

CHALLENGER OF RECORD & DEFENDER

AMERICA'S CUP 36

Interpretation 055

of

AC75 Class Rule Version 1.16 issued 30th September 2020

Rule References:

- 21.2 No **control system** or part thereof shall be capable of using feedback from the **yacht state** to control a **control surface**, except:
- (a) motion of a **control function** may be restricted where permitted by Rule 21.3;
 - (b) one or more **force input devices** may be connected **mechanically** and/or through an **HCC** to a single **control surface**; forces acting on that **control surface** can only be transmitted to those **force input devices**;
 - (c) one or more **force input devices** may be connected **mechanically** and/or through an **HCC** to common mechanical drive trains or common pressure supply lines that provide power to multiple **control surfaces**; forces acting on those **control surfaces** can be transmitted through those mechanical drive trains or pressure supply lines to those **force input devices**;
 - (d) as permitted within an **HCC** by Rules 22.5 (d) and 22.5 (e);
 - (e) as permitted within an **ECC** by Rule 24; and
 - (f) a **control surface** can move passively as the result of **external forces** acting on that **control surface**, providing the above Rules are respected.
- 22.8 If power from the **ECC** is used to drive a pump within an **HCC** permitted by Rule 24.2 (f):
- (a) that **HCC** must be entirely self-contained and disconnected from any other **HCC**; and
 - (b) one or more high-pressure accumulators are permitted to be installed in line with the pump.
- 24.1 Only the following sensors within, or inputs to an **ECC** are permitted:
- (a) outputs from **passive input devices**;
 - (b) sensors measuring the angle of a **foil flap** relative to a **foil wing**, or a proxy for that angle, at any number of spanwise locations along the **rondure** of the **foil wing**;
 - (c) one sensor measuring **rudder** rake angle relative to the **yacht**, or a proxy for that angle;
 - (d) sensors measuring the internal state of the **ECC**, such as voltage, current, CPU temperature, so long as those sensors provide no **yacht state** information, and are not used to estimate **yacht state** information;
 - (e) sensors measuring the internal geometric state of a **drive clutch** or **HCC** component, so long as those sensors do not directly measure **yacht state** information, and are not used to estimate **yacht state** information, for example:
 - (i) a sensor measuring the orientation of a cam in a hydraulic valve can be measured in order to drive that cam to a desired position, as long as the orientation of the cam is not used to estimate pressure or flow; and
 - (ii) current in a servo motor can be measured as part of a position control loop within the servo

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motor circuit, as long as the current is not used to estimate any part of the yacht state, such as control surface load; but

- (iii) a sensor measuring the position of a plunger in a pressure relief valve cannot be measured, as it provides direct information about pressure in the system; and
- (f) a sensor measuring the pressure of an accumulator permitted by Rule 22.8 (b).

24.2 Only the following **electric actuators** permitted within an **ECC**:

- (a) actuators of hydraulic valves within an **HCC**;
- (b) actuators of **drive clutches**;
- (c) actuators of locks permitted by Rule 21.3 (b);
- (d) actuators used to rotate or twist the **foil flaps**;
- (e) actuators used to rotate the **rudder** about its rake axis;
- (f) motors that drive pumps supplying **high-pressure circuits** within one or more **HCCs** that control only the rotation or twist of the **foil flaps** and/or the rotation of the **rudder** about its rake axis; and
- (g) devices within electronic circuits that affect only the circuits themselves, and have no other influence on a **control system** or the **yacht state**, such as CPU cooling fans and relays.

35.24 **ECC**

Electrical control circuit: an electrical and/or electronic circuit within a **control system** and/or for sending commands to an **FCS**.

35.25 **Electric actuator**

An electric linear or rotary motor, or functionally equivalent device, that converts electric power into force and translation, and/or torque and rotation.

35.26 **Yacht state**

The specific condition of the **yacht**, comprising all of the following:

- (a) the position and orientation of the **yacht** in space;
- (b) the position and orientation of any **control surface**;
- (c) the position and orientation of a **foil**;
- (d) the position and orientation of any **force input device** or part thereof;
- (e) the stress, strain, tension and force in any part of the **yacht**, except in **passive input devices**;
- (f) other force-related quantities in any part of the **yacht**;
- (g) the volume, velocity, flow rate or pressure of fluid within, or acting on, any part of the **yacht**;
- (h) all absolute measures of the above and quantities measured relative to each other;
- (i) the water or wave height or velocity relative to the **yacht**;
- (j) all time derivatives of the above;
- (k) all quantities derived from any of the above; and
- (l) all quantities from which the above can be derived or approximated.

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- 23.1 Electric or electronic components or circuits are permitted only as:
- (a) part of an **ECC, ILS, or CIS**;
 - (b) standalone **crew indication devices**, such as wristwatches, that are incapable of measuring or receiving any part of the **yacht state**;
 - (c) standalone **hardwired** cameras and screens mounted on the **yacht** to aid visibility of different parts of the **yacht**, providing no information other than raw audio and video from the **yacht** is transmitted, played or displayed;
 - (d) supplied and required by **COR/D**, the **Rules Committee** or the **Measurement Committee**, including permitted devices connected to these supplied components;
 - (e) bilge pumps; and
 - (f) supplied ultrasonic transmitters.

35.109 **Yacht state**

The specific condition of the **yacht**, comprising all of the following:

- (a) the position and orientation of the **yacht** in space;
- (b) the position and orientation of any **control surface**;
- (c) the position and orientation of a **foil**;
- (d) the position and orientation of any **force input device** or part thereof;
- (e) the stress, strain, tension and force in any part of the **yacht**, except in **passive input devices**;
- (f) other force-related quantities in any part of the **yacht**;
- (g) the volume, velocity, flow rate or pressure of fluid within, or acting on, any part of the **yacht**;
- (h) all absolute measures of the above and quantities measured relative to each other;
- (i) the water or wave height or velocity relative to the **yacht**;
- (j) all time derivatives of the above;
- (k) all quantities derived from any of the above; and
- (l) all quantities from which the above can be derived or approximated.

24.2 Only the following **electric actuators** permitted within an **ECC**:

- (a) actuators of hydraulic valves within an **HCC**;
- (b) actuators of **drive clutches**;
- (c) actuators of locks permitted by Rule 21.3 (b);
- (d) actuators used to rotate or twist the **foil flaps**;
- (e) actuators used to rotate the **rudder** about its rake axis;
- (f) motors that drive pumps supplying **high-pressure circuits** within one or more **HCCs** that control only the rotation or twist of the **foil flaps** and/or the rotation of the **rudder** about its rake axis; and
- (g) devices within electronic circuits that affect only the circuits themselves, and have no other influence on a **control system** or the **yacht state**, such as CPU cooling fans and relays.

It seems that the most relevant definition of the Oxford English Dictionary of the verb "Provide" is as follows:

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provide, v.

6. transitive. To supply (something) for use; to make available; to yield, afford. Frequently with *for*, *to*, indicating the beneficiary. Also occasionally with indirect object without *to*.

Context:

A brushless electric motor is used within an **ECC** to drive a hydraulic pump that supplies a **high-pressure circuit** within an **HCC** to control **foil flaps** rotation and **rudder rake**.

An accumulator is installed in line with the pump. Within the motor and the controller there are sensors to measure the internal state of the **ECC**: a current sensor, a rotational speed sensor and a temperature sensor.

The motor controller CAN messaging feature which transmits speed, torque, voltage and current can only be disabled using a dedicated password-protected procedure in the Manufacturer proprietary software via a personal computer.

Once the transmission of data outside the motor controller via the CAN bus is disabled in the presence of the Measurement Committee, the personal computer is removed from the CAN bus interface and all CAN bus connections are sealed by the Measurement Committee.

Motor speed, torque, voltage and current are not used to estimate **yacht state** information in any manner.

Questions:

1. Is the above described configuration Rule compliant? If not, which rules are infringed?
2. Is the above described configuration Rule compliant if speed, torque, voltage and current transmission on the CAN bus is not disabled? If not, which rules are infringed?

Interpretation:

- A. Rule 24.1(d) permits sensors measuring the internal state of the **ECC** that do not provide **yacht state** information and are not used to estimate **yacht state** information. However, Rule 35.109(l) makes the last phrase of Rule 24.1(d) meaningless (“and are not used to estimate yacht state information”). By rendering the second phrase of Rule 24.1 (d) meaningless, Rule 35.109 (l) contradicts 24.1(d), which has more detail. Following Rule 32.5(c), Rule 24.1(d) takes precedence over 35.109(l) with respect to sensors measuring the internal state of the **ECC** such as current.
- B. Motors are permitted by Rule 24.2, with no limitation on whether the motors use mechanical commutators and brushes, or whether the motors are brushless with internal sensors and associated control electronics.
- C. Rule 24.1 (e) (ii) specifically permits current in servo motor to be measured as part of a position control loop. An example of current measurement to sense position is a servo motor rotating the stem of a valve where current in the servo motor is used to detect when the valve stem is at the end of its rotation.
- D. Rule 24.1 (e)(ii) specifically prohibits current in a servo motor from being used to estimate any part of **yacht state** such as control surface load.

Answers.

1. Yes. However if the motor/pump supplies a control surface actuator in a configuration such that the motor torque or current is a function of control surface load, and the motor controller implements a control algorithm using sensed torque or current, then the motor controller itself breaks Rule 24.1(e)(ii).

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2. Yes. However if the motor/pump supplies a control surface actuator in a configuration such that the motor torque or current is a function of **control surface** load, then torque or current measurement data emitted on the CAN bus by the motor controller will likely attract the attention of the **Measurement Committee** and the team will need to demonstrate that those data are not being used to estimate **yacht state** such as **control surface** load.

END