FAI – CASI MEETING 2013

Proposal from the CASI Mathematics Working Group

It is proposed to replace General Section Chapter 7 “Measurement Requirements” with a new Chapter 7 entitled “Measurements, Calculations, and Margins.” It is further proposed to amend the General Section Glossary to support the new Chapter 7.

Reasons to support this proposal are contained in the “Report to CASI on Improvements to the Mathematics of the Sporting Code,” published separately and available from FAI.

From the summary of that Report:

> *As a result of the 2012 changes to Chapter 7 of the General Section, a mathematical paradox appeared. The conclusion of this study, commissioned by CASI, is that the level of mathematical sophistication of the Chapter is inappropriate for a modern international federation, and that the Chapter should be reorganized to support established practice and to meet the computational needs of all the Air Sports.*

The proposed new Chapter 7 and supporting amendments to the Glossary are attached.

Chapter 7

Measurements, Calculations, and Margins

7.1 Measurements

7.1.1 Units. The system of units to be used by FAI shall be the metric system (SI units), with the exception of angular units. Bearings shall be measured in degrees clockwise from True North. Coordinates shall be in units of degrees, with a preferred format of "degrees and decimal minutes."

7.1.2 General. The methods and standards of precision for measuring and recording of Position, Distance, Time, Altitude, Mass and other primary values, as well as equipment technical standards, shall be determined by each FAI Air Sport Commission and specified in the appropriate section of the Sporting Code. In the case of record flights, the conformity of the specific measuring and recording instruments and equipment used shall be checked by the Official Observer to be of the same type as approved by the respective FAI Air Sport Commissions. Note: in this section, the term "approved" means approved by the Air Sport Commission concerned.

7.1.3 Position. Position may be measured directly, by reference to approved maps, or by GNSS fix. If by GNSS fix, all fixes, points, locations, coordinates, and any maps concurrently used must be referenced to the WGS84 Earth Datum.

7.1.4 Distance. Distance may be measured directly or determined from approved maps.

7.1.5 Bearing. Bearing may be measured directly or determined from approved maps. The bearing at a point is the bearing from that point.

7.1.6 Time. Elapsed times and time of day may be measured either by approved timepieces or by GNSS.

7.1.7 Altitude. Pressure altitude may be measured using approved pressure-measuring devices. Geometric altitude and/or height above the surface may be measured using GNSS, optical methods, or radar.

7.1.8 Mass. Mass shall be determined using scales and methods approved by the Air Sport Commission concerned. The take-off mass of an aircraft shall be its total mass at take-off including flight crew.

7.2 Calculations

7.2.1 General. The methods and standards of precision for calculating Distance, Bearing, Altitude, Speed, and Scores shall be determined by each FAI Air Sport Commission and specified in the appropriate section of the Sporting Code. Note: in this section, the term "approved" means approved by the Air Sport Commission concerned.

7.2.2 Earth Model. The Air Sport Commissions are responsible for the specification of the basis of geometric calculations. If not otherwise specified by the Air Sport Commissions, the earth model to be used for geometric calculations shall be the WGS84 ellipsoid. If a sphere is specified, it shall be the "FAI Sphere." If a planar model is to be used, then the projection must be strictly defined.

7.2.3 Distance. If calculated from coordinates, distance shall be taken as the length of the geodesic on the earth model in use.

7.2.4 Bearing. If calculated from coordinates, bearing shall be taken as the initial bearing of a geodesic from a given point, on the earth model in use.

7.2.5 Altitude. The methods for calculations of corrections to measured altitudes (if required) shall be specified by the Air Sport Commissions. If a standard pressure model is required, it shall be the ICAO Standard Atmosphere.

7.2.6 Speed. Speed will be calculated from distances and elapsed times.

7.2.7 Scores. The methods for calculations of scores shall be specified by the Air Sport Commissions.

7.3 Margins and precision for records

7.3.1 Each Air Sport Commission is responsible for specifying the margins by which a record claim must exceed an existing record, subject to paragraph 7.4.2 of this Chapter.

7.3.2 Each Air Sport Commission shall determine the precision with which a record performance will be recorded. Records must not be certified with a higher precision than the technologies used to determine them.

7.4 Approvals

7.4.1 As an alternative to specifying algorithms, each Air Sport Commission may meet its obligation to specify computational methods by approving specific flight evaluation and scoring programs. If this method is used, then the ASC must implement procedures for testing, approval, and version control of the flight evaluation and scoring programs.

7.4.2 The FAI Executive Board reserves the right to review the standards of certification and the methods of analysis of any international record claim.

ADDITIONS AND SUBSTITUTIONS IN THE GENERAL SECTION GLOSSARY OF TERMS AND ABBREVIATIONS

Earth Model — The mathematical surface upon which geometric calculations are performed. Earth models in use are ellipsoidal, spherical, and planar.

Ellipsoid — For FAI purposes, an ellipsoid is the surface formed by the rotation of an ellipse about its minor axis.

FAI Sphere — A sphere of radius 6371 kilometres, exactly.

g — Acceleration due to the force of gravity (9.81 m/sec^2)

G — The force on an object under acceleration expressed in multiples of g.

Geodesic — The path of shortest length between two points on a surface.

Geodetic Datum — A specification of the shape, size and location in space of the surface of the Earth. Specification of the Geodetic Datum is necessary for unique GNSS solutions, and for map-making. *WGS84 (q.v.) is a geodetic datum.*

GNSS fix — The 4-dimensional (latitude, longitude, altitude, UTC) location of a point in space and time, as determined by a GNSS

ISA — International Standard Atmosphere, as defined by ICAO.
Reference: *Manual of the ICAO Standard Atmosphere (extended to 80 kilometres (262 500 feet))*, Doc 7488-CD, Third Edition, 1993, ISBN 92-9194-004-6.

QFE — Altimeter pressure setting that results in an indication of zero on the surface

QNH — Altimeter pressure setting that results in an indication of height above sea level

Sphere — (delete)

Vincenty method — An empirical method used to calculate the distance between pairs of points on the WGS84 ellipsoid.
Reference: http://www.ngs.noaa.gov/PUBS_LIB/inverse.pdf
Example: http://www.fai.org/how-to-set-a-record/world-distance-calculator

WGS84 Earth Datum — See WGS84

WGS84 — World Geodetic System 1984 – For FAI purposes, this is the standard Geodetic Datum.

WGS84 Ellipsoid — An *ellipsoid* (q.v) based on an ellipse with a semi-minor axis of 6356,7523 kilometres and a semi-major axis of 6378,1370 kilometres. The minor axis is the polar axis.