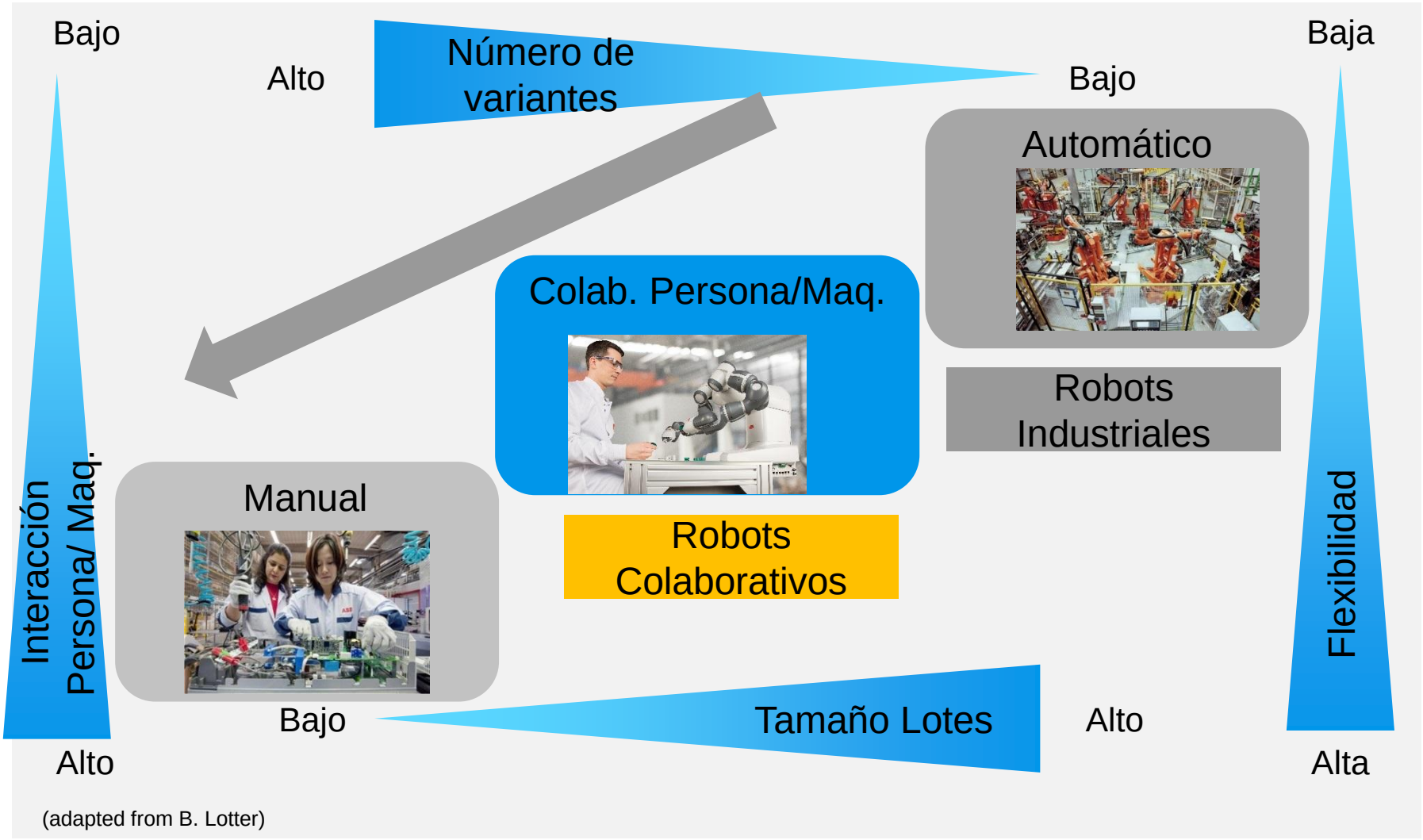
Jornada 23/09/2016. LOS RETOS DE LA PRL: NUEVOS FACTORES DE RIESGO DERIVADOS DE NUEVAS TECNOLOGÍAS, PROCESOS Y PRODUCTOS

Robótica Colaborativa

YuMi. Robot colaborativo ABB de doble brazo

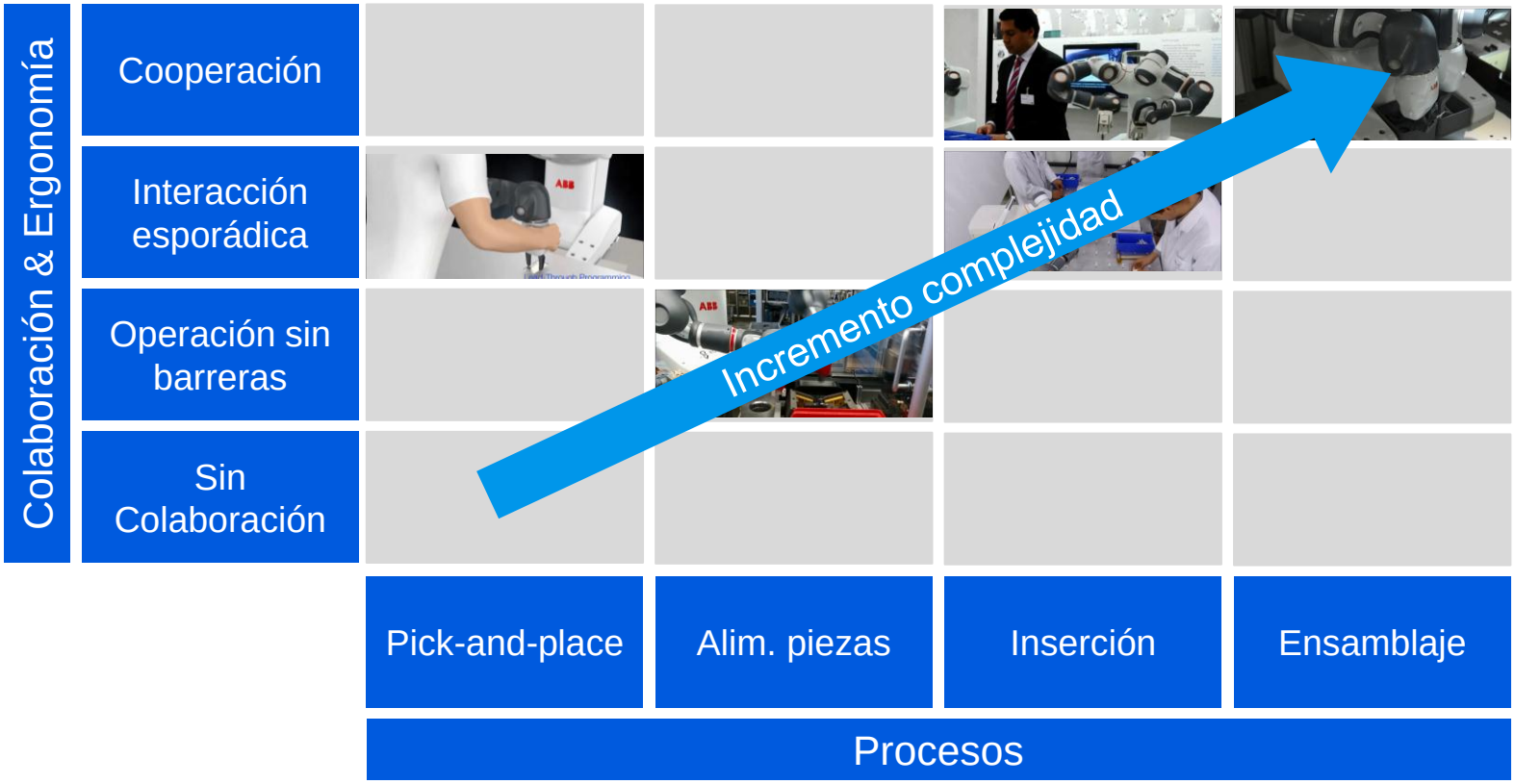
Jon Olazar Galdós

Tendencias de Mercado / Industria
Colaboración Hombre/Máquina. Robots Colaborativos



(adapted from B. Lotter)

Robótica Colaborativa
Nivel de complejidad

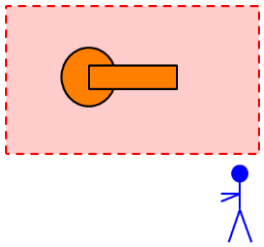


Colaboración / Ergonomía

Tipos de colaboración segun Norma ISO 10218

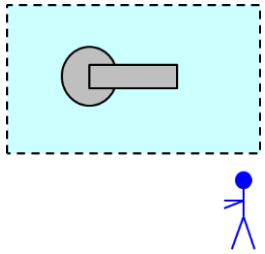
Sin colaboración

- El Operario y el Robot no comparten la misma area de trabajo
- Barreras de seguridad evitan el contacto Operario/Robot



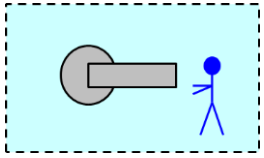
Operación sin barreras

- No se precisan barreras de separación entre Operario y Robot durante el proceso productivo



Interacción esporádica

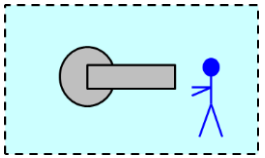
- El Operario entra en el area de trabajo del robot durante el proceso productivo esporadicamente



Interacción <= 1/60 min

Colaboración

- El Operario y el Robot ocupan la misma area de trabajo durante el proceso productivo.
- **ROBOT COLABORATIVO**



Interacción >1/60

Colaboración según la norma ISO 10218

Colaboración / Ergonomía

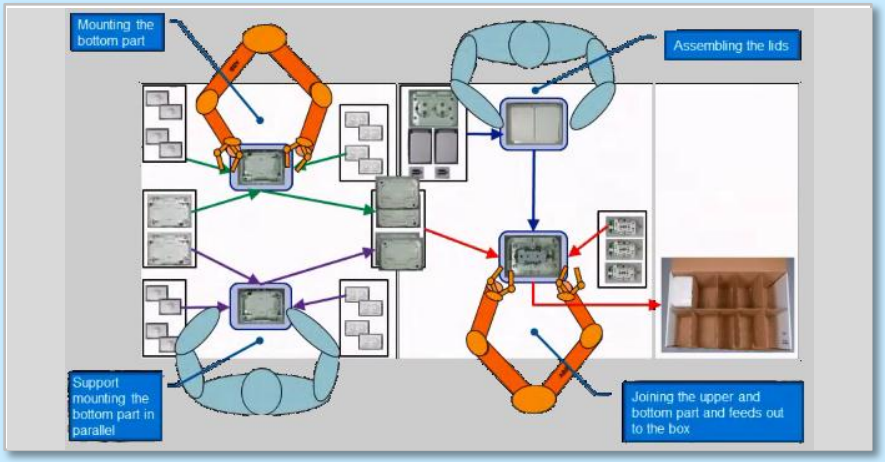
Tipos de colaboración Persona / Robot

Trabajo conjunto Operario / Robot

- Robot >= 7 grados de libertad que permita multiples orientaciones de sus ejes para acceder a un punto.
- Movimientos robot en un area reducida que eviten interferir con el Operario

Distribución de Tareas Operario / Robot

- Compartiendo tareas:
  - Las tareas repetitivas se asignan al robot.
  - Las tareas complejas las realiza el Operario.



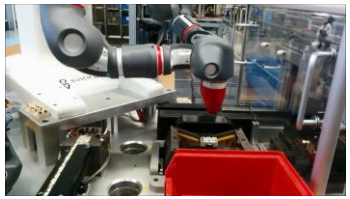
Procesos
Clasificación

Pick-and-Place

- Manejo de materiales en un espacio libre.
- Adecuado para programación mediante Tablet.
- Tareas típicas:
  - Clasificación
  - Reorientación

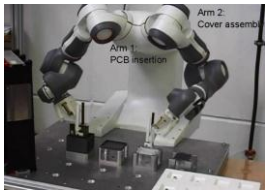
Alim. Piezas

- Manejo de materiales en un espacio libre.
- Movimientos complejos.
- Secuencias y comunicación.
- Tareas típicas:
  - Alimentac. piezas



Inserción

- Movimientos restringidos.
- Tolerancias ajustadas.
- Posición de dejada precisa
- Tarea típica:
  - Inserción de piezas en alojamiento



Ensamblaje

- Movimiento restringido.
- Fuerza de montaje controlada.
- Precisión elevada.
- Tareas típicas
  - Clipaje
  - Atornillado

Normativa Robots Industriales

Iso 10218-1 y Iso 10218-2. Estándar de seguridad en Robots Industriales

ISO 10218-1

- Robots and robotic devices — Safety requirements for industrial robots — Part 1: Robots
- Scope
  - Industrial use
  - Controller
  - Manipulator
- Main references
  - ISO 10218-2 – Robot systems and integration

Common references

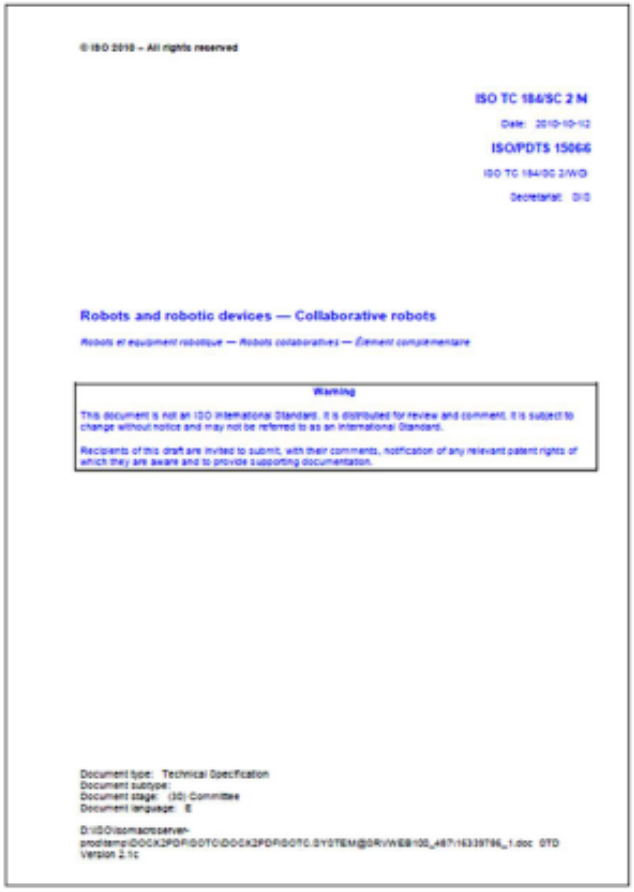
ISO 13849-1 / IEC 62061 – Safety-related parts of control systems
IEC 60204-1 – Electrical equipment (stopping fnc.)
ISO 12100 – Risk assessment
ISO 13850 – E-stop

ISO 10218-2

- Robots and robotic devices — Safety requirements for industrial robots — Part 2: Robot systems and integration
- Scope
  - Robot (see Part 1)
  - Tooling
  - Work pieces
  - Periphery
  - Safeguarding
- Main references
  - ISO 10218-1 – Robot
  - ISO 11161 – Integrated manufacturing systems
  - ISO 13854 – Minimum gaps to avoid crushing
  - ISO 13855 – Positioning of safeguards
  - ISO 13857 – Safety distances
  - ISO 14120 – Fixed and movable guards

Normativa Robots Colaborativos

ISO/TS 15066 – Seguridad de Robots colaborativos y criterios Biomecánicos



© ISO 2010 – All rights reserved

ISO TC 184/SC 2 N

Date: 2010-10-12

ISO/PDTS 15066

ISO TC 184/SC 2/WG

Secretariat: DIS

Robots and robotic devices — Collaborative robots

Robots et equipment robotique — Robots collaboratives — Élément complementaire

Warning

This document is not an ISO International Standard. It is distributed for review and comment. It is subject to change without notice and may not be referred to as an International Standard.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Document type: Technical Specification
Document subtype:
Document stage: (30) Committee
Document language: E

D:\ISO\isomacroserver-prod\temp\DOCX2PDF\ISOTC\DOCX2PDF\ISOTC.SYSTEM@DRIVWEB100_4871163397[6]_1.doc STD
Version 2.1c

- Design of collaborative work space
- Design of collaborative operation
  - Minimum separation distance S / maximum robot speed K_R
  - Static (worst case) or dynamic (continuously computed) limit values
  - Safety-rated sensing capabilities
  - Ergonomics
- Methods of collaborative working
  - Safety-rated monitored stop
  - Hand-guiding
  - Speed and separation monitoring
  - Power and force limiting (biomechanical criteria!)
- Changing between
  - Collaborative / non-collaborative
  - Different methods of collaboration
- Operator controls for different methods, applications
  - Question is subject of debate: What if a robot is purely collaborative? Must it fulfill all of ISO 10218-1, i.e. also have mode selector, auto / manual mode, etc.?

Normativa Robots Colaborativos

Safety Functions of Industrial Robot Controller Collaborative Operation (1)

Safety-rated monitored stop
(ISO 10218-1, 5.10.2, ISO/TS 15066)

- Reduce risk by ensuring robot standstill whenever a worker is in collaborative workspace
- Achieved by
  - Supervised standstill - Category 2 stop (IEC 60204-1)
  - Category 0 stop in case of fault (IEC 60204-1)
- Application
  - Manual loading of end-effector with drives energized
  - Automatic resume of motion

Hand guiding
(ISO 10218-1, 5.10.3, ISO/TS 15066)

- Reduce risk by providing worker with direct control over robot motion at all times in collaborative workspace
- Achieved by (controls close to end-effector)
  - Emergency stop, enabling device
  - Safety-rated monitored speed
- Application
  - Ergonomic work places
  - Coordination of manual + partially automated steps

Normativa Robots Colaborativos

Safety Functions of Industrial Robot Controller Collaborative Operation (2)

Speed and separation monitoring
(ISO 10218-1, 5.10.4, ISO/TS 15066)

- Reduce risk by maintaining sufficient distance between worker and robot in collaborative workspace
- Achieved by
  - distance supervision, speed supervision
  - protective stop if minimum separation distance or speed limit is violated
  - taking account of the braking distance in minimum separation distance
- Additional requirements on safety-rated periphery
  - for example, safety-rated camera systems

Power and force limiting by inherent design or control
(ISO 10218-1, 5.10.5, ISO/TS 15066)

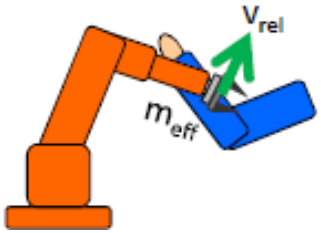
- Reduce risk by limiting mechanical loading of human-body parts by moving parts of robot, end-effector or work piece
- Achieved by low inertia, suitable geometry and material, control functions, …
- Applications involving transient and/or quasi-static physical contact (SPA = small parts assembly)

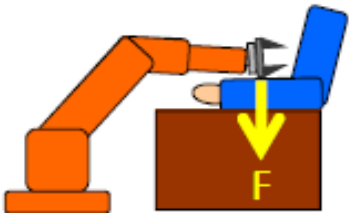
Normativa Robots Colaborativos

Biomechanical Limit Criteria
Types of Contact Events

ISO / TS 15066 – clause 5.4.4 “Power and force limiting”

Free impact / transient contact • Contact event is “short” (< 50 ms) • Human body part can recoil		Constrained contact / quasi-static contact • Contact duration is “extended” • Human body part cannot recoil, is trapped	
Accessible parameters in design or control • Effective mass (robot pose, payload) • Speed (relative)		Accessible parameters in design or control • Force (joint torques, pose)	
Pain threshold	Minor injury threshold	Pain threshold	Minor injury threshold
Highest loading level accepted in design	Highest loading level accepted in risk assessment in case of single failure	Highest loading level accepted in design	Highest loading level accepted in risk assessment in case of single failure





Normativa Robots Colaborativos

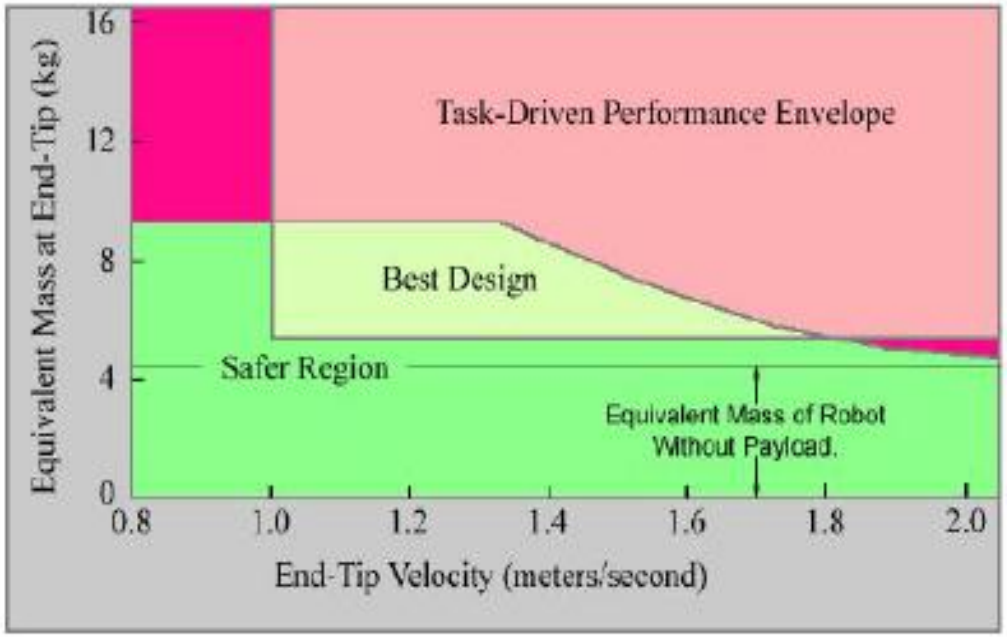


Figure 18 - Safety diagram for the robot design example.

Intrinsically Safer Robots, Prepared May 4, 1995, for the NASA Kennedy Space Center as the Final Report under NASA contract #NAS10-12178

http://www.smpp.northwestern.edu/savedLiterature/UlrichEtAlIntrinsicallySaferRobots.pdf

- Early work by W. Townsend et al. at Barrett Technologies
- Trade-off between moving mass and relative velocity

$$\frac{E}{A} = \frac{mv^2}{2A} \approx 2\frac{J}{cm^2}$$

assuming

$$m = 4\ kg$$

$$v = 1\frac{m}{s}$$

$$A = 1\ cm^2$$

Solución ABB:
YuMi. Robot colaborativo de doble brazo IRB 14000

Vision integrada o externa

Seguridad

Control de Movimiento

Pinzas colaborativas

Alimentadores

Comunicaciones con PLC

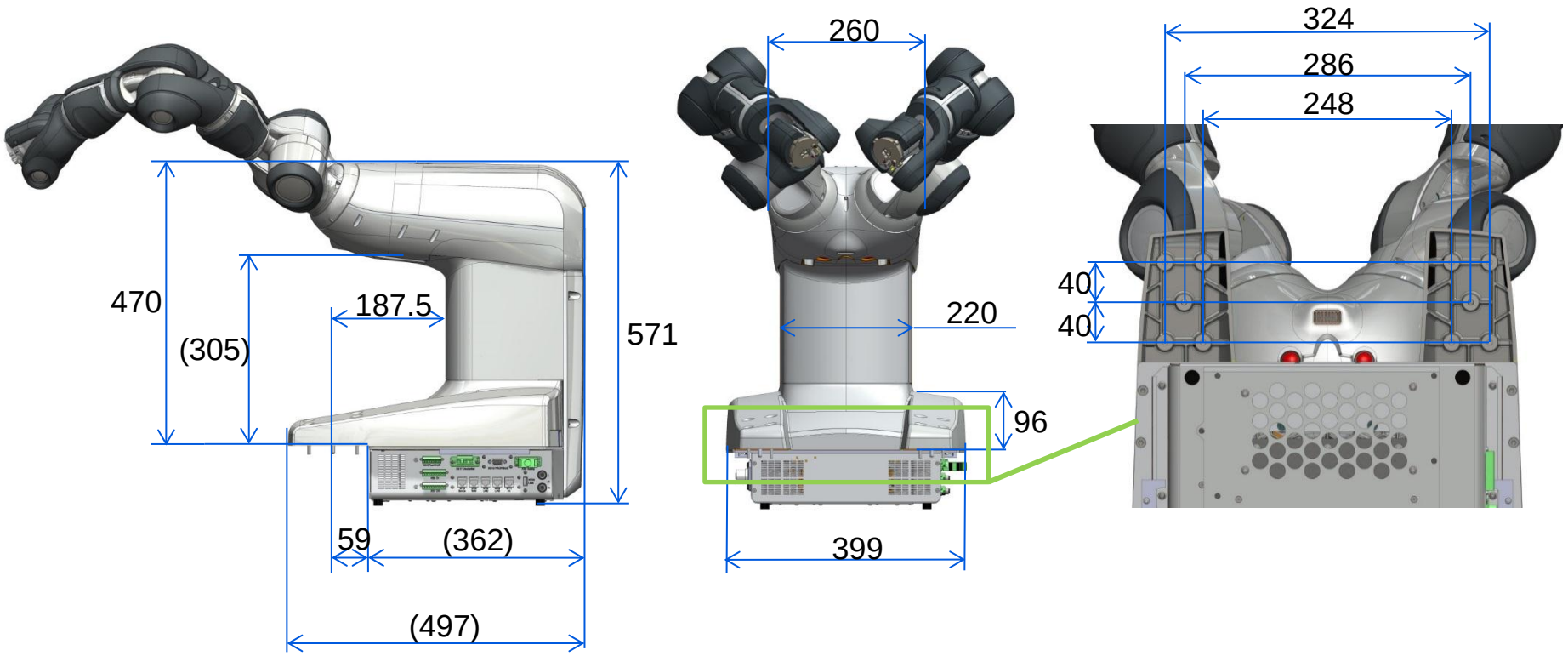
Simulación

Programación mediante Tablet o unidad de programación

Características

Dimensiones

IRB 14000 0.5/0.5

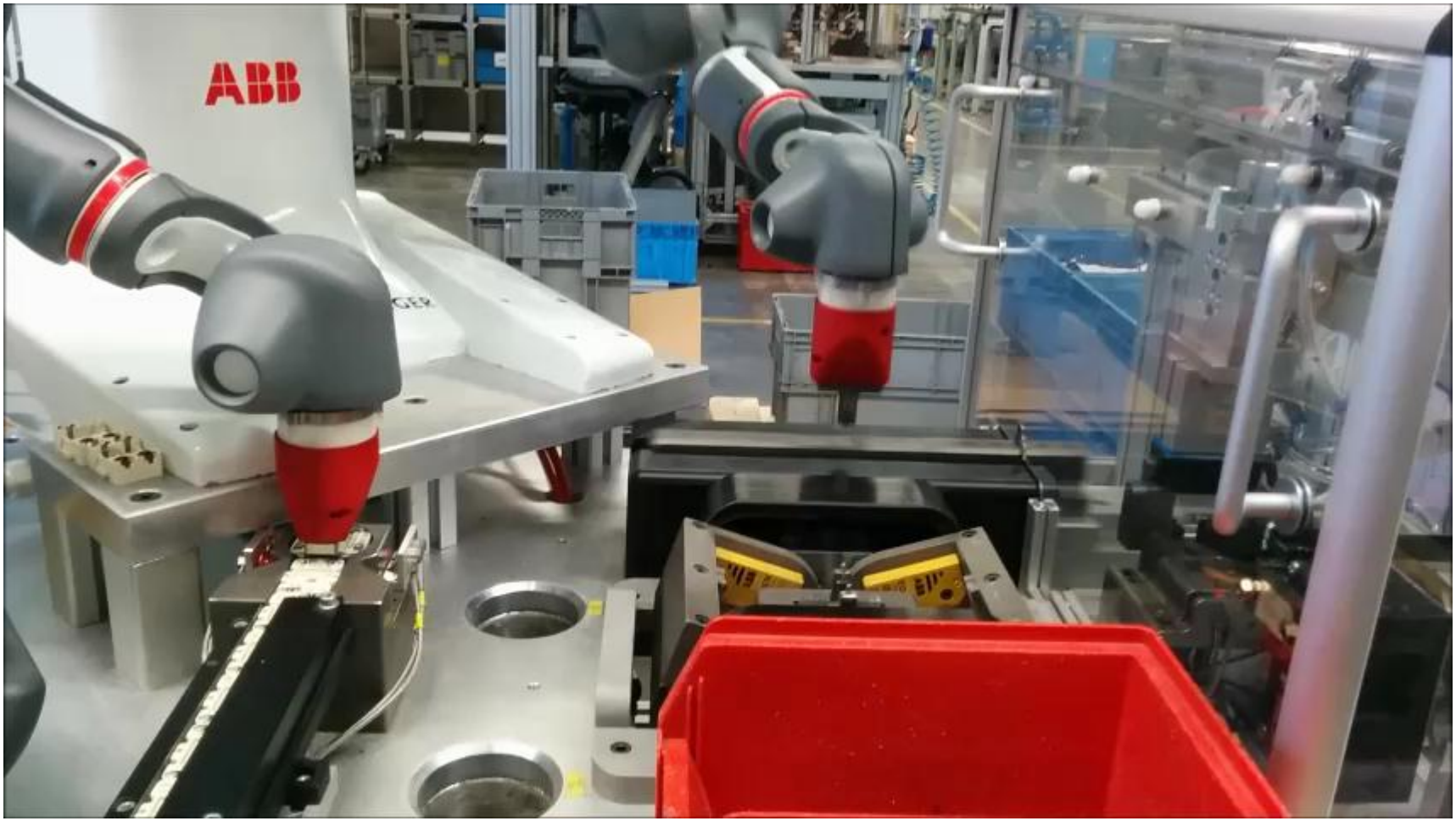


Características

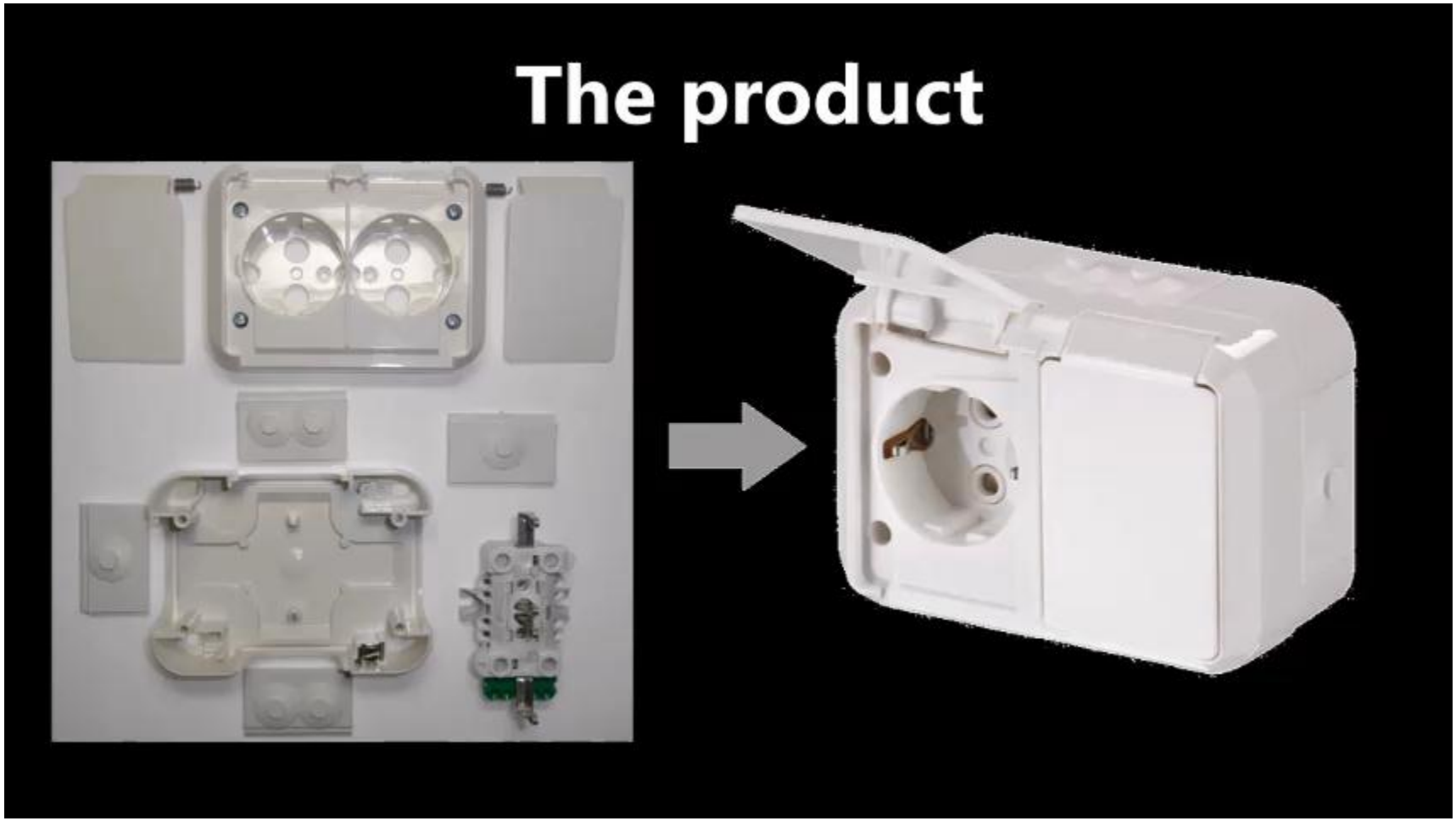
	IRB 14000 – 0.5/0.55
Capacidad de carga	0.5 kg en cada brazo
Alcance	559 mm en cada brazo
Precisión	0.02 mm
Dimensiones de la base	399 mm * 497 mm
Interface	Conectores en la base
Peso	38 kg
Posición de montaje	Sobre mesa
Temperatura de trabajo	5 C – 40 C
IP Protección	IP 30
Uso industrial	Si

Habilidades de manipulación

Manipulación de componentes



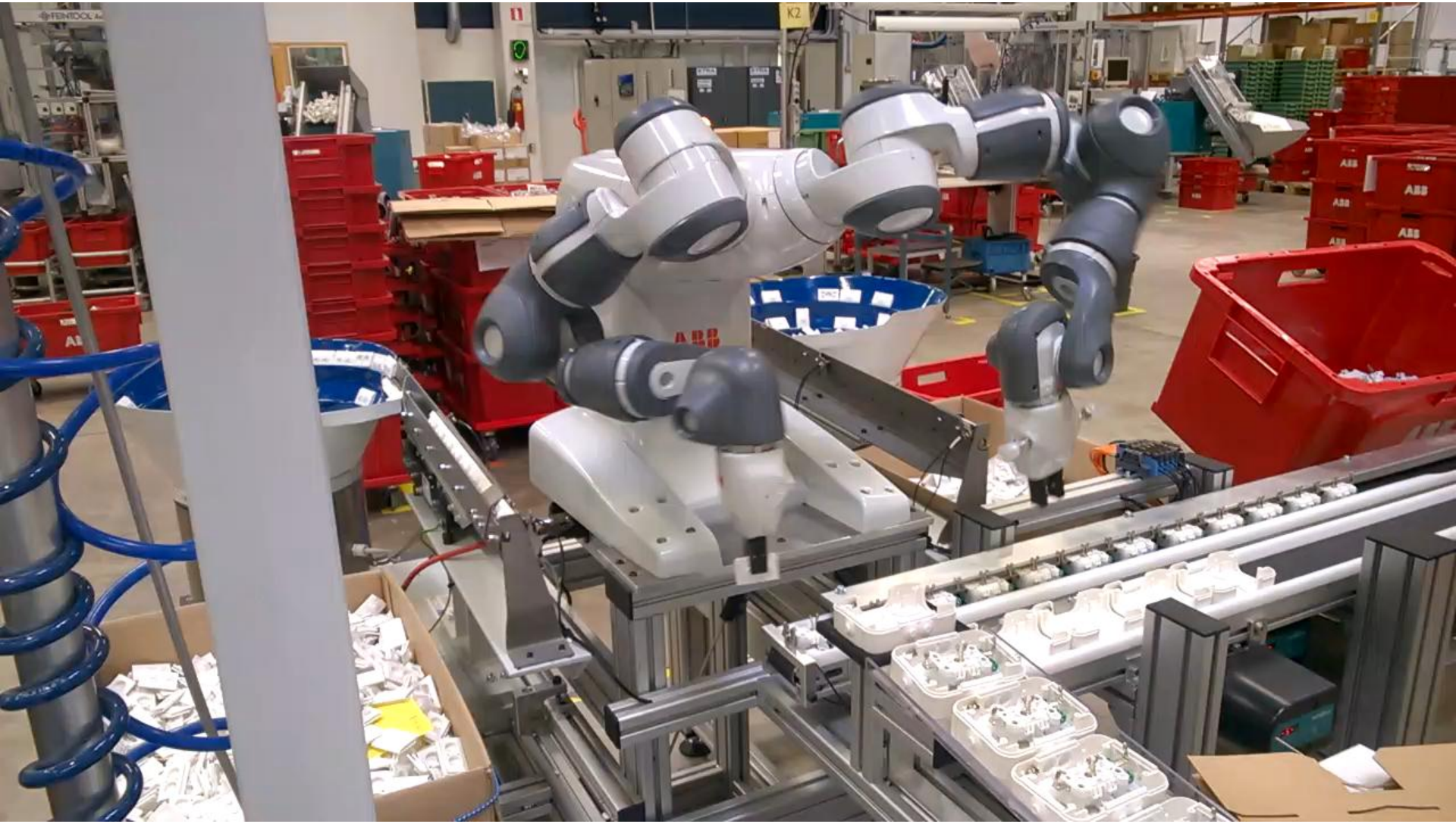
Ensamblaje de componentes y test



Ensamblaje de módulos de entradas/salidas

Guiado por visión

Célula de montaje



Power and productivity
for a better world™