

Truck EE Architectural design – a case study

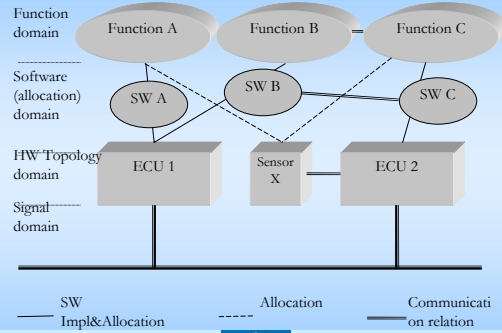
Main work by Ola Larses
with Jad El-khoury, Ola Redell, Mikael
Blackenfelt, and Martin Törngren
KTH/Scania cooperation

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Mapping

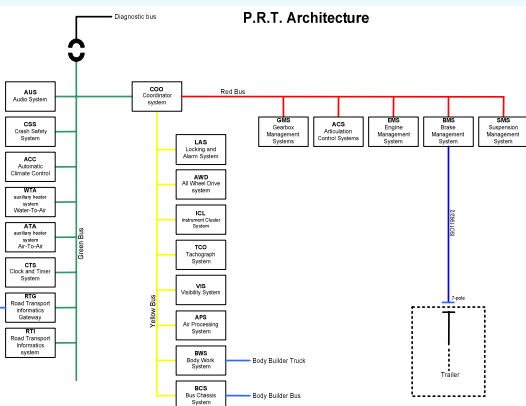


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Architecture design



Long-haulage
 ■ Efficient performance
 ■ High specification

Construction
 ■ High durability
 ■ Heavy loads

Distribution
 ■ Low weight
 ■ Easy to handle



City buses
 ■ Low noise
 ■ Low emissions
 ■ Easy access

Intercity buses and tourist coaches
 ■ Standard chassis
 ■ Standard powertrain
 ■ High comfort

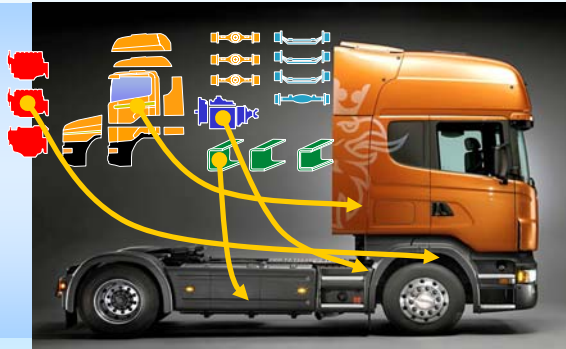
Industrial and marine engines
 ■ High reliability
 ■ Efficient performance

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Scania's modular building blocks



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Constraints (for trucks)

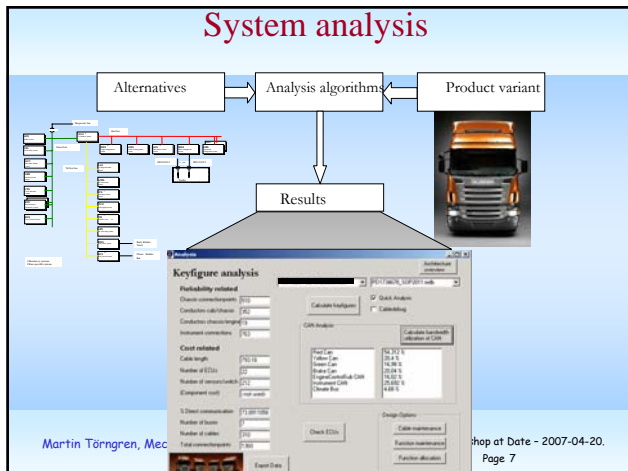
- Several important qualities
 - Functionality, Safety/reliability, Maintainability, Performance, Modularity and Evolution flexibility
- Configuration/customization
 - Customization based on as few modules as possible
 - Design time, production time, life time upgrade/downgrades
- Strategic concerns
 - Incremental development
 - Make/buy, technology change, ...
 - Organizational mapping

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System analysis



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Keyfigure analysis

Enable comparison of architecture alternatives

"What you measure is what you get!"

– Communicates goals of architecture/design

Conflicting qualities with shared parameters

→ weighting/priorities or pareto front for handling trade-offs

- Reliability
 - # Connections in a bad environment
 - # Cables in bad sections cab/frame/engine
- Production cost
 - Number of units
 - Amount of cables, length and number of cables
- Performance
 - Bandwidth requirements
 - Response time analysis
 - Weight

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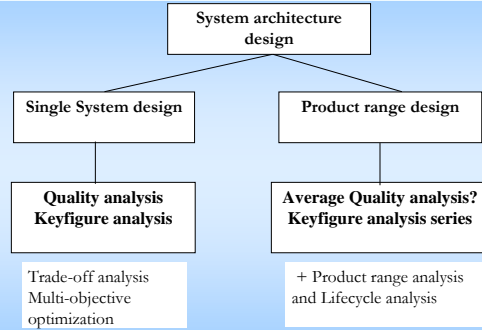


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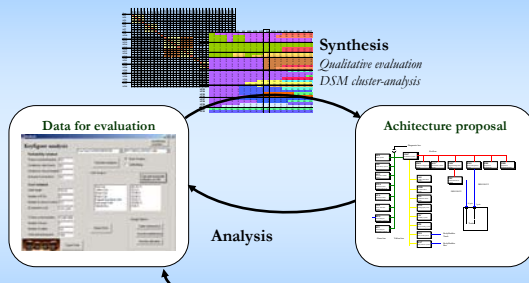
Qualities vs. Keyfigures vs. Design parameters

- Qualities
 - May not always be easy to estimate directly – e.g. Reliability
- Key-figures – can be direct or indirect measures of qualities of a design
- Many terms: utility-values, Figures-of-merit, Scores
- Often complex relationships between design parameters and qualities.
 - A design parameter may well influence several qualities → a trade-off point

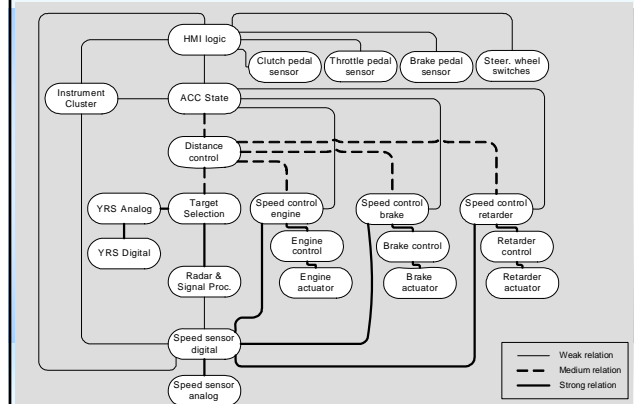
Approach?



Synthesis and analysis in architecture design



Functional relations



Modularization drivers

Functional relations

- Communication bandwidth requirements
- Communication delay requirements

Strategic classes

- Make/Buy
- Commonality/Variety
- Reuse/Develop
- Slow/fast change

Technical relations

- Cable topology

Functional classes

- Safety/Comfort
- Mission criticality
- Riding/Resting/Parking

Technical classes

- Integrity/Security risks
- Position

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Relations represented in a DSM

	LC1	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	LC10	LC11	LC12	LC13	LC14	LC15	LC16	LC17	LC18	LC19	LC20	LC21	
LC1	0	0.06	0	0	0	0	0	0	0.24	0	0.12	0.12	0	0	0	0	0	0	0	0	0	0
LC2	0.06	0	0	0	0	0	0	0	0	0.12	0	0	0	0	0	0	0	0	0	0	0	0
LC3	0	0	0	0	0	0	0.06	0.06	0.72	0	0	0	0	0	0	0	0	0	0	0	0	0
LC4	0	0	0	0	0	0	0	0	1.8	0	2.4	0	0	0.6	0	2.4	0	3	0	0	0	0
LC5	0	0	0	0	0	0	0	1.8	0	2.88	0	0	3.12	0.84	0.12	0	0	0	0	0	0	0
LC6	0	0	0	0	0	0	0.06	0.06	0.72	0	0	0	0	1.2	0.8	0.8	0	0	0	0	0	0
LC7	0	0	0.06	0	1.8	0.9	0	0	14.8	0	0	0	0	15.2	8.4	2.7	0	1.2	0	3	0	6
LC8	0	0	0.06	0	0	0	0	0	12	0	0	0	0	3.6	0.9	0	0	0	3	1.2	0	0
LC9	0.24	0	0.72	1.8	2.88	19.1	14.8	12	0	4.26	0.6	14.0	16.1	10.2	1.26	7.86	4.98	3	9	0	1.5	0
LC10	0	0	0	0	0	0	0	0	0	0.26	0	0	0	0	0.06	0	0	0	0	0	0	0
LC11	0.12	0.12	0	2.4	0	0	0	0	0	0.6	0	0	0	0	0.06	0	0	0	0	0	0	0.3
LC12	0.12	0	0	3	0	3.12	1.2	19.2	3.6	14.9	0	0	0	32	0.84	0	0.01	3.6	6	0.6	1.2	0
LC13	0	0	0	0	0	0.84	0.6	8.4	0	16.1	0	0	12	0.8	1.68	0	0	0	0	0	0	0
LC14	0	0	0.12	0.8	0.12	0.9	2.7	0.9	16.2	0	0.06	5.04	1.84	0.3	0.6	1.86	3.66	3	0	0	0	0
LC15	0	0	0	0	0	0	0	0	1.26	0.06	0	0	0	0	0.3	0	0.06	0	0	0.6	0	0
LC16	0	0	0	2.4	0	0	0	0	7.86	0	0.01	0	0.6	0.06	0	0	0	0	0	0	0	0
LC17	0	0	0.06	0	0	0	1.2	0	4.98	0	0	3.6	1.86	0	0	0	0	0	0	0	0	0
LC18	0	0	0	3	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LC19	3	0	0	0	0	0	0	3	1.2	9	0	0	0.6	0	0	0	0	0	0	0	0	0
LC20	0.12	0	0	0	0	0	0	0	0	0.3	1.2	0	0	0	0	0	0	0	0	0	0	0
LC21	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0

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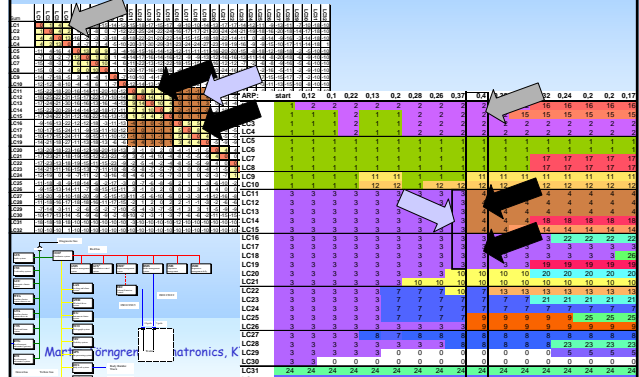
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Weighted DSM relations as a basis for clustering

Sum	LC1	LC2	LC3	LC4	LC5	LC6	LC7	LC8	LC9	LC10	LC11	LC12	LC13	LC14	LC15	LC16	LC17	LC18	LC19	LC20	LC21	
LC1	0	0.06	0	0	0	0	0	0	0.24	0	0.12	0.12	0	0	0	0	0	0	0	0	0	0
LC2	0.06	0	0	0	0	0	0	0	0	0.12	0	0	0	0	0	0	0	0	0	0	0	0
LC3	0	0	0	0	0	0	0.06	0.06	0.72	0	0	0	0	0	0	0	0	0	0	0	0	0
LC4	0	0	0	0	0	0	0	0	1.8	0	2.4	0	0	0.6	0	2.4	0	3	0	0	0	0
LC5	0	0	0	0	0	0	0	0	1.8	0	2.88	0	0	3.12	0.84	0.12	0	0	0	0	0	0
LC6	0	0	0	0	0	0	0.06	0.06	0.72	0	0	0	0	1.2	0.8	0.8	0	0	0	0	0	0
LC7	0	0	0.06	0	1.8	0.9	0	0	14.8	0	0	0	0	15.2	8.4	2.7	0	1.2	0	3	0	6
LC8	0	0	0.06	0	0	0	0	0	12	0	0	0	0	3.6	0.9	0	0	0	3	1.2	0	0
LC9	0.24	0	0.72	1.8	2.88	19.1	14.8	12	0	4.26	0.6	14.0	16.1	10.2	1.26	7.86	4.98	3	9	0	1.5	0
LC10	0	0	0	0	0	0	0	0	0	0.26	0	0	0	0	0.06	0	0	0	0	0	0	0
LC11	0.12	0.12	0	2.4	0	0	0	0	0	0.6	0	0	0	0	0.06	0	0	0	0	0	0	0.3
LC12	0.12	0	0	3	0	3.12	1.2	19.2	3.6	14.9	0	0	0	32	0.84	0	0.01	3.6	6	0.6	1.2	0
LC13	0	0	0	0	0	0.84	0.6	8.4	0	16.1	0	0	12	0.8	1.68	0	0	0	0	0	0	0
LC14	0	0	0.12	0.8	0.12	0.9	2.7	0.9	16.2	0	0.06	5.04	1.84	0.3	0.6	1.86	3.66	3	0	0	0	0
LC15	0	0	0	0	0	0	0	0	1.26	0.06	0	0	0	0	0.3	0	0.06	0	0	0.6	0	0
LC16	0	0	0	2.4	0	0	0	0	7.86	0	0.01	0	0.6	0.06	0	0	0	0	0	0	0	0
LC17	0	0	0.06	0	0	0	1.2	0	4.98	0	0	3.6	1.86	0	0	0	0	0	0	0	0	0
LC18	0	0	0	3	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LC19	3	0	0	0	0	0	0	3	1.2	9	0	0	0.6	0	0	0	0	0	0	0	0	0
LC20	0.12	0	0	0	0	0	0	0	0	0.3	1.2	0	0	0	0	0	0	0	0	0	0	0
LC21	0	0	0	0	0	0	0	0	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0

2007-04-20.

Cluster analysis as a basis for architecture proposals



Summary of approach

Design Structure Matrix (DSM) based clustering to assess modularity and to derive candidate decompositions

- Module drivers: different relations
- Combining relations
 - Valuing individual relations
 - Normalizing, weighting and summing of the relations
- Clustering: searching for cohesive modules

Key figures for analysis of system quality

- Analyzing proposed modularizations

Discussion

- Hardware modularization oriented
 - Should be possible to extend to software modularization
- Many open issues:
 - Selecting metrics (keyfigures) – dependencies
 - Weighting, optimization
- Information management and multiple views
- Versions, variants, product configurations
- Technical and strategic issues

References

Larses, O. 2005. "Architecting and Modeling Automotive Embedded Systems." Doctoral Thesis. TRITA-MMK 2005:31 ISSN 1400-1179, ISRN/KTH/MMK/R-05/31-SE. Mechatronics Lab. Royal Institute of Technology. Stockholm. Sweden.

Larses, O. 2005. "Applying quantitative methods for architecture design of embedded automotive systems." Proc. INCOSE International Symposium 2005. Rochester, NY. July 10-15. 2005.

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