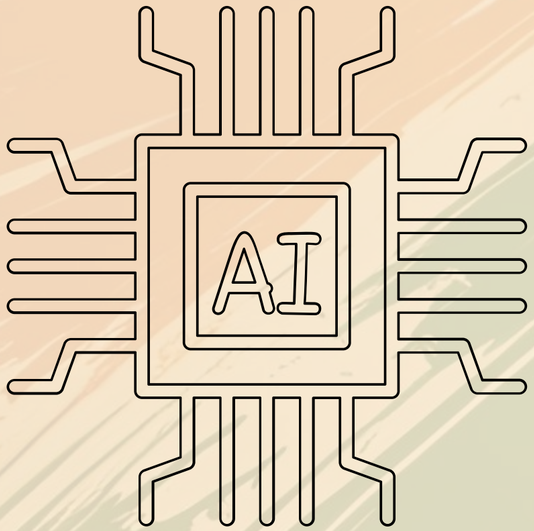
AI-BASED PREVENTIVE MAINTENANCE OF EQUIPMENT AND DEMAND FORECAST OF SPARES



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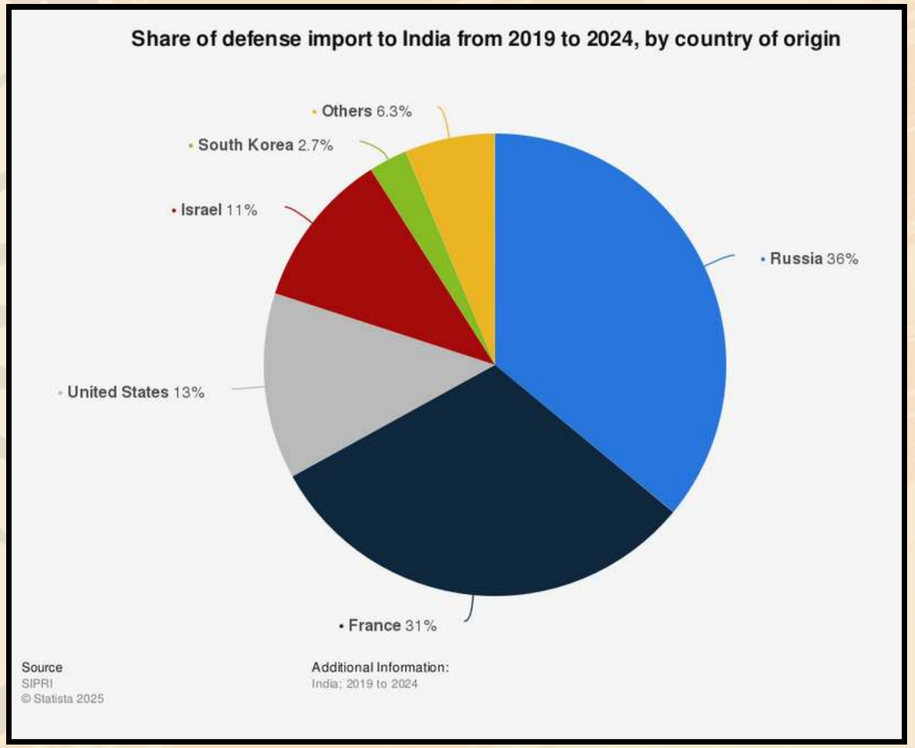
You can never feel alive till the time you have almost died. Life has a special flavor for those who choose to fight, which the protected ones cannot taste.

Capt R Subramaniam. Kirti Chakra (Posth).

INDIA'S DEFENCE IMPORTS AND SUPPLY CHAIN RISKS

India is among the world's largest importers of defense equipment, sourcing critical components and systems from a wide range of countries including Russia, Israel, France, the United States, South Korea, and the United Kingdom. These imports range from engines, missiles, and radar systems to communication equipment, fire-control systems, and night-vision devices. However, this global reliance exposes India to significant supply chain vulnerabilities, especially during geopolitical crises. For instance, sanctions on Russia due to the Ukraine war have delayed the supply of spare parts for Russian-origin platforms like the T-90 and Su-30MKI. Similarly, the Israel-Iran conflict temporarily disrupted shipments of Israeli defense electronics. Trade tensions or diplomatic setbacks with any partner nation can directly impact India's operational readiness. As such, it has become crucial to diversify suppliers, localize production, and leverage AI-based tools to track supplier risks, predict disruptions, and ensure the uninterrupted availability of mission-critical components.



INDIA'S DEFENCE IMPORTS BY COUNTRY OF ORIGIN

Country	Range of Products	Examples
Russia	Fighter jets, submarines, missiles, tanks	Sukhoi Su-30MKI fighter aircraft, T-90 tanks, S-400 missile defense system
United States	Aircraft, helicopters, maritime patrol aircraft	Boeing P-8I Poseidon for maritime surveillance, Lockheed Martin C-130J Super Hercules transport aircraft
France	Fighter aircraft, submarines, missiles	Dassault Rafale multirole fighter jets, Scorpene-class submarines through the P75 project
Israel	Missile defence systems, radars, drones	Barak-8 surface-to-air missile system, Heron UAVs, Spyder air defence system
United Kingdom	Military equipment, advanced technology, and aerospace components	Hawk advanced jet trainer (AJT) aircraft, Rolls Royce Engines, Jaguar Ground Attack Aircraft, Westland Helicopters
Germany	Submarines, engines, and machinery	HDW submarines (Shishumar-class) under Project 75

UNDERSTANDING THE PROBLEMS FACED BY THE INDIAN ARMY

CONTEXT

01 *Recent global events like wars and widespread pandemics have disrupted global defence supply chains, e.g., **COVID-19**, the **Russia-Ukraine War**, to name a few. The most recent were the attacks carried out in response to the **Pahalgam terror attack** on civilians.*

02 *The Indian Army relies on several technology-intensive platforms with components supplied by **multiple vendors** spread across **different countries**.*

CORE ISSUES FACED

01 ***Lack of visibility** beyond 1st-tier suppliers, hence an inability to predict disruptions or demand spikes.*

02 ***Low agility** in responding to supply chain shocks.*

COVID-19 PANDEMIC – A WAKE-UP CALL FOR MILITARY LOGISTICS

The COVID-19 pandemic exposed the vulnerabilities of global supply chains across industries — and defense was no exception. As nations shut down manufacturing plants, ports, and flights, even the most advanced militaries faced delays in receiving critical spares and systems.

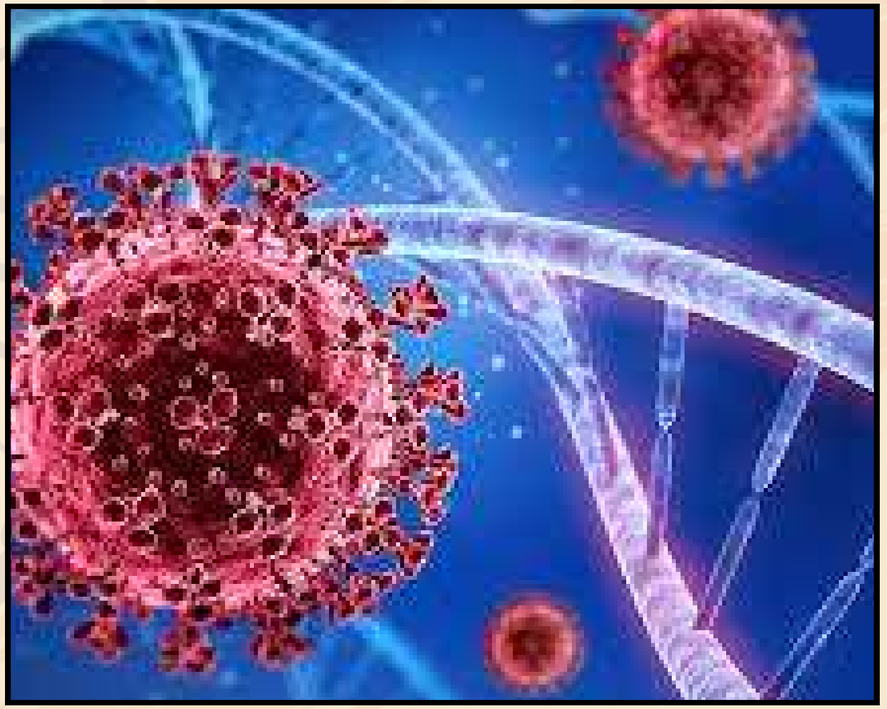
Key Impacts:

- Severe shortages of electronic chips, semiconductors, and precision optical systems.
- Lead times for vital spares increased from 4–6 weeks to 30–50+ weeks.
- OEMs in the U.S., Europe, and Asia reported backlogs and partial shutdowns.

Impact on India:

- Delays in procurement of components for tanks, missiles, and aircraft.
- Inability to service key systems like the T-90 Bhishma, which rely on a multi-national supply chain for electronics, fire control systems, and optics.
- Shift toward stockpiling and localization strategies.

Lesson: AI-powered forecasting and preventive maintenance systems are crucial for building resilience into defense logistics during future pandemics.



RUSSIA–UKRAINE WAR – SANCTIONS, SCARCITY, AND STRATEGIC DELAYS

The Russia–Ukraine war, beginning in February 2022, dramatically reshaped the global defense market. As sanctions were imposed on Russia — a key defense supplier for India — the ripple effects were deeply felt across Indian armed forces relying on Russian-origin systems.

Key Impacts:

- Sanctions blocked exports of Russian military parts, including tank engines, night vision devices, and missile guidance modules.
- Ukraine — a major source of titanium, avionics, and turbine components — halted defense exports entirely.
- Russia redirected its internal production toward its own war effort, leaving foreign buyers in limbo.

Impact on India:

- The T-90 Bhishma, assembled partly in India under license, still depends on Russian components. These became harder to acquire.
- Indian orders for missiles and spares were delayed; some contracts were frozen or renegotiated.
- Domestic R&D programs were accelerated, but local substitutes are still under development.

Lesson: The war underlined the need for geopolitical risk scoring of suppliers, and the development of an AI system that can flag vulnerability points in a multi-tier defense supply chain.

THE 2025 PAHALGAM TERROR ATTACK – STRATEGIC WAKE-UP CALL

In June 2025, the town of Pahalgam in Jammu & Kashmir witnessed a horrific terrorist ambush that killed several innocent civilians. The attack was one of the most brutal in recent years, targeting tourist convoys and triggering widespread outrage across the country.

The strike, carefully timed and executed, exposed deep vulnerabilities in local surveillance, area control, and emergency response infrastructure.

Key Impacts:

- The attack exposed vulnerabilities in area surveillance, mobility of security forces, and vehicle availability during emergency deployment.
- Delays in maintaining or mobilizing armored and patrol vehicles—often due to spare part shortages—were identified as a logistical bottleneck.
- The event renewed public and policy focus on the readiness and availability of frontline systems like the T-90 Bhishma and infantry combat vehicles for deterrence and quick deployment.

Impact on India:

- Increased pressure on intelligence and security agencies to preempt such attacks in high-tourism zones.
- Review of logistics and vehicle deployment protocols, particularly in sensitive districts.
- Demand for better situational awareness systems, real-time surveillance, and armored escort availability.

Lesson: Civilian lives depend on rapid and reliable military support in volatile areas. AI-driven demand forecasting, maintenance planning, and supply chain visibility can ensure that key systems are always ready to respond.

THE IRAN–ISRAEL CONFLICT – GLOBAL RIPPLE EFFECTS ON DEFENSE TRADE

The 2025Iran–Israel conflict escalated rapidly into a regional war, disrupting trade routes, manufacturing, and military partnerships across the Middle East. The ripple effects extended far beyond the region, impacting defense supply chains worldwide.

Key Impacts:

- Middle Eastern sea and air routes were affected, causing shipping delays and material shortages.
- Many Western nations ramped up defense stockpiling, reducing exports to partner countries like India.
- Israel temporarily paused select military exports, affecting radar and electro-optic systems.

Impact on India:

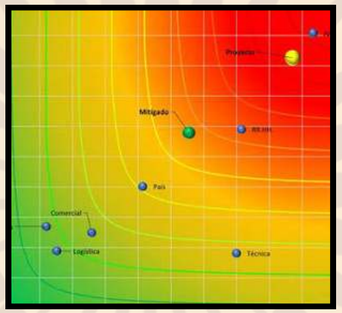
- India, which imports missile seekers, fire control systems, and optics from Israel, faced shipment delays.
- Several T-90 upgrade and modernization projects using Israeli systems were put on hold.
- Revealed the need to develop alternate suppliers and localized tech to mitigate such disruptions.

Lesson: Even conflicts not involving India directly can jeopardize our defense readiness. Strategic foresight, AI-powered forecasting, and supplier diversification are essential for uninterrupted operations.

WHY DOES THIS MATTER?

Combat Readiness

*Enhances **operational efficiency** and **combat readiness**, which depends on the availability of **critical spares**.*



Lower Dependency on Risky Sources

*Avoids **single-point failures** in the multi-tier supply chain by reducing dependency on **hostile** or **risky sources**.*

Make in India

*Supports the **Make in India** initiative by focusing on **in-house** manufacturing of defence products.*

HOW TO TACKLE THESE ISSUES

To address vulnerabilities in the defense supply chain, a multi-pronged strategy is essential. First, the Indian Army and its suppliers must adopt comprehensive supply chain mapping tools to gain visibility beyond the first tier, identifying critical sub-component dependencies and their country of origin. Second, the integration of AI/ML models can help monitor supplier health, geopolitical developments, and logistics data in real time — enabling predictive alerts before disruptions occur. Third, a robust risk classification system should be used to categorize countries and vendors based on their reliability and strategic alignment with India. Finally, proactive measures like strategic stockpiling, indigenization of key components, and the qualification of alternate vendors — especially from neutral or friendly nations — will greatly enhance resilience and response time in times of crisis.

MAPPING MULTI-TIER SUPPLY CHAINS AND USING AI/ML

In today's interconnected defense ecosystem, the supply chain for a single weapon system spans across dozens of companies and multiple countries. However, most organizations — including defense manufacturers — have visibility only up to their first-tier suppliers. The real vulnerabilities often lie deeper, in the second-, third-, or even fourth-tier suppliers, which are prone to disruptions caused by geopolitical tensions, natural disasters, or economic sanctions.

Mapping the full supply chain allows us to:

- Identify critical dependencies across layers,
- Assess geopolitical risk exposure,
- Evaluate the surge production capacity of each component.

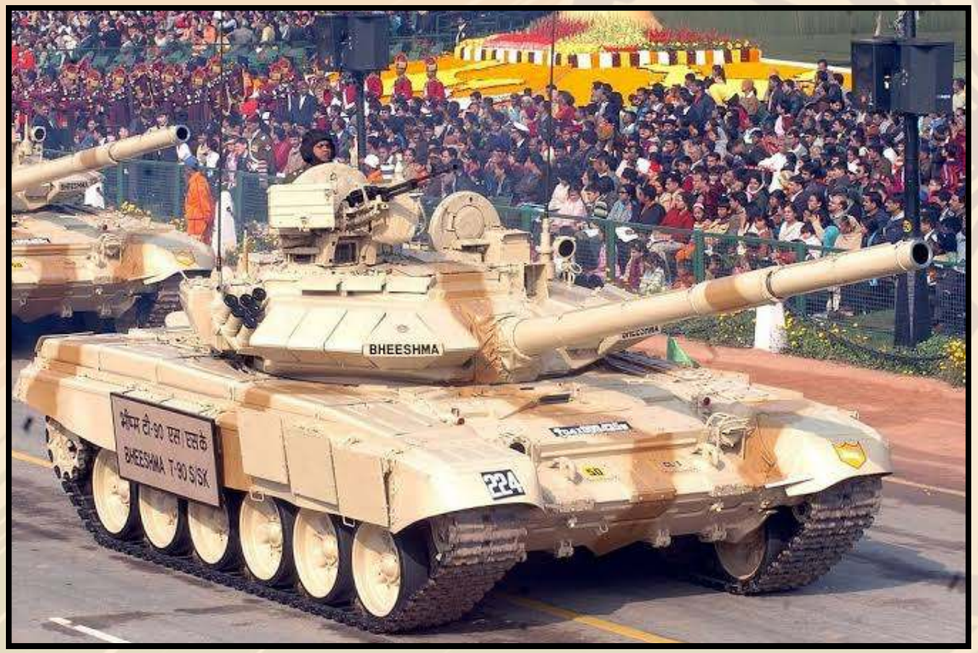
Once this multi-tier mapping is complete, AI and machine learning tools can be leveraged to:

- Continuously monitor suppliers for financial, political, or operational risks,
- Predict disruptions before they occur using real-time data (e.g., news, policy changes, shipment delays),
- Recommend alternative sources or routes, even before a crisis escalates.

For a system that relies on dozens of components from countries with varying relationships with India, such AI-driven supply chain intelligence ensures operational readiness even in the face of global uncertainty.

PRODUCT IN FOCUS

T-90 BHISHMA: India’s Main Battle Tank (MBT)



The **T-90 Bhishma** is a main battle tank (**MBT**) of the Indian Army, procured from **Russia** and also licensed for production in India. It is known for its **firepower**, **speed**, and **protection**, and has been the Indian Army's main battle tank since 2003. It is a Russian-origin tank, but it also has a significant amount of **indigenous** Indian production.

The T-90 Bhishma is a crucial part of India's defense posture, especially along the border with **China** and **Pakistan**. Approximately **83%** of its components are produced in India.

(1) Procurement and Manufacturing

Initial Imports: India initially imported fully built T-90S tanks and semi-knocked down (SKD) kits from Russia for local assembly.
Domestic Assembly: The Heavy Vehicles Factory (HVF) in Avadi, Tamil Nadu, is the primary site for assembly and manufacturing of T-90 Bhishma tanks in India.
Localization Drive: Over time, the proportion of indigenous components has increased, with a focus on local manufacturing of assemblies, sub-assemblies, and critical systems.

(2) Major Suppliers and Components

Component Name	Function	Vendor (if known)	Country
V-92S2 Diesel Engine	Propulsion System	Chelyabinsk Tractor Plant	Russia
Thermal Imager	Target Acquisition	Peleng	Belarus
Communication Radio	Internal Communications	BEL / ECIL	India
Kontakt-5 ERA	Tank Protection	Russian OEM	Russia
Composite Armor Plates	Tank Protection	DRDO / Mishra Dhatu Nigam	India
1A45T Fire Control System	Targeting	UralVagonZavod	Russia
Gunner’s Primary Sight	Target Acquisition	Peleng	Belarus
Commander’s Panoramic Si	Surveillance & Targeting	Thales (used in upgrade)	France
Navigation System	Battlefield Navigation	DRDO / BEL	India
Digital Fire Control Unit	Ballistic Computation	BEL	India
Track Assembly	Mobility	HVF / Russian OEM	India / Russia
Gun Barrel (2A46M)	Main Weapon System	OFB under license	India / Russia
Smoke Grenade Launchers	Concealment / Self-protect	BEL / Russian OEM	India / Russia
Autoloader System	Ammo Loading	Russian OEM	Russia
Gun Stabilization Unit	Targeting System	Russia / India	Russia / India

(3) Indigenisation and Upgrades

Mark-III Modernization: The T-90 Bhishma Mark-III is in line with India's "Make in India" program thanks to upgraded indigenous systems like digital communication, superior fire control, and better armor.
Higher levels of indigenous content are required in all new and upgraded production, with an emphasis on using local vendors for sub-systems, electronics, and armor.

In order to encourage local production, supply chain integration has mandated that both Western and Russian suppliers set up or collaborate with Indian manufacturing facilities.

(4) Supply Chain Management and Policy

Defence Industrial Corridors: To assist regional supply chains for aircraft such as the T-90 Bhishma, India has set up defence industrial corridors in Tamil Nadu and Uttar Pradesh.

Inventory and Maintenance: To expedite procurement, inventory, and maintenance for key platforms, such as the T-90 Bhishma, the Indian Army and Ministry of Defence have jointly adopted supply chain and logistics reforms.

Export Controls: All imported components, particularly those with sensitive or dual-use technology, are subject to stringent monitoring and end-user certification.

(5) Recent Developments

More than 200 components and sub-assemblies are being rebuilt using Indian capabilities as part of the Indian Army's recent repair and upgrades of its T-90 fleet.

Private Sector Participation: Particularly for electronics, armor, and support systems, the supply chain currently consists of an increasing number of Indian start-ups, MSMEs, and private sector companies.

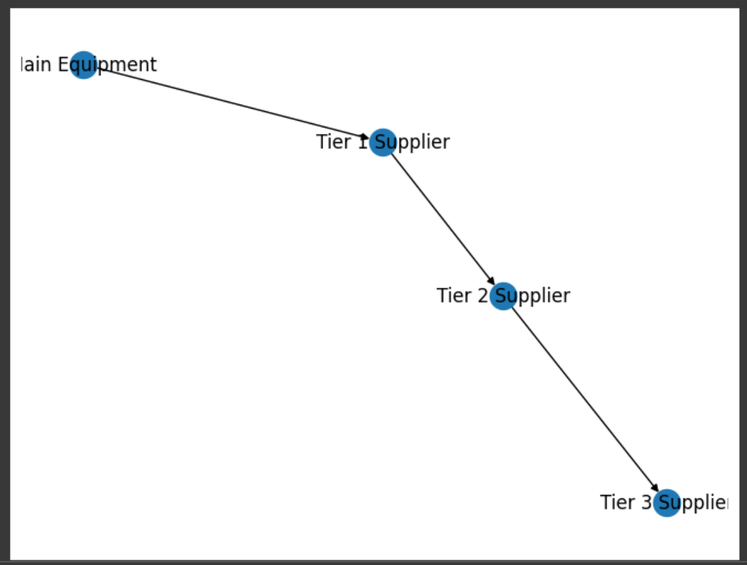
Future Roadmap: By 2028, the T-90 Bhishma supply chain is expected to be almost entirely indigenized, lowering dependency on imports and increasing operational independence.

(6) Aspects of Supply Chain

Aspect	Details
Assembly Location	HVF Avadi, Tamil Nadu
Key Imported Components	Engine, main gun, some electronics (in early batches)
Indigenized Components	Hull, chassis, armor, electronics, ammunition (increasing share)
Major Indian Suppliers	HVF Avadi, Bharat Electronics Ltd, private MSMEs
Policy Drivers	Make in India, Defence Industrial Corridors, positive indigenization lists
Upgrade Focus	Firepower, digital systems, indigenous armor, supply chain resilience

SUPPLY CHAIN CODE

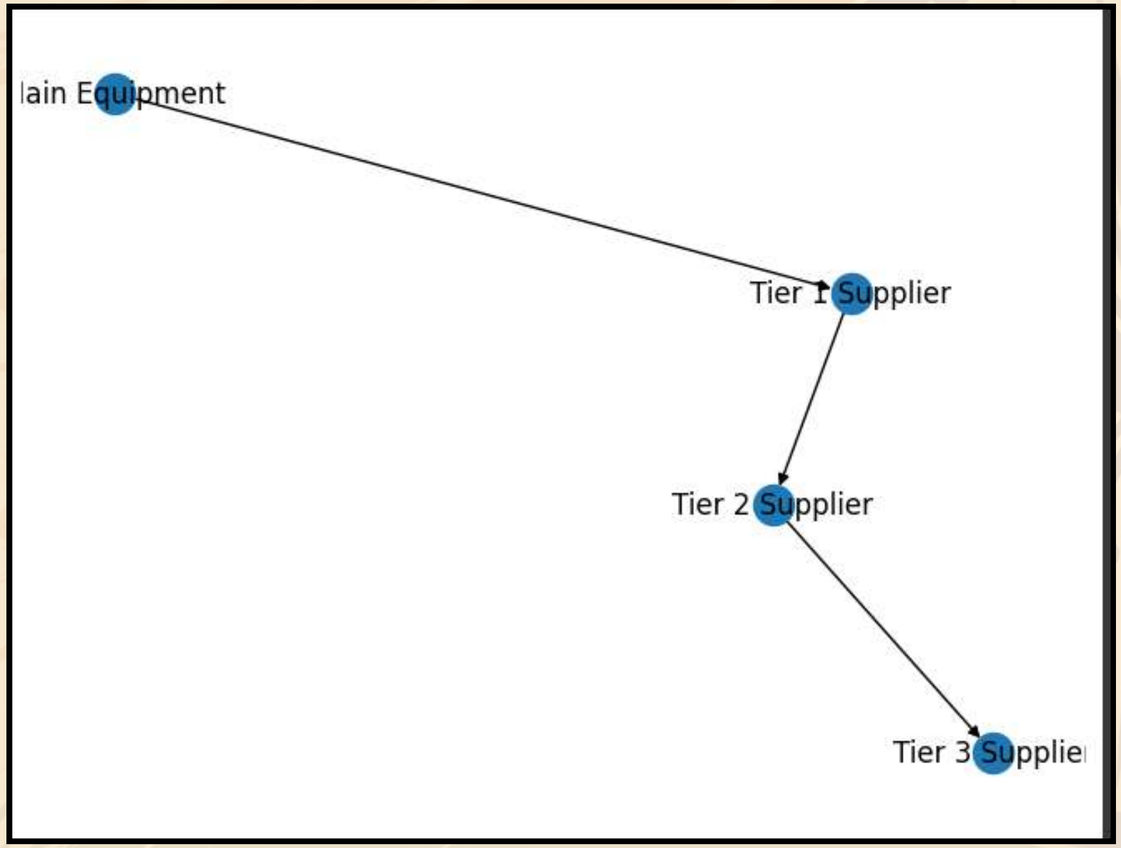
```
[ ]  import networkx as nx
     import matplotlib.pyplot as plt

     G = nx.DiGraph()
     G.add_edges_from([
         ('Main Equipment', 'Tier 1 Supplier'),
         ('Tier 1 Supplier', 'Tier 2 Supplier'),
         ('Tier 2 Supplier', 'Tier 3 Supplier'),
     ])

     nx.draw(G, with_labels=True)
     plt.show()
```



This snippet of the code on different Tiers of component suppliers to the Indian Army:

1) Main Supplier
2) Tier 1 Suppliers
3) Tier 2 Suppliers
4) Tier 3 Suppliers

OUTPUT OF SUPPLY CHAIN CODE



	A	B	C	D	E	F
1	Component Name	Function	Vendor	Country	Risk Category	Alternate Supplier Suggestion
2	V-92S2 Diesel Engine	Propulsion System	Chelyabinsk Tractor Plant	Russia	Friendly	No alternate needed
3	Thermal Imager	Target Acquisition	Peleng	Belarus	Moderately Hostile	Elbit Systems (Israel), Thales (France)
4	Communication Radio	Internal Communications	BEL / ECIL	India	Friendly	No alternate needed
5	Kontakt-5 ERA	Tank Protection	Russian OEM	Russia	Friendly	No alternate needed
6	Composite Armor Plates	Tank Protection	DRDO / Mishra Dhatu Nigam	India	Friendly	No alternate needed
7	1A45T Fire Control System	Targeting	UralVagonZavod	Russia	Friendly	No alternate needed
8	Gunner's Primary Sight	Target Acquisition	Peleng	Belarus	Moderately Hostile	Elbit Systems (Israel), Thales (France)
9	Commander's Panoramic Sight	Surveillance & Targeting	Thales	France	Friendly	No alternate needed
10	Navigation System	Battlefield Navigation	DRDO / BEL	India	Friendly	No alternate needed
11	Digital Fire Control Unit	Ballistic Computation	BEL	India	Friendly	No alternate needed
12	Track Assembly	Mobility	HVF / Russian OEM	India	Friendly	No alternate needed
13	Gun Barrel (2A46M)	Main Weapon System	OFB under license	India	Friendly	No alternate needed
14	Smoke Grenade Launchers	Self-protection	BEL / Russian OEM	India	Friendly	No alternate needed
15	Autoloader System	Ammo Loading	Russian OEM	Russia	Friendly	No alternate needed
16	Gun Stabilization Unit	Targeting System	Russia / India	Russia	Friendly	No alternate needed
17						
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SUPPLY CHAIN CODE

```python
def calculate_risk(ownership, origin_country):
    score = 0
    if ownership == 'SOE':
        score += 1
    if origin_country in ['China', 'Pakistan', 'Turkey', 'Afghanistan', 'Bangladesh']:
        score += 5
    return score
```

This code assigns a score to different countries that have military trade relations with India based on their hostility towards India.
We can replace the parts imported from a country which has high hostility towards India with a country which has low hostility towards India this is especially important after the India–Pakistan conflict that started in May 2025 and lasted 7 days.

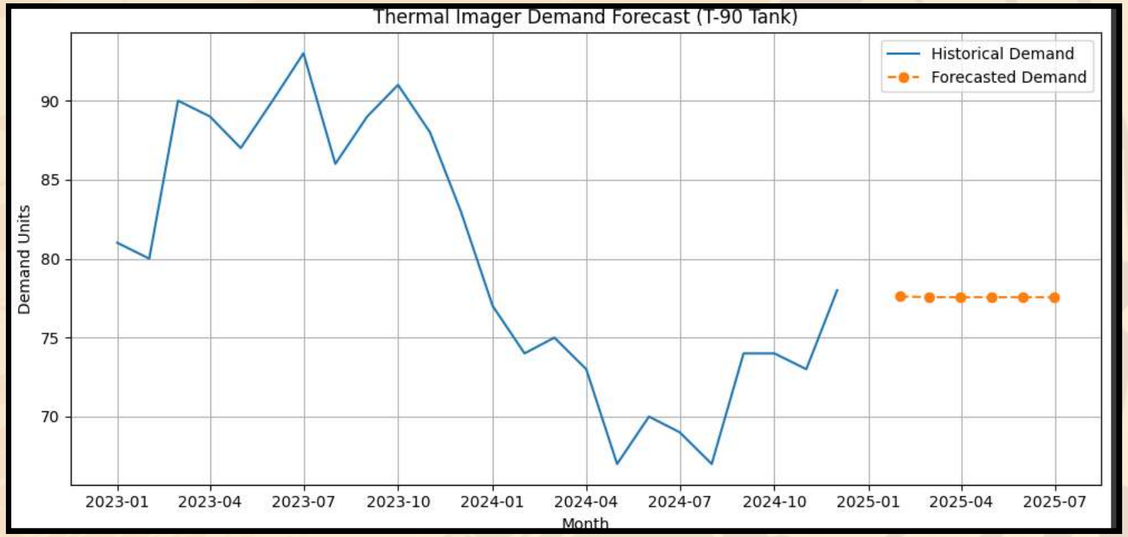
SOE – State Owned Enterprise

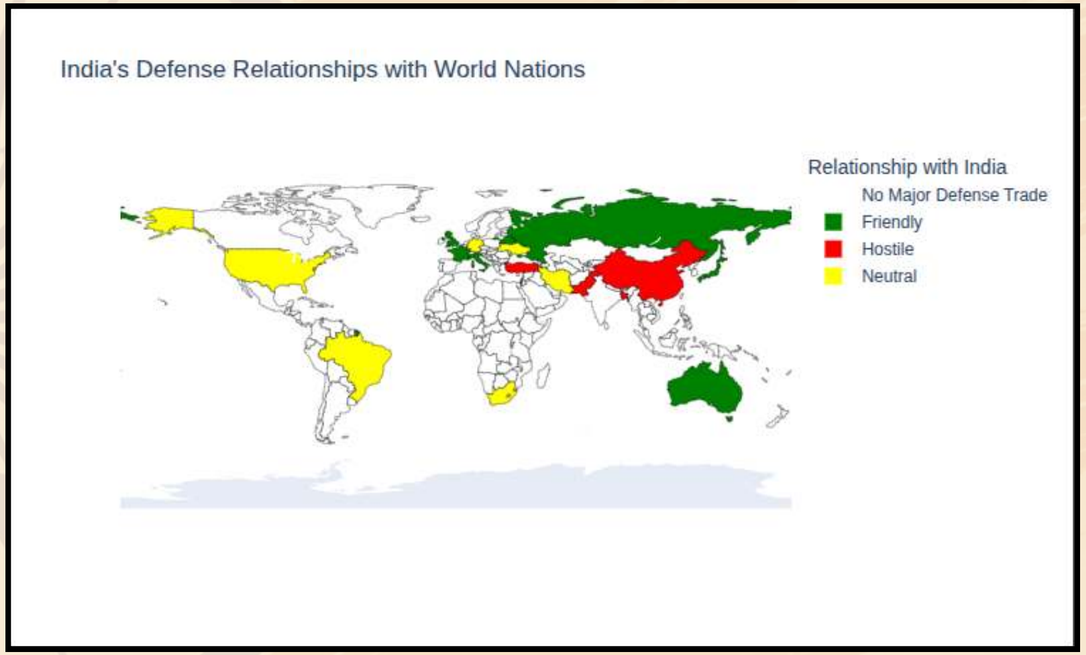
SUPPLY CHAIN CODE

```python
import pandas as pd
from prophet import Prophet

# Step 1: Load demand dataset (from thermal_imager_demand.csv)
demand_data = pd.read_csv('thermal_imager_demand.csv')  # Must have columns: Month, Component, Demand Units

# Step 2: Supplier capability database
supplier_info = {
    "MTU (Germany)": {
        "Country": "Germany",
        "Annual Capacity": 1000,
        "Quality Certs": ["ISO 9001", "NATO Standard"],
        "Past Export to India": True,
    },
    "Cummins (USA)": {
        "Country": "USA",
        "Annual Capacity": 1200,
        "Quality Certs": ["ISO 9001"],
        "Past Export to India": False,
    },
    "Ebit Systems (Israel)": {
        "Country": "Israel",
        "Annual Capacity": 800,
        "Quality Certs": ["ISO 9001", "NATO Standard"],
        "Past Export to India": True,
    }
}

# Step 3: Alternate suppliers by function/component
alternate_suppliers = {
    "Propulsion System": ["MTU (Germany)", "Cummins (USA)"],
    "Targeting": ["Raytheon (USA)", "Ebit Systems (Israel)"],
    # You can add more components here
}

# Step 4: Required quality standards per component
quality_standards = {
    "Propulsion System": ["ISO 9001", "NATO Standard"],
    "Targeting": ["ISO 9001"],
}
```

This is the ML Forecast for demand of thermal imager if a source country is hostile towards India if yes then it searches other countries who are friendly to India also checks for the quality for the alternate supplier and whether it meets the standards of Indian Army.

OUTPUT OF SUPPLY CHAIN CODE





THANK YOU

"We believe this approach can enhance India's defense resilience and readiness."

Link to the videos:
https://drive.google.com/drive/folders/1dtgtRd9A51m9yyBFoUByZk4K5b4eJu3X?usp=drive_link