

# Catégorie:User Manual 4.11

De Wiki

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## Introduction

This document is the main user manual of the PATRIUS library, which provides Java classes in a wide range of themes related with space flight dynamics.

The library has several purposes :

- to be a basis for the next generation FDS development
- to be used in mission analysis and internal studies

Its classes contain the main basis algorithms and objects representation that shall be used in further developments.

For each theme, a specific manual is available.

# Applicable and Reference Documents

## Applicable Documents

[A1] *CDCE- Fonctions de Base du Patrimoine de Dynamique du Vol*, V1.2, SIRIUS-CF-DV-0049-CN, 2011.

[A2] *Dossier de réutilisation Orekit et Commons Math*, V1.0, SIRIUS-DLR-DV-0080-CN, 2010.

## Glossary

- SDD** Software Design Document
- SRS** Software Requirements Specification
- SUM** Software User Manual
- SValP** Software Validation Plan
- SVerP** Software Verification Plan
- SVS** Software Validation Specification

## Conventions

All the user manuals contain some java code sample as use examples.

These samples are recognizable by the following colors convention :

```
Vector3D originCone = new Vector3D(1.0, 1.0, 1.0);
Vector3D direction = new Vector3D(2.0, 0.0, 0.0);
double angle = FastMath.PI / 4.0;
double height = 5.0;
RightCircularCone cone = new RightCircularCone(originCone, axis, angle,
height);
```

PATRIUS uses the **International System of Units (SI units)** (m, kg, s, N, etc.). It is used for all PATRIUS input/output as well as internally for any computation.

## Overview

This document is an aid for developers coding software using the PATRIUS library. The library provides Java classes to represent basis objects and contains low level algorithms to be used in the new FDS and mission analysis softwares. The user guide describes and explains the use of every class and functionality available.

Each theme of the library is the object of a specific document. These themes are :

- Math basis
- Flight dynamics basis
- Attitude
- Spacecraft
- Orbits
- Mission

- Tools
- Support

PATRIUS is under Apache Licence 2.0.

## Quick Start

Here is a description of each theme of the PATRIUS library and an overview of its contents. See each associated document for the details.

### Mathematics

This theme is not directly linked to flight dynamics. It include. It provides the mathematical tools for the rest of the library.

Its contains classes for :

- function analysis (interpolations, polynomials, ...)
- numerical intergrators
- geometry (planes, lines, shapes, rotations, 3d vectors and matrixes...)
- low level functions and constants (sine, cosine, PI, ...)
- linear algebra (real matrix and vectors, decompositions and other matrix computations, ...)

The Mathematics User Manual can be found [here](#).

### Flight Dynamics

This theme contains the basis of orbital mechanics :

- position-velocity and orbital parameters conversions
- frames and frames transforms
- dates and time scales
- time intervals

The Flight Dynamics User Manual can be found [here](#).

### Spacecraft

This theme contains everything useful to describe a spacecraft and its use :

- general architecture (describing the spacecraft by one or several parts)
- geometry
- mass characteristics
- equipments (GS, antenna, instruments and associated computations...)
- characteristics used in forces computations (radiative, drag...)
- torques computations

The Spacecraft User Manual can be found [here](#).

### Attitude

This theme contains the tools to predict the spacecraft attitude:

- attitude laws
- cinematics and guidance

The Attitude User Manual can be found [here](#).

## **Orbits**

This theme contains everything useful to propagate an orbit in time and perform orbits restitutions :

- numerical and analytical propagators
- physical models (for forces)
- Measures and filtering tools

The Orbits User Manual can be found [here](#).

## **Mission**

This theme regroups the events computation, projections and use tools.

The Mission User Manual can be found [here](#).

## **Tools**

This theme comprises some external tools such as the ephemeris comparator.

The Tools User Manual can be found [here](#).

## **Support**

This theme is cross-functional. It contains for example the explanation of the data manager use and action.

The Support User Manual can be found [here](#).

## **Thread-Safety**

For all content belonging to the PATRIUS library, the thread safety of every class will be evaluated, and the results listed here.

The known levels of thread safety for a class are:

- immutable: the contents of an instance never change after creation, therefore the class is thread-safe.
- unconditionally thread-safe / thread-safe: the whole class is thread-safe by design.
- conditionally thread-safe: the class is thread-safe if certain conditions (specific to the class) are met.
- not thread-safe: the class is not thread-safe. If the class is used in a threaded environment, all accesses

to the class must be synchronized.

- thread-hostile: the class is known to break threads, even when no instance is shared between threads!

## About the comments

Some recurring comments are explained here :

- "Exposed mutable attributes.": the class contains attributes that either "come" from outside the class, or whose reference can be obtained from the class. Unless the attributes are thread-safe or accessed in a thread-safe manner somehow, this breaks the thread safety of the class.
- "documented as immutable, but technically untrue": Patrius document classes that are non-final as immutable- but the (quite strict) usual definition of immutability mandates that an immutable class *must* be final, because a non-final class can be subclassed and this subclass can break immutability "silently" (an user could access this subclass through the superclass reference and believe it is immutable due to the superclasses' documentation.) Therefore: when a class is documented as immutable, it means *only the documented implementation* is immutable. For safety, we chose to document these classes here as "unconditionally thread-safe", a statement that is not assumed to be preserved by subclassing.

## Thread safety

Class (total number : 43)	Concurrency	Comment
fr.cnes.sirius.patrius.math.UtilsCommonsMath	immutable	
fr.cnes.sirius.patrius.math.analysis.differentiation.RiddersDifferentiator	immutable	
fr.cnes.sirius.patrius.math.analysis.interpolation.BiLinearIntervalsFunction	not thread-safe	input ISearchIndex not thread-safe
fr.cnes.sirius.patrius.math.analysis.interpolation.BiLinearIntervalsInterpolator	unconditionally thread-safe	
fr.cnes.sirius.patrius.math.analysis.interpolation.TriLinearIntervalsFunction	not thread-safe	input ISearchIndex not thread-safe
fr.cnes.sirius.patrius.math.analysis.interpolation.TriLinearIntervalsInterpolator	unconditionally thread-safe	
fr.cnes.sirius.patrius.math.analysis.interpolation.UniLinearIntervalsFunction	not thread-safe	input ISearchIndex not thread-safe
fr.cnes.sirius.patrius.math.analysis.interpolation.UniLinearIntervalsInterpolator	unconditionally thread-safe	
fr.cnes.sirius.patrius.math.analysis.polynomials.ElementaryMultiplicationTypes	unconditionally thread-safe	
fr.cnes.sirius.patrius.math.analysis.polynomials.FourierDecompositionEngine	not thread-safe	not thread safe because of the setFunction method that can change the UnivariateFunction being decomposed
fr.cnes.sirius.patrius.math.analysis.polynomials.FourierSeries	immutable	
fr.cnes.sirius.patrius.math.analysis.polynomials.FourierSeriesApproximation	immutable if function is immutable	
fr.cnes.sirius.patrius.math.analysis.polynomials.TrigonometricPolynomialFunction	immutable	
fr.cnes.sirius.patrius.math.analysis.polynomials.TrigonometricPolynomialPrimitive	immutable	
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Disk	immutable	
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Ellipse	immutable	
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Ellipsoid	immutable	
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.EllipticCone	immutable	
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.EllipticCylinder	immutable	
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.InfiniteEllipticCone	immutable	
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.InfiniteEllipticCylinder	immutable	
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.InfiniteRectangleCone	immutable	

fr.cnes.sirius.patrius.math.geometry.euclidean.threed.InfiniteRectangleCylinder	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.InfiniteRightCircularCone	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.InfiniteRightCircularCylinder	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.LineSegment	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Matrix3D	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Parallelepiped	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Plate	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.RectangleCone	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.RightCircularCone	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.RightCircularCylinder	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Sphere	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.SphericalCap	immutable
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Spheroid	immutable
fr.cnes.sirius.patrius.math.linear.UDDecompositionImpl	immutable
fr.cnes.sirius.patrius.math.ode.nonstiff.RungeKutta6Integrator	not thread-safe
fr.cnes.sirius.patrius.math.ode.nonstiff.RungeKutta6StepInterpolator	not thread-safe
fr.cnes.sirius.patrius.math.random.UniformlyCorrelatedRandomVectorGenerator	not thread-safe
fr.cnes.sirius.patrius.math.utils.BinarySearchIndexClosedOpen	immutable
fr.cnes.sirius.patrius.math.utils.BinarySearchIndexOpenClosed	immutable
fr.cnes.sirius.patrius.math.utils.RecordSegmentSearchIndex	immutable
fr.cnes.sirius.patrius.math.utils.SearchIndexLibrary	immutable

**Class (total number : 103)**

	<b>Concurrency</b>	<b>Comment</b>
fr.cnes.sirius.patrius.attitudes.AttitudeChronologicalComparator	immutable	
fr.cnes.sirius.patrius.attitudes.AttitudeFrame	not thread safe	it is a Frame.
fr.cnes.sirius.patrius.attitudes.AttitudeLawLeg	conditionally thread-safe	The use of an AttitudeLaw makes it thread-safe only if the AttitudeLaw is.
fr.cnes.sirius.patrius.attitudes.AttitudeLegLaw	conditionally thread-safe	The use of an AttitudeLegLaw makes it thread-safe only if the two AttitudeLaw and the AttitudeLeg are.
fr.cnes.sirius.patrius.attitudes.AttitudeLegsSequence	not thread-safe	The instances are mutable.
fr.cnes.sirius.patrius.attitudes.AttitudeTransformProvider	conditionally thread-safe	is thread-safe if all attributes are.
fr.cnes.sirius.patrius.attitudes.ComposedAttitudeLaw	conditionally thread-safe	is thread-safe if the AttitudeLaw attribute is.
fr.cnes.sirius.patrius.attitudes.ConstantSpinSlew	not thread safe	this class is not thread safe because the slew can be re-computed while the method getAttitude(PVCordinatesProvider, AbsoluteDate, Frame) is called.
fr.cnes.sirius.patrius.attitudes.DirectionTrackingOrientation	conditionally thread safe	the IDirection object has to be thread-safe itself
fr.cnes.sirius.patrius.attitudes.FixedStepAttitudeEphemerisGenerator	not thread-safe	The AttitudeLegsSequence attribute is mutable.
fr.cnes.sirius.patrius.attitudes.OrientationFrame	not thread safe	it is a Frame.
fr.cnes.sirius.patrius.attitudes.OrientationTransformProvider	conditionally thread-safe	thread-safe if all attributes are.
fr.cnes.sirius.patrius.attitudes.RelativeTabulatedAttitudeLaw	conditionally thread-safe	The use of an RelativeTabulatedAttitudeLaw makes it thread-safe only if the AttitudeLeglaw is
fr.cnes.sirius.patrius.attitudes.RelativeTabulatedAttitudeLeg	immutable	
fr.cnes.sirius.patrius.attitudes.SunPointing	unconditionally thread safe	
fr.cnes.sirius.patrius.attitudes.TabulatedAttitude	immutable	
fr.cnes.sirius.patrius.attitudes.TwoDirectionsAttitude	unconditionally thread safe	
fr.cnes.sirius.patrius.attitudes.TwoSpinBiasSlew	not thread safe	this class is not thread safe because the local attitude ephemeris is changed.
fr.cnes.sirius.patrius.attitudes.VariableStepAttitudeEphemerisGenerator	not thread-safe	The AttitudeLegsSequence attribute is mutable.

fr.cnes.sirius.patrius.attitudes.directions.CelestialBodyPolesAxisDirection	conditionally thread-safe	this class is thread-safe only if the underlying CelestialBody is too.
fr.cnes.sirius.patrius.attitudes.directions.CentralBodyCenterDirection	immutable	
fr.cnes.sirius.patrius.attitudes.directions.ConstantVectorDirection	not thread-safe	The use of a frame linked to the tree of frames makes this class not thread-safe.
fr.cnes.sirius.patrius.attitudes.directions.CrossProductDirection	conditionally thread-safe	this class is not thread-safe
fr.cnes.sirius.patrius.attitudes.directions.GenericTargetDirection	not thread-safe	Not thread-safe by default.No use case for sharing an instance between threads found.
fr.cnes.sirius.patrius.attitudes.directions.GlintApproximatePointingDirection	not thread-safe	Not thread-safe by default.No use case for sharing an instance between threads found.
fr.cnes.sirius.patrius.attitudes.directions.GroundVelocityDirection	conditionally thread-safe	The use of a celestial body linked to the tree of frames makes this class thread-safe only if the underlying CelestialBody is too.
fr.cnes.sirius.patrius.attitudes.directions.MomentumDirection	conditionally thread-safe	The use of a celestial body linked to the tree of frames makes this class thread-safe only if the underlying CelestialBody is too.
fr.cnes.sirius.patrius.attitudes.directions.NadirDirection	conditionally thread-safe	The use of a celestial body linked to the tree of frames makes this class thread-safe only if the underlying CelestialBody is too.
fr.cnes.sirius.patrius.attitudes.directions.ToCelestialBodyCenterDirection	conditionally thread-safe	The use of a celestial body linked to the tree of frames makes this class thread-safe only if the underlying CelestialBody is too.
fr.cnes.sirius.patrius.attitudes.directions.VelocityDirection	not thread-safe	Not thread-safe by default. No use case for sharing an instance between threads found.
fr.cnes.sirius.patrius.attitudes.kinematics.SlerpInterpolator	immutable	
fr.cnes.sirius.patrius.bodies.ExtendedOneAxisEllipsoid	not thread-safe	the use of frames makes this class not thread-safe
fr.cnes.sirius.patrius.bodies.MeeusMoon	immutable	
fr.cnes.sirius.patrius.bodies.MeeusSun	immutable	
fr.cnes.sirius.patrius.forces.atmospheres.MSIS2000.ApCoef	immutable	
fr.cnes.sirius.patrius.forces.atmospheres.MSIS2000.Flags	not thread-safe	
fr.cnes.sirius.patrius.forces.atmospheres.MSIS2000.Input	not thread-safe	
fr.cnes.sirius.patrius.forces.atmospheres.MSIS2000.NRLMSISE00	thread-hostile	
fr.cnes.sirius.patrius.forces.atmospheres.MSIS2000.NRLMSISE00Data	immutable	
fr.cnes.sirius.patrius.forces.atmospheres.MSIS2000.Output	not thread-safe	
fr.cnes.sirius.patrius.forces.atmospheres.MSISE2000	thread-hostile	The direct use of thread hostile objects makes this class thread hostile itself.
fr.cnes.sirius.patrius.forces.atmospheres.US76	thread-hostile	The direct use of thread hostile objects makes this class thread hostile itself.
fr.cnes.sirius.patrius.forces.atmospheres.US76Data	immutable	
fr.cnes.sirius.patrius.forces.atmospheres.solarActivity.ACSOLFormatReader	not thread-safe	instance is mutable
fr.cnes.sirius.patrius.forces.atmospheres.solarActivity.ConstantSolarActivity	immutable	
fr.cnes.sirius.patrius.forces.atmospheres.solarActivity.NOAAFormatReader	not thread-safe	instance is mutable
fr.cnes.sirius.patrius.forces.atmospheres.solarActivity.SolarActivityDataFactory	thread-hostile	uses {@link DataProvidersManager} which is thread hostile
fr.cnes.sirius.patrius.forces.atmospheres.solarActivity.SolarActivityToolbox	immutable	
fr.cnes.sirius.patrius.forces.atmospheres.solarActivity.specialized.ClassicalMSISE2000SolarData	conditionally thread-safe	thread-safe if SolarActivityDataProvider is thread-safe
fr.cnes.sirius.patrius.forces.atmospheres.solarActivity.specialized.ContinuousMSISE2000SolarData	conditionally thread-safe	thread-safe if SolarActivityDataProvider is thread-safe
fr.cnes.sirius.patrius.forces.atmospheres.solarActivity.specialized.DTM2000SolarData	conditionally thread-safe	thread-safe if SolarActivityDataProvider is thread-safe
fr.cnes.sirius.patrius.forces.gravity.EarthGravitationalModelFactory	not thread-safe	the presence of static methods makes this class not thread-safe
fr.cnes.sirius.patrius.forces.gravity.tides.OceanTides	not thread-safe	not thread safe because of the method updateCoefficientsCandS().
fr.cnes.sirius.patrius.forces.gravity.tides.OceanTidesDataProvider	immutable	
fr.cnes.sirius.patrius.forces.gravity.tides.OceanTidesWaves	immutable	
fr.cnes.sirius.patrius.forces.gravity.tides.TerrestrialTides	not thread-safe	not thread safe because of the method updateCoefficientsCandS().

fr.cnes.sirius.patrius.forces.gravity.tides.TerrestrialTidesDataProvider	thread safe
fr.cnes.sirius.patrius.forces.gravity.tides.TidesStandards	immutable
fr.cnes.sirius.patrius.forces.gravity.tides.TidesToolbox	immutable
fr.cnes.sirius.patrius.forces.gravity.tides.coefficients.FES2004FormatReader	not thread-safe instance is mutable
fr.cnes.sirius.patrius.forces.gravity.tides.coefficients.OceanTidesCoefficientsFactory	thread-hostile uses a thread-hostile DataProvidersManager
fr.cnes.sirius.patrius.forces.gravity.tides.coefficients.OceanTidesCoefficientsSet	immutable
fr.cnes.sirius.patrius.forces.gravity.variations.VariablePotentialAttractionModel	not thread-safe not thread-safe because of global arrays
fr.cnes.sirius.patrius.forces.gravity.variations.coefficients.GRGSRL02FormatReader	not thread-safe because of static fields
fr.cnes.sirius.patrius.forces.gravity.variations.coefficients.VariableGravityFieldFactory	not thread-safe because of static fields
fr.cnes.sirius.patrius.forces.gravity.variations.coefficients.VariablePotentialCoefficientsSet	immutable
fr.cnes.sirius.patrius.forces.maneuvers.ConstantThrustError	not thread-safe internal mutable attributes
fr.cnes.sirius.patrius.forces.maneuvers.VariableThrustManeuver	not thread-safe internal mutable attributes
fr.cnes.sirius.patrius.forces.radiation.ElementaryFlux	immutable immutable class
fr.cnes.sirius.patrius.forces.radiation.KnockeRiesModel	immutable
fr.cnes.sirius.patrius.forces.radiation.RediffusedFlux	conditionally thread-safe thread-safe if all constructor parameters are too.
fr.cnes.sirius.patrius.forces.radiation.RediffusedRadiationPressure	conditionally thread-safe thread-safe if the CelestialBody attribute is.
fr.cnes.sirius.patrius.propagation.analytical.covariance.CovarianceInterpolation	not thread-safe internal mutable attributes
fr.cnes.sirius.patrius.propagation.analytical.covariance.OrbitCovariance	immutable
fr.cnes.sirius.patrius.propagation.analytical.twod.Analytical2DOrbitModel	conditionally thread-safe thread safe if the underlying Analytical2DParameterModel andAbsoluteDate objects are thread safe
fr.cnes.sirius.patrius.propagation.analytical.twod.Analytical2DParameterModel	immutable
fr.cnes.sirius.patrius.propagation.analytical.twod.Analytical2DPropagator	not thread-safe extends the AbstractPropagator class
fr.cnes.sirius.patrius.propagation.analytical.twod.DateIntervalLinearFunction	thread-safe
fr.cnes.sirius.patrius.propagation.analytical.twod.DateIntervalParabolicFunction	thread-safe
fr.cnes.sirius.patrius.propagation.analytical.twod.DatePolynomialFunction	thread-safe
fr.cnes.sirius.patrius.propagation.events.AOLDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.AnomalyDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.BetaAngleDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.DistanceDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.ExtremaDistanceDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.ExtremaElevationDetector	not thread-safe the link to the tree of frames makes this class not thread-safe
fr.cnes.sirius.patrius.propagation.events.ExtremaLatitudeDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.ExtremaLongitudeDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.ExtremaThreeBodiesAngleDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.LatitudeDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.LocalTimeDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.LongitudeDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.NadirSolarIncidenceDetector	thread-hostile the earth celestial body is thread hostile itself.
fr.cnes.sirius.patrius.propagation.events.NthOccurrenceDetector	not thread-safe use of internal mutable attributes
fr.cnes.sirius.patrius.propagation.events.SolarTimeDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.events.ThreeBodiesAngleDetector	not thread-safe attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.precomputed.HermiteEphemeris	not thread-safe internal mutable attributes
fr.cnes.sirius.patrius.propagation.precomputed.LagrangeEphemeris	not thread-safe instances are mutable
fr.cnes.sirius.patrius.time.LocalTime	not thread-safe
fr.cnes.sirius.patrius.utils.AbsoluteDateIntervalsList	not thread-safe thread safety is not required for this class. And, TreeSet is not thread-safe.
fr.cnes.sirius.patrius.utils.EphemerisPvHermite	not thread-safe internal mutable attributes
fr.cnes.sirius.patrius.utils.EphemerisPvLagrange	not thread-safe internal mutable attributes



fr.cnes.sirius.patrius.utils.ReferencePointsDisplacement

conditionally  
thread-safe is thread-safe if the celestial body is too.

<b>Class (total number : 162)</b>	<b>Concurrency</b>	<b>Comment</b>
fr.cnes.sirius.patrius.utils.UtilsPatrius	immutable	
fr.cnes.sirius.patrius.assembly.Assembly	not thread-safe	The use of a frame linked to the tree of frames in each of the parts makes this class not thread-safe.
fr.cnes.sirius.patrius.assembly.AssemblyBuilder	not thread-safe	The assembly is not thread-safe itself
fr.cnes.sirius.patrius.assembly.MainPart	not thread-safe	The use of a frame linked to the tree of frames makes this class not thread-safe.
fr.cnes.sirius.patrius.assembly.Part	not thread-safe	The use of a frame linked to the tree of frames makes this class not thread-safe.
fr.cnes.sirius.patrius.assembly.models.AeroModel	not thread-safe	The use of a frame (Assembly attribute) linked to the tree of frames in each of the parts makes this class not thread-safe.
fr.cnes.sirius.patrius.assembly.models.AeroWrenchModel	not thread-safe	class uses internal mutable attributes and frames
fr.cnes.sirius.patrius.assembly.models.DirectRadiativeModel	not thread-safe	The use of a frame (Assembly attribute) linked to the tree of frames in each of the parts makes this class not thread-safe.
fr.cnes.sirius.patrius.assembly.models.DirectRadiativeWrenchModel	not thread-safe	class uses internal mutable attributes and frames
fr.cnes.sirius.patrius.assembly.models.DragLiftModel	not thread-safe	The use of a frame (Assembly attribute) linked to the tree of frames in each of the parts makes this class not thread-safe.
fr.cnes.sirius.patrius.assembly.models.InertiaComputedModel	not thread-safe	the direct use of a not thread-safe Assembly makes this class not thread-safe itself
fr.cnes.sirius.patrius.assembly.models.InertiaSimpleModel	not thread-safe	the frame and setters makes this class not thread-safe
fr.cnes.sirius.patrius.assembly.models.MagneticMoment	conditionally thread-safe	thread-safe if the underlying frame is thread-safe
fr.cnes.sirius.patrius.assembly.models.MassModel	not thread-safe	uses internal mutable attributes
fr.cnes.sirius.patrius.assembly.models.RFLinkBudgetModel	immutable	
fr.cnes.sirius.patrius.assembly.models.RediffusedRadiativeModel	not thread-safe	The use of a frame (Assembly attribute) linked to the tree of frames in each of the parts makes this class not thread-safe.
fr.cnes.sirius.patrius.assembly.models.SensorModel	not thread-safe	the direct use of a not thread-safe Assembly makes this class not thread-safe itself
fr.cnes.sirius.patrius.assembly.properties.AeroApplicationPoint	immutable	
fr.cnes.sirius.patrius.assembly.properties.AeroFacetProperty	immutable	
fr.cnes.sirius.patrius.assembly.properties.AeroGlobalProperty	immutable	
fr.cnes.sirius.patrius.assembly.properties.AeroSphereProperty	immutable	
fr.cnes.sirius.patrius.assembly.properties.CrossSectionProviderProperty	conditionally thread-safe	the CrossSectionProvider object must be immutable. In this case, this class is immutable itself and thus, is not subject to thread safety tests.
fr.cnes.sirius.patrius.assembly.properties.GeometricProperty	conditionally thread-safe	the SolidShape object must be immutable. In this case, this class is immutable itself and thus, is not subject to thread safety tests.
fr.cnes.sirius.patrius.assembly.properties.InertiaCylinderProperty	not thread-safe	the use of frames makes this class not thread-safe

fr.cnes.sirius.patrius.assembly.properties.InertiaParallelepipedProperty	not thread-safe	the use of frames makes this class not thread-safe
fr.cnes.sirius.patrius.assembly.properties.InertiaSimpleProperty	not thread-safe	the use of frames makes this class not thread-safe
fr.cnes.sirius.patrius.assembly.properties.InertiaSphereProperty	not thread-safe	the use of frames makes this class not thread-safe
fr.cnes.sirius.patrius.assembly.properties.MassEquation	not thread-safe	internal mutable attributes
fr.cnes.sirius.patrius.assembly.properties.MassProperty	immutable	
fr.cnes.sirius.patrius.assembly.properties.RFAntennaProperty	immutable	
fr.cnes.sirius.patrius.assembly.properties.RadiativeApplicationPoint	immutable	
fr.cnes.sirius.patrius.assembly.properties.RadiativeFacetProperty	immutable	
fr.cnes.sirius.patrius.assembly.properties.RadiativeIRProperty	immutable	
fr.cnes.sirius.patrius.assembly.properties.RadiativeProperty	immutable	
fr.cnes.sirius.patrius.assembly.properties.RadiativeSphereProperty	immutable	
fr.cnes.sirius.patrius.assembly.properties.SensorProperty	not thread-safe	
fr.cnes.sirius.patrius.assembly.properties.features.Facet	immutable	
fr.cnes.sirius.patrius.bodies.BasicBoardSun	immutable	
fr.cnes.sirius.patrius.events.CentralBodyMaskCircularFOVDetector	not thread-safe	one attribute not thread-safe and one conditionally thread-safe
fr.cnes.sirius.patrius.events.CodedEvent	immutable	
fr.cnes.sirius.patrius.events.CodedEventsList	not thread-safe	no thread-sharing use case was identified for this class, so thread safety is not required. Though, some precautions are taken, as an example, the method getList() returns a copy of the list and not directly the attribute list itself.
fr.cnes.sirius.patrius.events.CodedEventsLogger	not thread-safe	no thread-sharing use case was identified for this class, so thread safety is not required.
fr.cnes.sirius.patrius.events.CombinedPhenomenaDetector	not thread-safe or thread-hostile	As of now, existing EventDetector implementations are either not thread-safe or thread-hostile, so this class also is. But this class could probably become conditionally thread-safe, the main thread safety condition would then be that the included EventDetector should be thread-safe.
fr.cnes.sirius.patrius.events.EarthZoneDetector	not thread-safe	attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.events.GenericCodingEventDetector	not thread-safe or thread-hostile	As of now, existing EventDetector implementations are either not thread-safe or thread-hostile, so this class also is. But this class could probably become conditionally thread-safe, the main thread safety condition would then be that the included EventDetector should be thread-safe.
fr.cnes.sirius.patrius.events.PhenomenaList	not thread-safe	no thread-sharing use case was identified for this class, so thread safety is not required. Though, some precautions are taken, as an example, the method getList() returns a copy of the list and not directly the attribute list itself.
fr.cnes.sirius.patrius.events.Phenomenon	immutable	
fr.cnes.sirius.patrius.events.multi.MultiCodedEventsLogger	not thread-safe	no thread-sharing use case was identified for this class, so thread safety is not required.
fr.cnes.sirius.patrius.events.multi.MultiEventsLogger	not thread-safe	

fr.cnes.sirius.patrius.events.multi.MultiGenericCodingEventDetector	not thread-safe or thread-hostile	As of now, existing MultiEventDetector implementations are either not thread-safe or thread-hostile, so this class also is. But this class could probably become conditionally thread-safe, the main thread safety condition would then be that the included MultiEventDetector should be thread-safe.
fr.cnes.sirius.patrius.events.postprocessing.AndCriterion	immutable	
fr.cnes.sirius.patrius.events.postprocessing.DelayCriterion	immutable	
fr.cnes.sirius.patrius.events.postprocessing.ElementTypeFilter	immutable	
fr.cnes.sirius.patrius.events.postprocessing.EventsDuringPhenomenaFilter	immutable	
fr.cnes.sirius.patrius.events.postprocessing.MergePhenomenaCriterion	immutable	
fr.cnes.sirius.patrius.events.postprocessing.MergeTimelines	immutable	
fr.cnes.sirius.patrius.events.postprocessing.OccurrenceFilter	immutable	
fr.cnes.sirius.patrius.events.postprocessing.OrCriterion	immutable	
fr.cnes.sirius.patrius.events.postprocessing.PhenomenonDurationFilter	immutable	
fr.cnes.sirius.patrius.events.postprocessing.PolarizationSingleSelection	immutable	
fr.cnes.sirius.patrius.events.postprocessing.PolarizationSwitch	immutable	
fr.cnes.sirius.patrius.events.postprocessing.TimeFilter	immutable	
fr.cnes.sirius.patrius.events.postprocessing.Timeline	not thread-safe	the timeline is not thread safe due to the methods removeCodedEvent(CodedEvent) and removePhenomenon(Phenomenon) attributes are mutable and related to propagation, and the direct use of a not thread-safe Assembly makes this class not thread-safe itself
fr.cnes.sirius.patrius.events.sensor.ExtremaSightAxisDetector	not thread-safe	The use of a not thread-safe SensorModel makes this class not thread-safe.
fr.cnes.sirius.patrius.events.sensor.MaskingDetector	not thread-safe	the direct use of a not thread-safe Assembly makes this classnot thread-safe itself
fr.cnes.sirius.patrius.events.sensor.RFVisibilityDetector	not thread-safe	the direct use of a not thread-safe Assembly makes this class not thread-safe itself
fr.cnes.sirius.patrius.events.sensor.SatToSatMutualVisibilityDetector	not thread-safe	the direct use of a not thread-safe Assembly makes this classnot thread-safe itself
fr.cnes.sirius.patrius.events.sensor.SecondarySpacecraft	not thread-safe	the direct use of a not thread-safe Assembly makes this classnot thread-safe itself
fr.cnes.sirius.patrius.events.sensor.SensorInhibitionDetector	not thread-safe	the direct use of a not thread-safe Assembly makes this classnot thread-safe itself
fr.cnes.sirius.patrius.events.sensor.SensorVisibilityDetector	not thread-safe	the direct use of a not thread-safe Assembly makes this classnot thread-safe itself
fr.cnes.sirius.patrius.events.sensor.StationToSatMutualVisibilityDetector	not thread-safe	the direct use of a not thread-safe Assembly makes this classnot thread-safe itself
fr.cnes.sirius.patrius.events.sensor.TargetInFieldOfViewDetector	not thread-safe	the direct use of a not thread-safe Assembly makes this classnot thread-safe itself
fr.cnes.sirius.patrius.events.sensor.VisibilityFromStationDetector	not thread-safe	the direct use of a not thread-safe Assembly makes this classnot thread-safe itself
fr.cnes.sirius.patrius.fieldsofview.AzimuthElevationField	immutable	
fr.cnes.sirius.patrius.fieldsofview.BooleanField	conditionally thread-safe	the used fields must be thread-safe themselves.All available fields are immutable.
fr.cnes.sirius.patrius.fieldsofview.CircularField	immutable	
fr.cnes.sirius.patrius.fieldsofview.EllipticField	immutable	

fr.cnes.sirius.patrius.fieldsofview.FieldAngularFace	immutable	
fr.cnes.sirius.patrius.fieldsofview.InvertField	conditionally thread-safe	the used field must be thread-safe itself.All available fields are immutable.
fr.cnes.sirius.patrius.fieldsofview.OmnidirectionalField	immutable	
fr.cnes.sirius.patrius.fieldsofview.PyramidalField	immutable	
fr.cnes.sirius.patrius.fieldsofview.RectangleField	immutable	
fr.cnes.sirius.patrius.fieldsofview.SectorField	immutable	
fr.cnes.sirius.patrius.forces.EmpiricalForce	not thread-safe	attributes are mutable
fr.cnes.sirius.patrius.forces.maneuvers.ManeuversSequence	not thread-safe	The instances are mutable.
fr.cnes.sirius.patrius.forces.radiation.SolarRadiationPressureEllipsoidCircular	not thread-safe	fields use Frames
fr.cnes.sirius.patrius.groundstation.GeometricStationAntenna	not thread-safe	link to the tree of frames
fr.cnes.sirius.patrius.groundstation.RFStationAntenna	not thread-safe	link to the tree of frames
fr.cnes.sirius.patrius.guidance.AngularVelocitiesHarmonicProfile	conditionally thread-safe	thread-safe if the Frame attribute is thread-safe.
fr.cnes.sirius.patrius.guidance.AngularVelocitiesPolynomialProfile	conditionally thread-safe	thread-safe if the attributes are thread-safe
fr.cnes.sirius.patrius.guidance.GuidanceProfileBuilder	immutable	
fr.cnes.sirius.patrius.guidance.QuaternionHarmonicProfile	conditionally thread-safe	thread-safe if the Frame attribute is thread-safe.
fr.cnes.sirius.patrius.guidance.QuaternionPolynomialProfile	conditionally thread-safe	thread-safe if the attributes are thread-safe
fr.cnes.sirius.patrius.guidance.QuaternionPolynomialSegment	conditionally thread-safe	thread-safe if the UnivariateFunction attributes are thread-safe
fr.cnes.sirius.patrius.guidance.Vector3DPolynomialSegment	conditionally thread-safe	thread-safe if the UnivariateFunction attributes are thread-safe
fr.cnes.sirius.patrius.propagation.PVCoordinatePropagator	not thread-safe	extends the AbstractPropagator class
fr.cnes.sirius.patrius.propagation.SimpleAdditionalStateProvider	immutable	
fr.cnes.sirius.patrius.propagation.events.multi.AdaptedMonoEventDetector	conditionally thread-safe	Conditionally thread-safe if all attributes are thread-safe
fr.cnes.sirius.patrius.propagation.events.multi.AdaptedMultiEventDetector	conditionally thread-safe	Conditionally thread-safe if all attributes are thread-safe
fr.cnes.sirius.patrius.propagation.events.multi.OneSatEventDetectorWrapper	not thread-safe	
fr.cnes.sirius.patrius.propagation.numerical.multi.MultiEphemerisModeHandler	not thread-safe	
fr.cnes.sirius.patrius.propagation.numerical.multi.MultiNumericalPropagator	not thread-safe	attributes are mutable and related to propagation.
fr.cnes.sirius.patrius.propagation.numerical.multi.MultiStateVectorInfo	immutable	
fr.cnes.sirius.patrius.propagation.precomputed.multi.MultiIntegratedEphemeris	immutable	
fr.cnes.sirius.patrius.propagation.sampling.multi.MultiAdaptedStepHandler	not thread-safe	
fr.cnes.sirius.patrius.propagation.sampling.multi.MultiPatriusStepNormalizer	not thread-safe	
fr.cnes.sirius.patrius.signalpropagation.AzoulayModel	immutable	
fr.cnes.sirius.patrius.signalpropagation.SignalPropagation	not thread-safe	use of the frames tree
fr.cnes.sirius.patrius.signalpropagation.SignalPropagationModel	not thread-safe	use of the frames tree
fr.cnes.sirius.patrius.signalpropagation.iono.BentModel	thread-safe	with the use of a synchronized tag the instance is mutable, but no longer changes after the first call to getR12() (the first call triggers the DataProvidersManager on the instance). This means : an instance can be shared and used in several threads, if getR12() is called once in a single thread context first.
fr.cnes.sirius.patrius.signalpropagation.iono.R12Loader	conditionally thread-safe	
fr.cnes.sirius.patrius.signalpropagation.iono.USKData	immutable	

fr.cnes.sirius.patrius.signalpropagation.iono.USKLoader	conditionally thread-safe	the instance is mutable, but no longer changes after the first call to getData() (the first call triggers the DataProvidersManager on the instance). This means : an instance can be shared and used in several threads, if getData() is called once in a single thread context first.
fr.cnes.sirius.patrius.stela.JavaMathAdapter	unconditionally thread-safe	
fr.cnes.sirius.patrius.stela.PerigeeAltitudeDetector	conditionally thread-safe	the OrbitNatureConverter attribute needs to be thread-safe
fr.cnes.sirius.patrius.stela.StelaSpacecraftFactory	unconditionally thread-safe	access to the only static field is synchronized
fr.cnes.sirius.patrius.stela.bodies.EarthRotation	immutable	
fr.cnes.sirius.patrius.stela.bodies.GeodPosition	immutable	
fr.cnes.sirius.patrius.stela.bodies.MeeusMoonStela	immutable	
fr.cnes.sirius.patrius.stela.bodies.MeeusSunStela	immutable	
fr.cnes.sirius.patrius.stela.forces.Squaring	immutable	
fr.cnes.sirius.patrius.stela.forces.StelaLagrangeEquations	not thread-safe	not thread-safe because two threads can simultaneously modify global attributes of the class
fr.cnes.sirius.patrius.stela.forces.atmospheres.MSIS00Adapter	thread-hostile	The direct use of thread hostile objects makes this class thread hostile itself.
fr.cnes.sirius.patrius.stela.forces.drag.StelaAeroModel	immutable	
fr.cnes.sirius.patrius.stela.forces.drag.StelaAtmosphericDrag	not thread-safe	not thread-safe due to use of mutable attributes
fr.cnes.sirius.patrius.stela.forces.drag.StelaCd	immutable	
fr.cnes.sirius.patrius.stela.forces.gravity.StelaTesseralAttraction	not thread-safe	not thread-safe due to use of mutable attributes
fr.cnes.sirius.patrius.stela.forces.gravity.StelaThirdBodyAttraction	not thread-safe	not thread-safe because two threads can simultaneously modify attributes of the class
fr.cnes.sirius.patrius.stela.forces.gravity.StelaZonalAttraction	conditionally thread-safe	thread safe if the PotentialCoefficientsProvider used is thread safe
fr.cnes.sirius.patrius.stela.forces.gravity.StelaZonalAttractionJ10	thread-safe	
fr.cnes.sirius.patrius.stela.forces.gravity.StelaZonalAttractionJ11	thread-safe	
fr.cnes.sirius.patrius.stela.forces.gravity.StelaZonalAttractionJ12	thread-safe	
fr.cnes.sirius.patrius.stela.forces.gravity.StelaZonalAttractionJ13	thread-safe	
fr.cnes.sirius.patrius.stela.forces.gravity.StelaZonalAttractionJ14	thread-safe	
fr.cnes.sirius.patrius.stela.forces.gravity.StelaZonalAttractionJ15	thread-safe	
fr.cnes.sirius.patrius.stela.forces.gravity.StelaZonalAttractionJ8	thread-safe	
fr.cnes.sirius.patrius.stela.forces.gravity.StelaZonalAttractionJ9	thread-safe	
fr.cnes.sirius.patrius.stela.forces.gravity.TesseralQuad	not thread-safe	use of internal mutable attributes
fr.cnes.sirius.patrius.stela.forces.noninertial.NonInertialContribution	thread-safe	
fr.cnes.sirius.patrius.stela.forces.radiation.SRPPotential	conditionally thread-safe	thread safe if the CelestialBody used is thread safe
fr.cnes.sirius.patrius.stela.forces.radiation.SRPSquaring	conditionally thread-safe	thread-safe if the given sun is thread-safe
fr.cnes.sirius.patrius.stela.forces.radiation.StelaSRPSquaring	conditionally thread-safe	thread-safe if the SRPSquaring and SRPPotential models are thread-safe.
fr.cnes.sirius.patrius.stela.orbits.JacobianConverter	unconditionally thread-safe	
fr.cnes.sirius.patrius.stela.orbits.OrbitNatureConverter	not thread-safe	instances are mutable
fr.cnes.sirius.patrius.stela.orbits.StelaEquinoctialOrbit	immutable	
fr.cnes.sirius.patrius.stela.propagation.ForcesStepHandler	not thread-safe	
fr.cnes.sirius.patrius.stela.propagation.StelaBasicInterpolator	not thread-safe	
fr.cnes.sirius.patrius.stela.propagation.StelaDifferentialEquations	not thread-safe	not thread-safe due to use of mutable attributes
fr.cnes.sirius.patrius.stela.propagation.StelaGTOPropagator	not thread-safe	use of mutable attributes

fr.cnes.sirius.patrius.stela.propagation.StelaPartialDerivativesEquations	not thread-safe	use of mutable attributes
fr.cnes.sirius.patrius.stela.propagation.data.TimeDerivativeData	not thread-safe	
fr.cnes.sirius.patrius.orbits.pvcoordinates.AlmanacPVCoordinates	immutable	
fr.cnes.sirius.patrius.math.interval.AngleInterval	immutable	
fr.cnes.sirius.patrius.math.interval.AngleTools	unconditionally thread-safe	
fr.cnes.sirius.patrius.math.Comparators	unconditionally thread-safe	
fr.cnes.sirius.patrius.utils.GPSGalileoAlmanacParameter	immutable	
fr.cnes.sirius.patrius.math.interval.GenericInterval	immutable	
fr.cnes.sirius.patrius.wrenches.DragWrench	not thread-safe	class uses internal mutable attributes and frames
fr.cnes.sirius.patrius.wrenches.GenericWrenchModel	not thread-safe	uses frames
fr.cnes.sirius.patrius.wrenches.GravitationalAttractionWrench	conditionally thread-safe	thread-safe if the inertia model is thread-safe
fr.cnes.sirius.patrius.wrenches.MagneticWrench	conditionally thread-safe	thread-safe if the underlying geo magnetic field is also thread-safe
fr.cnes.sirius.patrius.wrenches.SolarRadiationWrench	not thread-safe	class uses internal mutable attributes and frames

## Patrius-tools thread safety

Here is a list of all patrius-tools classes and thread-safety:

Class (total number : 23)	Concurrency	Comment
fr.cnes.sirius.patrius.tools.ephemerisComparator.ComparisonData	not thread-safe	this class is not thread safe due to setThresholds(ArrayList) matches the
fr.cnes.sirius.patrius.tools.ephemerisComparator.Data	not thread-safe	concurrency of the parameter type : using an immutable type is HIGHLY recommended
fr.cnes.sirius.patrius.tools.ephemerisComparator.DateDPFacade	immutable	
fr.cnes.sirius.patrius.tools.ephemerisComparator.DeviationProviderFactory	immutable	
fr.cnes.sirius.patrius.tools.ephemerisComparator.DoubleDPFacade	immutable	
fr.cnes.sirius.patrius.tools.ephemerisComparator.EphemerisComparator	not thread-safe	it uses non thread-safe objects
fr.cnes.sirius.patrius.tools.ephemerisComparator.EphemerisComparatorMain	not thread-safe	it uses non thread-safe objects
fr.cnes.sirius.patrius.tools.ephemerisComparator.MeaningfulData	immutable	
fr.cnes.sirius.patrius.tools.ephemerisComparator.MeaningfulDataComparator	immutable	
fr.cnes.sirius.patrius.tools.ephemerisComparator.PSimuDataLoader	not thread-safe	the file could be tampered with while reading it
fr.cnes.sirius.patrius.tools.ephemerisComparator.PVCoordinatesDPFacade	immutable	
fr.cnes.sirius.patrius.tools.ephemerisComparator.QuaternionDPFacade	immutable	
fr.cnes.sirius.patrius.tools.ephemerisComparator.RawDataComparator	not thread-safe	this class is not thread safe due to the attribute 'relative' which can change
fr.cnes.sirius.patrius.tools.ephemerisComparator.Report	thread-safe	
fr.cnes.sirius.patrius.tools.ephemerisComparator.RotationDPFacade	immutable	
fr.cnes.sirius.patrius.tools.ephemerisComparator.Setup	not thread-safe	this class is not thread safe due to the fact that some attributes are not private

fr.cnes.sirius.patrius.tools.ephemerisComparator.ThresholdsData	not thread-safe	this class is not thread safe due to getFirstRefusedLines()
fr.cnes.sirius.patrius.tools.ephemerisComparator.VectorDPFacade	immutable	
fr.cnes.sirius.patrius.tools.exception.EphemerisComparatorException	not thread-safe	extends Exception
fr.cnes.sirius.patrius.tools.exception.EphemerisComparatorRuntimeException	not thread-safe	extends Exception
fr.cnes.sirius.patrius.tools.force.validation.BasicPVCordinatesProvider	not thread-safe	
fr.cnes.sirius.patrius.tools.force.validation.PVEphemerisLoader	not thread safe	
fr.cnes.sirius.patrius.tools.force.validation.Report	not thread safe	

<b>Class</b>	<b>Concurrency</b>	<b>Comment</b>
fr.cnes.sirius.patrius.math.analysis.integration.TrapezoidIntegrator	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.analysis.integration.SimpsonIntegrator	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.analysis.interpolation.BicubicSplineInterpolatingFunction	not thread-safe	Instances are mutable (unprotected lazy initialization).
fr.cnes.sirius.patrius.math.analysis.interpolation.BicubicSplineInterpolator	unconditionally thread-safe	Would be immutable if the class were final.
fr.cnes.sirius.patrius.math.analysis.interpolation.TricubicSplineInterpolatingFunction	unconditionally thread-safe	Would be immutable if the class were final.
fr.cnes.sirius.patrius.math.analysis.interpolation.TricubicSplineInterpolator	unconditionally thread-safe	Would be immutable if the class were final.
fr.cnes.sirius.patrius.math.analysis.polynomials.PolynomialFunction	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.math.analysis.polynomials.PolynomialFunctionLagrangeForm	not thread-safe	Instances are mutable (unprotected lazy initialization).
fr.cnes.sirius.patrius.math.analysis.polynomials.PolynomialFunctionNewtonForm	not thread-safe	Instances are mutable (unprotected lazy initialization).
fr.cnes.sirius.patrius.math.analysis.polynomials.HelmholtzPolynomial	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.analysis.solvers.BrentSolver	not thread-safe	Instances are mutable (inner Incrementor instance).

fr.cnes.sirius.patrius.math.analysis.solvers.NewtonSolver	not thread-safe	Instances are mutable (inner Incrementor instance).
fr.cnes.sirius.patrius.math.analysis.solvers.BisectionSolver	not thread-safe	Instances are mutable (inner Incrementor instance).
fr.cnes.sirius.patrius.math.analysis.solvers.MullerSolver	not thread-safe	Instances are mutable (inner Incrementor instance).
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Plane	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Rotation	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.RotationOrder	immutable	
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Vector3D	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.math.geometry.euclidean.threed.Screw	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.math.linear.Array2DRowRealMatrix	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.linear.ArrayRealVector	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.linear.CholeskyDecompositionImpl	not thread-safe	Exposed mutable attributes (getters on RealMtrix).
fr.cnes.sirius.patrius.math.linear.LUDecompositionImpl	not thread-safe	Exposed mutable attributes (getters on RealMtrix).
fr.cnes.sirius.patrius.math.linear.QRDecompositionImpl	not thread-safe	Exposed mutable attributes (getters on RealMtrix).
fr.cnes.sirius.patrius.math.ode.events.EventHandler	not thread-safe	Instances are mutable.



fr.cnes.sirius.patrius.math.ode.events.EventException	unconditionally thread-safe	Would be immutable if the class were final.
fr.cnes.sirius.patrius.math.ode.nonstiff.ClassicalRungeKuttaIntegrator	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.ode.nonstiff.DormandPrince54Integrator	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.ode.nonstiff.DormandPrince853Integrator	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.ode.nonstiff.GraggBulirschStoerIntegrator	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.random.JDKRandomGenerator	thread-safe	Extends a class from the Java API whose thread-safety status is undocumented, but probably thread-safe.
fr.cnes.sirius.patrius.math.stat.StatUtils	immutable	Final utility class with reentrant static methods only.
fr.cnes.sirius.patrius.math.stat.descriptive.rank.Median	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.stat.descriptive.rank.Percentile	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.math.util.FastMath	immutable	Final utility class with reentrant static methods only.
fr.cnes.sirius.patrius.math.util.MathUtils	immutable	Final utility class with reentrant static methods only.

- when these are documented as "immutable" in their javadoc, it is stated so.
- the remainder was evaluated by the PATRIUS team.

The list of all validated classes is also available in the SVS.

NOTE : thread hostility has not been systematically researched, so it is not fully documented in this revision.

Class	Concurrency	Comment
fr.cnes.sirius.patrius.attitudes.Attitude	conditionally thread-safe	Exposed mutable attribute (getter on Frame), Attitude is thread-safe when the Frame is.
fr.cnes.sirius.patrius.attitudes.AttitudesSequence	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.attitudes.BodyCenterPointing	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.

fr.cnes.sirius.patrius.attitudes.CelestialBodyPointed	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.attitudes.BodyCenterGroundPointing.java	immutable	
fr.cnes.sirius.patrius.attitudes.FixedRate	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.attitudes.InertialProvider	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.attitudes.LofOffset	conditionally thread-safe	Is thread-safe when the Frame attribute is.
fr.cnes.sirius.patrius.attitudes.NadirPointing	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.attitudes.SpinStabilized	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.attitudes.TargetGroundPointing.java	immutable	
fr.cnes.sirius.patrius.attitudes.TargetPointing	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.attitudes.YawCompensation	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.attitudes.YawSteering	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.attitudes.kinematics.KinematicsToolkit	immutable	
fr.cnes.sirius.patrius.attitudes.kinematics.AbstractOrientationFunction	conditionally thread-safe	Thread-safe if the attribute differentiator is thread-safe and if the implementation of this abstract class is thread-safe too.
fr.cnes.sirius.patrius.attitudes.kinematics.AbstractVector3DFunction	conditionally thread-safe	Thread-safe if the attributes differentiator and integrator are thread-safe and if the implementation of this abstract class is thread-safe too.
fr.cnes.sirius.patrius.attitudes.kinematics.DynamicsElements	immutable	
fr.cnes.sirius.patrius.bodies.GeodeticPoint	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.

fr.cnes.sirius.patrius.bodies.JPLEphemeridesLoader	conditionally thread-safe	Unprotected mutable fields are modified by the loadData() method. If this method call is protected, the instance is thread-safe.
fr.cnes.sirius.patrius.bodies.OneAxisEllipsoid	not thread-safe	Instances are mutable. The feed() method modifies a mutable reference (DataLoader) that may not be thread-safe. If the call to feed() is protected and the DataLoader is not thread-hostile, OR if the DataLoader is thread-safe, then the instance is thread-safe.
fr.cnes.sirius.patrius.data.ClasspathCrawler	conditionally thread-safe	Contains an unprotected singleton. The feed() method modifies a mutable reference (DataLoader) that may not be thread-safe. If the call to feed() is protected and the DataLoader is not thread-hostile, OR if the DataLoader is thread-safe, then the instance is thread-safe.
fr.cnes.sirius.patrius.data.DataProvidersManager	thread-hostile	The feed() method modifies a mutable reference (DataLoader) that may not be thread-safe. If the call to feed() is protected and the DataLoader is not thread-hostile, OR if the DataLoader is thread-safe, then the instance is thread-safe.
fr.cnes.sirius.patrius.data.DirectoryCrawler	conditionally thread-safe	The feed() method modifies a mutable reference (DataLoader) that may not be thread-safe. If the call to feed() is protected and the DataLoader is not thread-hostile, OR if the DataLoader is thread-safe, then the instance is thread-safe.
fr.cnes.sirius.patrius.data.NetworkCrawler	conditionally thread-safe	Technically non-immutable, but immutable "in practice". The feed() method modifies a mutable reference (DataLoader) that may not be thread-safe. If the call to feed() is protected and the DataLoader is not thread-hostile, OR if the DataLoader is thread-safe, then the instance is thread-safe.
fr.cnes.sirius.patrius.data.PoissonSeries	unconditionally thread-safe	The feed() method modifies a mutable reference (DataLoader) that may not be thread-safe. If the call to feed() is protected and the DataLoader is not thread-hostile, OR if the DataLoader is thread-safe, then the instance is thread-safe.
fr.cnes.sirius.patrius.data.ZipJarCrawler	conditionally thread-safe	The feed() method modifies a mutable reference (DataLoader) that may not be thread-safe. If the call to feed() is protected and the DataLoader is not thread-hostile, OR if the DataLoader is thread-safe, then the instance is thread-safe.

fr.cnes.sirius.patrius.utils.exception.PatriusException	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.utils.exception.PropagationException	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.forces.ConstantFunction	not thread-safe	uses internal mutable attributes.
fr.cnes.sirius.patrius.forces.IJacobiansParameterizable	not thread-safe	uses internal mutable attributes.
fr.cnes.sirius.patrius.forces.IParamDiffFunction	not thread-safe	uses internal mutable attributes.
fr.cnes.sirius.patrius.forces.IParameterizableFunction	not thread-safe	uses internal mutable attributes.
fr.cnes.sirius.patrius.forces.LinearFunction	not thread-safe	uses internal mutable attributes.
fr.cnes.sirius.patrius.forces.Parameter	not thread-safe	uses internal mutable attributes.
fr.cnes.sirius.patrius.forces.Parameterizable	not thread-safe	uses internal mutable attributes.
fr.cnes.sirius.patrius.forces.PiecewiseFunction	not thread-safe	uses internal mutable attributes.
fr.cnes.sirius.patrius.forces.BoxAndSolarArraySpacecraft	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.forces.drag.DTM2000	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.forces.drag.DragForce	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.forces.gravity.BalminoAttractionModel.java	not thread-safe	uses internal mutable attributes
fr.cnes.sirius.patrius.forces.gravity.potential.EGMFormatReader	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.forces.gravity.potential.GravityFieldFactory	unconditionally thread-safe	Access to mutable fields are synchronized.
fr.cnes.sirius.patrius.forces.gravity.potential.GRGSFormatReader	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.forces.gravity.potential.ICGEMFormatReader	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.forces.gravity.potential.SHMFormatReader	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.forces.gravity.CunninghamAttractionModel	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.forces.gravity.DrozinerAttractionModel	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.forces.gravity.GravityToolbox.java	immutable	
fr.cnes.sirius.patrius.forces.gravity.NewtonianAttraction	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.forces.gravity.ThirdBodyAttraction	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.forces.maneuvers.ConstantThrustManeuver	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.forces.radiation.SolarRadiationPressureCircular	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.frames.Frame	not thread-safe	Unprotected mutable attribute- but thread-safety problems relative to this attribute have yet to be found, so Frame is "almost" thread-safe.

fr.cnes.sirius.patrius.frames.FramesFactory	unconditionally thres-safe	Access to mutable fields are synchronized. NOTE : The IERS frames provided by this class are thread-safe, these are provided by the getGCRF(), getCIRF(), getTIRF() and getITRF() methods.
fr.cnes.sirius.patrius.frames.LocalOrbitalFrame	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.frames.OrphanFrame	unconditionally thread-safe	No attributes, static methods only.
fr.cnes.sirius.patrius.frames.TopocentricFrame	not thread-safe	Is a Frame.
fr.cnes.sirius.patrius.frames.configuration.DiurnalRotation	conditionally thread-safe	thread-safe if constructor parameters are thread safe
fr.cnes.sirius.patrius.frames.configuration.FramesConfigurationFactory	thread-safe	only static methods
fr.cnes.sirius.patrius.frames.configuration.FramesConfigurationImplementation	conditionally thread-safe	thread-safe if constructor parameters are thread safe
fr.cnes.sirius.patrius.frames.configuration.PolarMotion	conditionally thread-safe	thread-safe if constructor parameters are thread safe
fr.cnes.sirius.patrius.frames.configuration.eop.AbstractEOPHistory	conditionally thread-safe	Uses the time stamped cache mechanism. Thread-safe as long as the mechanisms that add entries to the lists do so in a thread-safe manner (see EOPHistoryFactory).
fr.cnes.sirius.patrius.frames.configuration.eop.BulletinBFilesLoader	unconditionally thread-safe	
fr.cnes.sirius.patrius.frames.configuration.eop.EOP05C04FilesLoader	unconditionally thread-safe	
fr.cnes.sirius.patrius.frames.configuration.eop.EOP08C04FilesLoader	unconditionally thread-safe	
fr.cnes.sirius.patrius.frames.configuration.eop.EOP1980Entry	immutable	
fr.cnes.sirius.patrius.frames.configuration.eop.EOP1980History.java	unconditionally thread-safe	
fr.cnes.sirius.patrius.frames.configuration.eop.EOP2000Entry	immutable	
fr.cnes.sirius.patrius.frames.configuration.eop.EOP2000History	unconditionally thread-safe	
fr.cnes.sirius.patrius.frames.configuration.eop.EOPEntry	immutable	
fr.cnes.sirius.patrius.frames.configuration.eop.EOPHistoryFactory	unconditionally thread-safe	getters use synchronized keyword were access to loader lists is performed
fr.cnes.sirius.patrius.frames.configuration.eop.NoEOP2000History	immutable	
fr.cnes.sirius.patrius.frames.configuration.eop.NutationCorrection	immutable	
fr.cnes.sirius.patrius.frames.configuration.eop.PoleCorrection	immutable	
fr.cnes.sirius.patrius.frames.configuration.eop.RapidDataAndPredictionColumnsLoader	unconditionally thread-safe	
fr.cnes.sirius.patrius.frames.configuration.eop.RapidDataAndPredictionXMLLoader	unconditionally thread-safe	
fr.cnes.sirius.patrius.frames.configuration.libration.LibrationCorrectionModelFactory	immutable	only static final fields
fr.cnes.sirius.patrius.frames.configuration.libration.IERS2010LibrationCorrection	unconditionally thread-safe	

fr.cnes.sirius.patrius.frames.configuration.libration.NoLibrationCorrection	immutable	
fr.cnes.sirius.patrius.frames.configuration.precessionnutaton.CIPCoordinates	immutable	
fr.cnes.sirius.patrius.frames.configuration.precessionnutaton.CIPCoordinatesGenerator	conditionally thread-safe	As long as a generator is referenced by one {@link TimeStampedCache} only, it is guaranteed to be called in a thread-safe way, even if the cache is used in a multi-threaded environment.
fr.cnes.sirius.patrius.frames.configuration.precessionnutaton.IERS20032010PrecessionNutation	unconditionally thread-safe	
fr.cnes.sirius.patrius.frames.configuration.precessionnutaton.PrecessionNutationCache	conditionally thread-safe	thread safe if precession nutation model is thread-safe
fr.cnes.sirius.patrius.frames.configuration.precessionnutaton.PrecessionNutationModelFactory	immutable	only static final fields
fr.cnes.sirius.patrius.frames.configuration.sp.IERS2010SPCorrection	immutable	
fr.cnes.sirius.patrius.frames.configuration.sp.NoSpCorrection	immutable	
fr.cnes.sirius.patrius.frames.configuration.sp.SPrimeModelFactory	immutable	
fr.cnes.sirius.patrius.frames.configuration.tides.TidelCorrectionCache	conditionally thread-safe	thread safe if tides model is thread-safe
fr.cnes.sirius.patrius.frames.configuration.tides.TidalCorrection	immutable	
fr.cnes.sirius.patrius.frames.configuration.tides.TidalCorrectionGenerator	conditionally thread-safe	As long as a generator is referenced by one {@link TimeStampedCache} only, it is guaranteed to be called in a thread-safe way, even if the cache is used in a multi-threaded environment.
fr.cnes.sirius.patrius.frames.configuration.tides.IERS2000TidalCorrection	unconditionally thread-safe	
fr.cnes.sirius.patrius.frames.configuration.tides.IERS2010TidalCorrection	unconditionally thread-safe	
fr.cnes.sirius.patrius.frames.configuration.tides.NoTidalCorrection	immutable	
fr.cnes.sirius.patrius.frames.configuration.tides.TidalCorrectionModelFactory	immutable	
fr.cnes.sirius.patrius.frames.transformations.HelmertTransformation	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.frames.transformations.Transform	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.models.earth.COFFileFormatReader.java	not thread-safe	instance is mutable
fr.cnes.sirius.patrius.models.earth.FixedDelayModel.java	not thread-safe	instance is mutable
fr.cnes.sirius.patrius.models.earth.GeoMagneticModelReader.java	not thread-safe	instance is mutable
fr.cnes.sirius.patrius.models.earth.GeoMagneticElements	unconditionally thread-safe	Would be immutable if the class were final
fr.cnes.sirius.patrius.models.earth.GeoMagneticField	not thread-safe	Instance are mutable
fr.cnes.sirius.patrius.models.earth.GeoMagneticFieldFactory	unconditionally thread-safe	Access to mutable fields are synchronized.
fr.cnes.sirius.patrius.models.earth.ModelLoader	not thread-safe	Mutable fields

fr.cnes.sirius.patrius.orbits.CartesianOrbit	immutable	Modified by Patrius team.
fr.cnes.sirius.patrius.orbits.CircularOrbit	immutable	Modified by Patrius team.
fr.cnes.sirius.patrius.orbits.EquinoctialOrbit	immutable	Modified by Patrius team.
fr.cnes.sirius.patrius.orbits.KeplerianOrbit	immutable	Modified by Patrius team.
fr.cnes.sirius.patrius.orbits.ApsisOrbit	immutable	Created by Patrius team.
fr.cnes.sirius.patrius.orbits.EquatorialOrbit	immutable	Created by Patrius team.
fr.cnes.sirius.patrius.propagation.analytical.EcksteinHechlerPropagator	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.propagation.analytical.KeplerianPropagator	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.propagation.events.AdaptedAdditionalStatesEventDetector	conditionally thread-safe	if all attributes are thread safe.
fr.cnes.sirius.patrius.propagation.events.AdaptedEventDetector	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.AdditionalStatesEventsLogger	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.AlignmentDetector	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.AltitudeDetector	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.ApsideDetector	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.CircularFieldOfViewDetector	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.DateDetector	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.propagation.events.DihedralFieldOfViewDetector	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.EclipseDetector	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.ElevationDetector	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.EventShifter	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.EventsLogger	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.EventState	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.GroundMaskElevationDetector	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.events.NodeDetector	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.propagation.numerical.AdditionalStateInfo	Immutable	
fr.cnes.sirius.patrius.propagation.numerical.JacobiansMapper	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.propagation.numerical.NumericalPropagator	not thread-safe	As documented.
fr.cnes.sirius.patrius.propagation.events.PartialDerivativesEquations	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.propagation.precomputed.Ephemeris	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.propagation.precomputed.IntegratedEphemeris	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.propagation.sampling.AdaptedStepHandler	not thread-safe	Instances are mutable.

fr.cnes.sirius.patrius.propagation.SpacecraftState	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.propagation.SimpleMassModel.java	not thread-safe	instance is mutable. WARNING : this class is wrongfully documented as immutable (javadoc)! It is mutable.
fr.cnes.sirius.patrius.time.AbsoluteDate	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.time.DateComponents	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.time.DateTimeComponents	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.time.GalileoScale	unconditionally thread-safe	Would be immutable if the class were final.
fr.cnes.sirius.patrius.time.GPSScale	thread-hostile	A deprecated method calls the thread-hostile TimeScalesFactory. When this method is removed, the class will become thread-safe.
fr.cnes.sirius.patrius.time.TimeComponents	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.time.TimeScalesFactory	thread-hostile	Contains unprotected singletons.
fr.cnes.sirius.patrius.time.TAIScale	thread-hostile	A deprecated method calls the thread-hostile TimeScalesFactory. When this method is removed, the class will become thread-safe.
fr.cnes.sirius.patrius.time.TTScale	thread-hostile	A deprecated method calls the thread-hostile TimeScalesFactory. When this method is removed, the class will become thread-safe.
fr.cnes.sirius.patrius.time.UTCScale	thread-hostile	A deprecated method calls the thread-hostile TimeScalesFactory. When this method is removed, the class will (likely) become thread-safe.
fr.cnes.sirius.patrius.time.UTCTAIHistoryFilesLoader	not thread-safe	Exposed mutable attributes.



fr.cnes.sirius.patrius.time.UTCTAIOffset	not thread-safe	Instances are mutable.
fr.cnes.sirius.patrius.time.UT1Scale	not thread-safe	Exposed mutable attributes.
fr.cnes.sirius.patrius.utils.PVCordinates	unconditionally thread-safe	Would be immutable if the class were final- documented as immutable, but technically untrue.
fr.cnes.sirius.patrius.wrenches.Wrench.java	immutable	

### Note : Frames and thread-safety

It was determined that several Frame implementations were thread-hostile.

The current evaluation of these changes from a thread-safety point of view leads us to state the following :

- The IERS frames (GCRF, CIRF, TIRF and ITRF) are thread-safe.

## Known Issues

None.

## Sous-catégories

Cette catégorie comprend 6 sous-catégories, dont les 6 ci-dessous.

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