

S.C.R.E.W.D. Constraint Communication Framework

Technical framework and kinematic logic developed by Webby1, refined through collaborative analytical dialogue with Gemini, ChatGPT, and Claude.

Purpose

This document exists to help analysts evaluate the S.C.R.E.W.D. mechanism without unintentionally changing the system assumptions.

The most common problem encountered during discussion and analysis is that observers instinctively reinterpret the mechanism using conventional planetary-gear assumptions. Once this happens, the mathematical model changes and the resulting conclusions no longer apply to the intended system.

The purpose of this framework is to establish the mechanism as a constrained kinematic state-space before any force or gear analysis begins.

1. Fundamental Principle

The S.C.R.E.W.D. system is not to be treated as a conventional planetary gearbox.

It is a constrained orbital gear system whose behavior is defined primarily by:

- enforced degrees of freedom,
- prohibited degrees of freedom,
- prescribed relative displacement,
- and closed-loop geometric compatibility.

If any of the constraints listed below are altered, then the mechanism being analyzed is no longer the same mechanism.

The constraints ARE the mechanism.

2. Idealized Analysis Assumptions

All analysis is performed under the following ideal-state conditions:

- rigid-body geometry,
- zero compliance,
- zero backlash,
- zero friction,
- zero thermal effects,
- no elastic energy storage,
- no deformation,
- no external hidden power source.

The system is analyzed strictly as a closed-loop geometric and force-constraint structure.

3. Reference Frame

Primary reference frame: F_{\blacksquare} = stationary pink frame.

Origin: Silver pivot center.

All motions and force vectors are defined relative to F_{\blacksquare} unless otherwise stated.

4. System Geometry

Component	Details
Ring Gear	Internal gear 240T Module 1 Pitch radius: 120 mm
Sun Gear	External gear 200T Module 1 Pitch radius: 100 mm
Orbital Carrier Arm	Radius: 10 mm Connected to the pivot Carries the pin and ring structure
Cross-Slide Constraint System	Distributed translational guidance system Allows orbital translation Prohibits sun rotation

5. Degree-of-Freedom Table

Component	Translation	Rotation
Sun	Allowed	Forbidden
Ring	Orbital motion allowed	Relative slip constrained
Carrier Arm	Prescribed orbital motion	Allowed
Cross-Slide	Translational guidance only	Prevents sun rotation
Pivot/ F_{\blacksquare}	Fixed	Fixed

This table defines the legal motion state-space. Any analysis that changes these allowed/prohibited motions is no longer analyzing the intended mechanism.

6. Kinematic Constraint Law

The relative-slip condition is prescribed as:

$$\theta_{rel} = -\theta_{input} \cdot (T_{sun} / T_{ring})$$

For $T_{sun} = 200$ and $T_{ring} = 240$, this yields:

$$\theta_{rel} = -300^\circ \text{ per full } 360^\circ \text{ orbital cycle.}$$

This relation defines the required relative displacement compatibility. It is not optional.

7. Eccentricity Constraint

Required gear eccentricity: 20 mm

Orbital arm contribution: 10 mm

Therefore the cross-slide system must enforce the complementary displacement component necessary to preserve continuous mesh closure.

This requires a maintained 180° phase relationship between orbital displacement and translational correction displacement.

8. Force Model

The mechanism is analyzed using a pure tangential interaction assumption.

Defined interaction: 1 N tangential force at the mesh. No normal/radial involute decomposition is assumed unless explicitly introduced.

This is intentional. The force model is defined directly as a tangential constraint interaction.

9. Torque Relationships

Ring Side: 1 N acting at the 120 mm ring radius produces: $\tau = 120 \text{ N}\cdot\text{mm}$

Carrier/Pivot Side: To oppose the same torque through the 10 mm carrier arm requires: $F = 12 \text{ N}$

- long radius → lower force,
- short radius → higher force,
- while torque equilibrium remains conserved.

10. Reaction Closure Requirement

The tangential mesh force can only exist if a complete reaction loop exists.

The force path is:

Sun → Mesh → Ring → Carrier → Pivot/F■ → Constraint Closure

If any required reaction element fails to provide the necessary opposing force or torque:

- equilibrium collapses,
- the tangential mesh force cannot be sustained,
- and the defined constraint state no longer exists.

11. Nature of the Cross-Slide

The cross-slide is not treated as a passive decorative guide. It is a geometric constraint manifold.

Its purpose is to:

- enforce translational-only motion of the sun,
- prohibit sun rotation,
- maintain mesh compatibility,
- and redirect forbidden rotational tendencies into frame-coupled reaction forces.

The cross-slide therefore acts as a reaction-transfer structure within the closed-loop constraint system.

12. Important Analytical Clarifications

The following concepts must not be conflated:

- Force
- Torque
- Reaction torque
- Constraint force
- Translational reaction
- Rotational tendency

The system behavior depends heavily on distinguishing these correctly.

13. Common Incorrect Assumptions

The following assumptions change the mechanism and therefore invalidate the intended analysis:

- Allowing the sun to rotate freely
- Treating the ring as fixed
- Introducing compliance without declaration
- Replacing tangential interaction with standard involute normal-force decomposition
- Ignoring the cross-slide constraints
- Treating the carrier arm as passive
- Ignoring the prescribed relative-slip law

Any of these changes alter the state-space and produce analysis of a different system.

14. Experimental Philosophy

The physical prototype is intended as a low-speed experimental validation platform.

Initial operating range: approximately 10–20 RPM.

Planned methodology:

- Run unloaded to lap and settle components.
- Observe stabilization of baseline stepper current.
- Gradually introduce opposing load torque.
- Monitor current draw, smoothness, and structural behavior.
- Identify the onset of measurable hard-part deflection.
- Operate conservatively below that threshold during early testing.

The purpose of this approach is to preserve the intended geometric regime while collecting useful reaction-force and motion data.

15. Final Statement

The S.C.R.E.W.D. mechanism should be analyzed as a constrained orbital reaction system whose behavior is fundamentally determined by:

- imposed kinematic compatibility,
- enforced geometric closure,
- prohibited rotational freedom,
- and continuous reaction-force equilibrium.

The mechanism cannot be analyzed correctly if conventional assumptions are silently substituted in place of the explicitly defined constraints.

The constraints define the system.