

OPTICAL 3D MEASUREMENT APPLICATIONS IN FIA 2026 FORMULA 1

Technical Regulations Analysis
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EXECUTIVE SUMMARY

The FIA 2026 Formula 1 Technical Regulations (Issue 8) define extensive dimensional, geometric, and structural compliance requirements that demand precision measurement solutions. This document identifies and catalogues all areas where optical 3D measurement equipment — including laser trackers, optical tracking systems, laser scanners, photogrammetry systems, and structured-light scanners — can be deployed for legality checking, deflection testing, wear measurement, and structural verification.

The regulations explicitly reference scanning technology, laser scanning, optical target mounting points, and calibrated measurement equipment in multiple articles. Beyond these direct references, the tolerances specified throughout the document (ranging from $\pm 0.2\text{mm}$ to $\pm 3\text{mm}$) and the complex 3D geometries defined by Reference Volumes make optical 3D measurement not just applicable but often the only practical verification method.

Key finding: The regulations specify at least 10 distinct application categories for optical 3D measurement, spanning from CAD-to-part validation ($\pm 3\text{mm}$) through deflection testing under load (laser scanning explicitly required) to crash structure deformation measurement. The FIA mandates optical target mounting points on all cars and requires all measurement equipment to be calibrated to the FIA technical delegate's satisfaction.

1. DIGITAL LEGALITY CHECKING & DIMENSIONAL VALIDATION

Regulation Reference: Articles 3.3.1, 3.3.2

The FIA requires all aerodynamic components to be designed as CAD models conforming to defined Reference Volumes. Scanning technology is explicitly referenced as the method the FIA uses to verify that the physical car matches the inspected CAD model. Cars may be measured at any time during a Competition to check CAD conformance.

Manufacturing Tolerances

The following tolerances apply when comparing measured geometry to CAD models:

Parameter	Specification
General CAD surface tolerance	$\pm 3\text{mm}$ for manufacturing purposes (measured surfaces must remain within Reference Volumes)
Positional tolerance	$\pm 2\text{mm}$ for Front Wing, Rear Wing, Exhaust Tailpipe, and Tail assemblies (assemblies may be translated up to 2mm for best-fit)
Z-plane tolerance	$\pm 2\text{mm}$ for parts on the Z=0 plane within specified X/Y coordinates
Plank geometry	$\pm 0.5\text{mm}$ general manufacturing tolerance
Plank thickness (new)	10mm $\pm 0.2\text{mm}$ measured normal to lower surface

Measurement Equipment Implications

These tolerance requirements place the following demands on measurement systems. A general tolerance of $\pm 3\text{mm}$ for aerodynamic surfaces requires a measurement system with an uncertainty significantly below 3mm — typically better than $\pm 0.5\text{mm}$ — across the full measurement volume of an F1 car (approximately 5.7m long, 2m wide). The tighter $\pm 2\text{mm}$ positional tolerances for wing assemblies demand measurement system accuracy in the $\pm 0.3\text{mm}$ range. CAD-to-part comparison

requires full 3D surface capture compatible with CAD import/export (STEP, IGES). Laser trackers, large-volume structured-light scanners, or photogrammetry systems combined with hand-held scanners are the natural solutions for these requirements.

The FIA states: “In cases where there is doubt over the conformity of a car, scanning technology will be used by the FIA to check that the physical car is the same as the inspected CAD.” (Article 3.3.1)

Digital Legality Check — CAD vs Physical Car Scanning
Article 3.3.1-3.3.2

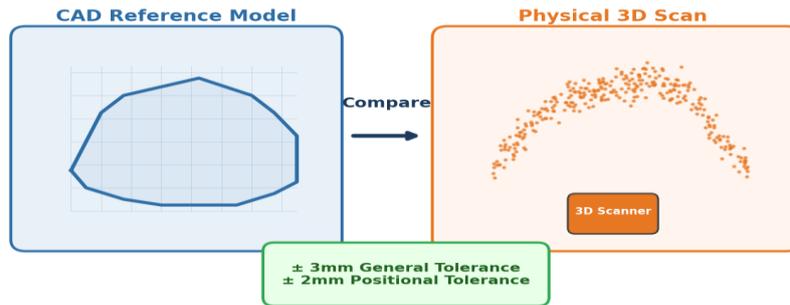


Figure: CAD-to-Part validation workflow — comparing scanned point cloud against reference CAD model within $\pm 3\text{mm}$ tolerance

2. OPTICAL TARGET MOUNTING POINTS & DATUM ALIGNMENT

Regulation Reference: Articles 3.3.3, 3.3.4, 12.2.8

The regulations mandate optical target mounting points on every car, creating a built-in coordinate reference system for 3D measurement alignment during scrutineering and deflection testing. This is a direct requirement for optical tracking systems.

Mandatory Optical Target Locations

Parameter	Specification
Location (a)	One on forward part of top of survival cell
Location (b)	Two symmetrical about Y=0 on top of survival cell, close to $X_c = -875$
Location (c)	Two symmetrical about Y=0 on side of survival cell, close to $X_c = -875$
Location (d)	Two symmetrical about Y=0 on side of survival cell, close to rear mounts of secondary roll structure
Location (e)	Two symmetrical about Y=0, within cuboid defined by diagonal $[X=0, 175, 970]$ to $[X=150, -175, 870]$
Location (f)	One probed point on RIS or gearbox case
Total targets	Minimum 10 optical target mounting points per car

FIA Mandatory Optical Target Mounting Points

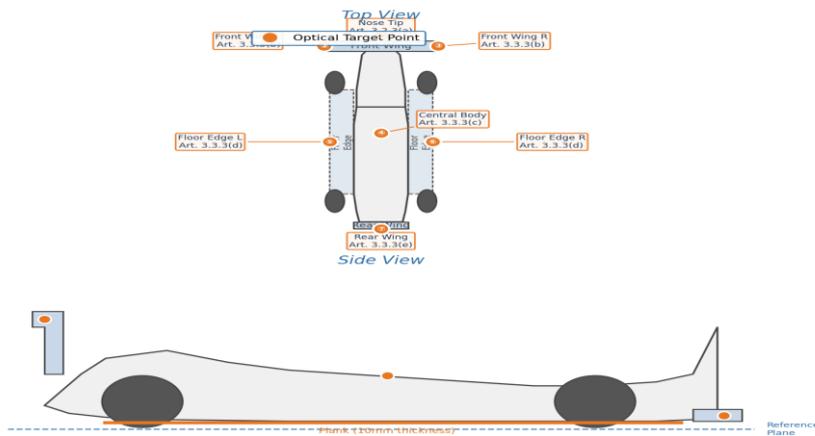


Figure: Mandatory optical target mounting locations per Article 3.3.3 — top and side view showing all 10 target positions

A coordinate file containing the precise positions of all datum points must be supplied for each survival cell. Additionally, three scrutineering support pads on $Z=0$ define the reference plane for underside inspection. Precisely machined details on the survival cell (Article 12.2.8) provide the legality datum point positions.

Tracking Target Pads for Deflection Testing

Article 3.18.9 specifically requires teams to provide four pads to support tracking targets on the rear wing for measuring angular deflection during load tests. These targets are measured relative to the Rear Impact Structure, requiring a dynamic tracking capability during load application. This is a direct application for optical tracker systems with real-time measurement capability.

FIA Reference Coordinate System Article 2.6 & 2.10

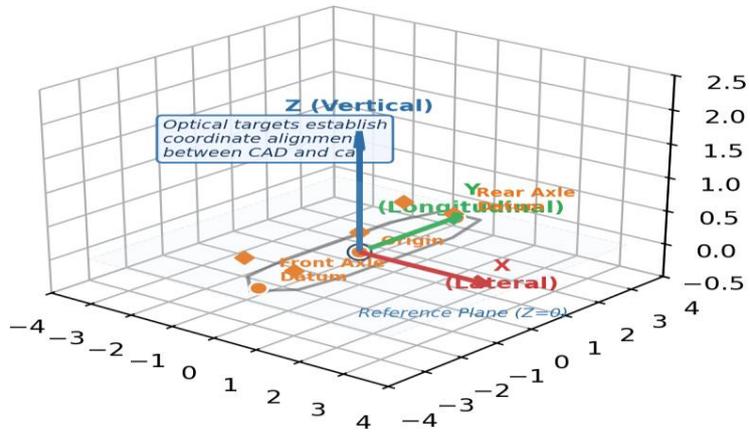


Figure: FIA reference coordinate system — X, Y, Z axes with optical target positions and datum alignment on car

3. LOAD/DEFLECTION TESTING

Regulation Reference: Articles 3.18.1 – 3.18.14

Deflection testing is the most measurement-intensive area of the regulations, with the FIA reserving the right to introduce load/deflection tests on any bodywork suspected of moving while the car is in motion. All tests require nominally linear elastic behaviour. Article 3.18.7 explicitly requires laser scanning for deflection measurement. Multiple tests require tracking-target-based measurement relative to reference structures.

**Rear Wing Deflection Test — Optical Measurement Setup
Article 3.18.9**

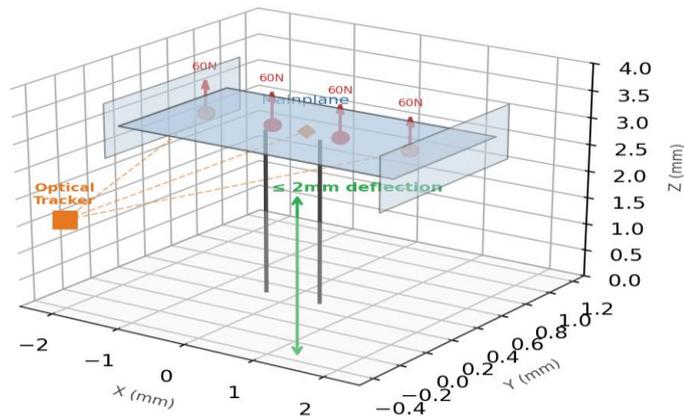


Figure: Rear wing skin deflection test setup — 4×60N load application with optical tracker measuring deflection $\leq 2\text{mm}$ at tracking targets

3a. Rear Wing Skin Deflection (Art. 3.18.3)

Parameter	Specification
Maximum deflection	2mm
Applied force	60N normal to skin, directed away from element
Load application	Vacuum cup, 50mm diameter
Measurement point	Outer diameter of vacuum cup
Measurement method	Deflection relative to wing structure

3b. Front Wing Bodywork Flexibility (Art. 3.18.4)

Parameter	Specification
Applied load	1000N vertically downward
Load points	$[X_f, Y, Z] = [-400, \pm 750, 200]$ or $[-600, \pm 750, 200]$
Load application	50mm diameter ram on 350×135mm rectangular adaptor
Symmetrical loading	Maximum 15mm vertical deflection
Single-side loading	Maximum 20mm vertical deflection

Reference	Measured relative to survival cell, along loading axis
Hydraulic system	Must be active during test

3c. Front Wing Flap Flexibility (Art. 3.18.5)

Parameter	Specification
Maximum deflection	5mm at trailing edge, measured along loading axis
Applied load	60N point load, normal to flap

3d. Front Floor Flexibility (Art. 3.18.6)

Parameter	Specification
Load application	50mm diameter pad with gimbal interface, vertically upward
Load position	Underside of plank, within quadrilateral defined by FIA
Load/deflection curve	Linear graph: (0mm, 0N) → (1mm, 0N) → (5mm, 4000N) → (25mm, 6000N)
Maximum test load	8000N or 15mm deflection (whichever first)
Requirement	Strictly monotonic load/deflection in both directions

3e. Outboard Floor Flexibility (Art. 3.18.7)

This article explicitly requires: “Deflection will be measured by laser scanning of the bodywork at each loading stage.”

Parameter	Specification
Maximum deflection	8mm in Z direction
Test region	X = -1260 to X = -350, Y = 695 each side
Load application	Distributed: 6 points per side through 2.3mm diameter rods
Loading stages	Stage 1: 50N per point (300N/side); Stage 2: 100N per point (600N/side)
Measurement method	Laser scanning at each loading stage
Position tolerance	2mm on load application positions

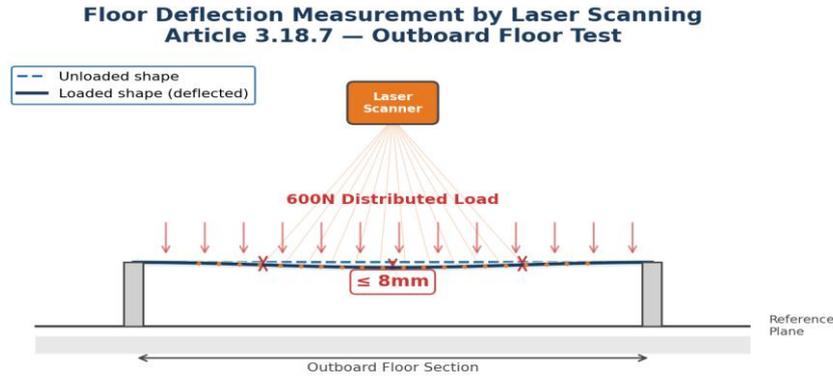


Figure: Outboard floor deflection measurement — laser scanner measuring $\leq 8\text{mm}$ deflection under 600N distributed load across 6 points per side

3f. Central Floor Flexibility (Art. 3.18.8)

Parameter	Specification
Maximum deflection (plank)	2mm at two plank holes ($X_f = 1080$) and rearmost hole
Support pads	70mm diameter, centred on holes
Minimum stiffness	15 kN/mm for deflections exceeding defined limits
Reference plane deflection	Maximum 0.2mm under same support conditions (40mm pads)
Reference points	Survival cell datum points (Art. 3.3.3) and power unit mounting studs

3g. Rear Wing Mainplane Flexibility (Art. 3.18.9)

Parameter	Specification
Test (a) — Vertical	$2 \times 1000\text{N}$ at [$X_r = 350, \pm 325, 835$]: max 6mm deflection, max 1.0° in Y-plane
Test (b) — Combined	$2 \times [324, 0, -940]\text{N}$ at [$X_r = 300, \pm 325, 825$]: max 6mm deflection, max 1.0° in Y-plane
Angular measurement	At [X_r, Y] = [$325, \pm 150$] and [$375, \pm 450$], relative to Rear Impact Structure
Tracking targets	Teams must provide 4 pads to support tracking targets

3h. Rear Wing Flap Flexibility (Art. 3.18.10)

Parameter	Specification
Maximum deflection	7mm horizontal
Applied load	500N horizontal, rearward direction
Load points	Within 50mm of centre plane and 300mm either side
Reference	Measured relative to forward part of Rear Wing Mainplane at same Y-station

3i. Rear Wing Trailing Edge (Art. 3.18.11)

Parameter	Specification
Maximum deflection	3mm along line of load application
Applied load	200N normal to lower surface
Measurement positions	Y = 0, ±150, or ±450

3j. Rear Wing Endplate (Art. 3.18.12)

Parameter	Specification
Maximum deflection	10mm along loading axis
Applied load	50N inward, normal to car centre plane
Load application	Spherical 15mm diameter tip at [Xr, Z] = [725, 500]
Note	Rigid-body rotation of whole wing assembly must be subtracted

3k. Rear Wing Slot Gap Deflection (Art. 3.18.13)

Parameter	Specification
Test method	Spherical gauge, 65mm diameter (+0.00/-0.05mm)
Applied load	10N during test
Requirement	Gauge must not pass through gap between profiles
Condition	Hydraulic system active, Rear Wing Rotation System deployed

3l. Visual Monitoring Markers (Art. 3.18.14)

Contrasting markers must be applied to bodywork within RV-RW-PROFILES to allow monitoring of rear wing behaviour via onboard cameras. This enables vision-based deflection monitoring during racing conditions — a potential application for image-based measurement systems.

4. PLANK WEAR & THICKNESS MEASUREMENT

Regulation Reference: Article 3.6

The floor plank is a critical legality component. Its thickness must be verified both when new and after use (wear). The regulations define precise measurement locations and tolerances that require high-accuracy normal-direction thickness measurement.

Parameter	Specification
New thickness	10mm \pm 0.2mm, measured normal to lower surface, must be uniform
Minimum wear thickness	9mm (conformity checked at periphery of designated holes)
Number of measurement holes	Four holes, positions defined by RV-PLANK
Measurement location	Only at designated holes, regardless of plank or skid material
Plank manufacturing tolerance	\pm 0.5mm general; thickness per specification above
Skid thickness	Minimum 7.5mm at edges; may protrude max 3mm below reference plane when new

Plank Thickness Measurement — Cross Section Article 3.6

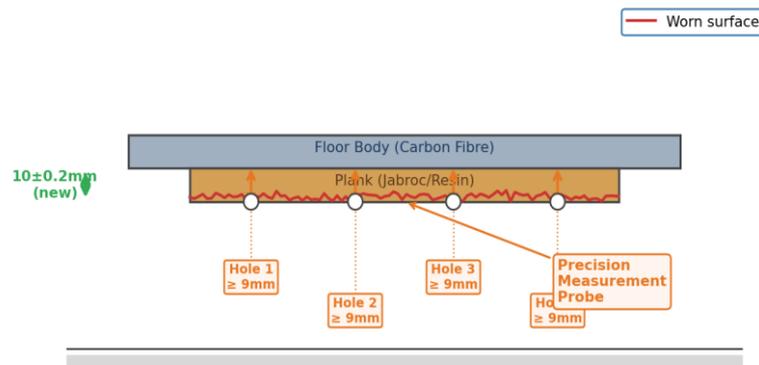


Figure: Plank wear measurement — precision probe at designated holes verifying 10 \pm 0.2mm new thickness and \geq 9mm post-wear minimum

The requirement to measure thickness “normal to the lower surface” at specific hole locations, combined with the tight \pm 0.2mm new-part tolerance, makes this an ideal application for laser trackers or structured-light scanners that can establish surface normals and measure perpendicular distances with sub-0.1mm accuracy.

5. SURFACE GEOMETRY & CONTOUR VERIFICATION

Regulation Reference: Articles 2.9, 3.5–3.11, Appendix 1

The aerodynamic regulations define complex 3D geometries through Reference Volumes (RV-prefix) and Reference Surfaces (RS-prefix). All aerodynamic components must lie within their designated Reference Volumes. The regulations specify radius of curvature minimums, tangent angle requirements, visibility/obscuration rules, and cross-sectional constraints that require comprehensive surface measurement.

Radius of Curvature Requirements

Parameter	Specification
Application	Minimum Radius Value
Various bodywork edges	15mm
General aerodynamic surfaces	25mm
Specific contour regions	50mm
Floor transition zones	200mm
Major body contours	1000mm

Profile & Visibility Requirements

Front Wing Profiles must fully obscure RS-FW-PROFILES when viewed from above. Multiple cross-sectional constraints define maximum/minimum dimensions, aspect ratios, and incidence angles. These verifications require 3D surface scanning with the ability to extract cross-sections, compute radii of curvature, and perform virtual visibility assessments from defined viewpoints.

Reference Volumes as Compliance Boundaries

Each bodywork group has a defined Reference Volume envelope. The measurement challenge is not just dimensional — it requires verifying that every point on a complex freeform surface lies within a defined 3D boundary. This is fundamentally a 3D scanning and CAD comparison problem that optical measurement systems are uniquely suited to address.

6. CLEARANCE, GAP & SEAL MEASUREMENT

Regulation Reference: Articles 3.17, 3.18.13

Several regulations define clearance and gap requirements between moving and stationary components, as well as between the car and ground at specified conditions.

Parameter	Specification
Suspension clearances	Minimum clearance with wheel rim at full steering lock (Art. 3.17.3)
Cross-sectional constraints	Maximum 100mm, aspect ratio 3.5:1 for suspension fairings
Incidence angles	10° range specifications for aerodynamic appendages
Aerodynamic seals	Flexible components between suspension fairings and bodywork
Slot gap measurement	65mm spherical gauge test on rear wing (Art. 3.18.13)
Ground clearance	Gap verification between sprung car and ground plane

Clearance verification at full steering lock is a dynamic measurement challenge. Optical tracking systems can measure in real-time as the steering is cycled, identifying minimum clearance points across the full range of motion. Gap measurement between flexible seals and bodywork benefits from non-contact optical methods that do not disturb the component positions being measured.

7. CRASH STRUCTURE TESTING & DEFORMATION MEASUREMENT

Regulation Reference: Articles 13.1–13.5

The safety structure homologation process involves extensive static and dynamic tests where deformation must be measured with calibrated equipment approved by the FIA technical delegate. All measuring equipment must be calibrated to the FIA technical delegate’s satisfaction (Art. 13.1.3).

Crash Structure Static Load & Deformation Testing Articles 13.1–13.5

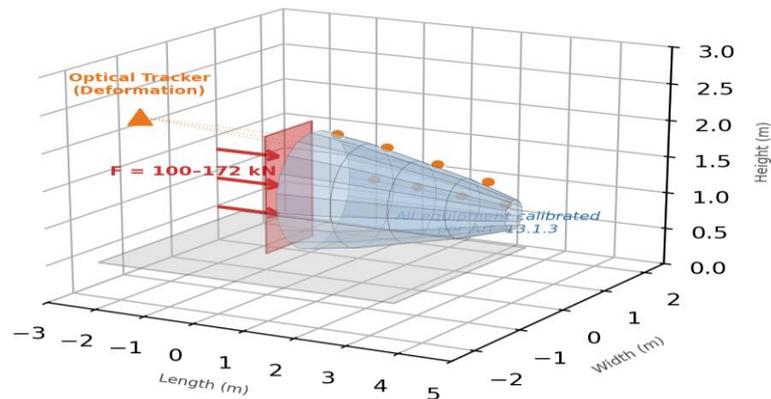


Figure: Crash structure deformation testing — optical tracker measuring displacement under 100–172 kN loads with calibrated equipment per Art. 13.1.3

Roll Structure Static Tests (Art. 13.3)

Parameter	Specification
75% load test	129 kN in specified direction
Full load test	172 kN in specified direction
Deformation recording	Load and displacement along axis of load application
Additional measurement	Vertical displacement of three attachment points
Methodology authentication	Calculated results must match physical test data (0–80 kN range)

Survival Cell Load Tests (Art. 13.4)

Parameter	Specification
Fuel tank side test	110 kN transverse; permanent deformation < 3mm after release
Wheel contact side test	100 kN transverse; total deflection ≤15mm; permanent deformation < 3mm
Floor test	Vertical upward load at FIA-determined positions
Deflection limit rule	Production cells must not exceed 120% of reference cell deflection
Minimum deflection rule	Where reference deflection < 3mm, maximum permitted is 3.6mm

Measurement point	Centre of area of load pad (unless otherwise stated)
Equipment requirement	Calibrated to FIA technical delegate's satisfaction

Impact Tests

Parameter	Specification
Frontal impact	15 m/s, 875–900 kg test mass, deceleration recording
Maximum survival cell displacement	425mm from T=Zero
Peak acceleration requirement	≥52g from T=30ms
Side impact	Lateral structure deformation measurement
Steering column impact	Art. 13.8 specifications
Wheel rim impact	Art. 13.10 specifications

Crash testing deformation measurement requires tracking displacement under load with high accuracy ($\leq 0.1\text{mm}$) while maintaining measurement relative to known reference points. Optical tracker systems can simultaneously measure load application points and reference points on the survival cell, providing real-time deformation data during the 30-second load hold periods specified in the regulations.

8. POWER UNIT & GEARBOX DIMENSIONAL VERIFICATION

Regulation Reference: Articles 5.6, 9.7

Gearbox Layout Verification (Art. 9.7)

Parameter	Specification
Primary shaft	Must be concentric with PU crankshaft centreline
Secondary shaft position	Within 30mm of Y=0, above primary shaft, parallel
Shaft spacing	90–110mm between primary and secondary shaft axes
Gear-change barrel	Must be above secondary shaft axis
Gear spacing	≥175mm between forward-most and rearmost gear faces
Final drive axis	Between $X_r = -60$ and $X_r = 60$, $Z = 260-280$
Final drive position	390–450mm behind forward-most gear faces
Final drive tip diameter	≥205mm

Verifying concentricity and parallelism between shafts, combined with positional constraints of the final drive axis, requires coordinate measurement with accuracy in the order of 0.01–0.05mm. While this may call for tactile CMM methods for the tightest tolerances, optical measurement can provide rapid verification of the geometric layout, and laser tracker measurements can verify the relative positions of shaft axes within the gearbox case.

9. SUSPENSION & WHEEL GEOMETRY VERIFICATION

Regulation Reference: Articles 10.10, 10.2

Parameter	Specification
Front wheel axis origin	Maximum Y = 603 at Legality Ride Height
Rear wheel axis origin	Maximum Y = 525 at Legality Ride Height
Ride height verification	Reference condition for all underside measurements
Wheel assembly dimensions	Specific diameter, width, and offset constraints

Verifying wheel axis positions at the specified Legality Ride Height requires the car to be set up in its reference condition with known loads. Optical tracker systems can measure wheel centre positions while simultaneously confirming ride height, providing a complete geometric picture of the suspension geometry in its reference state.

10. COORDINATE SYSTEM & MEASUREMENT FRAMEWORK

Regulation Reference: [Articles 2.6, 2.10](#)

The entire measurement framework for F1 car compliance is built on precisely defined coordinate systems. All measurement equipment must operate within these systems.

Parameter	Specification
Car coordinate system	Right-handed Cartesian (X, Y, Z)
Principal planes	X=0 (transverse), Y=0 (longitudinal vertical), Z=0 (ground reference)
Wheel coordinates	Subscript W system for wheel-relative measurements
Numerical precision	All limits are absolute — no additional tolerances on stated values (Art. 2.10)
Legality Ride Height	Defined reference condition for all geometry measurements
Multiple origins	Xc (chassis), Xf (front axle), Xr (rear axle), Xpu (power unit)

Establishing the car coordinate system from physical datum points is the first and most fundamental measurement task. The optical target mounting points (Article 3.3.3) and scrutineering support pads (Article 3.3.4) provide the physical interface between the car and the measurement coordinate system. Laser trackers and optical tracking systems with 6-DOF probing capability are ideally suited for establishing these coordinate frames and performing all subsequent measurements within them.

11. RESTRICTED MEASUREMENT TECHNIQUES

Regulation Reference: [Article 17.3.3](#)

While optical 3D measurement is extensively used for legality compliance, the regulations explicitly prohibit certain techniques when used for reverse engineering of competitor components. Understanding these restrictions is important for equipment suppliers who may also work with multiple teams.

Parameter	Specification
Prohibited for reverse engineering	Description
Photographs + point cloud software	Converting photographs/images to point clouds, curves, surfaces, or extracting CAD geometry
Stereophotogrammetry	Use of stereo camera pairs for 3D reconstruction
3D cameras / stereoscopic techniques	Any 3D depth-sensing camera technology
Contact or non-contact surface scanning	Any form of surface scanning of competitor components
Projection-based techniques	Any technique projecting points or curves onto surfaces

These restrictions apply specifically to reverse engineering of competitor Listed Technical Components (LTCs) and Transferable Restricted Components (TRCs). They do not restrict the use of optical measurement for a team’s own legality compliance, quality control, or FIA-mandated testing.

12. SUMMARY: MEASUREMENT EQUIPMENT REQUIREMENTS

Application Area	Key Specification	Suggested Equipment	Reg. Articles
CAD-to-part validation	Surfaces within $\pm 3\text{mm}$ of CAD; positional $\pm 2\text{mm}$	Laser tracker + scanner, structured light	3.3.1, 3.3.2
Optical target alignment	10+ targets per car; coordinate file per cell	Optical tracker, laser tracker	3.3.3
Rear Wing skin deflection	$\leq 2\text{mm}$ under 60N (vacuum cup)	Laser tracker, displacement sensor	3.18.3
Front Wing flexibility	$\leq 15/20\text{mm}$ under 1000N	Laser tracker, optical tracker	3.18.4
Front Wing flap	$\leq 5\text{mm}$ under 60N	Displacement sensor, laser tracker	3.18.5
Front Floor flexibility	Defined load/deflection curve to 8000N	Laser tracker, LVDT	3.18.6
Outboard Floor (laser scan)	$\leq 8\text{mm}$ under 600N distributed	Laser scanner (explicitly required)	3.18.7
Central Floor flexibility	$\leq 2\text{mm}$ / $\leq 0.2\text{mm}$; ≥ 15 kN/mm stiffness	Laser tracker, displacement sensors	3.18.8
RW Mainplane flexibility	$\leq 6\text{mm}$ + $\leq 1.0^\circ$; tracking targets	Optical tracker (real-time)	3.18.9
RW Flap flexibility	$\leq 7\text{mm}$ horizontal under 500N	Laser tracker	3.18.10
RW Endplate flexibility	$\leq 10\text{mm}$ under 50N; subtract rigid-body	Optical tracker system	3.18.12
RW Slot gap test	65mm spherical gauge under 10N	Precision gauge + tracker	3.18.13
Plank wear measurement	$10 \pm 0.2\text{mm}$ new; $\geq 9\text{mm}$ after wear	Laser tracker, contact probe	3.6
Surface contour verification	Radii 15–1000mm; visibility rules	3D scanner, structured light	3.5–3.11
Clearance measurement	Min clearance at full steering lock	Optical tracker (dynamic)	3.17
Crash structure deformation	Deflection under 100–172 kN loads	Laser tracker, optical tracker	13.3, 13.4
Gearbox layout	Shaft concentricity, 90–110mm spacing	Laser tracker, CMM	9.7
Suspension geometry	Wheel axis Y-positions at ride height	Laser tracker, optical tracker	10.10
Coordinate system setup	Car datum from optical targets	Laser tracker, optical tracker	2.6, 3.3.3

— End of Analysis —