# SURFACE VEHICLE RECOMMENDED PRACTICE

J670™ JUN2022

Issued 1952-07
Revised 2008-01
Reaffirmed 2022-06

Superseding J670 JAN2008

(R) Vehicle Dynamics Terminology

RATIONALE

SAE J670 was last updated over 30 years ago. Since the last revision, the field of vehicle dynamics has changed significantly. New systems such as four-wheel steering and active control have been applied to enhance the performance of vehicles. The terminology for vehicle dynamics needed to be updated to accommodate these new technologies and to make the definitions consistent with current usage in the field. Accordingly, many new terms have been added to the terminology to provide formal definitions for terms that are associated with these new technologies. A number of existing definitions, which were based on front-wheel steer vehicles with passive control, were also revised to accommodate new technologies.

In addition, new SAE and ISO standards have been published since the last revision of SAE J670 that directly relate to topics considered in SAE J670. The content of these new standards also indicated the need to revise SAE J670.

Specifically, in 1987, SAE published J1594, containing aerodynamics terminology previously appearing in SAE J670e. The aerodynamics section of SAE J670e is not included in the revised document, because those terms are now defined in SAE J1594.

In 1991, the International Organization for Standardization (ISO) published a vehicle dynamics vocabulary, ISO 8855. SAE J670e and ISO 8855 are incompatible in several aspects, the most notable being the axis systems defined in the two documents. SAE J670e utilizes an axis system based on aeronautical practice, with positive X forward, positive Y to the right, and positive Z down. ISO 8855 utilizes an axis system with positive X forward, positive Y to the left, and positive Z up. The revised SAE J670 embraces both of these axis orientations. The revised SAE J670 additionally addresses technical shortcomings found in both SAE J670e and ISO 8855 and is a harmonized superset of the two documents.

In 1998, SAE published J2047, containing definitions for tire performance terms that were previously defined in SAE J670e. The revised SAE J670 utilizes many definitions excerpted from SAE J2047, although some of these definitions are revised to enhance their applicability to vehicle dynamics.

Several of the sections of SAE J670e dealing with vibration terminology are not included in the new SAE J670, as the terms that were defined in these sections are commonly defined in engineering textbooks and the definitions are not specific to vehicle dynamics.

Finally, the terminology is extended to include definitions for many suspension and steering components, to enhance communication among vehicle dynamics professionals.

This seventh edition of SAE J670 replaces the preceding edition (SAE J670e) in its entirety.

SAE J670 has been reaffirmed to comply with the SAE Five-Year Review policy.



**TO PLACE A DOCUMENT ORDER:** **Tel: 877-606-7323 (inside USA and Canada)**
**Tel: +1 724 776 4970 (outside USA)**

**SAE WEB ADDRESS:**

**For more information on this standard, visit**
ds/content/J670_202206/

## FOREWORD

This terminology is intended to be sufficient to allow meaningful communication between vehicle dynamics professionals who need to describe the static and dynamic characteristics of automobiles, light trucks, and trailers. The terminology is to be used for presenting results and findings concerning the longitudinal, lateral, vertical and rotational dynamic performance of the applicable vehicles as predicted by analyses and simulations or as measured in tests and operational situations.

The purpose of this terminology is not to cover all terms in the manner of a dictionary or terms found in a basic engineering textbook. Rather, this document contains compatible definitions that have been carefully selected to aid in conveying ideas with rigor and accuracy in a readily understood and generally acceptable manner.

The terminology draws upon terms and definitions previously appearing in SAE J670e and ISO 8855 and further develops those that are applicable to the subjects covered by this document. For application to the study of vehicle dynamics, the tire terminology in this document contains pertinent definitions extracted from or based upon SAE J2047. Definitions for many chassis components are also provided.

Many of the definitions in the document contain terms appearing in italic font. Definitions for terms in italic may be found elsewhere in the document.

## INTRODUCTION

ISO 8855:1991 is the international standard corresponding to SAE J670. The scopes of these two standards are different. The scope of SAE J670 is limited to passenger cars and light trucks with two axles, plus those vehicles in combination with single-axle trailers. The scope of ISO 8855 additionally includes heavy commercial vehicles, with multiple axles and multiple units. SAE J670 recognizes axis systems with both Z-Up and Z-Down orientations, while ISO 8855 only recognizes the Z-Up orientation. SAE J670 defines five axis systems: Earth, intermediate, vehicle, tire, and wheel, while ISO 8855 defines four axis systems: Earth, intermediate, vehicle, and wheel (equivalent to the SAE J670 tire system). SAE J670 accommodates four-wheel steering, while ISO 8855 does not. SAE J670 accommodates an inclined road surface that is non-uniform, while ISO 8855 is limited to application on a flat, horizontal road surface. SAE J670 includes definitions for many suspension and steering components, while component definitions are not included in ISO 8855. SAE J670 also defines many more terms (over 600) than are defined in ISO 8855 (approximately 130).

TABLE OF CONTENTS

# 1. SCOPE

The vehicle dynamics terminology presented herein pertains to passenger cars and light trucks with two axles and to those vehicles pulling single-axle trailers. The terminology presents symbols and definitions covering the following subjects: axis systems, vehicle bodies, suspension and steering systems, brakes, tires and wheels, operating states and modes, control and disturbance inputs, vehicle responses, and vehicle characterizing descriptors. The scope does not include terms relating to the human perception of vehicle response.

# 2. REFERENCES

## 2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.

### 2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1594 Vehicle Aerodynamics Terminology

SAE J2047 Tire Performance Technology

SAE J2564 Automotive Stability Enhancement Systems

### 2.1.2 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036, Tel: 212-642-4900, www.ansi.org.

ISO 8855:1991 Road vehicles—Vehicle dynamics and road-holding ability—Vocabulary

## 2.2 Related Publications

### 2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1451 A Dictionary of Terms for the Dynamics and Handling of Single Track Vehicles (Motorcycles, Mopeds, and Bicycles)

SAE J1982 Nomenclature—Wheels for Passenger Cars, Light Trucks, and Multipurpose Vehicles

SAE M-105 SAE Glossary of Automotive Terms—Second Edition

SAE R-159 Dictionary of Automotive Engineering—Second Edition

2.2.2 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036, Tel: 212-642-4900, www.ansi.org.

ISO 611 Road vehicles—Braking of automotive vehicles and their trailers—Vocabulary

ISO 612 Road vehicles—Dimensions of motor vehicles and towed vehicles—Terms and definitions

ISO 1176 Road vehicles—Masses—Vocabulary and codes

ISO 3833 Road vehicles—Types—Terms and definitions

ISO 3877 Tyres, valves and tubes—List of equivalent terms—Part 1: Tyres

ISO 3911 Wheels and rims for pneumatic tyres—Vocabulary, designation and marking

ISO 4223 Definitions of some terms used in the tyre industry—Part 1: Pneumatic tyres

ISO 6725 Road vehicles—Dimensions of two-wheeled mopeds and motorcycles—Terms and definitions

ISO 6726 Mopeds and motorcycles with two wheels—Masses—Vocabulary

ISO 7237 Caravans—Masses and dimensions—Vocabulary

ISO 11838 Motorcycle and motorcycle-rider kinematics—Vocabulary

2.2.3 Other Publications

Bosch Automotive Handbook

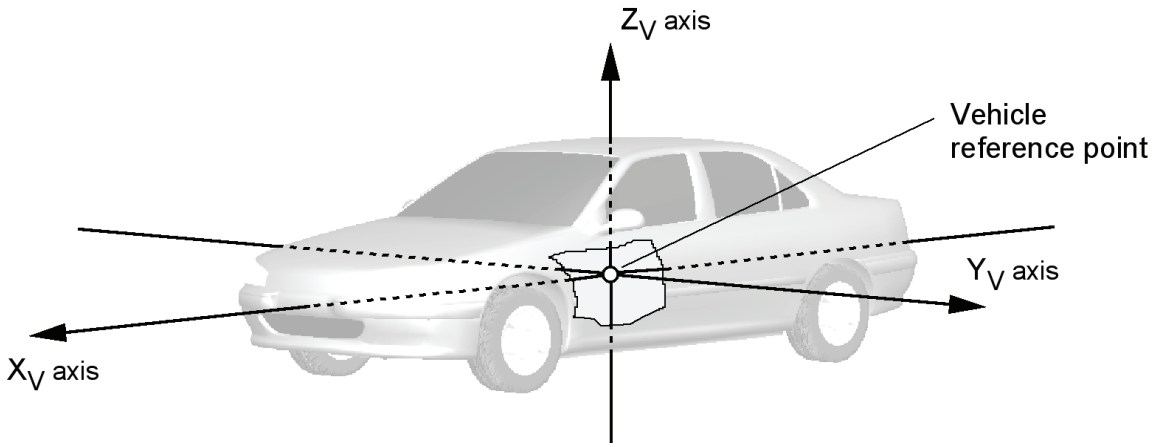
Bosch Automotive Terminology

Tire and Rim Association Year Book

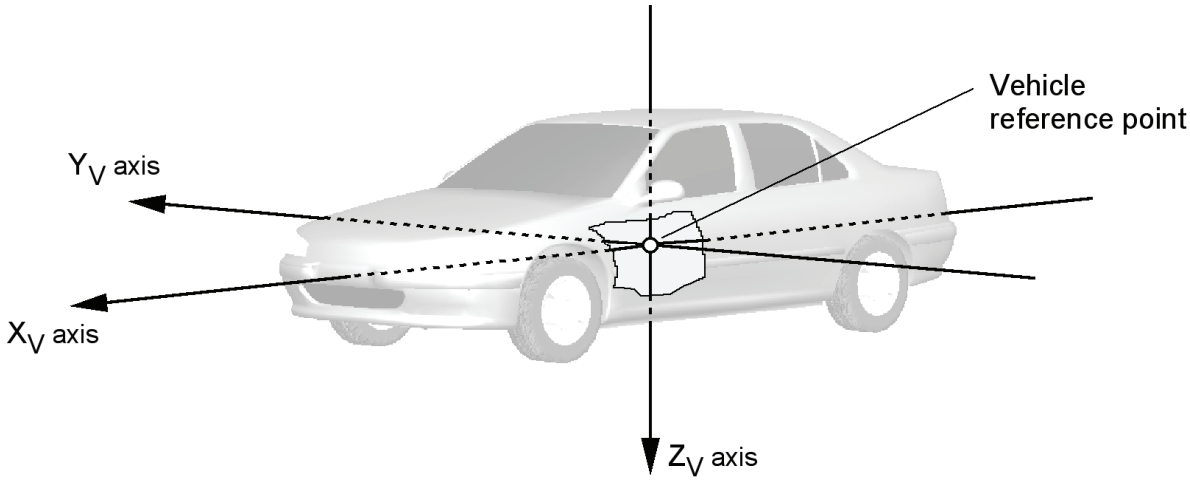
## 3. AXIS AND COORDINATE SYSTEMS

This terminology recognizes axis systems with two existing nominal orientations: the orientation originally defined by SAE J670, which was adopted from aeronautical convention, and the orientation defined in ISO 8855:1991. These axis orientations are equally acceptable, and the selection of the appropriate orientation should be based on the requirements of the analysis or test being performed. The ISO 8855 axis orientation is referred to as the Z-Up orientation, with the traditional SAE J670 axis orientation referred to as the Z-Down orientation. These two axis orientations are shown in Figure 1 below. When definitions are dependent upon the axis orientation, dual definitions are provided, with the definition based on the Z-Up axis orientation appearing first. Many of the terms in this section are also defined in SAE J2047.

The definitions in this section are intended to provide sufficient flexibility to accommodate the broad spectrum of modeling techniques that are currently used to represent the dynamics of vehicles as systems of multiple rigid bodies. Certain commonly used *axis systems* and *coordinate systems* are defined herein. However, there is no intent to limit an analyst or experimentalist to the use of only the *axis systems*, *coordinate systems*, or *reference frames* specifically defined.




A. VEHICLE AXIS SYSTEM – Z-UP




B. VEHICLE AXIS SYSTEM – Z-DOWN

FIGURE 1 – ORIENTATIONS OF AXIS SYSTEMS

3.1 Reference Frame—A geometric environment in which all points remain fixed with respect to each other at all times.

3.2 Inertial Reference (Newtonian Reference)—A *reference frame* that is assumed to have zero linear and angular acceleration and zero angular velocity. In Newtonian physics, the Earth is assumed to be an inertial reference.

3.3 Axis System—A set of three orthogonal directions associated with X, Y, and Z axes. A right-handed axis system is assumed throughout this document, where:

$$\vec{Z} = \vec{X} \quad \vec{Y} \tag{Eq. 1}$$

3.4 Coordinate System—A numbering convention used to assign a unique ordered trio (x, y, z) of values to each point in a *reference frame*. A coordinate system consists of an *axis system* plus an origin point.

3.5 Ground Plane—A horizontal plane in the *inertial reference*, normal to the gravitational vector.

3.6 Road Surface—The surface, flat, curved, undulated, or other shape, supporting the *tire* and providing friction necessary to generate *tire shear forces* in the *road plane*.

3.7 Road Plane—1) A plane representing the *road surface* within each *tire contact patch*. For an uneven road, a different road plane may exist at each *tire contact patch*. 2) The plane formed when the individual road planes at each *tire contact patch* are essentially coplanar.

NOTE—For a planar *road surface*, the *road plane* will be coincident with the *road surface*. For *road surfaces* with surface contours having a wavelength similar to or less than the size of the *tire contact patch*, as in the case of many ride events, an equivalent *road plane* must be determined. Determination of the equivalent *road plane* is dependent on the requirements of the analysis being performed. The equivalent *road plane* may not be coincident with the actual *road surface* at the *tire contact center*.

3.8 Vehicle Plane of Symmetry (Longitudinal Plane of Symmetry)—The median plane of a vehicle that is generally laterally symmetric. This plane typically contains the lateral midpoints of the *axles* and the *hitch point*.

3.9 Earth-Fixed Axis System ($X_E$, $Y_E$, $Z_E$)—An *axis system* fixed in the *inertial reference*. The $X_E$ and $Y_E$ axes are parallel to the *ground plane*. The $Z_E$ axis is aligned with the gravitational vector. The positive $Z_E$ axis points upward in the Z-Up orientation. The positive $Z_E$ axis points downward in the Z-Down orientation. The orientation of the $X_E$ and $Y_E$ axes is arbitrary and should be based on the needs of the analysis or test.

3.10 Earth-Fixed Coordinate System ($x_E$, $y_E$, $z_E$)—A *coordinate system* based on the *Earth-fixed axis system* with an origin that is fixed in the *ground plane*. The location of the origin is generally an arbitrary point defined by the user.

3.11 Vehicle Axis System ($X_V$, $Y_V$, $Z_V$)—An *axis system* fixed in the *reference frame* of the vehicle *sprung mass*, so that the $X_V$ axis is substantially horizontal and points forward (with the vehicle at rest), and is parallel to the *vehicle plane of symmetry*. The $Y_V$ axis is perpendicular to the *vehicle plane of symmetry*. The $Y_V$ axis points to the left and the $Z_V$ axis points upward in the Z-Up orientation. The $Y_V$ axis points to the right and the $Z_V$ axis points downward in the Z-Down orientation. For articulated vehicles, a separate vehicle axis system may be defined for each unit. See Figure 1.

3.12 Vehicle Coordinate System ($x_V$, $y_V$, $z_V$)—A *coordinate system* based on the *vehicle axis system* with the origin located at the *vehicle reference point*.

3.13 Vehicle Reference Point—A point fixed in the vehicle *sprung mass*. See Figure 1.

NOTE—The *vehicle reference point* may be defined in a variety of locations, based on the needs of the analysis or test. Commonly used locations include the static *vehicle center of gravity*, the static *sprung-mass center of gravity*, the mid-*wheelbase* point at the height of the static *vehicle center of gravity*, and the center of the front *axle*.