

# Develop Expansion of the UNC Charlotte Engineering Toolkit Website

Sarah Grepels [sgrepel@uncc.edu], Tyler Cloud [tcloud1@uncc.edu], Grayson Ward [gward5@uncc.edu], Eann Lawing [elawing4@uncc.edu], Moua Xiong [mxiong31@uncc.edu], Dusty Vernon [dvernon1@uncc.edu]

SENIOR DESIGN II – Spring 2020

Supporter/ Mentor: Bosch Rexroth: Mark Rohlinger / Kevin Lindsay

## PROJECT REQUIREMENTS

Information of each product on the Website will include:

- ❖ Theory
- ❖ Naming Conventions
- ❖ Tips on how to design and engineer projects using the products
- ❖ Product selection/ordering guides
- ❖ Develop product instructional video content

Create a physical demonstration

- ❖ Designed to be fun and educational
- ❖ Implement the products selected for the website
  - ❖ Aluminum Structural Framing
  - ❖ Profiled Rail Systems
  - ❖ Ball Screw Assemblies
  - ❖ Linear Motion Systems
  - ❖ Bushings



Sarah Grepels. "Ball Screw Assembly Introduction" YouTube, 17 Mar. 2020, <https://www.youtube.com/watch?v=MnuwVurF7c>

## MISSION STATEMENT

Expand the UNC Charlotte Engineering Toolkit website, with a focus on Bosch Rexroth products. The Engineering Tool Kit is a resource for Senior Design students to get quick access to information on concepts they would need to complete their own design projects. Having the most important information in one place will reduce the time spent researching concepts and increase the time spent on design processes; granting a team with a more effective design.

## PROJECT LIMITATIONS

Due to the Covid-19 outbreak, the BOSCH\_TOOL team was limited to labor limitations starting March 25<sup>th</sup>, 2020. The team was able to accomplish ordering all the parts of the physical model, developed a physical model assembly module, finalization of the Toolkit website additions, and completion of a Senior Design I and II website performance verification quiz.

## PRODUCT ANALYSIS RESEARCH

- ❖ Researched Bosch Rexroth's 10 product families
- ❖ Analyzed all Senior Design projects
  - ❖ Spring 2016 – Fall 2019
  - ❖ 90 of these Projects could potentially use Bosch Rexroth products
- ❖ Senior Design Student Survey discovered top used products

### Top Product List

1. Aluminum Structural Framing
2. Profiled Rail Systems
3. Ball Screw Assemblies
4. Bushings
5. Linear Motion Systems

## WEBSITE DESIGN

### Aluminum Structural Framing



**Introduction of Aluminum Structural Framing**  
Aluminum Structural Framing is extruded aluminum that is used as support and framing.  
**Applications of Aluminum Profiles**  
There is a vast amount of applications for aluminum structural framing, some applications include:  
• Frames  
• Enclosures  
• Workstations  
• Flow Racks  
• Machine Frames and Bases

### Profile Rail Systems

**Introduction to Profiled Rail Systems**  
Profiled rail systems are the guides of choice for applications requiring especially high precision, low maintenance, low wear and low friction, as well as highly accurate positioning. Profile rails are essentially "roller skates" that help guide heavy loads accurately. Profiled rail systems consist of a runner block and profiled rail systems consist of a runner block and a guide rail.  
**Theory**  
This section describes the structural design of a rail system, the types of rail systems (Ball Rail, Roller Rail, and Cam Roller Guides, general calculations, friction reduction techniques, and uses in integrated measuring systems.  
**Naming Conventions**  
Naming conventions are important for any design process as many variations of products exist. Some of the profile rail system abbreviations discussed are the Ball Rail System, Miniature Ball Rail System, eLINE Ball Rail System, Roller Rail System, and Cam Roller Guides. Naming conventions are also important for distinguishing dimensions of products. Some dimensions to be designated are width, length, height, and ball guide sizing.  
**Sizes, Designs, and Characteristics**  
As a follow-up to the naming conventions page, sizes and system characteristics are very important for the design process. Using this page, designers can find the

### Ball Screw Assembly

**Introduction to Ball Screw Assemblies**  
Ball Screw Assemblies are a type of linear motion technology. They are a smooth functioning process, in which rotational movement is translated into linear motion using a ball screw shaft, ball nut and balls.  
**Applications**  
Profile Rail Systems, Machine Tooling, Metal Forming, Semi-conductor, Aerospace tooling  
**Benefits of using Ball Screw Assemblies**  
• The principle of internal recirculation creates a smooth rotation  
• The large number of balls recirculating allows for a high load rating  
• Move heavy loads at fast speeds with accuracy  
**Ball Screw Theory**  
This section describes the structural design and functionality of a Ball Screw. It also covers any definitions you might need to know.  
**Ball Screw Naming Conventions**  
This section gives you the basic definitions of terms you might come across when dealing with Ball Screws.

### Linear Motion Systems

**Introduction to Linear Motion Systems**  
Linear Motion Systems are a combination of a guidance system and a driving system. Bosch Rexroth's Linear Motion Systems includes modules, drives units, linear tables and linear slides.  
**Guides** are components that provide guidance and power transmission to the machine's moving parts. The **guide** of a system is a huge factor in determining the accuracy of a machine. The types of guides that Bosch sells include Profiled Rail Systems, Cam Roller Guides and Linear Bushing Systems.  
**Drives** are components that convert one type of energy (usually electrical, hydraulic, or pneumatic) to mechanical energy. The types of drives that Bosch

### Bushings

**Vertical space requirement**- The available construction height and the height of the load carried will limit the size and the choice of linear bushing.  
**Direction of loading**- If the direction of loading is different from the main direction of loading, the load capacities of the linear bushing will be reduced. The deviation from the main direction has to be taken into account by applying a reduction factor in the design calculations.  
**Adjacent structure**- It is generally best to use ready-to-install linear sets because they save time and money during design and installation. When installing linear bushings in customer-built housings, please follow the recommendations in the product catalog.  
**Travel speed**- Not all types of linear bushings can be used when the velocity required is greater than 2 m/s.  
**Preventing rotary motion**- If rotary motion must be prevented in linear bushing guideways with only one shaft, torque resistant linear bushings must be used.  
**Environmental conditions**- Some types of linear bushings are better suited than others for particular environmental conditions because of their design. There are different sealing systems or corrosion-resistant versions to cater for different applications.  
**Initial selection**- An initial selection of appropriate linear bushings can be made by analyzing these parameters. The tables in sections 4.1.1.5 and 4.1.2.2 also provide assistance in this pre-selection process. Normally, several types of linear

Product Homepage

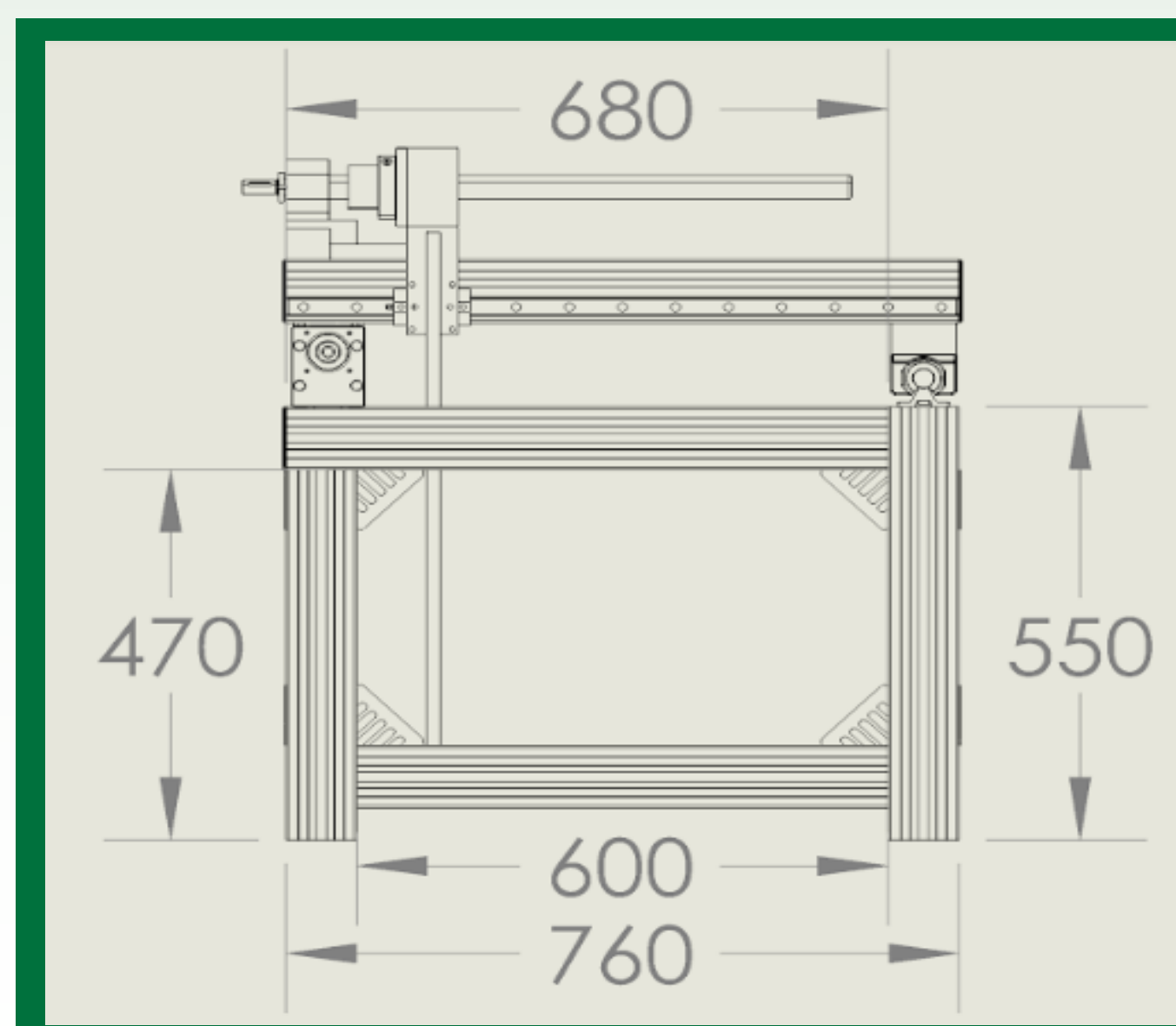
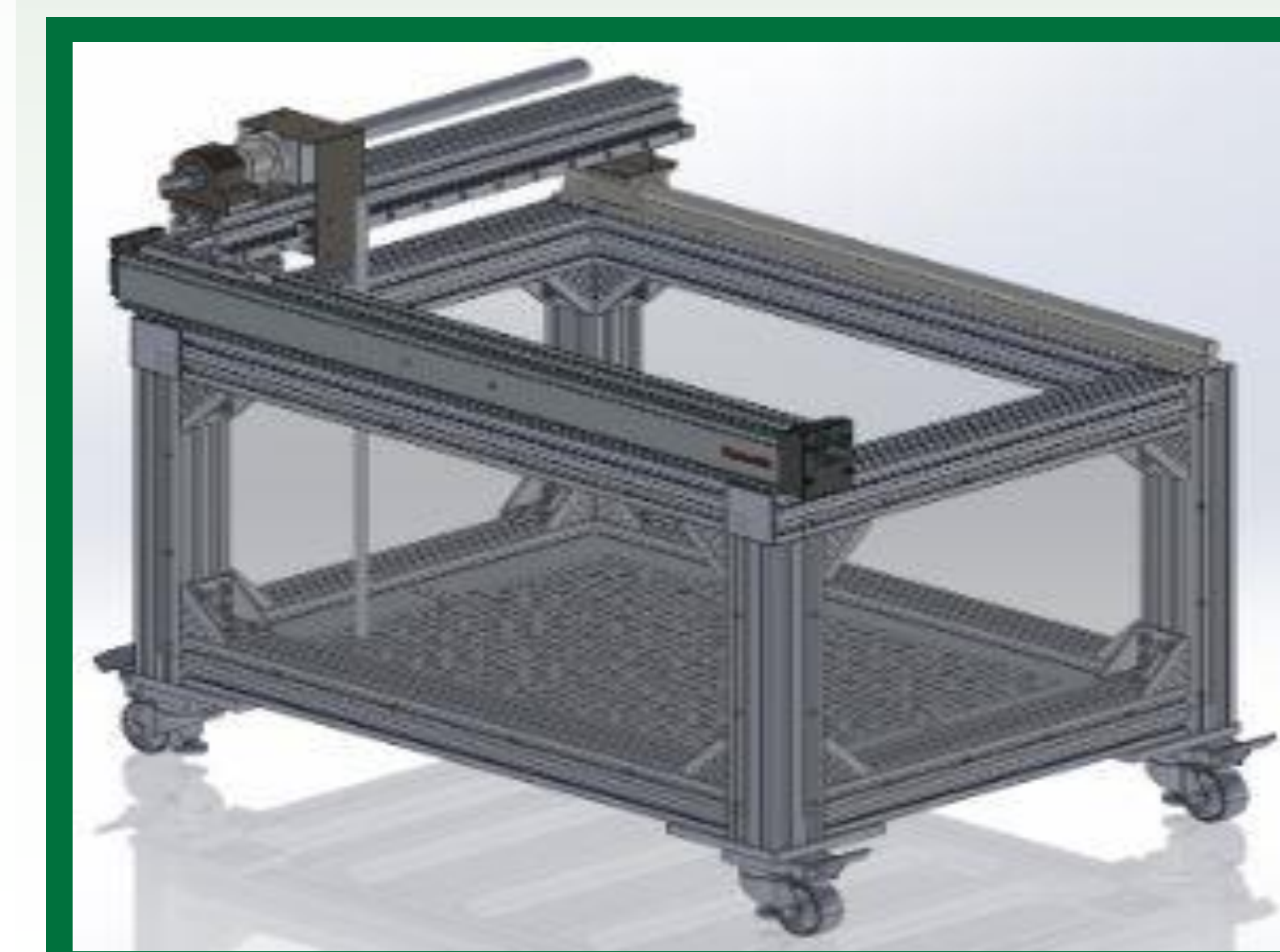
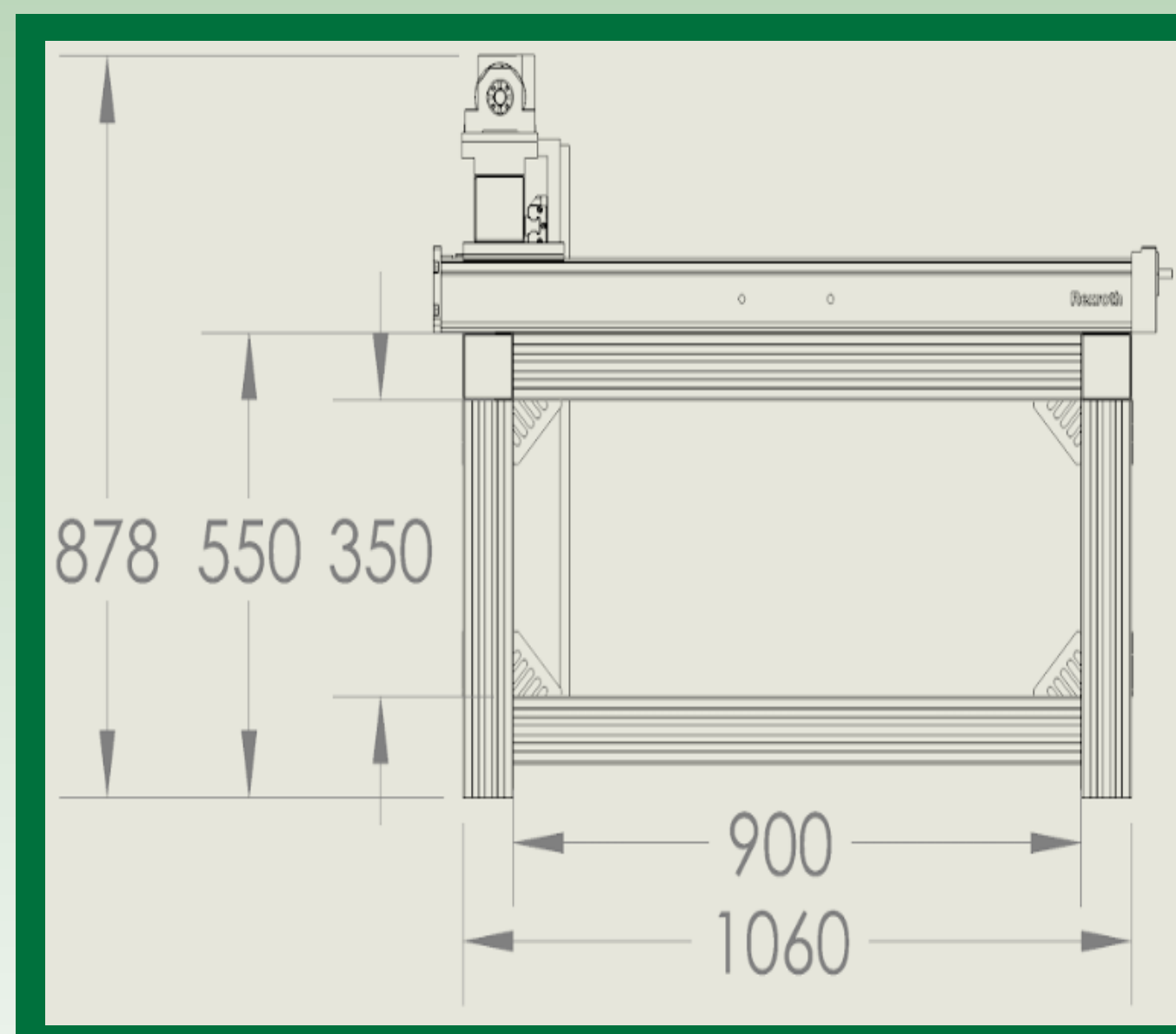
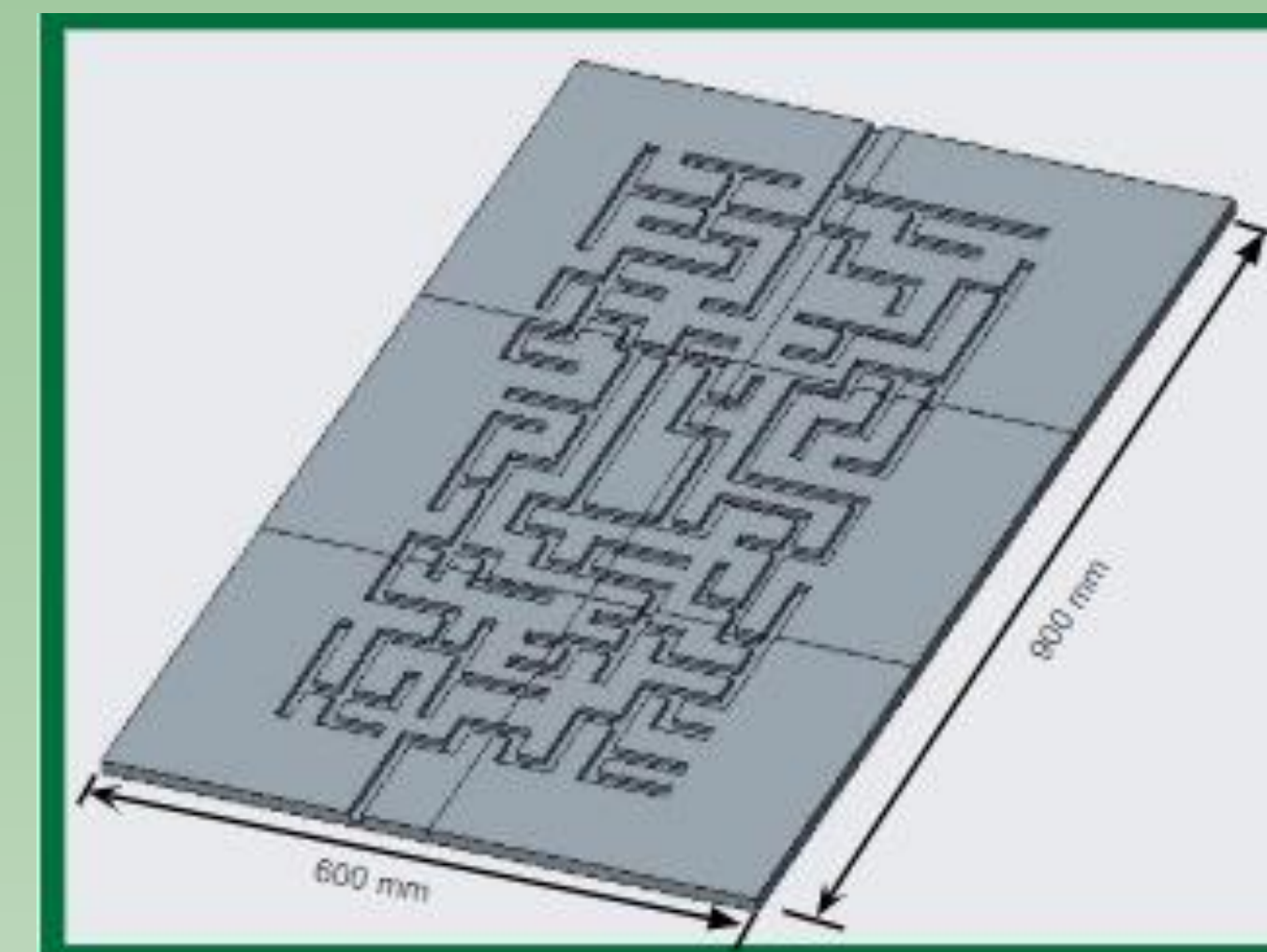
Theory

Selection Guide

## PHYSICAL MODEL

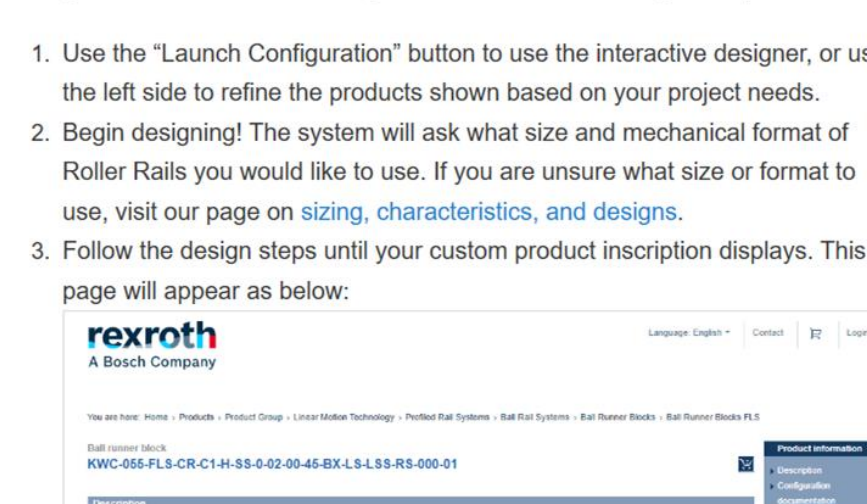
### Construction of Physical Model:

- ❖ Linear Function Module
- ❖ Ball Screw Assembly
  - ❖ Ball Nut, Nut Housing, Pillow Block
- ❖ Profiled Rail System
  - ❖ Ball Rail, Runner Block, Connection Plate
- ❖ Bushing System
  - ❖ Open Bushing, Guide Rail
- ❖ Aluminum Framing
  - ❖ 40x40, 40x40x80, 40x80, 80x80, 90x90
- ❖ Cover Caps
- ❖ Mounting brackets
- ❖ Aluminum Rod for Mandrel
- ❖ Hand Cranks
- ❖ Lexan Planes



### GoSelect Linear Profiled Rail Systems Selector

Looking for an interactive design process to help purchase items for your next project? Click here to see the advanced Bosch Rexroth GoSelect™ tool that makes designing a bore? GoSelect is a streamlined tool that essentially designs your project for you. Go Select will walk you through what parts you would like to add to your product and what sizes you will need. At the end, a bill of materials will automatically be generated and can be added to your shopping cart. Below are step by step instructions on how to use the GoSelect system, as well as the Profile Rail systems PDF Guide method (more calculation and theory based).



### 3. Calculate the Life Expectancy (LMT Handbook Section 5.1.3.2)

A. **Nominal Life**, the amount of revolutions or hours the Ball Screw can operate at a constant speed, before any initial signs of failure become evident.  
$$L = \frac{C}{F_{H1} \cdot 10^6}$$
  
Nominal Life in Revolutions  
$$L_h = \frac{L \cdot 60}{n_{rev} + 60}$$
  
Nominal Life in Hours  
B. **Average Rotary Speed**  
$$n_{avg} = \frac{|n_1| \cdot t_1 + |n_2| \cdot t_2 + |n_3| \cdot t_3 + |n_4| \cdot t_4}{t_{tot}}$$
  
C. **Equivalent Dynamic Axial Load**  
I. For the Ball Screw experience constant speed use:  
$$F_{eq} = \sqrt[3]{\left(\frac{F_{a1}}{1000}\right)^3 \cdot \frac{t_1}{t_{tot}} + \left(\frac{F_{a2}}{1000}\right)^3 \cdot \frac{t_2}{t_{tot}} + \left(\frac{F_{a3}}{1000}\right)^3 \cdot \frac{t_3}{t_{tot}} + \left(\frac{F_{a4}}{1000}\right)^3 \cdot \frac{t_4}{t_{tot}}}$$

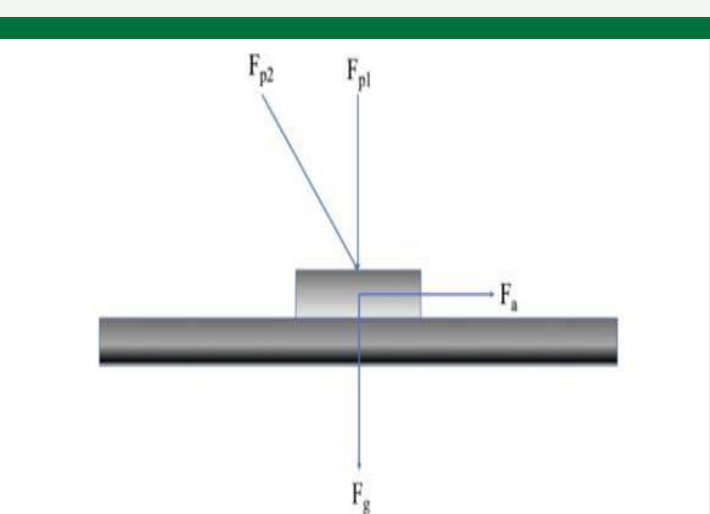


Image created by BOSCH\_TOOL  
Most linear motion systems have a maximum load capacity that it can support without too much deformation. When looking for a linear motion system, one should look for one with a load capacity greater than the maximum load. In most situations, one should calculate a factor of safety for the linear motion system and choose a linear motion system with a factor of safety of between 2 to 6.  
The linear modules are often not fully supported, but installed as unsupported structure. The system can be left unsupported or be supported at several points.

**Introduction to Bushings**  
Bushings are an extremely reliable, efficient, durable, and economical linear motion solution that can be used in an almost never ending list of applications. The format of bushings allows for it to be constructed in a large variety of shapes, sizes, and alternative designs.  
**Applications**  
Instead of using a profiled rail, linear bushings are a less expensive product that can be used in many different scenarios. Some examples are:  
• Self supporting guides that are only supported at the ends  
• Can be used on shafts rather than specific rails  
• Linear sets with iron, steel, or aluminum housings  
• Commonly used in medical, food, and industrial industries  
• Applications under vacuum  
**Benefits of using Bushings**  
• Maintenance-free guides  
• Linear bushings don't require much lubrication  
• Rugged and able to perform without damage  
• Corrosive environments