ZIPPTORK
Bolting Technology
Torque Control • Bolt Load Control

TCA/TCB/TCC/TCD
Torque Controller White Paper

An Innovative Torque Control Methodology
for
Air Impact Wrenches & Pulse Tools

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www.zipptork.com

Why Conventional Impact & Pulse Tools Need Smarter Torque Control

Air impact wrenches remain the most widely used fastening tools for medium- and high-torque applications. However, most fastening operations still rely on operator experience rather than controlled fastening processes.

Why They Are Still Widely Used

✓ High productivity
✓ High power-to-weight ratio
✓ Rugged and durable
✓ Widely used in medium- and high-torque fastening

Current Challenges

- Torque is difficult to control consistently
- Sensitive to operating conditions
- No real-time process monitoring
- No fastening data
- No traceability
- Difficult to integrate with MES / IIoT

Air Impact Wrenches

Air Pulse Tools

The challenge is no longer how to tighten bolts faster—but how to make every fastening operation measurable, controllable, and traceable.

From One Patented Control Logic to Three Operating Modes

ZIPPTORK's torque control technology originated from a patented pressure–residual torque control logic and has evolved through years of practical field application into an application-based training architecture with three operating modes.

Patented Control Logic

- Defined Tool
- Defined Fastening Combination
- Defined Fastening Duration
- Pressure–Residual Torque Relationship

Foundation of all **ZIPPTORK** torque controllers

PATENTED
Pressure–Residual Torque Correspondence Relationship

APPLICATION-BASED TRAINING

Define Fastening Conditions

↓

Perform Controller Training

↓

Establish Training Parameters

↓

CREATE & SAVE JOB PROFILE

Three Operating Modes

Pressure Mode

Tool + Controller

Pressure + Time

Transducer Mode

Tool + Wireless Rotary Torque Transducer + Controller

Torque Feedback

ACCU Mode

Tool + Wireless Rotary Torque Transducer + Controller + Extended Fastening Duration

Extended Time + Torque Feedback

One patented control logic. Application-based training. Three operating modes.

Introducing the ZIPPTORK Torque Control Platform

A practical upgrade solution that transforms conventional air impact and air pulse tools into controllable, connected, and traceable fastening systems.

Conventional Air Impact & Air Pulse Tools

Air Impact Wrenches

Air Pulse Tools

Problems

- Inconsistent torque control
- No fastening records
- No process traceability

ZIPPTORK

Torque Controller Platform

TCA / TCB / TCC

Three Operating Modes

Pressure Mode
Transducer Mode
ACCU Mode

Solutions

ZIPPTORK Smart Fastening System

Air Impact Wrenches

Air Pulse Tools

Transducer/ACCU Mode
Wireless Rotary Torque Transducer
TTES/TTEH/TTEB

Pressure Mode
Without Torque Transducer

Result

- ✓ Measurable
- ✓ Controllable
- ✓ Traceable
- ✓ Connected

• Add Intelligence • Control the Process • Assure the Result • Cost-effective Upgrade

ZIPPTORK Torque Control Architecture

The controller executes the operating mode defined by the selected Job Profile to achieve controlled, repeatable fastening.

1. ZIPPTORK Torque Controller

- Intelligent Control Logic
- Three Operating Modes
- Job Profile Management

2. Defined Job Profile

- Tool
- Fastener
- Joint Condition
- Operating Conditions
- Tightening Duration
- Target Torque
- Tolerance
- Operating Mode

Every fastening operation is based on a clearly defined Job Profile.

3. Job Profile Execution

Job Profile
(Defined Fastening Conditions + Operating Mode)

ZIPPTORK
Torque Controller

EXECUTE JOB PROFILE OPERATING MODE

- **Pressure Mode**
- **Transducer Mode**
- **ACCU Mode**

- Automatic Shut-Off
- OK / NOK Judgment
- Data Recording

Fastening Result

4. Controller Functions

ZIPPTORK
Torque Controller

Once a Job Profile has been selected, the controller performs:

- ✓ Execute the Job Profile operating mode
- ✓ Automatic shut-off
- ✓ OK / NOK judgment
- ✓ Data recording
- ✓ Job Profile management
- ✓ Operating parameter monitoring

The controller executes the control logic defined by the selected Job Profile.

Every fastening operation begins with a defined job profile and ends with a controlled, verified, and recorded fastening result.

Controller Training & Job Profile Establishment

Training converts defined fastening conditions into operating parameters for a repeatable Job Profile.

Step 1

Define the Fastening Combination

- **Tool**
- **Bolt / Nut / Washer**
- **Joint Condition**
- **Stable Workstation Air Supply**
- **Initial Fastening Time**

↓

Define Stable PH / Tool PL

Step 2

Select Operating Mode Based on Application Requirements

↓

Pressure Mode

(Tool + **Controller**)

or

Transducer Mode

(Tool + **Wireless Rotary Torque Transducer** + **Controller**)

or

ACCU Mode

(Tool + **Wireless Rotary Torque Transducer** + **Controller** + **Extended Fastening Duration**)

Step 3

Controller Training

Perform Training under Defined Conditions

↓

Measure & Correlate Fastening Results

↓

Establish Training Parameters

↓

CREATE & SAVE JOB PROFILE

• Tool • Fastener • Target Torque • Pressure • Fastening Time • Operating Mode

PH≈ Approximately 90–95% of the highest stable working air pressure available at the workstation.
PL≈ The lowest working air pressure at which the selected impact wrench or air pulse tool can still operate consistently.

Controller Training can be performed:
✓ ON-STATION TRAINING, or
✓ OFF-LINE TRAINING

Each Job Profile is established through mode-specific training under defined fastening conditions.

Pressure Mode Control Logic

Pressure Mode controls fastening through trained working air pressure and fastening time without direct torque feedback.

Fundamental Control Principle

Defined Tool + Fastening Combination

↓

Trained Working Air Pressure

↓

Trained Fastening Time

↓

Pressure Monitoring

↓

Automatic Shut-Off at Trained Time

Pressure Mode Training

METHOD 1 — PRESSURE / RESIDUAL TORQUE

PH → TH

PL → TL

↓

Pressure ↔ Residual Torque

↓

Required Working Pressure

OR

METHOD 2 — TIME-BASED

PH + Defined Fastening Time

↓

Clamping Force vs. Time

↓

Clamping Force ↔ Residual Torque Correlation

↓

Target Torque → Required Fastening Time

Pressure Mode Operation

Operation is based on the established Job Profile.

TCA/TCB

- Select the established Job Profile
- Apply trained working pressure and fastening time
- Automatically adjust working air pressure
- Continuously stabilize working pressure
- Automatic shut-off at trained fastening time
- Display estimated residual torque
- **OK** / **NOK** Judgment

TCC

- Select the established Job Profile
- Display trained working air pressure
- Operator manually adjusts working air pressure
- Continuously monitor working pressure
- Abnormal pressure → Alarm + **NOK**
- Automatic shut-off at trained fastening time
- Display estimated residual torque

No direct torque feedback or torque compensation

Controller Training can be performed:

✓ ON-STATION TRAINING, or

✓ OFF-LINE TRAINING

Typical Controllable Accuracy

Air Impact Wrench → ±15–20%

Air Pulse Tool → ±10–15%

Control accuracy depends on a correctly established Job Profile.

Transducer Mode Control Logic

Transducer Mode uses a wireless rotary torque transducer for real-time torque feedback and closed-loop torque control.
Real-time torque feedback and torque compensation provide higher control accuracy than Pressure Mode.

Fundamental Control Principle

Wireless Rotary Torque Transducer
↓
Real-Time Torque Feedback
↓
Torque + Pressure Monitoring
↓
Torque Compensation
↓
Target Torque Achieved
↓
Automatic Shut-Off

Transducer Mode Configuration

Install Wireless Rotary Torque Transducer
↓
Select Established Job Profile
↓
Load Trained Parameters
↓
Verify Operating Conditions
↓
Ready for Operation

Based on a correctly established Job Profile.

Transducer Mode Operation

- Select the established Job Profile
- Apply trained operating parameters
- Continuously monitor torque & pressure
- Compare measured torque with target torque
- Apply torque compensation as required
- Automatic shut-off at target torque
- Display measured torque
- OK / NOK Judgment

Torque compensation is based on the trained pressure–residual torque relationship established for the Job Profile.

Why Use Transducer Mode?

✓ Direct torque measurement
✓ Torque compensation
✓ Real-time process monitoring

Controller Training can be performed:

✓ ON-STATION TRAINING, or
✓ OFF-LINE TRAINING

Typical Controllable Accuracy

Air Impact Wrench → ±10–15%
Air Pulse Tool → ±5–10%

Control accuracy depends on correct transducer installation, stable operating conditions, and a correctly established Job Profile.

Real-time torque feedback and torque compensation enable higher-accuracy closed-loop torque control.

When & How to Use ACCU Mode

ACCU Mode is used when the selected tool cannot achieve the target torque within the original preset fastening duration. The operator can either replace the tool with a higher-capacity model or establish a new Job Profile using a longer preset fastening duration.

Fundamental Control Principle

Target Torque Cannot Be Achieved within Preset Fastening Duration
↓
Extend Fastening Duration
↓
Additional Impact Energy Accumulation
↓
Torque + Pressure Monitoring
↓
Operating Variation Detection
↓
Trained Extended Fastening Time
↓
Automatic Shut-Off
↓
Final Torque Estimation & OK / NOK Judgment

ACCU Mode Decision Process

Install Wireless Rotary Torque Transducer
↓
Input Preset Fastening Duration
↓
Train at PH
↓
Measure Residual Torque
↓
Residual Torque < Target Torque?
↓
YES

- Use a Higher-Capacity Tool → Retraining → Re-evaluate Operating Mode
- Retain Existing Tool → Extend Fastening Duration → Retraining → Establish New ACCU Mode Job Profile

ACCU Mode Operation

- Select the established ACCU Mode Job Profile
- Apply trained operating parameters
- Start fastening at the trained working pressure
- Continuously monitor torque signal and working air pressure
- Verify operating signals within allowable ranges
- Continue fastening to the trained extended fastening time
- Automatic shut-off at trained extended fastening time
- Calculate/display estimated final torque
- OK / NOK Judgment

Continuous torque monitoring during the extended fastening duration helps detect operating variations that may affect the fastening result.

Any change to the preset fastening duration requires retraining and the establishment of a new Job Profile.

Controller Training can be performed:
✓ ON-STATION TRAINING, or
✓ OFF-LINE TRAINING

Typical Controllable Accuracy
Air Impact Wrench → ±12–17%
Air Pulse Tool → ± 7 –12%

ACCU Mode uses trained extended fastening time and torque monitoring for controlled energy accumulation.

Selecting the Right Operating Mode

Each operating mode addresses a different balance of cost, control accuracy, and existing tool capability.

	Pressure Mode	Transducer Mode	ACCU Mode
Primary Consideration	Cost vs. Control Accuracy	Higher Control Accuracy	Retaining the Existing Tool
Control Method	Working Air Pressure + Fastening Time	Real-Time Torque Feedback + Working Air Pressure	Extended Fastening Time + Torque Feedback
Transducer	Not Required	Required	Required
Torque Compensation	No	Yes	No
Shut-Off	At Trained Fastening Time	At Target Torque	At Trained Extended Fastening Time
Impact Wrench Accuracy	±15–20%	±10–15%	±12–17%
Pulse Tool Accuracy	±10–15%	±5–10%	±7–12%

Operating Mode	When to Use
Pressure Mode	When cost efficiency is prioritized, and standard torque control accuracy is acceptable.
Transducer Mode	When higher torque control accuracy and direct torque feedback are required.
ACCU Mode	When the existing tool is retained and a longer fastening duration is acceptable for controlled energy accumulation.

One controller platform offers three control strategies to meet different fastening requirements.

ZIPPTORK Controller Capability & Pressure Management

TCA and TCB provide active control of working air pressure, while TCC monitors pressure variations and identifies out-of-range fastening as NOK.

Function	TCA	TCB	TCC
User Interface	Built-in HMI	External Tablet / Laptop	External Tablet / Laptop
Pressure Control Valve / Proportional Valve	✓	✓	—
Real-Time Pressure Adjustment	✓ Automatic	✓ Automatic	—
Automatic Pressure Stabilization	✓	✓	—
Pressure / Out-of-Range Monitoring	✓	✓	✓
Alarm + NOK	✓	✓	✓
Air Flow Meter*	Optional / Auxiliary	Optional / Auxiliary	—

*Air Flow Meter provides air-consumption information only and does not affect torque control accuracy.

TCA / TCB — ACTIVE PRESSURE CONTROL

Working Air Pressure Variation Detected

↓

Automatic Pressure Adjustment

↓

Pressure Stabilization

Maintains the trained working air pressure condition during fastening.

TCC — PRESSURE MONITORING ONLY

Working Air Pressure Monitoring

↓

Out of Allowable Range

↓

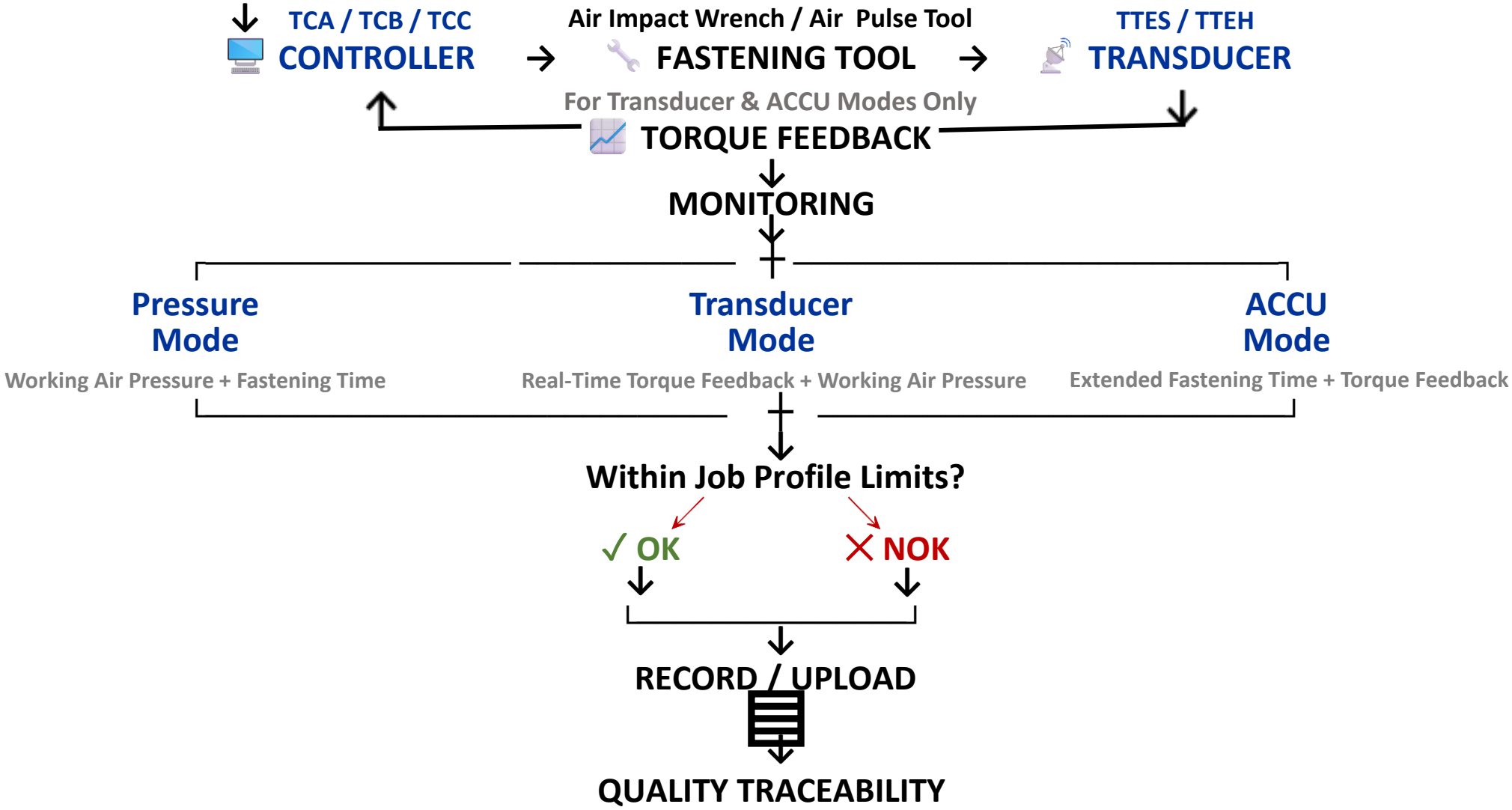
Alarm + NOK

Monitors pressure variation without automatic pressure adjustment.

Fastening Monitoring & Quality Judgment

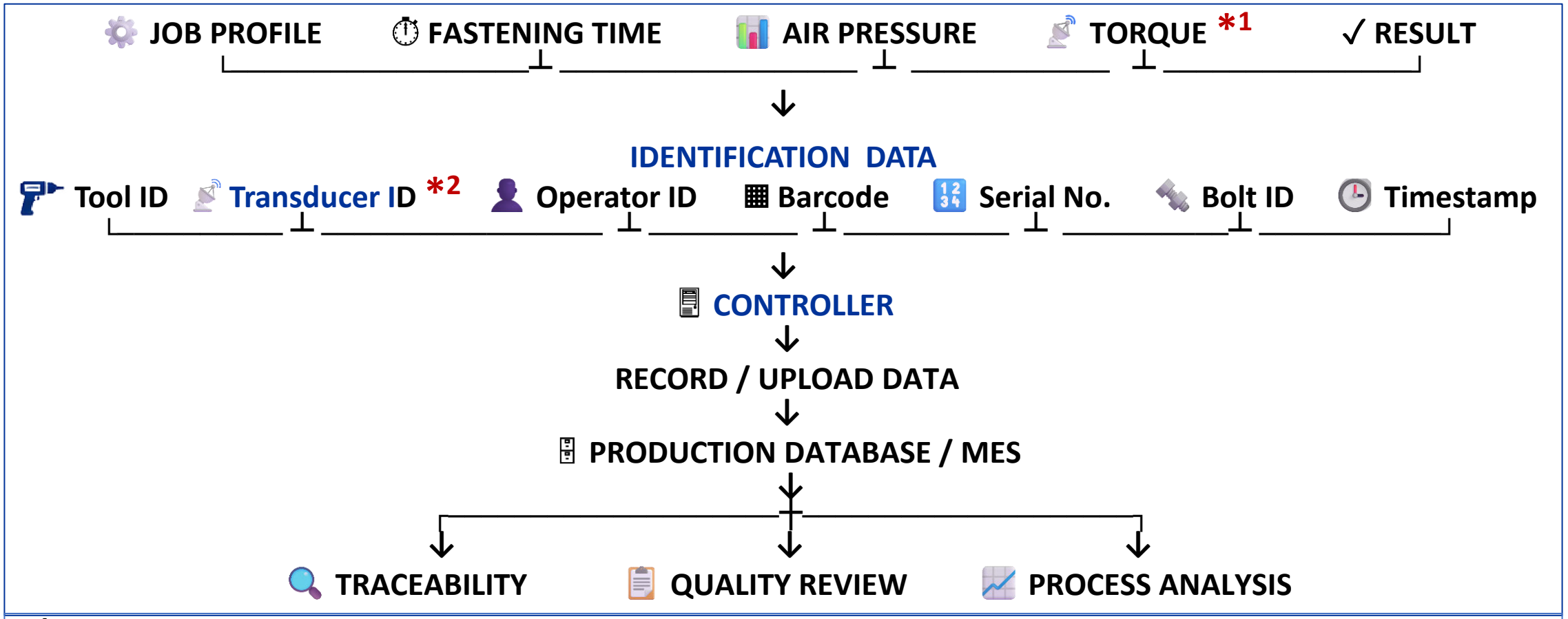
Every fastening cycle is monitored against the established Job Profile for process control and OK / NOK judgment.

JOB PROFILE—Provides the reference for fastening control and quality judgment, while recorded results support process traceability.



Fastening Data Recording & Traceability

Each fastening result can be recorded with its Job Profile, process parameters, and OK / NOK status for production traceability.



*1 Measured torque for Transducer Mode; estimated final torque for ACCU Mode; estimated residual torque for Pressure Mode.

*2 For Transducer and ACCU Modes only

Fastening data transforms each tightening cycle into a traceable production record.

CONTROLLER TRAINING ARCHITECTURE

Establishing the operating parameters required for each fastening Job Profile

ON-STATION TRAINING
[PREFERRED]

Actual Production Conditions

Defined Conditions

Direct / SWF + ST Assisted

OFF-LINE TRAINING
[ALTERNATIVE]

Replicated Production Conditions

Defined Conditions

Test Bench / FCA

SELECTED OPERATING MODE

↓

TRAINING METHODS

PRESSURE / RESIDUAL TORQUE RELATIONSHIP

$P_H \rightarrow T_H$ / $P_L \rightarrow T_L$

Pressure ↔ Residual Torque

TIME-BASED CHARACTERIZATION

P_H + Defined Fastening Time

Clamping Force vs. Time Curve

Clamping Force ↔ Residual Torque Correlation

Target Torque → Required Fastening Time

↓

TRAINING PARAMETERS

↓

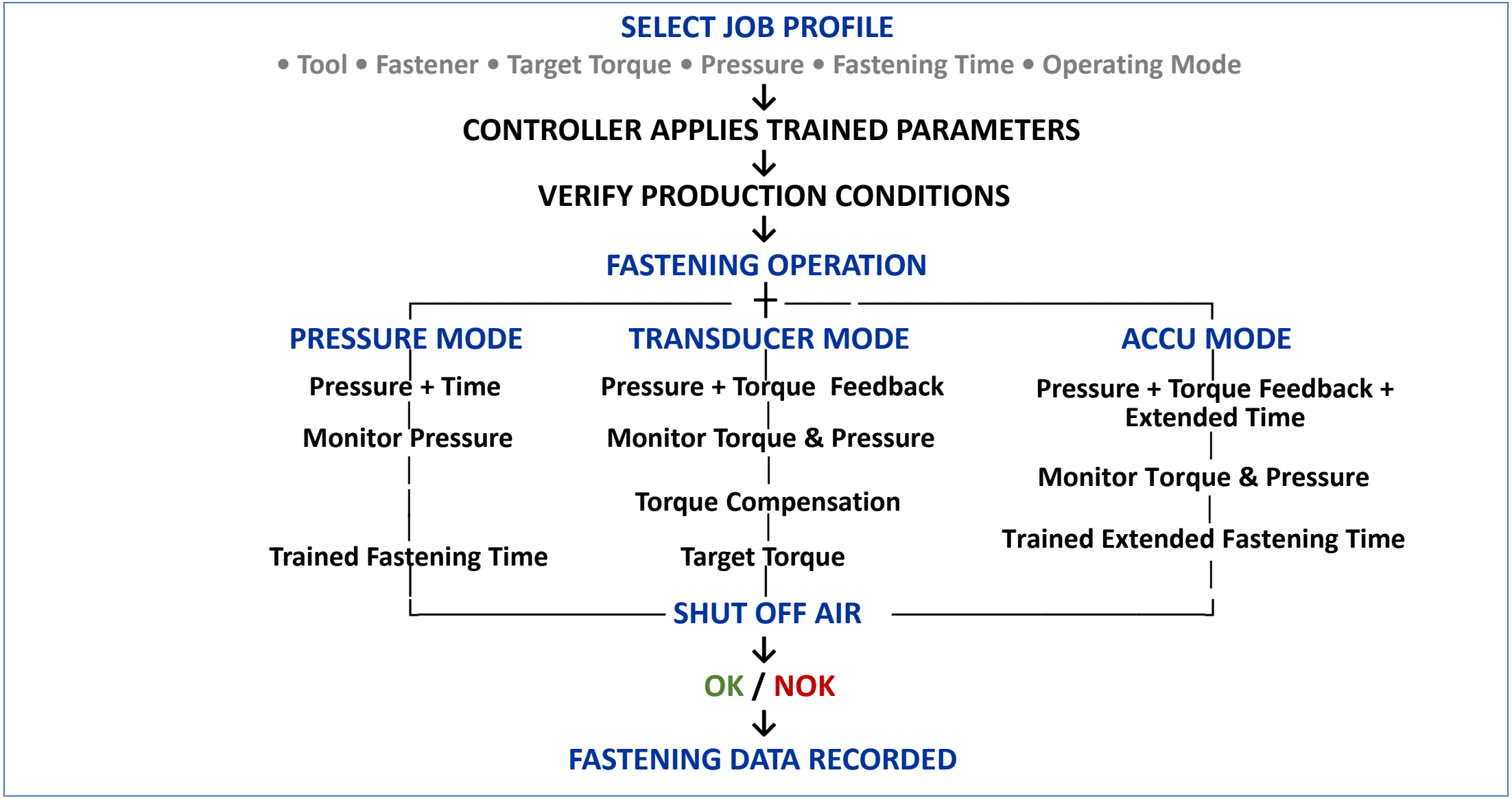
JOB PROFILE

• Tool • Fastener • Target Torque • Pressure • Fastening Time • Operating Mode

Controller training converts actual fastening behavior into defined operating parameters for a repeatable Job Profile.

FROM TRAINING TO PRODUCTION

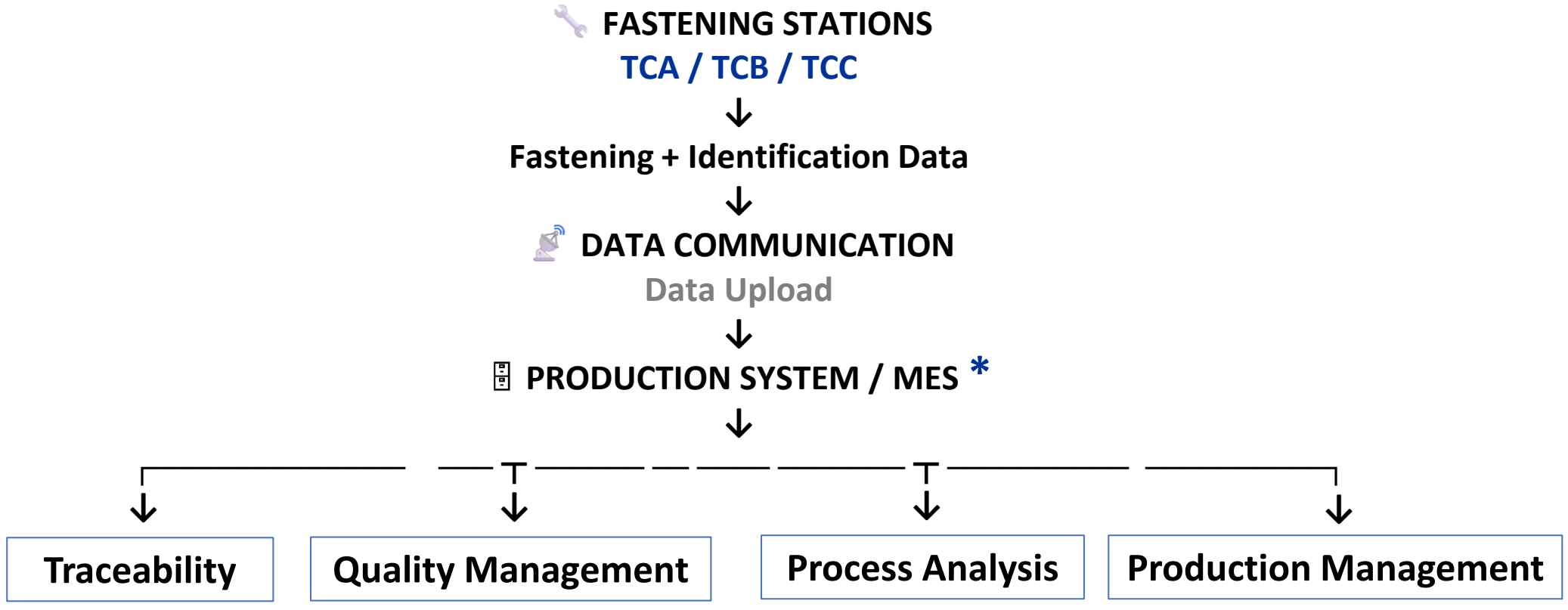
Applying trained Job Profile parameters to controlled fastening operations



A trained Job Profile converts fastening parameters into controlled, repeatable, and traceable production operations.

Production System Integration

Fastening data can be connected with production systems to support centralized monitoring, traceability, and process management.



Connected fastening data turns individual fastening stations into part of the digital production system.

* Production system / MES integration is application-dependent and may require optional integration services.

ZIPPTORK Torque Controller Family

A scalable controller platform for air impact and pulse tool fastening applications.

KEY FEATURES & CONFIGURATIONS

Feature	TCA	TCB	TCC
			
Control Modes Pressure/Transducer/ACCU Mode	✓	✓	✓
User Interface	Built-in HMI	PC / Laptop	PC / Tablet
Air Pressure Regulation	Automatic	Automatic	Manual
Abnormal Pressure Alarm / NOK	✓	✓	✓
Air Flow Measurement	Optional	Optional	—
Job Profile	✓	✓	✓
OK / NOK Judgment	✓	✓	✓
Identification Data	✓	✓	✓
Fastening Data Recording	✓	✓	✓
Data Upload	✓	✓	✓

One Control Architecture. Multiple Configurations. Built for Different Production Needs.

Technical Specifications

Key technical specifications for selecting the appropriate controller configuration.

Specification	TCA-2000	TCB-2000	TCC-2000
Max. Air Flow	2,000 L/min	2,000 L/min	2,000 L/min
User Interface	10" Built-in HMI	PC / Laptop	PC / Tablet
Operating System	Linux	Windows	Android / Windows
Control Modes Pressure/Transducer/ACCU Mode	✓	✓	✓
Air Pressure Regulation	Automatic	Automatic	Manual
Air Flow Measurement	Optional	Optional	—
Torque Curve Display	—	✓	✓
Communication	Ethernet / Wi-Fi	Wi-Fi / Bluetooth	Wi-Fi / Bluetooth
Serial Interface	2 × RS-232	1 × RS-232	—
Weight	10.5 kg	6 kg	3.7 kg

Specifications subject to engineering review and confirmation.

Select the controller configuration that best matches your application, operating environment, and system requirements.

Open-Platform Tool Compatibility

One controller platform for pneumatic impact and pulse tools — regardless of brand or torque mechanism.

BRAND INDEPENDENT
Works with compatible air impact and pulse tools from different manufacturers.

Twin Hammer / Jumbo Hammer / Pin Clutch / Rocking Dog & Others

MECHANISM INDEPENDENT
Control is not tied to a specific internal torque-generating mechanism.

Single / Multi-Blade / Piston-Type & Other Pulse Unit Designs


TCA


TCB


TCC

APPLICATION-BASED TRAINING
Control parameters are established under the actual tool, fastener, joint, fastening time, and workstation conditions.

↓

Pressure Mode | Transducer Mode | ACCU Mode

↓

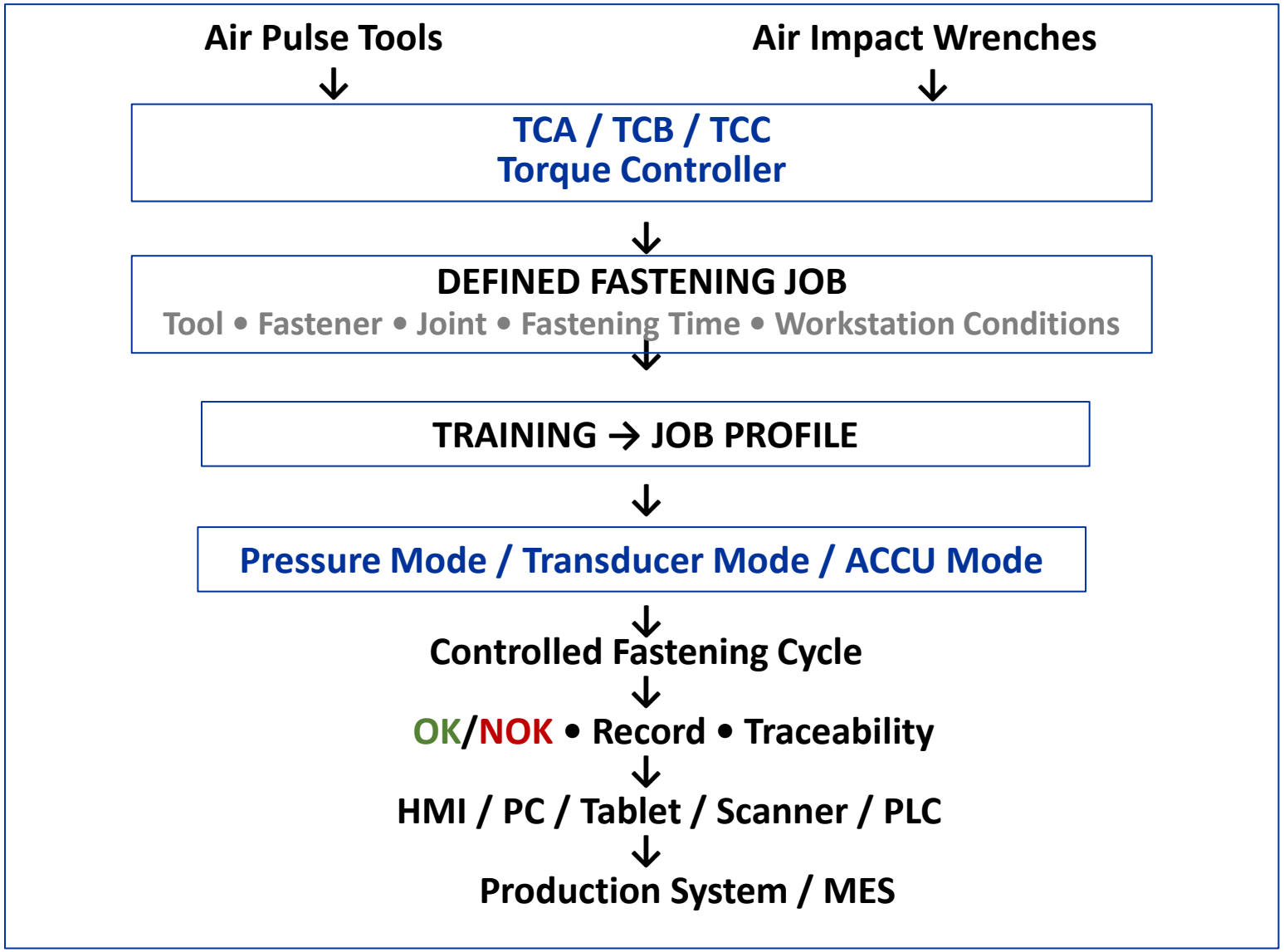
- **Torque Control**
- **Process Monitoring**
- **Quality Management**
- **Production Management**
- **Traceability**

Keep Your Tools. Add Intelligence.

Open architecture integrates existing pneumatic tools into controlled, connected, and traceable fastening systems.

Production Application Architecture

A trained fastening system for repetitive production stations with defined tools, fasteners, joints, and workstation conditions.



From trained fastening control to production connectivity — one architecture for repetitive assembly operations.

High-Torque Fastening: A Lightweight Smart Alternative

Combining the power-to-weight advantage of air impact wrenches with torque control, monitoring, and data traceability.

Bring Torque Control and Data Intelligence to the Power-to-Weight Advantage of Air Impact Wrenches.

HIGH-TORQUE AIR PULSE SOLUTION

Air Pulse Tools

Advantages

- Lower Noise & Vibration
- Better Torque Controllability
- Low Reaction

High-Torque Considerations

- Heavier Tool for Comparable Torque Output
- Higher Equipment Cost
- More Limited High-Torque Range

Typical Torque Control Accuracy

± 10 – 20%

VS

ZIPPTORK SMART AIR IMPACT SOLUTION

Air Impact Wrenches

+

TCA / TCB / TCC

Torque Controller

↓ **Pressure Mode**

± 15 – 20%

+ **Wireless Rotary Torque Transducer**

↓

↓ **Transducer Mode / ACCU Mode**

± 10 – 15% / ± 12 – 17%

↓

↓

Torque Control • OK/NOK • Data Recording • Traceability

For suitable high-torque production applications, smart impact fastening offers a lighter, controllable, and connected alternative.

Typical Production Applications

Best suited for repetitive assembly stations where fastening conditions can be defined, trained, and consistently repeated.

① HIGH-TORQUE ASSEMBLY

Large bolts and high-torque fastening at fixed production stations.

Air Impact Wrench + Controller

Air Impact Wrench + Wireless Rotary Torque Transducer + Torque Controller

② REPETITIVE ASSEMBLY

Repeated fastening of defined fasteners and joints under consistent workstation conditions.

Training → Job Profile

③ MULTIPLE FASTENING JOBS

Different fastening jobs can be managed through trained Job Profiles.

• Job Selection • OK/NOK • Recording

④ TRACEABLE PRODUCTION

Fastening results and identification data can be recorded for production traceability.

• Operator ID • Tool / Transducer ID • Job Profile • Fastening Results

The best application is not defined by industry — it is defined by a repeatable fastening process.