# Miliarium Ad Astra Grand Challenges

## Proposal for FAI Sporting Code, Section 8 Amendments

Presented to the ICARE Plenary 20 March 2024

**Background:** Section 8, Astronautics, of the FAI Sporting Code was last revised in 2009. In the intervening years there have been substantial advancement in astronautics with new vehicles and new capabilities including reusability. With the advent of commercial space activities, spaceflight is no longer limited to national governments and professional astronauts. In many places it appears portions of the code were written to accommodate specific missions or specific vehicles which are no longer operational. The astronautics sporting code needs a substantial revision to improve its content and make it more applicable to the spaceflight accomplishments of the coming decades.

As an observation, the Astronautics section of the Sporting Code is different than most other sections. In other disciplines, the Sporting Code can serve as inspiration and motivation to undertake technology improvements and vehicle development in order to set a World Record. There are several examples in aeronautics, ballooning, unmanned vehicles and others including Global Flyer and Voyager. In these disciplines, cost and complexity of operations are not insurmountable obstacles for a motivated record seeker. Astronautics, however, is different. The cost of developing a new spacecraft is high and only national governments or well-funded commercial enterprises with the expectation of a financial return can do it. Setting a world record by itself is not sufficient motivation, but it is worthwhile recognition of astronautic advancement. Therefore, the goal of the rewrite team should be to craft a revised Section 8, which is designed to capture the anticipated advancements in astronautics and mark the milestones of spaceflight history as they are being made.

As the new code will seek to mark the advances in astronautics, a distinction should be made between astronautic world records and one-time milestone events. A well-constructed Section 8 record task should allow for continuous future improvement. Other singular events should be recognized by the Astronautics Record Commission outside of the world record structure. These events happen once, cannot be improved upon, and mark a significant milestone or technical achievement in astronautics. An initial list of these events have been developed with the assistance of outside experts resulting in this proposal for the ICARE Miliarium Ad Astra Grand Challenges. This proposed amendment incorporates a description of and rules for five of the most near term or most significant milestones. Additional challenges will be developed in future years for approval of the commission. With the appropriate FAI Statute and By Law changes, achieving one of these milestones will automatically qualify for the award of the FAI Gold Space Medal or a new ICARE astronautics medal designated for the purpose of recognizing ICARE Grand Challenge milestone events.

# CHAPTER 9

## MILIARIUM AD ASTRA GRAND CHALLENGES

9.1. The Miliarium Ad Astra ("Milestones to the Stars") Grand Challenges ("Challenges") are a set of specific defined events designed to incentivize and recognize significant technical accomplishments and milestone human spaceflight events. These accomplishments represent singular events which happen once, cannot be improved upon, and mark a significant milestone in astronautics.

9.1.1 Challenges may be designed for crewed or uncrewed accomplishments.

9.1.2 Each challenge is defined in Annex A including criterion, conditions and challenge rules. The specific challenge accomplishment will be above the Karman line, however, there may also be conditions or rules which apply to activities associated with the challenge that occur below the Karman line.

9.2 GENERAL DEFINITIONS

9.2.1 Contestant – the organization, company, team or crew who are responsible for the operation of the spacecraft, space station or facility on a celestial body and have registered to attempt a Miliarium Ad Astra Grand Challenge event.

9.2.2 Mission Initiation – for the purpose of challenges, and unless otherwise noted in the specific challenge rules, the mission initiation is the launch of the spacecraft for missions where the spacecraft proceeds to the place of the challenge event without additional construction, logistics or crew transfer (if any). For spacecraft which are assembled, logistically supplied or require a crew transfer (if any) in space, the mission initiation is the initial application of thrust to proceed to the place of the challenge event, or when the spacecraft, space station or facility on a celestial body is in the final configuration for the challenge event.

9.3 GENERAL PROCEDURES

9.3.1 Prospective contestants must register their intent to attempt a challenge event with the Astronautic Records Commission (ICARE) no later than 150 days prior to mission initiation.

9.3.1.1 Contestants with an FAI Member submit their registration notification through their National Airsport Control (NAC). Contestants without an FAI Member may register directly with ICARE through the FAI Astronautic Records Commission webpage contact form.

9.3.1.2 The registration notification must include the following information:

- Name (Organization, Company, Team or Crew)
- Miliarium Ad Astra Grand Challenge event
- Contestant Point of Contact

- Contact information (address, email, phone number)

- Overview of Mission: General overview of the challenge event attempt including: description of spacecraft, space station or facility on a celestial body, and sequence of mission events

- Proposed Date of Mission Initiation

9.3.1.3 After receipt of a registration notification the ICARE Bureau shall conduct a consultation to assess the prospective contestant's technical capability to attempt the challenge event with a reasonable chance of success. If found to be satisfactory, the ICARE Bureau will accept the registration and notify the contestant.

9.3.1.4 Registration for a Miliarium Ad Astra Grand Challenge event is not a sanction and does not grant an exclusive right to attempt a challenge.

9.3.2 After acceptance of the registration, the ICARE Bureau will assign one or more official observers to work with the contestant and make the necessary observations to validate the required elements specified for the specific challenge event.

9.3.2.1 Official observers must have the technical qualifications and experience to control the challenge attempt and must know and understand the Sporting Code related to Miliarium Ad Astra Grand Challenge procedures, the data collection requirements and the rules for the specific challenge event to be validated.

9.3.2.2 Official observers must be granted reasonable access to the contestant's facilities and data to make direct and/or remote observations of the challenge activities.

9.3.3 The contestant is responsible for submitting a data plan to the official observer(s) no later than 30 days prior to mission initiation.

9.3.3.1 The data plan should address the critical elements necessary to validate the challenge event; sensor accuracy, precision and calibration; sensor reliability and alternatives available in case of failure; data processing and analysis; and data security and handling.

9.3.3.2 Measurements used to validate the challenge must be made with sufficient accuracy and precision to ensure that critical elements are unambiguously achieved.

9.3.4 The contestant is responsible for submitting a Challenge Report to the official observer(s) within 60 days following completion of the Miliarium Ad Astra Grand Challenge event.

9.3.4.1 The official observer(s) will validate the report and transmit the report to the ICARE Bureau along with their findings and recommendation for recognizing the achievement.

9.3.4.2 The Challenge Report will become a part of the historic record of spaceflight achievement and the basis for recognition with the appropriate FAI Award. Therefore, the Challenge Report should include highlights of the mission (planning and preflight activities, description of the mission and challenge activities, and completion of the mission) and specific details of the challenge event along with supporting data.

9.3.5 The following fees are applicable to challenge events:

9.3.5.1 A Miliarium Ad Astra Grand Challenge registration fee is due once the contestant's registration is accepted. The registration fee is in addition to any fees associated with a spaceflight world record attempted concurrently with the challenge event.

9.3.5.2 The contestant is responsible for the reasonable travel costs and expenses for the official observer(s) assigned to the challenge attempt.

9.3.5.3 For challenge events which involve a crew, each participating crewmember must obtain an FAI sporting license which is current from mission initiation through mission completion.

9.3.6 A contestant who achieves a validated Miliarium Ad Astra Grand Challenge event will be recognized by award of the [appropriate FAI award].

# ANNEX A

## MILIARIUM AD ASTRA GRAND CHALLENGES

A1.1 The Miliarium Ad Astra Grand Challenges are singular events in the history of spaceflight and/or demonstrations of significant technical capabilities which are critical to spaceflight advancement. The following challenges are recognized.

A2.1 THE ZAMKA CHALLENGE

A2.2 **Objective**: The Zamka Challenge recognizes the first orbital flight of a fully reusable human rated spacecraft.

A2.2.1 The ability to reuse orbital class spacecraft is a key enabling capability to allow routine and economical access to space.

A2.2.2 [The Zamka Challenge is named in honor of Col George Zamka, USMC(ret), an American test pilot, NASA astronaut and veteran of two Space Shuttle missions to the International Space Station. Col Zamka is also a member of the ICARE Expert Panel.]

A2.3 **Period of Performance**:

A2.3.1 Mission initiation is the launch of the spacecraft.

A2.3.2 The Zamka Challenge is achieved when a crewed human rated spacecraft makes a safe landing after a successful launch and orbital flight and post-flight inspection verifies that each major component of the spacecraft can be reused for a subsequent mission with only minor refurbishment.

A2.3.3 The mission is complete when all major components have landed or been recovered.

A2.4 **Critical Elements**:

A2.4.1 The spacecraft must be a crewed, human rated spacecraft designed for and flown on a mission profile the allows recovery and reuse of all major components.

A2.4.2 The spacecraft must successfully launch and achieve orbit.

A2.4.3 Each major component makes a successful landing and is recovered.

A2.4.4 Post-flight inspection and analysis shows that each major spacecraft component is spaceworthy and capable of a second flight with only minor maintenance and refurbishment activity.

A2.5 **Challenge Rules**:

A2.5.1 The spacecraft must be crewed during the challenge flight.

A2.5.2 The spacecraft or spacecraft component carrying the crew must achieve orbit and complete a minimum of 20 orbits before initiating a reentry.

A2.5.3 Each component of the spacecraft must make a safe landing and be recovered.

A2.5.4 All members of the mission crew must survive the flight. If a crewmember dies within 24 hours of a condition caused by or exasperated by the flight, the challenge attempt is invalid.

A2.5.5 A post-fight inspection must assess the condition of each major component. Each component must be capable of a second flight within 90 days of mission completion. In making this determination, minor maintenance actions and refurbishment are allowable to return a component to flight ready status.

A2.5.6 Components which are not repairable to flight ready status may be replaced, however, a minimum of 90% of the original spacecraft by weight must be flight ready and capable of a second flight to be considered reuseable. The 90% metric is determined using the original spacecraft dry weight.

A2.6 **Data and Measurements**:

A2.6.1 Dry weight of spacecraft in the takeoff configuration not including propellants, consumables and crew. Weight may be determined directly through weighing or by design and engineering information.

A2.6.2 Documentation of time and place of mission initiation (Launch).

A2.6.3 Documentation of time and orbital parameters of crewed spacecraft when established in orbit.

A2.6.3 Telemetry data documenting crewed spacecraft completion of 20 orbits prior to deorbit and reentry initiation.

A2.6.4 Documentation of time and orbital parameters of initiation of crewed spacecraft deorbit and reentry initiation.

A2.6.5 Documentation of time and place of landing of each spacecraft component.

A2.6.6 Data indicating the status of each spacecraft component following the flight and the post-flight inspection. Data must indicate the capability of the spacecraft to perform another flight within 90 days following mission completion.

A2.6.7 Documentation of maintenance and refurbishment tasks and component replacements required for spacecraft components to be spaceworthy for a second flight. documentation must show that a minimum of 90% of the original spacecraft (by dry weight) would be present for a second flight.

A3.1 <u>THE GREASON CHALLENGE</u>

A3.2 **Objective**: The Greason Challenge recognizes the first large mass spacecraft to spacecraft propellant transfer.

A3.2.1 On orbit refueling is a key enabling technology to extend missions and spacecraft mobility. Orbital refueling may also facilitate new spacecraft designs and mission profiles including transport class spacecraft constructed in orbit, orbital propellant storage and refueling depots and the ability to use in situ fuel produced on other celestial bodies.

A3.2.2 [The Greason Challenge is named in honor of Jeff Greason, an American commercial space entrepreneur, engineer and innovator. Mr. Greason is an Associate Fellow of American Institute of Aeronautics and Astronautics (AIAA), and a Governor of the National Space Society. Mr. Greason is also a member of the ICARE Expert Panel.]

A3.3 **Period of Performance**:

A3.3.1 Mission initiation is the launch of the receiver spacecraft or the tanker spacecraft whichever is earlier.

A3.3.2 The Greason Challenge is achieved when 25,000 kg of cryogenic spacecraft propellant (fuel, oxidizer or both) is transferred from a tanker spacecraft to a receiver spacecraft.

A3.3.3 The mission is complete when the transfer is complete, and the spacecraft have undocked or otherwise disconnected and moved to a safe separation distance.

A3.4 **Critical Elements**:

A3.4.1 The receiver and tanker spacecraft must both launch successfully, achieve orbit and rendezvous.

A3.4.2 The receiver and tanker spacecraft must maneuver and dock or otherwise conduct station keeping in close proximity and connect fuel transfer equipment as required by the refueling operation.

A3.4.3 A minimum of 25,000 kg of propellant must be transferred from the tanker spacecraft to the receiver spacecraft. A portion of the transfer must be cryogenic fuel or oxidizer.

A3.4.4 When the transfer is complete, the spacecraft undock or otherwise disconnect the transfer equipment and move to a safe separation distance.

A3.5 **Challenge Rules**:

A3.5.1 The propellant transfer must take place between one receiver spacecraft and one or more tanker spacecraft.

A3.5.2 The transfer must include a minimum of 2,500 kg of cryogenic propellant, either fuel or oxidizer, or both.

A3.6 **Data and Measurements**:

A3.6.1 Documentation of time and place of launch of the receiver spacecraft and each tanker spacecraft used for the challenge.

A3.6.2 Documentation of the time and orbital parameters when the receiver and tanker spacecraft dock or connect propellant transfer equipment.

A3.6.3 Documentation of the time and orbital parameters when the final transfer is complete.

A3.6.4 Documentation of the type and mass of total propellant mass transferred and the type and mass of cryogenic propellant. If more than one tanker spacecraft is used each transfer should be documented separately.

A4.1 THE MANX CHALLENGE

A4.2 **Objective**: The Manx Challenge recognizes the first third party active removal of orbital debris greater than 1000 kg.

A4.2.1 [Although space is vast, the low earth orbit (LEO) region (less than 2000 km orbital altitude) is becoming increasingly crowded. The growing number of active satellites and the amount of space debris (old or non-operational satellites, expended rocket bodies, and debris from space object collisions) increase the probability of collisions which can result in more debris and increased hazards to satellites and crewed spacecraft. Current best practice and some national regulations require satellites to deorbit or be moved to a "graveyard" orbit for safe storage at the end of life. However, older satellites, malfunctioning satellites and other objects may not have an integral deorbit capability. Active removal by a third-party operator is a key capability to address this need and protect the space environment and the safety of crewed and uncrewed space operations.]

A4.2.1 [The Manx Challenge was inspired by and is named after the book, *The Manx Prize*, written by author Laura Montgomery, in which a prize is offered for de-orbiting space debris. In addition to being an author, Ms. Montgomery is a noted attorney specializing in space law and a member of the ICARE expert panel.]

A4.3 **Period of Performance**:

A4.3.1 Mission initiation is either, 1) the launch of the debris removal spacecraft (DR spacecraft) or, 2) first movement of a pre-positioned DR spacecraft from a parking orbit or on-orbit depot to rendezvous with the target spacecraft.

A4.3.2 The Manx Challenge is achieved when the target spacecraft either, 1) deorbits, and burns up during reentry or reenters and impacts in a safe location or, 2) is moved to a stable graveyard orbit for safe storage.

A4.3.3 The mission is complete when the Manx challenge is achieved.

A4.4 **Critical Elements**:

A4.4.1 The DR spacecraft launches or a prepositioned DR spacecraft initiates orbital maneuvers to rendezvous with the target spacecraft.

A4.4.2 The DR spacecraft identifies, rendezvous with, and initiates removal of the target spacecraft.

A4.4.3 The target spacecraft deorbits and reenters or is established in a stable graveyard orbit.

A4.5 **Challenge Rules**:

A4.5.1 The target spacecraft must be a non-cooperating target. A “non-cooperating target” means that the target spacecraft cannot make attitude or orbital maneuvers or make configuration changes (including electronic equipment) to facilitate rendezvous and the debris removal operations.

A4.5.2 The target spacecraft must have a mass of 1000 kg or greater and must be in a LEO orbit with a minimum perigee of 800 km.

A4.5.3 For target spacecraft which are expected to survive reentry and impact Earth, the target area must be declared in advance, must meet the reentry safety requirements of the country with oversight of the DR spacecraft operator, and the actual impact location must be within 500 km of the declared target.

A4.5.4 For target spacecraft which are moved to a safe storage graveyard orbit, the orbital parameters of the final orbit must be declared in advance and achieved within 5% of the declared values.

A4.5.5 The Manx challenge must be completed within 30 days of mission initiation.

A4.6 **Data and Measurements**:

A4.6.1 Data or documentation indicating the mass of the target spacecraft in the on-orbit, “as-is” configuration.

A4.6.2 Documentation of orbital parameters of the target spacecraft prior to mission initiation.

A4.6.3 Documentation of time and place of mission initiation (launch or initiation of orbital maneuvering for rendezvous).

A4.6.4 Data indicating time and place of DR spacecraft rendezvous with target spacecraft.

A4.6.5 Data indicating time and place of either target spacecraft deorbit maneuver, or movement towards graveyard orbit.

A4.6.6 Documentation of time and place of target spacecraft impact or time and orbital parameters of target spacecraft when established in graveyard orbit.

A5.1 <u>THE HENRIK AKERSTEDT CHALLENGE</u>

A5.2 **Objective**: The Akerstedt Challenge recognizes the first human landing at and exploration of the lunar south polar region.

A5.3 **Period of Performance**:

A5.3.1 Mission initiation is the launch of the spacecraft carrying the mission crew.

A5.3.2 The Akerstedt Challenge is achieved when the descent and landing vehicle makes a successful landing on lunar surface, the surface expedition crewmembers have walked on the Moon and conducted extravehicular exploration activities, and the original mission crew have returned to and safely landed on the Earth.

A5.3.3 The mission is complete when the crew makes a successful return to and landing on Earth.

A5.4 **Critical Elements**:

A5.4.1 The decent and landing vehicle must land in the lunar south polar region defined as the area between 80 degrees and 90 degrees south latitude on the Moon.

A5.4.2 The surface expedition crewmembers conduct extravehicular exploration activities on the Moon's surface.

A5.4.3 The mission crew returns to and safely lands on the Earth.

A5.5 **Challenge Rules**:

A5.5.1 The decent and landing vehicle must make a successful landing between 80 degrees and 90 degrees south latitude on the Moon.

A5.5.2 The surface expedition crewmembers must exit the decent and landing vehicle and conduct extravehicular exploratory activities. Exploratory activities include taking measurements, collecting samples, and operating equipment.

A5.5.3 The surface expedition crew must make a successful ascent from the lunar surface.

A5.5.4 The mission crew must return to and safely land on the Earth.

A5.5.5 The surface expedition crewmembers will be identified, but each member of the mission crew will be recognized for the award of the FAI Gold Space Medal.

A5.6 **Data and Measurements**:

A5.6.1 Data indicating the time and place of mission initiation (spacecraft launch).

A5.6.2 Spacecraft telemetry data showing initiation of descent to the lunar surface.

A5.6.3 Spacecraft telemetry indicating time and place (latitude and longitude in lunar coordinate system) of the decent and landing vehicle touchdown on the Moon.

A5.6.4 Video, mission logs or other data documenting surface expedition crewmember extravehicular exploration activities on the lunar surface.

A5.6.5 Spacecraft telemetry data showing initiation of ascent from the lunar surface.

A5.6.6 Spacecraft telemetry or other data indicating time and place of mission crew landing on Earth.

A6.1 <u>THE NEUMANN CHALLENGE</u>

A6.2 **Objective**: The Neumann Challenge recognizes the first human landing and presence on Mars.

A6.3 **Period of Performance**:

A6.3.1 Mission initiation is the initial application of thrust to leave Earth near space and proceed to Mars.

A6.3.2 The Neumann Challenge is achieved when the descent and landing vehicle makes a successful landing on Mars and a crewmember takes the first steps on the surface of Mars.

A6.3.3 The mission is complete when the crew or portion thereof makes a successful return and landing on Earth.

A6.4 **Critical Elements**:

A6.4.1 The crew of the decent and landing vehicle must survive the landing [and remain alive for 24 hours following the first step.]

A6.4.2 A crewmember takes the first step onto the surface of Mars.

A6.5 **Challenge Rules**:

A6.5.1 The time of the first step on Mars will be recorded as local Earth time in UTC corrected for communications signal transit time from Mars.

A6.5.2 The person making the first step on Mars will be identified, but each member of the crew participating in the surface exploration of Mars will be recognized for the award of the FAI Gold Space Medal.

A6.6 **Data and Measurements**:

A6.6.2 Spacecraft telemetry data indicating time and place of mission initiation and initial trajectory for transit to Mars.

A6.6.3 Spacecraft telemetry data showing Mars orbital insertion.

A6.6.4 Spacecraft telemetry data showing initiation of decent.

A6.6.5 Spacecraft telemetry and video documentation of decent and landing vehicle touchdown on Mars.

A6.6.6 Video documentation of first step onto surface of Mars.

A6.6.7 [Video, personal medical telemetry or other data indicating crew survival for 24 hours following the first step.]

A6.6.8 Mission logs, video or other data identifying each crewmember who participates in surface exploration activities.