INDIAN AIR FORCE: BUILDING INDIGENOUS RESEARCH CAPABILITY

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In December 1903, the first powered and "heavier than air" manned flight flew 20 feet above the ground, to a distance of 120 feet and for duration of 12 seconds. A little over a century since, air forces of the world have emerged as a technologically intensive arm of the nations' military forces. Such intense development in technology could not ever be predicted in the December of 1903. Each successive decade, and even each progressive year (at times) has witnessed aviation technology progress by leaps and bounds. We have witnessed how the revolution in military affairs (RMA) has introduced concepts like information warfare (IW), sophisticated smart bombs and precision guided munitions (PGMs), and a marked change from platform-centric warfare to network-centric warfare, thereby, reducing the observe, orient decide, act (OODA) loop to near real-time execution. The virtual adaptation of the "system of systems approach" to all aspects of warfare has led to greater synergy and interoperability.

Gradually, but surely, air power has been asserting itself as an increasingly potent factor in conventional warfare. The single most important variable

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that has altered the calculus of conventional capability mix and elevated air power to a dominant status is technology. Compared to land and maritime forces, air power is unique in its reliance on technology. Because an air force is a technology-intensive outfit, technological progress, or lack of it, will ultimately determine the potential and limits of air power. Technological advances have traditionally yielded military advantages from the earliest times and in so doing, changed the relative balance between offensive and defensive capabilities. In this, emerging and existing technologies presently favour air power at the cutting edge which has provided a fillip to air power to the extent that air power can today claim to be offensive by definition. This is because air power is now relatively invulnerable and exponentially more capable, thanks to stealth, electronic warfare and precision munitions technologies. A yet more significant force multiplier lies in IW capabilities with the exploitation of space-based and airborne sensors coupled with real-time data transmissions. Such capabilities of aerospace power will enhance not only "dominant battlespace awareness" and "operational synchronisation" but also the tempo of war as decision cycles have been shortened.

The generation gap in military technology between informationalisation, on the one hand, and mechanisation-cum-semi-mechanisation, on the other, is widening, and the military imbalance worldwide has increased. The role played by military power in safeguarding national security is assuming greater prominence. The vital aerospace capabilities are translating into on RMA by leading to a fundamental change in the nature of war primarily due to three significant developments:

- Information dominance in time and space contributing to real-time situational awareness and precision engagement.
- Breakdown of the classical division of the levels of war—strategic, operational and tactical—into a seamless operation.

- Transformation from linear to non-linear prosecution of war.

Any fundamental change requires to be nurtured to maturity delicately, deliberately, precisely and with clarity of thought as well as execution. The elements of aerospace power are virtually limitless, where each existing and new element has to be so conceived, designed and produced that it meshes into the architecture of the system to fine tune and/or enhance the overall capability and efficiency of the system.

It is considered imperative, therefore, to create an integral organisation in the Indian Air Force (IAF) which will contribute to research in two distinct fields. Firstly, to forecast future requirements in the design, capabilities and avionics in aircraft, munitions, equipment, infrastructure and communications, leading to network agility. Secondly, to provide a catalytic edge, by suggesting upgradations and modifications to the existing inventory. In other words, planning and executing basic research to ensure continued technological superiority; developing and transitioning new technologies for air force weapon systems and their supporting infrastructure; and ensuring responsive technical support for emerging problems whenever and wherever they occur.

AIM

The aim of this paper is to suggest a self-sufficient and effective integrated organisation of the IAF to support the IAF's strategic vision with a mission to discover, integrate and deliver affordable technologies for war-fighting by harnessing and steering a partnership of the IAF, industry, and academia.

TECHNOLOGICAL PUSH VS OPERATIONAL PULL

In the IAF, the Air Officer Maintenance (AOM) branch in Air Headquarters (HQ) looks after spares acquisition and provisioning as well as providing technical inputs on all matters inclusive of technical infrastructure and avionics, while the Air Officer Administration (AOA) branch caters for administration and infrastructure based on inputs from both the AOM and Deputy Chief of Air Staff (DCAS) branches. The DCAS branch, on the other hand, is responsible for quantifying the Air Staff Requirements (ASRs) of all acquisitions, modifications, upgrades and equipment, after the Vice Chief of Air Staff (VCAS) branch places a demand. Invariably the ASRs drawn out rely heavily on published literature and the numerous glossies showered on the Air HQ (DCAS branch, in particular) by expectant vendors of national and international origin. There are operational experts also available for this purpose, but, generally, it is observed that this process is both too optimistic and far-fetched and may also fall well short, primarily because the gestation periods of research, testing and manufacture are not factored in totality. I recall the period in the mid to late 1970s when the ASRs were being drawn for the light combat aircraft (LCA). A series of presentations, discussions and demonstrations was held with operational and technical selected experts from the field and Air HQ staff. In a particular meeting, when a German group of experts for aircraft design-cum-manufacture was consulted, the response was, "*If you get all the performance figures, including the avionics and the armament capability you are asking for, you will have a ten-ton aircraft and not a LCA*."

Experience tells us that even where precise technical parameters and performance capabilities were quoted, the IAF had to remain content well short of the requirements because either indigenous capabilities fell short, or the internationally available equipment was not affordable economically. This is particularly true in relation to munitions. The reasons could be manifold but the end result was not satisfactory. It is also a fact that advanced, and more so, futuristic, technologies, that are or would be available internationally, came at prohibitive costs, with no possibility of achieving indigenous capability. **In other words, the IAF had to acquire what came its way by the available "technological push."**

The same situation prevails in all air forces where integrated operational research is absent. Though indeed desirable, the projected operational requirements of accretions, modifications and upgrades were pushed in the background and "technological push" has ruled the roost. It is the dream of all airmen that the accretions, modifications, upgrades, and munitions of the IAF's inventory be primarily responsive to "operational pull," be it for the present or the future. **In other words, we would like to see the day/s when "operational pull" scores well over "technological push."**

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The author has mentioned accretions, modifications, upgrades and munitions virtually in the same breath. In case one desires to ensure excellence in all departments, all these stages need to be catered for. More importantly, all these stages need to be pursued vigorously with "operational pull" as the basic denominator. Let us look at the programmes planned for development of a new entrant in the international market, viz, the Eurofighter Typhoon. Barely a couple of years have passed since its induction in service and the Eurofighter is already working on the first batch of enhancements for the Typhoon Phase I Enhancement (PIE). The company also refers to this as the "First Batch of Enhancement for the Eurofighter." This modification will be available to customer nations from 2011, with the final release available in late 2012. This phase includes a new software architecture, enhanced multi-role man-machine interface (MMI), full LDP integration, enhancements of the multifunction information and distribution, global positioning system (GPS), defensive aids sub-system, including decoys, communications and network-centricity, as well as the integration of additional weaponry such as Paveway IV and EGBU-16. The Phase 2 Enhancement (P2E) is currently being negotiated with customer nations and is scheduled to be available from late 2014. P2E includes the integration of the MBDA Storm Shadow and Taurus standoff cruise missiles as well as the supersonic Paveway IV. Additionally, Phase 2 includes the addition of an enhanced communications suite and improved network-centric capability. Further enhancements planned for the Typhoon include the MBDA Meteor beyond visual range air-to-air missile integration, which is required to be operational by 2012. The Meteor flew on the Typhoon in the UK in 2005, in Italy in May 2007, and in Spain in October/November 2007. The Meteor has not flown in Germany as yet. Thus, we see that **the time has come for us now not to be satisfied only by accretions — we need to plan modifications and upgrades well in time to remain on top of prevalent technologies, which has been an**

ongoing process for developed nations for a long time.

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With the introduction of commercially off the shelf (COTS) equipment and components in the aviation industry, several aspects of traditional military weapon system design are either modified or eliminated. Key areas include physical and environmental characteristics of the various COTS hardware components. An open system implies that the system and integration of components should be analogous. Open systems provide cost savings by allowing a number of vendors to compete for the various hardware and software components in the broader commercial market. The architecture will no longer be tied to a specific vendor selling unique components built to proprietary or closed interface standards. By opening the architecture, future upgrades and new mission capabilities may be integrated with minimal integration and testing requirements. COTS hardware in the architecture is not specifically designed to operate in an airborne environment. In order to take full advantage of COTS, the design team needs to determine if certain components could be used. For example, the temperature range specified in the original airborne warning and control system (AWACS) specification required that all electronics operate within the operating range of -55°C to +85°C. After flying the E-3 more than 20 years, Air Combat Command determined that such a wide operating temperature range was not necessary in most cases. The requirement was modified to specify use in the +50°C range that is typical for most COTS electronics. This modification to environmental requirements provided the opportunity for use of an increasing number of hardware components from various vendors. COTS hardware used in the architecture includes single board computer cards, graphics accelerator cards, power supplies, network interface cards, network switches, fibre optics cables and solid-state memory devices. Coupled with the COTS components, some custom hardware and software will also be required to interface the architecture to the remaining system. **This involvement of the Air Combat Command provides the proof of modifications suggested and accepted by "operational pull."**

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Achieving an IAF inventory that smarts with the state-of-the-art "operational pull" is easier said than done. The organisation so established must be able to accomplish five distinct spheres of research as its objectives**.** **Firstly**, it must be in a position to peep into the future in terms of appreciated emerging trends in all departments and prioritise them in time to remain well ahead of the contemporary standards. This applies to accretions, modifications, upgrades and integration with new munitions as well as avionics suites. **Secondly**, analytically assess indigenous capability as well as the will and economic capacity of indigenous participants who will execute the planned task after the basic inputs are provided by the IAF, i.e. they must be able to convert thoughts and plans into products in time, including additional research, if any. **Thirdly**, as and when required, work out the tradeoffs in terms of theoretical and optimistic capabilities versus practical ability of the participants and crew capability with the finished product. **Fourthly**, suggest procedures for harnessing and steering partnerships in the processes of development, trials, and production towards a win-win situation for all the participants. And, **fifthly**, in the absence of an all aspect indigenous capability, identify affordable COTS technologies of today, or even the near future. **Lastly**, it must be borne in mind that this list of objectives may be expanded in an incremental fashion as and when deemed fit and expedient.

It is, hence, considered inescapable that the IAF establishes an organisation and effectively exercises "operational pull" to equip its present and future inventories. It may be argued that with an organisation like the Defence Research and Development Organisation (DRDO) available, why can't this objective be achieved? It is submitted that the DRDO is basically a "technological push" agency comprising eminent individuals and scientists. Every proposal made by DRDO is vetted at Air HQ, and if accepted in principle, ASRs are drawn out. Most of the ASRs are futuristic but in a majority of cases, the indigenous products have not met the ASRs. The net result is either acceptance of machine and equipment short of the ASRs or outright rejection. The former scores over the latter because it is argued that the capital investments involved for aircraft, equipment, items and munitions are excessive and will not be assuredly maintainable since the maintenance factors for uninterrupted supply cannot be relied upon if they are not indigenous. The comments in this paragraph are statement of facts and are not meant to cast aspersions on an elite organisation of our nation.

It is an undisputed fact that the indigenous route is the best and only route to follow in the long run. However, it must be ensured that the reequipping/ upgrades as also acquisitions must operationally cater for the near and distant future in most cases, and probably, for the present and contemporary standards in the case of some selected items. It is also true that no country is fully capable of providing indigenous articles for its air force since the number of sub-units involved in production are many and each one of them demands specialised research. Hence, you have an American aircraft with a British engine, Spanish undercarriage, etc. How does one put all these pieces together in the puzzle? **The answer to that lies in creating an organisation whose main contribution is to ensure that the IAF inventory is "operational pull" orientated and that the same organisation is held responsible to discover, integrate and deliver affordable operational technologies.**

THE TIME FACTOR

A major question that comes to mind at this stage is, "When should such an organisation commence functioning?" The answer is, "It should have commenced functioning nearly 10 years ago." This is primarily so since our gross domestic product (GDP) growth rate commenced an upward trend around this period and India has a sound economy now. There is an article that appeared on the net on August 15, 2008, as follows: "Britain's property agents are now targeting an estimated 1.25 lakh Indian dollar millionaires

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who are expected to invest nearly $30 million (Rs 1.2 lakh crore) over the next decade in London apartments. Rich Indians could rescue or stabilise the market. Jones Lang La Salle reckons that by 2025, nearly 600 million Indians will have sufficient financial means to invest in 20,000 to 30,000 homes worth as much as $15 billion." While this article is not directly in the context of the subject matter, it is indicative of the effects a sound Indian economy has created internationally. Therefore, there is reason to believe that it is time now also for the Indian economy to also apply itself in the role of contributing towards building an enviable inventory for the military (and, in our case, the IAF) for the nation. Towards this effort, the essence will lie in building the indigenous production and ensuring that the present as well as predicted economy of India is capable of supporting this venture.

There was a time when everything to do with production of material, goods and acquisitions for the military (including the IAF) that was indigenous was only by the public sector/government agencies. This did create employment but the technological growth of the nation was very slow indeed. Supporters of yesteryear's policy may lay the blame entirely on the adverse international regime of sanctions, export controls and technology denial, but that is only half the truth. Today, there is an overwhelming demand for the private sector to participate at every level to provide a catalyst to the overall military production, and that too, of standards that are comparable or better than the available contemporary standards. Now that the green signal has been given for the private sector to contribute towards this aspect also, the speeding up process should be well on the cards. Perhaps two recent articles may highlight this further. Firstly: "Gone are the days when manufacturing companies used paper and pen to draw mechanical and electrical designs. Most use computer-aided-designing (CAD) solutions, which reduces costs, brings in efficiency and increases productivity. The impact of CAD is often dramatic. Stumpp, Schuele and Somapa, a Bangalore-based company, manufacturing springs and auto components, found CAD solutions a 40% reduction in development and testing cost. Ajay Advani, head of manufacturing solutions in India for Autodesk, one of the world's biggest CAD solutions companies, says some of the best-in-class manufacturers have reported that for their most complex products, they reached the market 99 days earlier, with $50,637 lower development costs with CAD solutions. From the CAD perspective, it is the 3D design technology that will give companies a major edge" (extracted from *The Times of India,* August 16, 2008). Secondly, is an extract from *Rediff Com* dated February 15, 2008, by George Iype: "Is India, and particularly, Bangalore, emerging as a global aerospace hub? In Feb 2008, Spirit Aero Systems, the world's largest independent supplier of structures for commercial aircraft, teamed up with Infosys Technologies to set up an engineering center at the Infosys campus in Bangalore. Spirit Aero Systems builds part of every Boeing commercial aircraft currently in production, except the Boeing 717. Its products include the 737 fuselages, nacelles and pylons, as well as nose sections, for the 747, 767, and 777 aircraft. Spirit also designs and produces slats, flaps, forward leading edges for 737 wings, slats and floor beams for the 777 airplane, and wing and fuselage components for the 747. The center, according to Infosys officials, will focus on high-end engineering services including product development, design and analysis of airframe structures, engineering change management and stress engineering support."

It is not Infosys alone that is taking up prestigious aerospace projects. Last year, the Indian Institute of Science (IISC), India's most prestigious science research institute, joined hands with Boeing, the leading manufacturer of satellites, commercial jetliners and military aircraft, to work on nine unique projects to build the next generation aircraft. Involved in this massive project are nearly 40 researchers at the IISC. It is for the first time that such an extraordinary project is being handled by an Indian institute. The project is managed by the Society for Innovation and Development (SID), which the IISC founded more than a decade back as its commercial arm. As per the IISC-Boeing understanding, the aerospace major would invest $5 million in research every year for the next few years in the company's aircraft projects with the institute. SID undertakes research and development projects based on individual or joint proposals from the faculty and scientists of IISC in collaboration with industries, business establishments, and national and international organisations.

It is a certainty that the IISC-SID combine can also cater for the "operational push" of the IAF if the demand is projected in the format asked for. Further, it is not only the IISC-SID combine that can propel the aerospace industry in India. There are many potential contributors waiting in the wings who yearn to be provided with the authority to tread on the path of aerospace development. It naturally follows that if clearly delineated procedures were followed, it would be possible to delegate responsibility along with authority for achieving the prescribed goals. It is, therefore, opined that **the time is now to establish the proposed organisation in the IAF for achieving operational excellence for the inventory of the IAF, when the Indian economy as well as technology development has reached standards of excellence.** It must be appreciated that for such an organisation to stabilise, the time required could be anywhere between 6 to 8 years. This period would be required for such an organisation to not only stabilise, but also to reach a credible stature as the prime adviser, coordinator and integrating centre for the objective set out by this paper.

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AIR FORCE RESEARCH LABORATORY (AFRL)

The above terminology and the organisation belong to the US Air Force (USAF). Prompt is the observation: Why must we ape the West? We need not, but there is no harm in analysing a well-honed organisation that has delivered the planned objectives and more. We must acknowledge, as indeed the world does, that the USAF **is** the best air force and that it has remained well ahead of all the air forces of the world. It is also a fact that the technologies adaptation of the USAF has been the envy of all. Therefore, a preview of the AFRL suits our proposal of establishing an organisation to precipitate operational pull. It must be noted at this stage that we need to develop an organisation which will suit our resources (both economic and human) and our future vision of the IAF.

THE AFRL OF THE USAF

The AFRL in its present state was formed in 1997 from an organisational consolidation of four former Air Force Laboratories. AFRL's goal is to create a more efficient, effective organisation to support the air force's global engagement vision. The laboratory is responsible for the air force's annual $1.2 billion science and technology programme, including the full spectrum of air force basic research, exploratory development, and advanced development. The laboratory is the air force's manager for technology transfer to, and exchange with, civilian enterprises. Its also the manager for the Small Business Innovation Research; Dual Use Science and Technology; the Air Force Science Fair Programme, which encourages high school students to pursue a technical education; and for monitoring the aerospace industries' independent research and development programmes.

AFRL employs more than 6,300 military and civilian personnel (1,600 military and 4,700 civilian). The laboratory and its predecessors have overseen more than 80 years of critical research efforts for the air force and Department of Defence (DoD). Its technological breakthroughs can be found in all of today's modern aircraft, spacecraft, and weapon systems, including the F-117 stealth fighter, B-2 bomber, C-17 airlifter, and F-22 fighter. AFRL has contributed to significant advancements in modern communications, electronics, manufacturing, and medical research and products. The laboratory is organised along nine technology disciplines as under:

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1. *Air Vehicles Directorate*. The directorate is organised into four technology divisions (Structures, Aeronautical Sciences, Control Sciences and Integration & Operations), which

collectively cover or interface with all research and development areas associated with the conception, analysis, experiment, simulation, design, and test of aerospace flight vehicles over the entire flight spectrum.

2. *Human Effectiveness Directorate.* The directorate is organised into six technology divisions (War-fighter Training Research, Crew Systems Interface, Directed Energy Bioeffects, Integration and Operations, Biodynamics and Protection, and Development and Sustainment). This directorate is responsible for improving human interfaces with weapon systems to assure the preeminence of US air and space forces.
3. *Information Directorate.* This directorate develops systems, concepts and technologies to enhance the air force's capability to successfully meet the aerospace information technology needs for the 21st century.
4. *Materials and Manufacturing Directorate.* This directorate develops materials, processes, and advanced manufacturing technologies for use in aircraft, spacecraft, missiles, rockets and ground-based systems.
5. *Munitions Directorate.* The directorate's emphasis is on the weapon's capability to operate with complete autonomy and with high accuracy.
6. *Propulsion Directorate.* The directorate provides "one-stop shopping" for all forms of propulsion science and technology of interest to the air and space forces. The directorate is also responsible for most forms of power technology (other than those required for spacecraft), making it one of the nation's leaders in the field of energetics.
7. *Sensors Directorate.* This directorate conceives, demonstrates, and transitions advanced sensors and sensor technologies for air and space reconnaissance, surveillance, precision engagement, and electronic warfare.
8. *Space Vehicles Directorate.* This directorate is organised to develop space technologies that support the evolving war-fighting requirements.
9. *Directed Energy Directorate.* This directorate develops, integrates, and transitions science and technology for directed energy to include high power microwaves, lasers, adaptive optics, imaging and effects to assure the preeminence of the US in air and space.

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In addition, the Air Force Office of Scientific Research manages the entire air force's basic research programme, and its technical experts sponsor and direct basic research conducted in the nation's universities, industry and government agencies.

SUGGESTED ROUTE PLAN

The First Step

The IAF already has a technological sensitive unit called "Software Development Institute" (SDI) manned totally by IAF personnel. This unit took over from the IIO and was initially involved in developing follow-up marks of the DARIN system. Today, it is involved in design, development, testing and production of avionics components for the SU-30, Bison and an ATC simulator. There may be more tasks allotted (I am sure), which the author is not aware of. The seminal point is that the IAF already has a readymade platform to take off from. The SDI is a self-accounting unit and its members accompanied the IAF team for the Red Flag exercise to cater for on the spot changes in the software programmes for interoperability. This unit probably could commence as the hub of activities for the entire operational pull programme. Along with this move, it is proposed that an institution called the Aeronautical Development Agency (ADA) be handed over to the IAF by DRDO. There should no apprehensions in the minds of the present civilian staff in respect of their jobs, since this IAF organisation will also have civilian staff at all levels. It is observed that the expertise built up during the manufacture of the HF-24 aircraft just disappeared when the project was foreclosed. The ADA is presently involved in the design of the LCA. Such a developed expertise pool must be put to good use by the IAF and the nation. **It is hoped that**

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The Second Step

Presuming that it is accepted that the time is right now, we need to be clear about how to proceed in a planned manner to achieve the operational pull. We have already established the facts that the indigenous route is the best available option, and that involving the private sector is an escapable necessity. The organisation created must, therefore, in the first place, ensure that the organisation builds the minimum credibility (to start with) to guide and propel the indigenous capabilities of both the public and private sector units towards perfection in the state-of-the-art in design and production of the components (big and small) to be used in aerospace power. It must be emphasised that these products or their variants will also, to a large extent, be capable of adoption in dual/triple use articles. Secondly, where possible, place such demands on multiple agencies to generate a competitive spirit that they will ultimately get used to in the future, like the USAF tasks companies like Boeing and Lockheed to do additional research for an aircraft and then chooses one out of the competitors' proven product for mass production. Thirdly, suggest the employment of selected ex-Service personnel in the private/public sector units who will assuredly contribute to the operational pull of the IAF. And, fourthly, suggest methods and procedures that ensure that the logistics footprint of the finished product is minimal. It is recommended that the first two steps be restricted and practical to ensure satisfactory achievement of objectives. **When such restricted objectives are achieved, then and then only, should action be taken to enlarge the scope of the organisation.**

The Third Step

"Tomorrow's war will be digitised and communications sensitive" is a statement we hear over and over again. Also, the qualities of precision weapons today permit an aircraft to fire and forget, and yet be assured that the cruise missile released will self navigate through streets in urban

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areas and hit targets through windows with NO collateral damage. The question that I pose is this: "Will anybody willingly give you this technology even if you purchase it"? The answer is NO. **A very structured plan must be evolved to acquire this technology. My suggestion is to follow the philosophy of "beg/borrow/steal".** I need not enumerate the various success stories where nations have achieved their objectives through this route.

The Fourth Step

Identify the public/private sector agencies, the academia and educational institutions for research that should be given contracts for the specified research. The research contracts could and should be given to more than one agency for the same subject, thus, creating the desired sense of competition in an advanced economy nation. In the ultimate analysis, such a move will ensure the highest standards of perfection and capability. In the event when no such research agency can be identified, **identify the COTS equipment that will ensure uninterrupted supply of the equipment and its spares.**

The Fifth Step

I have purposely not called it the last step since this will ALWAYS remain an incremental organisation. Here, I would like to suggest that a separate branch of officers and trade of airmen be created to man the organisation. It must also be ensured that there is a mix of civilian and uniformed personnel but the head of each organisation must be an officer in uniform who is professionally seasoned. This proposal will ensure continuity, which is so essential in the fields of analysis, research, design and production. Above all, the secret contents that every military arm needs to preserve and cherish should be well looked after when **the core knowledge is restricted to the minimum personnel.**