Configuring a maxon ESCON Speed Controller

The ESCON is a 4-Quadrant PWM servo controller used to control permanent magnet motors in a highly efficient manner. The ESCON can control motors rated up to 700W on a continuous basis and 2100W for a short period.

The following will provide an overview on configuring the ESCON based on your analog/digital input requirements, and the motor being used, assuming an appropriate power supply is in use.

Once the ESCON studio (http://escon.maxonmotor.com) has been downloaded and installed, the wiring must be set up according to the ESCON Hardware Reference (model specific). If the studio is downloaded, the hardware reference can be found:

C:\Program Files (x86)\maxon motor ag\ESCON Servo Controller

Following the wiring set up, launch the ESCON studio, and observe the safety instructions:
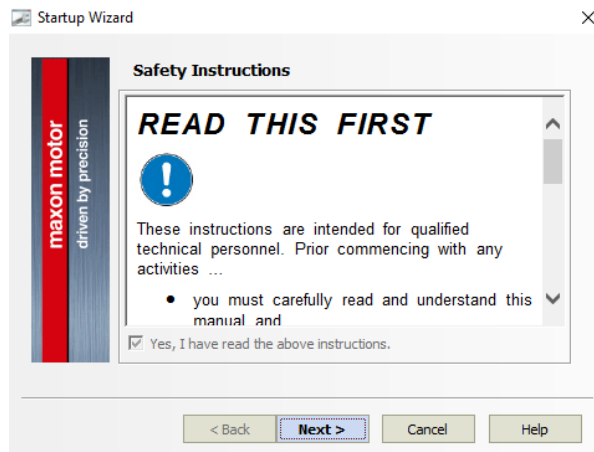

Figure 1 - Safety Instructions

If the controller has been connected via USB, the option will be available, alongside (USB0) in brackets, to indicate it is connected and it is not a virtual controller.
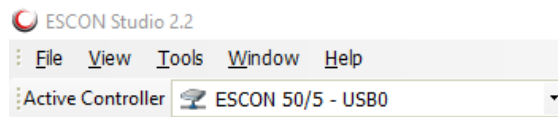

Figure 2 - Controller connected via USB

Following this stage, the Start-up Wizard is where all parameters are entered with regards to the motor data, system data and I/O implementation.

Motor Type

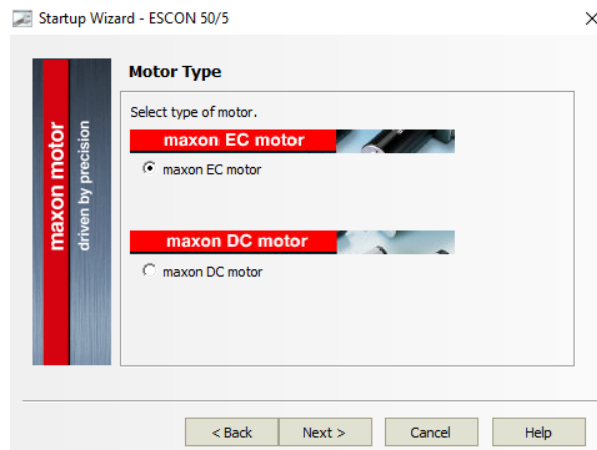The first step is to identify the type of motor in use; DC or EC, i.e. Brushed or Brushless DC commutation.

Figure 3 - Motor Type

Motor Data

Now the motor data can be added, including the speed constant, thermal time constant of the winding and the number of pole pairs.
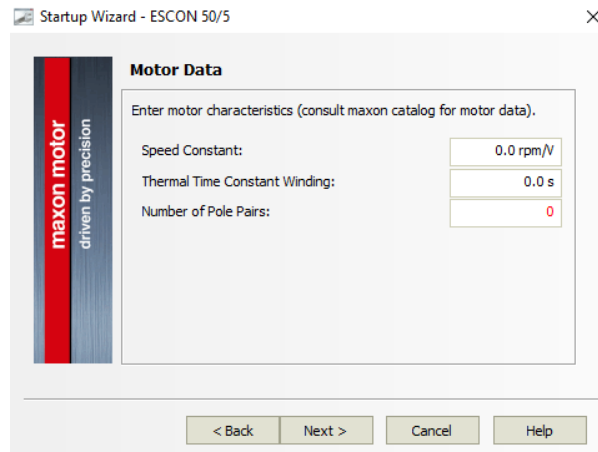

Figure 4 - Motor Data

This information can be found in the maxon catalogue, on the data sheet for the motor, on lines 13, 19 and 29 respectively.

Although the value for the speed constant is manually stated, it is also determined during the regulation tuning process, which occurs after the initial start-up.

The number of pole pairs has an impact on the maximum speed available from the controller and is only applicable to brushless DC motors.

System Data

The data for the overall system can now be configured. This is essentially the maximum permissible speed and the maximum current, which equates to the maximum torque.
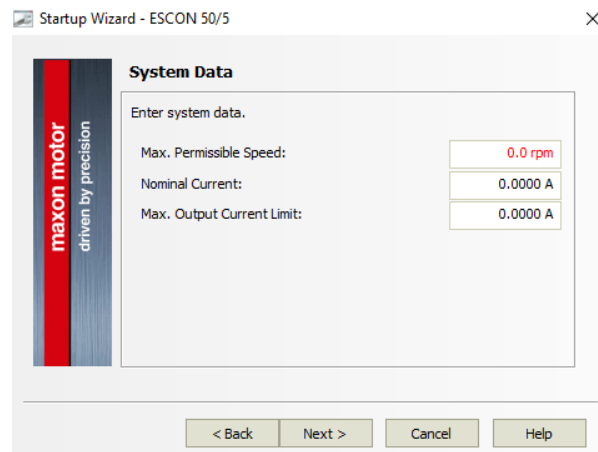

Figure 5 - System Data

The maximum permissible speed may be limited by several factors, such as:

- Maximum controller speed
- Number of pole pairs
- Maximum permissible speed of motor
- Maximum continuous input speed of gearbox
- Maximum speed of load
- Speed constant of motor / Voltage available.

The nominal current is applicable to the motor, see line 6 of the motor data in the maxon catalogue.

The limiting factors of the maximum output current are:

- Nominal torque of motor
- Maximum output torque of gearbox
- Available current
- Maximum torque of overall system
- Ambient temperature
- Current required for acceleration/deceleration.

It is typically recommended to have a maximum output current limit of twice the nominal current, to account for acceleration current. This can be later adjusted if required.

Rotor Position

When using the ESCON controller with a brushless DC motor, hall sensors are required for commutation unless the sensorless ESCON is used. The hall sensors detect the positioning of the rotor in order to fire the correct phase winding at the right time. For maxon motors, the polarity of the hall sensors will always be according to the maxon standard, however for third party motors, they may be inverted.
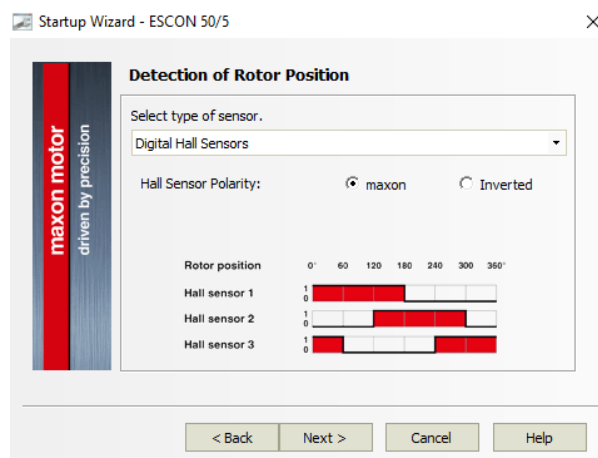

Figure 6 - Rotor Position

Speed Sensor

Depending on whether a DC motor or EC motor is being used, various configuration options are available for the speed sensor, they include:

- Digital Incremental Encoder (DC/EC)
- DC Tacho (DC)
- No sensor (DC)
- Hall Sensors (EC)

For low speeds and fluctuating loads, it is advised to use a digital incremental encoder for feedback. Note, the encoder must have a minimum of 16 counts per turn, which results in 64 quadcounts.
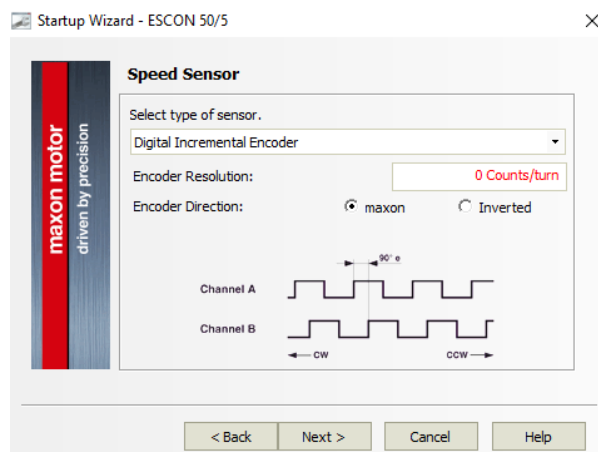

Figure 7 - Speed Sensor

Mode of Operation

The ESCON offers both speed and torque controllability, and dependant on whether a sensor is being used, the following modes are available:

- Current controller
- Speed controller (Closed loop)
- Speed controller (Open loop)
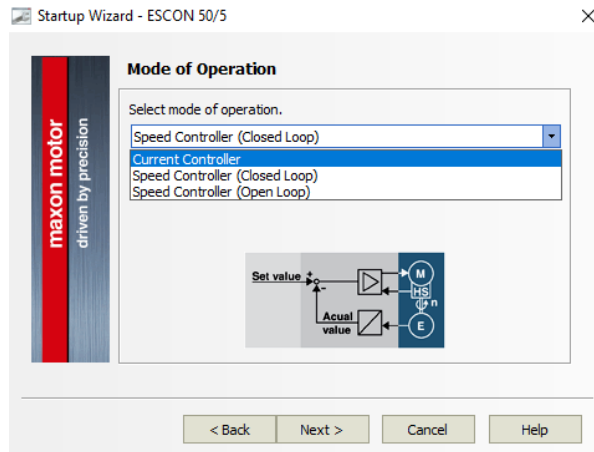   - Static IxR Compensation
    - Adaptive IxR Compensation

Figure 8 - Mode of Operation

When using ESCON for speed control, closed loop operation is usually the preferred choice, if the motor has an encoder or hall sensors. However open loop control can be used for certain low complexity applications, such as fans and pumps, where the load and speed remain consistent.

IxR compensation is implemented as a form of control when in open loop operation. The speed controller provides a voltage to the motor which corresponds to the set value speed, based on the speed constant. With an increasing load, the speed would reduce. IxR compensation accounts for this by observing the terminal resistance of the motor and the current draw.
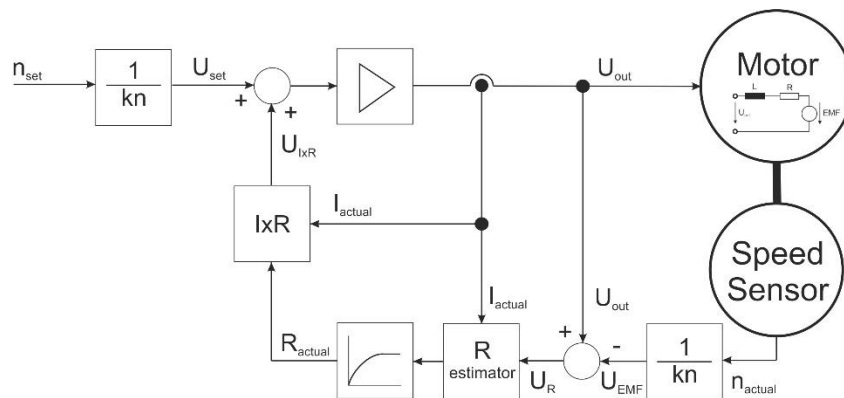

Figure 9 - IxR Compensation, Block Diagram

Due to the linear proportion between current and torque, current control allows you to maintain the required level of torque and adjust, depending on application. Typical applications would be torque wrenches and pressing tools. No additional sensors would be required for current control.

Enable Function

To enable the power stage of the ESCON, 5 volts must be supplied, which can be provided from the auxiliary voltage output function of the ESCON.

Besides Enable, other functions shown below can be configured too:
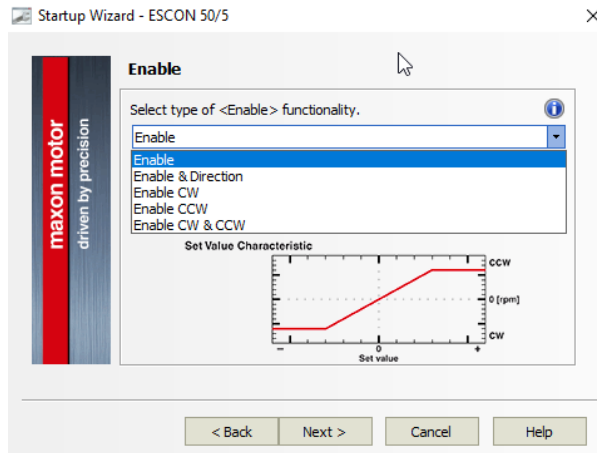

Figure 10 - Enable Function

These functions essentially allow you to just enable the power stage and to have the option to choose the direction of rotation as well.

The ESCON has up to 4 digital inputs, depending on how many digital outputs are utilised, this allows the enable function to be triggered by either one of the four digital inputs. However, it is important to understand that digital input 1 has a higher frequency capability, meaning if a PWM set value is used, it should be allocated to digital input 1, and the *Enable* function should be allocated to any other pin.

Set Value

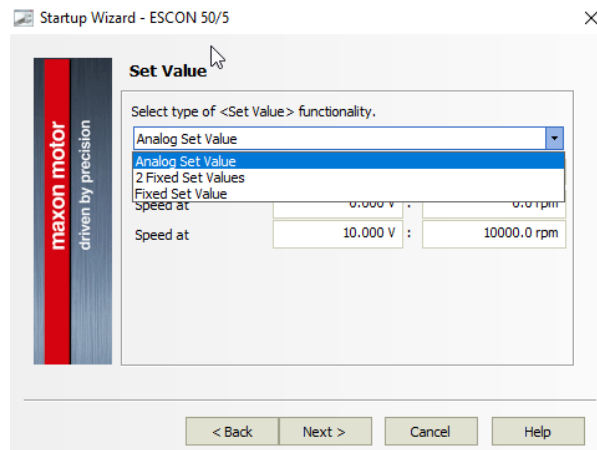The ESCON has both digital and analog inputs, meaning the set value can be processed by an option of commands.

Figure 11 - Set Value

The ESCON controllers have an analogue input range of -10 to 10v.

If two fixed set values are required, this can be done with the use of the digital inputs. One of which would maintain the initial speed, and another input would implement the second defined speed. The option to determine whether the switch is *high active or low active* is also possible.

If one constant speed is required, *fixed set value* would be the best option. This involves minimal wiring in terms of the I/Os except for the *enable* function which requires the 5v input.

Current Limit

As well as operating in current control mode, the ESCON can implement a current limit, commanded by both digital or analog signal, if operating in speed control mode.

The following shows the current limiting options which are available when operating in speed control mode, this will not appear in current control mode as the current limit will be set in the set value screen prior to this.
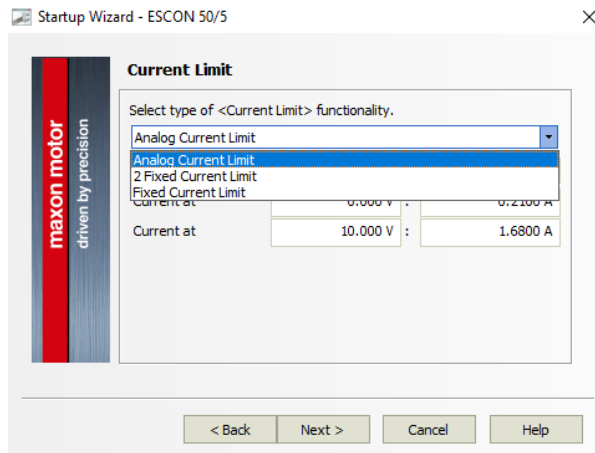

Figure 12 - Current Limit (Available in Speed Controller Mode)

A current limit would typically be required for protection purposes for the motor, gearbox or even the drive load.

Speed Ramp

As the ESCON controller is a 4-Quadrant controller, it means a torque can be applied in the direction opposite to motion. The acceleration/deceleration can be defined to achieve the final speed within a certain time frame.
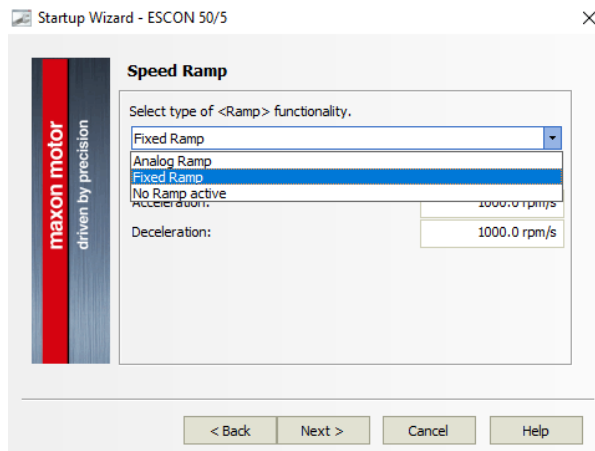

Figure 13 - Speed Ramp

When defining the acceleration ramp, it is important to consider numerous factors such as the available current and the inertia of the load.

The torque can be defined as the product of the moment of inertia of the load and the acceleration. Consider having a low acceleration ramp and incrementally increase accordingly.

During deceleration, be aware of the reversed energy that could go back into the controller/power supply. If the controller/power supply does not have the capacitance to absorb the energy, there will be a trip. The following graph shows the voltage increase when a load is required to decelerate.
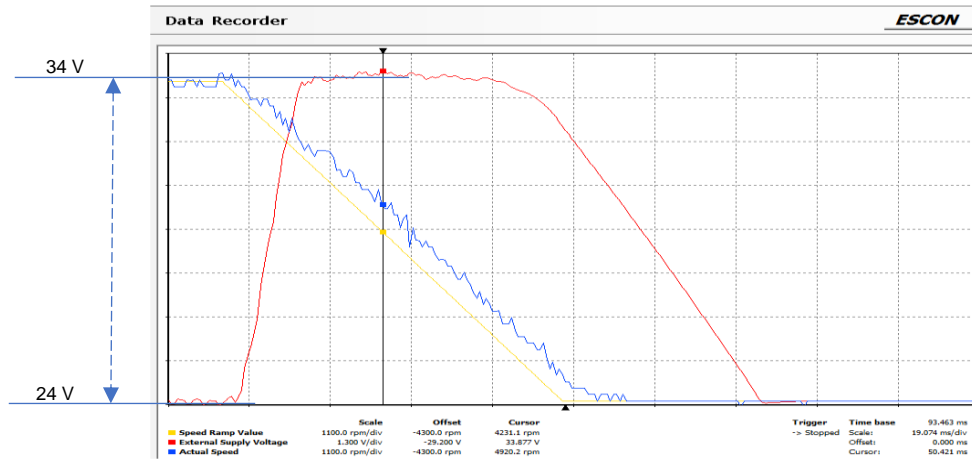
Figure 14 - Voltage Increase with Defined Deceleration

The graph shows that a constant supply of 24 volts was increased to 34 volts because of the reversed energy being sent back to the controller/power supply. The deceleration was defined at 10000rpm/s.

If the deceleration rate can't be reduced, along with the inertia of the load, it would be worth implementing additional capacitors or increasing your power supply.
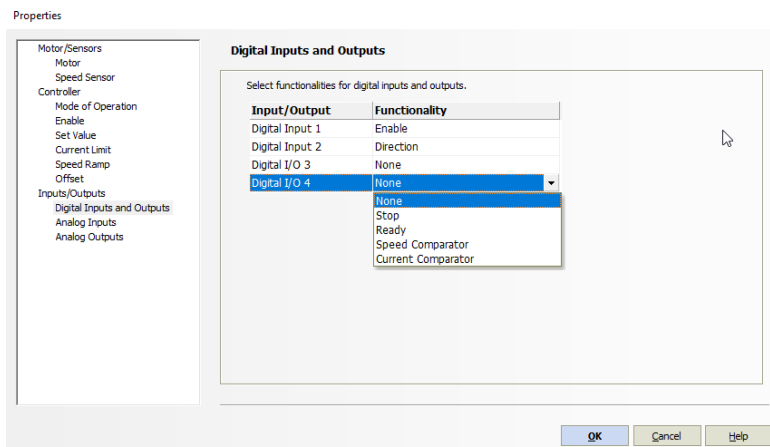

Figure 15 - maxon Shunt Regulator

Offset

Offset is where the output differs from the set value by a pre-defined amount. There are various methods of configuration for offset, such as:

- Analog offset
- PWM offset
- RC Servo offset
- Fixed offset

Digital Inputs and Outputs

Digital Inputs

In addition to *enable and/or direction*, the following digital inputs are available:

Stop

- Motor decelerates with a defined ramp to a halt
- High or low active polarity can be configured for the Stop function

PWM Set Value

Set value is defined by a fixed frequency and amplitude. The change in set value is achieved by essentially adjusting the variation of the duty cycle of 10-90%.

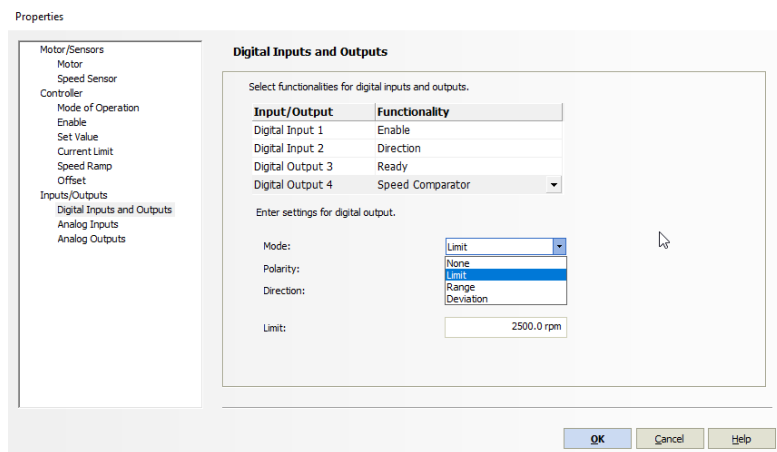If PWM set value is used, it must be configured to digital input 1.

Digital Outputs

If digital I/Os 3 and 4 are not used as inputs, the following outputs can be configured:

Ready

- Signal used to transmit ready/fault status to a superior control system
- High or low active polarity can be configured for the Ready function

Speed Comparator / Current Comparator

- Digital output is set in accordance to the actual value of speed/current. Various modes available include:
    - Limit: Once the pre-defined value is reaches, digital output is set
    - Range: Once the pre-defined value is within a set range, the digital output is set
    - Deviation: Once the pre-defined value is within the set deviance, the digital output is set
        - Note: Deviation is only available for current comparator mode if the controller is in current controller mode

Commutation Frequency

Digital output 4 also has the functionality to show the commutation frequency, providing a brushless DC motor is being used.

Analog Outputs

The ESCON controller offers 2 analog outputs, with a resolution of 12 bits, a range of -4 to 4v and a current rating of up to 1mA.

There are various functions which can be offered, these are typically used as a monitoring tool for the following:

- Actual current (Actual current averaged)
- Actual speed (Actual speed averaged)
- Demand speed and demand current
- Temperature power stage
- Fixed value

Once the appropriate output has been selected, the scaling can then be configured, bearing in mind the output goes up to 4v.
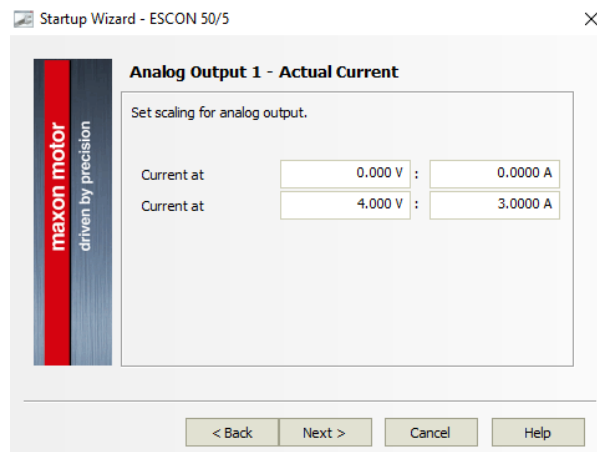
Summary

The maxon ESCON is a powerful, easy to use and adaptable speed controller. Functionalities of the multiple I/O's allow versatility across a broad range of applications. When configuring the ESCON, it is necessary to consider the system, as opposed to just the motor, as there may be a weaker link within the complete drive system which may need accounting for from a safety point of view.