1. PURPOSE:

Definition of the coordinate systems to be used in SALT with transformations between them

2. METHOD:

The definition of coordinate systems is such that it has practical and engineering significance wherever possible. All coordinate systems are right handed. The orientation of coordinate systems with respect to each other is described by the classical Euler method, using successive rotations. For SALT the rotations will consistently be :

- 1\textsuperscript{st} rotation: about $x$ – axis, through angle (\(\theta\) or as defined)
- 2\textsuperscript{nd} rotation: about $y'$ – axis, through angle (\(\phi\) or as defined)
- 3\textsuperscript{rd} rotation: about $z''$ – axis, through angle (\(\zeta\) or as defined)

3. RESULTS: (Defined Coordinate Systems)

a) Telescope System
   - SSF: SALT System Frame
   - ECEF: Earth Centred, Earth fixed Frame
   - CCF: Celestial Coordinate Frame

b) Facility
   - DFF: Dome Fixed Frame
   - TSF: Telescope Structure Frame

c) Primary Mirror
   - PMAF: Primary Mirror Apex Frame
   - COCF: Centre Of Curvature Frame

d) Tracker and Payload
   - ITF: Ideal Tracker Frame (Ideal refers to beam without flexure)
   - APF: Acquisition focal Plane Frame
   - GFP: Guidance focal Plane Frame
   - GPF: Guidance Probe Frame
   - FPF: Focal Plane Frame (Prime Focus)
   - HPF: Hexapod Frame
   - PMF: Payload Mechanical Frame

4. CONCLUSION: Transformations not defined yet.
1. **SALT System Frame (SSF):**
   1.1 Purpose: The position and attitude of all the SALT subsystems are defined relative to this frame.
   1.2 Origin:
   - At centre of pier
   - X-Y Plane coincides with top surface of 100% flat pier plane
   1.3 X-Axis
   - Pointing North
   1.4 Z-Axis
   - Pointing towards Earth Centre
   1.5 Y-Axis
   - Completes the right handed system

   This frame is fixed to the pier. Positive azimuth rotation of the telescope will be positive rotation about the Z-axis.

2. **Earth Centred, Earth fixed Frame (ECEF):**
   2.1 Purpose: Used to define the position and attitude of telescope relative to WGS84 Geoid
   2.2 Origin:
   - At Center of Earth
   2.3 X-Axis
   - In equator plane parallel to longitude of Telescope structure rotation shaft
   2.4 Y-Axis
   - Right handed complement
   2.5 Z-Axis
   - Up through north pole(True North)

   For open loop guidance the earth rotation rate will be defined in this frame.

3. **Celestial Coordinate Frame (CCF):**
   3.1 Purpose: Used to define the position of celestial bodies (Right Ascension and Declination)
   3.2 Origin:
   - At Centre of Earth
   3.3 X-Axis
   - In equator plane pointing to the vernal equinox (the point where the ecliptic crosses the celestial equator going from south to north
   3.4 Y-Axis
   - Right handed complement
   3.5 Z-Axis
   - Up through north pole(True North)

4. **Dome Fixed Frame (DFF):**
   4.1 Purpose: Used to define the position all dome subsystems
   4.2 Origin:
   - At Centre of Dome(rotation axis), XY Plane is coincident with rotation plane
   4.3 X-Axis
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4.4 Y-Axis
- Right handed complement
4.5 Z-Axis
- Down to earth centre

5. Telescope Structure Frame (TSF):
5.1 Purpose: Used to define the position and attitude of major subsystem interfaces
5.2 Origin:
- At Telescope rotation Shaft on level of pier
5.3 X-Axis
- X Axis pointing north in zero azimuth position, axis parallel to WGS84 geoid
5.4 Y-Axis
- Y Axis, a right handed complement
5.5 Z-Axis
- Down towards earth center

6. Primary Mirror Apex Frame (PMAF):
6.1 Purpose: Used to define the position and attitude of Primary Mirror subsystems
6.2 Origin:
- At Vertex of primary mirror
6.3 X-Axis
- XY plane tangential to vertex, X axis completing the right handed system
6.4 Y-Axis
- YZ plane coincident with telescope meridian when azimuth angle is zero, Y pointing upwards
6.5 Z-Axis
- Up from the vertex.

7. Centre Of Curvature Frame (COCF):
7.1 Purpose: Used to define position and attitude of CCAS instruments and act as intermediary frame to calculate the tracker motions in ITF. (This system is actually the ITF system displaced to centre of curvature)
7.2 Origin:
- At Center of Curvature of Primary Mirror
7.3 X-Axis
- X Axis parallel to ITF X Axis
7.4 Y-Axis
- Y Axis parallel to ITF Y Axis
7.5 Z-Axis
- Down along telecentric axis, towards Primary Mirror vertex

8. Ideal Tracker Frame (ITF):
8.1 Purpose: All the tracker motions are defined relative to this frame, any deviations from the ideal tracker beam should be compensated for by making adjustments to these commands, these deviations would be due to:
- structural deflections
- Skewness caused by X-drives
- manufacturing tolerances
8.2 Origin:
- At Vertex of Primary Mirror
- X-Y Plane coincides with Ideal X-Bearings on upper hexagon (deviations to be accommodated at higher level)

8.3 X-Axis
- In x-drive direction

8.4 Y-Axis
- Positive in y-drive direction (uphill- completing the right hand system)

8.5 Z-Axis - pointing towards Primary Mirror Vertex

9. Acquisition focal Plane Frame (APF):
9.1 Purpose: To define image positions at acquisition focus

9.2 Origin:
- At the centre of acquisition CCD
- X-Y Plane coincides with the image plane, parallel to SAC optical axis

9.3 X-Axis
- X parallel to SAC optical axis, pointing upwards.

9.4 Y-Axis
- Completes the right hand system

9.5 Z-Axis – Perpendicular to and away from SAC optical axis

10. Guidance focal Plane Frame (GPF):
10.1 Purpose: To define image positions at guidance focus

10.2 Origin:
- At the centre of guidance CCD
- X-Y Plane coincides with the image plane, parallel to SAC optical axis

10.3 X-Axis
- X parallel to SAC optical axis, pointing upwards.

10.4 Y-Axis
- Completes the right hand system

10.5 Z-Axis – Perpendicular to and away from SAC optical axis

11. Focal Plane Frame (Prime Focus) (FPF):
11.1 Purpose: To define image positions at prime focus

11.2 Origin:
- At the centre of prime focus
- X-Y Plane coincides with the image plane

11.3 X-Axis
- X pointing north when azimuth and payload tip and tilt angles are zero

11.4 Y-Axis
- YZ plane coincident with telescope meridian when azimuth and payload tip and tilt angles are zero, Y completes the right hand system

11.5 Z-Axis - down along SAC optical axis

12. Hexapod Frame (HPF):
12.1 Purpose: Used as intermediary frame to calculate Hexapod strut lengths, this frame is fixed to the Payload and its attitude relative to the ITF frame is given by $(\phi_1$ about $x_1, \phi_2$ about $y, \phi_3$ about $z_2)$ in order of rotation from ITF to HPF.

12.2 Origin:
- At Rotation point of Payload
- X-Y Axes parallel to ITF X-Y Axes at Primary Mirror vertex

12.3 X-Axis
- see ITF at PM Apex

12.4 Y-Axis
- see ITF at PM Apex

12.5 Z-Axis
- pointing towards Primary Mirror Vertex

13. **Payload Mechanical Frame (PMF)**

13.1 Purpose: To define position and attitude of payload subsystems.

13.2 Origin:
- At centre of payload structure in plane of mounting on rotation stage
- X-Y Axes parallel to ITF X-Y Axes at Primary Mirror vertex

13.3 X-Axis
- Coinciding with ITF X-Axis in zero position

13.4 Y-Axis
- Coinciding with ITF Y-Axis in zero position

13.5 Z-Axis
- pointing downwards along SAC optical axis