2024 Vision Centric Challenge

VBMS
Vision Based Measurement System

V 2.0 – Final Version for 2024 Season

This file can be found on the **Vcc** page on the website

Coaches are responsible for communicating rules updates to participants

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Room J233 Taubman Complex, LTU

21000 West 10 Mile Road, Southfield, MI 48075, USA

1. Vcc Overview

Learning Objectives:

- Video image processing
- Shape & Size detection
- Lighting
- Calibration
- Practical Real-World Applications
- Region of Interest (ROI)
- Thresholding
- Edge detection

Synopsis:

- **An Open Category** competition, which will take place at the World Robofest Championship
- A unique STEM (Science, Technology, Engineering, and Mathematics) competition with intelligent and interactive robots using vision-based systems to compete

ROBOFEST Lawrence Technological University

2. Age Divisions, Team Size and Fees

- Senior Age Division (Grades 9-12)
- Team Size: Maximum five (5) members
- Team Registration Fee: $75 at the World Championship
- Related important document - 2024 General Rules
- Each team member must bring the signed Robofest Consent and Release Form on the day of the event, if not completed online

3. Vcc Scenario

- Manufacturing involves making parts that meet the dimensional requirements of the blueprint. Teams will be given:
  - A blueprint with a number of dimensions
  - Ten numbered sample parts to measure
- The objective of the game will be to inspect each of the parts and to:
  - Identify if each dimension meets the print requirements or not
  - Provide the dimensions for a single Key Product Characteristic (KPC) on each part
    - The KPC is the key dimension on the part that must have the numeric value recorded
    - The KPC will be explicitly identified on the print (see examples)
    - Note: Even though there are 5 dimensions to measure, only one, the KPC needs a value reported
- Measurement must be done using visual/non-contact techniques
  - Students may touch parts to load and unload parts
- Teams will learn and utilize real world skills such as:
  - Computer Vision
  - Open CV Library

3. Programming Time

- Teams are given:
  - a single sample part
  - a print
  - the inspection report for that part
- Sample part for programming and testing
  - 45 minutes to program
  - During the work-time, no adult/coach's help is allowed
  - Team may be disqualified for receiving illegal help
- After the 45-minute work-time teams must move away from the robot
- Teams will not be permitted to access the internet during the programming time and will not be permitted use of cell phones

3. Game Synopsis (1/2)

- Robot starts after judge declares “three, two, one, start”
- Robot must measure 10 samples (same part) with 5 dimensions on each
  - These dimensions will be explicitly called out on the print
  - The same 10 parts will be used by all the teams
- Robot Reports if each dimension is In Tolerance (1) OR Out of Tolerance (0)
- Robot Reports if the part is a good part or a bad part (PASS/FAIL)
- Robot Reports the value for a Key Product Characteristic (KPC)
  - This dimension will be explicitly called out on the print

3. Game Synopsis (2/2)

- Teams will be given 2 minutes to complete the task
  - Students will operate the robot
  - Judges will not touch the robot
- Teams must output the results to the screen
- The unknown factors will be the part and the blueprint
- One restart will be permitted

4. Setup

- Lighting conditions at the competition are unknown and possibly dynamic
- Team will be given a table for the robot
- PC or Laptop can be in addition to the robot

5. The Parts (1/2)

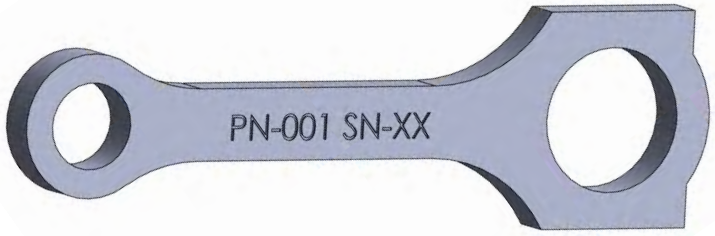
- Part will be:
  - 6mm thick
  - Maximum length of 250mm
  - Maximum width of 50mm
  - Made of aluminum
  - Identified with a Serial Number
  - Dimensions to measure will only be from the top
- Sample part for programming and testing
  - 45 minutes to program

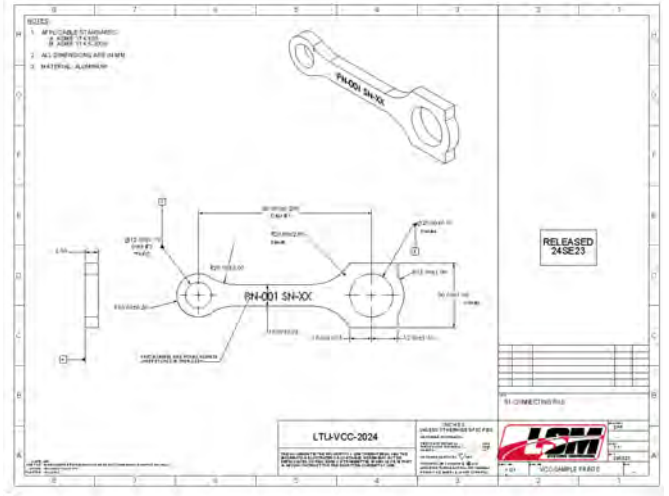
5. The Parts (2/2)

- Example Prints (PDF) will be available for download
- Example Models (STL) will be available for download

6. The Print (& Inspection Report)

- During the programming time teams will be provided with
  - One Sample Part
  - A blueprint identifying:
    - the 5 dimensions to measure and report InTol (1) or OutTol (0)
    - The one KPC to report size on
  - An inspection report for the sample part that they were provided with



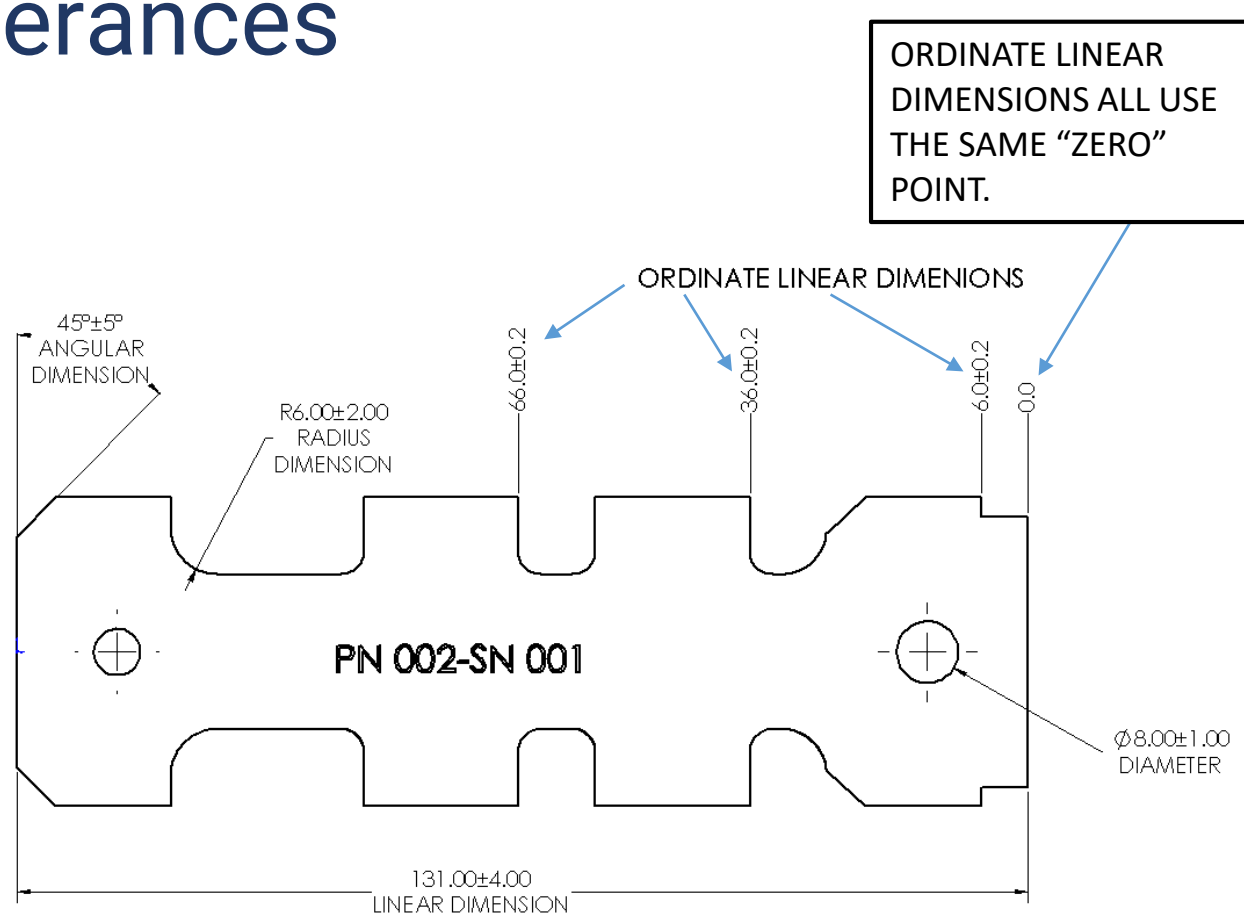


Sample Inspection Report:
Part: PN-001-SN-01

DIM#1	80.012
DIM#2	12.215** KPC
DIM#3	21.500
DIM#4	19.994
DIM#5	32.743

6. Print Dimensions & Tolerances

- Allowable dimensions includ
  - Linear dimensions
  - Ordinate Linear dimensions
  - Diameter dimensions
  - Radius dimensions
  - Angles
- Tolerances
  - Nominal ± tolerances [only]



7. Scoring

- Scoring will be done by judges
  - Each dimension correctly called out is worth 1 point (5 per part)
  - One Key dimension per part is measured by the accuracy of the measurement
    - Up to 5 points for this measurement
    - Error = Absolute Value of (Measured – Actual)
- Results will be posted when all teams have completed their runs
- Round 2 will proceed the same as round 1 except:
  - The physical part will be different
  - Will have a different print with different dimensions
  - The KPC will also be different

7. Scoring (of each round)

- Example:
  - Part 1: 3 correct = 3 points
  - Accuracy:
    - Measured 12.156
    - Actual: 12.111
    - Error = 12.156-12.111 = 0.045
    - Error < 0.050 so worth 4 points
- Note: Values in the “Actual” column are examples and will vary based on the actual samples.

Robofest 2024 VCC - Vision Based Measurement System
Updated 1/14/24

Division: Senior Team Name: _____

Organization Name _____ Team Number: _____

Round: First Second

	Round Score	Team Reported	Actual	Match	Point Value	Points	
PART 1	Dimensions correctly called in/out of specification				x1		Max 5
	KPC Error	Measured	-Actual	=Error	See Grid		Max 5
PART 2	Dimensions correctly called in/out of specification				x1		Max 5
	KPC Error	Measured	-Actual	=Error	See Grid		Max 5
PART 3	Dimensions correctly called in/out of specification				x1		Max 5
	KPC Error	Measured	-Actual	=Error	See Grid		Max 5
PART 4	Dimensions correctly called in/out of specification				x1		Max 5
	KPC Error	Measured	-Actual	=Error	See Grid		Max 5
PART 5	Dimensions correctly called in/out of specification				x1		Max 5
	KPC Error	Measured	-Actual	=Error	See Grid		Max 5
PART 6	Dimensions correctly called in/out of specification				x1		Max 5
	KPC Error	Measured	-Actual	=Error	See Grid		Max 5
PART 7	Dimensions correctly called in/out of specification				x1		Max 5
	KPC Error	Measured	-Actual	=Error	See Grid		Max 5
PART 8	Dimensions correctly called in/out of specification				x1		Max 5
	KPC Error	Measured	-Actual	=Error	See Grid		Max 5
PART 9	Dimensions correctly called in/out of specification				x1		Max 5
	KPC Error	Measured	-Actual	=Error	See Grid		Max 5
PART 10	Dimensions correctly called in/out of specification				x1		Max 5
	KPC Error	Measured	-Actual	=Error	See Grid		Max 5
	KPC Accuracy Scoring Grid	<=0.025 = 5 <=0.050 = 4 <=0.075 = 3		<=0.100 = 2 <=0.125 = 1 > 0.125 = 0			
	Reset was requested (reset penalty)	0 (No) 1 (Yes)			x(-1)		
					TOTAL		Max 100

Judge Initials: _____ Team Player Initials: _____

7. Scoring Example

- Here is a filled-out scoring round
- Notice points for the matches on the InTol[1] and OutTol[0] callouts
- Notice the points for the KPC based on the calculated error

Robofest 2024 VCC - Vision Based Measurement System
Updated 1/14/24

Division: Senior Team Name: _____

Organization Name _____ Team Number: _____

Round: First Second

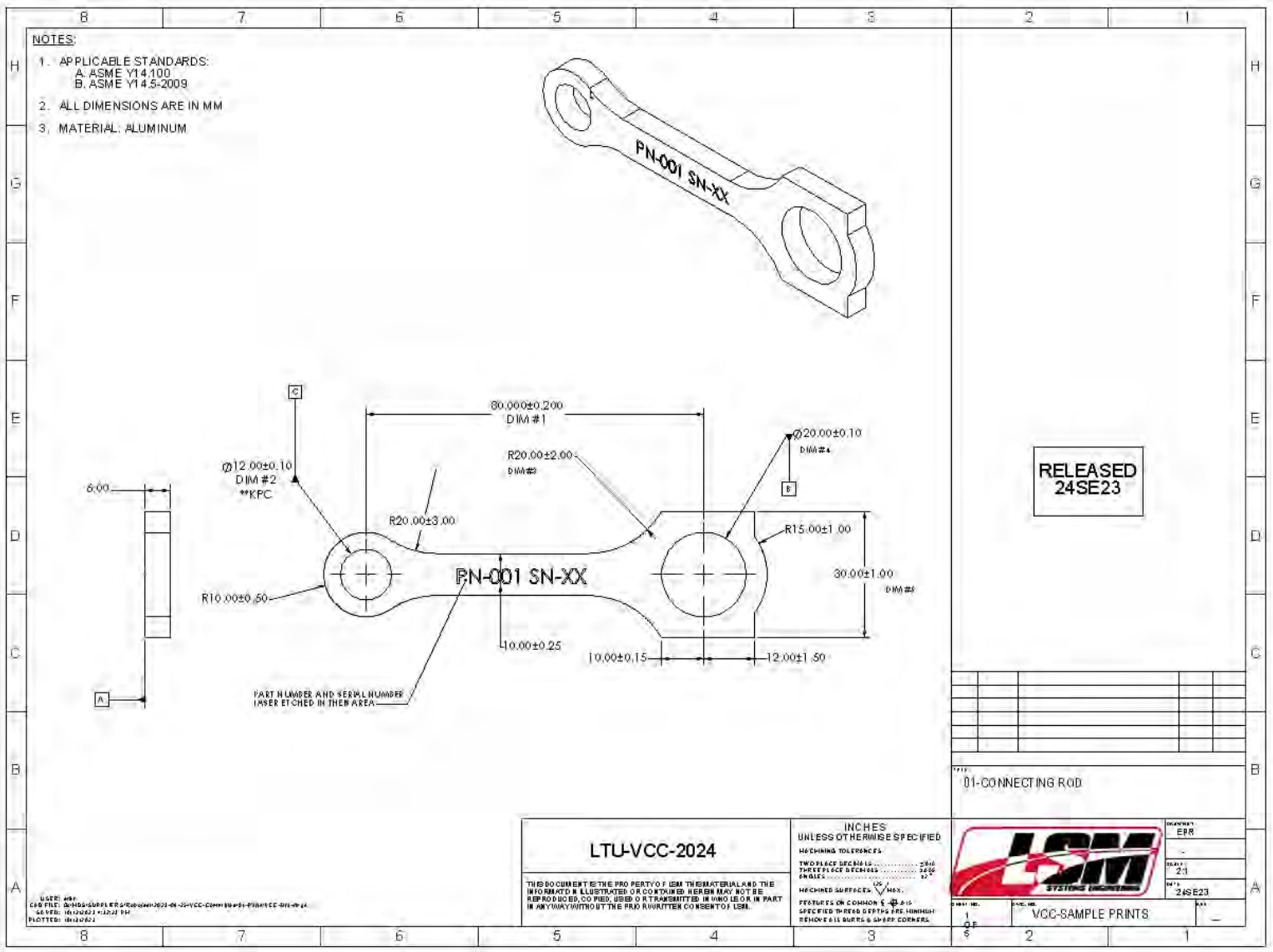
	Round Score	Team Reported	Actual	Match	Point Value	Points	
PART 1	Dimensions correctly called in/out of specification	11001	11001	5	x1	5	Max 5
	KPC Error	Measured 12.101	-Actual 12.111	=Error 0.010	See Grid	5	Max 5
PART 2	Dimensions correctly called in/out of specification	11001	11000	4	x1	4	Max 5
	KPC Error	Measured 12.265	-Actual 12.222	=Error 0.043	See Grid	4	Max 5
PART 3	Dimensions correctly called in/out of specification	11110	01010	3	x1	3	Max 5
	KPC Error	Measured 12.400	-Actual 12.333	=Error 0.067	See Grid	3	Max 5
PART 4	Dimensions correctly called in/out of specification	10011	10100	2	x1	2	Max 5
	KPC Error	Measured 12.354	-Actual 12.444	=Error 0.090	See Grid	2	Max 5
PART 5	Dimensions correctly called in/out of specification	10000	11111	1	x1	1	Max 5
	KPC Error	Measured 12.666	-Actual 12.555	=Error 0.111	See Grid	1	Max 5
PART 6	Dimensions correctly called in/out of specification	11111	00000	0	x1	0	Max 5
	KPC Error	Measured 12.955	-Actual 12.666	=Error 0.289	See Grid	0	Max 5
PART 7	Dimensions correctly called in/out of specification	11010	11000	4	x1	4	Max 5
	KPC Error	Measured 12.656	-Actual 12.777	=Error 0.121	See Grid	1	Max 5
PART 8	Dimensions correctly called in/out of specification	11101	10111	3	x1	3	Max 5
	KPC Error	Measured 12.905	-Actual 12.888	=Error 0.017	See Grid	5	Max 5
PART 9	Dimensions correctly called in/out of specification	01111	11110	3	x1	3	Max 5
	KPC Error	Measured 13.075	-Actual 12.999	=Error 0.076	See Grid	2	Max 5
PART 10	Dimensions correctly called in/out of specification	01011	00011	4	x1	4	Max 5
	KPC Error	Measured 12.052	-Actual 12.000	=Error 0.052	See Grid	3	Max 5
	KPC Accuracy Scoring Grid	<=0.025 = 5 <=0.050 = 4 <=0.075 = 3		<=0.100 = 2 <=0.125 = 1 > 0.125 = 0			
	Reset was requested (reset penalty)	0 (No) 1 (Yes)			x(-1)	0	
					TOTAL	55	Max 100

Judge Initials: _____ Team Player Initials: _____

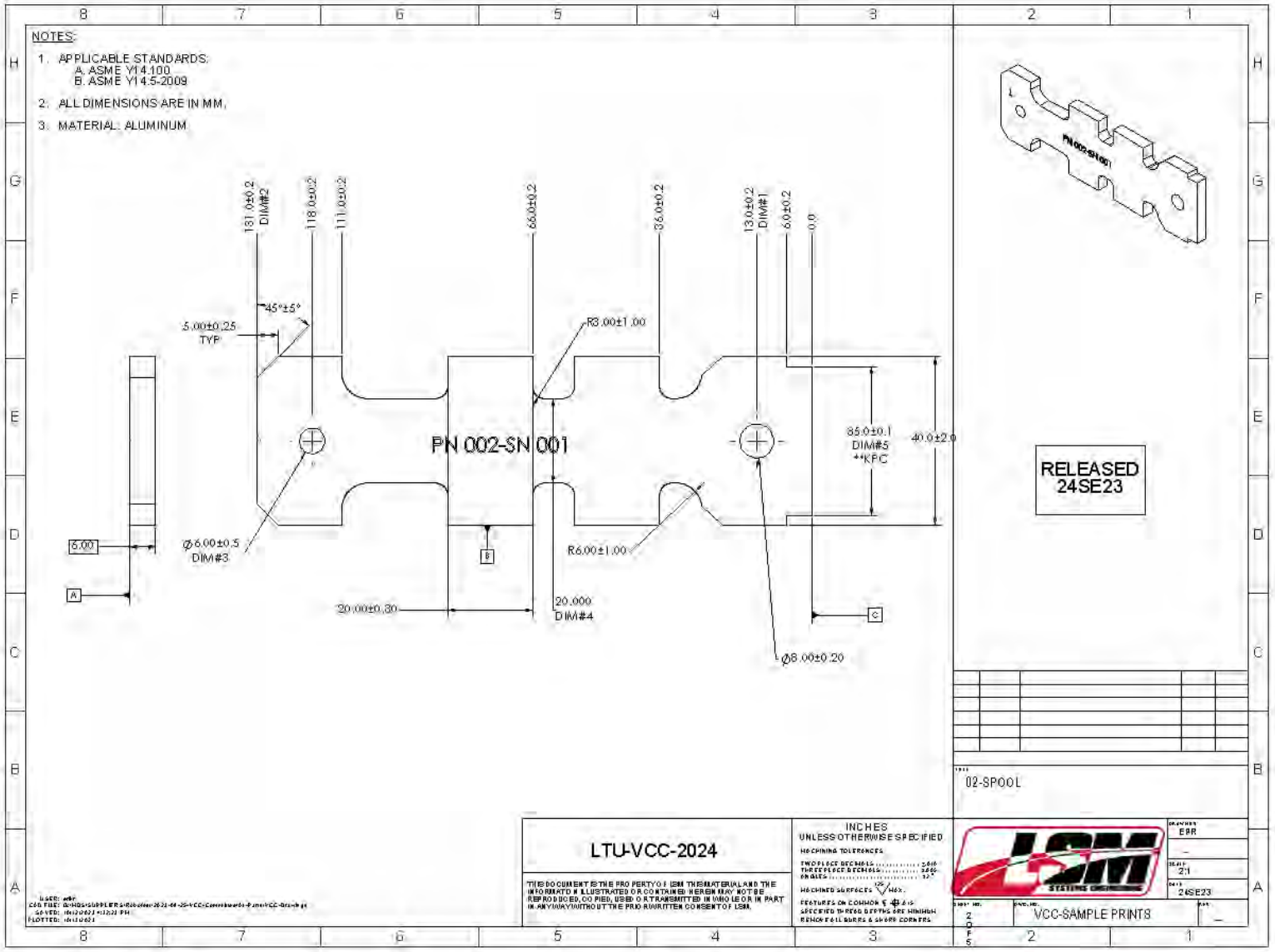
8. Rules to Determine Winners & Break Ties

- Winners will be decided by average points of 2 rounds
- Tie breakers will be on KPC measurement (Closest to actual wins):
  - 10th part from Round 2
  - If tied go to 9th part from Round 2… until there is a winner

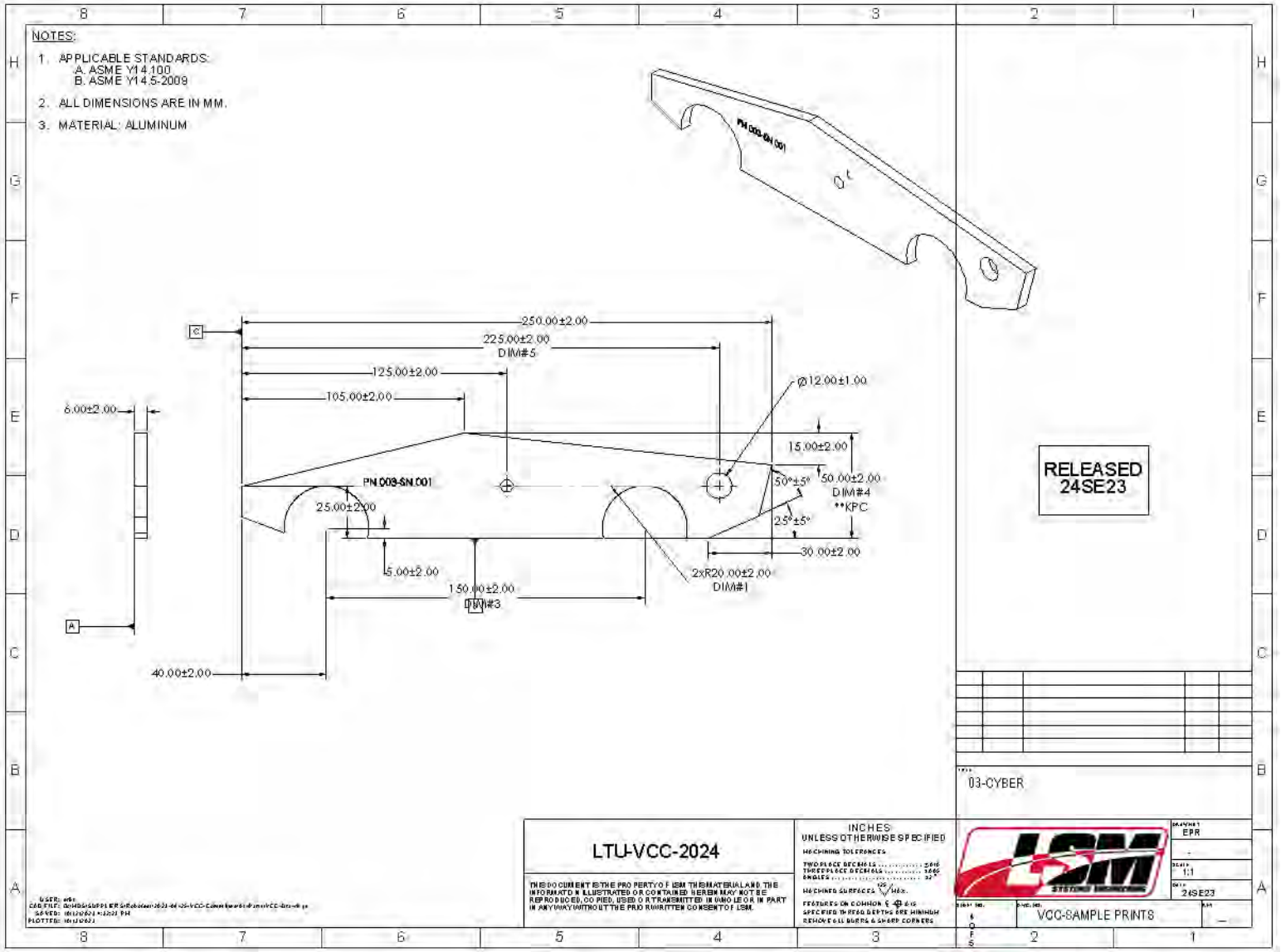
9. Example #1


NOTES:
1. APPLICABLE STANDARDS:
A. ASME Y14.100
B. ASME Y14.5-2009
2. ALL DIMENSIONS ARE IN MM
3. MATERIAL: ALUMINUM
PN-001 SN-XX
80.000±0.200
DIM #1
Ø12.00±0.10
DIM #2
**KPC
R20.00±2.00
DIM #3
Ø20.00±0.10
DIM #4
6.00
R20.00±3.00
R15.00±1.00
30.00±1.00
DIM #5
PN-001 SN-XX
R10.00±0.50
10.00±0.25
10.00±0.15
12.00±1.50
PART NUMBER AND SERIAL NUMBER
LASER ETCHED IN THIS AREA
RELEASED
24SE23
01-CONNECTING ROD
LTU-VCC-2024
INCHES
UNLESS OTHERWISE SPECIFIED
VCC-SAMPLE PRINTS
24SE23

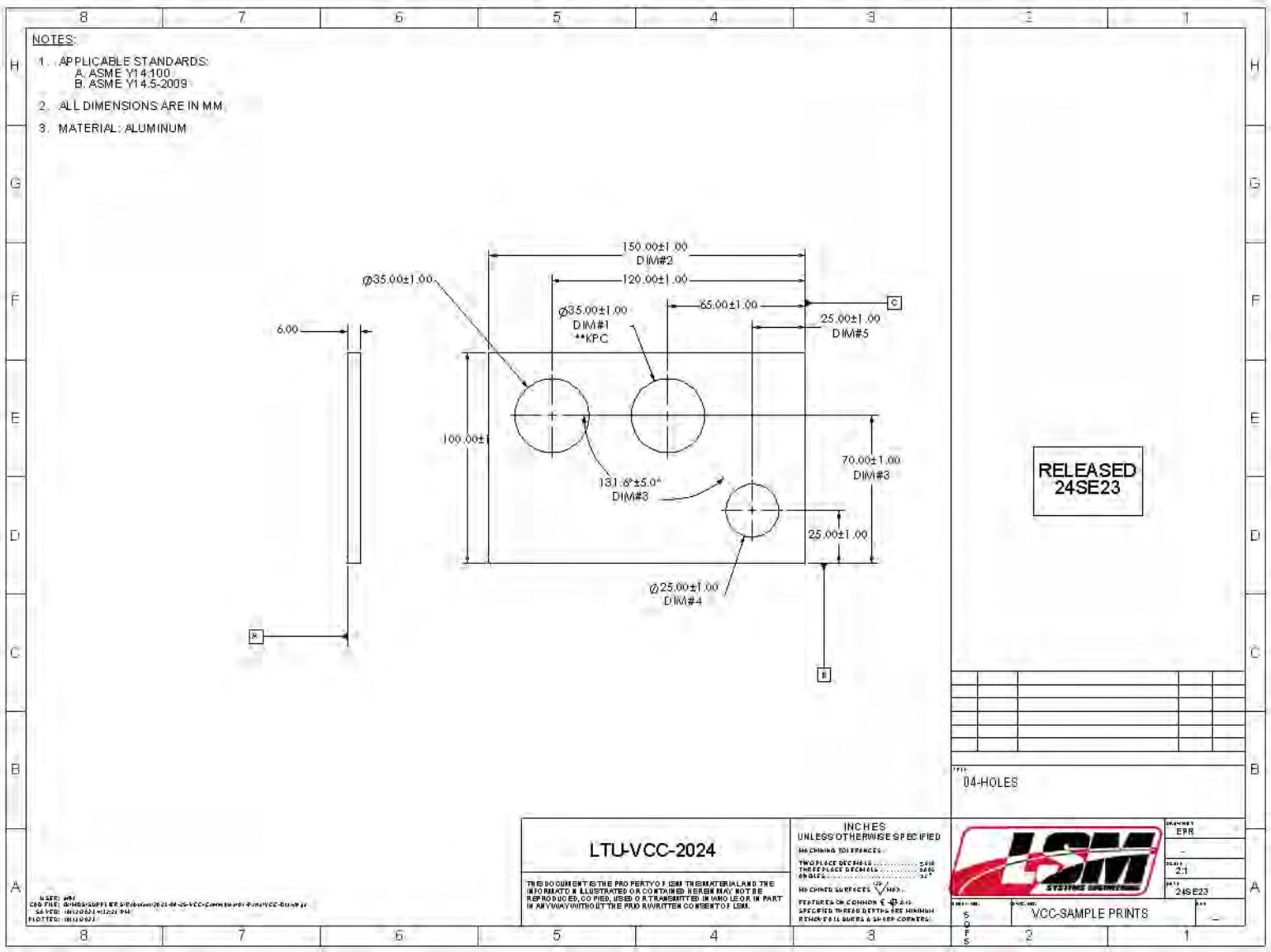
9. Example #2


NOTES:
1. APPLICABLE STANDARDS:
A. ASME Y14.100
B. ASME Y14.5-2009
2. ALL DIMENSIONS ARE IN MM.
3. MATERIAL: ALUMINUM
181.0±0.2
DIM#2
118.0±0.2
111.0±0.2
66.0±0.2
36.0±0.2
13.0±0.2
DIM#1
6.0±0.2
0.0
45°±5°
5.00±0.25
TYP
R3.00±1.00
PN 002-SN 001
85.0±0.1
DIM#5
**KPC
40.0±2.0
5.00
Ø6.00±0.5
DIM#3
R6.00±1.00
20.00±0.30
20.000
DIM#4
Ø8.00±0.20
RELEASED
24SE23
02-SPOOL
LTU-VCC-2024
INCHES
UNLESS OTHERWISE SPECIFIED
VCC-SAMPLE PRINTS
24SE23

9. Example #3


NOTES:
1. APPLICABLE STANDARDS:
A. ASME Y14.100
B. ASME Y14.5-2009
2. ALL DIMENSIONS ARE IN MM.
3. MATERIAL: ALUMINUM
250.00±2.00
225.00±2.00
DIM#5
125.00±2.00
105.00±2.00
6.00±2.00
Ø12.00±1.00
15.00±2.00
50°±5°
50.00±2.00
DIM#4
**KPC
PN.003-SN.001
25.00±2.00
25°±5°
30.00±2.00
5.00±2.00
150.00±2.00
DIM#3
2xR20.00±2.00
DIM#1
40.00±2.00
RELEASED
24SE23
03-CYBER
LTU-VCC-2024
INCHES
UNLESS OTHERWISE SPECIFIED
MACHINING TOLERANCES
TWO PLACE DECIMALS ±.010
THREE PLACE DECIMALS ±.005
ANGLES ±2°
MACHINED SURFACES 125 MAX.
FEATURES IN COMMON ⌖ Ø.010 M
SPECIFIED THREAD DEPTHS ARE MINIMUM
REMOVE ALL BURRS & SHARP CORNERS
THIS DOCUMENT IS THE PROPERTY OF LSM. THIS MATERIAL AND THE INFORMATION ILLUSTRATED OR CONTAINED HEREIN MAY NOT BE REPRODUCED, COPIED, USED OR TRANSMITTED IN WHOLE OR IN PART IN ANY WAY WITHOUT THE PRIOR WRITTEN CONSENT OF LSM.
LSM
EPR
1:1
24SE23
VCC-SAMPLE PRINTS

9. Example #4


NOTES:
1. APPLICABLE STANDARDS:
A. ASME Y14.100
B. ASME Y14.5-2009
2. ALL DIMENSIONS ARE IN MM
3. MATERIAL: ALUMINUM
150.00±1.00
DIM#2
120.00±1.00
Ø35.00±1.00
65.00±1.00
Ø35.00±1.00
DIM#1
**KPC
25.00±1.00
DIM#5
6.00
100.00±1
131.6°±5.0°
DIM#3
70.00±1.00
DIM#3
25.00±1.00
Ø25.00±1.00
DIM#4
RELEASED
24SE23
04-HOLES
LTU-VCC-2024
INCHES
UNLESS OTHERWISE SPECIFIED
EPR
2:1
24SE23
VCC-SAMPLE PRINTS

10. Displaying Results

The results must be saved and displayed for the judges

- Team Name
- Team Number
- Part 1, 1/0, 1/0, 1/0, 1/0, 1/0, Pass/Fail, KPC
- Part 1, 1/0, 1/0, 1/0, 1/0, 1/0, Pass/Fail, KPC
- Part 1, 1/0, 1/0, 1/0, 1/0, 1/0, Pass/Fail, KPC
- …
- Part 1, 1/0, 1/0, 1/0, 1/0, 1/0, Pass/Fail, KPC
  - Where 1 is InTol, 0 is OutTol
  - Pass is good part, Fail is bad, (for each of the 5 dimensions) then an overall pass/fail for the part
  - KPC is the measurement for the KPC value

Part 1	1	1	1	1	1	PASS	10.234
Part 2	0	1	1	1	1	FAIL	12.234
Part 3	1	1	0	1	0	FAIL	12.203
Part 4	1	0	1	0	1	FAIL	12.456
Part 5	1	0	1	0	1	FAIL	12.456
Part 6	1	0	1	1	1	FAIL	12.456
Part 7	1	0	1	0	1	FAIL	12.456
Part 8	1	0	1	1	1	FAIL	12.456
Part 9	1	0	1	0	1	FAIL	12.456
Part 10	1	1	1	1	0	FAIL	12.874

TEAM 12345-1
The Measurebots
Part 1, 1, 1, 1, 1, 1, PASS, 10.234
Part 2, 0, 1, 1, 1, 1, FAIL, 12.234
Part 3, 1, 1, 0, 1, 0, FAIL, 12.203
Part 4, 1, 0, 1, 0, 1, FAIL, 12.456
Part 5, 1, 0, 1, 0, 1, FAIL, 12.456
Part 6, 1, 0, 1, 1, 1, FAIL, 12.456
Part 7, 1, 0, 1, 0, 1, FAIL, 12.456
Part 8, 1, 0, 1, 1, 1, FAIL, 12.456
Part 9, 1, 0, 1, 0, 1, FAIL, 12.456
Part 10, 1, 1, 1, 1, 0, FAIL, 12.874

11. Robot Specifications

- Must be completely autonomous (other than part loading/unloading & Measure). (Any type of remote control by a human driver or remote computer is not allowed.) The main controller can be a laptop, notebook, tablet, micro-controller, open MV, Jetson Nano, or even a smart phone.
- Any robot platform with up to 2 cameras is allowed. Must be USB, single lens camera. Any lens is acceptable.
- Any programming language may be used
- Width must be less than 24 inches (60.7 cm)
- Length must be less than 36 inches (91.4cm)
- Height must be less than 36 inches (91.4cm)
- Weight: no limit
- PC or computer is not included in dimensions
- Additional sensors may be used but inspection must be done visually
- Additional lighting can be provided by the robot
- The robot may *not* automatically expand its dimension larger than the specified maximum values
- Camera angle: no restriction. You may use motors to move the camera. Wide angle lens can be used
- A Robofest team name & team ID tag on the robot are required
- No communication via WiFi or Bluetooth or similar will be permitted

12. Human-Robot Interface Specifications

The HRI (Human Robot Interface) May include:

- Keyboard is permitted
  - Only the space bar may be pressed
- Mouse not to be used during competition
- Single or Multiple monitors
- At the end of the round the team will display the results on the screen and the judge will record values from the screen for scoring

13. Allowable Interactions/Violations and Full Reset

Team is allowed to:

- Place parts onto the robot
- Take parts off of the robot
- Operate the HRI (Human Robot Interface)
- Members are not allowed to modify lighting once round has started
  - Robot may adjust lighting

When any of the above violations occurs, the team can request a one-time “full reset” OR declare the end of the run. Teams reset their robot and continue

14. World Championship

- Winning Team(s) may be invited to present their robots on Saturday and be eligible for “People’s Choice” award

15. Important Notes

- Teams from the same organization must have clearly different solutions. Judge decision is final.
- Final decisions are at the discretion of the Chief Vcc Judge

17. FAQ’s

- Will there be slopped edges in the part? For example, countersink holes or curved edges. **The parts will consist of a 2D profile. Edges may be broken to prevent sharp edges.**
- How big will the variance of the parts be comparing between the work time part and the competition part? For example, the part on page 12 is 131mm long. Will it be possible for the part to become 250mm long during one of the runs? **Dimensions that are out of tolerance will be a minimum of 0.1mm out of tolerance (above the maximum or below the minimum) and a maximum of 5mm out of tolerance. Note some dimensions may be near the 0.1mm out of tolerance and be more difficult for the team to measure and some may be out by 5mm and easy for the team to identify as out of tolerance.**
- Some of the tolerances appear to be “too tight” for measurement. **No tolerance will be tighter than ±0.1mm which should be easily measurable with calipers. Teams will also be given a sheet with the official measurements.**
- If there is a question on the measurement what can a team challenge an official measurement? **The game parts will be very accurately measured and will be the official measurement. During competition it is possible to verify that the part has not been damaged.**
- Will the 10 parts all be the same part? **The 10 parts will be identical parts apart from the dimensional values. They will all use the same drawing.**
- Is there a required orientation of the parts? **Teams can orient the parts any way that they wish.**
- May the team press the space bar between measurements? **Teams may use the spacebar in any method that they want during the competition. The spacebar, however, is the only key that can be pressed during competition.**

18. Committee

Member:	Bio:
Erik Rosvold (*)	Chief Operating Officer at LSM Systems Engineering. Bachelor's degree in electrical engineering from Kettering University and a master's degree in manufacturing systems from the University of Michigan. Robofest Coach, host and volunteer since 2015. LTU adjunct professor
Tejaskumar B Patil	Tejaskumar received his BSEE from Walchand College of Engineering, Sangli, Maharashtra, India and a MS in Industrial Engineering from Wayne State University in Detroit, MI. Presently, he serves as a Senior Systems Engineer at Qualcomm in Novi, Michigan, where he spearheads crucial initiatives in Functional Safety, Safety of Intended Functionality (SOTIF), and Systems Engineering. He actively participates in automotive standard committees. He is a Senior IEEE member.
Nathaniel Johnson	Nate graduated from LTU in 2007 with a MS in Electrical Engineering. His experience as a Robofest volunteer kick started his robotics career. He has travelled to Europe and Asia for autonomous driving, and now works in spatial computing, specializing in Unreal and Unity software, and he's a VCC judge!
Rodrigo Rodriguez	Rodrigo is a System Integration ENG at Ford Motor Co, Bachelor's Degree in Mechatronics From Tecnologico de Monterrey, Master degree in Artificial Intelligence from Tecnologico de Monterrey, Being Committed to improve STEAM education in Latin America Since 2012, Robofest Coach and member of Robofest Mexico Committee from 2017 to 2023.
Emily Trudell	Emily graduated with a MS in Computer Science from LTU in 2009. During her time at LTU she captained the Aibo Soccer team, competed in IGVC, Robogames and RoboCup. She also worked as a student assistant for Robofest and later volunteered as a judge for VCC. She has been a professional Android developer for 10 years.
Steven Lowe, Jr	Steve is the CEO of LSM Systems Engineering, a specialty parts manufacturer producing parts for the automotive, aerospace and defense industries. Steve is skilled in manufacuting techniques, CNC programming, CMM operation and business management and planning.
CJ Chung	Professor of Computer Science. Founder of Robofest. Director of Robofest 1999-2020. Director of LTU's CAR (CS AI Robotics) Lab. Launched Vision-based Mini Urban Challenge using L2Bots in 2007. The category name changed to Vcc in 2009. Designed Vcc challenge rules 2007-2020

(*) Chairperson