APPLICATION // 05

Dimensional inspection and measurement with machine vision

Non-contact dimensional measurement and inspection of lengths, diameters, hole positions and gaps, and with 3D sensors heights and steps, on machined, stamped and moulded parts in South African plants.

TECHNICAL REVIEW: Frank Guo (https://www.linkedin.com/in/frank-g-15b59b57) · REVIEWED 25 SEPTEMBER 2026

Request an assessment for this application

// SHORT ANSWER

Machine vision dimension measurement, or dimensional inspection with machine vision, measures lengths, diameters, hole positions, gaps and angles on every part without touching it, and flags parts outside tolerance. Its accuracy depends on field of view, camera resolution, optics, calibration, how the part is presented and the environment, so no single accuracy figure applies. We establish it on your own parts, against your tolerances and your reference measurements. It complements a CMM rather than replacing it.

// WHAT IT CHECKS

What a vision measuring machine or station checks

Machine vision measurement works from edges in the image. These are the four groups of dimensions it covers.

01 // LENGTH

Lengths and widths

Distances between edges, such as overall length, slot width or step position: the most common dimension measurement.

NEEDS

Sharp, well-lit edges

02 // DIAMETER

Diameters and radii

Outer and inner diameters, radii and roundness as seen in the image plane.

NEEDS

The feature square to the camera

03 // POSITION

Hole positions

Hole and feature positions relative to datums on the part, and pitch between holes.

NEEDS

Datums visible in the same image

04 // GAP

Gaps and angles

Gaps between assembled parts, edge distances and angles between edges.

NEEDS

Both edges visible at once

What sets the accuracy

FACTOR	WHY IT MATTERS	HOW IT IS HANDLED
Field of view and resolution	Each pixel covers a patch of the part; a larger view means coarser pixels.	Chosen from your tolerances; a large part may need several cameras.

FACTOR	WHY IT MATTERS	HOW IT IS HANDLED
Optics	With a standard lens, apparent size changes with distance from the lens.	A telecentric lens keeps size constant over its depth range, for parts at varying height.
Calibration	Converts pixels to units and corrects lens distortion.	Done with a calibration target and checked with master parts at agreed intervals.
Part presentation	Tilt or movement looks like a dimension change.	A fixture or datum stops hold each part the same way.
Lighting and edges	The measurement is only as good as the edge the software finds.	Backlight gives crisp silhouette edges; burrs and chamfers are agreed in advance.
Temperature and vibration	Parts and mountings expand and move.	A rigid mount and measuring parts at a known condition.

Vision system vs CMM

ASPECT	VISION STATION	CMM
Where it works	In the line, on every part.	In the metrology room, on sampled parts.
What it measures	Features visible in the camera view, mostly in one plane.	3D geometry wherever the probe or sensor can reach, including features hidden from a camera.

ASPECT	VISION STATION	CMM
Its role	Sorts every part against tolerance and shows trends.	Reference measurement and first-article inspection; checks the vision station.

CMM dimensional inspection, and CMM dimensional measurement services from a metrology laboratory, remain the reference for full 3D geometry and first-article checks. A vision station is dimensional measurement equipment for the line: it measures the agreed features on every part and logs the values, and your CMM checks the station. A benchtop dimension measurement machine or vision measuring machine in the quality room does a similar job on sampled parts; an in-line station removes the sampling. addaScan builds in-line stations; we do not offer dimensional measurement services or calibration of your gauges.

Reading serial numbers marked on the same parts is covered under **DPM code reading and traceability**. Length, width and squareness checks on tiles, boards and blocks are described under **building materials**.

// LIMITS

Where vision measurement stops

We agree these boundaries before a project starts. We do not quote an accuracy figure before testing your parts.

× Not measurable with a standard camera

- **Hidden features.** Internal bores, undercuts and faces the camera cannot see.
- **Height and flatness.** A camera looking straight down sees one plane; depth needs a 3D sensor.

✓ Works reliably when

- **Parts sit the same way.** A fixture or datum stops remove tilt and movement.
- **Edges are well defined.** Backlit silhouettes or clean, lit features.

- **Soft or unstable parts.** Parts that deform or move during imaging do not give a stable result.
- **The tolerance is wide enough.** The station's variation is small compared with the tolerance, as shown by the study below.

// EVIDENCE

What you can check before you ask us

How feasibility is decided on your own samples, and the published budgets of complete line solutions that use this check.

ENGINEERING METHOD

How a sample test is judged

Samples
Good samples that show normal variation, and defective samples for each defect you need to catch, including borderline ones.

Imaging
Imaged under candidate lighting and optics; what is, and is not, visible is recorded.

Acceptance
False rejects and missed defects are agreed in writing and measured at FAT and SAT.

Outcome
A written feasibility conclusion with example images, before any proposal.

The method used on every project; not a measured result.

How to prepare inspection samples →

BUDGET MODEL

Installed budgets of line solutions that use this check

Glue and sealant beads
R 230 000 – R 1 590 000

Fasteners and turned parts
R 270 000 – R 930 000

Plastic closures
R 370 000 – R 1 290 000

Copper and carbon anodes
R 1 190 000 – R 2 760 000

Basis
Indicative budget for a typical application, in rand, excluding VAT, as at 2 October 2026, low to high configuration. A firm price follows the sample test.

Each figure is for a complete station on that line, not a price for this check on its own.

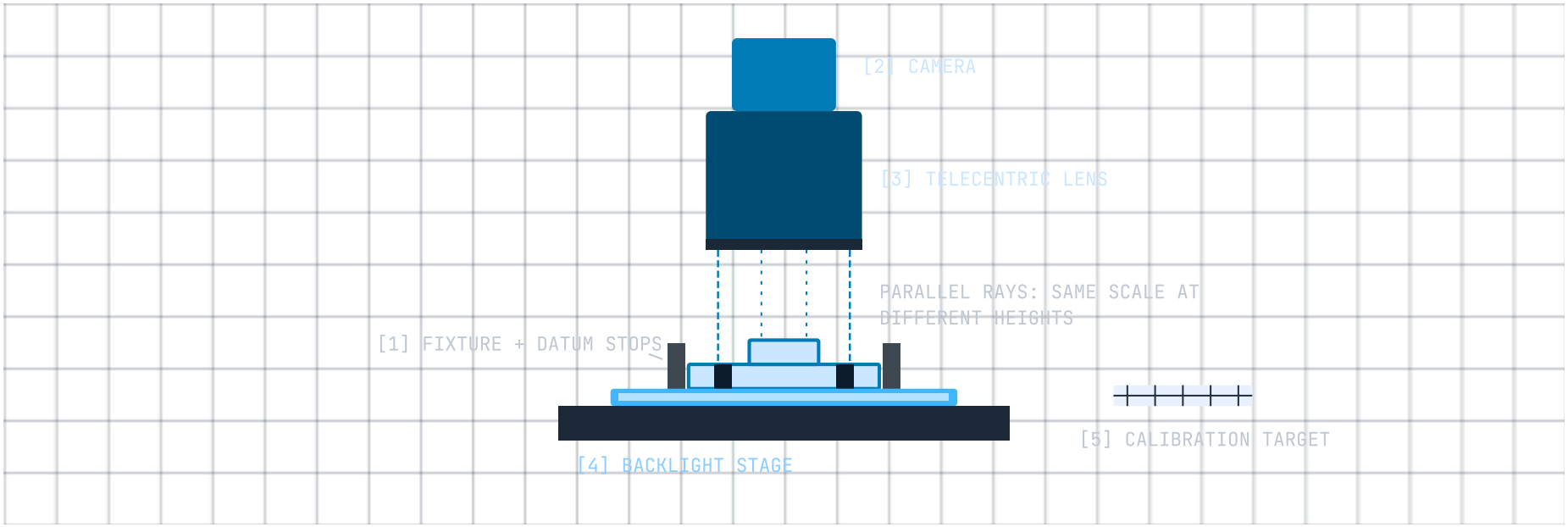
All line solutions with budgets →

// STATION LAYOUT

How a measuring station is laid out

Side view of a typical backlit station with a telecentric lens. The real layout follows your drawings and the sample test.

[Schematic] SIDE VIEW · NOT TO SCALE



[1] Fixture: datum stops hold every part in the same position.

[2] Camera: resolution chosen from your tightest tolerance.

[3] Telecentric lens: keeps scale constant when features sit at different heights.

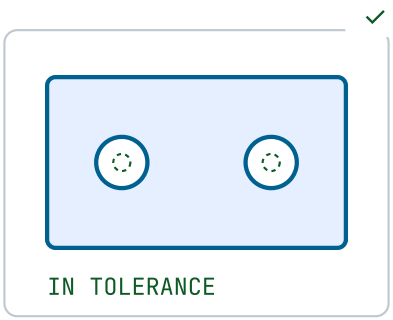
[4] Backlight stage: gives crisp silhouette edges.

[5] Calibration target: used to calibrate and to check the station.

// PASS AND REJECT [Illustrative examples]

What a pass and a reject look like

Illustrations, not measurements from a real part. Tolerances come from your drawing; how near-limit parts are handled is agreed with you.

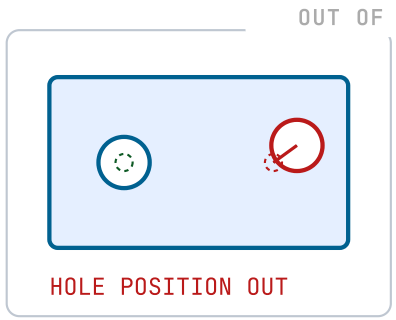


EXAMPLE // STAMPED BRACKET

Dimensions in tolerance

Both hole positions lie inside their tolerance zones relative to the datums.

HOLES: IN TOLERANCE ACTION: PASS

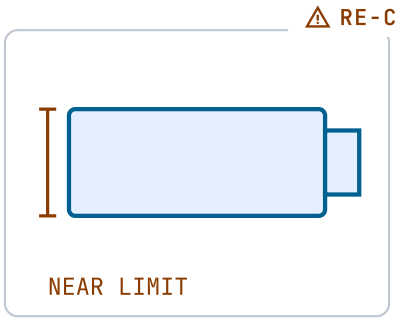


EXAMPLE // STAMPED BRACKET

Hole position out

One hole is shifted outside its tolerance zone. The part is rejected and the value logged.

POSITION: ✗ OUT ACTION: REJECT



EXAMPLE // TURNED PART

Close to the limit

The diameter is within the station's own variation of the limit, so the part is diverted for a check on your gauge.

DIAMETER: NEAR LIMIT ACTION: DIVERT

// LINE INTERFACE

What we need to know about your line

These conditions decide the station design. Each is confirmed on site or during the sample test.

CONDITION	WHAT WE NEED TO KNOW	WHY IT MATTERS	CONFIRMED DURING
Drawings and tolerances	The critical dimensions, their tolerances and datums.	Decides field of view, resolution, optics and whether one camera is enough.	Design review

CONDITION	WHAT WE NEED TO KNOW	WHY IT MATTERS	CONFIRMED DURING
Part presentation	Conveyor, fixture, rotary table or robot; how repeatable it is.	Movement and tilt add directly to measurement error.	Site survey
Cycle time	Parts per minute or machine cycle time.	Sets exposure, trigger and whether parts must stop to be measured.	Site survey
Environment	Temperature swings, vibration, dust, coolant or oil on parts.	Affects calibration stability and the edges the camera sees.	Site survey
Reference measurement	Your CMM, gauges and measured master parts.	Needed to prove the station agrees with your accepted method.	Sample test
PLC and data	PLC make and model; whether measured values must be logged.	Decides reject handling and data output for trend monitoring.	Design review

// 3D MEASUREMENT

Laser triangulation and 3D laser profilers for height and volume

When a dimension is not in the image plane, 3D vision measures it.

A 2D camera measures in one plane. When the tolerance is on a height, a step, flatness or volume, the station uses a 3D sensor instead.

Laser triangulation projects a laser line onto the part and views it with a camera at a fixed angle. A higher surface shifts the line in the image, and the shift is calculated as height. A **3D laser profiler** puts laser and camera in one housing and builds a height map, a

point cloud, as the part moves beneath it, usually triggered by an encoder so that the spacing between profiles stays constant.

Laser profilers measure heights, steps, gaps, flatness and the volume of material on a surface. They struggle with very shiny and very dark surfaces, and with steep walls that hide the laser line from the camera, known as occlusion. **Time-of-flight** cameras measure distance from the travel time of light and suit larger objects and coarser measurements, such as the size of a box, rather than fine features on a machined part.

// ACCEPTANCE

How accuracy is established and accepted

Measurement stations are accepted on evidence from your own parts, such as a repeatability study, not on a catalogue figure.

01

Repeatability study

The same parts are measured repeatedly, with reloading, to show how much the station varies. The result is compared with your tolerance.

02

Agreement with reference

Parts measured on your CMM or gauges are measured by the station, and any systematic difference is found and corrected.

03

Calibration routine

A written procedure for checking the station with a master part or target, at an interval agreed with you, with records kept.

Dimensional inspection reports and records

In production the station records each measured value with its pass or fail result, and can keep the image. The acceptance report contains the repeatability study, often run in the form of a gauge R&R study, the comparison with your reference measurements and the calibration procedure. Which dimensions are measured, and their tolerances, come from your drawing; the station measures only what the camera or 3D sensor can see.

// EVIDENCE

From tolerance to camera: a worked example, the metrics and the references

How a measuring station is sized, what the acceptance numbers mean, and where traceability comes from.

Worked example, for planning only. A stamped bracket has a hole position toleranced at ±0.10 mm, a band 0.20 mm wide. With a 5-megapixel camera that is 2,448 pixels across, each pixel covers the field of view divided by 2,448. The table shows how the choice of field of view changes how many pixels span the tolerance band. These figures are arithmetic on the stated assumptions, not a promised accuracy: what the station actually achieves is shown by the study on your parts.

FIELD OF VIEW ACROSS	PIXELS ACROSS	SIZE OF ONE PIXEL ON THE PART	PIXELS ACROSS A 0.20 MM BAND	WHAT IT MEANS
30 mm	2448	0.012 mm	about 16 pixels	Comfortable margin; small parts or one feature
60 mm	2448	0.025 mm	about 8 pixels	Typical single-part view with room for position tolerance

FIELD OF VIEW ACROSS	PIXELS ACROSS	SIZE OF ONE PIXEL ON THE PART	PIXELS ACROSS A 0.20 MM BAND	WHAT IT MEANS
120 mm	2448	0.049 mm	about 4 pixels	Relies heavily on sub-pixel edge fitting and very stable light; often split into two cameras

Two things follow. First, the field of view is the main lever: halving it doubles the pixels across the tolerance. Second, edge-finding tools in vision software, such as the size measurement tools in HIKROBOT VisionMaster (HIKROBOT VisionMaster), fit edges to sub-pixel positions, but only on crisp, stable edges. That is why precision stations pair a parallel backlight with a telecentric lens, as HIKROBOT's own catalogue describes (HIKROBOT light catalogue).

How the acceptance numbers are defined

The acceptance report uses the terms below. NIST's handbook describes gauge R&R studies as characterising the errors that affect measurements made by production gauges (NIST e-Handbook, 2.4). The AIAG thresholds are quoted from BPI Consulting, which also argues they can mislead (BPI Consulting); uncertainty follows the GUM (JCGM 100:2008).

TERM	WHAT IT MEANS ON A VISION STATION	HOW IT IS REPORTED
Repeatability	Variation when the same part is measured again under the same conditions, with the part reloaded each time	Standard deviation of repeat measurements; NIST treats it as the basic precision of the gauge
Reproducibility	Variation when conditions change: shift, recipe reload, fixture, temperature	Extra spread between condition groups

TERM	WHAT IT MEANS ON A VISION STATION	HOW IT IS REPORTED
%GRR	Repeatability and reproducibility together, as a share of the tolerance or of process variation	AIAG guideline: under 10 % adequate, 10 to 30 % may be acceptable, over 30 % unacceptable; criteria are agreed with the customer
Bias (agreement)	Average difference between the station and your reference (CMM or calibrated gauge) on the same parts	Corrected in calibration, then re-checked on reference parts at set intervals
Measurement uncertainty	The doubt that remains about a measured value, combining all known error sources	Evaluated with the GUM method; decides how wide the near-limit divert band is

Traceability in South Africa

A station is only as right as the reference it is compared with. In South Africa, the Measurement Units and Measurement Standards Act provides for national measurement standards and establishes the National Metrology Institute, whose role includes disseminating traceability to industry (Act 18 of 2006). SANAS is recognised as the only national body that accredits calibration, testing and verification laboratories (Act 19 of 2006, s4). In practice: the reference parts used to accept a vision station are measured on a CMM or with gauges whose calibration certificates come from an accredited laboratory, and those certificates go into the acceptance file.

SOURCES FOR THIS PAGE

1. NIST/SEMATECH e-Handbook of Statistical Methods, 2.4 Gauge R&R studies (https://www.itl.nist.gov/div898/handbook/mpc/section4/mpc4.htm) (NIST, read 2026-10-27)

2. BPI Consulting: Acceptance criteria for measurement systems analysis (quotes the AIAG MSA 4th edition guideline) (https://www.spcforexcel.com/Downloads/pdf/Acceptance-Criteria-for-Measurement-Systems-Analysis.pdf) (read 2026-10-26)
3. JCGM 100:2008, Evaluation of measurement data: Guide to the expression of uncertainty in measurement (GUM) (https://doi.org/10.59161/JCGM100-2008E) (BIPM / JCGM)
4. Measurement Units and Measurement Standards Act 18 of 2006 (South Africa) (https://www.gov.za/sites/default/files/gcis_document/201409/a18-060.pdf) (Government Gazette, read 2026-10-27)
5. Accreditation for Conformity Assessment, Calibration and Good Laboratory Practice Act 19 of 2006 (South Africa), section 4 (https://www.gov.za/sites/default/files/gcis_document/201409/a19-060.pdf) (Government Gazette, read 2026-10-27)
6. HIKROBOT Light Source Catalogue 2025 Q3, glossary p.78 (parallel backlight with telecentric lens) (https://www.hikrobotics.com/en2/source/vision/video/2025/7/21/Light%20Source%20Catalog_ENG_2025Q3_v2.pdf#page=78) (vendor catalogue, checked 2026-10-02)
7. HIKROBOT VisionMaster software (size measurement tools) (https://www.hikrobotics.com/en/machinevision/visionmaster/) (vendor page, re-verified 2026-09-25)

// BEFORE WE START

What to prepare for the sample test

We compare our results with your measurements before proposing a station. We confirm quantities and shipping with you first.

Sample preparation guide

Drawings
Part drawings with critical dimensions, tolerances and datums marked.

Measured parts
Parts with your CMM or gauge results, including near-limit and out-of-tolerance parts.

Part variation
Parts from different batches, tools or cavities, as they arrive at the station.

Line information
Cycle time, how parts are handled, environment, PLC make and model.

// FAQ

Dimensional measurement questions

What is dimensional inspection?

Dimensional inspection checks that a part’s sizes and positions, such as lengths, diameters, hole positions and angles, are within the tolerances on its drawing. It can be done with gauges, a CMM or, in the line, with a camera or 3D sensor that measures every part.

What is machine vision measurement?

Machine vision measurement, also called machine vision dimension measurement, finds the edges of a part in a calibrated image and calculates lengths, diameters, positions and angles from them. A 3D sensor adds heights and steps. It measures every part in the line without touching it.

Is an in-line vision station the same as a dimension measurement machine?

Not quite. A benchtop dimension measurement machine or vision measuring machine measures sampled parts in the quality room. An in-line station is dimensional measurement equipment built into the line, so every part is measured at production speed and out-of-tolerance parts are rejected.

Can a camera do non-contact length measurement on the line?

Yes, for lengths and positions visible in the image, on every part as it passes. This is the usual automated inspection to measure machined parts in the line; how close it gets is shown on your parts in a repeatability study, not promised in advance.

What is laser triangulation?

A laser line is projected onto the part and viewed by a camera at an angle. Where the surface is higher, the line shifts in the image, and that shift is converted into height. Moving the part under the line builds up a height profile of the whole surface.

What is 3D vision?

3D vision measures the height of every point in view as well as its position, using laser triangulation, structured light, stereo cameras or time of flight. It is used where heights, steps, flatness or volume matter, which a 2D camera looking straight down cannot measure.

How accurate is camera-based dimensional measurement?

There is no single figure. Accuracy depends on field of view, resolution, optics, calibration, part presentation, lighting and temperature. We establish it on your parts: a repeatability study shows how much the station varies, and comparison with your CMM or gauges shows how well it agrees.

When are telecentric lenses needed?

When measured features sit at different heights, or part distance varies, because a standard lens makes nearer features look larger. A telecentric lens keeps size constant over its depth range, but its field of view is no larger than the lens itself.

Can a vision station replace our CMM?

No. The vision station checks every part in the line; the CMM stays the reference for full 3D geometry, first-article checks and verifying the station.

Can it measure height or flatness?

Not with a standard 2D camera looking straight down. Height, step and flatness need a 3D sensor or a side view, which is a different station design.

RELATED: Camera and lens selection → Metal components → Plastics & packaging → Surface defect detection → Inspection technology → Glossary: telecentric lens, 3D vision → Preparing samples → Cost & budget guide →

LINE SOLUTIONS USING THIS: Plastic closures → Fasteners and turned parts → Glue and sealant beads → Copper and carbon anodes → Machined part dimensional inspection →

COMMON IN THESE INDUSTRIES: Plastics & packaging → Metal components → Machining →

TYPICALLY BUILT WITH: Area scan cameras with a vision controller → 2D measurement (backlight, telecentric optics) → 3D laser profiling →

// DIMENSIONAL MEASUREMENT

Request an assessment for this application

Send your drawing and a few measured parts. We will tell you whether a vision station can measure them and how we would prove it.

Start application assessment