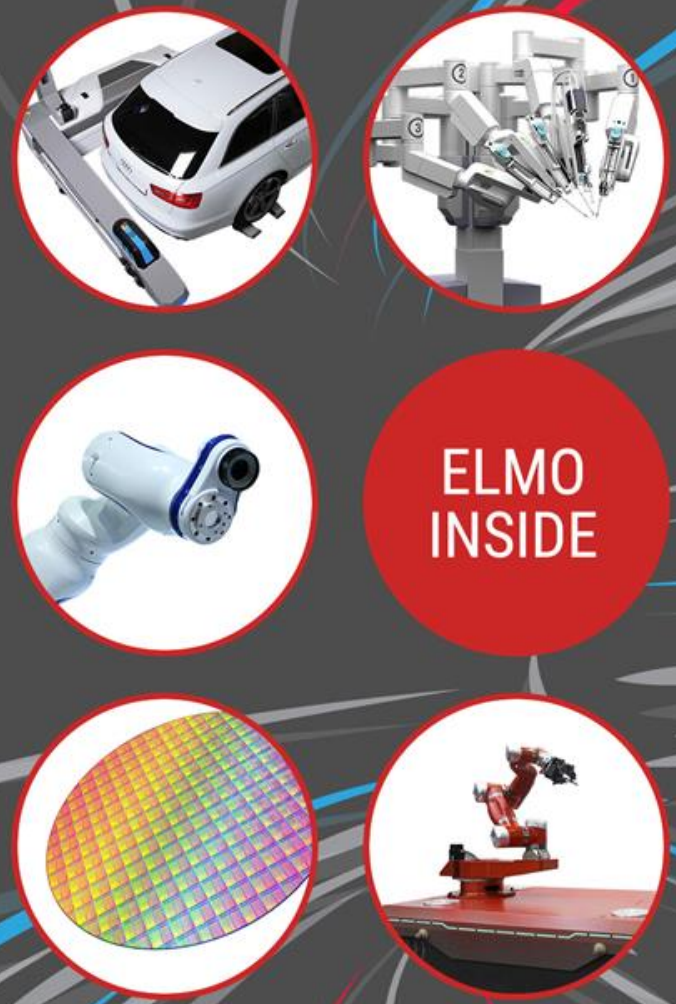
Elmo
Motion Control

ROBOTICS IN **MOTION**

Making Smart
Machines Smarter



Tomer Goldenberg
Elmo Motion Control

Robotics Today

We live in an interesting world…

We want our workers to perform like robots:

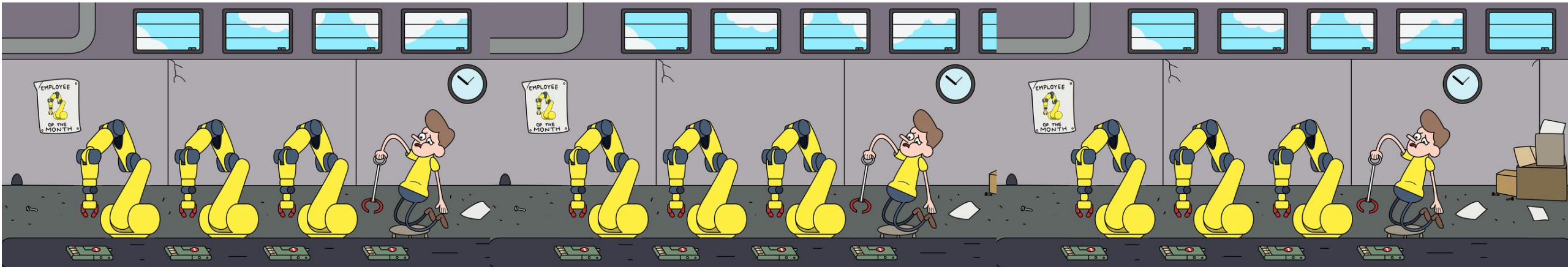


Illustration by Kallum Best

Yet…

We want our robots to be more human:

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Robotics Today

Intelligent
Independent
Sensible
Mindful
Eco Friendly
Powerful
Flexible
Responsible

We want our robots to be more human

While also ensuring manufacturing them is:
Simple & Affordable

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Robotics Today

The role of **servo and motion technology** within Robotics is now more important than ever

During this talk we will cover:

Intelligent Motion
Independent
Sensible
Mindful
Eco Friendly & Green Automation
Powerful
Flexible
Responsible & Safe Collaboration

While also ensuring manufacturing them is:
Simple & Affordable Implementation

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Motion Challenges in Robotics

Can be resolved with intelligent motion & smart servo control

Intelligent Motion > Simple Implementation > Green Automation > Safe Collaboration

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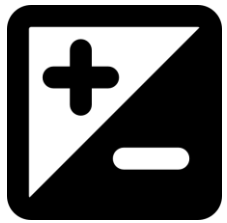
Motion Challenges in Robotics

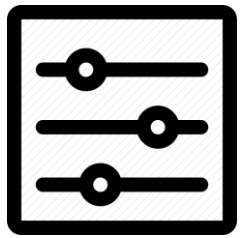
Can be resolved with intelligent motion & smart servo control

High Bandwidth

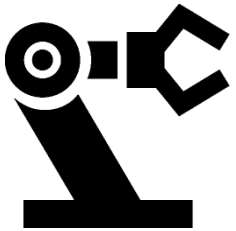
High sensitively, good resolution



Cogging Compensation



Current & Velocity Gain Scheduling



Advanced Kinematic Support

Intelligent Motion

Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration

*Best results with Any Servo Load *Wide bandwidth >4.5 KHz **fast & accurate PI Vector Control *Safety Feedback, Advance commutation (>3KHz) *Smart Phase advancing *High current dynamics 2000:1 *60us current loop *Current Loop Gain Scheduling *60us Velocity loop *Velocity Loop Gain Scheduling *60us Position loop *Position Loop Gain Scheduling *Selectable 1:1:1 or 1:2:2 Servo control *60us Velocity loop *60us Position loop *High order filters on different control loop segments *Low Pass filters *High Pass filters *Notch and Anti-Notch filters *Lead lag filters *Filters on references

*Functional Safety (IEC 61800-5-2 , SIL-3): STO, SOS, SLS, SS1, SS2, SLT, SBC, SLA, SAR…*FIR *Glitch *LPF *High order general bi quad filters *Scheduled filters *Unlimited Control Numerical values *Automatic calibration Procedures*Commutation alignment*Phase sequencing *Current loop *offset adjustment *Current loop gain tuning *Current gain scheduling *Velocity loop offset adjustment *Velocity gain tuning*Velocity gain scheduling *Position gain tuning * and much servo capabilities *Any Feedback on the market support *Absolute serial * incremental Quadrature *Incremental Quadrature + Halls

*Digital Halls only *Analog Halls (single turn sin- cos) *Serial Single and Multi Turn *Resolver with wide frequencies support *Analog Sin-Cos Encoder *8192 Internal multiplier *reaching 500,000,000 counts/ revolution *SAFE I/O *Encoder Emulation outputs *PWM (Pulse Width Modulation)

Emulation, Qu… Emulation *Current and velocity PWM Emulation *Wide referen… …ture reference

*P… & Direction re… e, CW/CCW reference, 50/100% P… M …erence *PL-e, CAT-4 …O 13849) *Advance Real Time Pro…ar… Environment *Full Redundancy *Elmo proprietary progra…ing language *ECAM *… Error correction *Output Compar… Master-Slave F… wer *Modulo *Dynamic "electronic… Braking *D… oop*MIMO Gantry* Planar Motor * …wer* Fast Event Capture Inputs

*Wide Homing methods *two advanced independent motion profilers *2 Analog inputs supports current, velocity, position loop* "By the Book" standardized IEC61158 EtherCAT

Gold Twitter | Highest Intelligence-Density Drive

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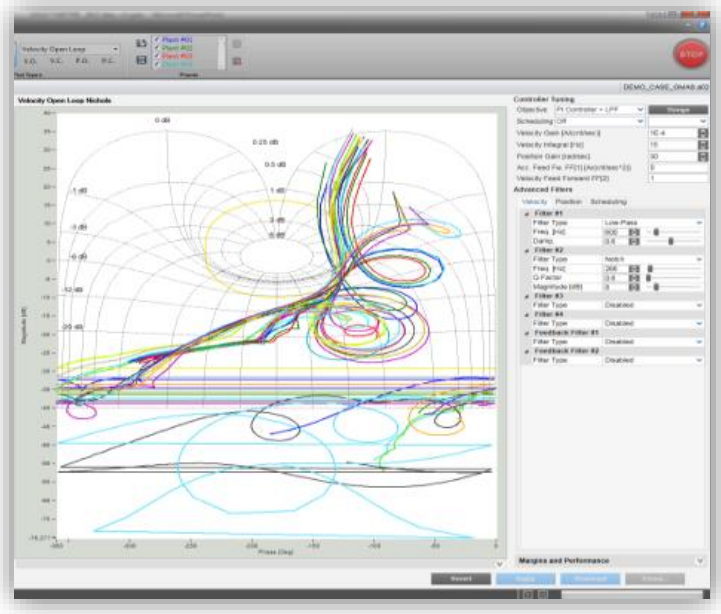
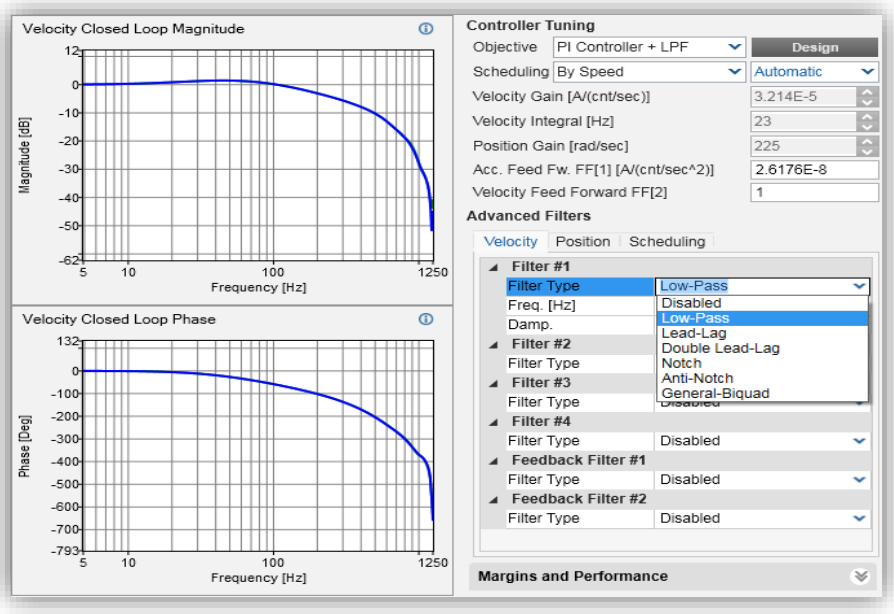
Advanced Tuning Tools

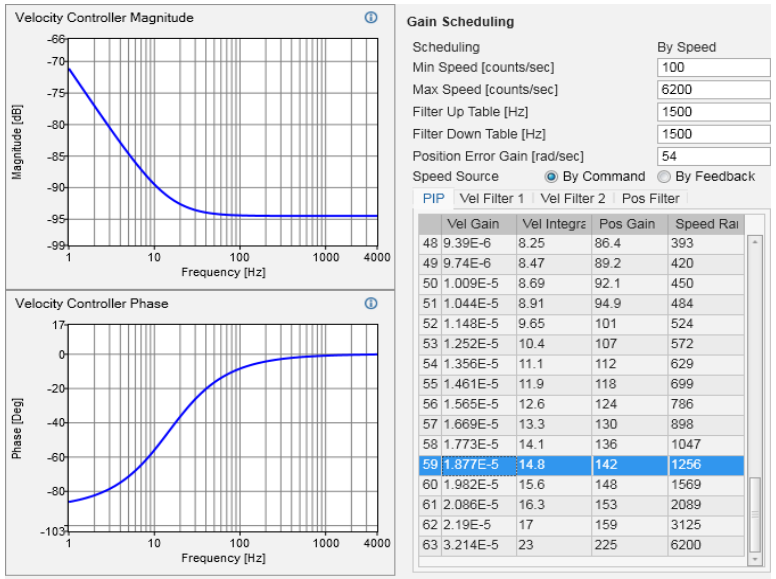
Enable robot manufacturers to achieve optimum performance at any position, with any load



Plant design



Filter design



Gain Scheduling

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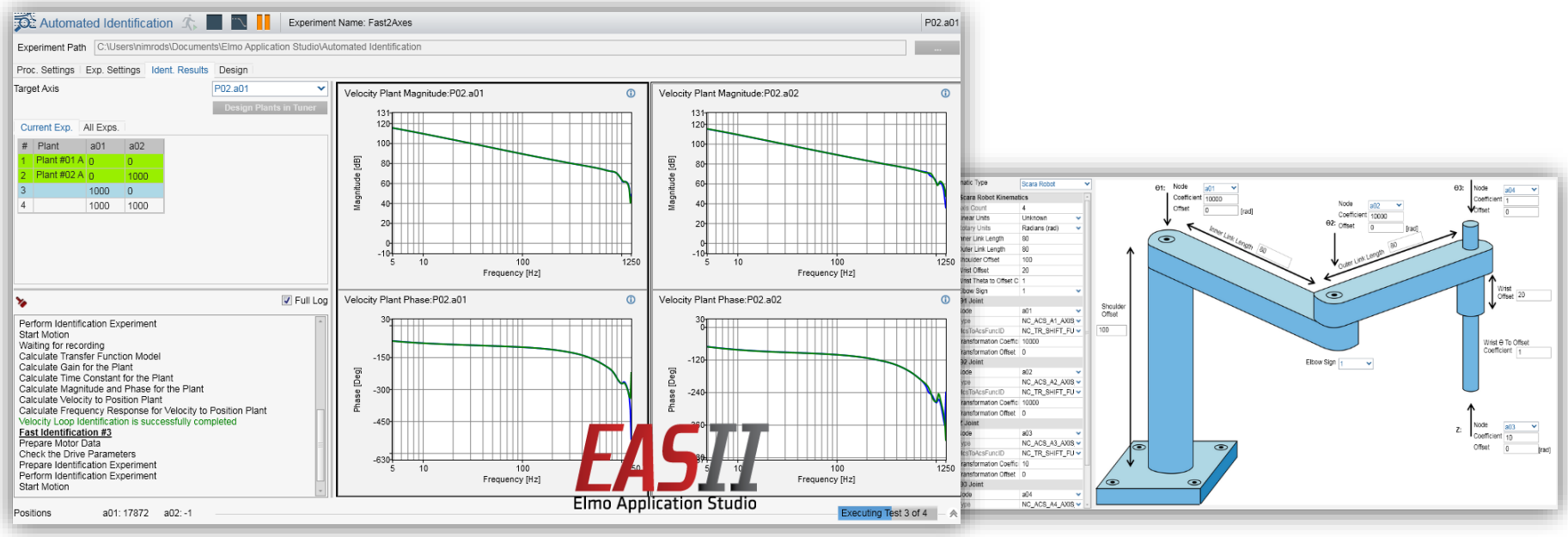
Automatic Multi Dimensional Tuning

Intelligently performs automatic 3D tuning and gain scheduling, to achieve optimal control algorithms for multi axis robots, with a click of a button



Robotics in Motion

Intelligent motion is about extending the barriers of the mechanics, taking robots beyond their limits.

Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration

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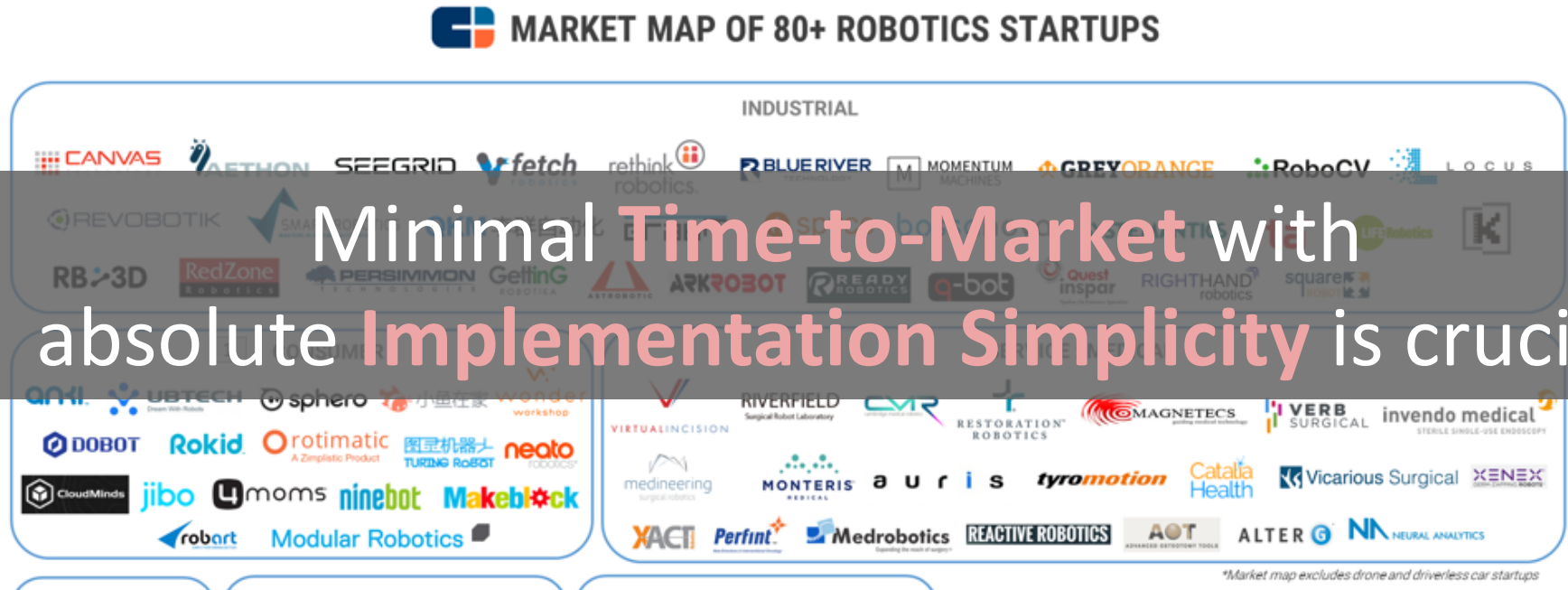
Instant Robotics

Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration

Everyone's Game | Robotics no longer just for big name companies

Small to medium size companies are creating innovative Robotics in all sectors



Minimal **Time-to-Market** with absolute **Implementation Simplicity** is crucial

Source: CB Insights

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Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration

Dedicated Robotic Motion Tools

Contribute to design, simulation, and commissioning **Simplicity**

Manufactures today decrease their time-to-market with:

advanced motion simulation tools

Tools for simple implementation and complex multi axis motion

Kinematic package presets, saving lots of time

Let’s examine some of these tools

The flexibility to **program in any stands language**, not needing to handling with code conversions

Automatic network identifications tools

Intuitive **visualization creation tools**

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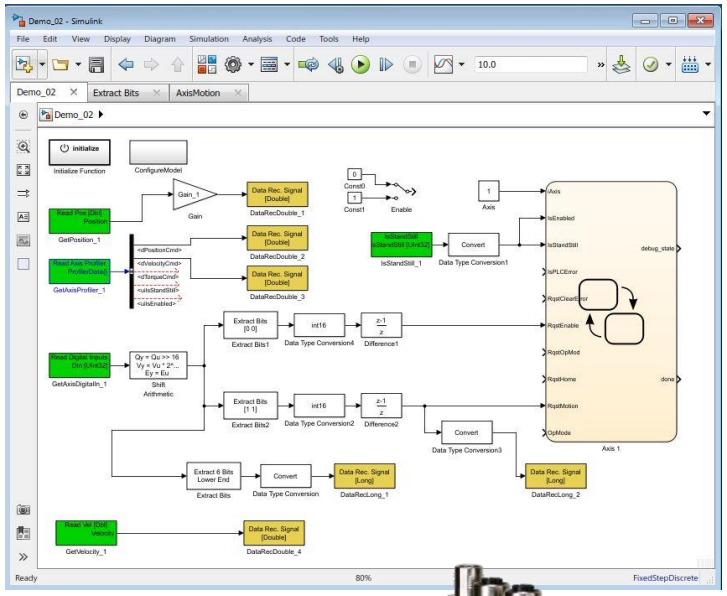
Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration

Software in the Loop (SIL)

A huge milestone for robotic manufacturers.

Complex models, profiles, kinematics and more are commonly programmed in a MATLAB/SIMULINK environment.

Special infrastructure within Elmo controllers allow for **integration of MATLAB code within the real time code of the robot**



Why does it matter?

(for example) customers can program their own unique kinematics, not needing drive manufacturer to pre-embed into the firmware, which may be raveling to their IP

Automatic code conversions | huge time saving | keep your motion IP

MATLAB → C++ →

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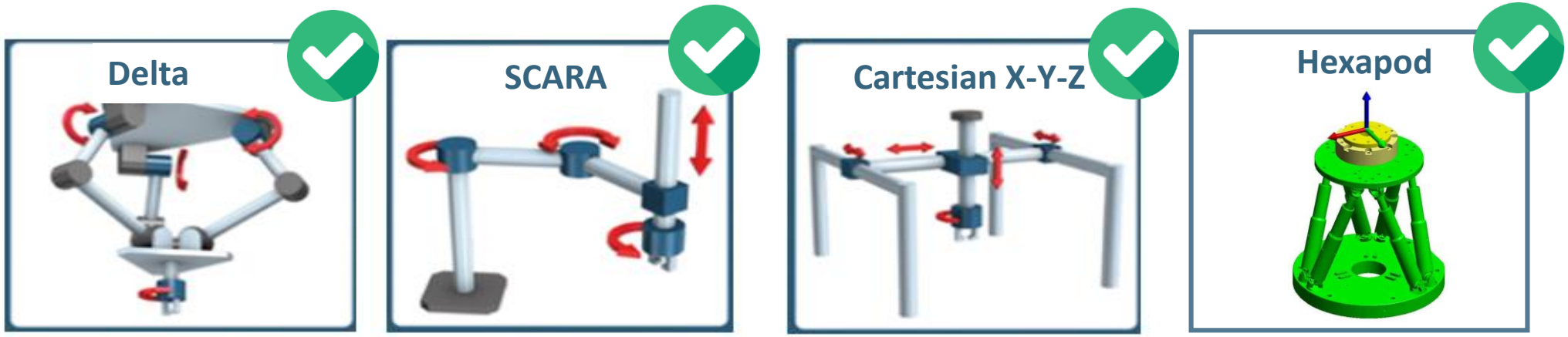
Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration

Built in Kinematics

For those with “standard” robot kinematics, the road to implementation is even shorter.



Built-in to firmware| standard feature | no time wasted on complex equations

Allows manufacturers to focus on their application

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Simplifying Motion

The Motion Interface that does it all

Simple multi axis motion implementations

Advanced tools for machine building, testing and performance enhancements

Visual 2D/3D tools for simulations and recording of profiles

Tools to **increase** machine **accuracy** and **throughput**

Saves time in setting up a system, and simulating, and commissioning a robot/machine

Enhanced Visualization Tools

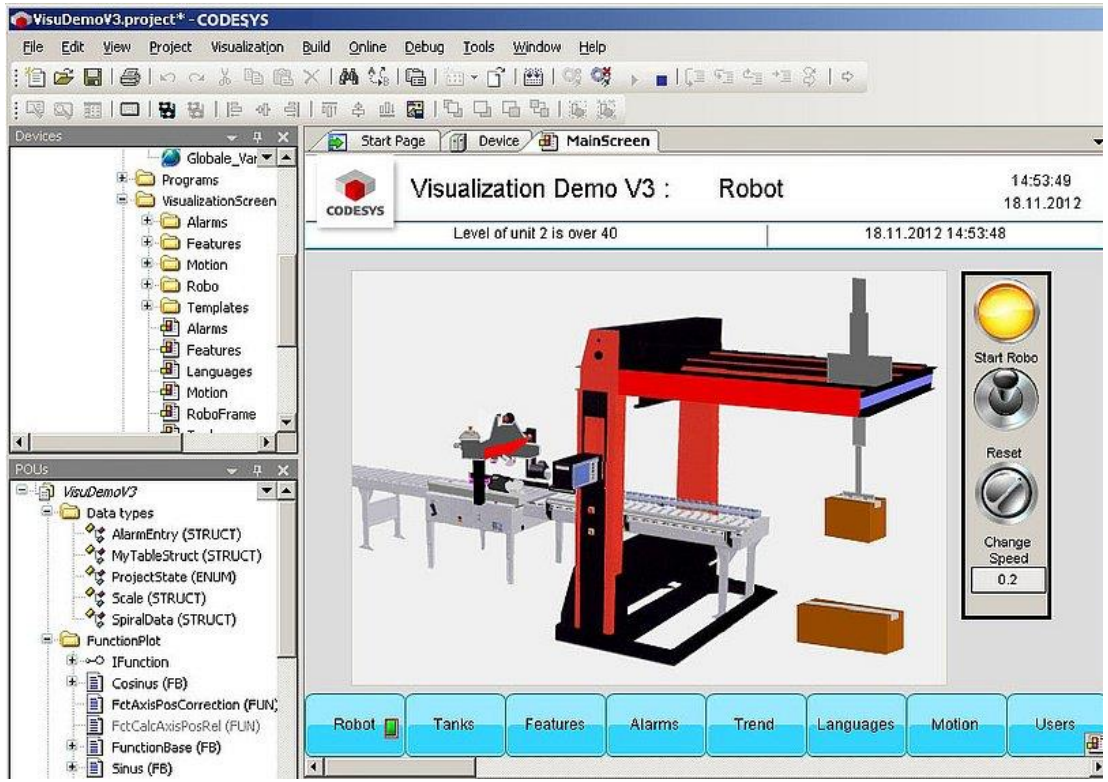
Allow manufactures to create fully functioning remote/target HMI screens simply and intuitively

Operators want to **monitor** robot and component operation **in a simple and graphic way**

Development of **high level HMI** Screens directly in the **IEC 61131-3** IDE, with direct access to all application and motion variables

Target device (HMI) or **Remote Visualization** (web browser HTML5)

Operation is **straightforward and easy to use**



Profile Simulator

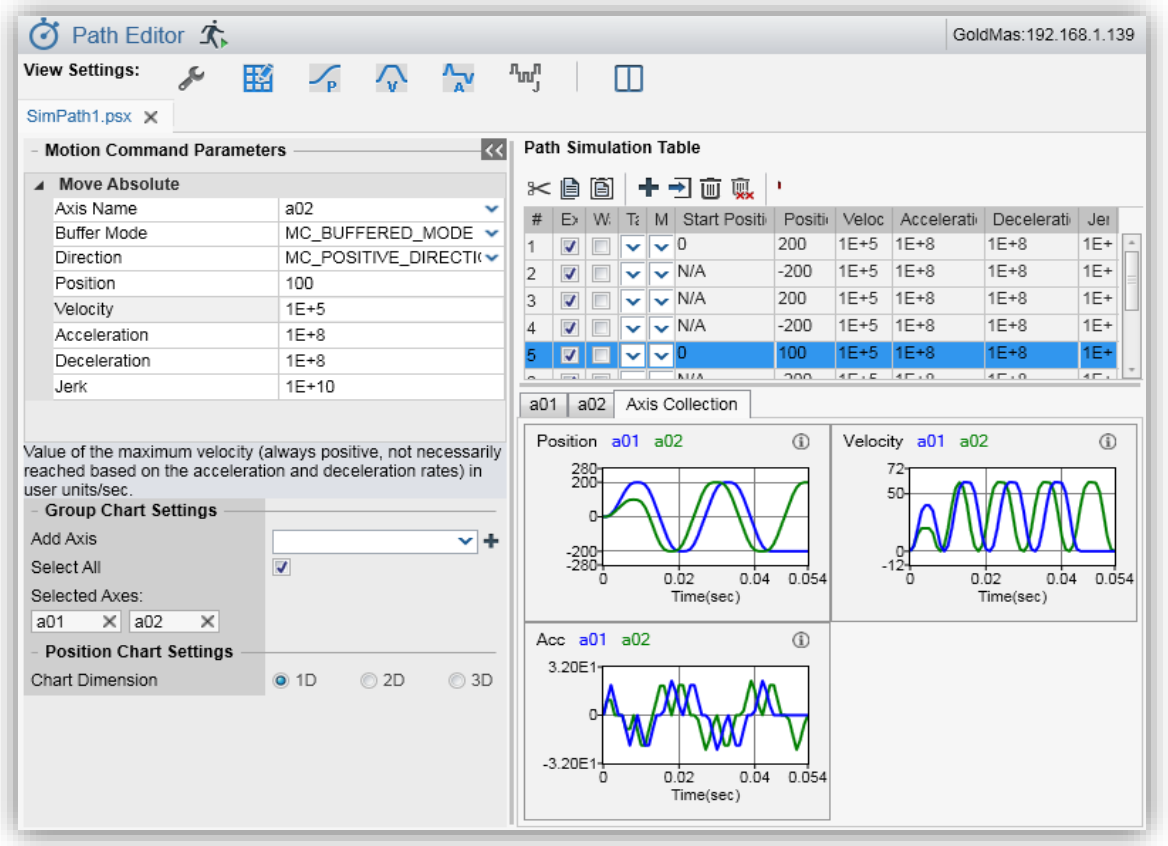
Comprehensive Motion Prediction

Manufacturers can **plan and simulate motion** from a .NET library interface

Profile simulation for **single/multi axis**

Understand in advance where robot mechanics will experience jerks, oscillations, and other mechanical behaviors

Save time | predict behavior | immediate results



Simple Implementation of robotics is helping manufactures improve their time-to-market, while increasing overall competitiveness

Intelligent Motion | **Simple Implementation** | Green Automation | Safe Collaboration

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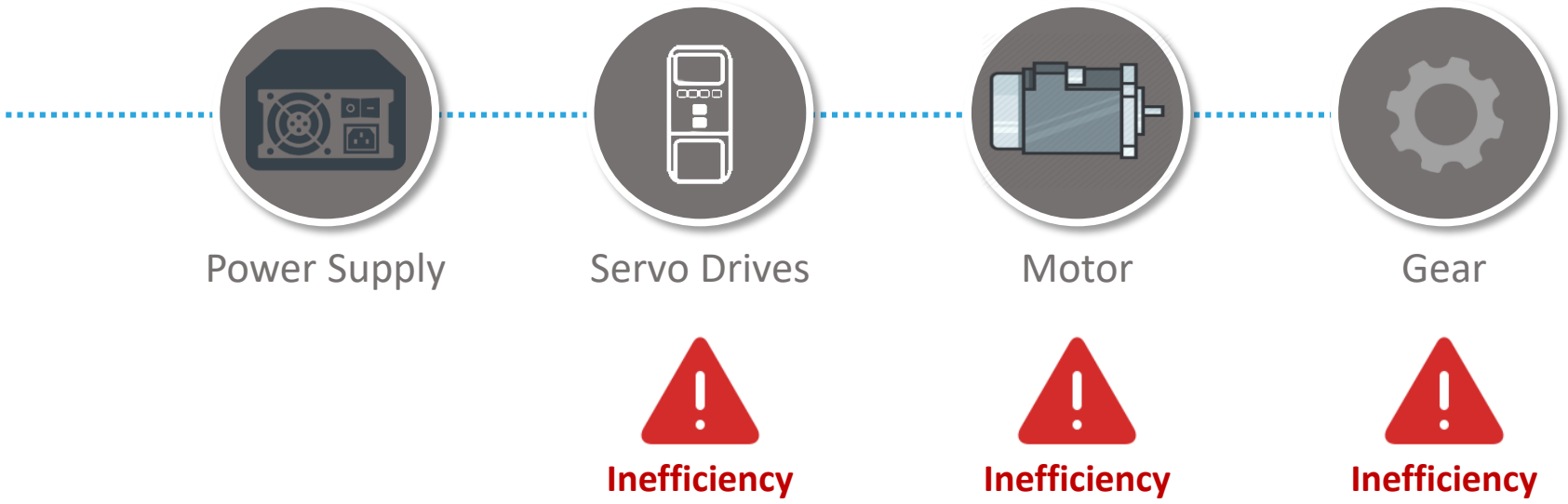
Battery Operating Mobile Robotics

Efficiency of the Servo drive is mandatory and critical to all types of battery-operated AGVs

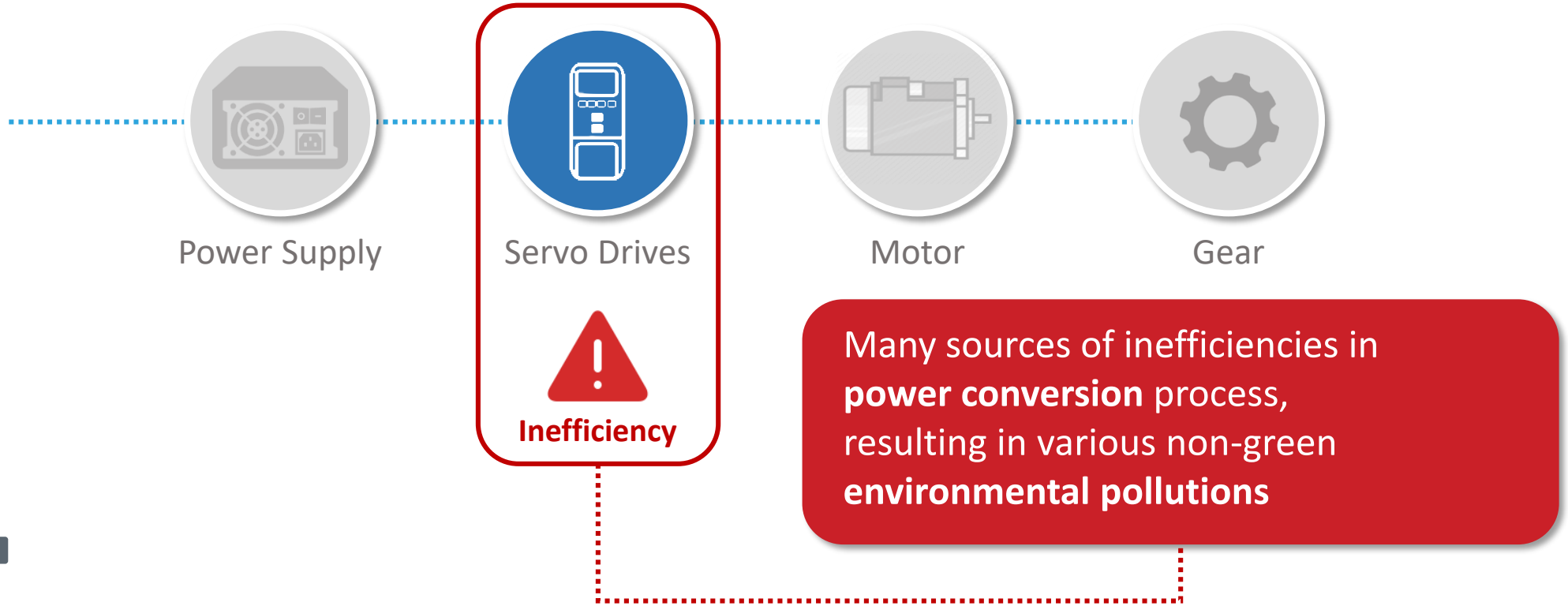
Higher efficiency means **longer AGV operation between charges.**

Better efficiency also means taking better care of the battery and prolonging its lifetime

Inefficiencies in Motion Control Systems



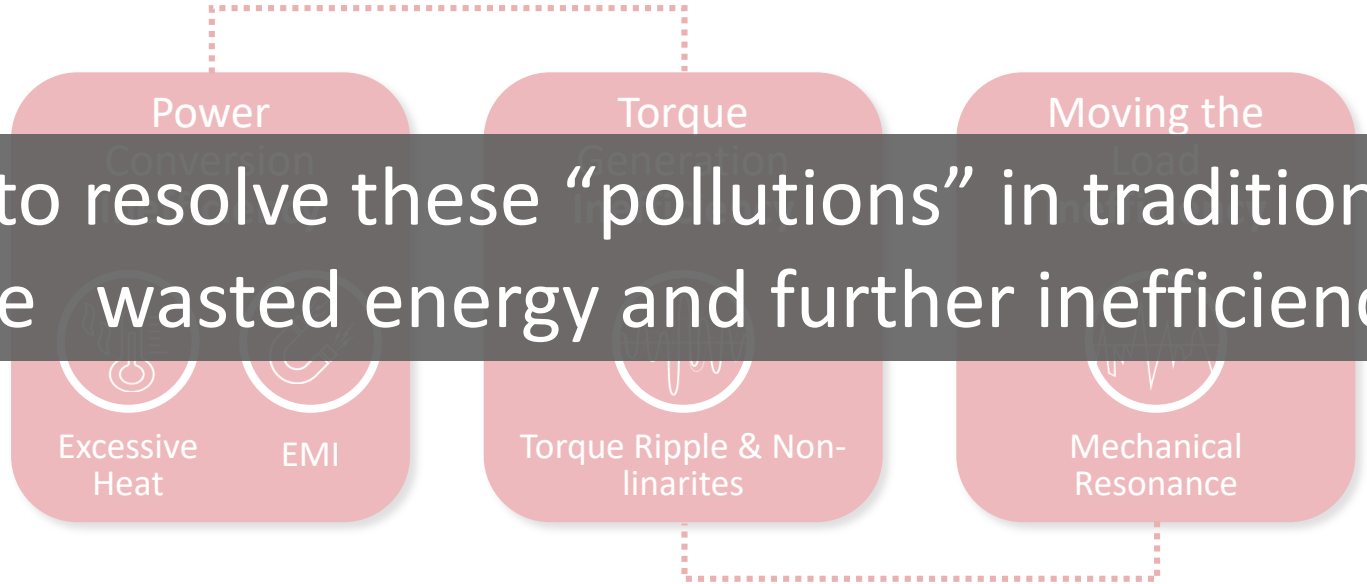
Inefficiencies in Motion Control Systems



Green Automation

Inefficiencies in Motion Control Systems

The **inefficiencies** in the servo world result in non-green **environmental pollutions**:



Trying to resolve these “pollutions” in traditional ways, will lead to more wasted energy and further inefficiency

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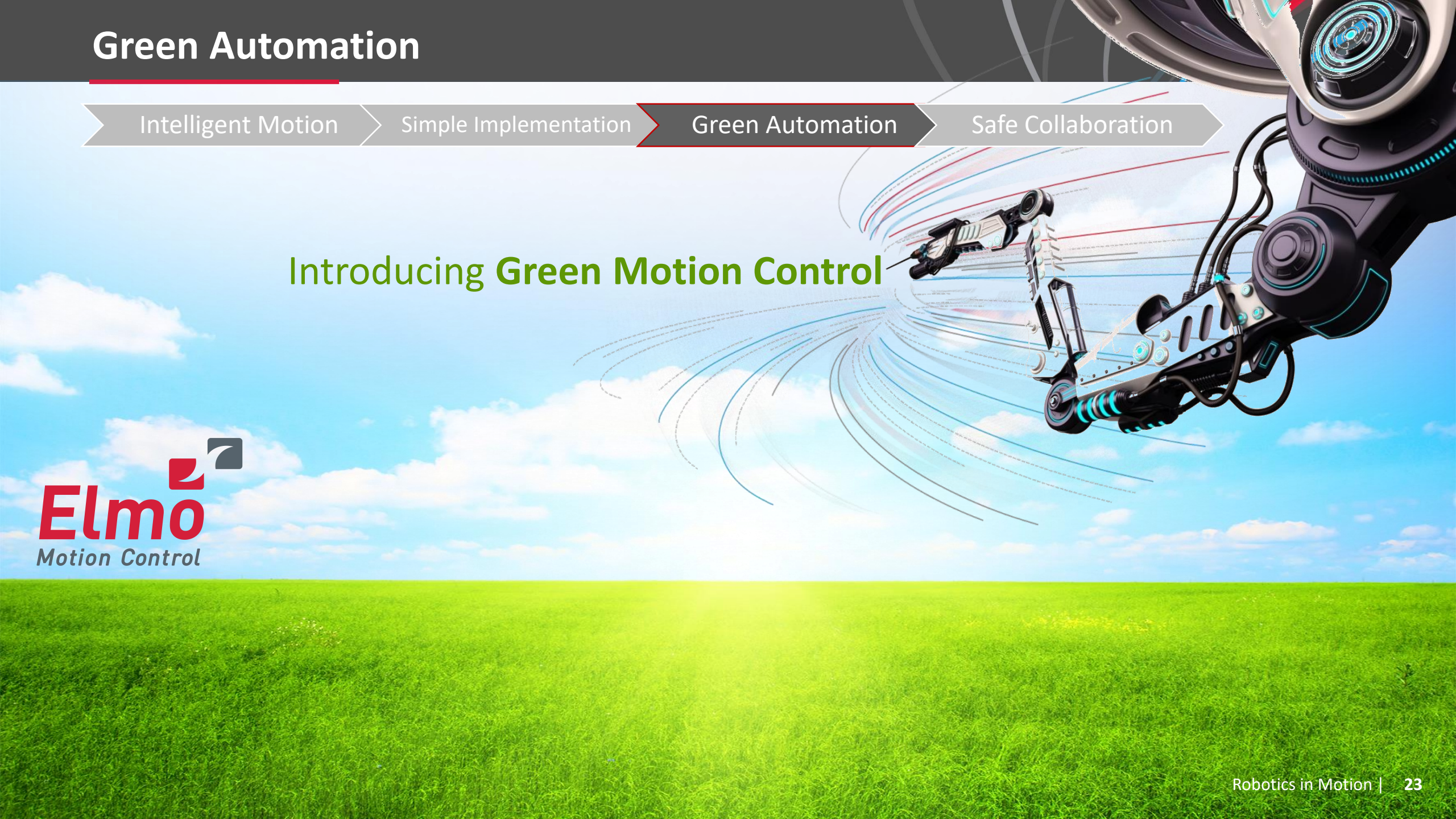
Green Automation

Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration



Introducing **Green Motion Control**

Elmo Motion Control

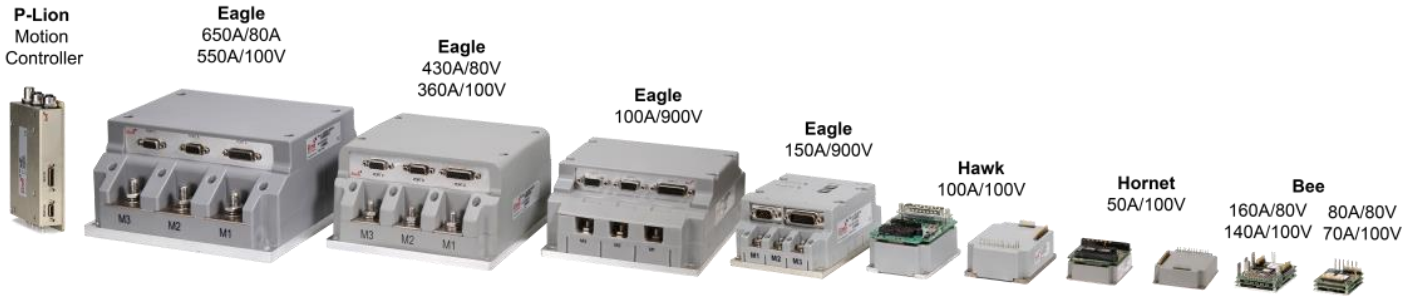
Green Automation

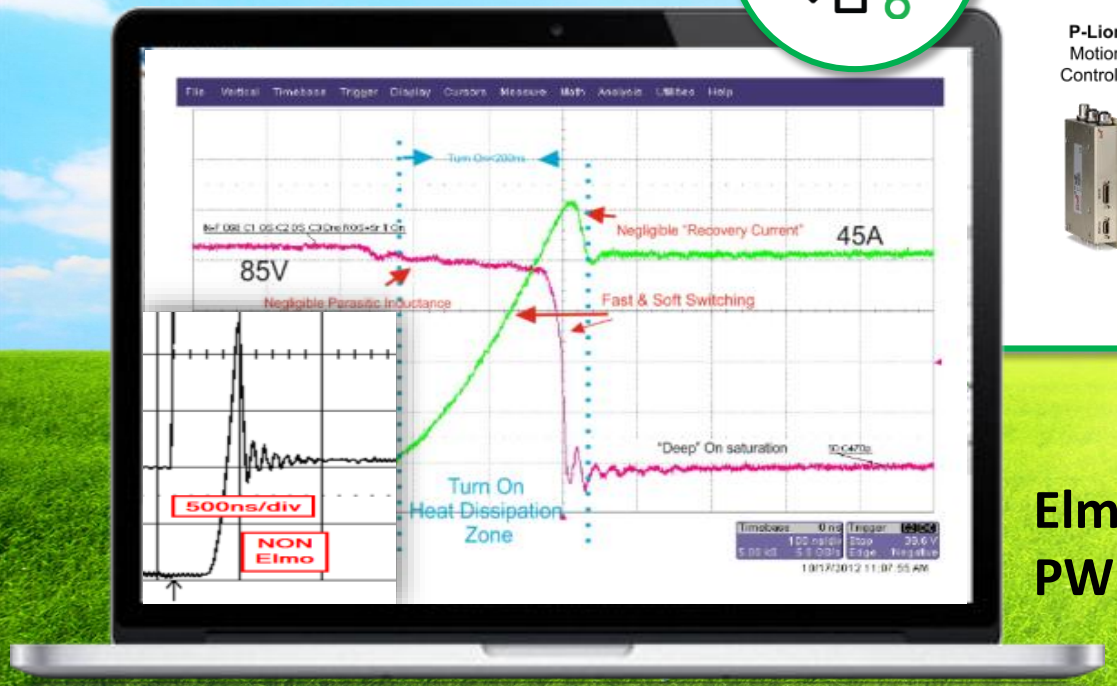
Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration

Green Motion Control

With ultra Efficient Power Conversion

Elmo servo drives are **99% efficient** in power conversion |**Minimal heat** generated| **Minimal EMI** |





Elmo's proprietary FASST PWM switching technology

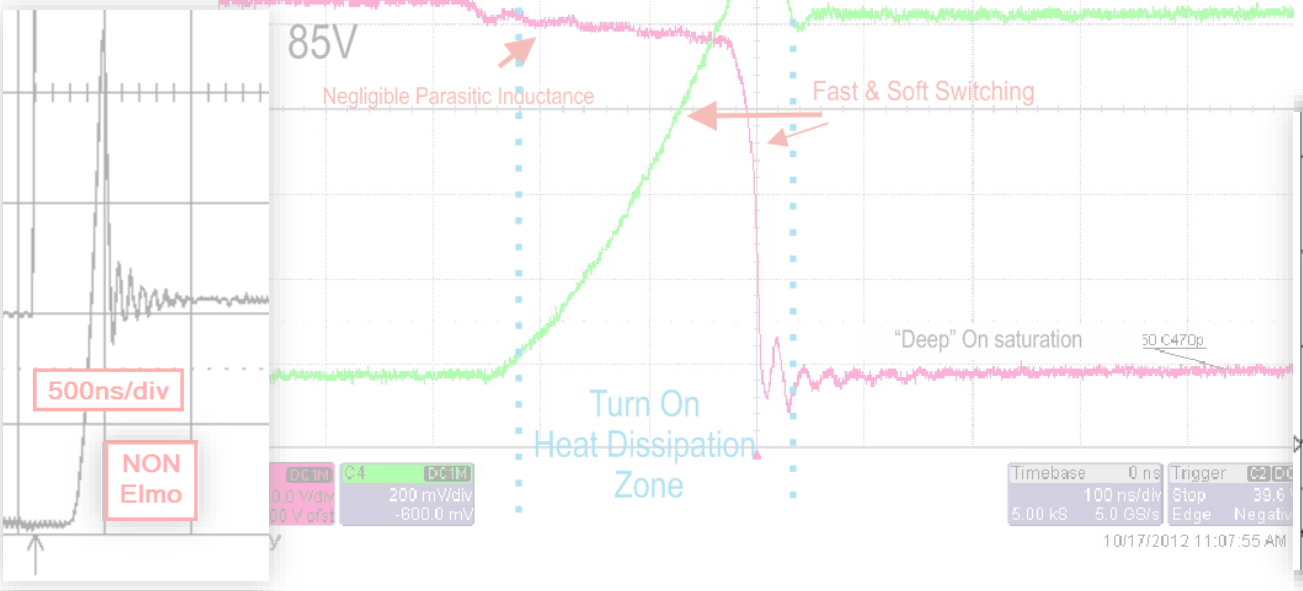
Green Automation

Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration

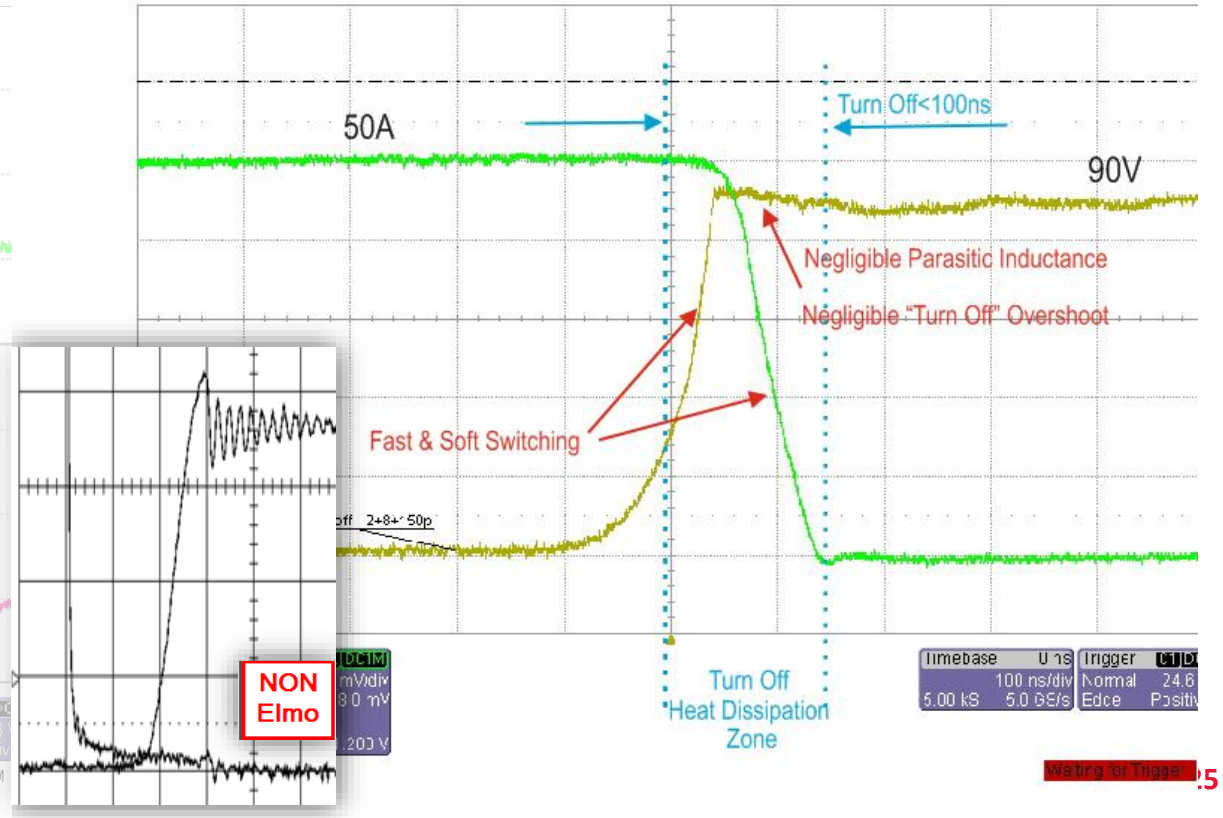
Fast and Soft Switching Technology (FASST)

99% efficient in power conversion | **Minimal heat** generated | **Minimal EMI** |

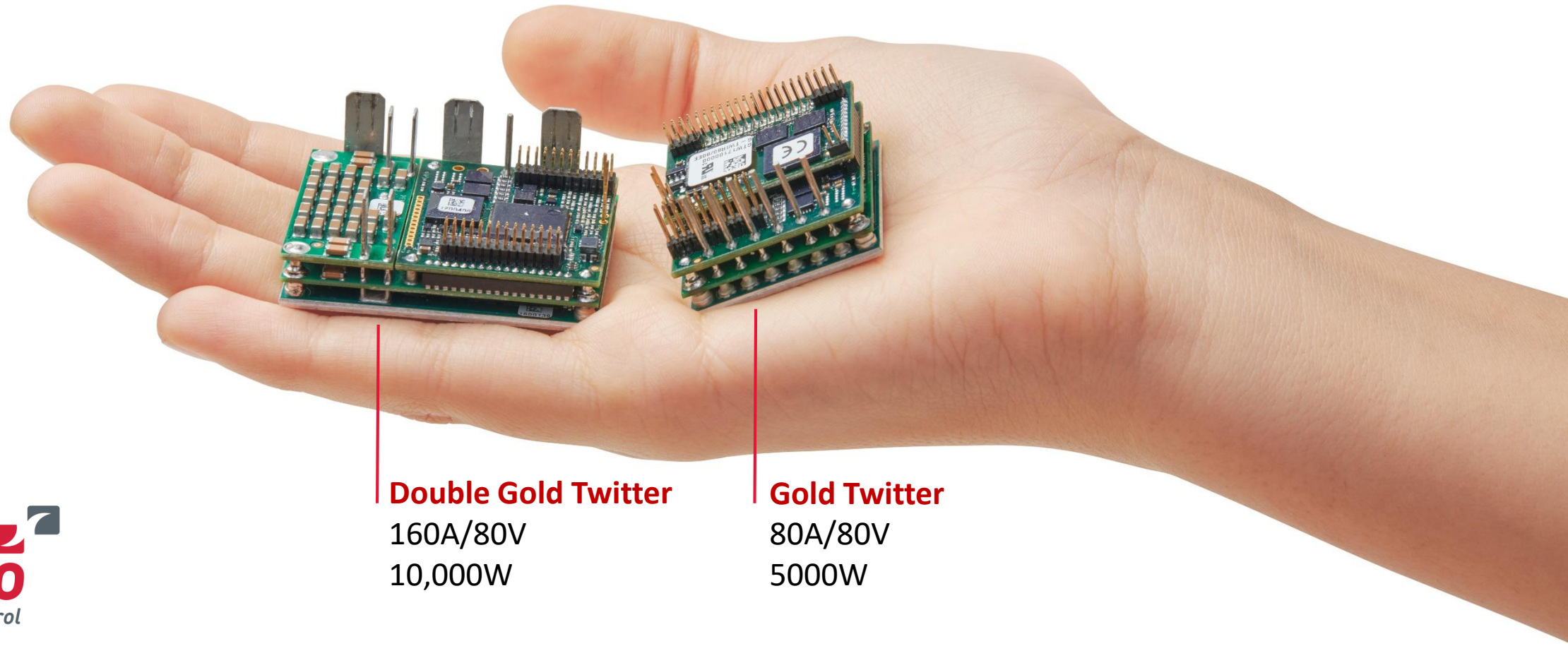
Turn On



Turn Off



What Ultra Efficient Servo Drives look like!



Double Gold Twitter
160A/80V
10,000W

Gold Twitter
80A/80V
5000W

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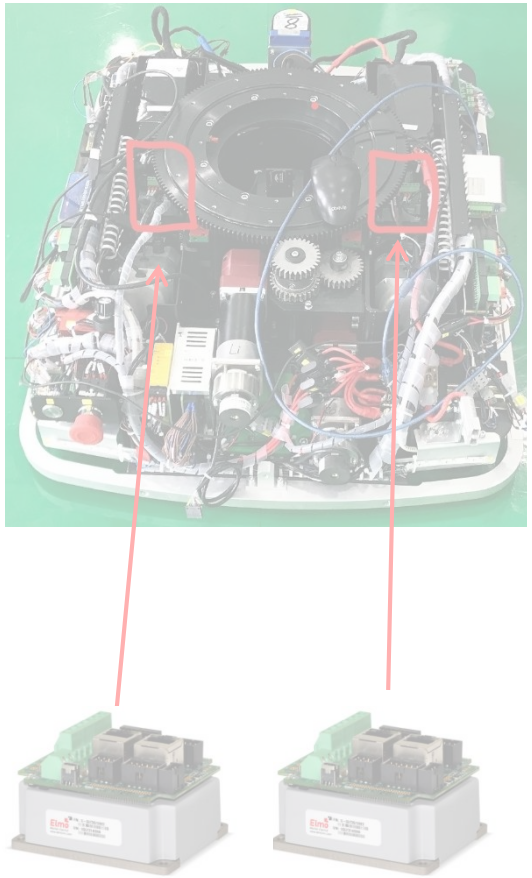
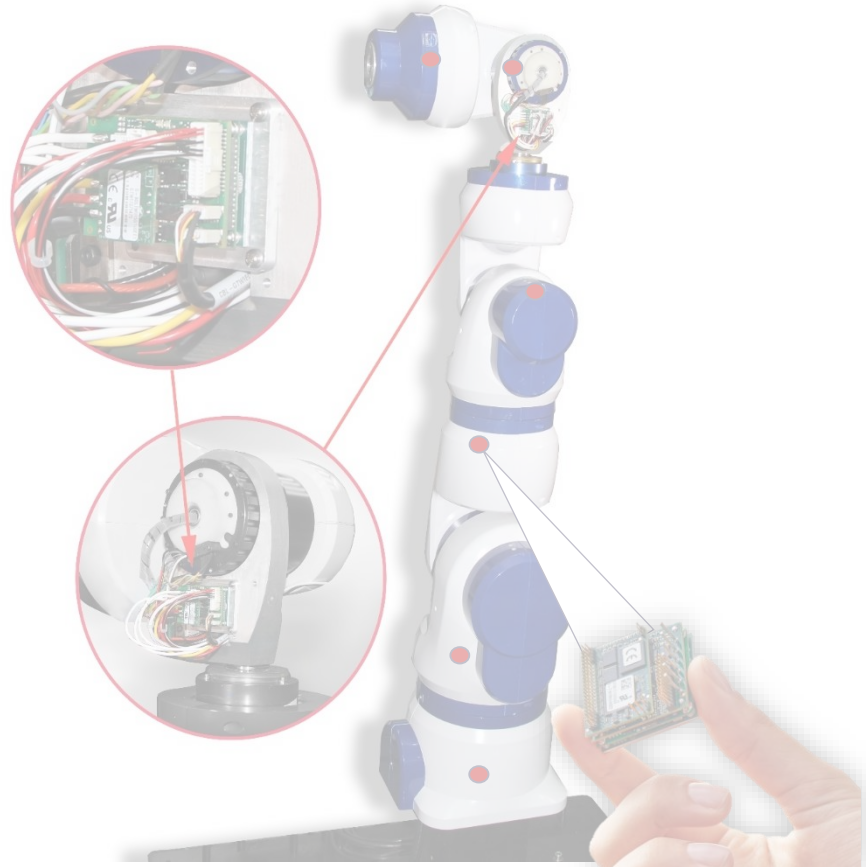
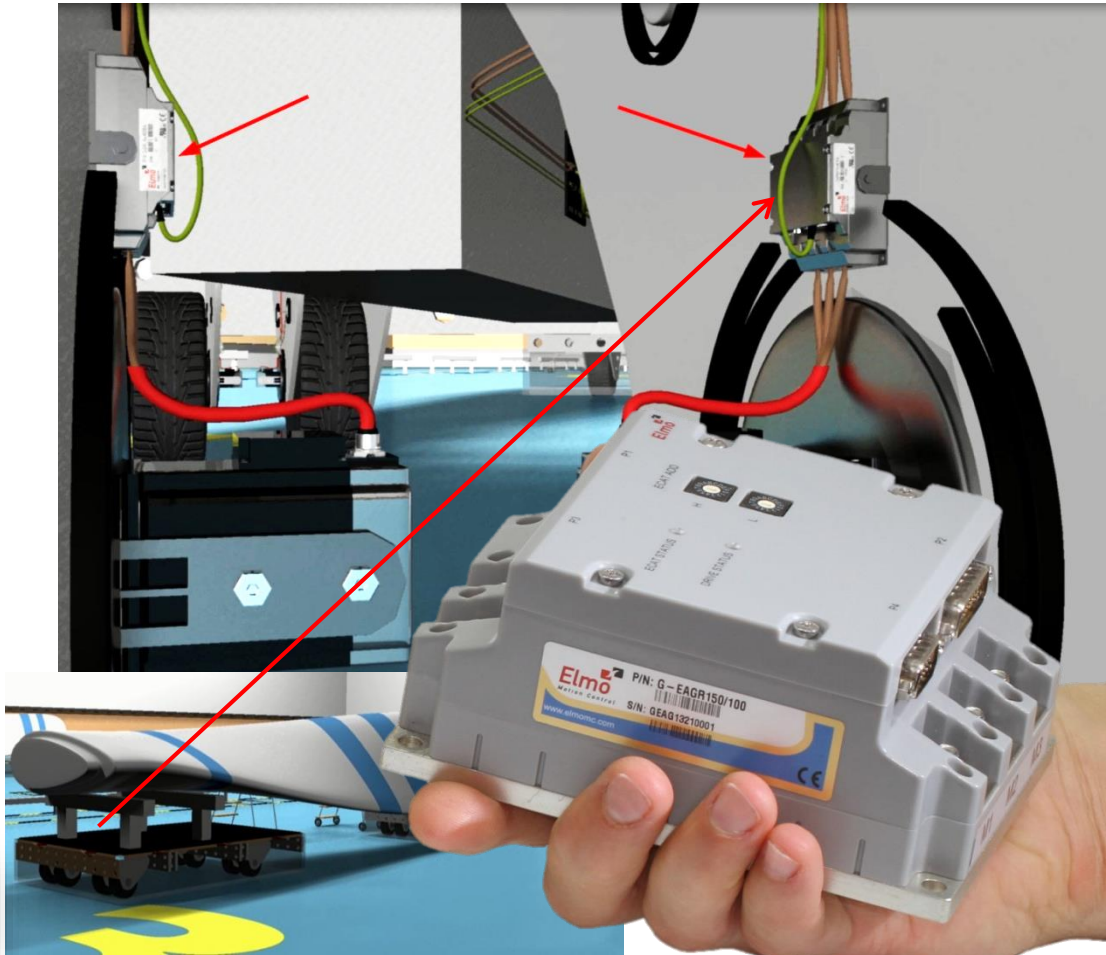
What Robots with Ultra Efficient Servo Drives look like!





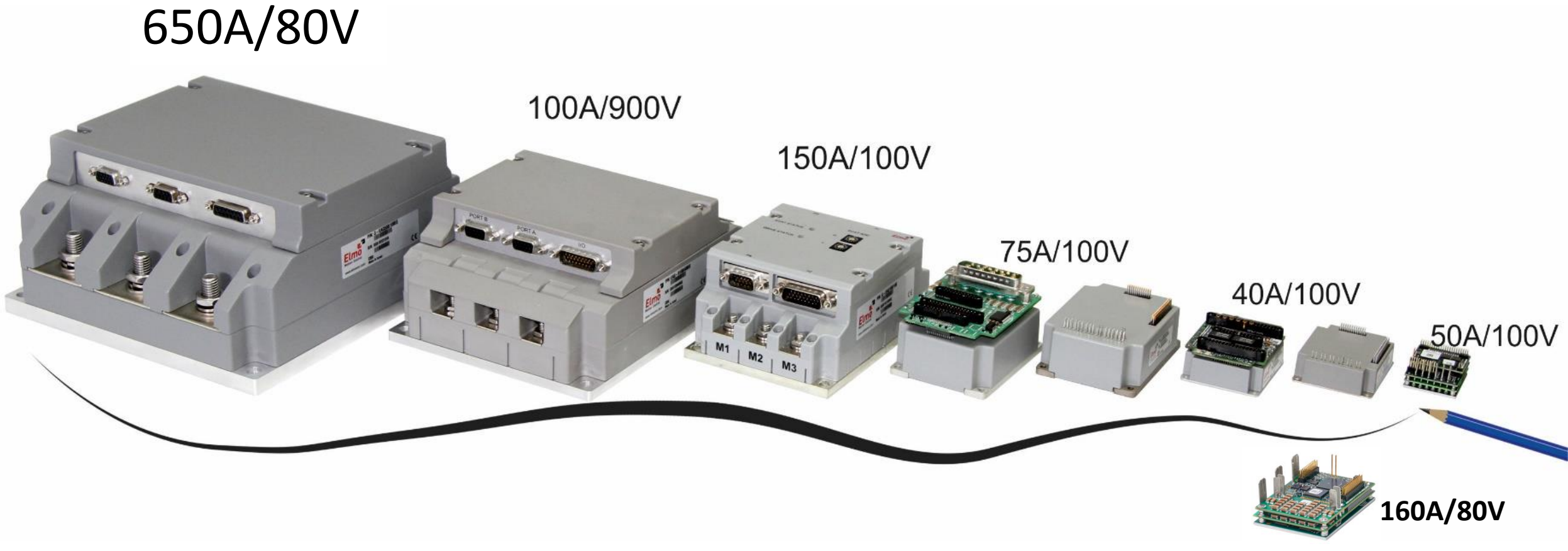


Green Automation

Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration

High Efficiency Means High Currents in Small Packages

Ideal for high power robotic applications, with confined space, and battery operation



Green Automation driven by efficient servo drives contributes to minimized robotic design, with high power, low EMI, and energy savings

Intelligent Motion | Simple Implementation | **Green Automation** | Safe Collaboration

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Traditional Machine/Robot Safety

A machine/robot that cannot injure humans

Safety guards

Safety **cages** and **fences** around industrial robot

Safe mechanical construction

No sharp edges, accessible hazards, etc.

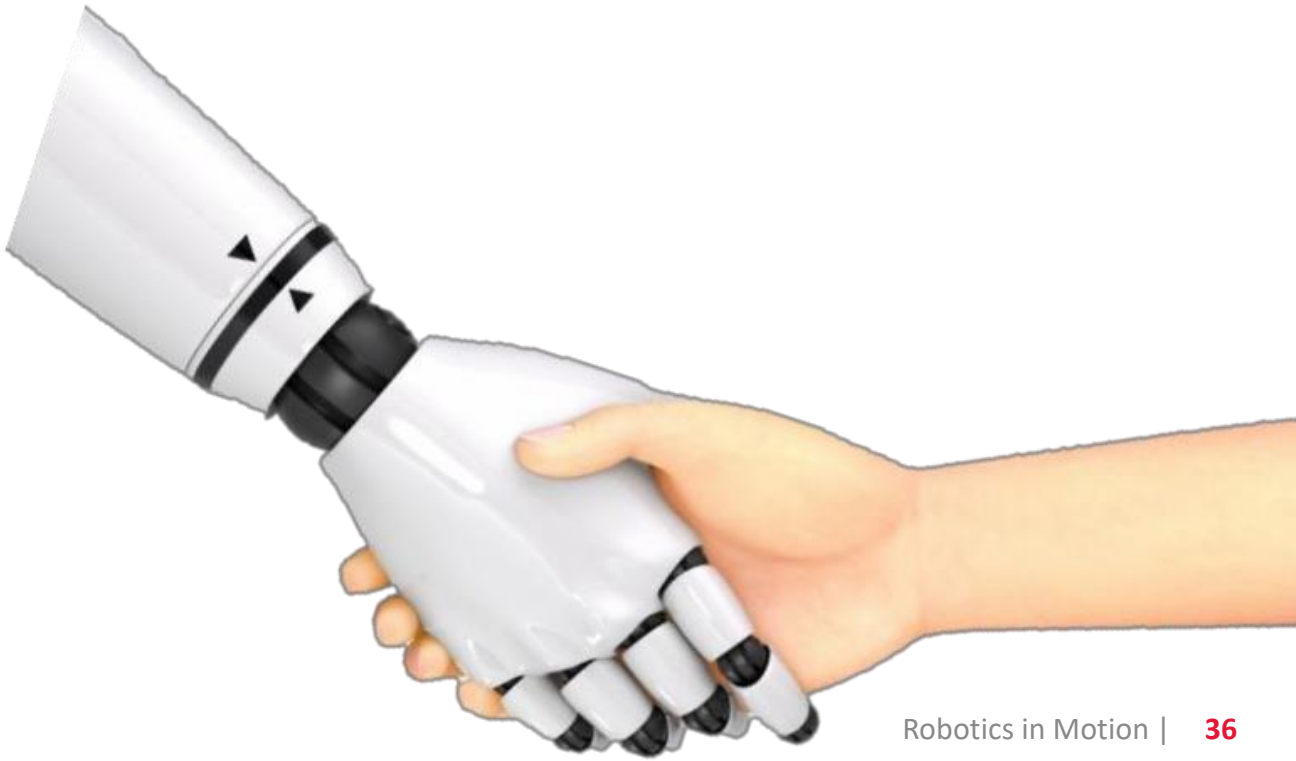
No manual loading/unloading

The traditional way:

No access no risk

Safe Collaboration

But production today is more complex, there is a higher degree of **human-machine interaction.**



Safe Collaboration

Intelligent Motion | Simple Implementation | Green Automation | Safe Collaboration

The New Wave of Robotics

Human-Machine Collaboration

Human-Machine "Intimate" Interaction

Unmanned / Uncaged / Autonomous

Adaptable/Flexible Workspace

Safety, more than ever is an **integral part of today's smart factory,** with Servo Drives in its heart

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Safe Collaboration

‘Functional Safety’ shift the safety responsibility, now **relying on the servo drive** for critical safety functions

This shift creates a huge advantage for manufacturing:

Less Hardware

Less Price

Less Time to Market

Safe Collaboration

Doing all of that,

with this…. And much more

That, is **SMART SAFETY.**

Less Hardware

Less Price

Less Time to Market

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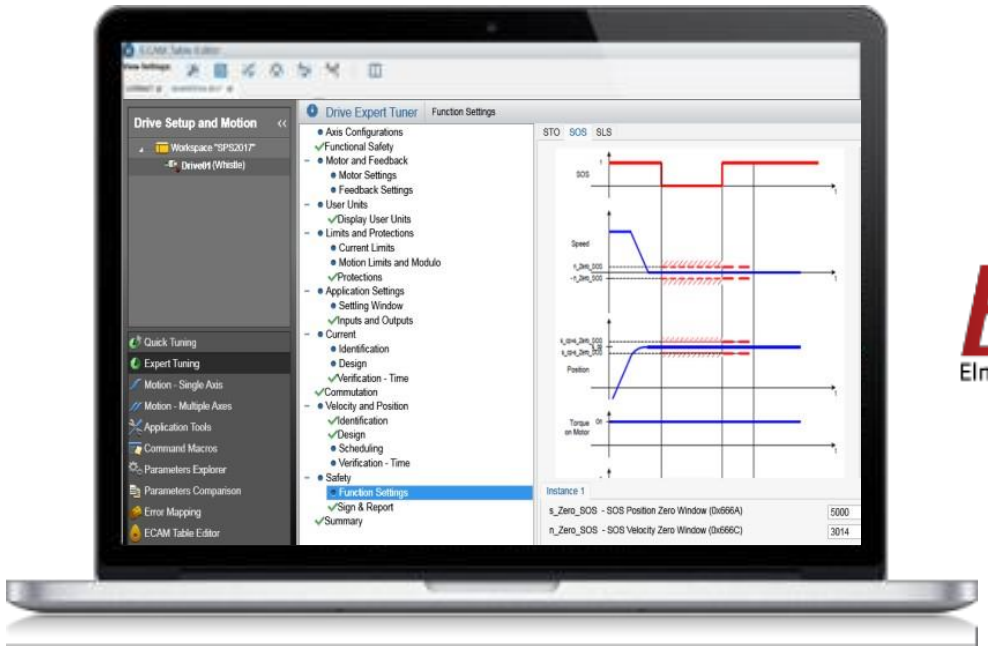
Safe Collaboration

Fast & Simple Safety Implementation

The world's most advanced motion implementations software is now where you can **easily customize your robot's Functional Safety.**



SOS (Safe Operating Stop) Implementation

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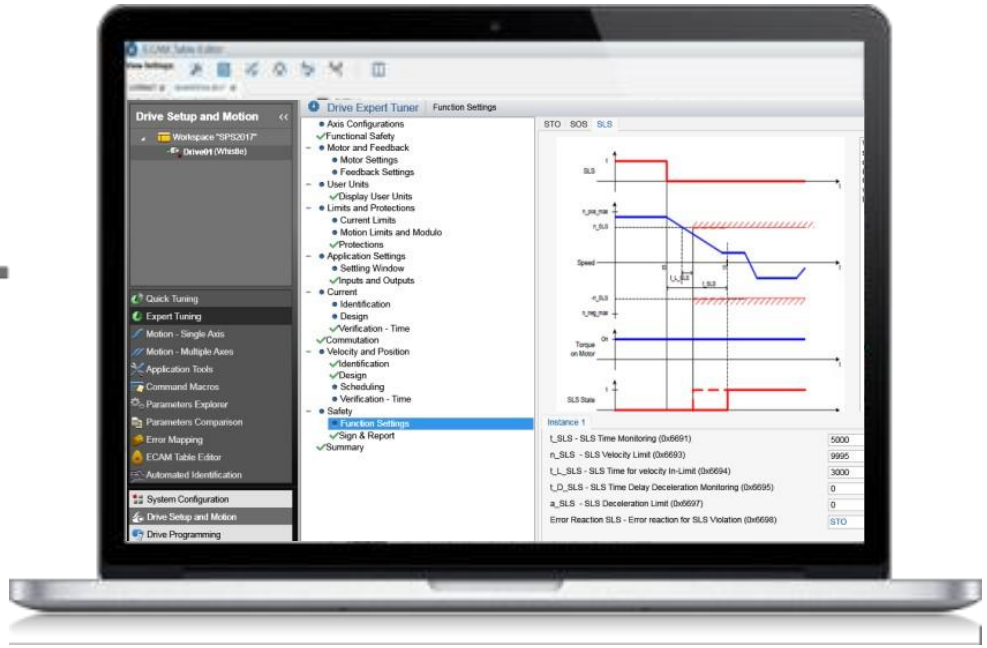

SLS (Safely Limited Speed) Implementation

Safe Collaboration is about truly reliable safety orchestrated by servo drives, leading manufacturers to save on hardware, cost, and development time

Intelligent Motion > Simple Implementation > Green Automation > Safe Collaboration

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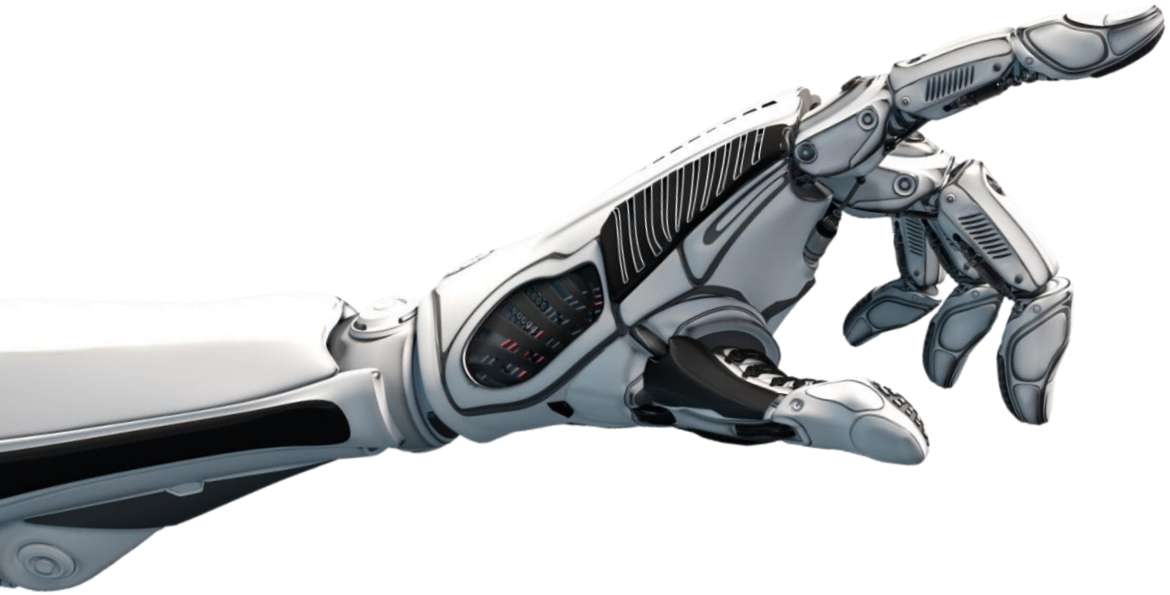
The role of **servo and motion technology** within Robotics is now more important than ever



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THANK YOU

ROBOTICS IN
MOTION

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