Digital Transformation in the Elevator Industry
Moving from Physical Testing to Simulation

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Schindler Elevators - Digital Transformation - Modelling
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Key Takeaways

Digital Transformation is a change management project

Reduction of the time for a Software Release Test (SRT) from 4 Weeks to 1 night

Model based approaches drive fact based development

“We elevate Digital Transformation – Globally – For everyone”
Agenda

1. Schindler Elevator Ltd.
2. Goals and Challenges of Digital Transformation
3. EDEn – The Elevator Dynamics Environment
4. Garden of EDEn – The Power of MATLAB Web Apps
5. Hardware In the Loop – From Physical Testing to a Model Based Approach
6. Conclusion & Outlook
Schindler Elevator Ltd.

Founded:
1874, in the city of Lucerne, Switzerland.

Headquarter:
Ebikon, canton of Lucerne, Switzerland.

Activities:
Schindler develops, manufactures, installs, maintains (services) and modernizes elevators, escalators, moving walks and transit management solutions for all kinds of application requirements e.g. from train stations and hospitals to commercial and residential buildings.

Locations:
A network of more than 1,000 branches in over 100 countries.

Employees:
More than 64,000 (Dec. 2018).

Revenue:
Group revenue CHF 10.879 billion in 2018
Goals and Challenges of Digital Transformation

Goals and Challenges

- Decrease the time and costs which are invested for physical testing (3200 hours in 2016 for software qualification tests in test towers)
- Elevator industry and certification is conservative

- Automated verification of different system configurations
- ~ 20,000 independent system variants with hundreds of different component configurations

- Drive a model and fact based development process
- Mindset of people and organizational structures
EDEn – The Elevator Dynamics Environment

What it is

- EDEn as a pilot project
  Simulation of the physical behavior of elevator systems

- EDEn today
  Modeling and simulation framework for system-centric analysis and verification to support a holistic development of elevator products in an early stage

- EDEn is globally established
  Developed in Ebikon (CH) and India – used all over the world from internal customers in the engineering

Project Setup

- Project start
  July 2017

- Project team
  4,5 people
  (Switzerland & India)

- Development Process
  SCRUM approach with 4 week sprints

- Strong Collaboration with MathWorks
  Training, Technical Support, Engineering, Development
EDEn – The Elevator Dynamics Environment

The Model

Model Facts

- One generic System Model
- ~11’000 blocks
- ~1’500 physical signals
- Covers 60 different system architectures
- 350 parameter to configure an elevator system
- ~70’000 lines of code
EDEn – The Elevator Dynamics Environment

Development Environment

- **Data Management (MATLAB)**
  - MATLAB Simscape
  - Model Libraries
  - Implementation (Simulink)
    - Physical modelling (Simscape)
    - Generic Elevator System Model
  - Model in the loop testing (Simulink Test)
    - Test Suite definitions
    - Automated Test Manager
    - Test Harness models
    - Test Reports

- **Automation (MATLAB)**
  - Scripts for automation
  - Data Dictionary
  - GUIs
  - Documentation

Deployment Environment

- **App based web deployment (Web App Server)**
  - Web App
  - HIL System

- **Code Generation**
  - Hardware in the loop deployment (Simulink Real-Time)

Project Management Environment

- **Version Management**
  - GIT
  - Bitbucket

- **Requirements & Change Management**
  - JIRA

- **IT & Process Automation**
  - IT-Management
  - Jenkins
EDEn – The Elevator Dynamics Environment
Processes & Workflow
Garden of EDEn – The Power of MATLAB Web Apps

- **Goal**
  - Enable the end-user to use EDEn and make system simulations with focus on his key issue

- **Solution**
  - Provide different view points on one generic system model (single source of truth) with different GUIs
  - Deployment of GUIs as applications which support & guide the handling of the model and the simulations

- **MATLAB Web Apps** empowers us to deploy Matlab applications so that they can be used inside our organization with an internet browser without any MATLAB license or installation

**Applications**

- Today 8 applications supporting the whole simulation process
  - Simulation request and bug reporting
  - Configuration of elevator system
  - Definition of Simulation scenario
  - Simulation of different viewpoints
  - Reporting
Garden of EDEn – The Power of MATLAB Web Apps

MATLAB Web Apps

Configuration Interface
App to configure elevator systems and export the parameter file.
version 17.0

Elevator System Simulation App
Perform customized virtual elevator trips. There is even the possibility to conduct special operations such as...
version 17.0

L1L2 Interface
An interface for importing configuration parameters from L1L2 to EDEn apps.
version 17.0

Load Factor App
The Load Factor App simulates load cases and calculates all relevant load factors.
version 17.0

PEBO App
The PEBO app provides required evacuation distances and required battery charges for the powered...
version 17.0

Rope Bouncing App
The app simulates the car kinematics after inserting car load.
version 17.0

Seismic Oscillation App
Seismic oscillations of the magnetic band of SAL/SAS are simulated and the displacement of the tower...
version 17.0

UCMP App
Unintended car motion within the floor zone is detected and the maximum car displacement is...
version 17.0

Jira Interface
Report feature requests and bugs to the development team. Track status of reported issues.
version 17.0

Garden of EDEn
HIL – From Physical Testing to a Model Based Approach

Real Product Components (SW/HW) allows to perform SRTs

Elevator Control and Peripherals (Real HW and SW)
- Communication
- Drive Ctrl
- Brake Ctrl
- Car Position
- Car Load

System and Drive Simulation (Virtual on Real Time System)
- IGBT
- Brake
- M
- EC
- Safety Circuit
- Safety Devices
  (Safety gear, Overload, governor, buffers, ...)

Virtual Drive and virtual mechanical system allows to change to any configurations

«TOWER IN A BOX»
## HIL – From Physical Testing to a Model Based Approach

<table>
<thead>
<tr>
<th>Resources</th>
<th>Elevator Controller HIL</th>
<th>Test tower testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure</td>
<td>1 HIL test bench</td>
<td>1 Test Tower installation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 people (test engineer, fitter)</td>
</tr>
<tr>
<td>One example of SRT task: &quot;Safety Gear Acceptance Test&quot;</td>
<td>90 s</td>
<td>2 – 6h</td>
</tr>
<tr>
<td>Cost</td>
<td>70’000 CHF (investment for HIL simulator)</td>
<td>x times 45’000 CHF (material + installation of x Elevators)</td>
</tr>
</tbody>
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**Benefits with EC-HIL**

- Increased variant coverage
- Earlier system integration
- Less real test tower installation needed
- Virtual Enhanced test execution
- Faster software releases
- Boundary tests
Conclusion

Digital Transformation as a change management project
Best practice projects and benefit of model based processes

Reduction of time for physical testing
Software Release Test in 1 night instead of 4 weeks with HIL and test automation

Fact based development
Successful support for several projects in different development stages

Outlook

- Controller HIL deployment to international sites
- Fully automated simulation process with Web apps
- Further model validation

“We elevate Digital Transformation – Globally – For everyone”
Thanks for your attention!