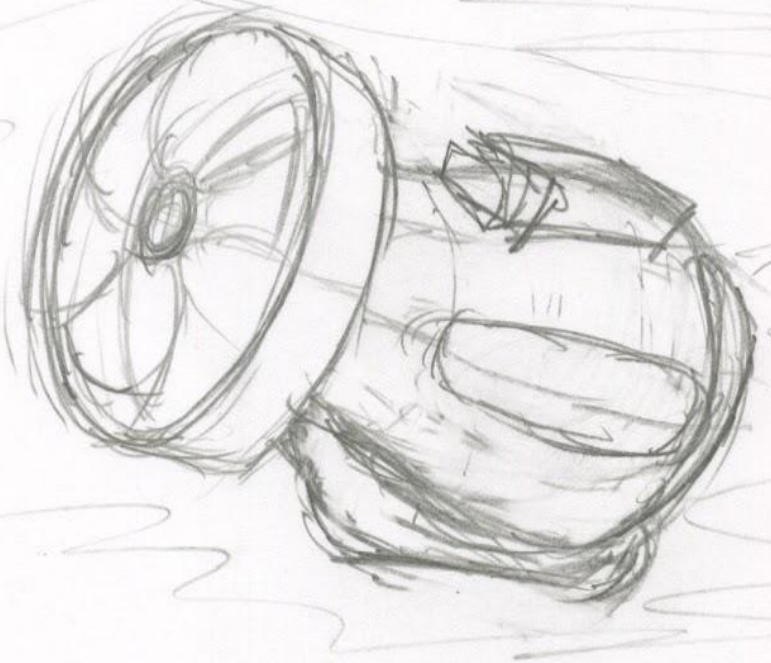
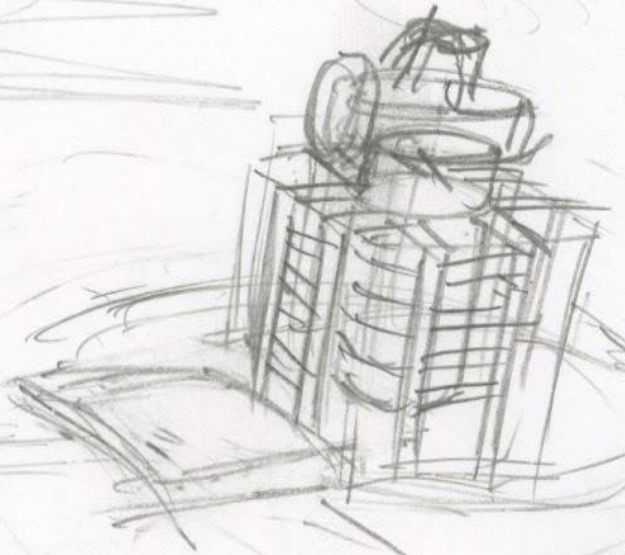
Standards and Regulations





TEAM C: Column Robotics

Mar, 2016

Overview of Presentation

ISO Standards Covered

ISO 13842:2014

Robots and Robotic Devices -
Safety Requirements for Personal Care Robots

ISO 13849-1

Safety of Machinery -
Safety Related Parts of Control Systems
Part 1: General Principles for Design

Structure of Each Standard Discussion

- What this standard is about
- Products and Markets in Scope
- Products and Markets Out of Scope
- Main Prescriptions of Standard (3x)
- How Standard Applies to Our Project

ISO 13482:2014
Robots and Robotic Devices – Safety Requirements for Personal Care Robotics

What ISO 13482 Is About

Personal Care Robots

- Risk Assessment
- Safety requirements and protective measures
- Safety-related control system requirements
- Verification and validation
- Information for use
- Examples of significant hazards, implementations, and markings

Products and Markets In Scope

Inherently safe design, protective measures, and information for use of **personal care robots**

Examples include:

- mobile servant robot
- physical assistant robot
- person carrier robot

https://www.pertexa.net/modules/addons/productimage/product_images/8.png
http://eu.mouser.com/images/microsites/funny-thing-becoming-human-robotics-fig4.png
https://cdn2.vox-cdn.com/thumbor/tn4kgpeNVDWWvvHD3pACehaSUMw=/cdn0.vox-cdn.com/uploads/chorus_asset/file/3649262/DSCF1366.0.jpg

Products and Markets Out of Scope

This International standard does not apply to:

- robots travelling faster than 20 km/h
- robot toys
- water-borne robots and flying robots
- industrial robots (ISO 10218)
- robots as medical devices
- military or public force application robots.

However, **“The safety principles established in this International Standard can be useful for these robots”** since many standards do not yet exist.

http://img01.thedrum.com/s3fs-public/styles/news_article_lightbox/public/news/tmp/61194/dbd_media_-_first_person_view_drone_quadcopter.png?itok=z9INdnxr

Main Prescriptions (1)

5.13 Hazards due to contact with moving components

- Robots shall be designed so that risk of exposure to components: motor shafts, gears, drive belts, wheels
- No Hazard Zones being reached by parts of the body.

http://1.bp.blogspot.com/-IkzFqi9KiNE/VmGhjRBycBI/AAAAAAAAAADE/Emw2qU-OJu0/s1600/aa.jpeg

Applied to Our Project:

- Quadrotor blades / propellers should be guarded to prevent contact with body parts

Main Prescriptions (2)

6.3 Limits to Operational Spaces

- Operational space limitations required to reduce risk.
- Defined volume for robot activity and exclusion zones.
- Zones can stop robot at a full rated load and speed.

Applied to Our Project:

- Use of net while obstacle avoidance not yet complete.

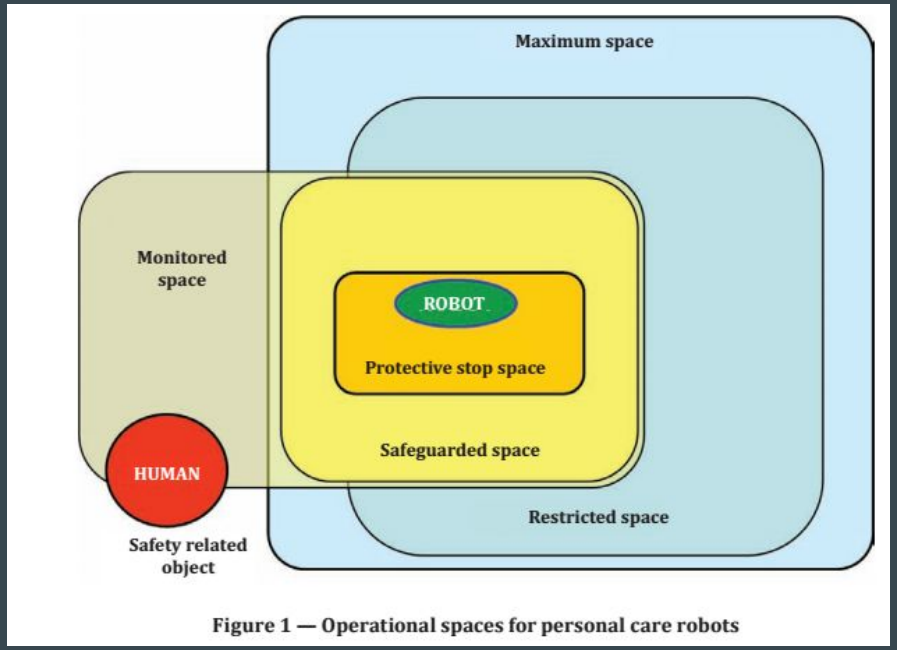


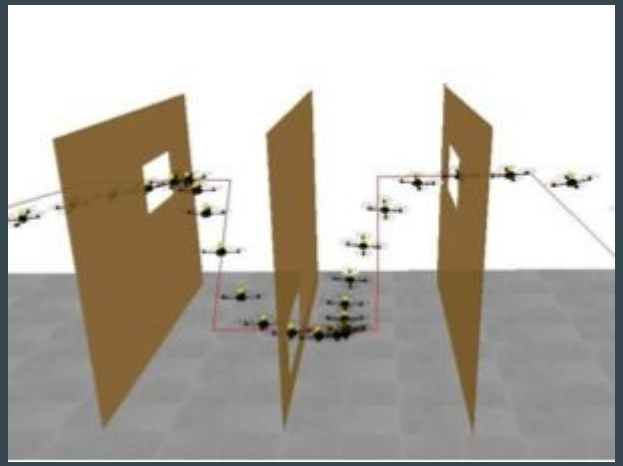
Figure 1 — Operational spaces for personal care robots

From: ISO_13482-2014 Document

Main Prescriptions (3)

5.12 Hazards due to incorrect autonomous decision and actions

- Robot must be designed to make autonomous decisions and actions to ensure that the incorrect action does not cause unacceptable risk of harm



http://wwwx.cs.unc.edu/~sjguy/new/img/quad.jpg

Applied to Our Project:

- Use obstacle avoidance, perception of people, software constraint on mobility range

How ISO 13482 Applies to Our Project

- In an underwater environment, there are few incidents where Human robot interaction would occur, such as undersea welders, but in the event this occurs:
  - These systems will have guarded moving components in the underwater environment
  - Systems will autonomously avoid objects it detects as human, and seek alternative paths
  - Underwater welders and other humans working in the water around the wellhead could be dangerously injured by a failure of a control system

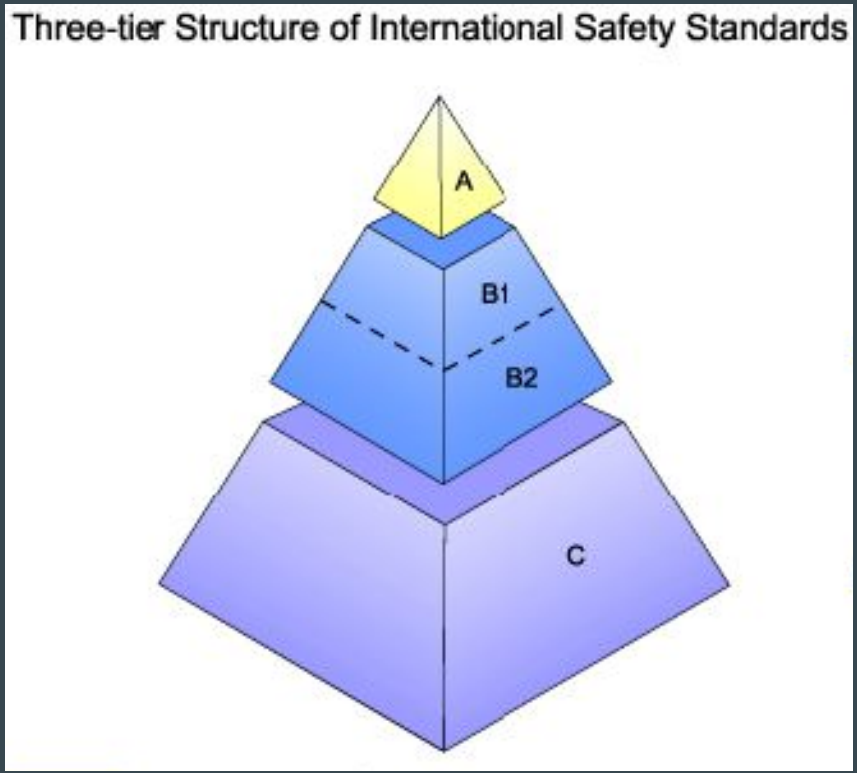
- A quadcopter working in a setting around humans could dangerously injure those working around it
  - Blades are an obvious danger, and shields must be employed to prevent injury
  - The system must not maneuver in such a way that could injure a human
  - System will have onboard perception to avoid human-like objects and obstacles

ISO 13849-1
Safety of Machinery -
Safety Related Parts of Control Systems
Part 1: General Principles for Design

What ISO 13849-1 is About

- Provides safety requirements and guidance on the principles for the design of safety-related parts of control systems (SRP/CS), including the design of software
- Specifies characteristics that include the performance level required for carrying out safety functions
- Specifies these for the following systems: non-electrical (hydraulics), electromechanical (relays), complex electronics (programmable)
- Does not specify the safety functions or performance levels that are to be used

What ISO 13849-1 is About



ISO 13849-1 is ISS Type B1

Type A Fundamental safety standards applicable to all machinery. Type A standards deal with basic concepts, principles for design, and general aspects.

Type B Standards applicable to a wide range of machinery. Type B is divided into two catagories:

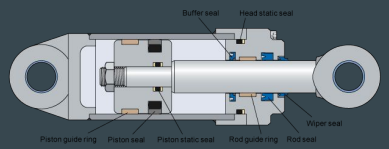
B1: Specific safety aspects (ie., safety distance, surface temperature, and noise)

B2: Safety related devices (ie., two-hand controls, interlocking devices, pressure sensitive devices, and guards)

Type C Detailed standards applicable to a specific machine or a particular group of machines.

Products and Markets In Scope

- Non-electrical (hydraulics)
- Electromechanical (relays, and/or non-complex electronics)
- Complex Electronics (programmable)
- And any combination of the three previous including safety embedded software



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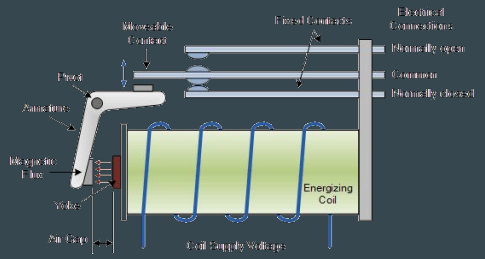
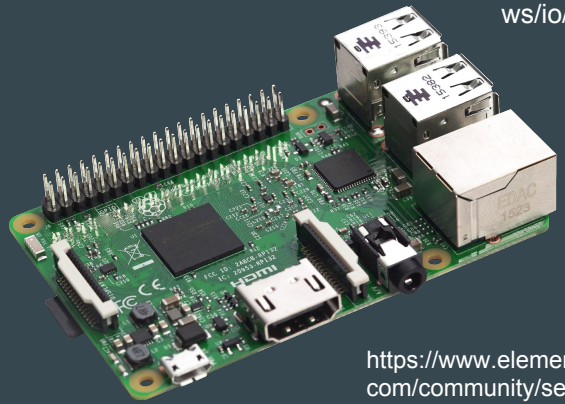


http://www.electronics-tutorials.ws/io/io23.gif?81223b



https://www.element14.com/community/servlet/JiveServlet/showImage/2-175718-252364/piE_outlined.png

Products and Markets In Scope

- Robotics
- Aeronautical
- Automotive
- Manufacturing
- Chemical Processing Equipment

Image source: http://www.nordicsemi.com/; http://www.conniesurvivors.com/pictures/;

Main Prescriptions (1)

Determine a **Required Performance** Level for your System (PL_r)

- PL_r is based on the average probability of dangerous failure per hour
- Parameters of the PL_r:
  - Frequency and time of exposure to the hazard
  - Possibility of avoiding the hazard or limiting the harm
  - The severity of injury caused

Applied to Our Project:

- Frequency and time of exposure: Aim for one failure per 10,000 operating hours
- Severity of injury: Aim for low-moderate severity due to lightweight platform

Main Prescriptions (1)

Determine a **Required Performance** Level for your System (PL_r)

Table 3 — Performance levels (PL)

PL	Average probability of dangerous failure per hour 1/h
a	$\geqslant 10^{-5}$ to $< 10^{-4}$
b	$\geqslant 3 \times 10^{-6}$ to $< 10^{-5}$
c	$\geqslant 10^{-6}$ to $< 3 \times 10^{-6}$
d	$\geqslant 10^{-7}$ to $< 10^{-6}$
e	$\geqslant 10^{-8}$ to $< 10^{-7}$
NOTE Besides the average probability of dangerous failure per hour other measures are also necessary to achieve the PL.	

Applied to Our Project: PL will require level A - between 10^-5 and 10^-4 failures per hour

Main Prescriptions (2)

Determine the **current Performance** Level for your System (PL)

- PL is based on the average probability of dangerous failure per hour
- Compute based on the current level of your system
- Parameters of the PL:
  - Mean time to dangerous failure of each channel ($MTFF_d$)
  - Diagnostic Channel (DC)
  - Common Cause Failures (CCF)

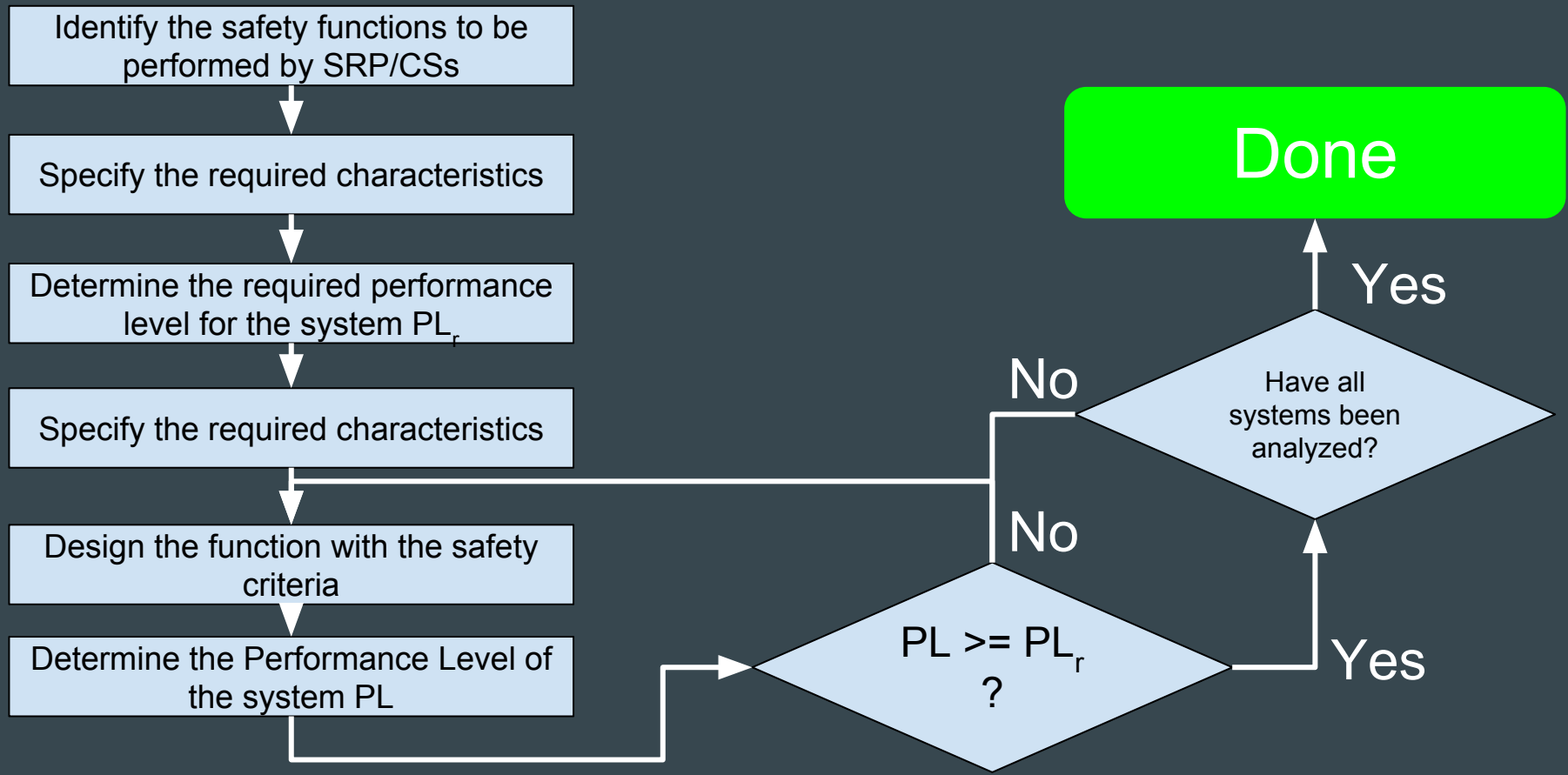
Applied to Our Project:

- Time of exposure: Low due to netting
- Severity of injury: Moderate-high due to unprotected quadcopter blades

Main Prescriptions (3)

Iterate your design until the current PL matches or exceeds the PL_r

Main Prescriptions (3)



How ISO 13849-1 Applies to Our Project

- In an underwater environment, there will be many control systems that will need to be tested for failure
  - These systems will directly affect the performance of the robot in the underwater environment
  - A failure will result in loss of operating time and cost to retrieve the malfunctioning system
  - Underwater welders and other humans working in the water around the wellhead could be dangerously injured by a failure of a control system

- A quadcopter working in a setting around humans could dangerously injure those working around it

Questions ?