# Symposium on The Lift and Escalator Technologies

## Interdependencies Between the development of a Belt type Suspension and Transmission mean and lift components/system design

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### INTRODUCTION

In today's lift systems the steel wire rope is the most commonly used technology for suspension and transmission means. The steel wire rope technology used in Lift and hoisting applications has worked very well for more than 100 Years. Constant improvement in wire rope design, selection and combination of material, as well as advances in manufacturing technology has helped to gain the reputation that lifts are one of the safest transportation systems for Humans.

The component and system design for traction type lift application using steel wire ropes as well as the construction of steel wire ropes in today's technology state, is the best found compromise at this point in time. Codes and standards have been implemented and tailored to create the framework for steel wire ropes in elevator applications to insure safety and consistency in lift applications.

Compromise in case of improvement means, addressing an isolated item does have an impact on other system areas. Furthermore, there are interdependencies which have to be addressed and can influence the design of a complete system significantly.

Implementation of improvements in one area of the lift system will lead to strive for the best compromise on the remaining system, with the goal the overall solution has improved compared to the previous best compromise.

Although the steel wire ropes have matured over the last decades they still have some disadvantages which are part of the compromise for the overall lift application. Disadvantages such as sheave diameter are to big (D/d 40), the weight, elongation and traction issues do not allow the development of advanced elevator system design without addressing those problems/restrictions.

Recent research and current development of the belt technology demonstrates the efforts made by a number of companies to circumvent the disadvantages of steel wire ropes. Although the currently introduced belt technology still uses steel wire cords within the belts, some of the disadvantages of the traditional steel wire ropes are addressed, for example the reduction of traction sheave diameters and traction issues. Future development of belt system technologies focuses on belt systems without steel wire ropes inside. This addresses an even broader range of today's compromises made in Lift systems.

This presentation provides an outline of a Master Thesis in progress and will highlight the interdependencies between the development of a new belt type suspension and transmission means and the impact this has on the Lift system as well as on system component design. The final Thesis will act as an input and help the system and component designer to identify, calculate and address issues throughout the design process with focus on belts systems *without containing steel cords.*

### GENERAL IDENTIFICATION

The initial focus in relation to Suspension and Transmission means clearly is on some of the main properties / terms used by Lift designer, Engineers or component developers. The properties / terms listed below address the most critical criteria of the new to be developed Suspension and Transmission means and will be used as a base line throughout this text.

Breaking strength
Weight,
D/d 40,
Elongation,
Traction,
Discard criteria,
Life cycle,
Handling / Maintenance.

Although it is acknowledged the list can be extended, but for the purpose of this text the list will be restricted to the above mentioned terms.
If each term is used as a headline and the direct relationship this headline has to the lift system will be described in general and listed, the list will serve as an input for the development of a new suspension and transmission means with the ultimate goal to improve all of the named areas.

**Breaking strength**. A minimum Safety Factor of 12 or higher as a general rule, will results in a certain minimum number of suspension members, or in suspension members with increased strength. There is a direct dependency to safety and system capacity.

**Weight.** The weight of the suspension and transmission means has a direct influence of the overall static system mass as well as dynamic masses (inertia etc.). [3]

**D/d 40.** Traction sheave geometry e.g. diameter, width, groove size, in conjunction with diameter / thickness of suspension and transmission mean. [1]

**Elongation**. Permanent elongation (stretch over time) and elastic elongation (dependent on dynamics such as load changes and acceleration changes) directly impact the system. [4]

**Traction.** Sheave surface design in regards to geometry and Material in conjunction with material and dimensions of the suspension and transmission means. [1]

**Discard and replacement criteria.** Currently visual inspection and broken wire counts, diameter reduction as well as magnetic field or resistance measurements methods are used to detect remaining Breaking strength, loss in traction, or overall deterioration over time.

**Life cycle.** Number of bending cycles, bending conditions e.g. number of reverse bends in systems, distance between pulleys, environmental influences, etc. [3]

**Handling / Maintenance.** Delivery to construction site, installation procedures e.g. end terminations. Maintenance requirements such as lubrication and cleaning, etc.

**Relationship to lift system**. *Table.1* below takes the above terms and lists them in the left column from top to bottom (note this is no classification). The top row represents some of the major components of a lift system. The bolded Capital "**X"** demonstrates direct dependency whereby the smaller "x" shows indirect or less influence.

| Terms/Components | Motor | Sheave | Brake | Safety gear | Compensation system | Termination | Controller |
|---|---|---|---|---|---|---|---|
| Breaking strength | x | x | x | x | **X** | **X** | x |
| Weight | **X** | x | **X** | **X** | **X** | x | **X** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| D/d 40 | **X** | **X** | **X** | x | x | **X** | **X** |
| Elongation | **X** | **X** | x | x | x | **X** | **X** |
| Traction | **X** | **X** | **X** | **X** | **X** | x | **X** |
| Discard Criteria | x | x | x | x | x | **X** | **X** |
| Life cycle | x | **X** | **X** | **X** | **X** | x | **X** |
| Handling/ Maintenance | x | **X** | x | x | **X** | **X** | **X** |

*Table 1* Suspension/ transmission criteria in relation to major components

It has to be acknowledged that the components Motor, Sheave and Brake are often named as one assembly simply referred to as the *Lift Machine*, but for the development of belt type suspension and transmission means it is important to view these components individually.
The term *D/d 40* actually refers to a ratio between the sheave diameter and suspension rope based on code requirements for steel wire ropes, which may not apply for a belt system without steel wires inside.

**Relationship to component.** Up to this point the dependencies can be seen generic and apply to all types of Suspension and Transmission means for traction type Lift systems. With the finished design and known properties of the new suspension and transmission mean the system and component developer can follow the matrix above and evaluate the dependency for each component on a defined Lift system based on the properties.
This can be achieved by listing the main parts and parameters of the component [2] as indicated in the example for the Motor in *Table 2* below.

| Criteria/ parts prop. | torque | speed | power | Shaft load/size | Bearings | dimensions |
|---|---|---|---|---|---|---|
| Weight | **X** | x | **X** | **X** | **X** | **X** |
| D/d 40 | **X** | **X** | **X** | **X** | **X** | **X** |
| Elongation | **X** | **X** | x | x | x | **X** |
| Traction | **X** | **X** | **X** | **X** | x | **X** |

*Table 2* Suspension/ transmission criteria in relation to Motor parts and properties

Calculating values e.g. torque, speed, power, shaft load, bearings depend on the belt properties and criteria listed in the left column, this in return influences the dimensions of the Motor and creates input for the system designer to design the best compromise in relation to the new suspension and transmission mean.
**System impact.** A new suspension and transmission mean allows the designer to create new system approaches. This can be based on the changed components, based on the belt properties, or a combination of both. For example an increase in traction could allow new lightweight systems. Fig.1 below indicates some of the interdependencies this could have to a new system.

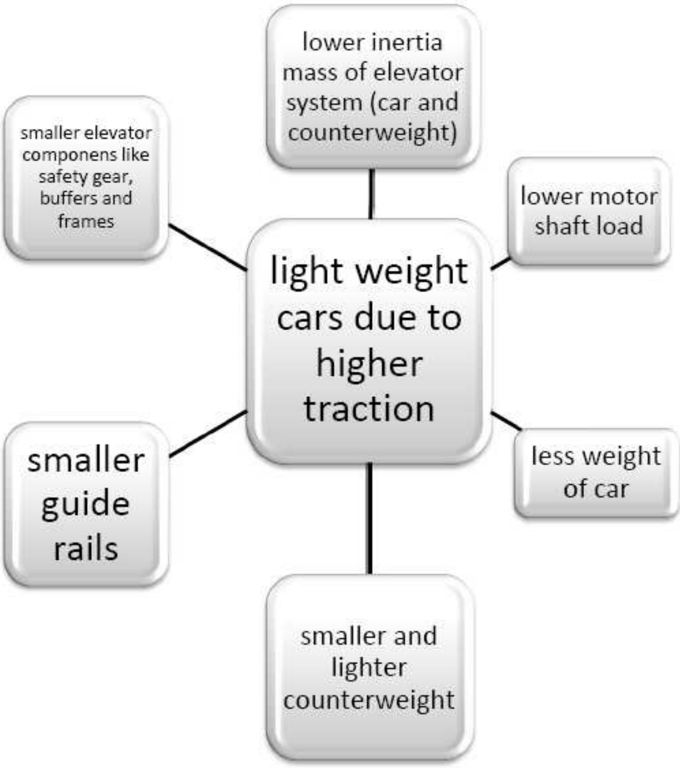


*Fig.1*

**SUMMARY**

This extended abstract from a Master Thesis in progress identifies some of the interdependencies between a belt type suspension/transmission mean with the Lift system and major components of the system described on a few examples. The text and tables demonstrate relationships and dependencies which require detailed investigation and calculations not only for the development of the belt but also on the system and component level. The required level of investigation on all aspects of a lift system will enable the system and component designer to think outside the box and apply solutions for new system approaches.

**REFERENCES**

[1] G.R. Strakosch, *The Vertical Transportation Handbook.* John Wiley, New York (1998).

[2] I. Fischer, *Elektrische Maschinen. 6th ed*., Munich, Germany Carl Hanser Verlag (1996)

[3] L. Janovsky, *Elevator Mechanical Design. 3rd ed.* Mobile, AL (1999).

[4] A. J. Paris, J. Appl. Mech., *Elasticity Approach to Load Transfer in Cord-Composite Materials,* 76, 061002 (2009), DOI:10.1115/1.3130442