Short Recoil System for Artillery Systems and its Application in the Indian Army

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Abstract

Modern artillery faces an increasingly lethal counter-bombardment environment, demanding rapid deployment, high mobility, and the ability to 'Shoot and Scoot' before adversary precision fires can respond. The ongoing war in Ukraine has underscored that survivability is now inseparable from mobility and reduced signatures. Against this backdrop, Soft Recoil System (SRS) technology represents a transformative shift in artillery design and employment. By introducing a controlled forward movement of the gun barrel prior to firing, SRS offsets recoil forces through momentum balancing, reducing trunnion pull by up to 60 per cent. This enables large-calibre artillery to be mounted on significantly lighter carriages or vehicles without compromising performance. This article examines the technical principles, operational advantages, and limitations of SRS, and assesses its relevance to the Indian Army's Field Artillery Rationalisation Plan. It highlights how SRS can enhance mobility, reduce deployment time, lower logistics and manpower requirements, and improve rates and consistency of fire. International developments, including combat validation in Ukraine and indigenous progress through systems such as the Garuda 105 mm, are analysed to draw lessons for India. The article

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argues for a phased adoption strategy encompassing indigenous development, retrofitting of existing guns, and expansion to 155 mm calibres. SRS is presented as a critical enabler for modern, agile artillery, and a strategic opportunity for India's defence industrial ecosystem.

Introduction

Modern artillery systems should be capable of rapid deployment, fire, and move before enemy Counter Bombardment (CB) becomes effective. There is, thus, a requirement for mobile, responsive artillery systems that can provide quick fire support and be adequately mobile to avoid adversaries' CB. The 'Shoot and Scoot' capability has become essential for survival against modern precision strike capabilities, which is more than evident from observations of the ongoing Ukraine War. It is imperative that innovative technologies are incorporated in the artillery systems to acquire this requirement. Adoption of a few emerging technologies may fundamentally change the operation of artillery guns, one of these is the Soft Recoil System (SRS). This can provide unique advantages in terms of mobility and, thus, operational effectiveness.

The Indian Army's ongoing artillery modernisation program under the Field Artillery Rationalisation Plan (FARP) involves significant transformations in artillery firepower capabilities. FARP aims to acquire 2,800 modern 155 mm artillery systems by 2027, including 1,580 towed guns, 814 mounted systems, 180 self-propelled wheeled guns, 100 tracked self-propelled guns, and 145 ultra-light howitzers.[1] It is imperative that this ambitious plan embodies technologies such as SRS. In this article, SRS is discussed with respect to the modernisation of India's artillery.

Technical Principles and Mechanism

The SRS is a paradigm shift from conventional recoil mechanisms, offering up to 60 per cent reduction[2] in recoil forces and enabling the deployment of larger calibre guns on smaller and more mobile carriages and mountings. Unlike traditional systems, where the gun barrel fires from a stationary fully runout position and absorbs the full recoil force, SRS employs a rapid pre-firing forward movement of the barrel that significantly reduces the Trunnion

Pull (TP). The rearward momentum of the barrel is due to the Newton's Third Law of Motion and the principle of conservation of momentum. A conventional recoil cycle requires the gun to absorb the entire recoil force generated by the projectile's forward momentum. In the case of SRS, the forward momentum of the barrel partially counteracts the rearward momentum due to the forward movement of the projectile. This results in significantly reduced net forces transmitted to the trunnions and, thus, the basic structure of the gun.

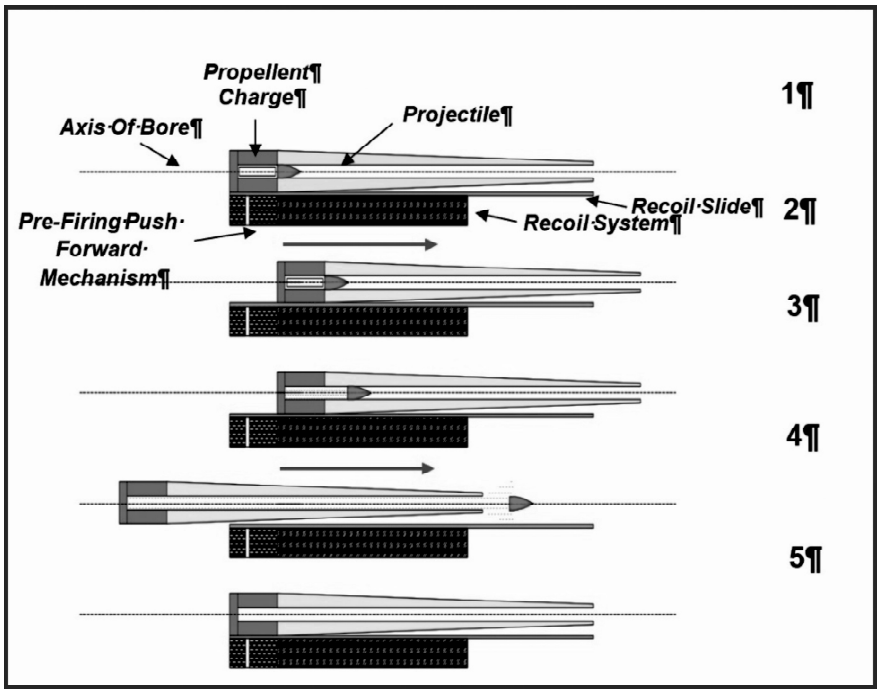

Figure 1: The Broad Stages of SRS
Source: Compiled by the author

The operational sequence of SRS is illustrated in the figure above. It can be described in five stages, as follows:

- **Stage 1: The Gun Barrel (Ordnance) Positioned in a Fully Runout Position**. Though the barrel is at rest any fully runout (advanced position post-recoil) position, it can move forward rapidly along the recoil slide by using the energy stored by compressed gases in hydro-pneumatic system, which can also be termed as Pre-Firing Push Forward System

(PFPFS). It is held in runout position by a restraining mechanism, which can be released when required to initiate the firing sequence.

- **Stage 2: Initiation of the Firing Sequence**. When the firing sequence initiates, the restraining mechanism releases the barrel. The barrel moves forward rapidly using the energy stored in the PFPFS to a pre-determined distance.

- **Stage 3: Ignition of Propellant Charge**. Upon reaching the optimal run-up distance of the barrel, the propellant charge is ignited, and projectile commences its forward movement. The precise timing of the ignition at an optimal runout distance is critical; it is calculated by onboard sensors and electronics based mainly on the type of ammunition. Part of the rearward recoil momentum is offset by the forward momentum of the barrel.

- **Stage 4: Movement to Fully Recoiled Position**. The hybrid recoil mechanism, comprising the conventional recoil system and PFPFS, absorbs the remaining part of the momentum of the recoiling mass and brings it to the rest in the fully recoiled position. The remaining recoil energy is stored in two components in compressed air and gas, one part in the PFPFS for the next firing cycle and rest to push the recoiling mass to fully runout position.

- **Stage 5: Barrel in Fully Runout Position for Next Firing Cycle**. The recoiling mass including the barrel is pushed forward to its fully runout position by compressed gases in the recoil system. The PFPFS has adequate energy stored in the form of compressed gas to move the recoiling mass forward for the next firing sequence.

This SRS technology leverages advanced hybrid hydro-pneumatic systems, which cater to both PFPFS and conventional recoil systems, where compressed air acts as a spring mechanism for storing energy in the Stage 1 position (refer to Figure 1) for forward movement of the barrel. Moreover, the recoil impulse is spread over a longer period rather than over the shorter interval in a conventional recoil system. This distribution of forces significantly reduces peak TP on the basic structure.

Advantages Over Conventional Recoil Systems

- **Reduction of TP**. The reduction of the TP represents the most significant benefit, with SRS systems achieving almost 60 per cent reduction in forces transferred to the platform, as compared to conventional systems. This reduction enables the mounting of larger calibre weapons on significantly lighter carriage and mounting, thus, reducing the weight-to-firepower ratio of the system. This reduction of the TP unleashes a plethora of options and opportunities for the development of artillery systems, which are elaborated further.

- **Reduction of Weight**. Due to the reduced TP, the weight of the bulky systems (trails, spades, or mountings) required to transmit firing stresses to the ground reduces significantly. SRS may enable up to 50 per cent lighter gun carriages compared to conventional recoil systems.[3] This weight reduction directly translates to enhanced mobility. Mounted Gun Systems (MGS) with lighter mounts provides a dramatic advantage in the on-road and off-road mobility of artillery gun systems and enables artillery pieces to be deployed by lighter prime movers or aircraft. The reduced structural requirements simplify logistics and transportation.

- **Higher Rate of Fire**. Higher firing rates represent another operational benefit. SRS can achieve significantly higher firing rates due to increased stability and faster return to runout position.

- **Improved Consistency**. Reduced firing stress allows for a higher degree of stability during firing sequences for higher consistency of fire at the target end.

- **Time to Come into Acton**. With reduced weight, the time required to bring an artillery piece into action is likely to reduce drastically; it is estimated that the time may reduce by half.[4] This parameter is valuable in modern warfare scenarios, where rapid deployment and redeployment are essential for survival.

- **Reduction of Gun Detachments**. The strength of gun detachments is likely to reduce with lighter and efficient systems fostered by SRS. This, again, reduces the logistics tail and enables the manning of additional assets within the same manpower.

- **Reduction of Moving Parts**. The SRS itself is a complex technology, however, the number of moving parts reduce significantly. The reduction of number of moving parts is directly related to reduction of stabilising assemblies like trails, etc. This reduces the maintenance tail and engenders economy.

- **Economy**. In the longer run, SRS is likely to reduce the overall cost of the equipment. While initial system costs may be higher, reduced infrastructure requirements and enhanced capability provide favourable lifecycle economics.

- **Reduced Logistics Trail**. There is a meaningful reduction in logistics tail in SRS-equipped systems. This is primarily due to lighter equipment, where mobile gun mounts will eliminate requirement of separate Field Artillery Tractors (FAT), and result in lesser fuel consumption, limited spares inventory, and reduced manpower.

Limitations

- **Complex System**. The SRS is a complex system which requires sophisticated timing and control systems to ensure proper firing sequence coordination. Moreover, different charges and projectile weights require varying run-up velocities to optimise the system. However, this can be overcome by using high-grade sensors and microcontrollers. This necessitates advanced systems with integrated sensors, which can calculate optimal timing parameters for different ammunition types.

- **Misfires and Premature Firing**. If a round fails to fire during the run-up phase (refer to Stage 2 in Figure 1), the mechanism and force required to bring the forward-moving mass to zero will cause instability to the weapon and may even cause damage. Similarly, premature firing before reaching the optimal velocity and distance can generate immense recoil forces, which will lead to instability or severe damage.

International Adoption and Development

- **Hawkeye: 105mm Mobile Howitzer System (Refer Table 1 below)**. SRS has evoked interest in a few countries to develop this technology. The United States (US) leads in

practical application through the AM General and Mandus Group collaboration, which has developed the Hawkeye 105mm Mobile Howitzer System. This system has undergone extensive testing with the US Army and has been deployed to Ukraine for combat evaluation, representing the first operational use of SRS in an active conflict.[2] The system was delivered in Apr 2024 and immediately entered combat testing, providing real-world performance data under actual battlefield conditions.

Image 1: Hawkeye: 105mm Mobile Howitzer System (Lightweight Trails and Platform Stabilisers)

Source: Mandus Group[3]

- **Brutus: 155 mm System (Refer Table 1 below)**. Brutus is a 155 mm mobile hybrid soft recoil howitzer, jointly developed by AM General and Mandus Group. It employs SRS like that of the Hawkeye 105 mm mobile weapon system. It meets the requirement of a lightweight, vehicle-mounted large calibre howitzer. The equipment was tested in Feb 2018[4]; its present status of induction into the US Army is not known.

Image 2: Brutus 155 mm System (Lightweight Trails and Platform Stabilisers)

Source: AM General[8]

- **Garuda 105/37 mm V2 4×4 Go-Anywhere System (Refer to Appendix A)**. This equipment has been developed by Kalyani Strategic Systems Limited (KSSL), in collaboration with Mandus Group. It demonstrates India's capability to develop indigenous SRS. This ultra-light system, weighing about 900 kgs as compared to the conventional 105 mm systems at 3.2 tons[9], showcases the technology's potential. The system can be mounted on standard tactical vehicles like the TATA 4×4 or lighter platforms, providing exceptional mobility. Initial trials were conducted by the Indian Army with purportedly positive results.[10]

Image 3: Garuda 105/37 mm system (Lightweight Trails and Platform Stabilisers)

Source: KSSL[11]

Weapon System	Garuda 105 V2 4×4 Go-Anywhere Gun by KSSL India[12]	Hawkeye: 105 mm Mobile Howitzer System by AM General and Mandus Group[13]	Brutus Mobile Howitzer System by AM General[14]
Calibre and Mount	105/37 mm Mounted on TATA 4x4/Humvee or 6×6 High-Mobility Vehicles; Towed/Mounted versions	105 mm/3 mm mounted on M1152A1w/B2 Humvee. The system consists of two trucks	155/39 mm
Range	Rocket-Assisted Projectile (RAP): 19.6 kms; Standard: 11.6kms	RAP: 19.6 kms; Standard: 11.6 kms	RAP: 30 kms; Charge 5: 24.7 kms
Traverse	Traverses 30 degrees left and right Elevation-5 to 72 degrees	Traverses 180 degrees. 360 degrees possible, if required. Elevation: 5 to 72 degrees	Traverses 360 degrees Elevation: 5 to 72 degrees
Weight (without Mount)	900 kgs[15] Air-portable using helicopters	1,156 Kgs	2,890 kgs
Rate of Fire	NA	Maximum 8 rounds per hour for 3 mins Sustained: 3 rounds per hour	Max 5 rounds per hour Sustained: 2 rounds per hour
Time to Come into Action and Shoot and Scoot Capability	1.5 mins-Day 2 Mins-Night	Fire a two-round mission and vacate the firing position in 3 minutes, i.e., 1.5 mins to first round fired	NA
Crew	3-5	4 2 in extreme conditions	5-7 5 in extreme conditions
Equivalent Full Charge	4,500	6,500	NA
Carriage Material	High Strength Aluminium	Aluminium Alloy	Aluminium

Table 1: Major Parameters of Current and Under Development Artillery Systems with SRS

The evolution of SRS continues advancing toward more sophisticated and reliable systems. Automation integration is critical in SRS, wherein high technology is used to transfer data between different systems and applications. These systems incorporate advanced sensors and computer control to optimise firing sequences automatically. These systems should be able to work out and apply run-up distances and timings in real time, based on ammunition type, environmental conditions, and target posture.

The initial applications have been focussed on 105 mm calibre, which has been operationalised. However, SRS must be extrapolated to minimum calibre of 155 mm for an optimal operational effect. Brutus 155 mm system, developed by AM General and Mandus Group, is one such example, however, its operational status is not known yet. The differential in weight and mobility from conventional systems is evident in the details of artillery systems in Table 2 below:

Gun/How System	**105 mm Light Field Gun (LFG)[16]**	**Dhanush Artillery System[17]**
Calibre	105/37 mm LFG	155/45 mm with auxiliary propulsion gun
Range	17.2 kms	38 kms with base bleed unit
Traverse and Elevation	Traverses 360 degrees on platform; 5 degrees left and right Elevation-5 to 72 degrees	Traverses 30 degrees left and right Elevation-3 to 70 degrees
Weight	2,380 kgs	13,000 kgs
Time to Come into and out of Action and Shoot and Scoot Capability	2-3 mins	NA
Crew	7	6-8
Equivalent Full Charge	4,500	NA
Rate of Fire	Normal-4 Intense-6 Sustained Operations Up to Charge 5: 1 round per hour for 2 hrs For Super Charge: 1 round per 2 min for 2 hrs	3 Rounds in 15 seconds (burst mode) Sustained Operations: 60 rounds per hour in sustained operations.
Carriage Material	Conventional	Conventional

Table 2: Details of Existing Artillery Systems with Conventional Recoil Systems

The Way Forward

The future development of SRS in India should follow a structured approach, progressing from developed systems like the 105 mm Garuda towards advance technologies. Initially, India should focus on 105 mm systems, where it has already reached a fieldable level of development. Thereafter, 155 mm calibre should be developed building on experience gained with 105 mm systems. The development of SRS variants of Advanced Towed Artillery Gun System (ATAGS) or Dhanush could provide enhanced capabilities while leveraging existing state of indigenous development. The progress on 105 mm and 155 mm systems could progress in tandem.

- **Retrofitting of Existing Equipment.** India has a large inventory of non-SRS artillery equipment, which should be retrofitted with SRS. Once the SRS has been perfected, the existing towed assets should be retrofitted with SRS and mounted on light mounts. The aim should be to hold on to existing barrels and ammunition while replacing the remaining systems with SRS. This will also eliminate the requirement of FAT. Several major retrofitments have been made in Indian Artillery on earlier occasions and should be feasible at the level of base workshops. This turns out to be the only viable option till the entire inventory is 'SRS-ised'.

  The current concept of MGS is a hybrid between self-propelled and towed artillery without SRS. It provides significant mobility advantages over towed artillery. Since, India has a large inventory of towed artillery, adoption of MGS could proceed side-by-side till the retro fitment with SRS is completed and deployed. The target should have all towed assets with SRS while resorting to MGS as a stop gap, in a phased manner.

- **ATAGS.** ATAGS enhancement with SRS would be a force multiplier in the Indian context. The gun's present weight of 18 tons can be significantly reduced by the SRS while retaining its other features. The heavy FATs can be eliminated once the SRS-fitted equipment is fixed on light mounts.

- **Research and Development (R&D).** R&D infrastructure supporting SRS includes specialised manufacturing facilities and design centres. Indian industry has developed expertise in critical technologies including advanced metallurgy, hydraulic systems, and precision timing mechanisms essential for soft

recoil operations. India's pursuit of SRS reflects the nation's broader commitment to developing indigenous defence capabilities under the 'Make in India' initiative. KSSL, a subsidiary of Bharat Forge, has emerged as the primary developer of SRS in India through their Garuda 105 mm howitzer. Defence Research and Development Organisation's involvement in soft recoil research extends through various laboratories, including the Armament Research and Development Establishment and Vehicle Research and Development Establishment. These organisations have developed expertise in advanced recoil mechanisms and continue researching applications for larger calibre systems. Tata Advanced Systems, Mahindra Defence, and Advanced Weapons and Equipment India Limited have the potential to develop SRS. They can create a competitive development environment. Technology transfer opportunities through partnerships with companies like AM General and Mandus Group could provide Indian industry with advanced artillery technologies while supporting its Make in India objectives.

- **Exports.** KSSL is already an arms exporter with export of 100 artillery guns (non-SRS), in 2024. The export order covers the sale of the MAG 155 mm wheeled self-propelled howitzer and ATAGS 155 mm towed gun to Armenia. This achievement showcases the growing presence of India in the global artillery market. KSSL's ability to produce one gun barrel per day with an annual capacity of 350 barrels represents significant industrial capability.[19] The SRS technology is already in the reach of Indian Industry within the existing industrial and technological environment, with KSSL well on the way of perfecting this technology. The growing global interest in lightweight artillery systems creates export opportunities for India. Export validation through international trials will provide additional validation of Indian SRS technology capabilities and demonstrating its export potential.

Conclusion

SRS represents a transformative advancement in artillery systems with relevance for the Indian Army's operational requirements and modernisation objectives. The successful combat deployment of SRSs in Ukraine validates the technology's battlefield effectiveness while demonstrating its readiness for operational use. The

successful development and initial trials of indigenous systems, like the Garuda 105 mm, demonstrate India's capability to develop and deploy this advanced technology independently. Initial trials of this technology by the Indian Army provides confidence in the technology's reliability. Looking forward, the Indian Army should pursue graduated adoption of SRS. The technology's potential for enhancing India's capabilities while supporting indigenous defence industrial development makes it a strategic priority, worthy of deserving continued investment and development. Through pragmatic implementation and continued technological advancement, SRSs can provide the Indian Army with the desired artillery capabilities. India should capitalise on the enviable progress already made in this field by its industry in a short period.

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