



The Indian Aerospace Industry 2019

An Analysis of the Political, Technological and Economic Conditions

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EADS-SMI Endowed Chair
for Sourcing and Supply Management

Indian Institute of Management Bangalore



European Business School
International University · Schloss Reichartshausen

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Imprint



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Welcome

Aerospace Industry – the Litmus Test for India’s Global Power

Perhaps no other industry has as much symbolic power as the aerospace industry. And with good reason, for an aircraft is in fact a kind of metaphor for modern society in its entirety: firstly, with its mobility it represents the central aspect of the global economy. That today’s “world is flat” is largely thanks to the aircraft. Secondly, it is the sum of the most advanced industrial technologies available to the world and the apex of industrial and process complexity with regard to both production and the supply chain. And, thirdly, there is probably no better example of the dense interweaving of business, economic, political and military networks and interdependencies than the aerospace industry.

At the same time the aircraft is also a symbol of the shortages, fragilities and limitations of today’s global economy. A vigorous aerospace industry must be in a position to find effective ways to cope with raw material shortages, changing legal norms, protectionist barriers, geopolitical and ecological threats, planning uncertainties and financial instability.

In this context it is understandable that a competitive aerospace industry – as a kind of proof of the capabilities of a country – was for decades the domain of highly developed, economically and politically powerful states such as the US, France, Germany, Great Britain and Russia. And the fact that new aerospace industrial centers are developing outside these established regions is strikingly important evidence of the shift in global power.

Over the coming decades India undoubtedly has the potential to become one of the key players on the international stage. And fundamental global economic and political decisions hinge on how far India has progressed and how quickly this highly complex country can become a global powerhouse. Knowledge of the current status and future “development path” of the Indian aerospace industry is a crucial indicator of this.

We hope that you enjoy reading this study and that it will provide valuable impetus for strategic decisions over the coming years.



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Foreword

The Indian Aerospace Industry – Ready For Takeoff

The Aerospace world is changing at high velocity. For an industry once characterized by the phrase ‘if it ain’t broke, don’t fix it’, the incentive to change was practically non-existent unless forced in some way from dire necessity. This sudden transformation means a huge departure in the way things are getting done. The era where OEMs (airframe manufacturers) did almost everything themselves, bearing all of the associated costs, is long gone. Now they’re moving into a phase where sharing the workload with suppliers, including the associated costs (the Non-Recurring Engineering “NRE costs”) and risks (as well as rewards) is common place. The OEM should act as aircraft’s ‘concept-creator’ and ‘super-integrator’ in the future, letting their suppliers do pretty much everything else along the way.

This aerospace industry transformation has also led to the evolution of the aerospace supply chain. New players are now emerging in new regions (Brazil, China, India, and Mexico), while old players from long established regions (the USA, Canada, France, Germany, the UK, Spain, and Italy) are facing challenges that sometimes threaten their very survival. India is hearing the talk, and seeing a lot, of action relating to the huge potential for aerospace goods and services. Until recently, the Indian aerospace industry has been dominated by government owned R&D organizations and aircraft development and manufacturing units, which are primarily focused on domestic defense needs. Not a lot of work has been done in India for the aerospace industry outside of India, and the private sector has likewise done little for Indian aerospace. Yet the opportunity for India is huge – various estimates for aerospace engineering and manufacturing prognosticate figures of between US\$ 8 billion and US\$ 15 billion over the next 10 years.

This report attempts to paint a picture of what the Indian aerospace industry will look like 10 years from now. By taking into account various possible occurrences in the political and technological environments as well as the value-chain structure that could impact the Indian aerospace industry, this report anticipates future scenarios which can be used by Indian aerospace players for strategic decision making relating to long-term investments for building capability and capacity. The timing of this report is very opportune, given the amount of activity and publicity that the Indian aerospace industry is currently experiencing. For players in the Indian aerospace industry, I am absolutely positive that this report will be informative, educational and insightful. The Indian aerospace industry is ready for takeoff – are you on board yet?!



Bejoy George
Chief Marketing Officer,
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I. Introduction

The advent of modern aerospace can be traced back to the Wright brothers who made the first powered flight at Kitty Hawk, North Carolina on December 17, 1903. Since then the field of aerospace has seen remarkable growth and development. From the hot-air balloons and gliders to the bombers during the 1st world war to the manned mission to the moon and the new developments in supersonic travel and commercial aviation there has been a tremendous growth in the last century. During the same period, the structure of the aerospace industry itself has changed from companies managing the entire set of operations on their own to clustered value chains in a few countries consisting of highly integrated yet independent and interdependent players. However, the last few years have witnessed a clear trend towards a true globalization of the aerospace industry in a way somewhat similar to that in the automotive industry, providing new regions and players the opportunity to benefit from the chances and contribute to the current and future bottlenecks of this industry.

Riding on the back of low cost labor and high-level science, India has recently emerged as a new player in the aerospace industry. The growth in India's manufacturing sector and the rising stock of its R&D capabilities are bound to have repercussions not only in the Indian but also in the international aerospace markets. It has recently been forecast that India's MRO (maintenance, repair and overhaul) segment will grow at 10%, reaching US\$ 1.17 Billion by 2010 and US\$ 2.6 Billion by 2020.

In this context the study aims at creating awareness and fostering the interaction between executives, academics and other interested parties; to not only create an understanding of the state of the aerospace industry in India at present but especially to develop a clearer picture of what the structure of the Indian aerospace industry will be in the future. Through the discussion of various propositions for the future of the Indian aerospace industry the study aims to generate various scenarios which will provide a basis for long-term decision making and support companies with their strategic decisions.

A two-stage Delphi-based scenario approach of the Supply Chain Management Institute (SMI) was conducted. First, experts from business, politics, and academia were given 18 future theses, i.e. projections, via a web-based, real-time Delphi application to provide their opinions on from the following subject areas:

- » Political environment
- » Technological environment
- » Value-chain configuration

In total 34 participants were asked to assess the 18 projections in terms of the probability of occurrence for the year 2019, their impact on the Indian economy, and their desirability using the ratings scale provided. They were also given the opportunity to justify their responses by providing comments. Each panel expert could log in the system at any time during the survey to follow the ongoing discussions as well as to add or revise her/ his answers. The overall rationale of the Delphi was to achieve a consensus or significant dissent on each projection.

In the second part of the study, we developed future scenario options for the Indian aerospace industry based on the Delphi expert survey and in-depth desk research as well as the existing extensive scenario database of the SMI. Conceivable opportunities and surprises have been sketched out in detail. The opportunities present future scenarios that can be actively shaped. Developing these opportunities broadens companies' horizons for what may happen in the future in terms of products and services, strategies, processes, and solutions. The surprise analysis in turn acts as guideline for contingency planning.



2. Methodology

Scope of Research

The scope of research can be characterized by three main issues:

» Broad industry perspective

The research includes perspectives of senior experts from business, politics and academia. Apart from various supplier perspectives customer views are covered by means of targeting responses from industry players at different steps in the value chain. The study also integrates the viewpoints of experts from different countries. While the majority comes from India, experts representing the experiences and interests of other leading aerospace nations in India are also included.

» Long-term horizon: Year 2019

The idea of this Delphi study is to provide a guidance for companies on how the industry might develop till 2019. In this way it looks beyond existing trend studies that focus on the short- to mid-term horizon. However, 10 years are a short time in the aerospace industry. Executives, politicians and academics need to act quickly in order to seize the current opportunities.

» India-focused approach

The focus of the report is primarily to analyze Indian aerospace industry in order to develop projections and scenarios that support strategic decision making as well as innovation and risk management.

Process of the study

The project was launched in the second half of 2009 when the study was designed and the online portal for the web-based Delphi survey was developed. A list of possible experts was compiled by gathering extensive data from various public and internal sources of the

EADS-SMI Endowed Chair at IIM Bangalore. Since expert selection is crucial for data validity each expert was carefully chosen by a number of critical criteria, such as industry experience, company position, education/academic title. The final participation list

included 34 experts from business, politics and academia. Finally, a personalized invitation link was sent providing personalized and exclusive access to the real-time-Delphi

Real-time Delphi – Procedure for Respondents

The Delphi technique is one of the most commonly known methods of futures research. It is a systematic, multi-stage survey procedure and was developed by the RAND Corporation at the end of the 1950s to avoid the general problems associated with group discussions (bandwagon effect, halo effect). A classical Delphi survey comprises several survey rounds. Once future projections have been developed, experts are individually and anonymously confronted with them in order to give quantitative estimates (probability of occurrence, impact on e.g. industry, desirability of occurrence). In addition to

the estimates, each expert may also provide comments to justify his or her opinion. Before the next survey round, all participants can check the cumulated group opinions and comments made. The participants then have the opportunity to modify their former round estimates. The overall rationale of the process is to reach group consensus or dissent on future estimates, which have proven to be more precise than forecasts of single individuals.

For this study we chose for an innovative web-based and real-time Delphi approach of the SMI which professionalizes the Delphi

process significantly. Immediately after providing an estimate on a projection, real-time calculations provided the statistical group opinion and comments collected so far. The 34 participants were then able to reconsider and change the responses directly. Once probability, impact and desirability of our 18 projections had been answered, the session ended automatically. With subsequent logins, each participant was taken to a consensus portal as a form of control panel from where a respondent could jump into and review each single projection again.

3. Present Picture of the Indian Aerospace Industry

3.1 Political Influences

The commercial and defense-focused aerospace industry in India has been active for a long time; however it has only recently opened up to private sector participation through various government policies and initiatives. Overall, the following issues can be considered as key forces affecting the aerospace industry in India:

- a) It has allowed up to 100% domestic private sector participation, although the foreign direct investment is still limited to 26% in the defense-related segment.
- b) The offset policy requirement of 30% is meant to encourage further development of indigenous production capabilities in land, air and naval defense equipments by allowing co-development and co-production of Indian companies with international manufacturers.
- c) The federal tax structure of India imposes a range of taxes. While the Central Government levies income taxes on individuals and corporations, and indirect taxes such as customs duties, central excise and service tax, the State Governments impose other indirect taxes like a Value Added Tax (VAT). Such a multi-tiered tax structure is a disadvantage for domestic manufacturing as imported defense goods are taxed less compared to locally supplied goods. The indirect taxes on aircraft servicing present another challenge for MRO activities in India, which needs to be addressed in the coming years.

3.2 Technological Influences

With several government organizations like Hindustan Aeronautics Limited (HAL), Defense Research Development Organization (DRDO), NAL, ISRO etc. research and development in industry has progressed but at a slow pace. Considering the backlog of defense related aircrafts and technology for the near future, India still needs to invest into the future. Realizing the R&D investment needs, government has also invited domestic and foreign players for participation with an offer of 80% funding. The government is especially looking for joint production with global players in order to transfer technology and know-how into the country.

The availability of low cost engineers and scientists has attracted global players to build up captive R&D units in India. For example, the Airbus Engineering Centre located in Bangalore is one of the company's key units in India which works on design tools for aircraft manufacturing and simulation tools

for analyzing stress, strain and other material properties. Similarly another aircraft companies such as Snecma have established their R&D centers focusing on the development of aircraft components. Other companies like Boeing have collaborated with research and technical institutes like the Indian Institute of Science (IISc), Bangalore, and the Indian Institute of Technology (IIT) Kanpur for high-end research in aircraft design. In March 2009 for example, Boeing also opened its Research and Technology-India Centre which will focus on development of high-technology applications, particularly in the field of aero structure and avionics. A new trend of Public-Private-Partnerships (PPP) has also emerged wherein private Indian players like Mahindra & Mahindra are collaborating with government bodies such as NAL for the joint production of aircrafts.

Although less has been done in the field of research on green fuels so far, government

agencies like DRDO and Bharat Electronics Limited (BHEL) have started working on projects to develop Unmanned Aerial Vehicles (UAV). BHEL has, for example, collaborated with IAI-Malat for the development of similar technologies. The development of new composites for the manufacturing of aircrafts is one of the areas where the Department of Science and Technology (DST) is currently focusing on. Such composites will not only help in enhancing the strength of the aircraft but also in increasing fuel efficiency and lowering maintenance costs. As of now, India imports almost all material for manufacturing. Companies such as HAL or Tata Advanced Services are working on new material technologies for the development of composites. However, India has been restricted so far to a 3rd tier supplier to the industry with focus on low-tech design and engineering activities. Therefore, future research efforts in terms of R&D investment and high-technology product developments are expected to increase

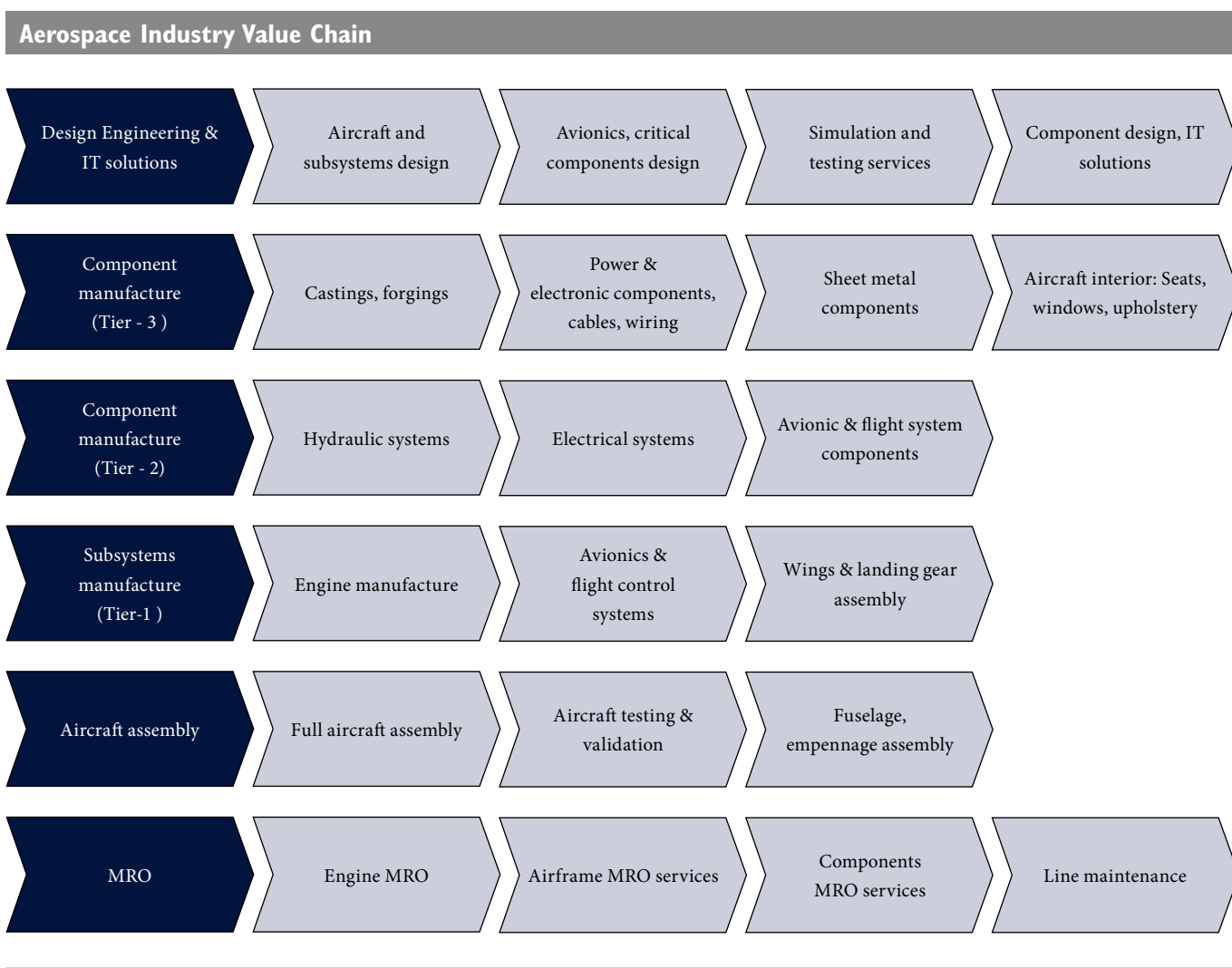
3. Present Picture of the Indian Aerospace Industry

3.3 Value-Chain

The first step in the value chain involves research, design and engineering services. This is followed by high-quality component manufacturing and sub-systems manufacturing. Sub-systems include complex structures

like engines and therefore also involves the assembly of a large number of components. Finally comes the final aircraft assembly and testing. The last step in the value chain, considered here, also involves MRO services.

It may be noted at this point that some other services like aircraft financing, leasing, etc. have not been considered for this study.



The aerospace industry in India is mainly concentrated in 'Design, Engineering & IT solutions' and 'Tier-3 manufacturing supplier' space. Of late, MRO is also emerging as a major sector with OEMs, airlines and private MRO service providers setting up their business in India. Nevertheless, the Indian aerospace industry has a very fragmented coverage along the overall value chain. Of

course, public sector entities like HAL and DRDO have developed capabilities in most parts of the value chain but they still struggle to master some critical high-end technologies. The rest of the industry remains woefully short in technological capabilities and experience. Hence, most of the business can be categorized so far as low-tech, low cost and low volume.

3. Present Picture of the Indian Aerospace Industry

3.4 Major Players

3.4.1 Public Sector

| Company | Key Capabilities | Segment | Major Products & Services |
|-------------------|---|----------|--|
| HAL | Aircraft manufacture & assembly, design, R&D, Tier-2 & 3 supplier to foreign OEMs | Military | LCA, Dhruv, licensed manufacture of Soviet/Russian origin crafts (Su-30MKI, MiG-21, 27), Piston & Jet trainers, MRO for Indian Air Force |
| NAL | Aircraft manufacture & assembly, design, R&D | Civilian | Saras, Hansa, regional craft under joint development with ATR |
| DRDO labs | Subsystems manufacture, design, R&D | Military | Missiles, Radars, Avionics, EW suites, |
| ISRO | Satellites: remote sensing & geostationary, launch vehicles, space probes | Civilian | INSAT satellites, GSLV, PSLV, Chandrayaan, launch services for satellites |
| Air India/ Boeing | MRO for civilian airliners | Civilian | MRO for Air India fleet |

3.4.2 Private Sector Domestic Firms

| Company | Tie-ups with | Major Products & Services |
|--------------------------------------|-------------------------------|---|
| Tata (excluding TCS) | Sikorsky, IAI, Boeing | Composites, Avionics, electrical systems, planned aircraft & subsystems assembly |
| L&T | EADS, Boeing, Lockheed Martin | CAD, testing |
| Mahindra & Mahindra, Mahindra Satyam | NAL | CAD, testing, IT & PLM solutions, Planned small jet manufacture, component design & manufacture |
| Infosys | Boeing, Airbus | CAD, testing, IT & PLM solutions, embedded systems |
| TCS | NAL, HAL | CAD, testing, IT & PLM solutions |
| Wipro | BAe, Lockheed Martin | CAD, testing, IT & PLM solutions, embedded systems |
| Taneja Aerospace | HAL, NAL, ISRO | Tier-2&3 components, CAD, MRO services, |
| Dynamatic Technologies | HAL, DRDO, EADS | Tier-2&3 components, CAD, testing |
| QuEST Global | | Tier-3 components, CAD, testing, IT & PLM solutions, embedded systems |
| HCL | GE, Boeing | CAD, testing, IT & PLM solutions, embedded systems |
| HAMCO | | MRO |
| Air Works Engineering | | MRO |

3.4.3 Major Foreign Players

| Company | Origin | Organization Type | India Presence |
|-------------------|--------|-------------------|--|
| EADS, Airbus | EU | OEM | JVs planned with local players |
| Boeing | USA | OEM | JVs planned with local players, MRO existing |
| UAC (Sukhoi, MiG) | Russia | OEM | Tie-up with public sector firms |
| Lockheed Martin | USA | OEM | JVs planned with local players |
| Dassault | France | OEM | Tie-up with public sector firms |
| Sikorsky | USA | OEM | JVs planned with local players |
| Thales | France | Tier-1 | Tie-up with public sector firms |
| Snecma | France | Tier-1 | Tie-up with public sector firms |
| IAI | Israel | Tier-1&2 | Tie-up with public sector firms |

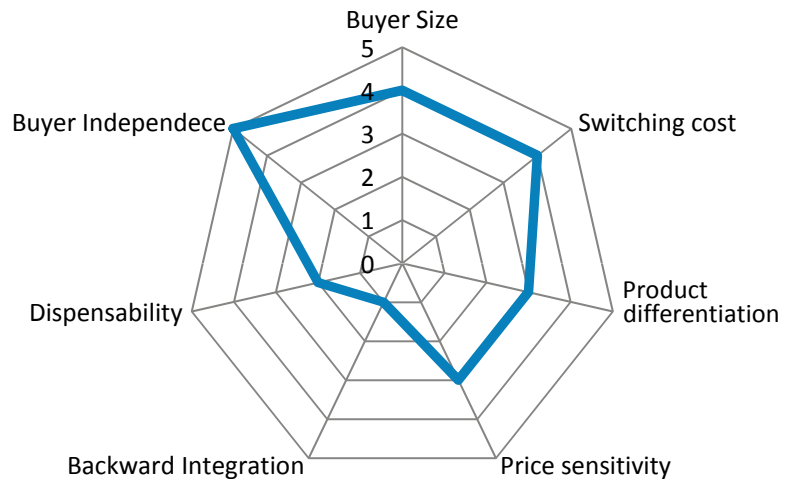
3. Present Picture of the Indian Aerospace Industry

3.5 Five-Forces-Analysis of the Indian Aerospace Industry

3.5.1 Moderate Buyer Power

The number of buyers is typically very small (e.g. Boeing, Airbus or government agencies, ISRO, NASA) and hence they have a greater influence than the sellers. The costs of switching are quite high since there are only few buyers in the market with the two biggest players – Boeing and Airbus. The products are only slightly differentiated to ensure the two major players do not go head to head. Buyers are fairly price sensitive and also in most cases have the backing of governments which gives them an advantage. There is also little threat of backward integration as most of the labor intensive and non-core work is outsourced to cheaper locations. This is supported by the fact that most of these parts and systems are integral to the manufacturing of the aircraft and hence indispensable.

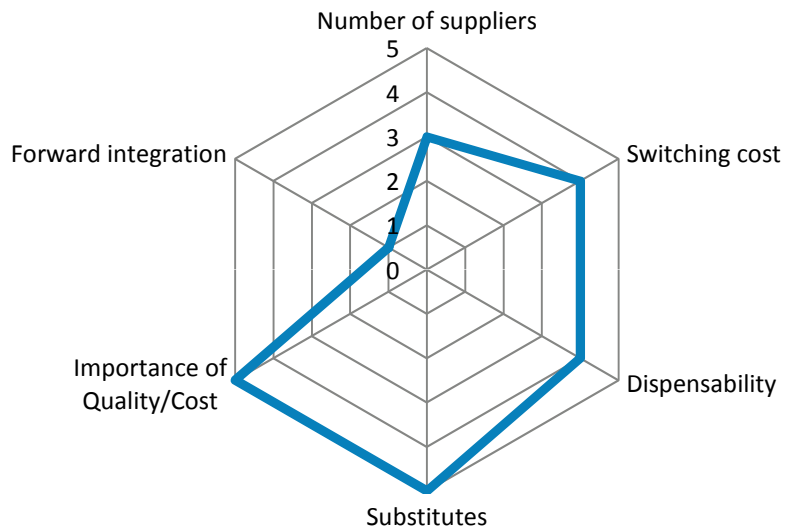
Moderate Buyer Power



3.5.2 Strong Supplier Power

The suppliers are typically smaller in size as well as larger in number and hence have lower bargaining power. The products or raw material they supply are though highly essential, which places an issue for the industry. Suppliers typically provide to a large number of industries like automotive, rail, or precision industries which reduces their dependence on aerospace. Switching from one supplier to another will typically involve significant additional costs. However, there is little threat of forward integration from the suppliers as the level of investment needed is beyond their financial capabilities.

Strong Supplier Power

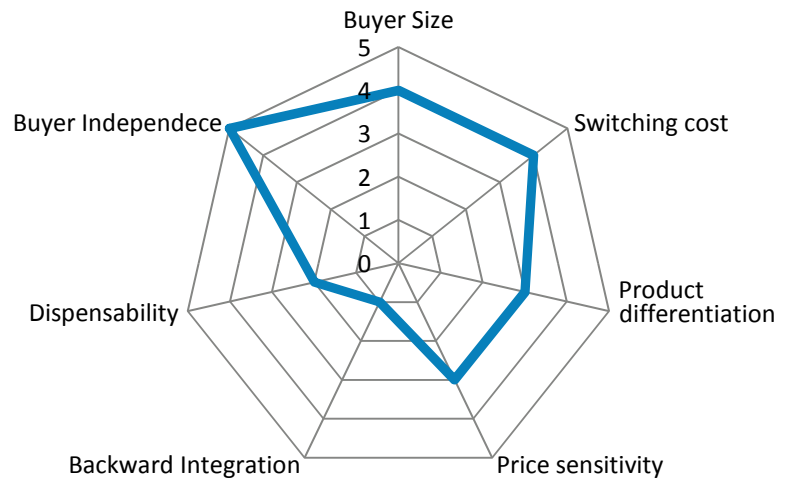


3. Present Picture of the Indian Aerospace Industry

3.5.3 Weak Threat of New Entrants

To have any success against the entrenched, established companies, new entrants in India will have to enter as fully-integrated companies. This would require a large level of investment apart from technical and domain expertise. The cost of switching is very low as the products are more or less similar in nature with minor differences. The suppliers are high in numbers so accessibility to suppliers is not likely to be an issue. The existing brands themselves have been around for years and are very strong which makes the job of marketing a new brand difficult. One factor which makes the industry attractive is the high level of growth still seen in the industry.

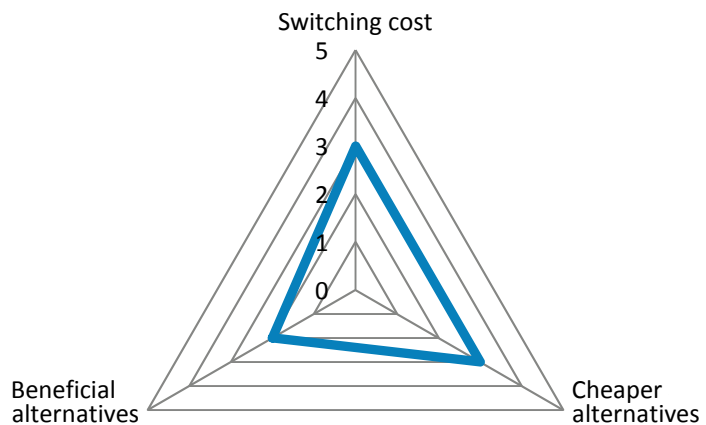
Weak Threat of New Entrants



3.5.4 Weak Threat of Substitutes

There are no substitutes to defense equipment but in the case of commercial aircrafts there are partially options available. Travellers in India concerned about global warming are making use of other options such as roadways and railways. But there always remain certain time constraints which require air travel.

Weak Threat of Substitutes

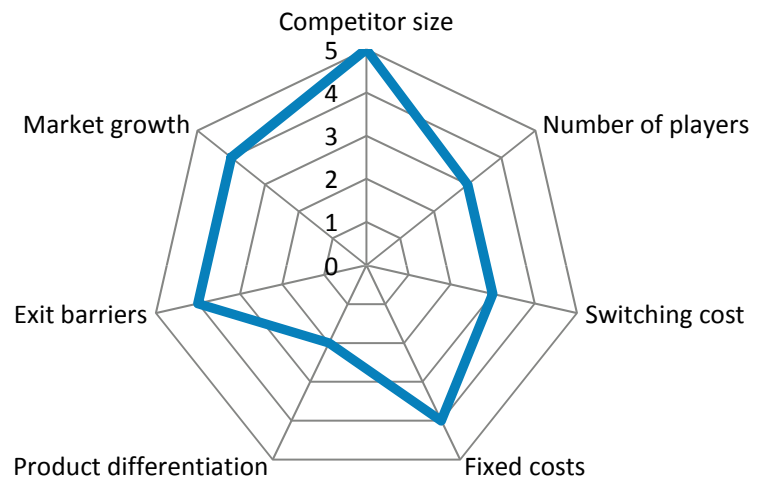


3. Present Picture of the Indian Aerospace Industry

3.5.5 Strong Rivalry

The market in India is dominated by multinationals like Boeing, Airbus and by government organizations like ISRO and NASA, even though the number of players is very low. The products are not much differentiated and the cost of switching is low. The level of investment needed is very high as well as the barriers to entry and exit are. The growth in the Asia-pacific, especially the Indian, market is expected to be very high which makes the market very attractive.

Strong Rivalry



4. Analysis of Delphi Panel Discussions

4.1 Overview of Delphi Results

The real-time-Delphi survey included 18 projections from 3 key subject areas: political, technological and value chain configuration issues. During the analysis, the intensity of convergence and degree of consensus were evaluated alongside the expectational probability, impact, and desirability. Convergence describes the process of reaching a consensus, i.e. the extent to which the level of agreement among the expert panel increases over

successive Delphi rounds. The intensity of convergence is based on the percentage difference between the standard deviations from the first round of the survey and the final round. The degree of consensus was measured using the interquartile range. The interquartile range (IQR) is the measure of dispersion for the median and consists of the middle 50% of the observations. Thus, an IQR of less than 1 means that more than 50% of all opinions

fall within 1 point on the scale. For the real-time-Delphi, an IQR of 25 or lower was used to indicate consensus. In total 4 of the 18 projections (22%) resulted in consensus, while 14 of the projections were still controversially discussed at the closure of the Delphi portal. This result underlines the ambivalence and complexity of the topic under consideration, which has also been reflected in the broad and extensive qualitative data collected.

| | No | Projections for the year 2019 | EP | CV | C | I | D |
|---------------|----|---|-----|-----------------|--------------|-----|-----|
| Political | 1 | In 2019, the FDI limit in the Indian Defense sector does not exist anymore. | 26% | +++ (-49.0%) | ✓✓ (17.5) | 4.2 | 3.4 |
| | 2 | In 2019, direct and indirect tax benefits give aerospace manufacturers and service providers in India an advantage over competitors located in other countries. | 45% | +++ (-21.3%) | ✖✖ (30) | 3.7 | 3.6 |
| | 3 | In 2019, the offset policy requirements of the Indian government have led to the development of a globally competitive aerospace manufacturing industry. | 44% | +++ (-18.5%) | ✖✖ (30) | 4.1 | 3.7 |
| | 4 | In 2019, the government's regulation on IP protection and technology transfer make aerospace manufacturers and service providers in India the most preferred business partners among companies in emerging markets. | 48% | +++ (-21.2%) | ✖✖ (33.5) | 4.2 | 4.2 |
| | 5 | In 2019, the problem of a highly-skilled manpower shortage in the Indian aerospace industry is solved. | 52% | +++ (-24.3%) | ✖✖ (30) | 4.1 | 4.6 |
| Technological | 6 | In 2019, aerospace manufacturers and service providers in India have tripled their domestic R&D investments compared to 2008. | 62% | ++ (-10.2%) | ✖ (27.5) | 4.1 | 4.3 |
| | 7 | In 2019, technological challenges like unmanned aircraft or hypersonic flight are <u>the</u> key research focus for aerospace manufacturers and service providers in India. | 38% | +++ (-26.4%) | ✓✓ (16.5) | 3.4 | 3.8 |
| | 8 | In 2019, alternative fuels are <u>the</u> key research focus for aerospace manufacturers and service providers in India. | 34% | + (-5.0%) | ✖✖ (30) | 3.1 | 3.2 |
| | 9 | In 2019, material technologies focusing on new composites are <u>the</u> key research focus for aerospace manufacturers and service providers in India. | 45% | +++ (-21.3%) | ✖✖ (32.5) | 3.8 | 3.7 |
| | 10 | In 2019, aerospace manufacturers and service providers have embraced all relevant cutting edge technologies in their product and service offers. | 51% | ++ (-14.6%) | ✖✖ (38.5) | 3.4 | 2.8 |
| Value Chain | 11 | In 2019, foreign companies dominate the Indian aerospace industry. | 53% | + (-7.5%) | ✖ (25) | 3.7 | 2.9 |
| | 12 | In 2019, the only globally competitive activity area for the Indian aerospace Industry is R&D and Engineering/Design. | 46% | ++ (-19.6%) | ✖✖ (35) | 3.6 | 3.0 |
| | 13 | In 2019, Indian aerospace manufacturers are globally competitive across the full range of aircraft models. | 27% | ++ (-19.9%) | ✖✖ (32.5) | 4.1 | 3.8 |
| | 14 | In 2019, the Indian aerospace Industry is worldwide leading in offering integrated solutions including R&D, Engineering/Design and Manufacturing. | 43% | ++ (-13.2%) | ✓ (22.5) | 4.2 | 3.9 |
| | 15 | In 2019, Indian companies alone (without foreign partners) are dominating the aerospace MRO service industry. | 33% | ++ (-17.3%) | ✓✓ (20) | 3.3 | 3.0 |
| | 16 | In 2019, India is the leading hub for MRO services in Asia. | 58% | ++ (-13.6%) | ✖ (25) | 3.9 | 3.8 |
| | 17 | In 2019, cost advantages are the only growth driver of the Indian aerospace industry. | 51% | ++ (-13.3%) | ✖✖ (32.5) | 3.4 | 2.6 |
| | 18 | In 2019, the access to highly-skilled R&D personnel is the only advantage of the Indian aerospace industry. | 46% | ++ (-7.7%) | ✖✖ (30) | 3.7 | 3.1 |

4. Analysis of Delphi Panel Discussions

Captions

| | |
|----|---|
| EP | Expectational probability (metric scale 0-100%) |
| CV | Intensity of convergence (% change of mean standard deviation: first vs. final value) |
| C | Degree of consensus/ dissent |
| I | Impact on industry, if occurred (5pt-Likert scale) |
| D | Desirability of occurrence (5pt-Likert scale) |

Measures of "CV"

| | |
|-----|---|
| +++ | Very strong convergence (decrease in standard dev. of $\geq 20\%$) |
| ++ | Strong convergence (decrease in standard dev. of 10-20%) |
| + | Moderate convergence (decrease in standard dev. of $\leq 10\%$) |

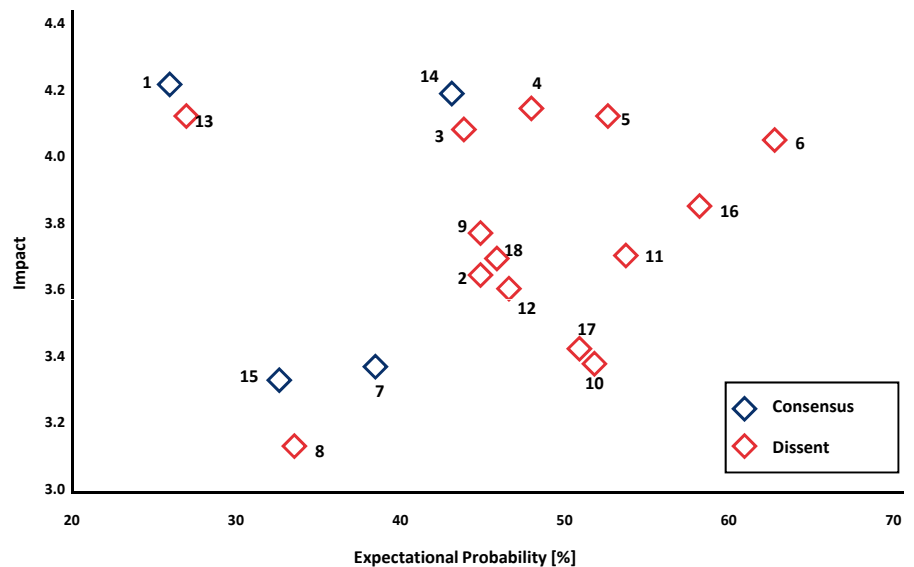
Measures of "C"

| | |
|----|--|
| ✓✓ | Strong consensus (interquartile range of ≤ 20) |
| ✓ | Moderate consensus (interquartile range of 20-25) |
| ✗ | Moderate dissent (interquartile range of 25-30) |
| ✗✗ | Strong dissent (interquartile range of ≥ 30) |

The subsequent scatterplot summarizes the experts' assessment concerning the 18 future projections. The diamonds show how the expert panel assesses the probability of occurrence of a projection (mean expectational probability) and its mean impact on the industry if the projection were to occur. In addition to that blue diamonds indicate panel consensus on an estimate while red diamonds indicate that the topic was still controversially discussed at the end of the Delphi and no consensus could be found.

It becomes apparent that the development and selection of projections prior to the survey was successfully done since all projections yield a medium to high mean impact and are thus of relevance for the industry.

Map of Projections



4. Analysis of Delphi Panel Discussions

4.2 Political Projections

4.2.1 Projection I

In 2019, the FDI limit in the Indian Defense sector does not exist anymore.

Although, there is a high degree of convergence on the projection that the FDI limit will be raised from 26% (current level), none of the experts see it move beyond 49% as the government is expected to retain some level of control on the defence industry.

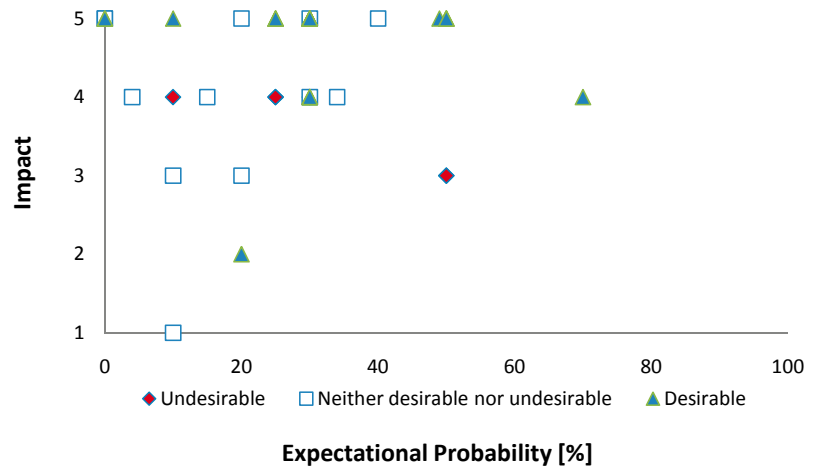
The government has been progressively liberalizing FDI norms in key sectors including aerospace industry. Still, India seems to be struggling with technological challenges in the defense sector and FDI is the only way to cope with them. However, the FDI limit is not expected to cross 49% as India has traditionally been wary of opening up sectors to foreign companies. Other reasons cited for a slow and low liberalization were the bureaucratic approach to industry regulation and government's insistence on including local partners for defense projects.

"The government has been progressively liberalizing foreign direct investment (FDI) norms in key sectors, including aerospace. Though the present limit of FDI in Indian companies engaged in defence production as per Note No 4 of the Department of Industrial Policy and Promotion (DIPP) is 26%, it might well be raised in the coming DPPs."

"India has traditionally been wary of opening up sectors to foreign companies, and the defence sector is certainly one that they would want to control. However, I see FDI limit being increased from current 24% to 49% very soon."

"Due to past experience, India is acutely conscious of the need for self reliance in defence production. Govt. will always insist on local partners and hence there will be a limit on FDI. However govt. will initiate liberal policies to attract critical technologies to India."

Projection I: FDI Limit



Statistical Group Opinion: Probability: 26% | Impact: 4.2 / 5 | Desirability: 3.4 / 5

It's a common view among the experts that the increased liberalization will have a very positive impact on the Indian aerospace industry. It will promote an increased implementation of technology in research and development, engineering and manufacturing sectors of the Indian economy. In addition, it is expected that better collaboration with foreign companies and an increasing number of joint ventures will be undertaken in the general, commercial and defense aviation sectors until 2019. The overall market scenario is expected to be quite attractive due to the high levels of expected spending especially on the Indian defense sector, coupled with a growing engineering talent base. It is even likely to impact India's manufacturing capabilities in non-critical areas, which will get a boost from a growing aerospace industry.

As such, the desirability of better FDI norms is generally quite high among the participants of the Delphi panel, as it is expected to help Indian companies in moving up the value chain and capitalizing on opportunities in addressing global markets. Nevertheless, there are some concerns on the national interests being compromised by an increased involvement of foreign companies in a strategic sector like defense. Therefore, most of the participants recommended a cautious approach to moving in this direction.

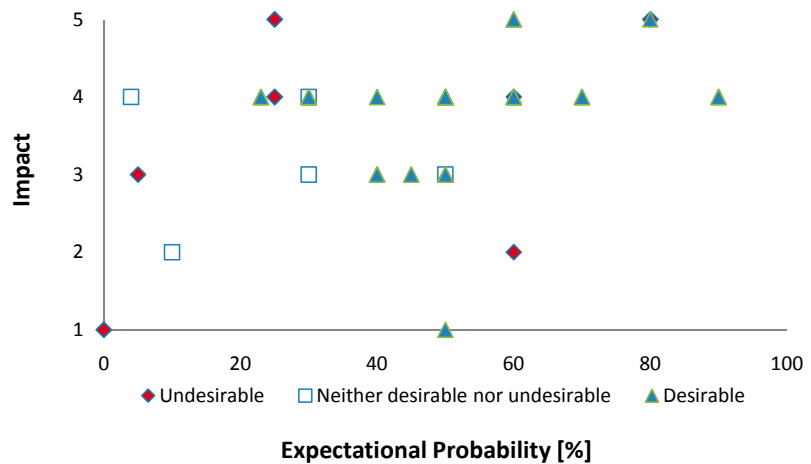
4. Analysis of Delphi Panel Discussions

4.2.2 Projection 2:

In 2019, direct and indirect tax benefits give aerospace manufacturers and service providers in India an advantage over competitors located in other countries.

Most of the experts agree that direct and indirect tax benefits can incentivize local companies to enter the industry with a cost advantage over competitors from other low-cost destinations like China. This may even encourage many foreign players to move business to India considering that they may have to be present in India for fulfilling offset conditions anyway. However, there is a contrasting view among some of the participants that there is no real need for giving such tax incentives to the local industry. They believe that it might limit the growth of indigenous technology development. Also, similar benefits may be provided by competing nations eroding any advantage that it can provide over them.

Projection 2: Tax Benefits



Statistical Group Opinion: Probability: 45% | Impact: 3.7 / 5 | Desirability: 3.6 / 5

Overall, the expected impact of such benefits is definitely positive, not just for the bigger domestic firms like HAL, but also the private companies who can improve their competitiveness at a global level. A strong need has

been voiced for such a development for the industry. Apart from the manufacturing sector, which is dominated mostly by a few companies like HA, the services sector could similarly benefit from such tax incentives

Experts' Comments

“As costs of doing business, including personnel costs, increase in India, there will be growing use of tax benefits to attract companies to operate in the sector. The need to counter the growing competition from other low-cost countries will also drive the introduction of tax benefits.”

“High Tax benefits may not be passed on to Aerospace manufacturers as against other industries; also other countries may pass on comparable benefits to their Aerospace Manufacturers”

“This capital intensive industry can hope for better return on investment. The benefits will enable more industrialists to venture into aerospace industry.”

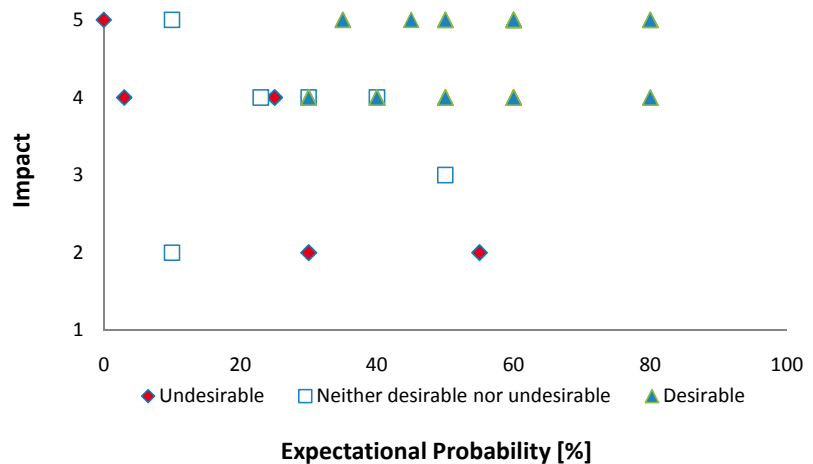
4. Analysis of Delphi Panel Discussions

4.2.3 Projection 3:

In 2019, the offset policy requirements of the Indian government have led to the development of a globally competitive aerospace manufacturing industry.

The offset policy of the Indian government is believed to be very crucial for the development of the Indian aerospace industry. While the pace of implementation has been perceived to be slow, the policy is now being clearly laid down by the government, and the aerospace sellers supplying the Indian market will have to fulfill such conditions. The successful implementation of such policies in other developing countries like Brazil and Korea provides some encouragement for a similar success in India. These countries had similar objectives in pursuing an offset policy, i.e. the development of indigenous capability and stimulating civilian industrial sector apart from the military sector.

Projection 3: Offset Policy



Statistical Group Opinion: Probability: 44% | Impact: 4.1 / 5 | Desirability: 3.7 / 5

However, the key to a successful offset policy is implementation and compliance. The Defense Offsets Facilitation Agency (DOFA) has an important role to play in ensuring full compliance with the offset policies in India. Such policies are expected to have a high impact on the aerospace and ancillary industries apart from building a large skill base. However, these measures will still not be enough to establish a core competence

in the analysis and design of new aerospace products. Overall, the offset policies are believed to be very much desirable assuming they are implemented properly with an active monitoring agency to ensure proper compliance. The Delphi expert panel recommends that the government should make these policies transparent and seek for feedback from the industry on a regular basis

“If Korea can do it, so can India. While the pace of implementation may be slow, the defence offset and civil offset conditions are very clearly being laid down, and Aerospace sellers into India have no option other than to fulfil offset conditions.”

“India’s aerospace industry could experience a steady increase of its capabilities. It would lead to a broad diffusion of technology throughout the economy. Foreign companies on their part will benefit by leveraging the advantages of the Indian market.”

“The offset policy requirements have not been enforced in the right ways in order to benefit Indian Aerospace industry. Positive impact of this policy is yet to be seen.”

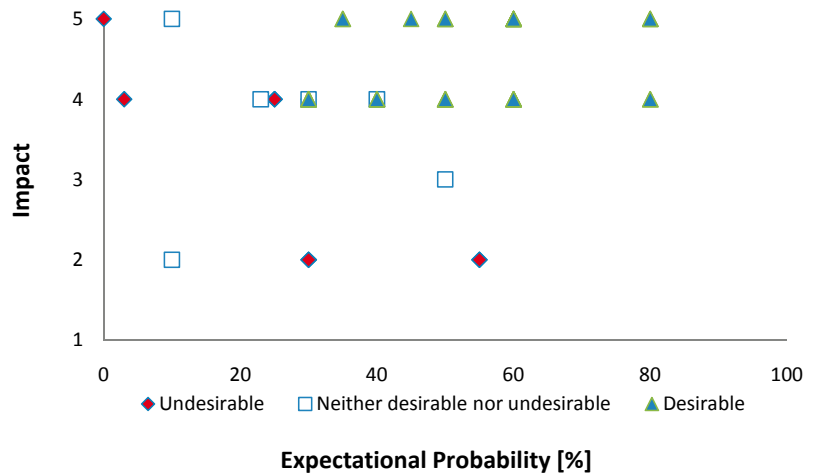
4. Analysis of Delphi Panel Discussions

4.2.4 Projection 4:

In 2019, the government's regulation on IP protection and technology transfer make aerospace manufacturers and service providers in India the most preferred business partners among companies in emerging markets.

India is believed to have an inherent advantage in becoming a preferred partner especially also for emerging markets like Africa, Middle East and South East Asia due to friendly relations and low labor cost. As the Indian government is expected to continue favorable Intellectual Property and Technology Transfer policies, it will continue to attract investors in high technology sectors.

Projection 4: IP Protection



Statistical Group Opinion: Probability: 48% | Impact: 4.2 / 5 | Desirability: 4.2 / 5

The Delphi panel believes that any improvement in the perception of India as a secure destination for locating IP-focused processes and technologies will definitely promote increasing investments in such areas. It is likely to complement India's other strengths such as a reliable local management, a suc-

cessful track record, skilled manpower and reliable legal frameworks. Adequate mechanisms to IP protection and technology transfer are expected to attract more OEMs to establish local manufacturing units in high-technology sectors

"We have good potential to become preferred partners in emerging markets of Africa, Middle East, Southeast Asia in view of nearness & low labour cost & good relations"

"The amendments in the Indian Copyright Law introduced in 1994 made Indian Copyright law one of the toughest in the world. Intellectual property right protection of software has been a success."

"India still does not have the best reputation when it comes to IP protection and technology transfer. This issue will persist in the minds of foreign companies seeking partnerships unless giant strides are made in both policy formulation and implementation. Also, this issue is linked with the FDI limit."

4. Analysis of Delphi Panel Discussions

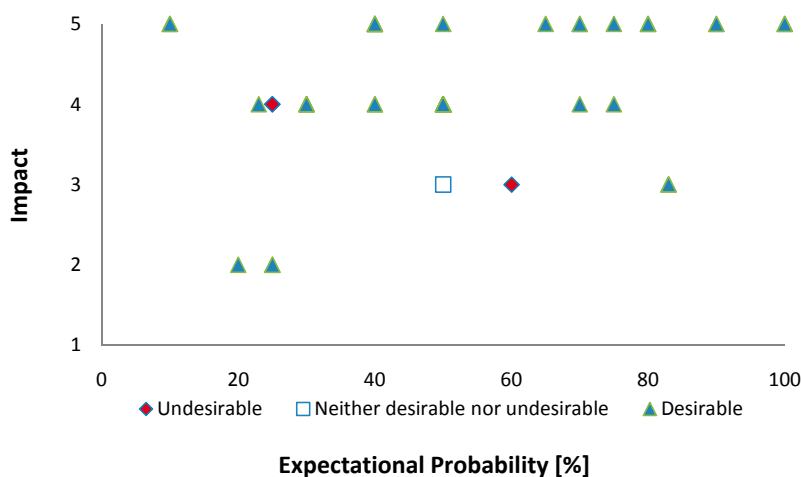
4.2.5 Projection 5:

In 2019, the problem of a highly-skilled manpower shortage in the Indian aerospace industry is solved.

The majority of Delphi experts believe that the high level of attention given by central and state governments to the issue of manpower development in high-skill sectors is expected to ease this problem in the coming years. However, specialized knowledge at the highest levels of domain expertise will continue to be in short supply. Many educational institutions have now set up aeronautical departments. The government's education policy will lead to many new research institutes of higher education being set up across the country. Also, several foreign trained experts and researchers from the aerospace sector are believed to be returning to India.

However, there are still doubts on the pace of such reforms taking place in the coming years. The quality of graduates being qualified by such institutes is another concern that has been discussed during the Delphi debate. A significant reorganization of India's higher education system is felt to be the need of the hour. In the context of the aerospace industry, it is important for these institutes to develop industry specific courses. According to the Delphi panel this can only be achieved with an active involvement of both the government and the private sector aerospace companies. The Delphi panel believes that any improvement in the perception of India as a secure destination for locating IP-focused processes and technologies will definitely promote increasing investments in such areas. It is likely to complement India's other strengths such as a reliable local management, a successful track record, skilled manpower and reliable legal frameworks. Adequate mechanisms to IP protection and technology transfer are expected to attract more OEMs to establish local manufacturing units in high-technology sectors.

Projection 5: High-skilled Manpower



Statistical Group Opinion: Probability: 52% | Impact: 4.1 / 5 | Desirability: 4.6 / 5

Our experts believe that the availability of high-skilled manpower will have significant impact as Indian companies will be able to move faster up the value chain and be able to contract more service outsourcing and/or manufacturing projects for India. It is believed that the manpower skill level and

the movement of the Indian manufacturing sector up the value chain will have to take place in parallel. Otherwise, such manpower is being transferred to foreign countries with no particular advantage to the Indian industry.

“The attention given by central and state governments to this issue, as well as the involvement of local industry and educational institutes, will solve this problem in the next 5 to 7 years. However, people at the very highest level of domain knowledge/experience will still be in short supply.”

“The problem of highly-skilled manpower shortage will not go away unless there are industry-specific incentives. Further, though India produces ca. 200k engineering graduates each year, it is important to impart aerospace-specific skills. I think the skills shortage getting addressed successfully will be a function of both government and corporate investment in aerospace educational institutes. This will come with growth in the industry but it is difficult at this point to be confident that this will surely happen. (Note that competition for manpower will be high in India as other industries also grow significantly in the face of economic expansion).”

4. Analysis of Delphi Panel Discussions

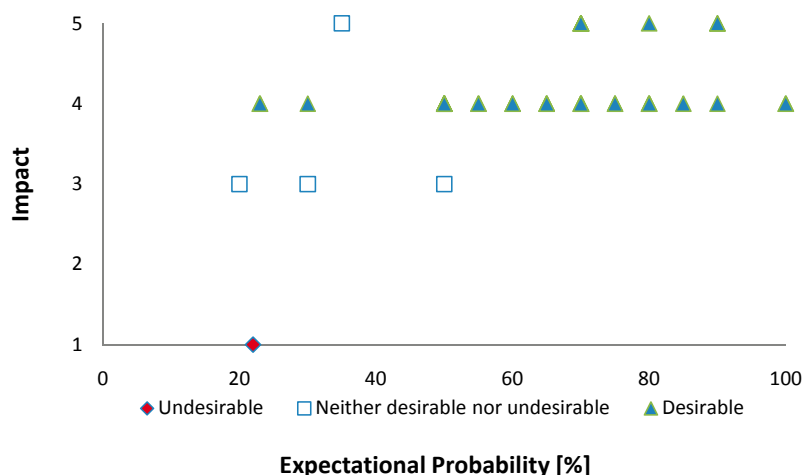
4.3 Technological Projections

4.3.1 Projection 6:

In 2019, aerospace manufacturers and service providers in India have tripled their domestic investments in basic R&D activities compared to 2008.

Although there are promising growth opportunities in the Indian aerospace industry, an expected low company focus on capital intensive R&D activities has been highlighted as a key reason against the occurrence of this projection. Nevertheless, the majority of experts argue that given a small current R&D base and several growth opportunities in the pipeline significant increases in R&D investments are thinkable - even if not tripled. Moreover, apart from companies like Boeing, Airbus, GE and Honeywell, new players like Thales Avionics, Rockwell Collins, Hamilton Sundstrand and Pratt & Whitney have started research and development activities in India. Indigenous companies like Tata, Mahindra, L&T and Hero Motors have also focused their attention to the sector recently. Despite these indicators, some other Delphi experts are of the opinion that the private sector is likely to concentrate on non-R&D activities like manufacturing and MRO and hence growth will not affect such investments. They argue that only government institutions like HAL, ISRO may make some progress in this area which, in turn, could not be enough effort to triple the investment amount.

Projection 6: R&D Investments



Statistical Group Opinion: Probability: 62% | Impact: 4.1 / 5 | Desirability: 4.3 / 5

The Delphi majority feels that the acceleration in R&D activities will substantially impact the industry, primarily in moving up the value chain in core areas like design and manufacturing. It will help in attracting bigger projects and involve partnering with major players like Boeing or Airbus. It will also help in nurturing and building an indigenous industry. Since India has a cost advantage in terms of skilled labor, investment in R&D activities can lead to a radical relocation of numerous research activities to India where they serve as global competency

hubs. It may also encourage research initiatives in the area of aerospace engineering. The Delphi study further reveals a high desirability for the Indian aerospace industry to invest in R&D activities. Until and unless this takes place, India cannot capture the market and may remain a low-end, small player. It will also help in developing core technologies and filling technological gaps. However, a few experts believe that India may keep its focus in non-R&D activities as investments can make the companies less competitive in short run.

“Given that very little investment has happened so far in basic R&D activities in India, this is guaranteed to happen in the next 10 years. At the moment it is only Boeing, Airbus, GE and Honeywell who have done this in some significant way. Raytheon, Lockheed Martin, etc. also have some R&D activities initiated. Thales Avionics, Rockwell Collins, Hamilton Sundstrand, Pratt & Whitney, etc. have invested in development activities in India; they will soon start R&D activities also, though the scope may be limited initially. Soon, Indian companies will also follow suit. (Currently Tata Advanced Materials has invested in R&D in composites; more will follow suit)”

“R&D activities will help India move up the value chain in terms of design. This in turn will allow bigger projects (end to end) to be executed in India.”

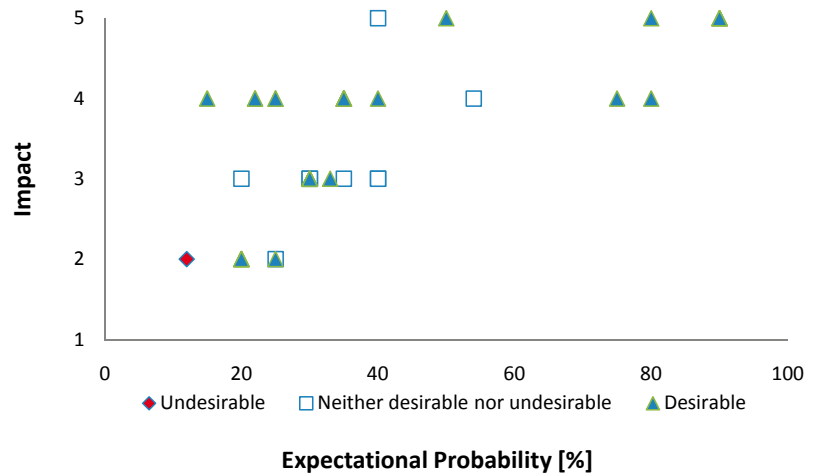
4. Analysis of Delphi Panel Discussions

4.3.2 Projection 7:

In 2019, technological challenges like unmanned aircraft or hypersonic flight are the key research focus for aerospace manufacturers and service providers in India.

According to the panel the Indian aerospace industry is unlikely to focus on research on unmanned or hypersonic flights. There is strong consensus among the experts on the projection's non-occurrence. Indian companies are rather likely to focus on existing conventional markets than targeting futuristic segments. Given the growth opportunities in traditional aircrafts, it seems more obvious for the companies to focus on these areas. Moreover, big players with strong alliances are considered to be better equipped to do R&D in the area of unmanned flights. Some panel members stressed that e.g. the Indian Air Force is as small as one-third of its Chinese counterpart. To mitigate the associated risks of R&D India's offset policy is expected to encourage companies to focus more in traditional practices as it already has a huge market potential.

Projection 7: Technological Challenges



Statistical Group Opinion: Probability: 38% | Impact: 3.4 / 5 | Desirability: 3.8 / 5

Research activities in unmanned-aircraft vehicle (UAV)/supersonic jets will only impact big state owned players that have strong ties with advanced companies. Once there is some success in offers, small players may come in to leverage upon them. Despite the low probability of occurrence of this projection, the Delphi panel feels a desirability of

occurrence. Apart from providing economic boost to small and medium scale industries, such a concentration would result in large leverages to Indian Defense. Some experts argue in favor for this projection since a leading role in UAV technology would enforce military strengths

Experts' Comments

“Indian Manufacturers are likely to focus on meeting the projected large market requirements in next few years rather than future opportunities. Likewise, Service providers will ignore future fantasies.”

“The Indian Air force (IAF) fleet strength is just one-third of China's. Hence the government will be looking to acquire conventional high-tech crafts to build capacity.”

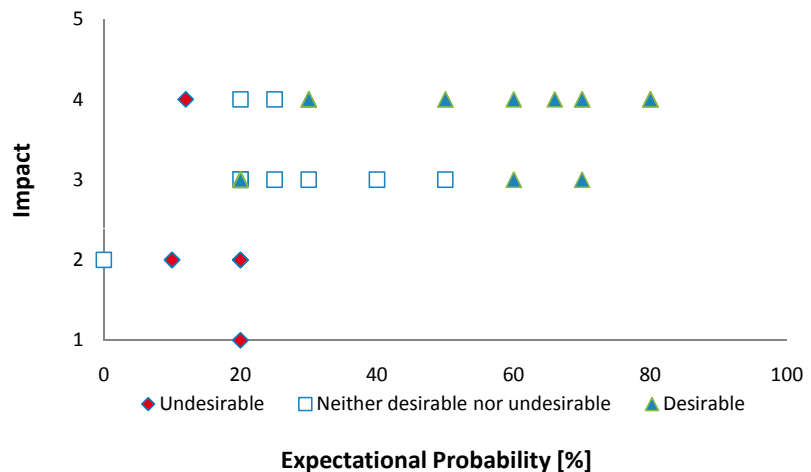
4. Analysis of Delphi Panel Discussions

4.3.3 Projection 8:

In 2019, alternative fuels are the key research focus for aerospace manufacturers and service providers in India.

The expert opinions show strong dissent on this projection with moderate levels of opinion convergence. Overall, the panel feels that it is highly unlikely for Indian companies to shift their focus to alternate fuels. In order to capture the existing market, industry is more likely to focus on design, manufacturing and MRO capabilities rather than alternate fuel technologies. India is expected to follow more of a wait-and-watch policy wherein it will first evaluate success of similar projects in the advanced world. Experts believe that at present, it looks to be less lucrative and a risky proposition. Moreover, it is more likely for the core energy sector and engine manufacturers like GE, Rolls Royce to concentrate research in this area.

Projection 8: Alternative Fuels



Statistical Group Opinion: Probability: 34% | Impact: 3.1 / 5 | Desirability: 3.2 / 5

Only few of the experts believe that depleting fossil fuel reserves and strict carbon emission laws may drive Indian companies to explore alternative fuels. Nevertheless, a concentration on alternate fuels would help the industry to 'go green' and to keep up with competition globally. It would also boost the space technology research. However, backward compatibility of the alternate fuels related to conventional fuel based aircrafts may pose a big challenge in the adaptability of the new technology.

Regarding desirability, some experts consider this projection imperative for future requirements and the adherence to climate change commitments. Nevertheless, the majority of experts argues that for India such a research focus remains a secondary domain and industry should maintain its focus in conventional practices of design, manufacturing and MRO, where the industry still needs to cover a long distance.

Experts' Comments

"Again, research into new/ emerging areas such as alternative fuels will be driven by the western economies more than India. India will still play catch-up over the next 10 years than leapfrog advanced economies in all forms of basic/applied research in aerospace."

"Carbon Emissions laws will make it increasingly important to study alternative fuels."

"India's focus is to acquire and develop manufacturing competence, services and sub-systems to create a world class aerospace production industry."

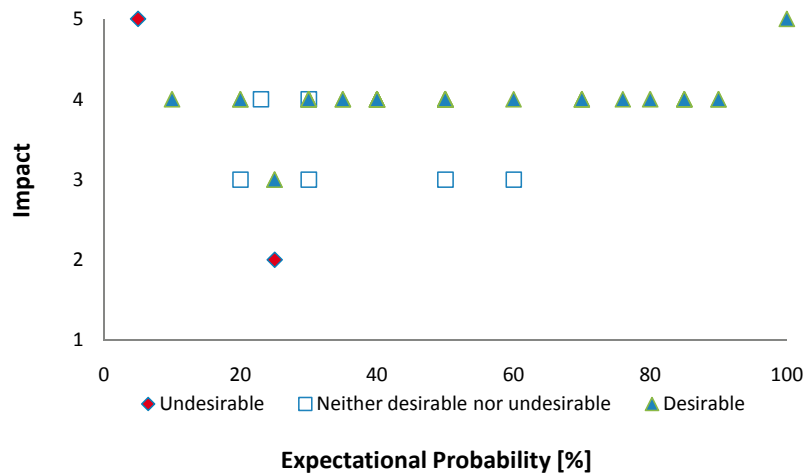
4. Analysis of Delphi Panel Discussions

4.3.4 Projection 9:

In 2019, material technologies focusing on new composites are the key research focus for aerospace manufacturers and service providers in India.

As with the previous two projections, experts are not optimistic that material technology will be the key focus of the industry. In addition, there is no consensus on this estimate. From today's point of view the future of composites in the Indian aerospace industry is still unclear. Research in composite materials is already under process by labs like DMRL, NAL and DRDO. However, the Indian industry seems aware of the recent trends in the composite research and given that small players can also enter in this field, at least some companies might enter business until 2019.

Projection 9: Material Technologies



Statistical Group Opinion: Probability: 45% | Impact: 3.8 / 5 | Desirability: 3.7 / 5

Technologically advanced countries in the West and Japan are more likely to invest in composite research since such type of research is strongly connected to design and manufacturing capabilities, in which India still lags behind. The panel agrees that composite materials will play a greater role in the future. They will go on to be extensively used in products and their usage will positively contribute to overall costs. Any

new composite is likely to provide competitive advantages in terms flexibility of material selection, too. It may also boost the LCA segment tremendously. Given the benefits offered by advanced composites they are highly desirable and can help in reducing import costs of traditional materials, engine and framework weight as well as optimizing designs.

Experts' Comments

"Unlike many other emerging areas in aerospace, composites is an area where many Indian companies are already prominent. The Indian industry is already well aware of the trends in composite usage in aircraft. It is quite conceivable that composites will be focused on in a big way in India by 2019."

"A handful of companies only will enter this space, as composites development will see more R&D in the West and Japan. India will do more work on metal than on composites, for the next few years."

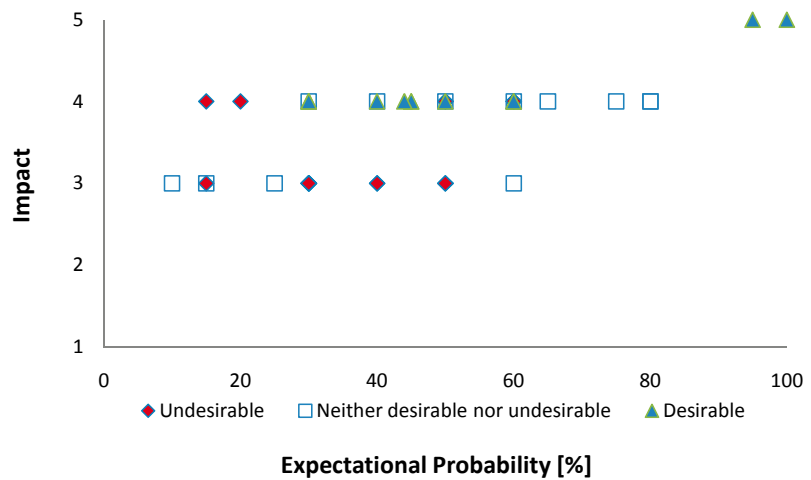
4. Analysis of Delphi Panel Discussions

4.3.5 Projection 10:

In 2019, aerospace manufacturers and service providers only integrate 1st generation technologies in their product and service offers.

In general, it seems highly unlikely for the Indian aerospace industry to provide the most advanced solutions in the foreseeable future. Nevertheless, there is no consensus among the experts concerning this estimate, which means that the variance of opinions is still very broad. Most experts believe that global players will try to exploit the cost effectiveness of low-tech outsourcing capabilities of India. In combination with an expected lack of R&D investments and consequently lower engineering capabilities, the Indian industry may focus only on few elements of the value chain like MRO as well as parts manufacturing.

Projection 10: First Generation Technologies



Statistical Group Opinion: Probability: 51% | Impact: 3.4 / 5 | Desirability: 2.8 / 5

Our panel does not see a highly positive impact of the projection's occurrence on the industry since they believe that specialization will still remain in parts of the value chain. The expert panel recommends that in order

to maintain competitive, the Indian industry should rather focus on single elements of low-tech manufacturing rather than on the most advanced technological and integrated solutions.

"Companies that set up Greenfield ventures in India will try and ensure that they use the latest technology in their operations. Given that there is a need for more efficient, safer and reliable aircraft, the probability of old technology being used in a big way is low."

"Low-tech, outsourcing will be a significant part of what India does"

"Indian Original Equipment Manufacturers (OEMs) are aiming at supplying lower end technologies to the global aerospace industry. They anticipate a lot of business as they have a 40% cost saving advantage over the West. Hence emphasis will be on lower tier technology over the next few years. However, incorporating state-of-the-art technologies into the aerospace industry in India is the main objective stated by the government of India."

4. Analysis of Delphi Panel Discussions

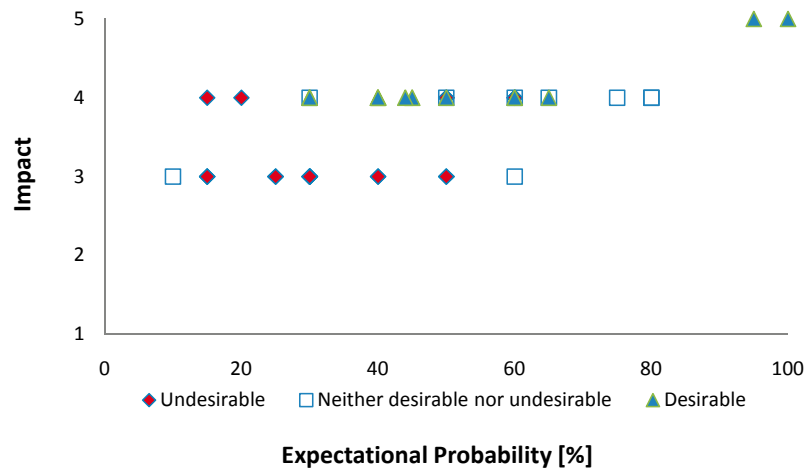
4.4 Value Chain Projections

4.4.1 Projection II:

In 2019, foreign companies dominate the Indian aerospace industry (R&D, Design/Engineering and Manufacturing).

Most experts believe that Indian firms by themselves will play a minor role, unless larger players like Tata, Mahindra and Mahindra, L&T, Godrej, Hero Motors enter the fray on a large scale.

Projection II: Foreign Companies



Statistical Group Opinion: Probability: 53% | Impact: 3.7 / 5 | Desirability: 2.9 / 5

In fact, Indian private firms resp. their operations currently involved in the aerospace sector are small and the investments needed to become a major player are huge. Foreign companies are expected to be present but will most likely be operating through joint ventures and strategic alliances to get a better local touch. Companies combining engineering expertise and local manufacturing platforms such as QuEST Global might serve as ideal collaboration partners. Especially the civilian sector might be dominated by foreign players but the military sector is still expected to be guarded by the government.

Most experts also agree that foreign presence is beneficial to this nascent industry in India but they are cautious about the impact it will have on the domestic players. The way the industry is developing will define development priorities as well as targeted markets and cost structures. On one hand, there is the fear of Indian companies losing their brand image by becoming mere suppliers for foreign players or the fear of a threat to national security as a result of foreign players entering the military segment. On the other hand, there is also the recognition that foreign presence might result in reduced lead-times to new developments and a globally more competitive industry

“Most foreign companies have, or will have, domestic partnerships for their aerospace activities in India. This is likely to be true for all activities across the value chain. Therefore, I tend to say that the probability of occurrence is only half - foreign companies will 100% be present in India but will be operating joint ventures/strategic alliances.”

”Priorities in development, markets to address, cost structures, etc. will be defined by whether foreign companies dominate.”

“In Military and space sectors, Indian govt. owned organizations will play lead roles. Govt. will initiate more platform development projects where govt. will take lead roles in R&D, Design & Engineering and Manufacturing.”

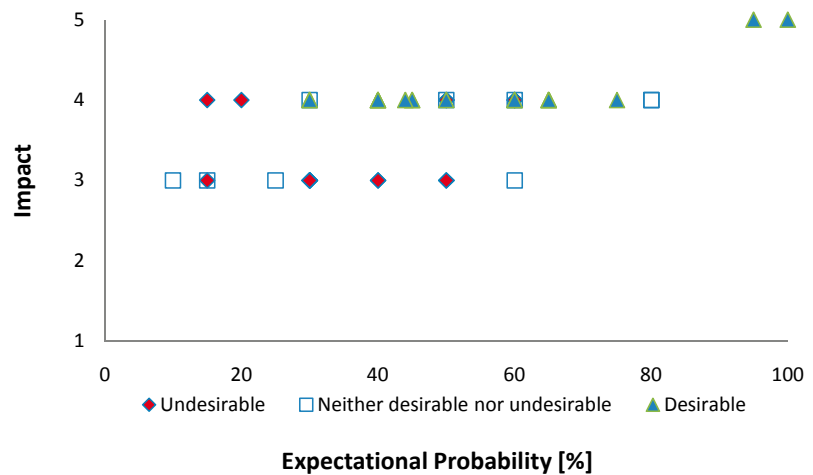
4. Analysis of Delphi Panel Discussions

4.4.2 Projection 12:

In 2019, the only globally competitive activity area of the Indian aerospace industry is R&D and Engineering/Design.

According to our expert panel arguments for a high likelihood of this projection include the solid base in engineering in India as well as the low cost of manpower which will act as a source of advantage for at least a few more years if not decades. Most of these activities will though be limited to the low-tech aircraft sector.

Projection 12: R&D and Engineering



Statistical Group Opinion: Probability: 46% | Impact: 3.6 / 5 | Desirability: 3.0 / 5

According to our own analyses, Indian companies are also expected to further develop into MRO, training (pilots, cabin crew, maintenance/repair engineering), airports map digitization, and software (i.e. not avionics but IT applications used in the aerospace industry) sub-segments. They are also expected to thrive in the manufacturing sector based on low labor cost levels in general and strength in low automation that supports to cope with the high degree of customization required in this sector. Most experts seem though pessimistic about India becoming a hub for high-end R&D activity - at least until 2019. If Indian companies start excelling in high-end

R&D and engineering it will mean less focus on basic manufacturing which, in turn, is likely to weaken the industry as a whole as engineering and R&D at a top-notch level is unlikely to be successful without a solid connection to manufacturing. However, if Indian firms also do not start moving up the value chain, their contributions may become very limited and they will be finally heavily reliant on foreign players. This would severely restrict the bargaining power of the Indian companies (most of which are MROs) and hence it is, according to the Delphi panel, not in the long-term strategic interest of the Indian aerospace industry from a local perspective.

Experts' Comments

“There will be other areas like MRO, Training (pilots, cabin crew, maintenance/repair engineering, etc), airports map digitization, software. Also, aero manufacturing will be a significant area.”

“India is competitive in software development, servicing, repair, refurbishing, refit and also some types of testing activities.”

“If the trend occurs as described, India will fail to emerge as a global aerospace power because it will be active only in certain parts of the value chain.”

“To be a meaningful player globally, this should be a priority.”

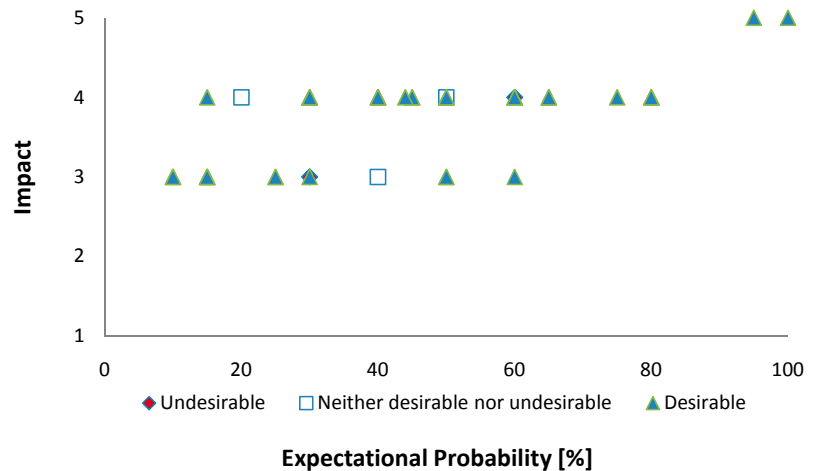
4. Analysis of Delphi Panel Discussions

4.4.3 Projection 13:

In 2019, Indian aerospace manufacturers are globally competitive across the full range of aircraft models.

Although Indian aerospace firms like Hero Motors or Mahindra & Mahindra have taken some first steps towards creating a globally competitive range of aircrafts, they are still some way off from reaching their visions. Also, given the scale of investments required they are unlikely to compete in the high-end and large aircraft segments.

Projection 13: Full Range of Aircrafts



Statistical Group Opinion: Probability: 27% | Impact: 4.1 / 5 | Desirability: 3.8 / 5

The experts believe that even though Indian firms have expertise in small aircraft and small/medium combat aircraft engineering and manufacturing, they are unlikely to compete in the large transport aircraft segments on their own (selling aircrafts as integrated product and not sub-systems or components). Our panel agrees that future developments will probably focus on niche areas rather than

across the entire range of aircraft products and services. In case these efforts are successful it is likely to make Indian firms more prominent players in the region and to help winning larger contracts. A very high potential for export and employment opportunities make this a very desirable occurrence for the panel.

Experts' Comments

“Indian aerospace manufacturers will be globally competitive in a limited range of aircraft models for which large western companies make investments in India.”

“This cannot happen in such a short time. India may have competitiveness in regional aircraft, small aircraft and light/medium combat aircraft, but certainly not in large transport aircraft. (The assumption here is that the question is about whether India can be competitive in designing and selling complete aircrafts, and not only components/subsystems/modules. If it is components/modules/systems, then India will be competitive across the full range).”

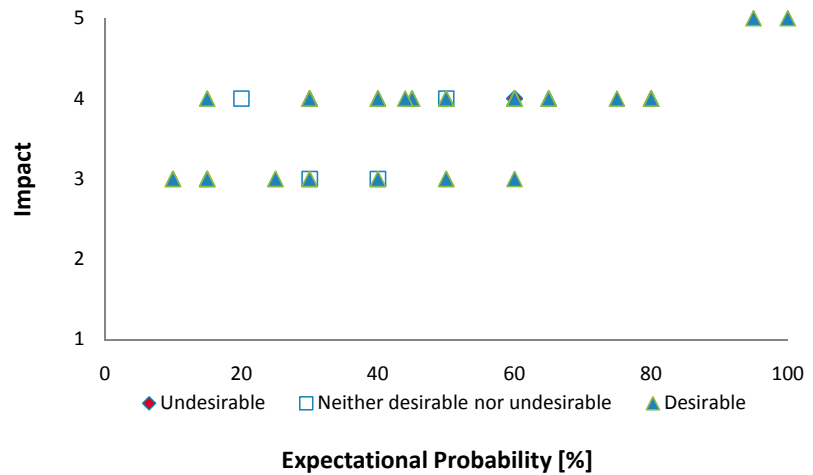
4. Analysis of Delphi Panel Discussions

4.4.4 Projection 14:

In 2019, the Indian aerospace Industry is globally competitive in offering integrated solutions including R&D, Engineering/Design and Manufacturing.

According to the Delphi panel the factors favoring such developments include labor cost benefits, resource availability, a big domestic market as well as strong reliability especially in the space and military development projects. In fact, Indian firms have already started moving business models towards integrated solutions but most experts agree that 2019 will be too early for Indian firms to achieve remarkable integrated product portfolios. Until 2019, Indian firms are expected to be heavily involved in global development projects but not in leading roles and as integrated solution providers.

Projection 14: Integrated Solutions



Statistical Group Opinion: Probability: 43% | Impact: 4.2 / 5 | Desirability: 3.9 / 5

The occurrence of this projection would be highly desirable for the Indian aerospace industry because an increased business volume as integrator would result in larger revenues which in turn would end up in an increase in capacity and capabilities for the respective In-

dian players. Such a situation would additionally give a huge boost to India as an aerospace nation and positively brand many products that result of spin-offs and might lead to the creation of jobs as well as increased prosperity for the country.

“Likely to happen only in case of space and strategic military aircraft development projects.”

“Apart from capability building, spin off of technologies from aerospace sector will be beneficial to the society.”

“ In a few years time, I can foresee India being involved in global development projects but not in an integrated product or as a project leader.”

“Indian aerospace is moving towards integrated solution and may reach half way mark by 2019 .”

4. Analysis of Delphi Panel Discussions

4.4.5 Projection 15:

In 2019, Indian companies only (with no foreign partners) dominate the aerospace MRO service industry.

An analysis of the experts' estimates reveals a low likelihood that Indian firms on their own will dominate the MRO industry in India. Most Experts stress that the major challenges for the Indian MRO sector are two-fold: low-scale business and missing maturity of operations. India lags behind other Asian MRO destinations like China, Japan and even Singapore when it comes to the size of the MRO industry segment. While the Indian MRO sector is witnessing average annual growth rates of over 10%, it still remains under the billion dollar mark in terms of revenues while e.g. Singapore realizes already about \$5.1 billion in revenues from the MRO sector at present.

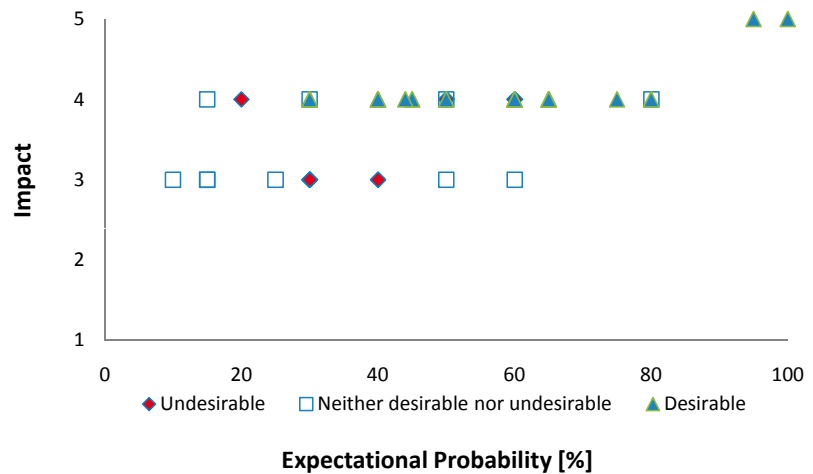
As a consequence, another major challenge is the low technological expertise of the Indian MRO sector. As a result, foreign collaboration often becomes vital. In fact, several experts pointed out that most of the existing or upcoming MRO facilities in India have significant foreign participation and often the level of technological expertise of MRO facilities in India is directly attributed to the level of foreign participation or assistance in them.

"Today Air Works, Air India & Jet Airways dominate Indian MRO but they do not cover the complete range of activities; new MRO entrants are likely to be in partnerships with foreign companies"

"Dominant Aerospace OEMs will strive to have major presence in MRO markets in India & China, in the interest of the major future market shares. Indian companies will only have limited presence in niche segments."

"HAL will be dominant in military MRO. Civilian sector will have foreign partnerships."

Projection 15: Dominance in MRO



Statistical Group Opinion: Probability: 53% | Impact: 3.7 / 5 | Desirability: 2.9 / 5

While the Indian MRO sector can offer significant cost advantages today, the experts point out that the rising labor costs as well as existing tax regulations might erode the cost advantages in the future. It must also be noted that the currently growing volumes of MRO business in India could stagnate as the effectiveness and efficiency of aircraft maintenance will rise. According to the Delphi panel, it will be critical for the Indian MRO sector to quickly build up on its successes and scale up in terms of capabilities and business volume. From a public perspective, it seems favorable to concentrate on this sector as it can provide large scale employment. One may also want to separate the MRO sector into civilian and military segments. Experts point

out that HAL, a public sector undertaking, is a major MRO player in the military segment and has significant expertise in servicing and overhauling aircrafts for the Indian armed forces as well as for foreign armed forces in Vietnam and Malaysia. Upcoming defense acquisitions in India could significantly boost military MRO and also provide a major opportunity for large private MRO providers to enter this field. India could emerge as a dominant military MRO destination and provide services for foreign military operators in Asia and Africa. But foreign participation will only go on to play a major role in the success of the Indian MRO sector by imparting technological expertise as well as providing financial resources in this capital intensive sector.

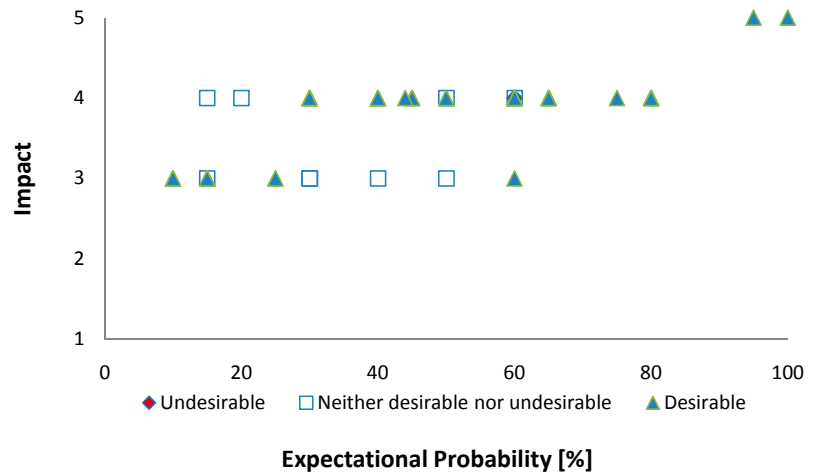
4. Analysis of Delphi Panel Discussions

4.4.6 Projection 16:

In 2019, India is the leading hub for MRO services in Asia.

The experts reach consensus that the probability of India turning into Asia's leading MRO hub is high. While it has been pointed out that China, Japan and Singapore are already ahead of India in the MRO sector we must also note that the Indian MRO sector has been logging annual growth rates in excess of 10% over the past few years and this is expected to continue or even accelerate as the global slowdown recedes – given that no other unexpected events happen, but none of the experts made any such comment. The experts feel that as MRO is a volume based business, there are few locations apart from India and China that can offer significant economies of scale. Further, India's favorable geographical location will be a significant advantage in the future as aircraft operators not only value price and quality but also quicker service times which therefore ensure a quick turnaround time for their fleet.

Projection 16: Leading MRO hub in Asia



Statistical Group Opinion: Probability: 58% | Impact: 3.9 / 5 | Desirability: 3.8 / 5

Our experts feel that India is likely to be preferred over China for MRO services given the political context and language issues in China. The emergence of India as a leading MRO hub in Asia would not only bring in large volumes of work and revenues, but it could also provide large scale employment opportunities for skilled blue-collar workers. Further, the domestic aviation sector can be one of the major beneficiaries of a strong MRO sector in India.

However, a leading MRO hub in Asia will be strongly contested by the existing players like China, Singapore as well as other emerging players like Abu Dhabi and South Korea. While the Indian MRO sector is expected to be a USD 1.17 billion market by 2010, the corresponding figures for Singapore are expected to be well above USD 5 billion. Further, poor domestic infrastructure and governmental support as well as cost competitiveness of other Asian hubs are likely to hamper the growth of the Indian MRO sector in the near future. Some experts therefore feel that India may not have a significant lead against the other MRO hubs by the end of the next decade. They recommend that it is essential for the Indian MRO sector to identify specialty segments within the business and to strive for domination within these segments.

Experts' Comments

“Highly probable because there aren't any other viable locations that can do this at scale apart from China. China may be a less preferred MRO destination than India due to its political context, language issues as well as geographical location.”

“India could be the specialist hub in some size and specialty segments of aerospace industry.”

“Given the volume and cost competitiveness, this is very likely.”

“Other countries in Asia will have also cost and skill advantages.”

4. Analysis of Delphi Panel Discussions

4.4.7 Projection 17:

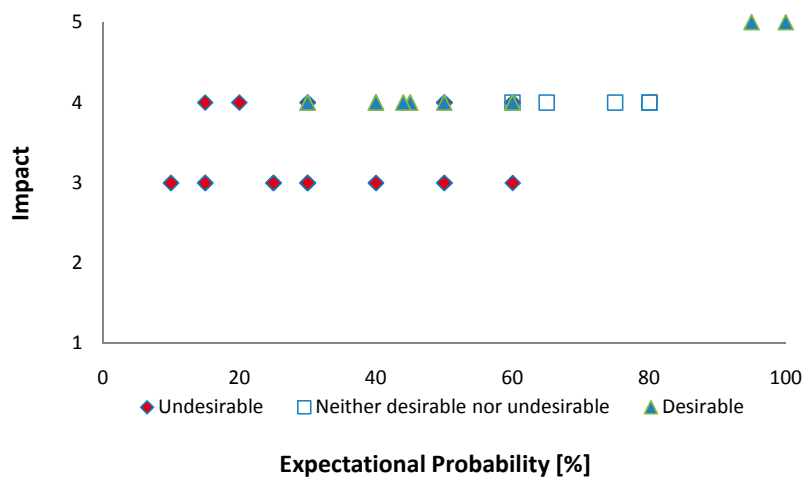
In 2019, cost advantages are the only growth driver of the Indian aerospace industry.

The Delphi panel ends up with a mean probability of 51 percent for this projection and a high degree of convergence during the Delphi process. Most of the panel members agree that the cost competitiveness is the major advantage of the Indian aerospace industry today.

However, the Indian aerospace industry cannot grow purely on a low-cost approach. Given the ongoing downturn, there is an increasing focus on lowering costs globally. Companies are putting off large capital expenditures and are increasingly outsourcing their activities to keep costs low. While the low-cost approach will help in the initial growth of the Indian aerospace sector, rising labor and input costs are almost inevitable. Rising compensation levels and inflation will squeeze the margins for the Indian industry till 2019. Further, in the medium to long-term, experts note that further growth implies the availability of a highly skilled workforce, well developed services and value chains, the availability of materials and a developed high-tech industrial manufacturing base.

Among those factors, the availability of a highly skilled workforce remains a major concern for most experts. While India has a large pool of young engineers and technicians, there are few world class educational institutes and research facilities in the field of aerospace. Similarly, given the extremely complex and long value chain in the aerospace sector, a lot of effort has to go into developing the value chain in India. Most Indian aerospace firms today operate at the Tier-2/3 level. With the exception of HAL, there is barely any other firm that has any presence in the Tier-1 or the system integration space. Moreover, the availability of materials is another concern given that Indian aerospace firms have to import large amounts of raw materials. This situation might change slightly in the long-term when composite materials are commonly used in a broad range of smaller aircrafts as well.

Projection 17: Cost advantages only Growth Driver



Statistical Group Opinion: Probability: 51% | Impact: 3.4 / 5 | Desirability: 2.6 / 5

The experts agree that for sustained growth, massive investments in education and workforce training facilities have to be made. Further, high costs of setting up or expanding facilities will be a major impediment towards maintaining low costs, especially given the high cost of capital in India. The development of an indigenous raw materials industry shall also take time – if possible at all for some of the crucial material inputs. While reducing imports may keep costs low, it has to be noted that a modified supply chain will have to be built to ensure an efficient flow of materials and components through the industry. Due

to the increasing complexity of operations significant efforts will have to be put into project management and coordination of operations across the industry – problems that are well-known from experiences in the Indian automotive industry.

In essence, the low-cost approach is suitable to jumpstart the Indian aerospace industry in the short run, but it will have to be coupled with technological progress as well as a reliable value chain development in order to achieve sustained growth in the future.

“At this stage of development of the Aerospace Industry, cost competitiveness will bring investment and business opportunities.”

“Over time, India will become prominent in the aerospace industry on account of its skilled manpower and ability to offer integrated solutions. Cost may be the main initial growth driver for Indian aerospace but, over the long term, its importance will diminish.”

“Highly qualified technical graduates, availability of high tech precision equipments, services & support networks, availability of materials and consumables, world-class educational institutions, manufacturing/assembly facilities are some of the other essential growth drivers.”

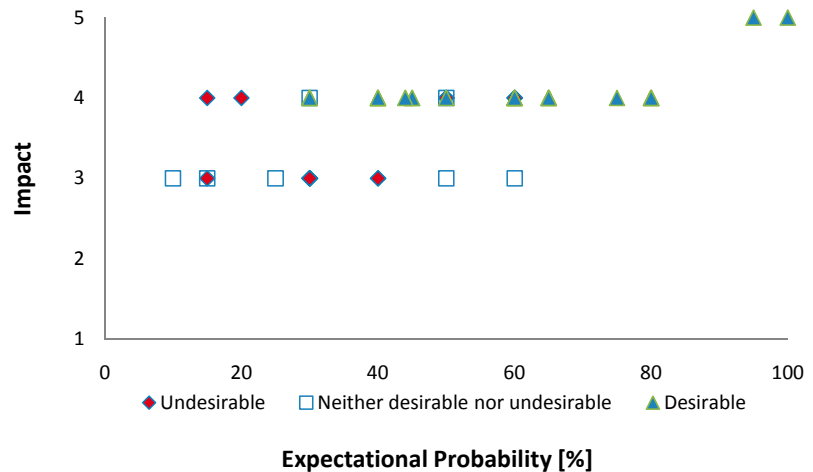
4. Analysis of Delphi Panel Discussions

4.4.8 Projection 18:

In 2019, the access to an abundant number of highly-skilled R&D personnel is the only advantage of the Indian aerospace industry.

According to its mean probability this projection can be classified as eventuality. The experts' arguments reflect that India is establishing world-class engineering and technology schools. Over the next decade, the central government is expected to boost its investments in higher education and research across India. Therefore, the shortage of high-skilled personnel is expected to decrease at least. It is without question that R&D skills are critical for the future growth of the Indian aerospace sector. Technological breakthroughs and innovations are not possible without systematic investment in R&D.

Projection 18: Access to skilled Personnel



Statistical Group Opinion: Probability: 46% | Impact: 3.7 / 5 | Desirability: 2.6 / 5

However, the Indian aerospace industry still suffers from poor aerospace domain knowledge and this is likely to hamper or at least slow down R&D, even if India can quickly get over the shortage of skilled personnel. Some

experts argue that R&D by itself can provide limited growth only. Rather, R&D will have to be complemented with manufacturing and service industries, which represent the major volume of work in the aerospace value chain.

Experts' Comments

“With good educational background of Indian engineers coming out of IITs, IISc, this is highly probable.”

“At present R&D and Engineering personnel do not have domain knowledge in aerospace sector.”

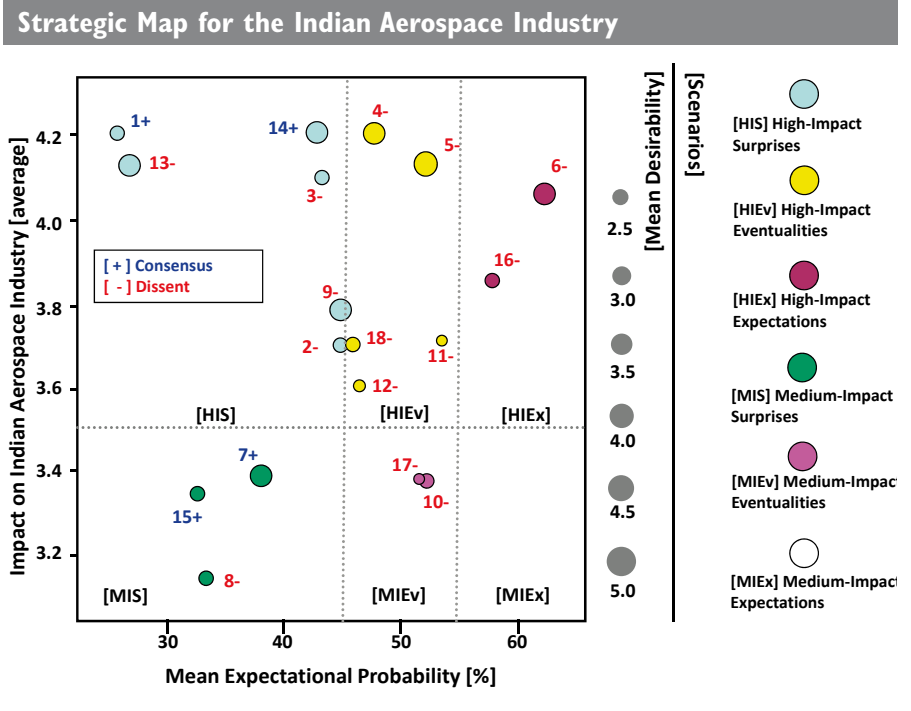
“R&D skills have to be built up together with manufacturing and testing practices. In absence of the other two, R&D will be handicapped.”

“No single advantage will be overridingly important to be deemed the 'only advantage' or 'only key advantage'. The advantage of the Indian aerospace industry will be a function of skilled R&D personnel, skilled manufacturing/service personnel, favourable cost structures, offset policy and tax incentives among other things.”

4. Analysis of Delphi Panel Discussions

4.5 Strategic Map for the Future

Strategic maps present meaningful clusters of projections that have strategic significance for the industry. The members of a cluster are very similar in terms of the characteristics investigated. We can therefore conclude that the strategies used for different subject areas in a cluster must also be similar.



| Political Projections | Technological Projections | Value Chain Projections |
|------------------------------|-------------------------------------|---------------------------------|
| 1: FDI limit (+) | 6: R&D investments (-) | 11: Foreign companies (-) |
| 2: Tax benefits (-) | 7: Technological challenges (+) | 12: R&D and engineering (-) |
| 3: Offset policy (-) | 8: Alternative fuels (-) | 13: Full range of aircrafts (-) |
| 4: IP protection (-) | 9: Material technologies (-) | 14: Integrated solutions (+) |
| 5: High-skilled manpower (-) | 10: 1st generation technologies (-) | 15: Dominance in MRO (+) |
| | | 16: MRO in Asia (-) |
| | | 17: Cost advantages (-) |
| | | 18: Access to personnel (-) |

The diagram shows a clustering of the 18 projections examined which allows for strategic grading similar to a portfolio analysis. Using the “Expectation Probability”, “Impact”, and “Desirability” as dimensions, we found six clusters out of which three clusters (High-Impact Surprises, High-Impact Eventualities and High-Impact Expectations) are of particular strategic importance due to their high impact and often high desirability. The other three clusters consist of projections that

score low to medium on probability, impact and/or desirability. As such, they do not represent variables that are primarily used for exploring new opportunities; however they do provide insights that could be further explored in individual scenario mapping approaches since external factors or incidents could still drive them into one of the other three clusters. However, in the course of this scenario report we concentrate on the high-impact clusters.

4. Analysis of Delphi Panel Discussions

4.5.1 High-Impact Surprises

High-impact surprises are characterized by a low expectational probability and a high impact. Such developments and events are often neglected by companies as they are considered improbable. But if they do occur they have a huge impact on the market or individual companies. It is therefore important for such developments to be considered when developing strategies alongside expectations. Six projections from this study were assigned to this cluster – Projection 1 (FDI limit), 2 (Tax benefits), 3 (Offset policy), 9 (Nascent stage), 13 (Full range of aircrafts) and 14 (Integrated solutions). While there is, for example, a panel consensus on the very unlikely event of a total absence of any FDI limit in India in the aerospace sector by 2019, it would have an extremely high impact on the industry in case the government changes its current policies and industry development approaches (Projection 1 FDI limit). Similarly, Projection 13 (Full range of aircrafts) is considered to be unlikely, but with a high potential impact. However, while Projection 1 can come quite quickly after new elections or other major events, Projection 13 needs to develop over time so that it comes less as a real surprise. Nevertheless, companies need to consider all these aspects when developing their roadmap for the Indian aerospace industry. High-impact surprises have thus the power to change business radically and may have significant positive or negative effects for an industry or single company. Therefore, executives need to discuss these “wildcards” in their strategy development. They form especially the basis for contingency strategies. The high number of potential surprises in this study reflects the turbulent environment of the Indian aerospace industry and stresses the need for cautious and systematic planning procedures.

4.5.2 High-Impact Eventualities

The second cluster, high-impact eventualities, refers to projections that are characterized by a moderate expectational probability and a high impact. In contrast to potential surprises, these projections are considered possible, but not very likely. Eventualities are usually a subject of dispute, often leading to dissent among experts. Such projections represent the highest degree of uncertainty and are neither believed to be probable nor very improbable. Therefore, executives need to pay particular attention to the high-impact eventualities in their strategic planning as these developments can not be classified as total surprises. Since they may also influence the business radically, such projections should be monitored continuously as the industry develops. The primary basis for developing roadmaps will remain on expected projections. Nevertheless, eventualities, in particular the high-impact ones, may form a second basis and can be taken into account when drawing up a strategy. Five of our 18 projections fall into this cluster: Projections 4 (IP protection) and 5 (High-skilled manpower) score a high impact and desirability, although the panel could not reach a final consensus on the probability estimates. The projections 11 (Foreign companies), 12 (R&D and engineering) and 18 (Access to personnel) yield a low desirability and a significantly lower impact than the other two projections. The cluster-internal differentiation into two poles is very valuable since it indicates the preferred direction for policy making and strategy preparation as well as contingency planning respectively.

4.5.3 High-Impact Expectations

The third cluster refers to high-impact expectations. Projections that fall into this category are characterized by a high expectational probability and a high impact. They are therefore of important strategic relevance for a company and any strategic planning should integrate them at least. Such projections form the primary fundament for the development of goals and strategies since they are mostly believed to become a reality at a certain time in the future. Nevertheless, executives should keep in mind that expectations turn into potential surprises, if they do not occur. Thus, their non-occurrence should also be considered in discontinuity analyses. In this scenario study, two projections fall into the high-impact expectations cluster. Of these, Projection 6 (R&D investments) is considered highly desirable and underlines the willingness for growth and development also in the R&D area. The Projection 16 (MRO in Asia), in turn, reflects the panel's expectation of India becoming a leading MRO hub in Asia and indicates the direction of industrial concentration. However, both high-impact expectations did not reach a high consensus level which implies that the expectations, beliefs, visions and perceptions regarding the industry are broad among the experts. Such a result definitely asks for a concrete strategy and vision development for the years to come in order to stabilize its path. The government of India may take an active role in providing the framework for a positive policy development.

5. Priority Areas

Besides strategic mapping, Delphi data and expert arguments offer the possibility to develop a strategic agenda for policy makers. The Delphi statistics show the general direction to go, whereas the expert arguments and the procedure of discussions help to refine the priority areas of focus. Based upon the data we have identified major areas of action for the development of the Indian aerospace industry. We differentiated between three major priority levels, i.e. high, medium and low.

Areas of Focus

High priority

- Eliminate shortage of high-skilled workers (Projection 5)
- Ramp up R&D investment (Projection 6)
- Invite foreign Aerospace companies to India via JVs, FDI, etc. (Projection 11)
- Concentrate on the MRO segment (Projection 16)

Medium priority

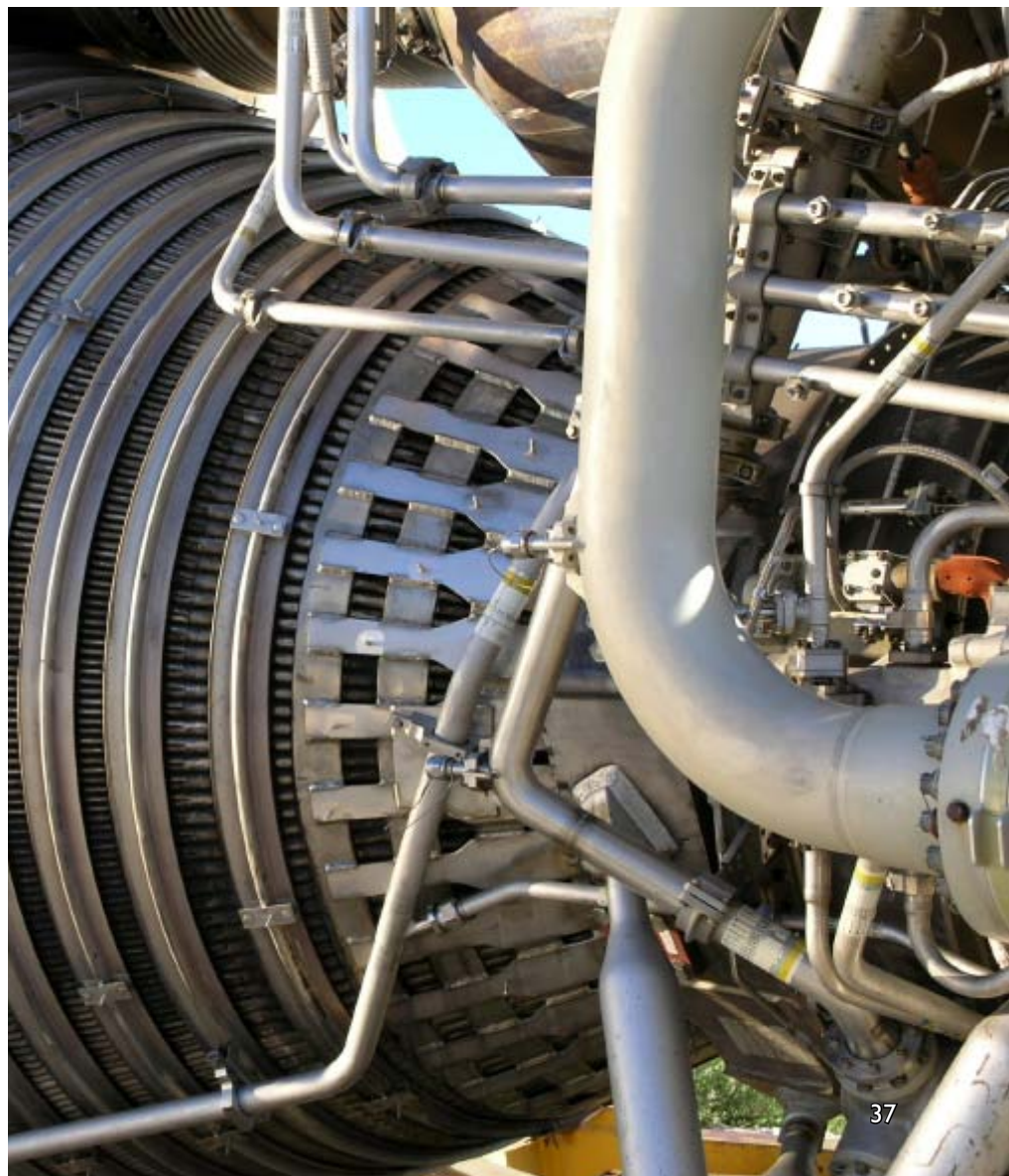
- Focus on acquiring basic technologies across the value chain (Projection 10)
- Maintain cost advantages over competing geographies (Projection 17)
- Government focus on implementation of offset policies, IP protection (Projections 3, 4)
- Develop capability to deliver integrated products & solutions (Projection 14)

Low priority

- Focus on cutting edge R&D (Projections 7, 8, 9)
- Offering high end R&D, engineering & design solutions (Projection 12)

For each projection we devised a priority ranking scheme based on its probability of occurrence and its impact. We calculated compound indexes in order to assess the overall values. The resulting policy agenda clearly shows the preferred activity areas for the future. It has to be noted that these recommendations are not the sole and only way - but according to the expert panel and the Delphi results it highly supportive for a positive industry development until 2019. It helps to concentrate resources on specific foci of interest thereby making the best use of the available resources.

As a consequence, high priority areas and therefore strong concentration should be on education, the investment policy regulations of the government, collaboration among different players and the identification of MRO market niches.



6. Opportunity Analysis

A key step in scenario analysis involves the identification of opportunities. This includes the derivation of new strategies, business models, technologies as well as products

and services. Valuable input comes from the expert panel, internal futures workshops and more in-depth desk research.

6.1 Leveraging the MRO Segment

The MRO segment in India has experienced over 10% growth per annum over the last several years and is expected to touch \$1.17 billion in 2010. With further expansion in civil and military aviation in India over the next decade, the MRO segment is therefore likely to face a sustained period of high growth. MRO firms do not need as much investment in facilities or technological know-how as

compared to other aerospace sub-segments. Therefore, Indian firms might focus especially on the MRO area by leveraging their competency in low cost manufacturing and services as well as India's central geographical location. Within the MRO segment, experts see a great potential for the military MRO business. Until now, military aircraft servicing was carried out by the armed forces and HAL only. But

opportunities can open up in this space as foreign military OEMs invest in developing maintenance and overhaul operations in India under offset requirements. Moreover, India's political role in Asia might offer additional opportunities in the region as examples in Vietnam or Malaysia already show.

6.2 Defense Offset Program

India is expected to procure about \$100 billion worth of military aircrafts over the next decade, most of which will be imported. Hence, we already see foreign firms putting up aggressive bids for governmental projects and also increasing their presence in India. It is quite likely that going forward the government may mandate manufacturing of aircrafts in India under the offset policy. Even without such policy requirements, foreign companies would want to assemble or manufacture aircraft components in India. Doing so will help them to reduce costs as well as improve their chances at winning orders from the government.

The offset policy is therefore expected to be a major boost to aircraft manufacturing in India especially for the private sector companies. Domestic aerospace companies need to invest in manufacturing facilities and also look at tie-ups with foreign OEMs and

Tier-1 companies. However, the development will not be – different to the evolution of the automotive industry in India – based on a linear development but rather move along a step-wise increase mostly determined by the implementation of major programs such a huge plane orders from the commercial or military sector. Indian companies and their foreign partners need to be aware that they have to prepare the readiness of their operations for each “leap-frogging” development prior to its start. This will require huge investments in trust and joint developments.

For example, the offset policy of the government will necessitate a crucial technology transfer by the OEMs in Europe or US to India. This will be a major opportunity for Indian aerospace firms to rapidly upgrade their technological capabilities as they can build upon an existing and proven technology base.

Additional opportunities under the defense offset program would include areas like project management and product lifecycle management (PLM). Given that the Indian aerospace sector is rather fragmented with most companies having annual revenues below \$10 million USD, any major aircraft manufacturing activity in India will involve a large number of firms or huge consolidation efforts of the industry. Hence, project management as well as supply chain management will be critical. Indian as well as foreign companies have to invest upfront in such offset management programs in order to control and execute their business when it actually comes. This, in turn, is an opportunity for the information technology sector as well as such providers can deliver specialized platforms for the aerospace firms in India.

6. Opportunity Analysis

6.3 R&D Opportunities

While Indian firms are likely to increase their R&D expenditure significantly, these efforts are not likely to yield any major breakthroughs especially in high-end research areas like hypersonic aircrafts, alternate fuels, or materials technology. Hence, Indian firms might rather focus on improving their production processes. Other sectors, especially the automotive business, are currently demonstrating their capabilities in “frugal engineering” and low-cost yet high-tech design and manufacturing. Hence, aerospace firms may look at transferring such models to their industry sector from related industries.

6.4 Project Financing and M&A

Aerospace is a capital intensive industry and Indian aerospace firms have historically faced difficulties in raising capital. Hence, if the industry has to grow rapidly it shall need abundant and cheap sources of capital. This opens up opportunity for investment banks and private equity firms to help Indian aerospace companies to raise capital. Also, given the fragmented nature of the Indian industry, attractive M&A opportunities are likely to appear in the future. Foreign firms may be keen on taking strategic stakes in their local suppliers. Further, with the aerospace sector expected to witness rapid growth, there will be opportunities even for pure financial investors to make attractive returns on their investments in this industry.



7. Final Recommendations

According to the expert panel, the most critical areas for the Indian aerospace sector over the next decade are the availability of high-skilled workers and R&D activities. For both of these activities, adequate education and training facilities will have to be developed.

Professional education in India is regulated by the government. It will have to promote education and research in aerospace engineering and related subjects in order to achieve a prosperous industry landscape as has been pictured in this scenario study. Aerospace companies could additionally try to alleviate this bottleneck by setting up training institutes themselves, i.e. corporate universities in collaboration with public or semi-public bodies but also tying up with existing education institutes to promote the aerospace domain as an interesting career choice. Partnerships and joint research projects should be undertaken by both public sector and private companies but can only be the cream of the crop.

The Government of India will also have to define concise policy implementation steps for the future. While most experts agree that the basic policies to boost the aerospace sector are in place, there are concerns on their implementation. The government will have to concentrate on faster and more effective implementation plans especially regarding the offset policy and IP protection regulations. These policies are important to attract foreign aerospace companies including OEMs and Tier-1 companies to set up operations in India and facilitate a knowledge exchange. The entry of such firms is expected not only to lead to rapid growth in the Indian aerospace sector but also drive the technological capabilities of Indian firms.

Another critical issue for the Indian aerospace sector will be the set up of the overall industry structure. The aerospace sectors in the US and the EU consist of large independent OEMs with well established ancillary firms and partners. At the same time, some emerging countries like China have taken a consortium route. Indian public sector companies and institutes follow a similar path. The consortium model seems better in the early stages of industry development in India because it allows for firms to concentrate and bundle efforts. However, it is also likely to result in

less (healthy) competition and efficiency. As a matter of fact, the Indian aerospace industry needs an industry structure that not only fosters competition and efficiency in the system but also provides the environment to grow and to improve technological capabilities. Hence, a combination of an independent OEM and the consortium-strategy may be the central success factor for India – given the focus on each at a different point in time. This could involve following an overall consortium model but encouraging competition among the various segments of the value chain.



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