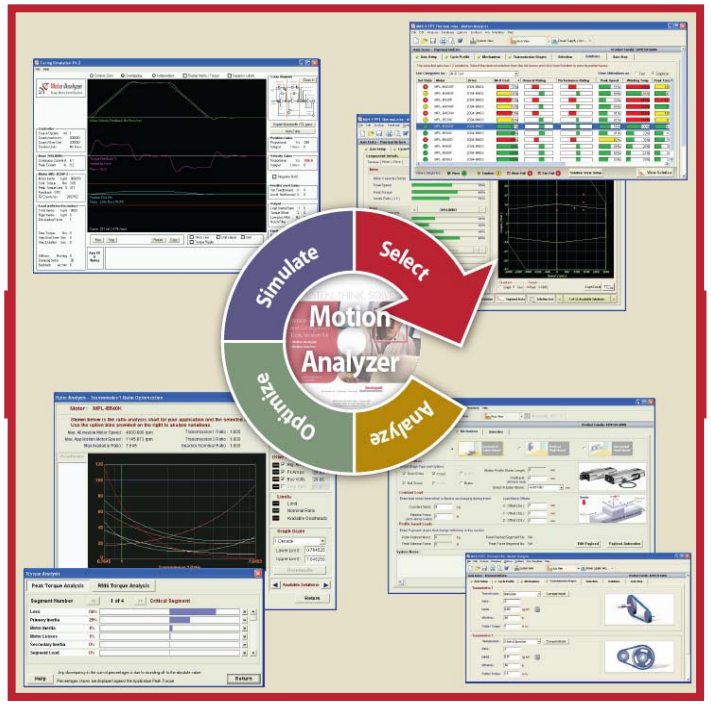
LISTEN. THINK. SOLVE.®

Schaedler Yesco EXPO 2010



Mechatronic Design Overview

Presented by
Kevin Miller Schaedler Yesco
Darryl Jacobs Rockwell Automation

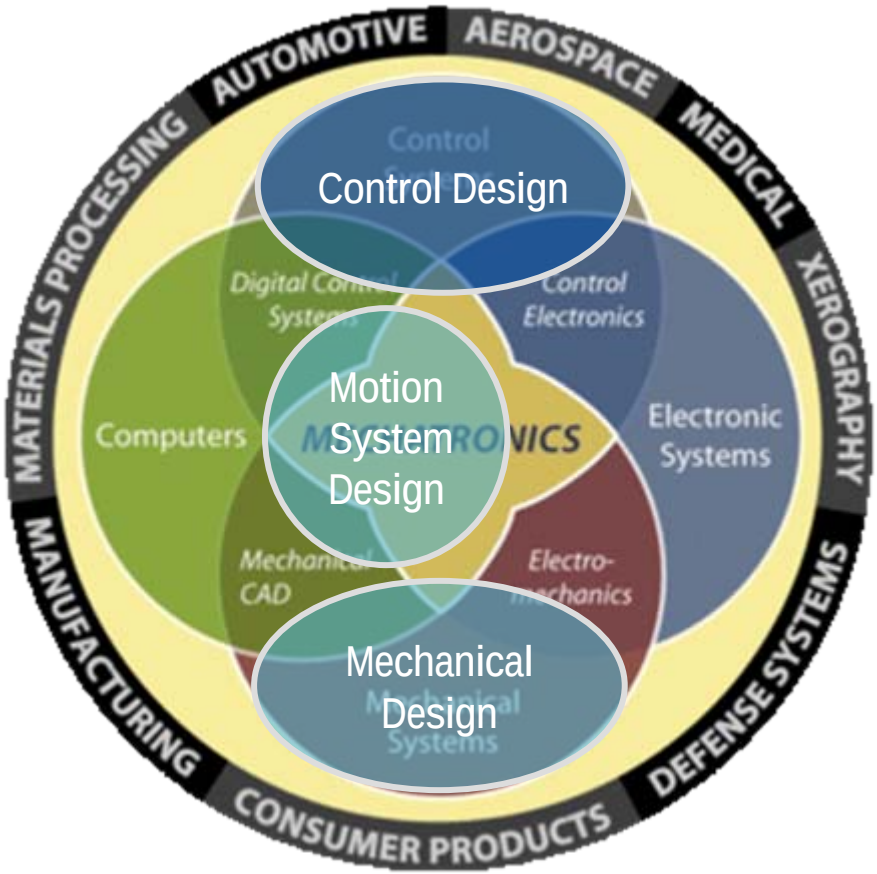
Allen-Bradley • Rockwell Software

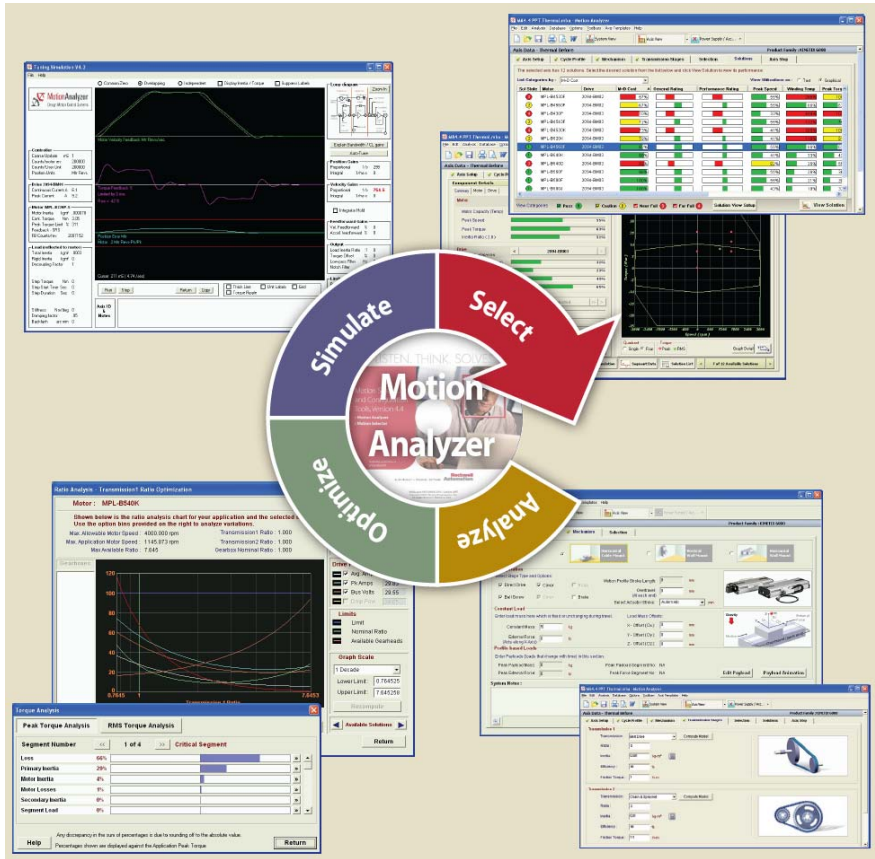
Rockwell Automation

Agenda

1. Mechatronics and Machine Design
2. Benefits of Mechatronics
3. Motion Analyzer
4. Machine Example

Mechatronics and Machine Design





"synergy of several engineering disciplines..."

Mechatronic design is a collaborative venture between mechanical, electrical, and control design engineers – the outcome is a machine design optimized for high performance controls

Mechatronics and Machine Evolution

Increased Automation Technology Adoption

Mechanical

Simplicity

High cost and scarcity of servo drive technology drives machine builders to build a predominantly mechanical machine
e.g. One constant speed motor driving a line shaft that performs machine function using cams, sprockets, gears, pulleys…product change over is either impossible or tricky at best

Hybrid

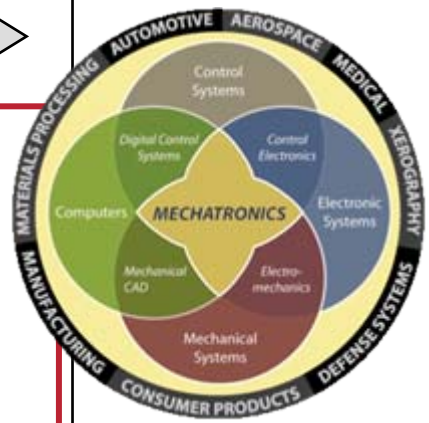
Flexibility

Falling cost & increased confidence in servo drives causes machine builders to try automation on a few critical machine functions.
e.g. Retrofit some mechanical axes with servo motors driving, in most cases, the same sprockets, gears, pulleys…main benefit is increased flexibility (faster product change over). A small % of the possible performance is realized.

Servo

Performance

Pressure to increase machine throughput, flexibility and OEE drives machine builders to increase automation on machine and extract full performance potential.
e.g. All mechanical axes replaced with servo/VFD motors. Drive mechanism re-designed for greater efficiency and to cope with higher bandwidths. System fully integrated for fast product change over, OEE monitoring…



Mechatronics (or *Mechanical* and *Electronics Engineering*) is the combination of mechanical engineering, electronic engineering and software engineering.

Mechatronic design is a collaborative venture between mechanical, electrical, and control design engineers – the outcome is a machine design optimized for high performance controls

Benefits of Mechatronics

- Increased Machine Value
  - The value of a machine is closely tied to it's ability to produce (PPM x OEE)
  - Design optimization often results in increased machine throughput at no additional cost
- Sustainability
  - Machine owners & operators are increasingly concerned with sustainability issues
  - Efficiency analysis can help decrease energy consumption and reduce waste
- Greater Innovation Agility
  - Offering a shorter lead time can often help win the order and even command a premium
  - Virtual prototyping reduces the time to 'Design, Develop & Deliver'
- Risk Mitigation
  - Any design change carries an associated risk
  - Simulation helps reduce risk by predicting the likely outcome of design changes before they occur

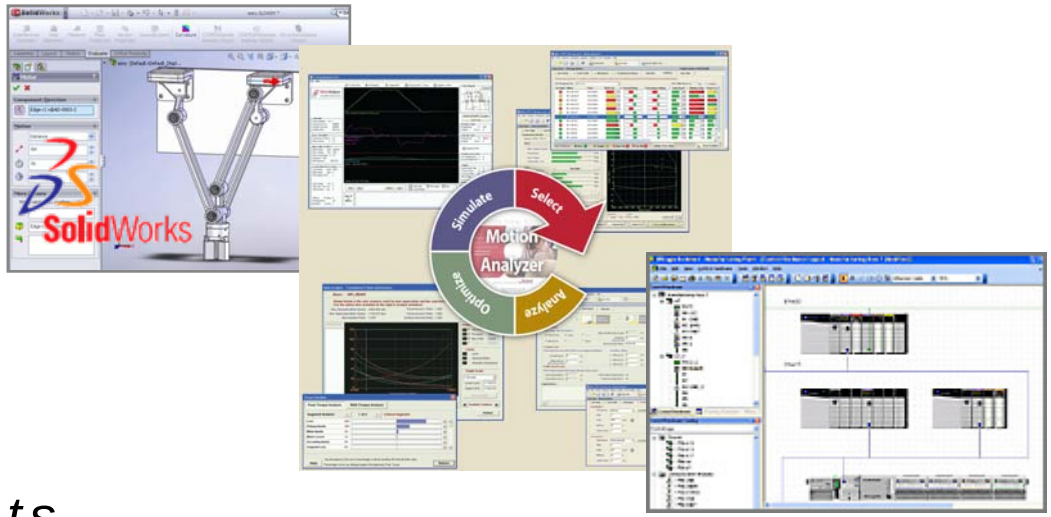
Using this approach we can reduce our physical prototypes from 20 to around 2-3 and can trim hundreds of thousands of dollars from development costs [Leading packaging OEM]

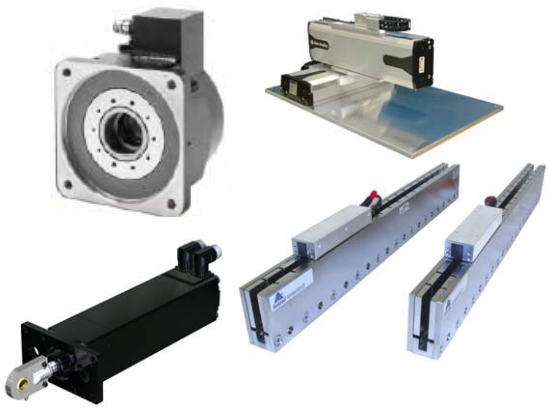
Finding & fixing design flaws late in the development cycle can cost 10 to 100 times what it costs to make changes early [Major tire OEM]

Rockwell Automation's Mechatronic Offering

Virtual Design Tools

Motion Analyzer links mechanics with controls. Analyze, optimize, simulate, and select in a virtual environment before committing to a final machine design





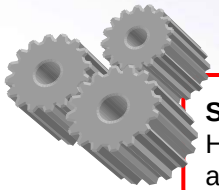
Products

Comprehensive motion offering including direct drive motors, linear stages, stacked stages, and electric servo actuators that deliver a superior mechatronic outcome

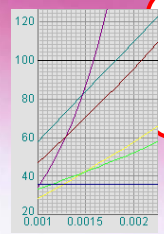
Expertise

Mechatronic support and services to augment your existing design team

Virtual Design Tools – Machine Example

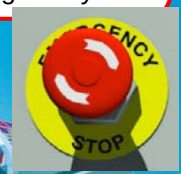


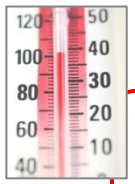
System Efficiency Analysis
Helps boosts machine performance and reduce energy consumption.



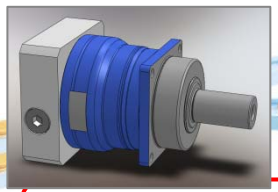
System Tolerance Analysis
Provides an insight into a machine's ability to cope with change.

Emergency Stop Analysis
Maximize output without compromising safety

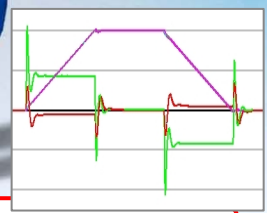




System Thermal Modeling
Especially useful for machine builders exporting to countries with hot weather.

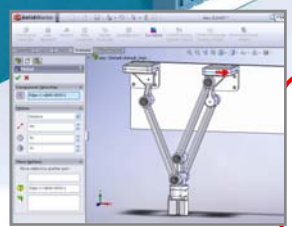


Ratio Design Analysis
Guides designers to an optimized solution.



System Tuning Simulation
Helps reduce design error and can save time during machine commissioning.

Supply Voltage Tolerance Analysis
Reduces chance of machine issues in the field that result in costly support.



3D CAD Integration
Download models of motion product and verify motion profiles at the mechanical design phase.

Lifetime Estimation
Size an integrated linear stages and automatically get an L10 service life estimation.

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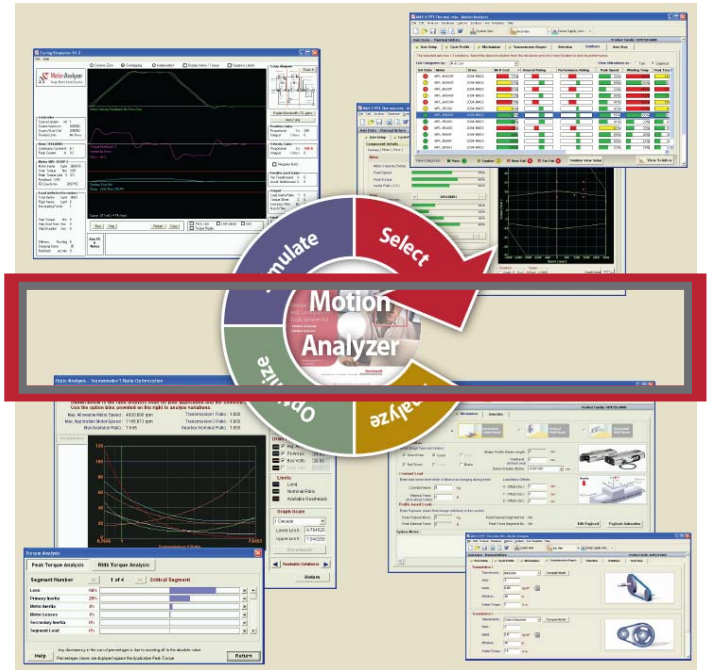


Motion Analyzer 4.73

Analyze, Optimize, Simulate, Select

Allen-Bradley • Rockwell Software

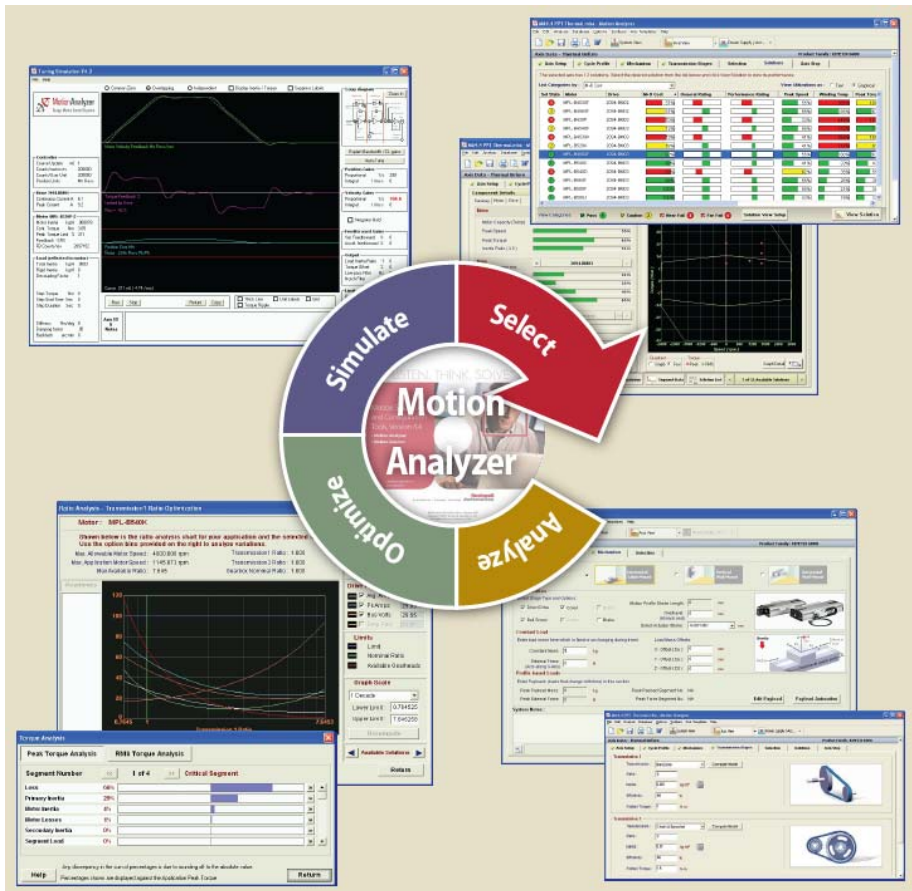
Rockwell Automation

What does Motion Analyzer do?

- Sizing and simulation software covering
  - Kinetix 300, 2000, 6000, 6200, 6500, 7000 servo drives
  - Ultra 1500, 3000 and 5000 servo drives
  - All Allen Bradley servo rotary and linear servo motors
  - Powerflex 70, 700 and 755 architecture class AC drives
  - Gear box manufacturers in Stober, Apex and generic
- Export motion profiles, camming, amplifier gains/tuning to PLC/PAC programming software
- Import SolidWorks data into MA modeling

Motion Analyzer – What It Does

- Motion Analyzer takes customer machine design data and outputs a recommended motor drive combination
- It also offers a host of optimisation, simulation & performance prediction tools



Motion Analyzer lab

- Quick look at some features
- A few labs designed to see basic navigation and features
- Don’t expect to get through all of these. Recommendation is do the first lab than skip to a topic that most interests you.
- We’ll come back and do a wrap up.

Motion Analyzer – Speeds Up Design

- Manual calculation & selection
  - Complex
  - Error prone
  - Rule of thumb based decisions
  - *Slow*
- Motion Analyzer
  - Simple
  - Accurate
  - *Fast*

Before

- Design Engineers use long hand calculations, often in home baked spreadsheets
- Requires manual selection of product, manual updating…

After

- Motion Analyzer holds all the application information as well as product information
- Initial selection is faster, alterations & 'what if's' are 'instant'

Business Impact

- Faster design & selection means machine is faster to ship to customer
- Invoice earlier!

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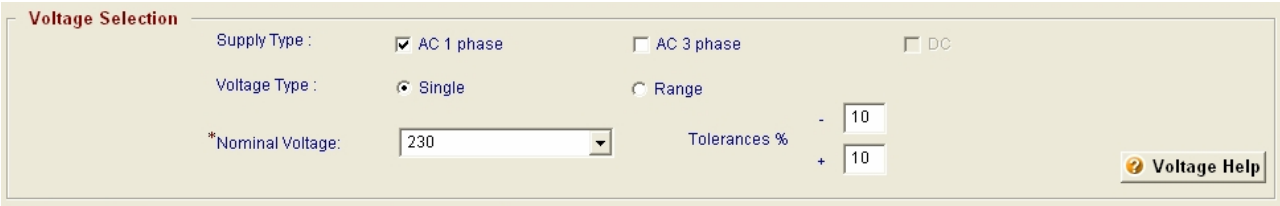
Motion Analyzer – Voltage Tolerance Analysis

- Especially useful for machine builders exporting machines abroad, the supply voltage tolerance analysis feature ensures machine operation with varying supply voltages
- Allows for
  - Reduced high speed performance when supply voltage is low
  - Increased regenerative burden when supply voltage is high



Before
- Machine operates normally during pre-ship trials
- Starts to display nuisance trips at customer site
- Engineer sent to investigate

After
- Motion Analyzer identifies issue and selects accordingly
- System operates normally during pre-ship trials and at customers site during sign off

Business Impact
- Cost of sending engineer to customers site ($10K for a weeks trip abroad)
- Cost of in field design changes
- Reputation

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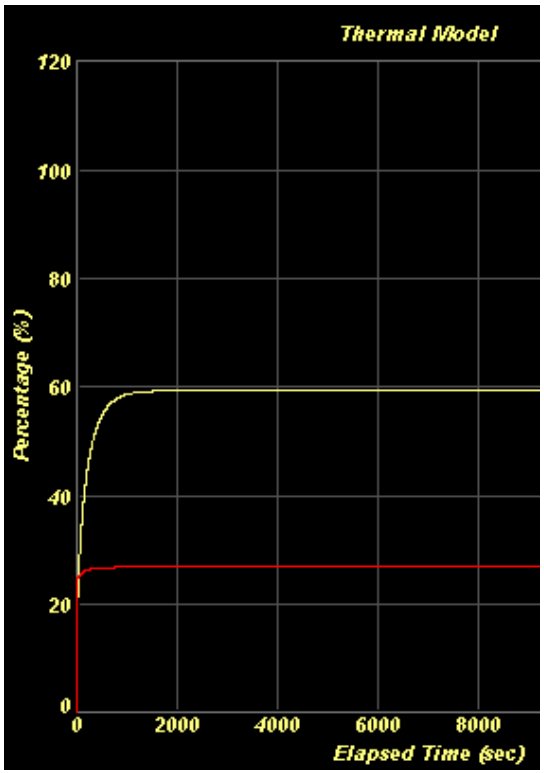
Motion Analyzer – Thermal Performance



- Motion Analyzer uses a dynamic thermal model to verify system performance
- Model can take account of motor ambient temperature and altitude
- Especially useful for machine builders exporting to countries with hot weather
- Estimates time to reach steady state - helpful during machine trials

Before

- Machine operates normally during trials at 21°C ambient
- Starts to display nuisance trips at customer site which is 40°C
- Engineer sent to investigate

After

- Motion Analyzer sizes motor for operation at 40°C
- System operates normally during trials and at customers site during sign off

Business Impact

- Cost of sending engineer to customers site ($10K for a weeks trip abroad)
- Cost of in field design changes
- Reputation

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Motion Analyzer – Linear Stages

- Motion Analyzer features Allen-Bradley integrated linear stages
- Offers off-the-shelf linear motion without the need to search through catalogues looking for suitable ball screws, timing belts, pulleys, bearings…
- No mechanical data to enter – just input load information and move profile

Before
- Mechanical designers had to select a number of components required for linear motion
- Time consuming, tricky and prone to selection errors

After
- Simply enter information about the load and how it needs to be moved
- Motion Analyzer selects a suitable linear stage & drive

Business Impact
- Design time reduced by up to a day per axis
- Design errors reduced leading to less changes during start up and on site at customer

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Motion Analyzer – Life Estimates

- When Allen-Bradley integrated linear stages are used, Motion Analyzer provides a life estimate
- Uses load, orientation, move profile & duty cycle data to calculate an industry standard 'L10' life estimate for bearings and flex cable life based on number of reversals

Before
- Due to the complex relationship of forces and motion, very tricky to accurately estimate life
- Engineers oversize to be safe, or accidentally undersize

After
- Enter information about the load and how it needs to be moved
- Motion Analyzer selects a linear stage and gives life estimates for bearings & flex cable

Business Impact
- No need for over design - save cost on components
- Reduce failures in the field by scheduling routine maintenance when required (if at all)

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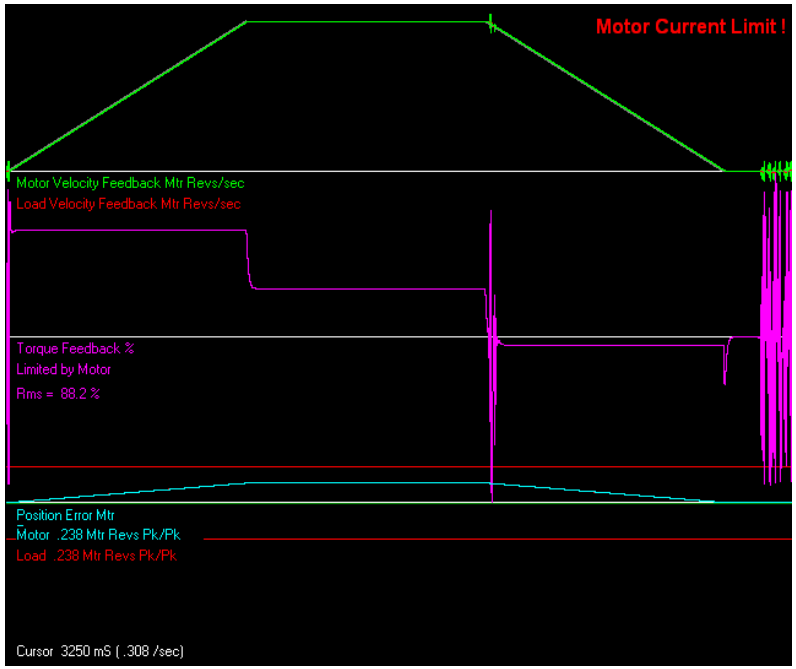
Motion Analyzer – Tuning Simulation



- Tool to help predict how your machine will perform in the real world
- Try different types of tuning and then simulates the behaviour of the load, motor and drive
- Factors in mechanical compliance or backlash to give a realistic estimation

Before

- Tuning was attempted only after the machine was built
- Components selected by the "That is what we have always used" method

After

- Motion Analyzer simulates Motor / Compliance / Load to help define initial tuning parameters for use in RSLogix 5000
- Increased confidence

Business Impact

- Reduced commissioning times – Reducing time to shipment and start-up
- Helps increase machine reliability

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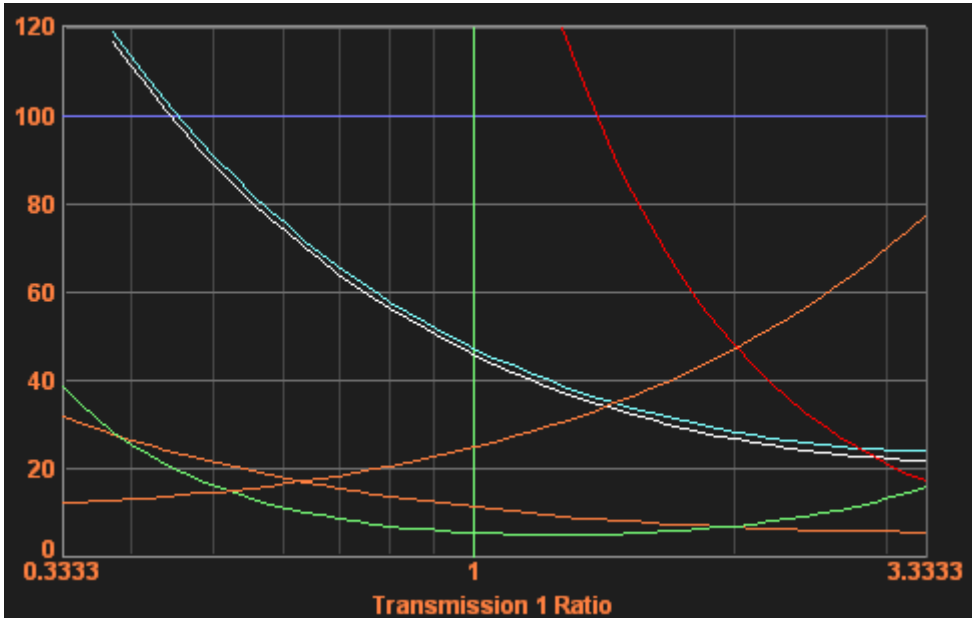
Motion Analyzer – Ratio Analysis



- Ratio analysis is a tool that helps mechanical design engineers make a more ‘Mechatronic’ selection of gearboxes, timing belts and ball screws
- It provides an ‘at-a-glance’ view of the trade offs necessary, and guides the user to an optimised solution

Before
- Unclear relationship between selection of mechanical components and system performance mean ‘rule of thumb’s are generally used

After
- Motion Analyzer guides design engineer to select optimal mechanical solution
- Selection is now more ‘Mechatronic’

Business Impact
- Optimized mechanical design boosts machine performance
- Requires smaller motor & drive which require less panel space, smaller contactor…

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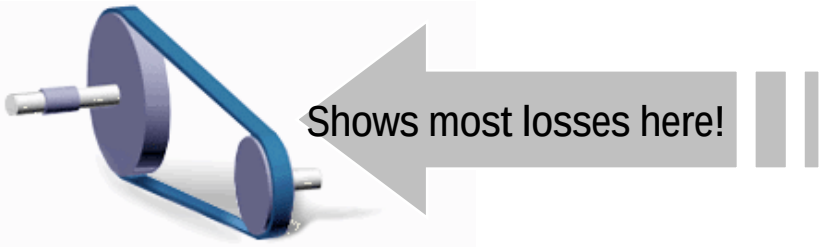
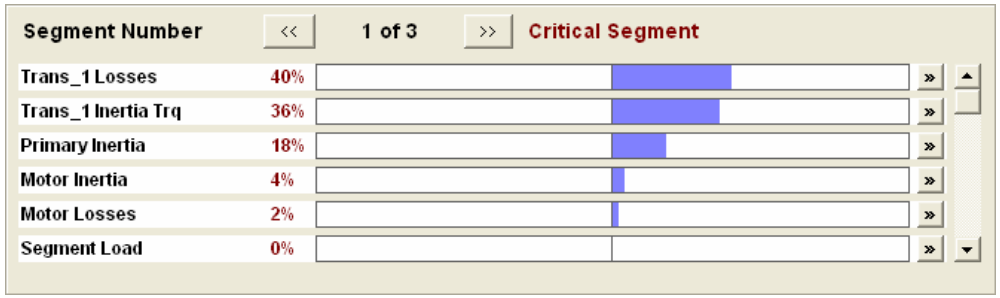
Motion Analyzer – Torque Analysis

- Torque Analysis provides a ‘sanity’ check by showing where the torque produced by the motor is ‘consumed’
- If the majority is being used to move the load the design is sound
- If over 75% is being lost in the transmission, it’s back to the drawing board…





Before

- Design engineers generally focus on how to move the load
- Transmission losses are sometimes factored in, but rarely checked v. load losses

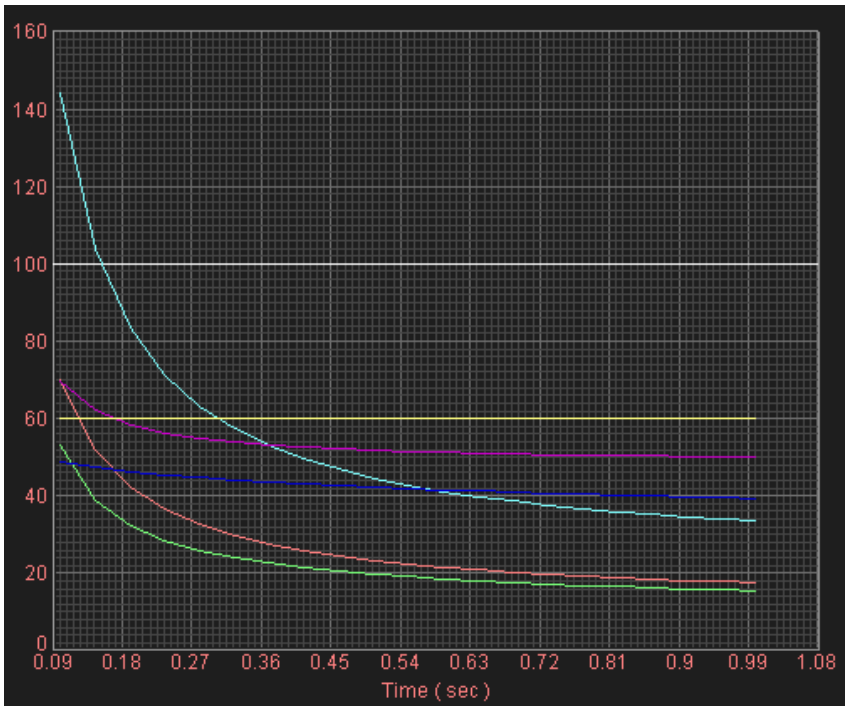
After

- Motion Analyzer provides torque analysis as standard
- Makes checking simple, and enables rapid ‘what if’ analysis if improvements are required

Business Impact

- Optimized mechanical design boosts machine performance
- Requires smaller motor & drive which require less panel space, smaller cables…..

Motion Analyzer – Tolerance Analysis



- Motion Analyzer is able to answer the question – 'how fast will it go'?
- Tolerance Analysis enables application data such as move time, mass, losses, ambient temperature to be plotted against 'health parameters' for the system
- Seeing which hits 100% tells you the system limit – and the limiting factor

Before

- Design engineers are often able to select a appropriate servo system, but struggle to answer what the limit for the machine is
- System sometimes 'on the edge'

After

- Motion Analyzer provides means to rapidly analyze the system's tolerance to changes
- Alerts engineer to any marginal design issues

Business Impact

- Reduces chance of operational issues due to marginal design (in field design changes $10K+)
- Allows possible increase in machine spec with no changes

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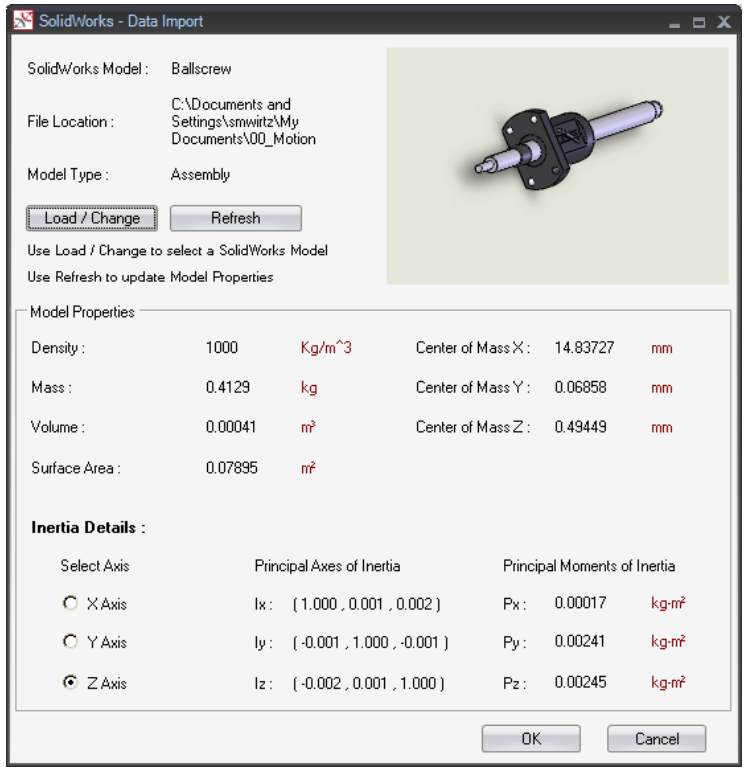
Motion Analyzer – SolidWorks Inertia Import

- Useful for machine builders utilizing SolidWorks 3-D CAD.
- Allows for
  - Static Inertia data directly from the mechanical design team
  - Linking the file not just the inertia data for quick updates.



Before

- Machine data passed by hand between Mechanical and Control engineers
- Control engineers attempted to calculate mechanical data for sizing

After

- Motion Analyzer linked directly to mechanical drawing
- System data can be refreshed quickly if drawings are changed

Business Impact

- True Mechatronic design approach, Mechanical and Control engineering working closely together to reduce design risks

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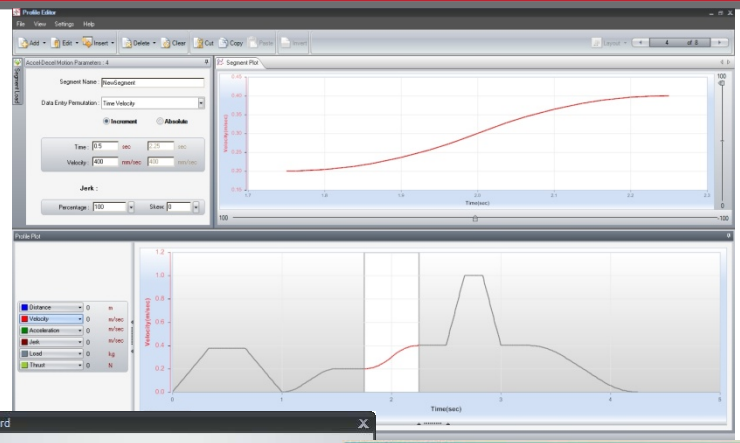
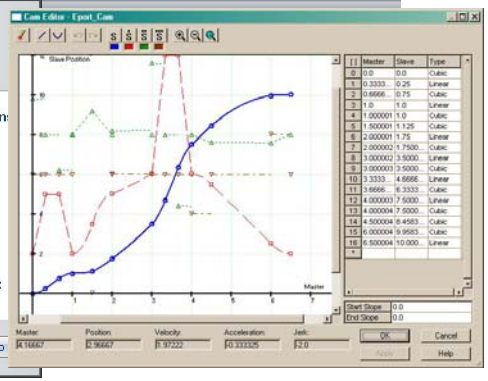
Motion Analyzer – Enhanced Profile Editor

- Motion Analyzer is able to create complex motion profiles for proper system analysis.
- Profile Editor allows export of the motion profile directly to
  - RSLogix 5000 MATC (Motion Axis Time Cam) and MAPC (Motion Axis Position Cam) instructions
  - Solid Works Motion Studies
  - User defined export





Before

- Machine Move profiles created in RSLogix 5000 and again in Motion Analyzer.

After

- Complex move profiles created and analyzed directly in Motion Analyzer. Move profiles exported to RSLogix 5000 Time Cam or Position Cam instructions

Business Impact

- True Mechatronic design approach, Mechanical and Control engineering working closely together to reduce design risks

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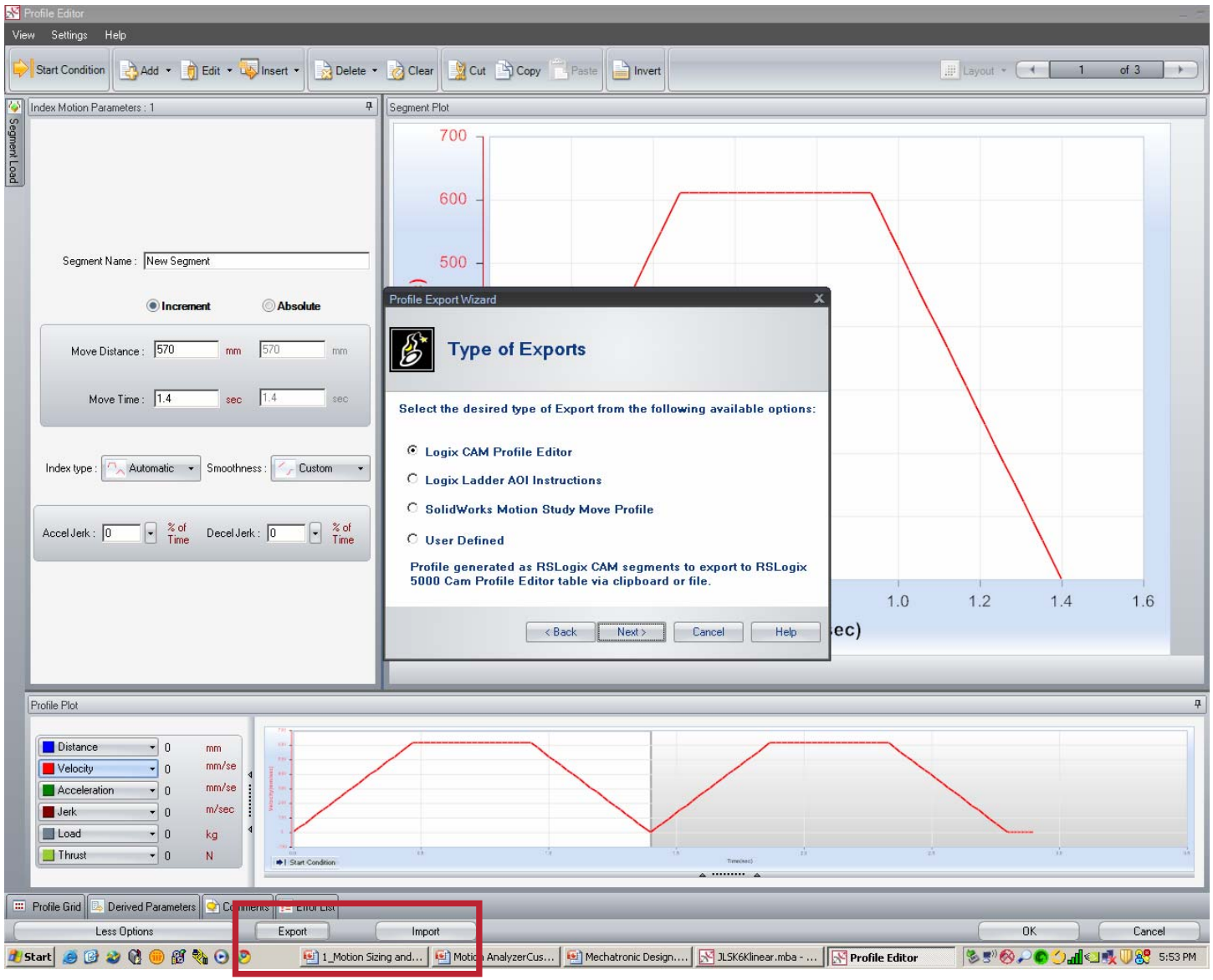
Import and export profiles

Export profiles directly to programming software for CAM editors and Add On Instructions.

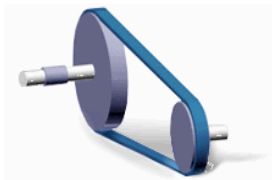
Merge into a SolidWorks study.



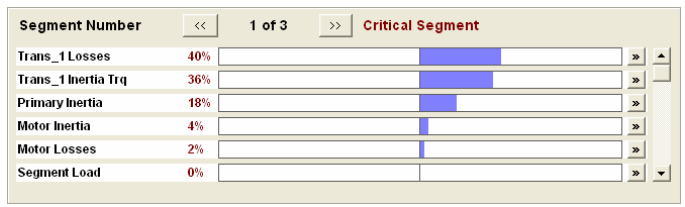
System Efficiency Analysis

Shows where power produced by the motor is consumed. If the majority is being used to move the load the design is sound; if most is being lost in transmission, it may be back to the drawing board.

Using the tool in several 'what if?' scenarios helps arrive at an optimized mechanical design that can boosts machine performance and reduce energy consumption.



Most losses here!



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- Motion Analyzer provides torque analysis as standard
- Makes checking simple, and enables rapid 'what if' analysis if improvements are required

Business Impact

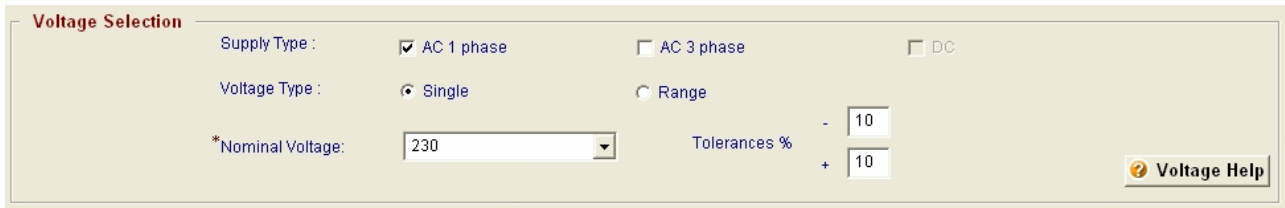
- Optimized mechanical design boosts machine performance
- Requires smaller motor & drive which require less panel space, smaller contactor…

Supply Voltage Tolerance Analysis

Especially useful for machine builders exporting machines abroad, the tolerance analysis feature helps ensure machine operation with varying supply voltages.

Allows for reduced high speed performance when supply voltage is low, and increased regenerative burden when supply voltage is high.

Reduces chance of machine issues in the field that result in costly support.



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- Starts to display nuisance trips at customer site
- Engineer sent to investigate

After

- Motion Analyzer identifies issue and selects accordingly
- System operates normally during pre-ship trials and at customers site during sign off

Business Impact

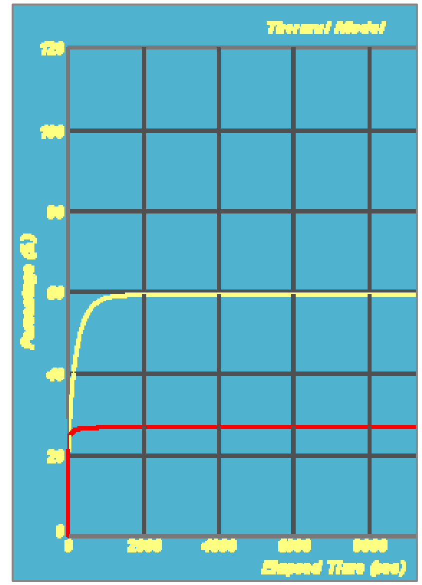
- Cost of sending engineer to customers site ($10K for a weeks trip abroad)
- Cost of in field design changes
- Reputation

System Thermal Modeling

Motion Analyzer uses a dynamic thermal model of the motor and drive to verify system performance.

Model takes into account motor ambient temperature and is able to predict how long it takes for motor & drive to reach operating temperature.

Especially useful for machine builders exporting to countries with hot weather.



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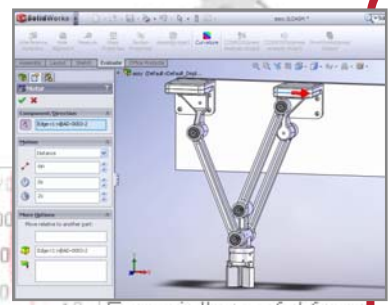
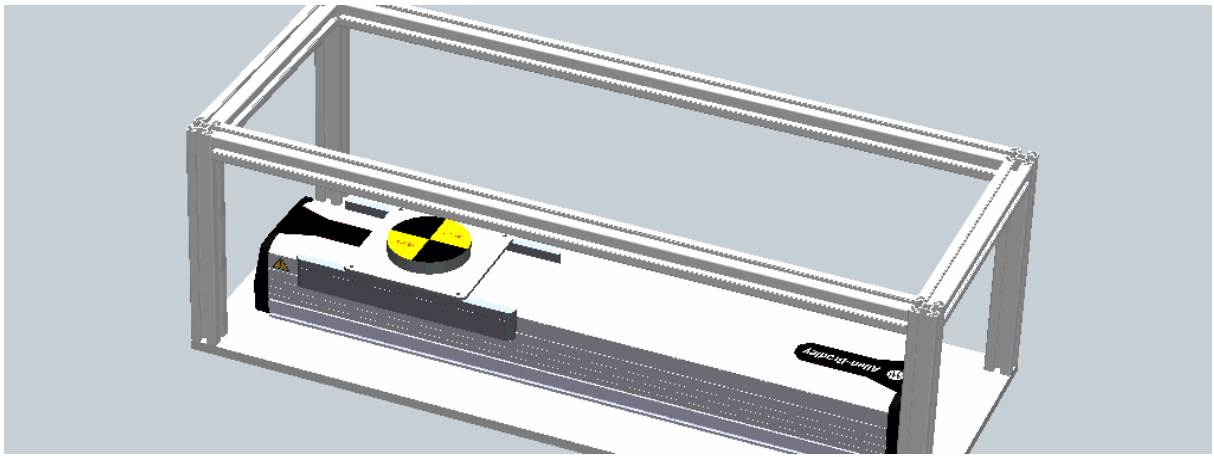
3D CAD Integration



Simplify mechanical design by utilizing off-the-shelf linear stages. Download 3D models of mechanical motion products and verify motion profiles at the mechanical design phase.

Removes the need to search through catalogues looking for suitable ball screws, timing belts, pulleys, bearings…



Before

- Mechanical designers had to select a number of components required for linear motion
- Time consuming, tricky and prone to selection errors

After

- Simply enter information about the load and how it needs to be moved
- Motion Analyzer selects a suitable linear stage & drive

Business Impact

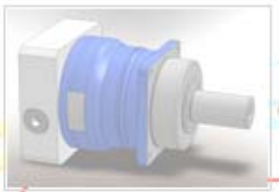
- Design time reduced by up to a day per axis
- Design errors reduced leading to less changes during start up and on site at customer

Lifetime Estimation

Motion Analyzer features Allen-Bradley integrated linear stages that combine off-the-shelf convenience with the reassurance of a service life estimation.

Simply input load information and a move profile; Motion Analyzer will automatically size the system and also provide an L10 service life and flex cable life estimation.

System Thermal Modeling
Especially useful for machine builders exporting to countries with hot weather.



Ratio Design Analysis
Guides designers to an optimized solution.

System Tuning Simulation
Helps reduce design error and can save time during machine commissioning.

Before

- Due to the complex relationship of forces and motion, very tricky to accurately estimate life
- Engineers oversize to be safe, or accidentally undersize

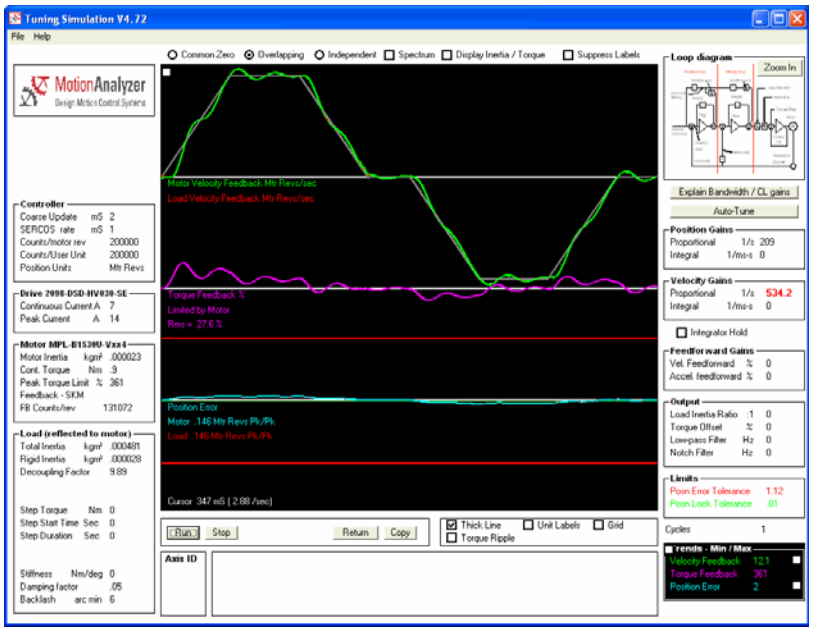
After

- Enter information about the load and how it needs to be moved
- Motion Analyzer selects a linear stage and gives life estimates for bearings & flex cable

Business Impact

- No need for over design - save cost on components
- Reduce failures in the field by scheduling routine maintenance when required (if at all)

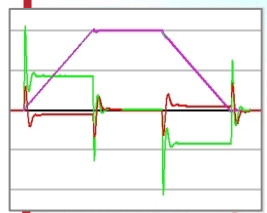
System Tuning Simulation



Tuning simulation helps predict how machines perform in the real world.

Emulates tuning an axis in RSLogix5000 (including 'Auto-tune') and then simulates the behavior of the load, motor and drive while factoring in mechanical compliance or backlash to give a realistic result.

Helps reduce design error and can save time during machine commissioning.



Before

- Almost impossible to predict the overall performance of a servo driven mechatronic system
- Necessary to build a prototype in order to verify system solution

After

- Enter information about the application and size as normal
- Run tuning simulation to view likely behavior of system under different conditions

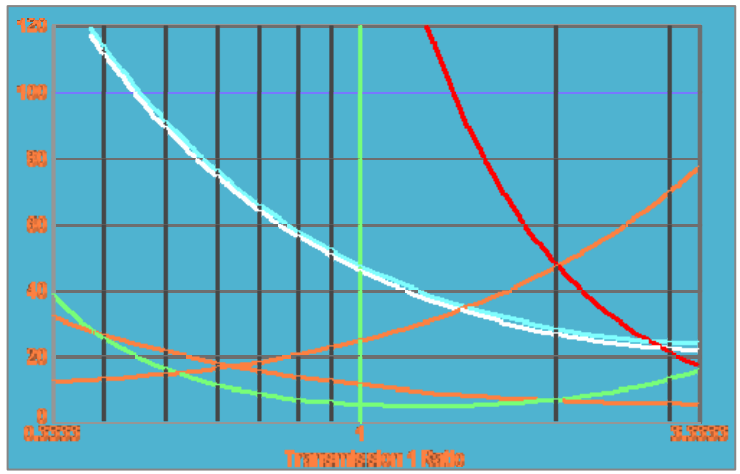
Business Impact

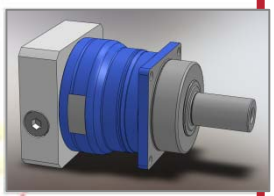
- Gain insight into machine performance earlier in design cycle
- Reduce number of prototypes
- Meet performance goals
- Same commissioning time

Ratio Design Analysis

Ratio analysis is a tool that helps mechanical design engineers select gearboxes, timing belts and ball screws.

It provides an ‘at-a-glance’ view of the trade-offs associated with altering the mechanical advantage between motor & load, and guides the user to an optimized solution.





Before

- Unclear relationship between selection of mechanical components and system performance mean ‘rule of thumb’s are generally used

After

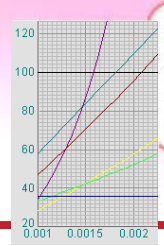
- Motion Analyzer guides design engineer to select optimal mechanical solution
- Selection is now more ‘Mechatronic’

Business Impact

- Optimized mechanical design boosts machine performance
- Requires smaller motor & drive which require less panel space, smaller contactor…

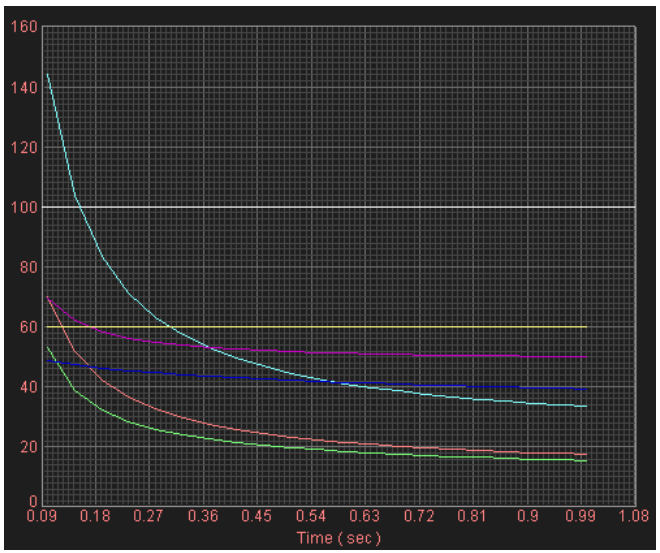
System Tolerance Analysis

System Efficiency Analysis
Helps boosts machine performance and reduce energy consumption.



System Tolerance Analysis
Provides an insight into a machine's ability to cope with change.

Emergency Stop Analysis
Maximize output without compromising safety



Tolerance Analysis enables application data such as move time, mass, losses, ambient temperature to be plotted against 'health parameters' for the system.

This provides an insight into a machine's ability to cope with change, identifies the weakest link and estimates the system envelope.

Tuning Simulation
reduce design error
can save time during machine commissioning.

Before

- Design engineers are often able to select a appropriate servo system, but struggle to answer what the limit for the machine is
- System sometimes 'on the edge'

After

- Motion Analyzer provides means to rapidly analyze the system's tolerance to changes
- Alerts engineer to any marginal design issues

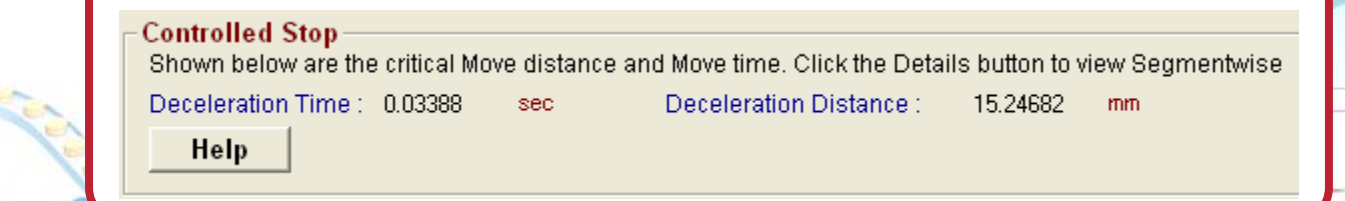
Business Impact

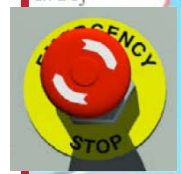
- Reduces chance of operational issues due to marginal design (in field design changes $10K+)
- Allows possible increase in machine spec with no changes

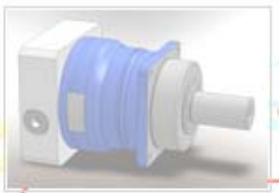
Emergency Stop Analysis

One of the greatest challenges for machine designers is to combine performance with safety.

Emergency stop analysis in Motion Analyzer helps take the guess work out of understanding safe stop distances and times, allowing designers the freedom to pursue output without compromising safety.







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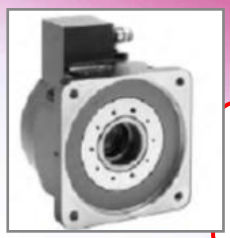
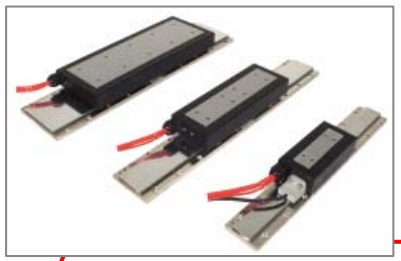
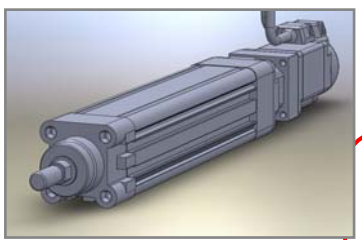
Mechatronic Technologies – Machine Example



Direct Drive Rotary Servo Motors
Help boost machine performance and reduce design complexity for rotary loads.



Direct Drive Linear Motors
Offer ultimate design flexibility and performance with speeds of up to 5 meters per second and accelerations up to 50G.



Electric Servo Cylinders
Greater control, accuracy and repeatability than pneumatic cylinders. Also offer sustainability benefits.

Direct Drive Linear Stages
Help boost machine performance and reduce design complexity for linear loads. Also available as stacked stages for multi-axis applications requiring an off-the-shelf solution.

Direct Drive Rotary Servo Motor

Use of direct drive rotary servo motor technology eliminates the need for transmission components between motor and load.

During the design phase this helps reduce complexity which often means a shorter design time.

Fewer mechanical components can also boost machine performance, reduce energy consumption, and increase machine availability.

Before

- Design engineers often have to use a transmission to match the load requirements with the motor
- Transmission design can be tricky and involves multiple components

After

- Design load and motion profile
- Use Motion Analyzer to search for best direct drive rotary servo motor
- Carry out tuning simulation to verify performance

Business Impact

- Shorter design time, less complex
- Boosted machine performance increases value of machine
- Mechanical simplification increases machine availability

Direct Drive Linear Servo Motors & Stages

Use of direct drive linear servo motor technology eliminates the need for rotary-to-linear translation between motor and load.

During the design phase this helps reduce complexity which often means a shorter design time. Use of off-the-shelf linear stages can further increase this saving.

Fewer mechanical components can also boost machine performance, reduce energy consumption, and increase machine availability.

Before

- Design engineers often have to use mechanical translation to drive a linear load with a rotary motor
- Translation design can be tricky and involves multiple components

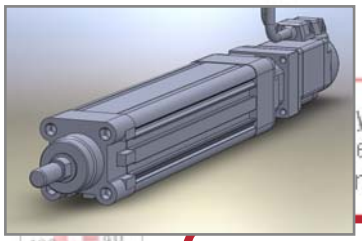
After

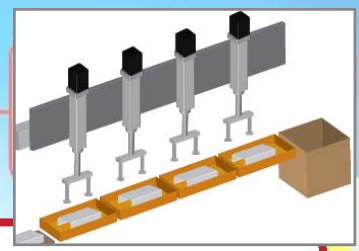
- Design load and motion profile
- Use Motion Analyzer to search for best direct drive linear servo motor
- Carry out tuning simulation to verify performance

Business Impact

- Shorter design time, less complex
- Boosted machine performance increases value of machine
- Mechanical simplification increases machine availability

Electric Servo Cylinders





Use of electric servo cylinders eliminates the need for compressed air.

As well as offering greater control, flexibility & repeatability than pneumatic cylinders, electric servo cylinders can also offer the benefit of reduced noise.

Electric servo cylinders can also help boost machine performance, reduce energy consumption, and increase machine availability.

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After

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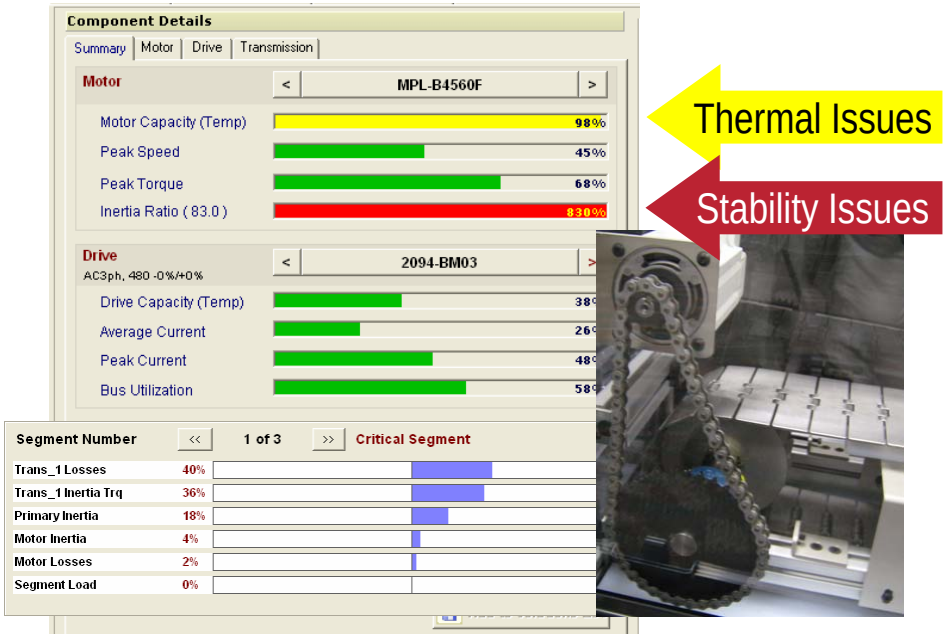
Customer Example – Thermoforming

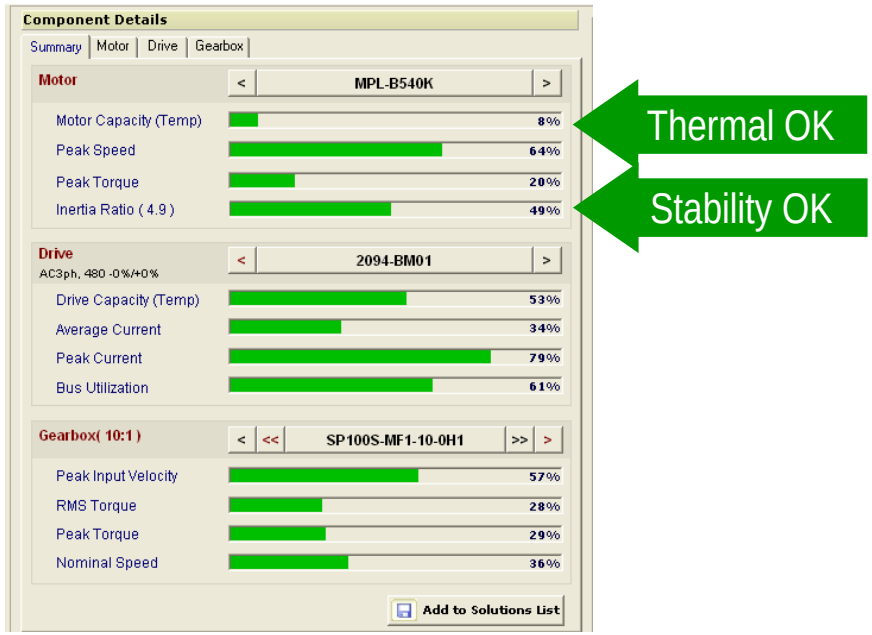
Before



Thermal Issues

Stability Issues

After



Thermal OK

Stability OK

- Chain driven transmission responsible for majority of losses & stability issues
- Motor operating at 98% of thermal limit, combined with stability issues, causing nuisance trips and material waste
- Design not suited to machine speed up

- Transmission losses reduced
- Drive size reduced from 13.5kW to 4kW
- Waste due to nuisance trips eliminated
- Line speed increased – greater output per machine footprint

Motion Analyzer - Summary

- Motion Analyzer takes customer machine design data and outputs a recommended motor drive combination
- It also offers a host of optimisation, simulation & performance prediction tools
- Use of Motion Analyzer helps machine builders
  - Enhance machine performance
  - Optimise system selection
  - Decrease time to shipment
  - Reduce risk
- Motion Analyzer is available as a free download
  - Go to www.ab.com/motion
  - Select ‘Motion Software’ then ‘Motion Analyzer’ from the navigation menu

Motion Analyzer 4.73 wrap up

- Free download comprehensive sizing and selection tool.
- Web updates either automatic or manual.
- Please fill out the survey form. If you have a question that needs some space please add it to the back of the form.

Coming in June 2010 Motion Analyzer 4.8.
More CAD linkage and Ethernet IP 6500 Kinetix drives enhanced safety.
More motors, actuators and drives added to the database.

Remember guess work is expensive.
Prove it before you buy it with Motion Analyzer.