Functional Safety Unit

Evolution of Safety for Industrial Robots

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Presentation Overview

- **Standards Update**

- **Description of Functional Safety Unit, FSU**

- **FSU specifications**

- **Example configurations**
    - **Robot Stopped State monitoring**
    - **Up To 3 External Axis Stopped State monitoring**
    - **Ability to define "safe" soft-limits for robot axes and external axes**
    - **Ability to Configure and select up to 8 Safety Zones**
    - **Safe tool orientation definition**
    - **Collaborative work zone**
    - **Speed Limiting to 250mm/sec in Play Mode**

Standards

- **ANSI/RIA 15.06 1999 is the current industry standard.**
- **Earlier this year a revised ANSI/RIA 15.06 passed the RIA committee, and ANSI review process**
- **This standard drives harmony between the ISO and RIA standards.**
- **The document will be effective in two years.**
- **On May 21, 2013 the revised ANSI/RIA 15.06-2012 standard was approved by ANSI.**

The "new" ANSI/RIA R15.06-2012

New Robot Safety Standard Approved

- (Ann Arbor, Michigan – May 21, 2013) A new American national robot safety standard has been approved by the American National Standards Institute (ANSI). Developed by Robotic Industries Association (RIA), the ANSI/RIA R15.06-2012 standard has been updated for the first time since 1999 and is now harmonized with the International ISO 10218:2011 standard for robot manufacturers and integrators.

- A key feature in the standard is "collaborative operation," which is the introduction of a worker to the loop of active interaction during automatic robot operation. Systems can now be designed for the operator to directly load/unload the robot or manually drive the robot to a selected location thus eliminating costly fixtures.

- Another key feature is that the standard addresses "safety-rated soft axis and space limiting" technology. This optional feature available on new robots may have different names depending on the robot manufacturer, but the functionality remains the same. Safety-rated software is used to control the robot motion so that restricted space can be more flexibly designed. Case studies have shown that that this saves both floor space and cost in the system design.

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ANSI and ISO Relationship

- **European standards divide the manufacturer requirements and the end-user responsibilities into different documents:**

  - **ISO10218-1 Manufacturer Requirements**

  - **ISO10218-2 User/Integrator Requirements**

- **ISO10218-1+ISO10218-2 = ANSI/RIA 15.06**

General Changes

- **Guidance is provide on collaborative environments.**
- **How to perform a risk assessment has been removed from the standard.**
  - **Risk assessment is mandatory for all designs!**
  - **Prescribed method is no longer an option!**
- **Safety system probability of failure must be calculated.**
  - **IS013849-1 provides guidance on these requirements.**
- **The revised ANSI/RIA 15.06 <u>does not</u> provide guidance on risk assessment or safeguarding technics. Therefore the following TR's are being created by the committee:**
  - **TR406 General Safeguarding**
 - **TR306 Risk Assessment**

ISO13849-1 Standard

- **This standard provides guidance on probabilistic calculation of the safety system.**
  - **Not for the faint of heart.**
- **Tools are available to reduce the calculation burden.**
  - **Sistema Software: http://download.ifa.dguv.de/sendmail.aspx?lang=e**
 - **Pilz: PAScal special pricing for our partners**

Optimized Floorspace - Functional Safety

- ANSI/RIA/ISO 10218-1-2007 allows robot controller software to act as a safety device; requires software to be compliant to EN954-1 Cat 3

- Previous standard (ANSI/RIA 15.06-1999) required external monitoring

- Robot restricted space can be defined by the programmed task

- Safeguarded space can be reduced accordingly

RIA 15.06 space

**ISO10218 space**

Safety Fence

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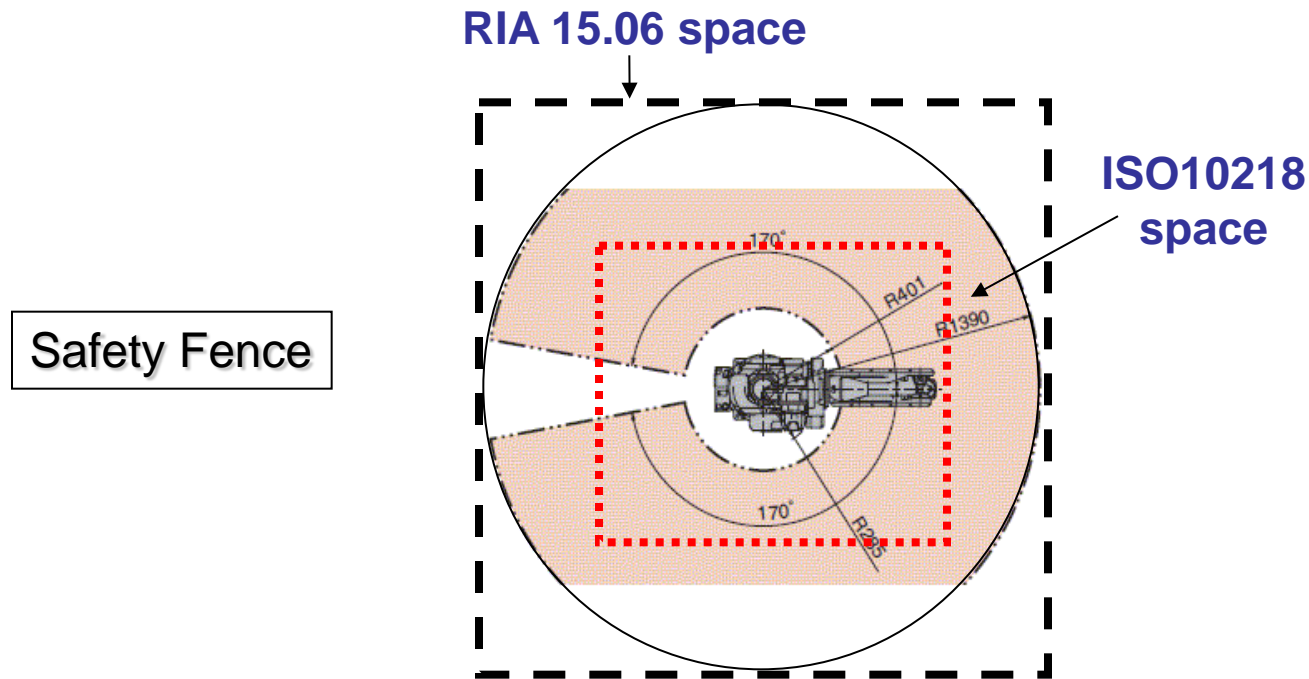
Axis Limit and Restricted Space Monitoring

- FSU calculates the speed vector of each axis (up to 9 axes/unit) to shutdown the motor power if the robot would exceed the pulse limit value

- Simplified manipulator model is monitored in real time

- Calculations account for deceleration time within the bounded space

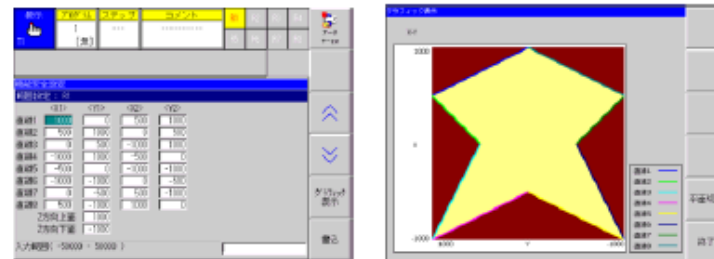- The manipulator will stop before violating the define barrier
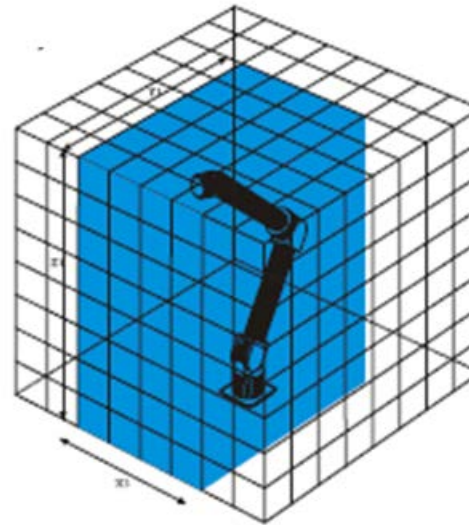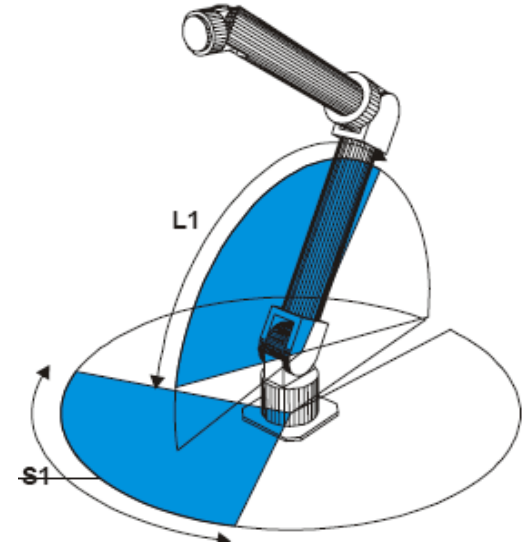
Configuration Software

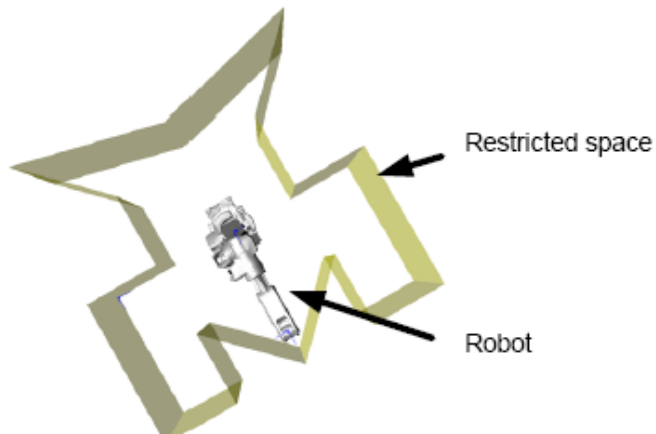- **Restricted space is programmed on the DX100 pendant with a graphical utility.**

- **Each zone is defined by multiple straight lines.**

Restricted space
Robot
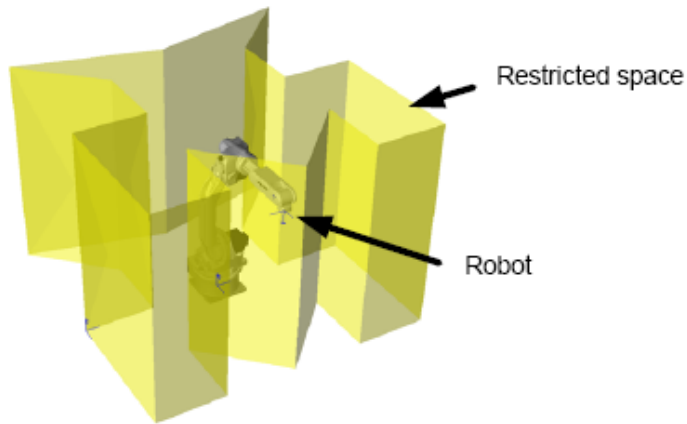
Multiplicity pillar defined by 16 straight lines or less

Setting display

Restricted space
Robot

Safety Speed and Stopped State Monitoring

- **FSU monitors the speed of the control point and flange part to limit it to less than 250mm/sec in Teach Mode or Safety Speed Mode**

- **FSU Stopped State monitor will detect unexpected motion of the manipulator and/or each external axis when the function is active, removing power when unexpected motion is detected**

- **Monitoring is active in Play and Teach modes**

FSU Specifications

E-Stop/Safety Gate Function – Category & Performance Level	Category 4 PLe
Zone/Stopped State Monitor – Category & Performance Level	Category 3 PLd
Position Monitor	Yes
Reduced Speed to 250mm/sec in Play Mode	Yes
Robot and External Axis Stopped-State Monitor	Yes
Restricted space monitor (includes all robots and base axis)	8 zones
Zones active in Play and Teach	Yes
Outputs (In Zone 1, 2, and 3)	3
Robot Axis Limiting Function	Yes
Axis supported per FSU (6 robot+3 external, 7 robot+2 external, SDA robot w/base axis)	9
Number of robots in multiple robot controller configuration with external axis.	4
Robot and external axis coordinated motion on same servo control (Example MH6+tilt-rotate positioner)	2

Application Example Applying FSU
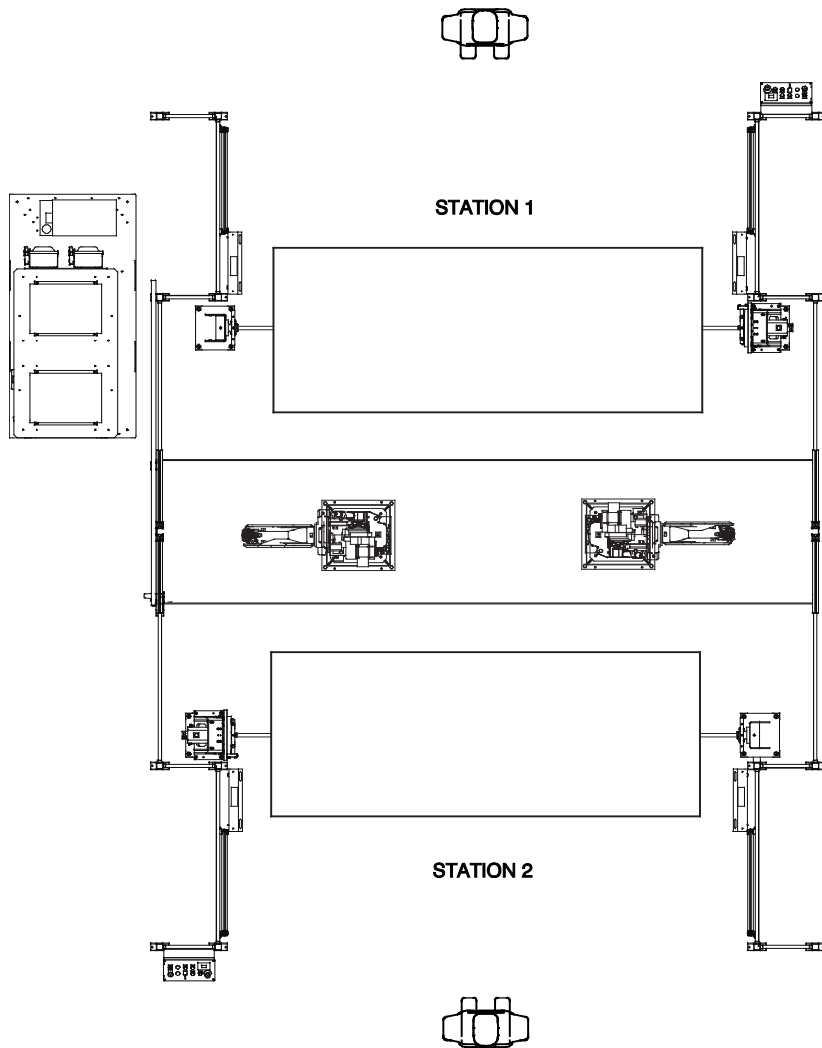
STATION 1

STATION 2

Eight Safety Zones Available

Zone #	1	2	3	4	5	6	7	8
D0 bit	0	1	0	1	0	1	0	1
D1 bit	0	0	1	1	0	0	1	1
D2 bit	0	0	0	0	1	1	1	1

Operator Station 1 & Station 2 Blocked

STATION 1

Safety LC Sta. 1
OSSD1 = 0
OSSD2 = 0

FSU Safety Zone

Zone #	1	2	3	4
D0 (Sta.1)	**0**	1	0	1
D1 (Sta.2)	**0**	0	1	1

Safety L.C. Status

Safety Zone 1
Selected

STATION 2

Safety LC Sta. 2
OSSD1 = 0
OSSD2 = 0
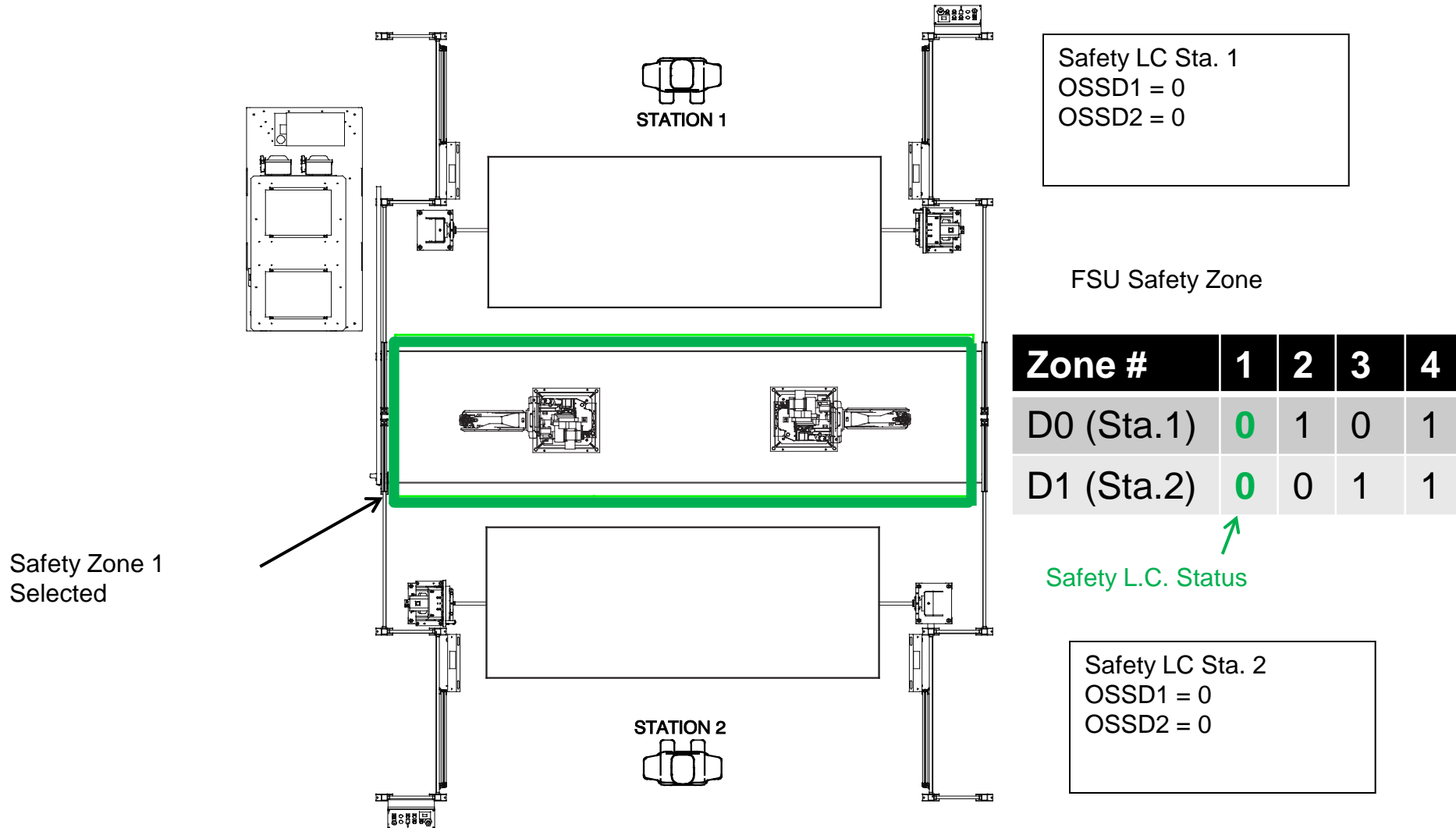
Operator Station 1 Clear, Station 2 Blocked

STATION 1

STATION 2

Safety Zone 2 Selected
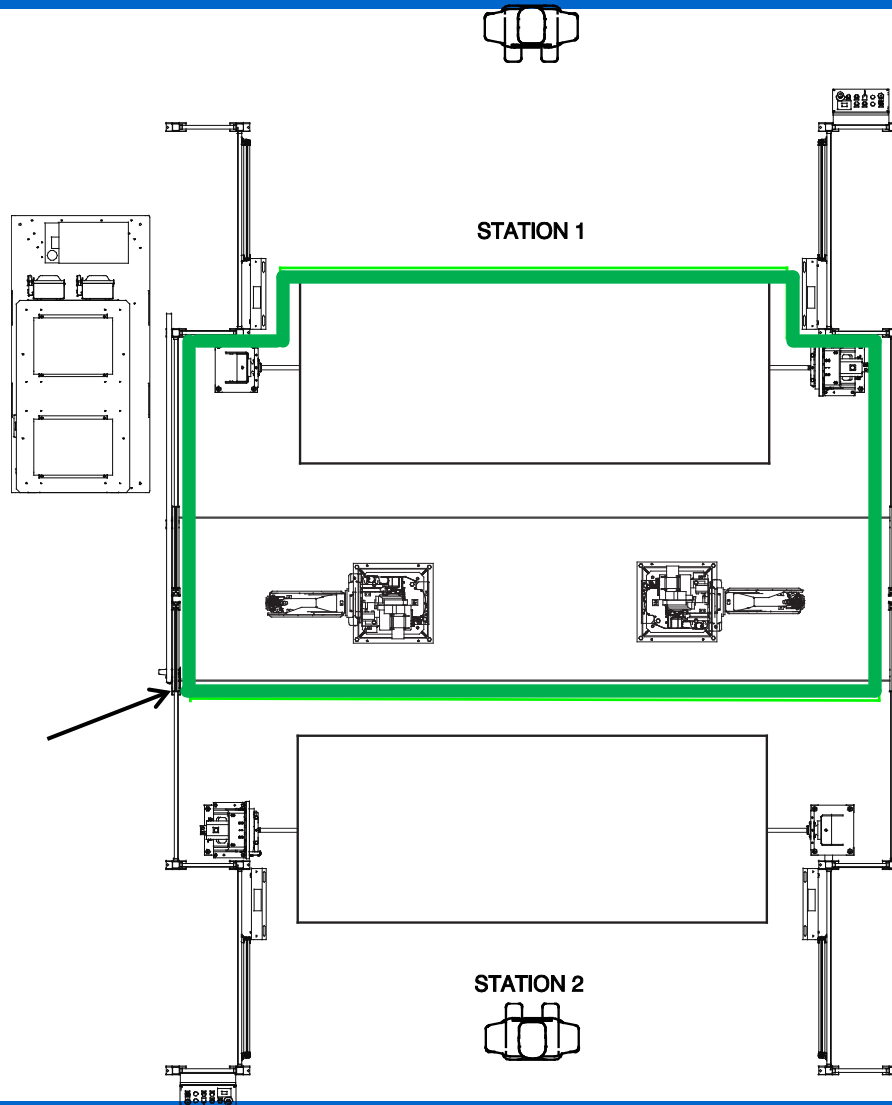
Safety LC Sta. 1
OSSD1 = 1
OSSD2 = 1

FSU Safety Zone

Zone #	1	2	3	4
D0 (Sta.1)	0	1	0	1
D1 (Sta.2)	0	0	1	1

Safety L.C. Status

Safety LC Sta. 2
OSSD1 = 0
OSSD2 = 0

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Motoman Robotics Division

Operator Station 1 Blocked, Station 2 Clear

STATION 1

STATION 2

Safety Zone 3
Selected

Safety LC Sta. 1
OSSD1 = 0
OSSD2 = 0

FSU Safety Zone

Zone #	1	2	3	4
D0 (Sta.1)	0	1	0	1
D1 (Sta.2)	0	0	1	1

Safety L.C. Status

Safety LC Sta. 2
OSSD1 = 1
OSSD2 = 1

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Motoman Robotics Division

Operator Station 1 & Station 2 Clear

Safety LC Sta. 1
OSSD1 = 1
OSSD2 = 1

STATION 1

STATION 2

Safety Zone 4
Selected

FSU Safety Zone

Zone #	1	2	3	4
D0 (Sta.1)	0	1	0	**1**
D1 (Sta.2)	0	0	1	**1**

Safety L.C. Status

Safety LC Sta. 2
OSSD1 = 1
OSSD2 = 1

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Motoman Robotics Division

Example 2: Stopped-State Monitoring

- **FSU enables Stopped State monitoring of the external axis**

Light Curtain
Axis 7
Axis 9
Axis 8
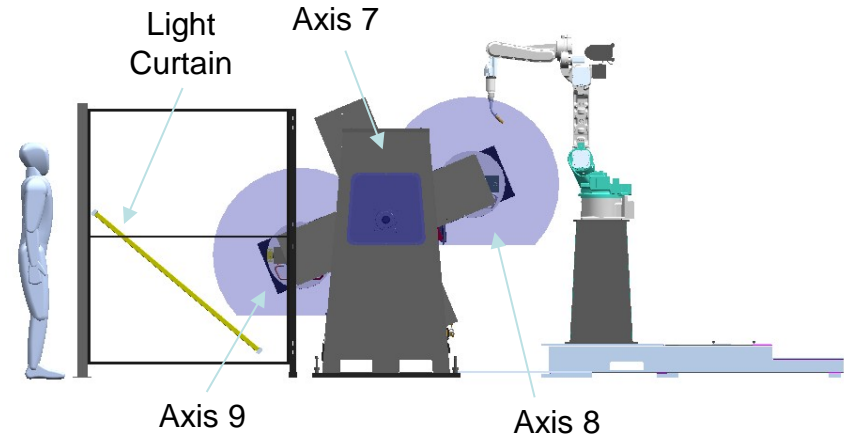
	Axis 7	Axis 8	Axis 9
Indexing	Motion Enabled	Motion Enabled	Motion Enabled
Loading Part	Motion Prohibited	Motion Enabled	Motion Prohibited
LC Clear	Motion Enabled	Motion Enabled	Motion Enabled

Example 3: Collaborative Work Zone

- **Collaborative work environments require manipulators and operators to share the same space. Examples include**
  - **Part loading**
  - **Part verification**
  - **Part adjustment**
- **FSU supports standard velocity programming and a 250mm/sec velocity setting Operator presence is detected by Sick PLS 3000 or similar device**
- **Automatic resume when distance between robot and operator is safe as defined in ISO10218-1 item 5.10.2 and IS10218-2 item 5.11.4**

Velocity	Operators Location		
	Zone 1	Zone 2	Zone 3
100%	Yes	No	No
Safety Speed	-	Yes	No
Safety Rated Monitored Stop (Cat 2, with or without Auto Resume). CAT0 if illegal	-	-	Yes

Summary

- **The Functional Safety Unit (FSU) eliminates the need for mechanical interlocks which are prone to wear and failure. Examples: Robot axis hard-stops and zone rings.**

- **The flexibility of the functional safety unit allows for the system to meet the safety requirements for various applications**

- **The FSU is certified by 3rd party.**

Summary

- **Purchase the revised ANSI/RIA 15.06 upon publication by ANSI.**

- **Evaluate current Risk Assessment practices and incorporate in current design practices.**

- **Select appropriate ISO13849-1 tool which best fits your business.**

THANK YOU!

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