GE: Automated Tool Preparation

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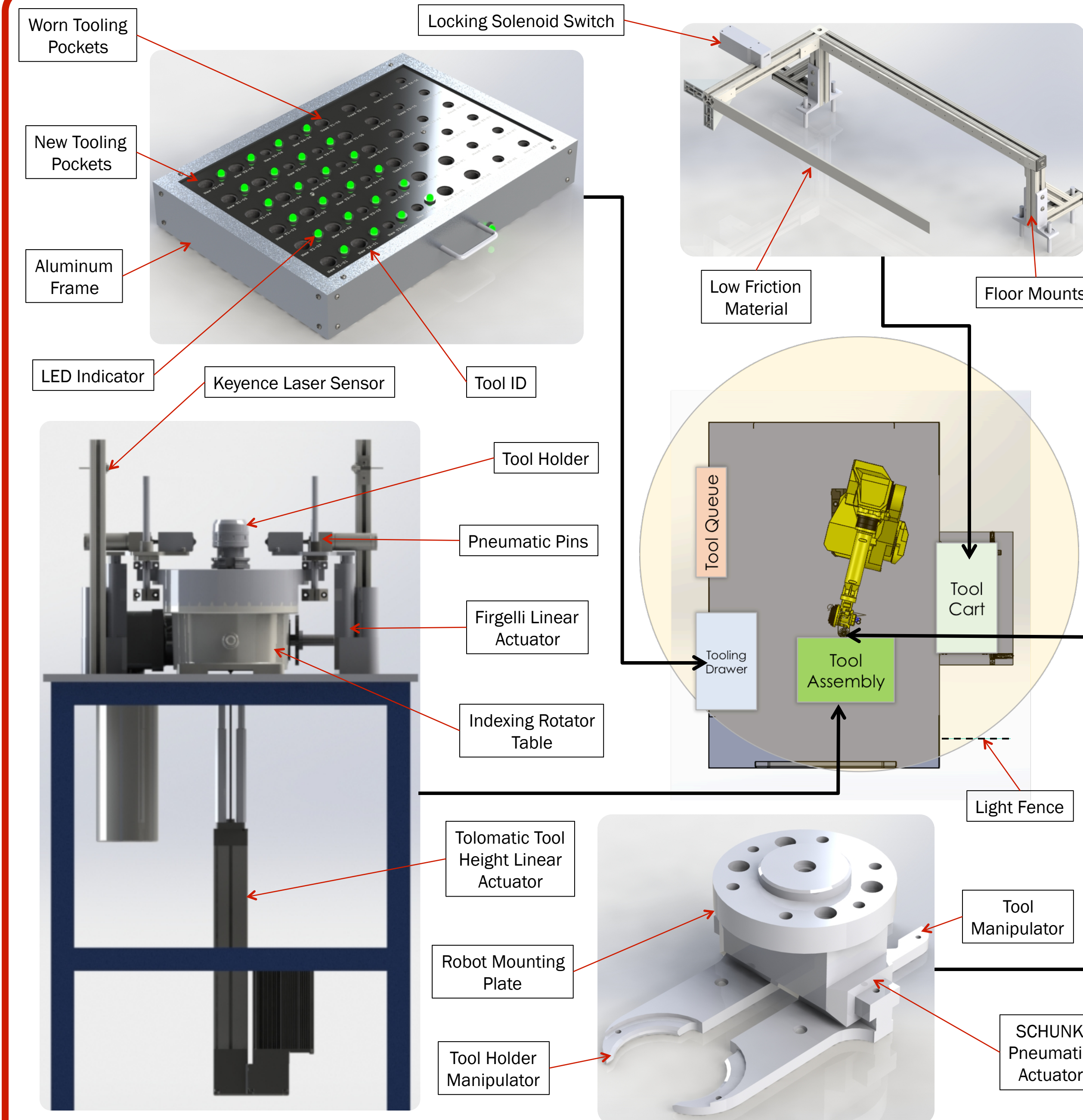Acknowledgements: John Graham, General Electric Aviation
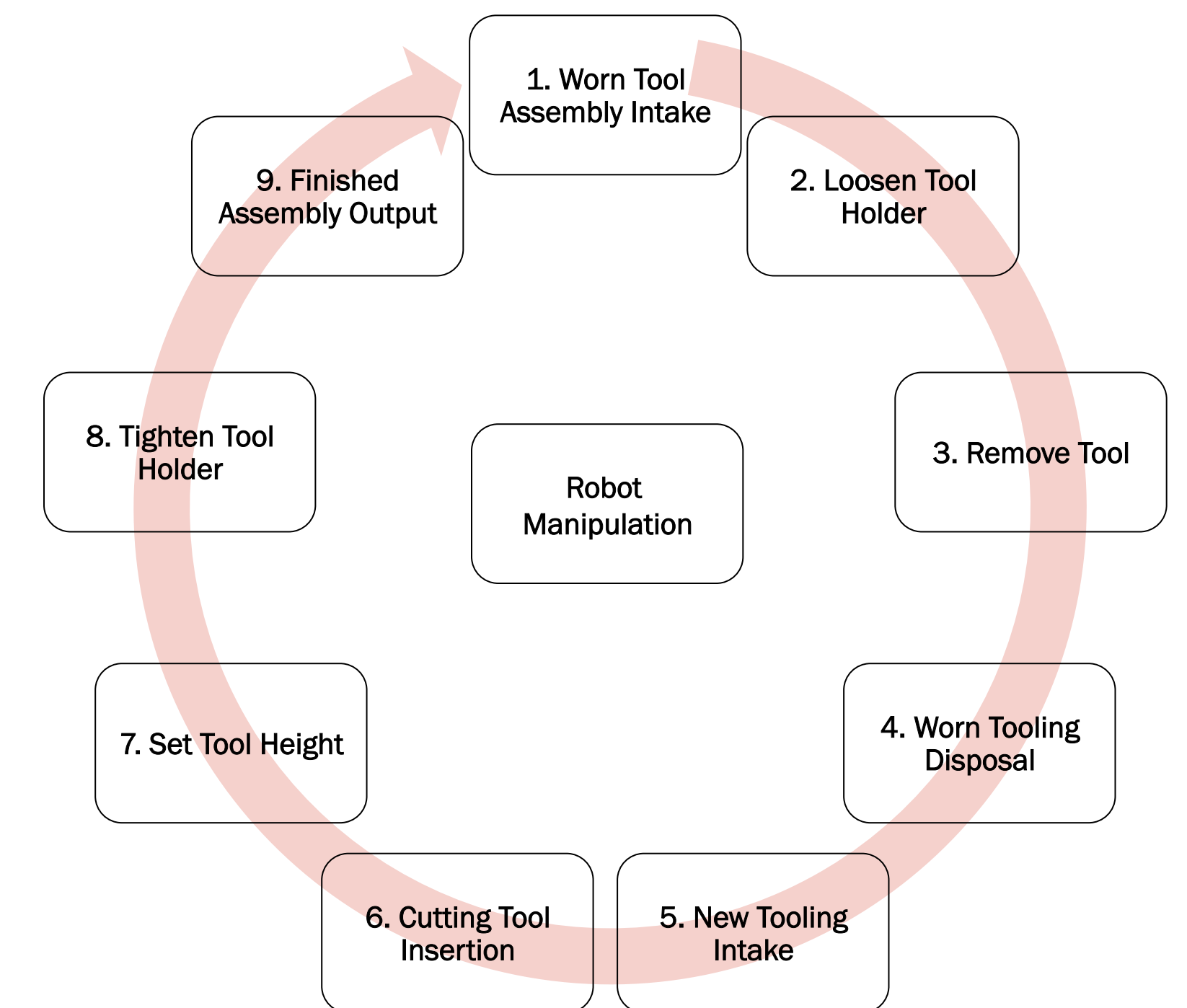
Abstract

Modern manufacturing methods employ the use of automated CNC machine tools. The use of this equipment, in conjunction with the wider adoption of "lights out" manufacturing, results in higher production output while also requiring more frequent tooling maintenance. The purpose of this project, as chartered by our sponsor, General Electric Aviation, is to develop an automated system for replacing cutting tools as they wear. The system is designed such that an operator will be able to load a cart of used cutting tools into a work cell and retrieve a cart of newly prepared tooling upon process completion. The team implemented the use of an industrial robot for material handling and designed custom fixtures to process each tool. This system eliminates the human error related with tool height setting, and can be universally adapted with alternate tooling in the future.
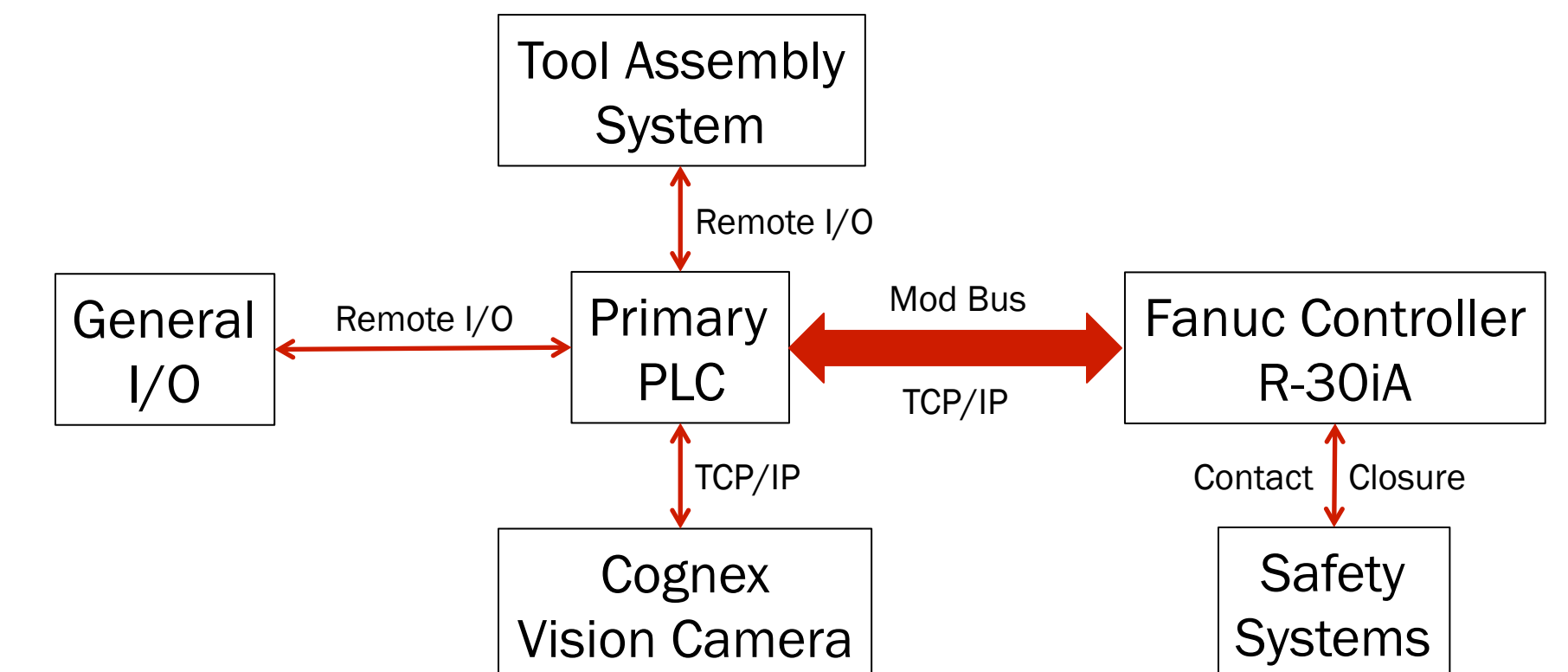
System Specifications

- Cutting tool shank diameter must be ½" or ¾"
- Can process 24 tools in one cycle with a maximum of 2 types with a ½" shank and 2 types with a ¾" shank.
- There can be a maximum of 6 tools of the same type
- Cutting tools must be end mills
- Only nut and collet CAT or MCAT milling chucks with a "through-tool coolant" pull stud may be used
- The tooling assembly cannot weight more than 50kg
- Designed to use a modified Huot SpeedyScoot CAT40 tool cart
- There must be sufficient ambient lighting for tool cart pocket recognition
- Milling chucks must not be exceptionally dirty for tool cart pocket recognition


Process Flow

1. Worn Tool Assembly Intake
2. Loosen Tool Holder
3. Remove Tool
4. Worn Tooling Disposal
5. New Tooling Intake
6. Cutting Tool Insertion
7. Set Tool Height
8. Tighten Tool Holder
9. Finished Assembly Output

Robot Manipulation

System Architecture

Tool Assembly System — Remote I/O — Primary PLC
General I/O — Remote I/O — Primary PLC
Primary PLC — Mod Bus / TCP/IP — Fanuc Controller R-30iA
Primary PLC — TCP/IP — Cognex Vision Camera
Fanuc Controller R-30iA — Contact Closure — Safety Systems

Tooling Drawer

- Foam adds compliance to the system
- LED indicators tell operator that the proximity sensor has been triggered, meaning the tool is properly inserted
- DB-25 and PowerPole connectors on back side
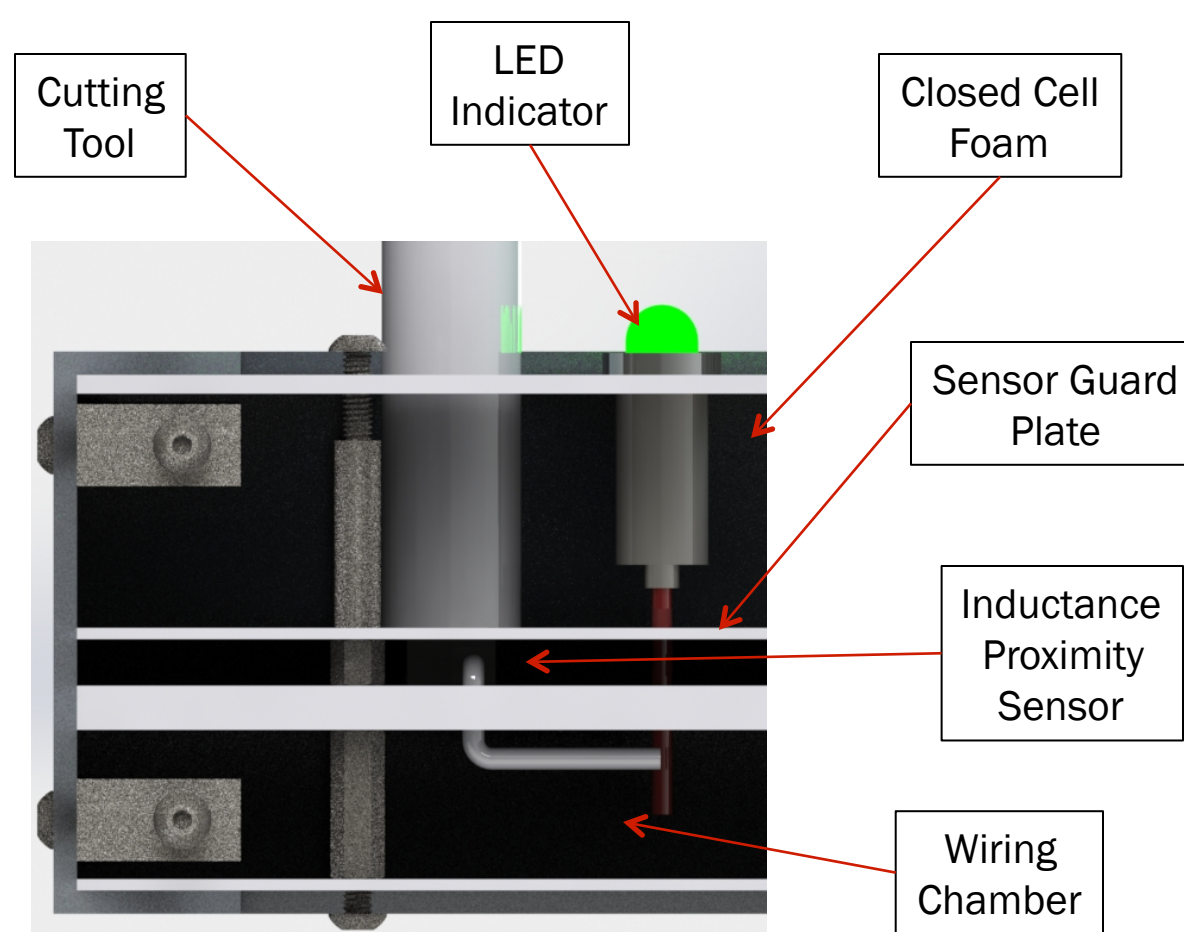
Tool Assembly System

- Pneumatic pins lock the nut as an indexing table rotates the milling chuck. An encoder indicates motion has stopped and the tool is tightened
- A long pin is fed through the "through-tool coolant" hole in the pull stud and used to control tool height
- The tool is raised until a laser sensor is triggered. From this known location, the tool height is properly adjusted
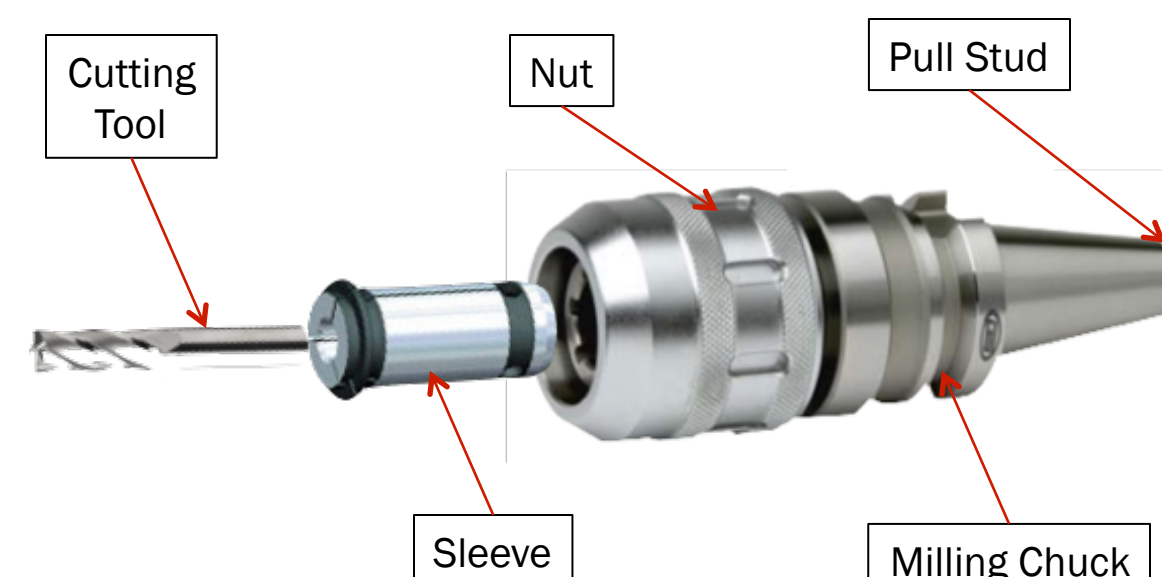

Cart Pocket Recognition

- Cognex 5100 Insight smart camera
- Identifies filled pockets using pre-defined pixel clusters of brightness

Green squares signify pockets identified as holding a tool holder
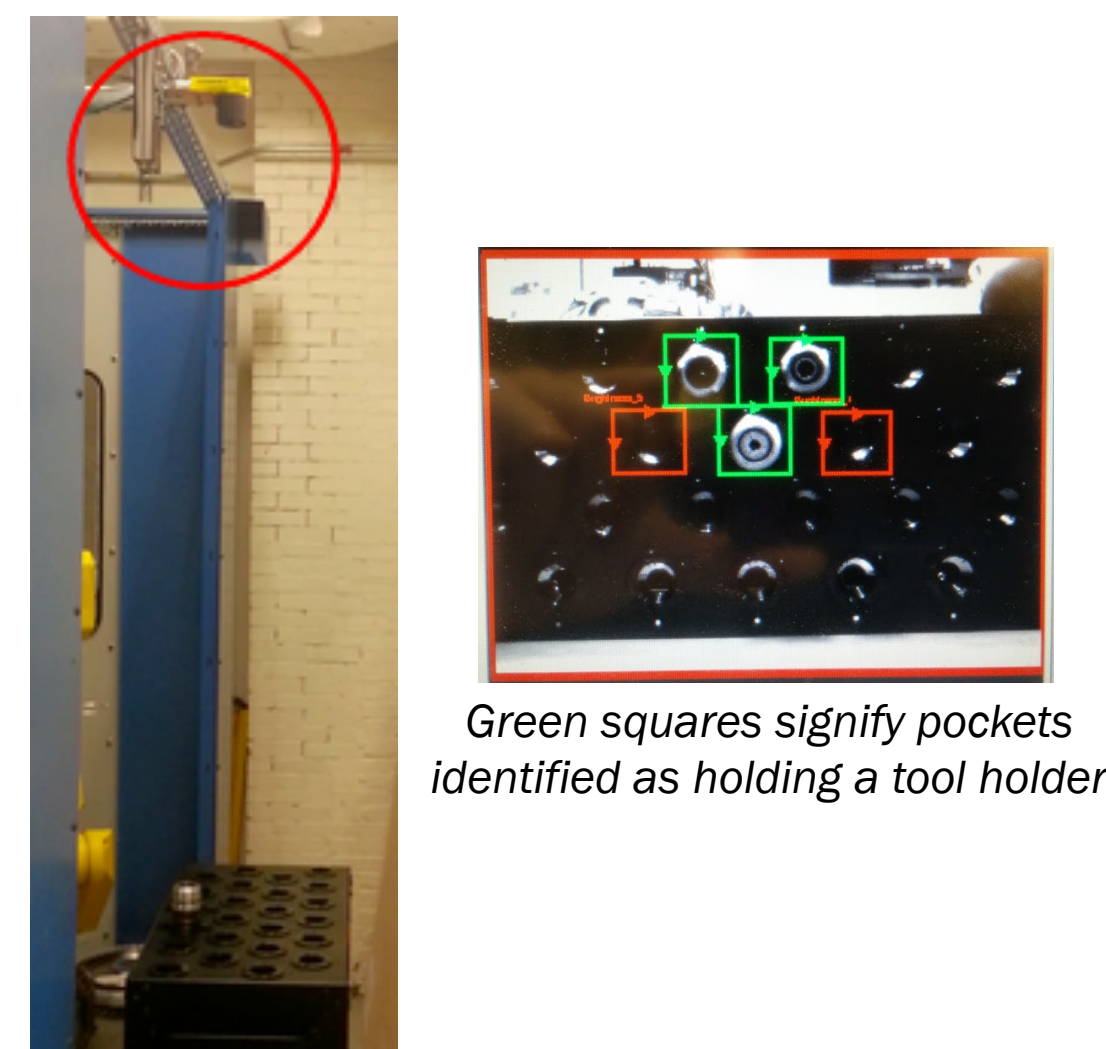
PLC Control

- Automation Direct Do-More! Module PLC solution
- 40 discrete inputs
- 48 discrete relay outputs
- 8 analog voltage control
- 4 high speed counter inputs
- Communication protocols:
  - Modbus TCP/IP
  - TCP/IP
- Remote I/O communication utilized by tool assembly system

Tool Assembly I/O *PLC Control Box*
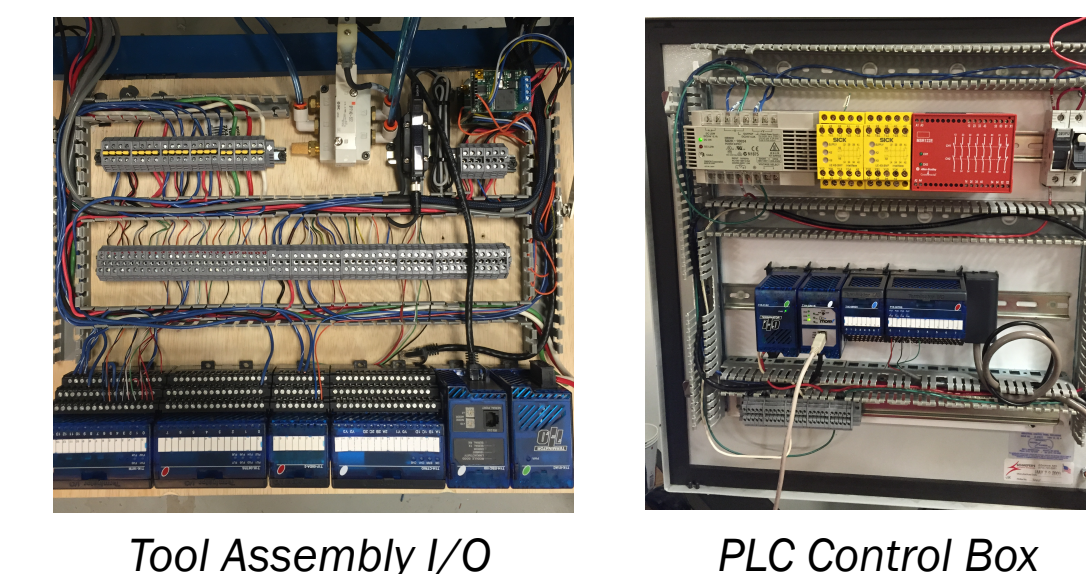
Safety

- Tool cart and drawer are locked in place during operation
- Light fence used to protect operator from one side of the work cell
- Interlock switch on the one door to the work cell
- E-stop switch on exterior of the work cell