Risks of disruption of supply chains for military and aerospace industries

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A case study : « Rare Earths Magnets » in PGMs.
(Precision Guided Munitions)

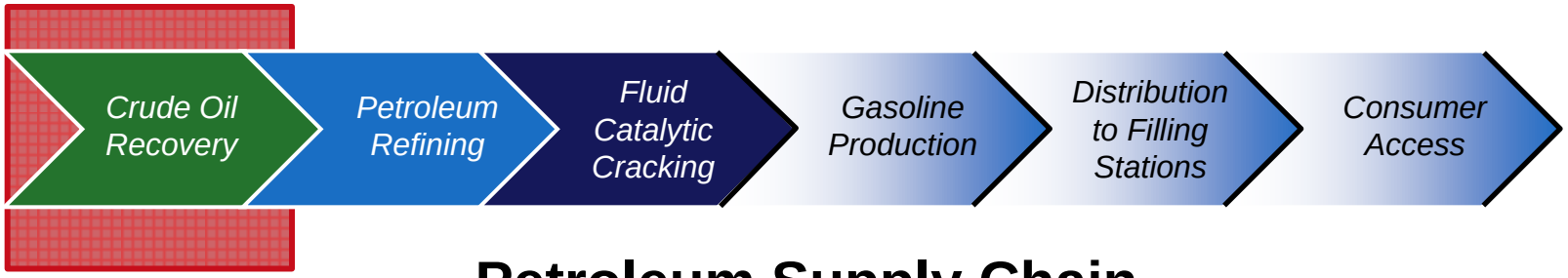
- "Rare earth magnets" (Nd-Fe-B) ⟶ a vast reduction of size for electric actuators
- Recent PGM are designed "around" these actuators ⟶ no substitute available without major redesign of the weapon
- Up to 1995 the "Rare earths magnets" supply chain for the needs of NATO's forces was safe, with a mine and a magnet production plant in the USA.

Actions of China: take hold of most of the supply chains of "rare earths" products, from mining to the high value added final products:

- sale to China of the US magnet plant in 1995: plant moved to China in 2001
- closing down of the US mine in 2002 (unprofitable due to Chinese prices)

So from 2001 on, supply of "Rare earth magnets" for NATO's systems was extremely vulnerable to hostile action. This situation was only detected in 2009,(China imposes quotas on "Rare Earth" exports)

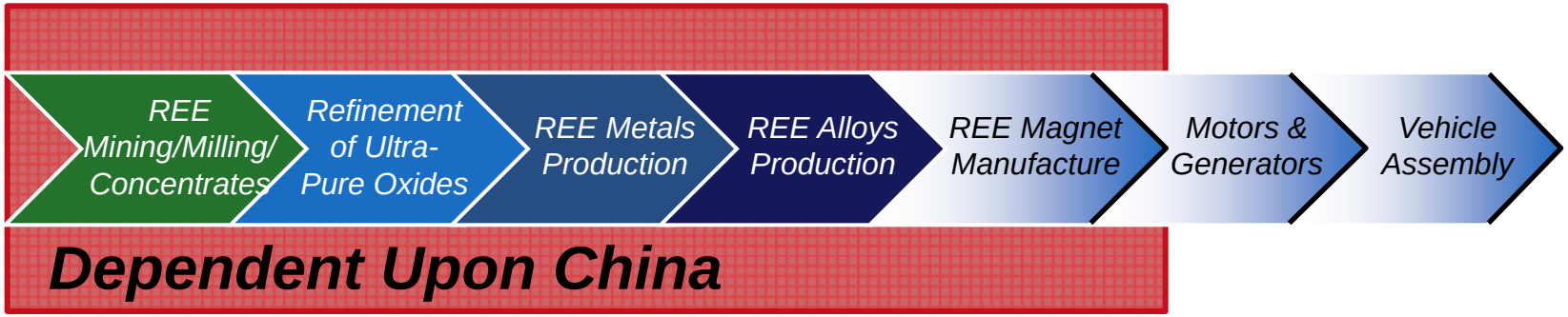
Actions of China: taking hold of the « Rare earth magnets » supply chain



Petroleum Supply Chain

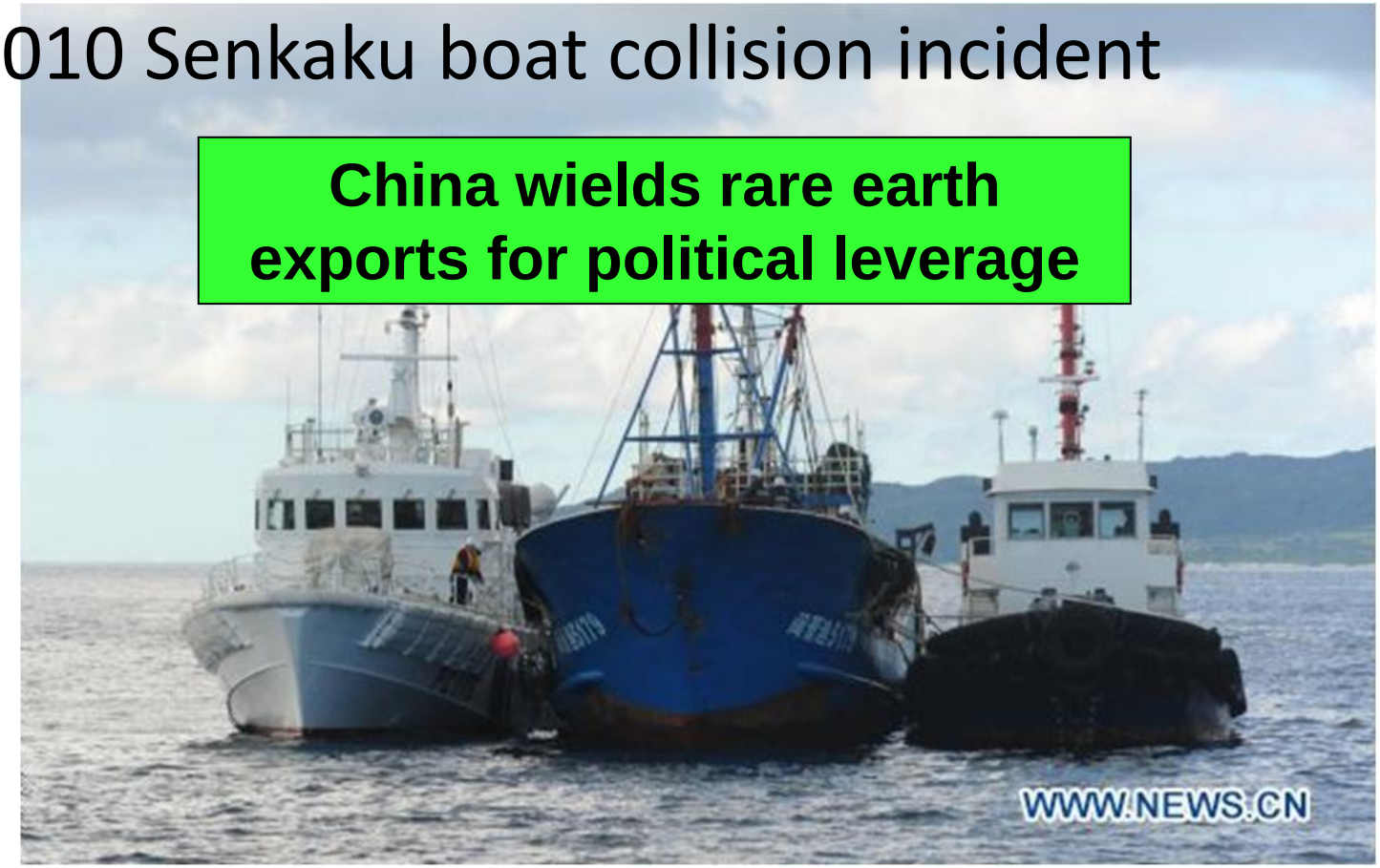
Source:
STO-AVT- ST-002

Hybrid Vehicle Supply Chain



Chinese Policy

- Suspension of REE exports to Japan following 2010 Senkaku boat collision incident



Slide from STO-AVT-ST-002 sept 2011

STO/AVT actions for scarcity of materials

- **The Applied Vehicle Technology Panel (AVT) of the Science and Technology Organization (STO)** launched since 2008 a number of actions on the subject of "scarcity of materials:

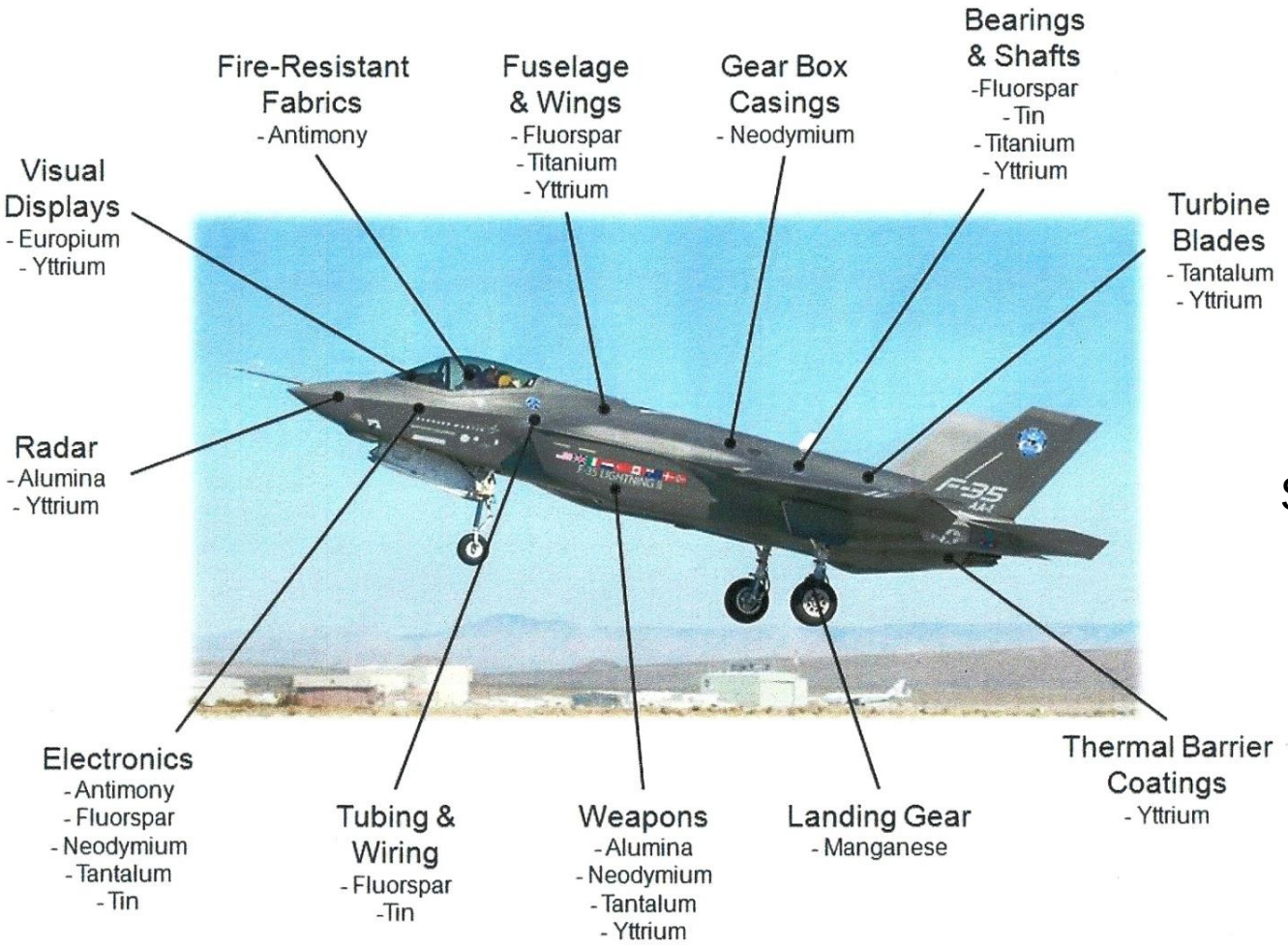
  Specialists teams, specialist meetings, technical courses and the task group AVT-196**.**

- **The task group AVT-196 (2011-2016) " Impact of scarcity of strategic materials on NATO operations"**

  Objectives of the task group:

  - Evaluate the risks of non availability of materials, elements and spare parts for NATO military systems
  - Evaluate the consequences of such disruption of supplies on NATO operational effectiveness
  - Look at the effects of possible mitigation actions

Material use: some examples



Source: DLA

The list includes materials other than rare earths!

Why a novel « supply risks and consequences » analysis

EC and DOE methods where considered. These methods are valuable, but are not adapted to the military case:

1) **They are concentrating on mineral resources:.**
We definitely have to look at any possible disruption of military supply chains.
:.

2) **They are not considering defence specific supply risks**:

- The defence market is not a free market even in peacetime.
- Beyond NATO countries, there are neutral countries, and potential adversaries.
- Neutral countries may decide to bar the sale of any hardware for military end-use.

3) **They are considering only economical consequences**, mostly in term of the financial effect on the business affected:. AVT 196 objective is : impact on NATO forces operational capabilities

For criticality assessments the EC and DOE studies are using weighted average methods, combining quotations for different parameters: not very well adapted to the military problem.

So AVT-196 opted for the use of decision matrices, more flexible and more adapted to the specifics of defence.

An evaluation of two parameters:
- the number of companies or plants producing the required product installed within NATO
- the number of neutral countries producing the required product

The resulting scores from one (least critical) to four (most critical) are given by the criticality matrix

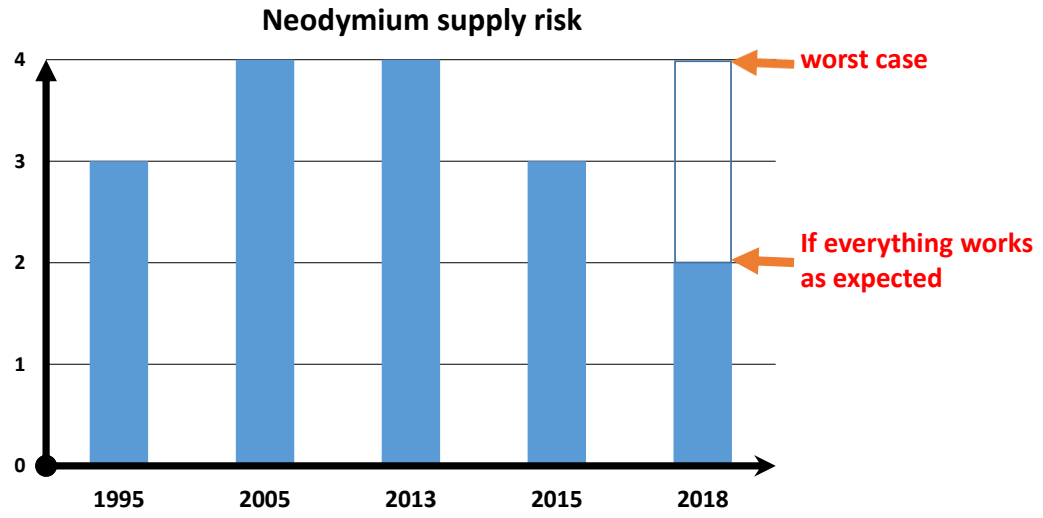
<u>This analysis must be repeated for all weak links in the supply chain</u>

DEFENSE SPECIFIC SUPPLY RISKS

		Number of producers in Nato countries			
		3 or more	2	1	0
Number of neutral countries producing the material	3 or more	0	0	1	2
	2	0	1	2	3
	1	1	2	3	4
	0	1	2	3	4

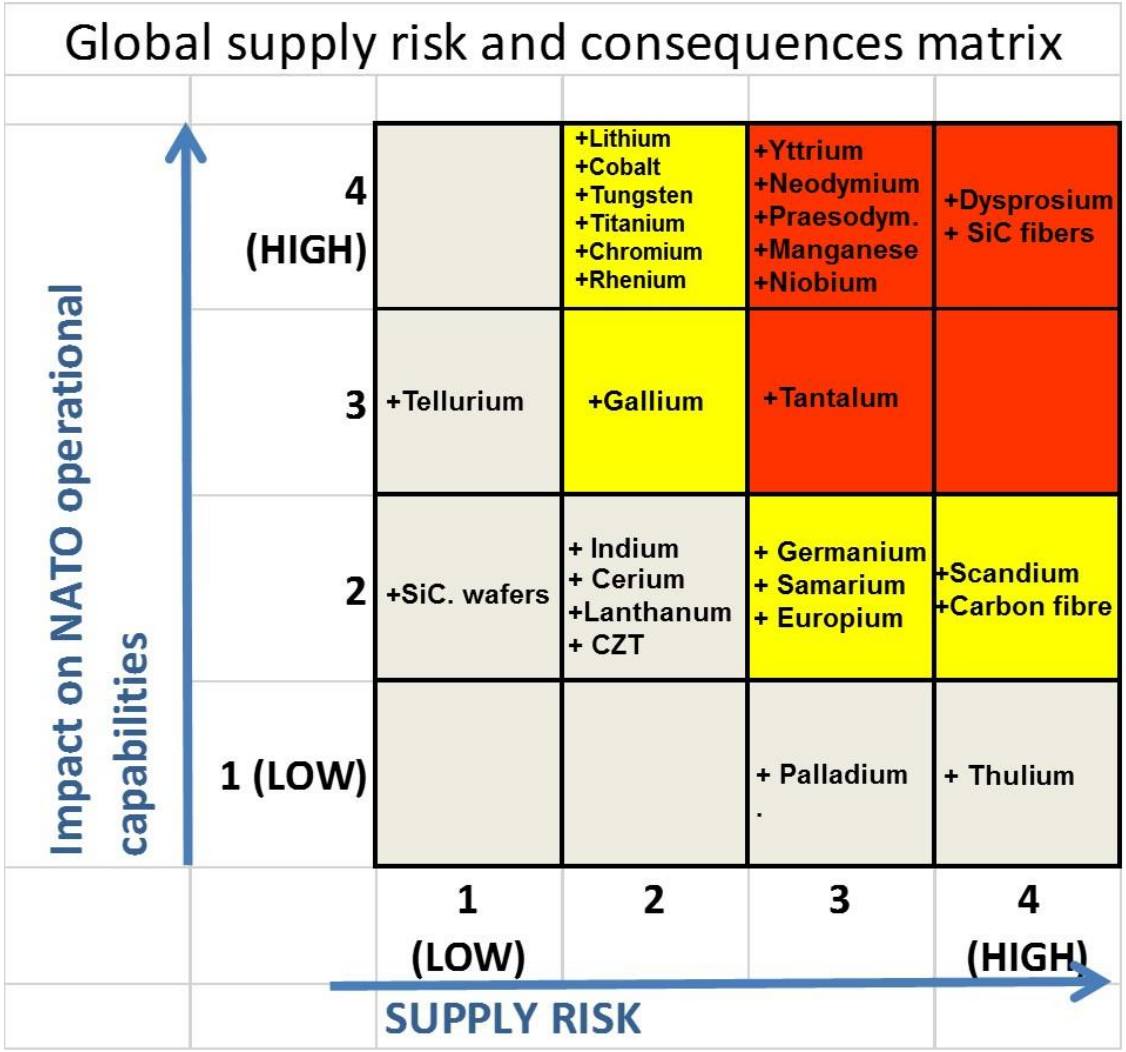
Application of AVT-196 method to « rare earth magnets »

Material:neodymium	Atomic number:60
Characteristics	Neodymium (Nd) is a light rare earth element (REE) used in high-strength permanent magnets (PMs). Other applications include use as a component of didymium (mixture of Nd and praseodymium) for coloring glass and ceramics, astronomical instruments and glass lasers.
Main uses	
Civilian	The major use of Nd is high-strength magnets formed from an alloy with iron (Fe) and boron (B). NdFeB magnets are used extensively in high-efficiency, brushless motors in electric vehicles and in direct-drive generators
Miltary	Very important to magnets used in recent guided munitions and as generators,electric motors and servo controls in important vehicles and weapon systems
General supply risk	
Basic availability(40%) cotation: 2	Demand for NdFeB magnets is likely to exceed producers' ability in the short term.New mines will significantly increase supply by 2015. Recycling magnets will be of interest but only in long term when enough large magnets containing systems will be discarded.
Political, regulatory and cotation: 3	Nd is mainly produced from mines in China.New non-Chinese mines will increase diversity significantly by 2015, even though global supply is projected to remain tight.
Producer diversity (30%) cotation: 3	Nd is mainly produced from mines in China.New non-Chinese mines are increasing diversity significantly in 2015, even though global supply is projected to remain tight.
	Resulting quotation:3
Defense specific supply risk	
Mining Resulting Quotation:3	one mine operating in USA one neutral country producing ore (Australia) all the rest coming from China. Magnet recycling not operationnal
Supply chain weak point 1 Resulting Quotation: 3	Ore refining and metal prod.: only in China and Japan(Other facilities are coming on line:Malaysia, Estonia, potentially France).
Supply chain weak point 2 Resulting Quotation: 3	Magnet production: one plant in USA, plants in Japan (note that the problem is common with Praesodymium and Dysprosium)
Supply risk final quotation: 3	
Impact on NATO operational capabilities	
Criticality for operational capacities quotation: 3 to 4	For the affected vehicles lack of spare parts may prevent operations For the affected precision munitions, no new production feasible
Substituability quotation: 5	For most cases no substitution possible without a complete redesign
Impact on NATO operational capabilities final quotation: 4	



The method developed in AVT-196 has predictive capabilities. If that method was applied in the past, it would have permitted an early detection of the incipient "Rare Earth" crisis.

AVT-196: SYNTHESIS OF CRITICAL CASES



Valid:
Sept. 2015

AVT-196: Return from experience

- The “rare earths crisis” went largely undetected, and not acted upon, for years . It is still not completely over in 2017!
- Lack of some critical components can impair large sections of the military system.
- Mining is not anymore the worst problem for the military supply chains.
- Stockpiling of raw materials may be useless: other weak links in the supply
- Experience has shown that reinstating a lost critical manufacturing facility if often more expensive (and riskier) than maintaining it alive when it is still possible to do so.
- The STO AVT 196 Task Group has developed a novel method(using decision matrices) to evaluate military supply risks. This methods has demonstrated predictive capabilities.

Civil and military aerospace industries: much in common:

- Long development times, long production runs, very long service lives!
- Mostly similar materials and technologies (synergies?)
- Both have safety of flight constraints (qualification/certification)
- Both relying on a network of highly specialized providers (difficult to replace)
- The main difference: less risks from procuring abroad for civilian aerospace **but** :

  - civilian aircraft are very often dual-use
  - aircraft industry is a high profile industry, tempting to many developing countries

Civil aerospace industry may benefit from a supply risk analysis based on a variant of AVT196 method