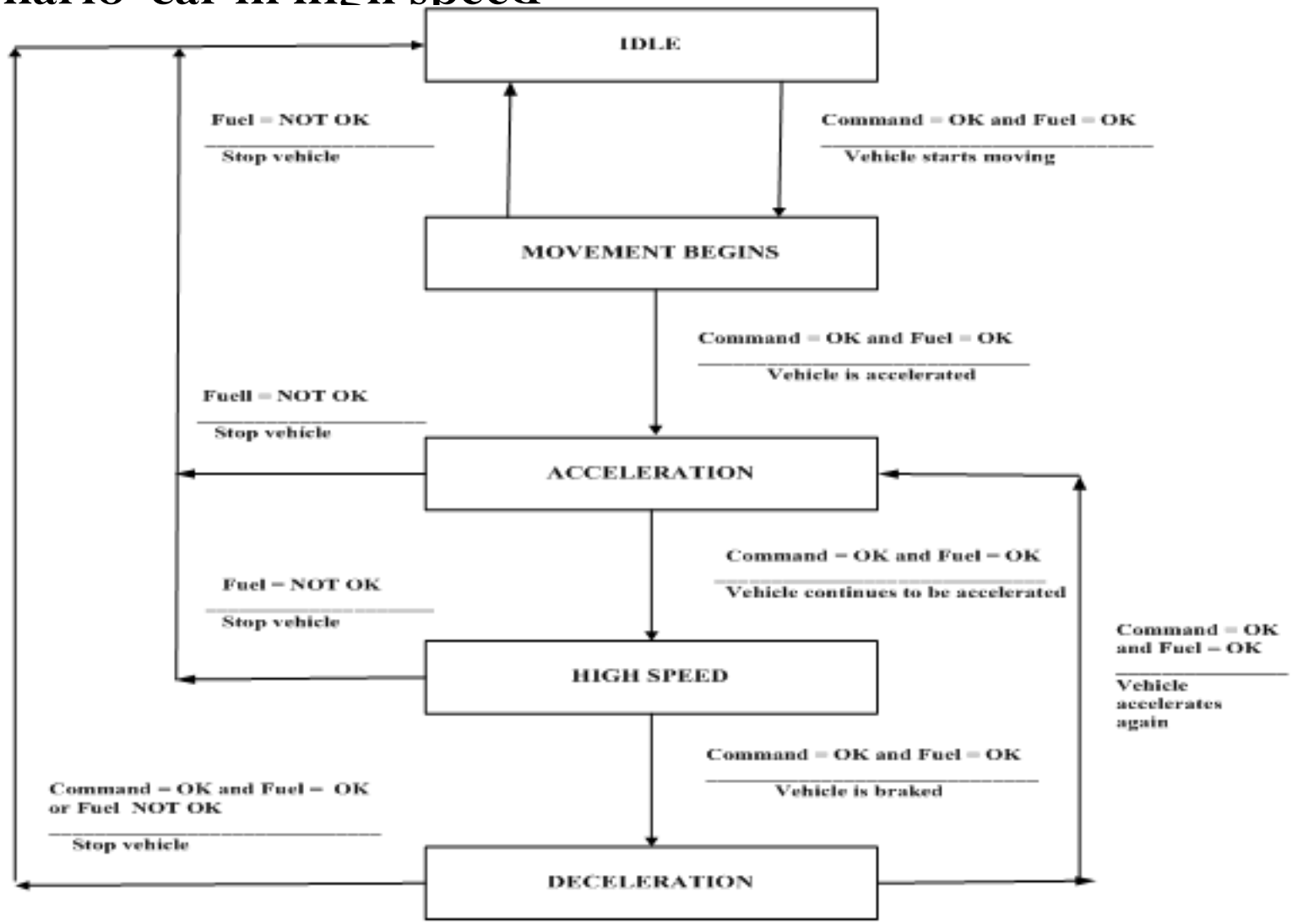
Functional context of the product in the 'high speed' scenario



From the functional context, functional structure and behavior are derived.

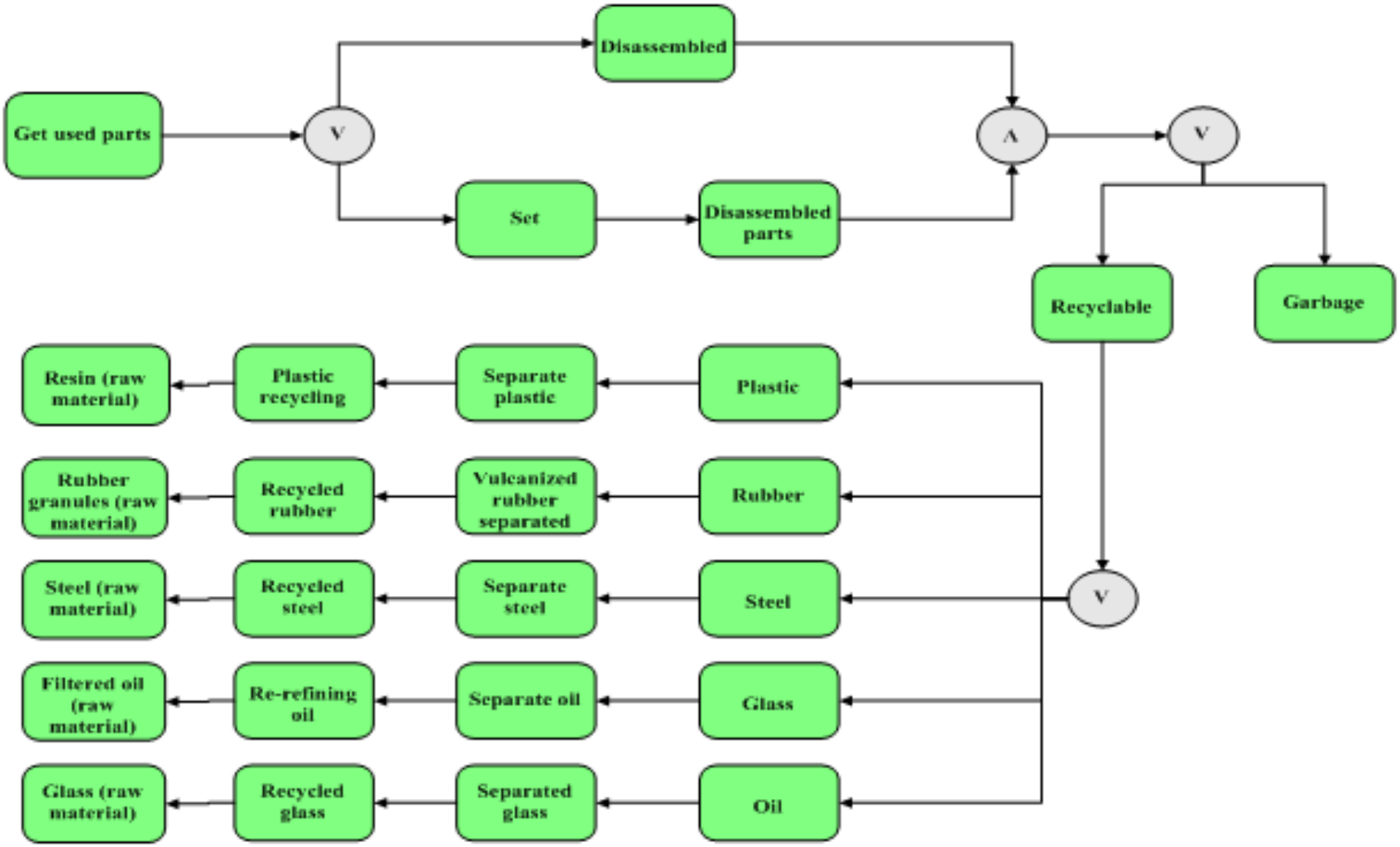
Product functional behaviour

scenario 'car in high speed'



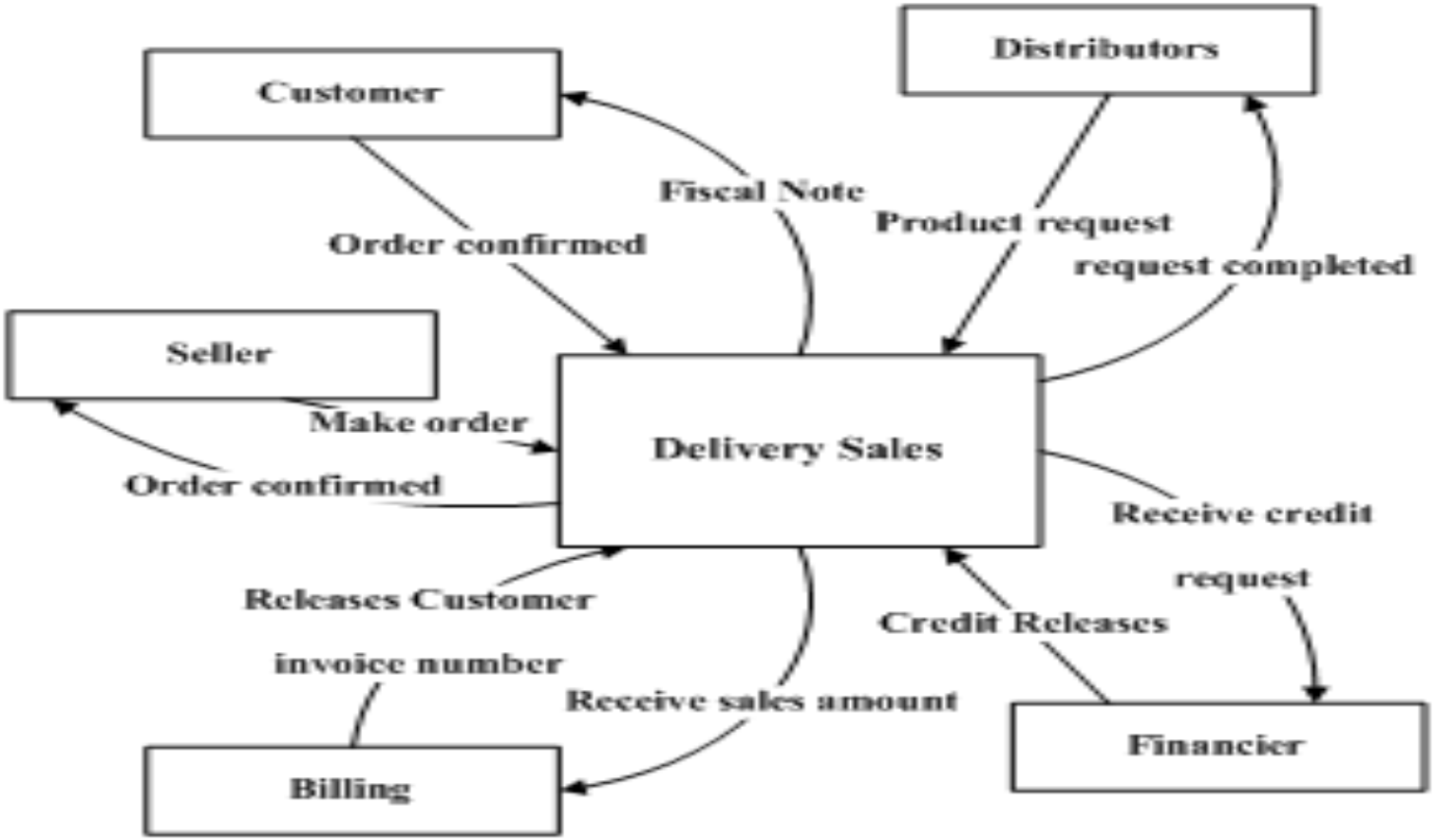
Product functional behaviour

scenario 'car in disassembly'



Organization functional analysis

Functional context of the 'delivery' organization



From the functional context, functional structure and behavior are derived.

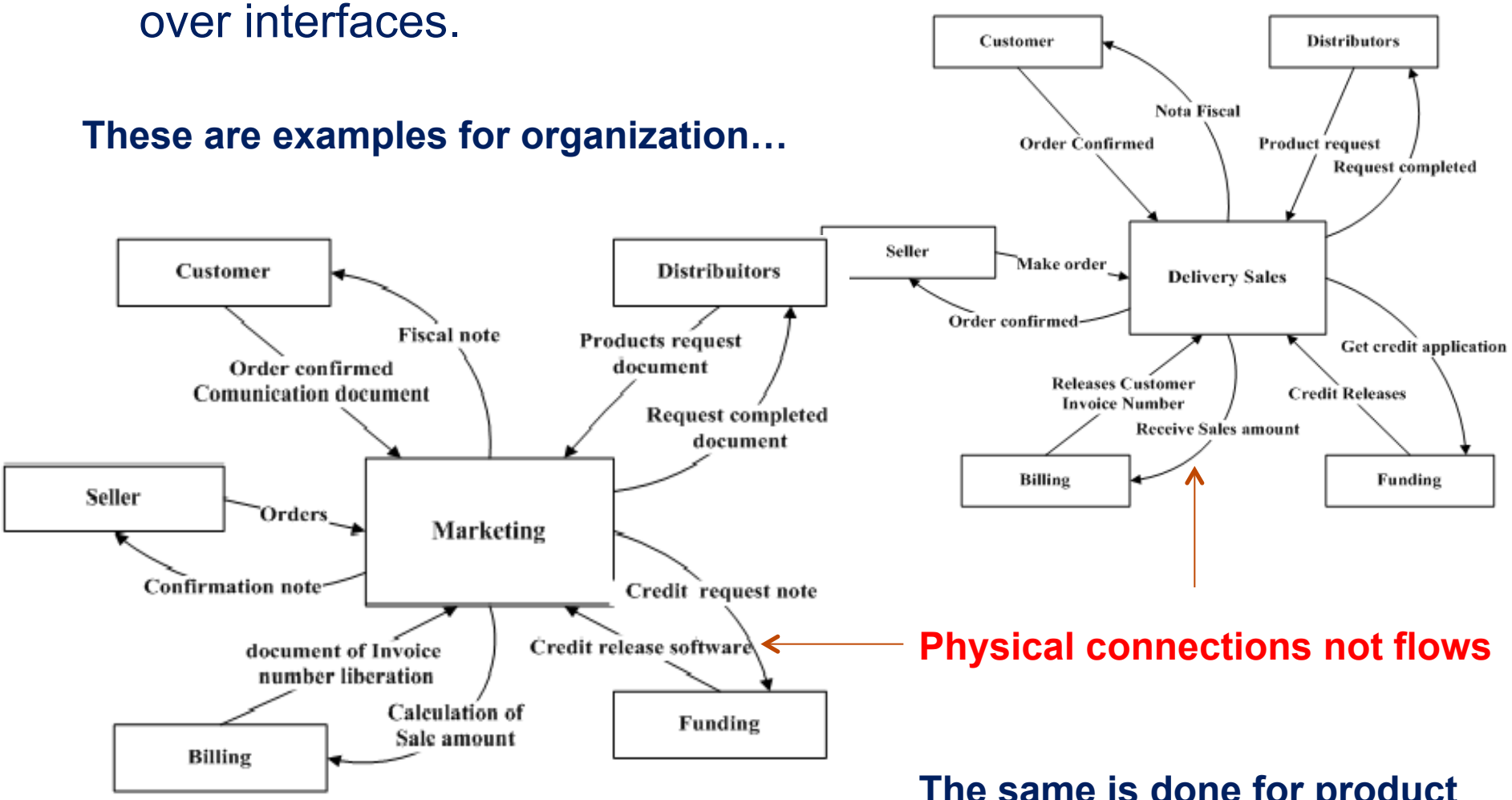
PROBLEM	DANGER	CONSEQUENCE	GRAVITY (1 to 5)	CAUSE	PROBABILITY (1 to 5)	DETECTION DIFFICULTY (1 to 5)	RISK G x P x D
Front and rear traction problems	Vehicle out of control	Loss of control	4	Holes in the track	2	4	32
Brake problems	Vehicle don't stop	Accidents	5	Worn brake pad	4	2	40
Front lights problems	Vehicle is a threat to population	Accidents	4	Strong raining and lack of preventing maintenance	3	2	24
Direction system problems	Vehicle out of control	Accidents	5	Lack of preventing maintenance	2	3	30

It is also done for the organizations within the development effort

Implementation (physical or architecture) analysis

- Also start with a context…
- Context is decomposed to show parts, interfaces and flows over interfaces.

These are examples for organization…

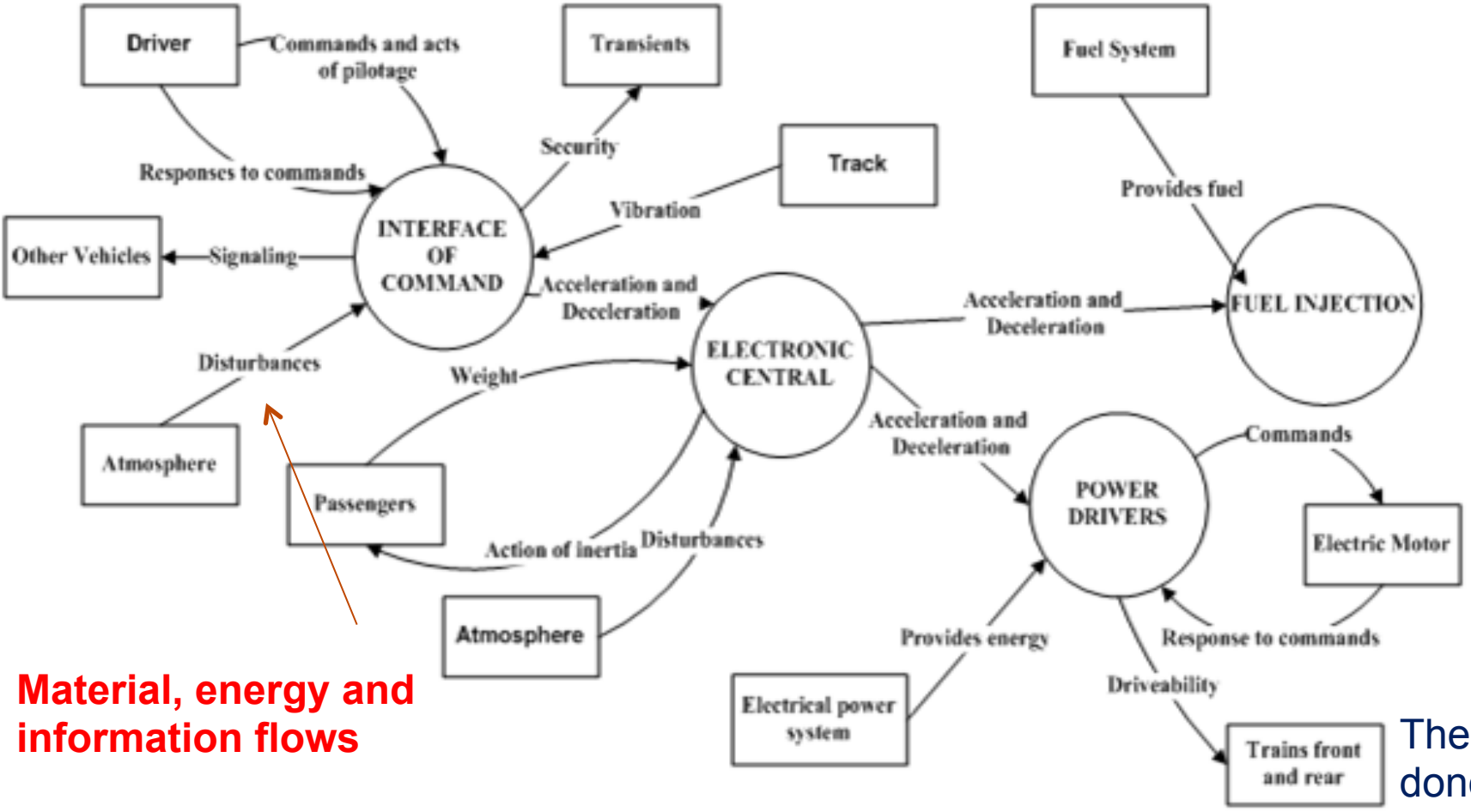


Physical connections not flows

The same is done for product

Implementation (physical or architecture) analysis

Product architecture context decomposed...
Product in the 'High Speed' scenario
Architecture flow diagram

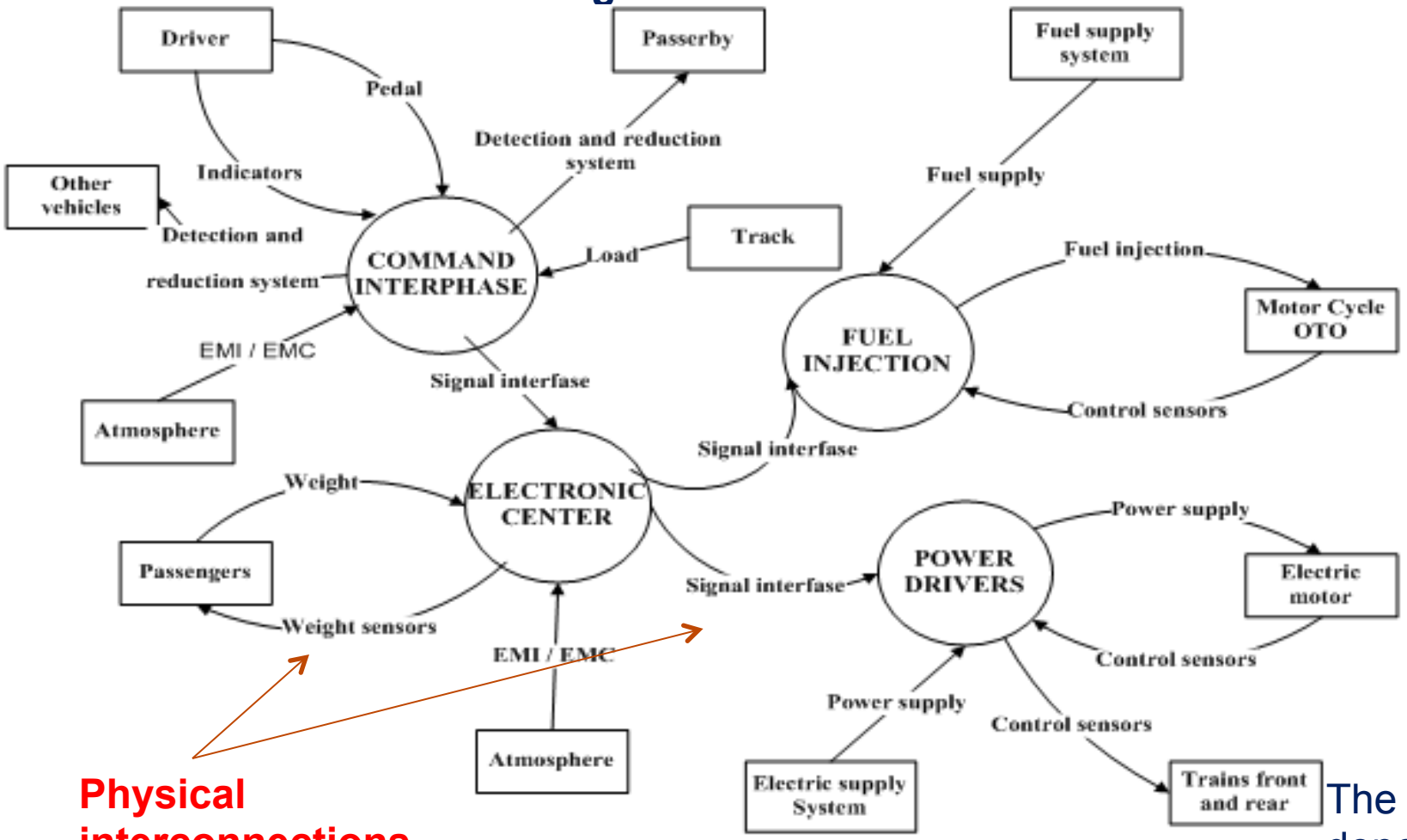


Material, energy and information flows

The same is done for organization

Implementation (physical or architecture) analysis

Product architecture context decomposed…
Product in the 'High Speed' scenario
Architecture interconnect diagram



Physical interconnections

The same is done for organization

Product allocation matrix

Product in the ‘high speed’ scenario

		Subsystems			
		Electronic Accelerator	Electronics Central	Power Driver	Fuel Injector
Functions	Provide Command Interface	■			
	Provide Data Treatment		■		
	Provide Supply Power			■	
	Provide Fuel Injection				■

Organization allocation matrix

Sales organization

Item	Function	Secretary	General Manager	Marketing	Logistics	Sales	Legal Advice	Human Resource	Technical Advice	Production
1	Monthly production of cars will ensure the delivery of 100% of the commitments made	S			S	R			O	S
2	Regulations and Standards Control						S		R	
3	Customer Management	S	O	R		O				
4	Distributors Management	S		S		R	S		S	O
4	Supplier Management	S			R	O			S	O
5	Scrappers Management	S			R	S	S		S	S
6	Academic Coordination	S		S				R	S	
7	Benchmarking	S	O	R		S	S		S	S

S – Support **R – Sponsor** **O – Orientation**

Discussion

- Stakeholder and requirements must be identified, from the outset of the system architecting process, considering the product in every stage and scenario of its life cycle process;
- Organizations that are within the scope of the development effort shall be engineered simultaneously to the product systems engineering process
- This will reduce the risk for changes in later stages of product and organization lives
- This will also improve productivity of life cycle process performing organization
- Systems engineering can be used for the concurrent engineering of complex products and their life cycle process organization

Conclusion

- systems concurrent engineering approach presented
- ‘green’ car example presented
- Approach anticipates life cycle process requirements to the early stages of product development
- Approach can be applied for, simultaneously, systems engineer product and its life cycle performing organization
- Gains in quality, cost, lead time and productivity are foreseen.

Thanks for your attention!

Questions?

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