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GS Paper II: International Relations

1. Pax Silica and Its Importance for India

a. Introduction

In the 21st century, technology has emerged as a decisive source of national power, shaping economic growth, military capability, governance capacity, and societal transformation. Technologies such as semiconductors, Artificial Intelligence (AI), and advanced electronics are now as strategically significant as oil or nuclear energy were in earlier periods.

However, these technologies are critically dependent on complex and highly concentrated global supply chains, especially those involving Rare Earth Elements (REEs) and advanced manufacturing inputs. Disruptions in these supply chains can paralyse entire industries and constrain national decision-making.

It is in this context that the concept of Pax Silica has emerged. It represents an effort by technologically advanced and like-minded countries to build secure, diversified, and trusted technology supply chains, ensuring that technological interdependence promotes stability rather than strategic vulnerability. For India, Pax Silica has direct implications for strategic autonomy, economic resilience, and technological self-reliance.

b. What Is Pax Silica?

Pax Silica is an emerging strategic framework aimed at ensuring peace and stability in the global technology ecosystem.

- *Pax* denotes peace, order, and stability
- *Silica* refers to silicon, the foundational material of semiconductor technology

Together, Pax Silica signifies a global order where critical technology supply chains—semiconductors, AI hardware, and rare earths—are governed by cooperation, transparency, explainability, and trust, rather than coercion or monopoly control.

In essence, it seeks to prevent the weaponisation of technology supply chains in geopolitics.

c. Why Pax Silica Has Become Necessary

i. Centrality of Semiconductors and AI

Semiconductors are the backbone of:

- Digital economy
- Telecommunications
- Defence platforms
- Electric vehicles

- Artificial Intelligence systems

AI systems, in turn, depend on high-performance chips, data centres, and advanced computing hardware. Control over these inputs translates into economic power and strategic leverage.

ii. Concentration of Rare Earth Supply Chains

Rare Earth Elements are essential for:

- Semiconductor manufacturing
- EV motors and batteries
- Renewable energy systems
- Precision defence electronics

Currently, China dominates mining, processing, and refining of REEs, creating a structural dependency for many countries, including India.

iii. Strategic Use of Supply Chains

Recent years have shown that:

- Export controls
- Licensing regimes
- Technology restrictions

can be used as tools of geopolitical pressure. These developments have demonstrated that economic dependence can directly constrain strategic choices, making supply chain security a core national interest.

d. Core Objectives of Pax Silica

The Pax Silica framework rests on three interlinked objectives:

- **Reducing coercive dependencies**
  Avoid excessive reliance on any single country for critical technologies or minerals.
- **Securing end-to-end supply chains**
  From mining and processing to manufacturing, logistics, and digital infrastructure.
- **Building trusted technology ecosystems**
  Based on transparency, reliability, rule-based cooperation, and shared norms.

e. India's Experience: Why Pax Silica Matters

India's own industrial experience highlights the risks of concentrated supply chains.

- Dependence on Chinese rare-earth magnets disrupted automobile and electronics manufacturing.
- Supplies were restored only after restrictive licensing conditions, exposing India's vulnerability to external decisions.

These episodes underline a key lesson:
Technological dependence directly narrows strategic autonomy, especially during geopolitical tensions.

f. Importance of Pax Silica for India

i. Securing Critical Minerals

Pax Silica can help India:

- Diversify sources of Rare Earth Elements
- Reduce exposure to export restrictions
- Support key sectors such as electronics, EVs, renewables, and defence manufacturing

ii. Supporting Semiconductor Mission

India's Semiconductor Mission aims to build:

- Fabrication
- Assembly
- Testing and packaging capabilities

Integration with trusted global supply chains can:

- Enable access to advanced equipment and materials
- Facilitate technology partnerships
- Strengthen India's position in global value chains

iii. Strengthening the AI Ecosystem

India's AI growth is supported by:

- Digital public infrastructure
- Start-up ecosystem
- Large domestic market

Pax Silica can enhance:

- Access to advanced computing hardware
- Research collaboration
- Scalable deployment of Indian AI solutions

iv. Leveraging India's Human Capital

India possesses a large pool of:

- Engineers
- Scientists
- Semiconductor and AI professionals

This allows India to act as a technology partner and contributor, not merely a consumer within Pax Silica arrangements.

g. India's Strategic Value to Pax Silica

India contributes uniquely to the framework through:

- **Market scale**: Large domestic demand
- **Manufacturing potential**: Alternative to concentrated hubs
- **Rule-based democracy**: Enhances trust
- **Digital governance experience**: Proven large-scale deployment capability

As a strategically autonomous country, India also broadens Pax Silica's legitimacy beyond a narrow alliance-centric structure.

h. Challenges and Cautions for India

Despite benefits, India must proceed carefully:

- Domestic semiconductor and AI ecosystems are still evolving
- Risk of asymmetric dependence on advanced technology providers
- Need to preserve policy flexibility and strategic autonomy
- Avoid replacing one dependency with another through restrictive technology regimes

i. China Factor and Emerging Technology Blocs

The global order is witnessing the emergence of parallel technology ecosystems:

- One centred on China-dominated supply chains
- Another around Pax Silica-type trusted networks

India's engagement choices will shape:

- Its long-term technological resilience
- Its position in fragmented global value chains
- Its ability to navigate great-power competition

j. Way Forward for India

India should:

- Engage with Pax Silica in a calibrated and issue-based manner
- Use it to diversify critical minerals and accelerate semiconductor capacity
- Strengthen AI research and hardware access
- Maintain partnerships beyond any single bloc to preserve autonomy

Conclusion

Pax Silica reflects a fundamental shift in global geopolitics, where control over technology and supply chains rivals traditional strategic resources. For India, it offers an opportunity to secure critical inputs, advance frontier technologies, and emerge as a trusted and responsible global technology partner. With a balanced approach, India can leverage Pax Silica to strengthen its technological future while safeguarding its long-term strategic independence.

GS Paper III: Science and Technology

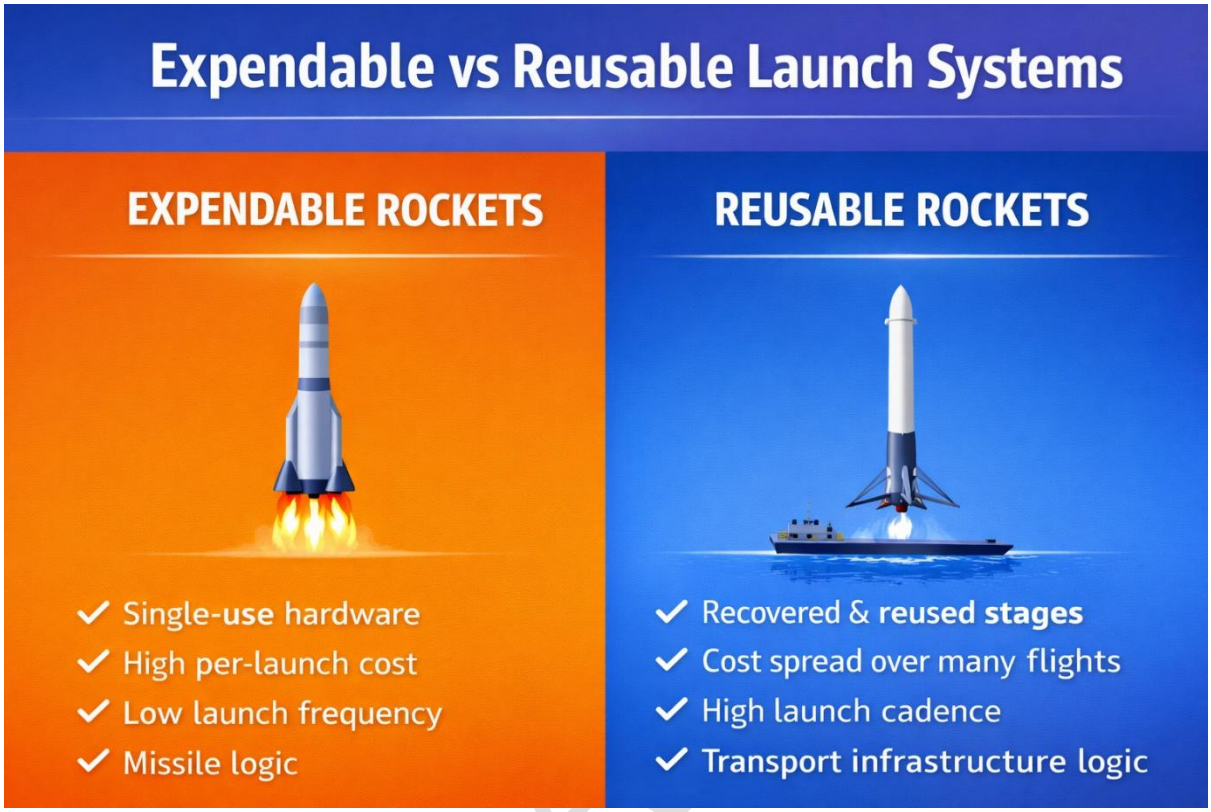
2. Reusability in Space Launch Systems

a. Introduction

For decades, access to outer space was based on expendable launch vehicles (ELVs)—rockets that were used once and discarded after a single mission. While technically reliable, this approach made space activities high-cost, resource-intensive, and slow to scale, limiting participation largely to governments and a few strategic missions.

The emergence of reusable launch systems (RLS) represents a structural shift in space technology. By enabling the recovery and reuse of major rocket components, especially the first stage, reusability transforms spaceflight from a one-time engineering feat into a repeatable transportation system,

similar in logic to civil aviation. This shift is central to making space activities economically viable, environmentally sustainable, and strategically scalable.



b. Why Space Access Has Historically Been Expensive

Rocket Mass and Fuel Constraint

Rocket design is constrained by a fundamental physical reality: fuel is heavy. To lift fuel, additional fuel is required, which further increases mass. This creates a cascading effect where:

- Over 90% of a rocket's launch mass is fuel and fuel tanks
- Less than 3–4% is useful payload

This relationship is explained by the Tsiolkovsky Rocket Equation, which shows that achieving orbital velocity requires exponentially increasing propellant.

Economic Consequence

As a result:

- Rockets are extremely large and complex
- Manufacturing costs are high
- Each launch consumes enormous material and energy resources

This structural inefficiency historically made space access expensive and infrequent.

c. Why Rockets Traditionally Use Multiple Stages

Logic of Staging

To reduce dead weight, rockets are designed with multiple stages:

- Each stage has its own engines and fuel
- Once fuel is exhausted, the stage is jettisoned
- Remaining stages accelerate more efficiently

Economic Limitation of Expendability

While staging improves performance, it also means:

- High-value hardware is discarded after every launch
- Entire rockets must be rebuilt for each mission

India's PSLV and LVM-3, like most traditional launch vehicles, follow this fully expendable model, which keeps per-launch costs high despite reliability.

d. What Is Reusability in Launch Systems?

Reusability refers to the recovery, refurbishment, and repeated use of rocket components, primarily the first stage, which performs the most energy-intensive phase of flight.

Why the First Stage Matters

- Accounts for 60–70% of total launch vehicle cost
- Operates in dense atmosphere
- Experiences maximum mechanical and thermal stress

Recovering this stage yields the highest economic return.

Philosophical Shift

Reusability marks a shift from:

- Rockets as *disposable missiles*
  to
- Rockets as *reusable transport infrastructure*

e. Methods of Achieving Reusability

Vertical Landing via Retro-Propulsion

- Engines are reignited during descent
- Controlled deceleration and vertical landing
- Requires high-precision guidance and navigation

Example: SpaceX Falcon 9, Blue Origin New Shepard

Winged Re-entry and Horizontal Landing

- Vehicle re-enters atmosphere like a spaceplane
- Lands on a runway similar to an aircraft
- Reduces landing stress and refurbishment needs

Indian context: ISRO's Reusable Launch Vehicle – LEX (Landing Experiment)

Sea-Based Recovery

- Downrange landing on autonomous drone ships
- Enables higher payload capacity for certain missions
- Expands recovery flexibility

f. Technological Enablers of Reusability

Reusability became feasible due to multiple technological advances:

Technology Area	Contribution
Engine design	Throttling, multiple restarts
Materials science	Heat-resistant alloys, thermal protection
Automation & AI	Precision navigation and landing
Additive manufacturing	Faster, cheaper component production
Systems integration	Rapid inspection and turnaround

Together, these advances converted reusability from a conceptual idea into an operational capability.

g. Economic Significance

Cost Reduction

- Hardware cost spread over multiple flights
- Launch cost per kg reduced by 5–20 times
- Enables affordable satellite deployment

Higher Launch Frequency

- Faster turnaround times
- Rapid constellation deployment
- Responsive space missions (defence, disaster management)

Commercial Space Expansion

Lower entry barriers have driven private participation. The global space economy is projected to cross USD 1 trillion in the coming decade.

h. Environmental and Sustainability Dimension

Reusable systems contribute to sustainable space activities by:

- Reducing demand for raw materials
- Lowering manufacturing energy consumption
- Preventing ocean pollution from discarded stages
- Minimising space debris generation

i. Importance for Human Spaceflight

Human missions involve:

- Life-support systems
- Redundancy and safety margins
- Higher mission costs

Reusable systems reduce the marginal cost per mission, making:

- Sustained low Earth orbit presence

- Lunar and interplanetary missions more economically viable.

This is critical for long-term human space exploration.

j. Challenges and Limitations

Reusability has practical constraints:

- Material fatigue due to repeated thermal and mechanical stress
- Inspection and refurbishment costs
- Economic trade-off beyond a certain number of reuses

Hence, success depends not on maximum reuse, but on minimal maintenance and rapid turnaround design.

k. Global Status of Reusable Launch Systems

- SpaceX: First-stage reuse exceeding 30 flights
- Blue Origin: Proven vertical landing technology
- China: Active testing by private firms
- Global trend: Shift towards partially and fully reusable architectures

l. India's Position

Current Progress

- Winged RLV experiments
- Autonomous landing capabilities demonstrated

Existing Gaps

- Operational launch vehicles remain expendable
- Higher per-launch costs compared to reusable systems

Strategic Imperative

Reusability is essential for:

- Global competitiveness
- Commercial launch market participation
- Long-term human spaceflight programmes

m. Way Forward

- Integrate reusability into future launch vehicle design
- Reduce stages and improve engine efficiency
- Minimise refurbishment cycles
- Strengthen public–private collaboration
- Align space policy with sustainability and cost-efficiency

Conclusion

Reusability represents a paradigm shift in space access. By transforming rockets from disposable assets into reusable infrastructure, it enables affordable, frequent, and environmentally responsible

spaceflight. For India, advancing reusable launch systems is not merely a technological choice, but a strategic necessity for securing a strong position in the future global space economy.

GS Paper III: Security

3. Digital Arrest and Financial Frauds: Role of Kill Switch and Insurance Mechanisms

a. Introduction

India's rapid shift towards digital payments, online banking, and cashless transactions has transformed everyday economic life by improving convenience, speed, and financial inclusion. However, this digital expansion has also created new vulnerabilities in the form of cyber-enabled financial frauds, which exploit technology, anonymity, and human psychology.

Among these, digital arrest scams have emerged as one of the most damaging forms of fraud. They rely on fear, impersonation of state authority, and real-time coercion to extract money within minutes. Traditional responses based on post-fraud investigation and legal recovery have proven inadequate in preventing losses.

This has necessitated a policy shift towards preventive and system-level safeguards, notably:

- Financial kill switch mechanisms, and
- Insurance-based compensation frameworks for digital fraud victims

Together, these measures reflect a move towards proactive, citizen-centric, and ethically grounded digital governance.

b. What Is Digital Arrest?

Digital arrest is a cyber fraud technique where criminals impersonate:

- Police officers
- Investigative agencies
- Courts or regulatory authorities

Victims are falsely accused of serious offences such as:

- Money laundering
- Illegal financial transactions
- Criminal conspiracies

They are threatened with:

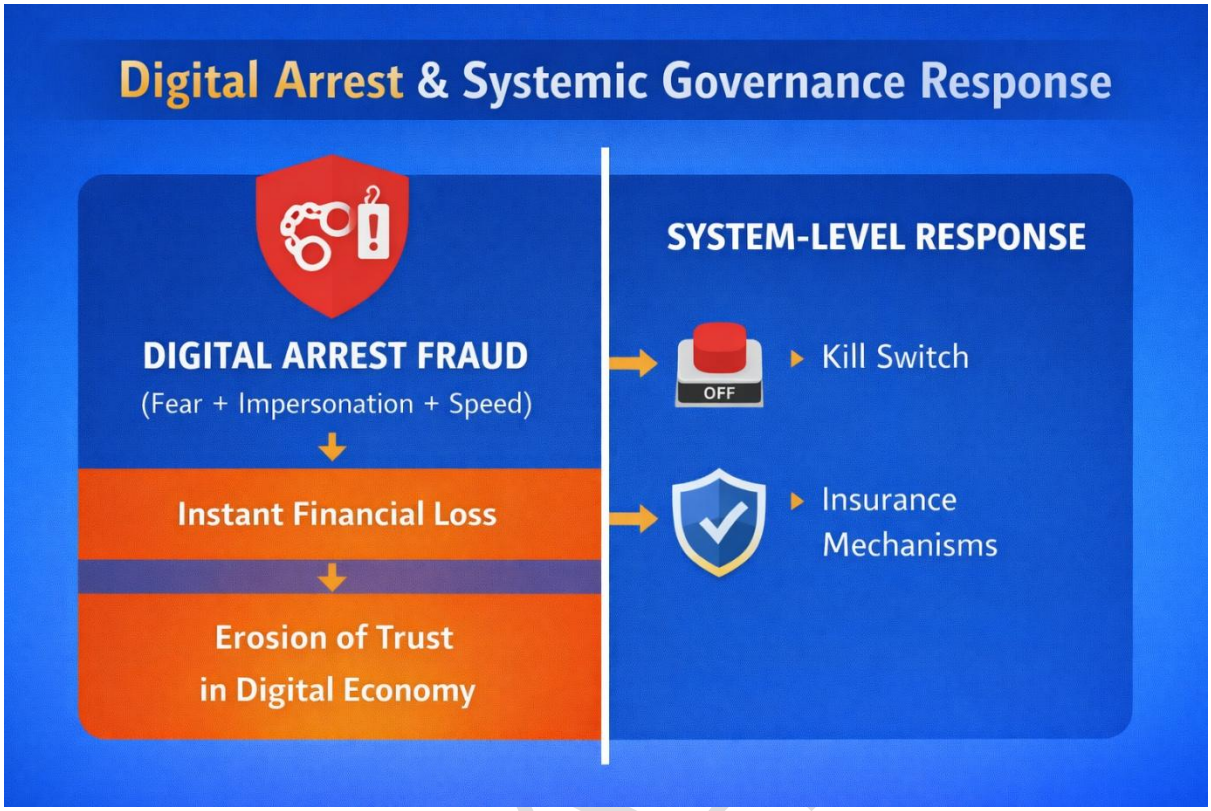
- Immediate arrest
- Account freezing
- Legal action

Under intense pressure, victims are instructed to transfer money to so-called "verification" or "safe" accounts.

Why Digital Arrest Is Especially Dangerous

- It uses psychological coercion, not just deception
- Victims are isolated and prevented from seeking advice
- Video calls, forged documents, and official language enhance credibility

- Elderly citizens and digitally less-literate individuals are particularly vulnerable



c. Governance Challenge Posed by Digital Arrest

Immediate and Irreversible Financial Loss

Digital payment systems allow instant fund transfers, enabling fraudsters to drain accounts within minutes. Recovery is rare, slow, and uncertain.

Erosion of Trust in Digital Systems

Repeated fraud incidents:

- Reduce public confidence in digital banking
- Discourage adoption of cashless payments
- Undermine financial inclusion and e-governance goals

Law Enforcement Limitations

- Funds are quickly routed through mule accounts
- Layering across platforms and jurisdictions complicates investigation
- Cross-border elements delay recovery

d. Financial Kill Switch: A Preventive Tool

Concept and Purpose

A financial kill switch is an emergency mechanism that allows users to:

- Instantly block all outgoing transactions

- Freeze bank accounts, cards, UPI, and wallets

Its core logic is speed over procedure—preventing loss before it occurs.

How the Kill Switch Works

- User activates the switch via banking app, helpline, or portal
- All outgoing transactions are immediately suspended
- Verification is conducted before services are restored

This creates a critical pause during suspected fraud attempts.

Governance Significance

- Shifts focus from post-fraud recovery to real-time prevention
- Empowers citizens with direct control
- Reduces systemic financial damage
- Supports law enforcement by stopping fund movement early

e. Insurance Mechanisms for Digital Fraud Losses

Conceptual Basis

Digital fraud insurance involves compensating verified victims through:

- Banks
- Insurance companies
- In some cases, state-backed mechanisms

Losses are shared institutionally, rather than borne solely by individuals.

Why Insurance Is Necessary

- Digital frauds are increasing in scale and sophistication
- Legal recovery is slow and uncertain
- Victims often lose life savings, causing long-term distress

Insurance:

- Provides financial relief
- Restores trust in digital systems
- Incentivises banks to strengthen fraud detection

This treats digital fraud as a systemic risk, not a personal failure.

f. Governance Perspective: From Individual Blame to Institutional Responsibility

Citizens participate in digital finance with the expectation that:

- Systems are regulated
- Platforms are monitored
- Risks are reasonably mitigated

When fraud arises from systemic vulnerabilities, assigning full responsibility to individuals is neither fair nor sustainable.

Kill switches and insurance mechanisms reflect a shift towards:

- Shared responsibility

- Responsive governance
- Citizen-first policy design

g. Challenges in Implementation

Despite their benefits, these mechanisms face challenges:

- False activation may disrupt genuine transactions
- Integration across banks and platforms is complex
- Insurance costs and moral hazard concerns
- Data security and privacy risks

These require:

- Clear protocols
- Transparent rules
- Strong regulatory oversight

h. Way Forward

India should adopt a comprehensive, nationwide approach by:

- Implementing a uniform kill switch framework
- Ensuring simple activation and rapid verification
- Developing co-insurance models involving banks and insurers
- Strengthening AI-based fraud detection
- Enhancing digital literacy and public awareness
- Improving coordination between banks, regulators, and cyber crime units

Conclusion

As India's financial systems become increasingly digital, cyber frauds are evolving faster than traditional safeguards. Digital arrest scams expose the limitations of post-facto remedies and underline the need for real-time, system-driven protection. Kill switches and insurance mechanisms represent a shift towards proactive, ethical, and citizen-centric governance, where technology not only enables transactions but also protects trust in the digital economy.

Reader's Note — About This Current Affairs Compilation

Dear Aspirant,

This document is part of the PrepAlpine Current Affairs Series — designed to bring clarity, structure, and precision to your daily UPSC learning.

While every effort has been made to balance depth with brevity, please keep the following in mind:

1. Orientation & Purpose

This compilation is curated primarily from the UPSC Mains perspective — with emphasis on conceptual clarity, analytical depth, and interlinkages across GS papers.

However, the PrepAlpine team is simultaneously developing a dedicated Prelims-focused Current Affairs Series, designed for:

- factual coverage
- data recall
- Prelims-style MCQs
- objective pattern analysis

This Prelims Edition will be released separately as a standalone publication.

2. Content Length

Some sections may feel shorter or longer depending on topic relevance and news density.
To fit your personal preference, you may freely resize or summarize sections using any LLM tool (ChatGPT, Gemini, Claude, etc.) at your convenience.

3. Format Flexibility

The formatting combines:

- paragraphs
- lists
- tables
- visual cues

—all optimised for retention.

If you prefer a specific style (lists → paras, paras → tables, etc.), feel free to convert using any free LLM.

4. Monthly Current Affairs Release

The complete Monthly Current Affairs Module will be released soon, optimized to a compact 100–150 pages — comprehensive yet concise, exam-ready, and revision-efficient.