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APPLICATION OF RISK BREAK DOWN STRUCTURE AS A PROGRAMME MANAGEMENT TOOL IN DESIGN & DEVELOPMENT OF ADVANCED FIGHTER AIRCRAFT

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ABSTRACT

The purchase of advanced fighter Aircraft is the Government of India's costliest acquisition. Time, cost & meeting the performance requirements are very important parameters as far as design & development of advanced Fighter is concerned. Many of our projects are not completed on time due to technological complexities, poor aerospace manufacturing infrastructure in the country, uncertainties. and risks inherent in R&D work and dynamics of technology control regimes. Delays cause cost overruns and loss of opportunities in scaling up the technological competence ladder and the inherent risk in security preparedness. It will be very difficult for the program managers to justify the delay. In Most of the developing countries, public money / Tax payer's money will be utilized for Defense development programs. Government is answerable to the public about defense spending and trade-off benefits. If there is a delay in development it leads to huge cost escalation and it would be difficult for the Government to provide budget support. Finally, the development program may have to be abandoned and program stakeholders shall be held responsible for this failure.

Uncertainties are inherent in design & development of advanced fighter aircraft program due to the complexities involved in advanced technologies, changing security requirements, lack of infrastructure, and non-availability of skilled manpower. In other words, huge Risk is involved in design & development of advanced fighter aircraft. Risk management plays a vital role in addressing this kind of complex program. It is necessary to adopt a suitable execution model for the design & development of advanced fighter aircraft to mitigate risks which could be encountered during the course of design & development. Feasible execution models need to be identified for design & development of advanced fighter aircraft. However to decide on most preferred execution model is not a simple task. Multiple criteria's are involved and suitable program management technique is required to decide on the most preferred execution model. Risk break down structure will provide the required insight about the proposed feasible execution models and it will be useful for the experts to make qualitative judgments to decide on the most preferred execution model. In this paper, an effort has been made to create a risk break down structure for the various feasible execution models and various risk elements have been tabulated in a hierarchical fashion. This shall help the experts in the aerospace domain to make semi-quantitative judgments to carry out a strategic analysis of feasible execution models

KEYWORDS: *Military Aircraft, Programmed Management, Cost, Schedule, Performance Requirements, Multiple Criteria, Risk Management, Schedule Risk, Execution Model, Risk Break Down Structure*

INTRODUCTION

The Defense Systems Management College, Defense Acquisition University in its seminal paper " DSMC Risk Management Guide for DoD Acquisition" outlines the changing contours of risk management and states of no magic formula for risk management. [1]. As applied to Design and development of Advanced Aircraft, the challenges in risk management are:

- **Technical Obsolescence Risk**: Its usually in the design of fighter Aircraft (whose development time from Air force requirements to fleet equipment is typically over 15 years), there is the concurrent development of technologies which either would mature to better ones or may not succeed.
- **Suppliers Risk**: Either on account of sales control from the Government or supply-side constraints the program would become hostage to the concerned supply. For example, the jet engine, canopy severance system, etc wherein there are hardly competing vendors.
- **Technical Inexperience Risks**: This causes direct delays in development, production, and integration. At the core, the risks cannot be eliminated but can be minimized by judicious management.

Development of Advanced Fighter Aircraft is very complex and it requires huge funding. It is probably defences costliest R&D investment. Lots of uncertainties are inherent in the development cycle of advanced fighter aircraft. The research outcome of advanced technologies which are required for advanced Fighter aircraft is uncertain. Typically, advanced fighter aircraft contains more than 40000 parts and lots of uncertainties involved in procuring these parts for the fighter aircraft.

Despite the advent of tectonic changes in technologies backed by Information technology infrastructure, not much product development cycle compression as seen in other industries has taken place in the Aeronautical industry. [2]. There is a need to harness the developments in technology for time compression in the design and development of critical assets as military Aircraft.

In other words, the program manager should ensure that there will be a minimum time delay and cost overrun in the development life cycle and also at the same time the developed fighter aircraft should meet the performance requirements as stipulated in Air staff requirements.

The major reason for time delay & Cost overrun in design & development of advanced fighter aircraft is the incorrect handling of risk. Risk management is concerned with the identification of uncertainties that threaten cost, schedule, and performance Objectives.

Risk management & schedule are closely tied. Consideration of one requires a reassessment of the other. For example, in creating the strategy and plans to handle program risk, a PM must consider how the approach affects the Program Schedule. Similarly, any tradeoffs between cost and performance must take into account schedule implications. Conversely, any change to the program schedule must consider the impact on the overall program objectives and on cost and performance. The challenge is to develop a plan that balances risk, cost, schedule, overall project goals and performance. Schedule risk is defined as the likelihood and consequences of failing to meet the Program schedule and it is an integral part of program risk.

It is necessary to identify the most preferred way of Program execution to minimize the schedule risk and thereby avoiding schedule slippage. This is possible with proper decision making about the preferred execution model at the start of the program. Research revealed that, decision making by program management team plays a vital role in successful completion of the program. However, decision making in a complex program like advanced Fighter Aircraft is not an easy one. Multiple criteria's are responsible for program success. Appropriate Programme Management technique is needed, which helps to take decisions which would have long-term implications on Schedule & Cost.

It is necessary to identify the risk involved in each of the execution models. To do so Risk breakdown structure for each of the feasible execution models has been created. This will help the experts to make judgments to decide about most preferred execution model using Multi- Criteria decision analysis. In this paper, an effort has been made to create risk breakdown structure for each of the feasible execution models and thereby identifying the risk elements. This will help the experts to make judgments during pairwise comparison of feasible execution model with reference to Goals of the program.

LITERATURE REVIEW

According to ISO 31000, risk is the "effect of uncertainty on objectives "and an effect is a positive or negative deviation from what is expected and Risk management refers to a coordinated set of activities and methods that are used to direct an organization and to control the many risks that can affect its ability to achieve objectives. From a purely theoretical perspective risk management can be active by anticipating events in real time or passive by avoiding risk.

One of the important tools available for managing risk is the Risk Breakdown Structure (RBS)[3]. Darlie Rodriguez et al [4] consider a mathematical approach of MTBF, MTTF etc. for minimizing lifecycle costs. As any management technique, the flow sequence of Risk management consists of risk identification, its effects on downstream activities and their interrelationships break down of risks and evaluation of risk mitigation options. As a value addition increases exponentially in any Aircraft project, early identification of risk would mitigate costs and delays.

Risk Management Process [5]

Figure 1

As per RISK MANAGEMENT GUIDE FOR DOD ACQUISITION [6], Risk management must be viewed as a continuous process executed over the entire life cycle spectrum. We suggest that risk management systems must form part

of project activities and subject to constant evaluation and improvements and should also cover post-sales operations and maintenance. A risk management system consists of:

- Identifications of all risks
- Segregating risks based on its likely impact values (a.k.a. ABC analysis)
- Identifying and choosing the best mitigation options based on What If analysis.
- Implementation
- Based on feedback bridging the gaps between anticipated and actual.

Emphasis on risk management coincides with overall DoD efforts to reduce life-cycle costs (LCC) of system acquisitions.

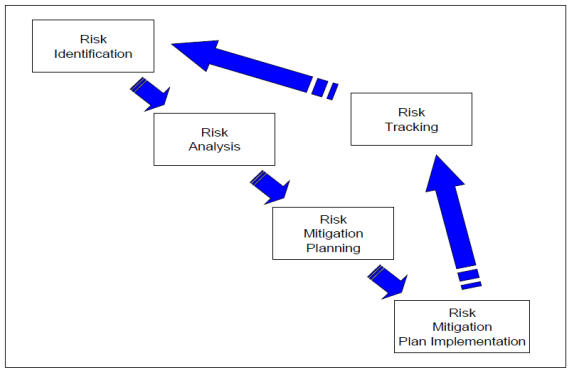

Figure 2: DOD Risk Management Process

Figure 2 gives the DOD Risk Management process template. It shows a continuous flow cycle from risk identification to risk mitigation plan implementation.

Three Elements of Project Risk Analysis [7]

There are three basic concerns in project management:

- **Schedule:** Will the project go over schedule?
- **Cost:** Will the project overrun its budget?
- **Performance:** Will the output satisfy the goal(s) of the project?

An Introduction to the Risk Breakdown Structure

Hillson, D. (2002) use a risk breakdown structure (RBS) to understand your risks, Paper presented at Project Management Institute Annual Seminars & Symposium, San Antonio, TX. Newtown Square, PA: Project Management Institute.

Hillson explains that key to understanding risks is in the identification of risks. For easy handling of complex tasks, it's a usual practice to break it down into simpler manageable units. Similarly, risk breakdown structure breaks

complex risks to manageable subunits. And, Hillson introduces the concept of levels with level-1 giving an overall view and levels2 and 3 giving increasingly more detail description (more suitable for operating personnel).

Here is an Example Risk Management Breakdown: [8]

- Technical
  - Requirements
  - Technology
  - Complexity
  - Quality
  - Performance
- Management
  - Resources
  - Company Vision
  - Capital
- Organizational
  - Dependencies
  - Budget
  - Prioritization
  - External
  - Contractors
  - Vendors
  - Customer
- Project Management
  - Estimating
  - Planning
  - Controlling
  - Communication

How to Prepare Risk Breakdown Structure (RBS)[9]

RBS for Construction Design (after Chapman, 2001)

Table 1

LEVEL 0	LEVEL 1	LEVEL 2	LEVEL 3
Project risk	Environment	Statutory	Planning approval delay
			Legislation changes
			Ecological constraints
			…etc…
	Industry	Market	Increase in competition
			Change in demand
			Cost/availability of raw materials
			…etc…
	Client	Client team	Client representative fails to perform duties
			No single point of contact
			Client team responsibilities ill-defined
			…etc…
		PM team	Inadequate project management controls
			Incorrect balance of resources & expertise
			PM team responsibilities ill-defined
			…etc…
		Targets	Project objectives ill-defined
			Project objectives changed mid-design
			Conflict between primary & secondary objectives
			…etc…
		Funding	Late requirement for cost savings
			Inadequate project funding
			Funds availability does not meet cashflow forecasts
			…etc…
		Tactics	Brief changes not confirmed in writing
			Change control procedure not accepted
			Unable to comply with design sign-off dates
			…etc…
	Project	Team	Poor team communication
			Changes in core team
			Inadequate number of staff
			…etc…
		Tactics	Cost control …
			Time control …
			Quality control …
			Change control …
		Task	Site…
			Design…

As illustrated in the table -, RBS is divided into levels 0,1,2,3 with each level indicating more details and giving template to operating personnel to work. (i.e. top down approach).

Uses of RBS

RBS can be Used for

- Risk identification
- Gap analysis between anticipated and projected risks as well as gaps between various methods.
- To conduct root cause analysis
- Identifying more riskier elements to enable greater management focus.
- As it is hierarchical the entire risk management process can be automated and software tool driven.

Importance of Risk Break Down Structure in Design & Development of Advanced Fighter Aircraft

The following section of paper illustrates how RBS could be used as a programme management tool in Design & Development of advanced Fighter Aircraft. Development of Advanced Fighter aircraft is defense's costliest acquisition. It is very important that Development and induction of advanced fighter aircraft to the services within the schedule and budget and also it should meet the performance requirements. However Development of advanced fighter aircraft is very complex and many advanced technologies need to be incorporated in advanced fighter aircraft. Uncertainty looms large over the development of these technologies due to its complexity. These uncertainties lead to schedule risk and it needs to be addressed. Hence Risk management plays vital role in design & development of advanced Fighter aircraft. Good Risk management strategy has to be evolved at the start of the program to minimize the effect of risk on design & development. In this context an attempt has been to identify the risks and also the importance of Risk break down structure as a programmed management tool has been discussed in this paper.

Program Execution Model: The important elements of risk analysis in advanced fighter aircraft are Schedule, Cost & Performance. The design & development of Advanced Fighter aircraft take considerable time. Huge funding is required to realize the advanced Fighter Aircraft. Any time delay in development will have an adverse effect on Cost and also at the same tome the developed advanced fighter Aircraft has to meet the performance requirements as per Air Staff requirements (ASR). Delay in development due to uncertainties will lead to cost escalation & technological obsolescence of the product. Due to time delay there will be a huge cost escalation and Govt may not support to continue the development and it may stop funding as it involves public money.

Keeping these things in mind, it is necessary to adopt suitable program execution model, which minimizes the time delay and there by schedule risk could be mitigated. Another important area that needs to be focused is development of advanced technologies for the advanced Fighter aircraft. It may not be possible to develop all the technologies required under one roof within the stipulated time. This is mainly because lack of technical capability, availability of skilled Human resources and adequate infrastructure to realize the advanced technologies. To overcome these problems, many feasible program execution models could be considered. However, the selection of most preferred execution model is very complex process. Wrong selection of execution model for the design & development leads to time delay, cost overrun and not meeting the performance requirements. A proper decision making technique is required as multiple criteria are involved in the design & development of advanced fighter aircraft. To aid decision making to select the most preferred execution model, risk analysis of this execution model with reference to multiple criteria like access to technology, skilled human resources, Implementation of execution models, govt policy, diplomatic policy needs to be carried out. Risk identification in each of the feasible execution model has to be done. Risk Breakdown structure as program management technique plays significant role in identifying the risks in each of the feasible execution models.

Proposed Feasible execution models for the design & development of Advanced Fighter Aircraft

- Joint venture with International Aircraft House (Govt to Govt)
- Joint venture with International Aircraft House & Domestic Aircraft House
- Joint Venture with Domestic Aircraft House and International Aircraft House as consultant
- International Aircraft House as consultant

Brief Description of Proposed Feasible Execution Models

Joint Venture (JV) with IAH: This execution model considers JV with an International Aircraft House (IAH) who is having expertise in design & development of advanced fighter aircraft. This Strategic Option assumes IAH participation as cost & Risk sharing partner.The International Aircraft House will have necessary technologies or will have the capability to develop the required technology for the Advanced Fighter Aircraft. The pre-condition for JV partner i.e International Aircraft House should be able to fill the resource Gap in terms of technology, Skilled Man power & Infrastructure.

JV with IAH & DAH: This Execution model considers JV with an International Aircraft House (IAH) who is having experience in the design & development of an advanced fighter aircraft and a Domestic Aircraft House (DAH) who is having some expertise/experience in design, development and/or manufacture of Fighter aircraft. It is assumed that, first the JV will be formed with the IAH and this company will subsequently bring-in a suitable DAH as JV partner. This Strategic Option assumes that both IAH & DAH participate as cost & Risk sharing partners. The cost sharing could be in terms of financial investment, Technology transfer / technology development, Skilled Human resources & infrastructure. This JV Company shall exist till the retirement of the product

JV with DAH, IAH as Consultant: This execution model will have a Domestic Aircraft House (DAH) as a JV partner for full life cycle of the product with an International Aircraft House(IAH) as a consultant in all phases of Design & Development. In this arrangement It is assumed that DAH participates as a JV partner with Cost & Risk Sharing. The cost sharing could be in terms of Financial, investment, Technology transfer / technology development, Skilled Human resources & infrastructure. The Domestic Aircraft House should have considerable expertise in the design & development of Fighter Aircraft. In this arrangement single International Aircraft House will be selected as the consultant for all the phases of development of advanced Fighter Aircraft. The Selected IAH as a consultant shall have thecapability to provide consultancy in developing Advanced Fighter Aircraft (5th Generation Aircraft)

IAH as Consultant: This strategic option is about the execution of the Program by a prior-identified Indian Agency with an IAH as a consultant in all phases of design & development. In this execution model Indian agency will carry out the design & development of Advanced Fighter Aircraft by identifying principal partner with varied outsourcing levels. This model shall fill the gap in terms of technology, Skilled Human resources and Infrastructure by developing the required Advanced Technologies indigenously along with principal partner and International consultancy.

To Create Risk Break Down Structure for Each of the Proposed Feasible Execution Models for the Design & Development of Advanced Fighter Aircraft

To create a risk break down structure for each of the proposed strategic options it is necessary to identify the Major Risk Areas. To identify major risk areas extensive interactions were held with domain experts who are competent enough to identify the risk areas based on their experience. These risk areas and associated risk elements are considered for making judgments during Multi criteria Decision Analysis of Strategic options.

Strategic Option 1: Risk Break down structure for Joint Venture with International Aircraft House (IAH)

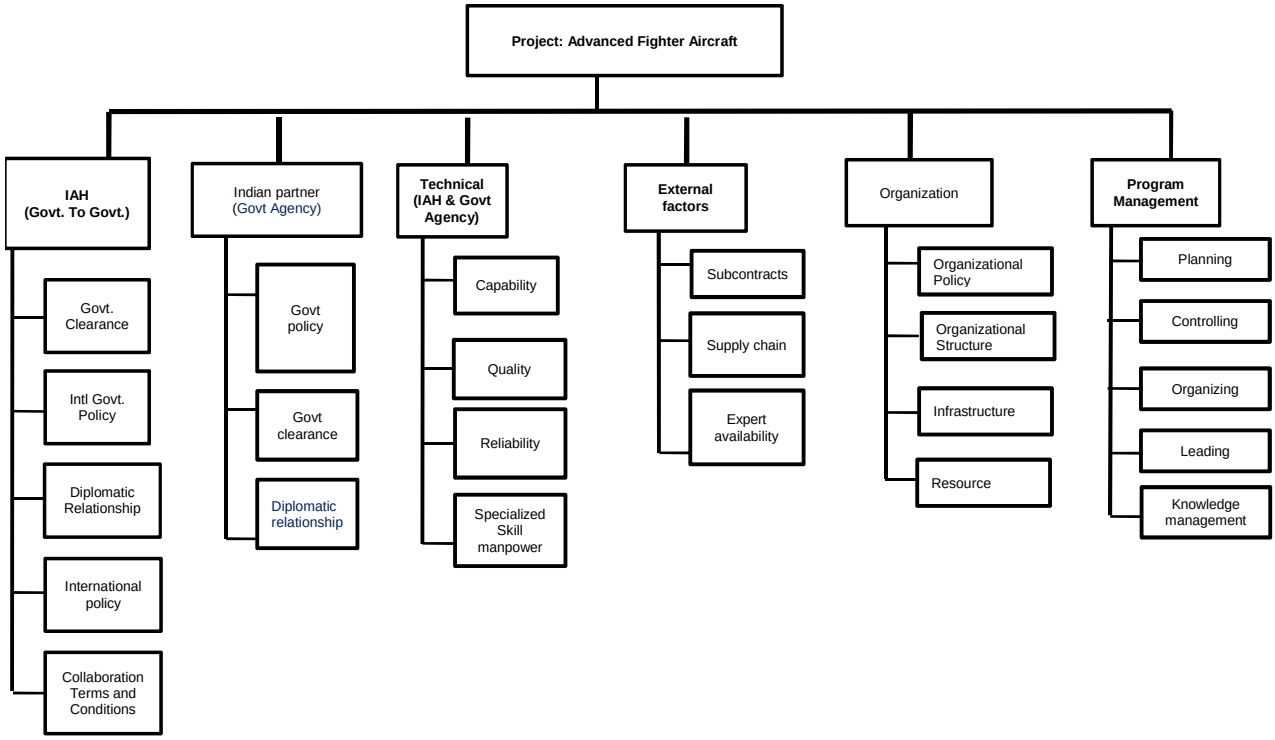

Figure 3

Major Risk Areas & Associated Risk Elements

Table 2

Sl. No	Critical Risk Areas	Risk Elements	
1	International Aircraft House	1.1 Govt Policy (intl)	1.1.1 Restrictions
			1.1.2 Stringent Guide Lines
			1.1.3 FDI
		1.2 Intl Govt Clearance	1.2.1 Single Window Clearance
			1.2.2 Multilple window clearance
			1.2.3 Bureaucracy
		1.3 Diplomatic Relation ship	1.3.1 Moderate
			1.3.2 Good
			1.3.4 Very Good
		1.4 International Policy	1.4.1 Developed Countries / Developing countries
			1.4.2 Collaboration
			1.4.3 Human Resources
		1.5 Collaboration Terms & conditions	1.5.1 MOU
			1.5.2 NDA
			1.5.3 Violation
2	Indian Partner (Govt Agency)	2.1 Govt Policy	2.1.1 Restrictions
			2.1.2 Stringent Guide Lines
			2.1.3 FDI policy
		2.2 Govt Clearance	2.2.1 Single Window Clearance
			2.2.2 Multilple window clearance
			2.2.3 Bureaucracy

		2.3 Diplomatic Relation ship	2.3.1 Moderate
			2.3.2 Good
			2.3.3 Very Good
3	Technical (IAH)	3.1 capability	3.1.1 Design
			3.1.2 Manufacturing
			3.1.3 Testing
			3.1.4 Integration
			3.1.5 Flight Testing
			3.1.6 Advanced Technologies
		3.2 Quality	3.2.1 Inspection methodology
			3.2.2 Total Quality Management
			3.2.3 Quality Standards
			3.2.4 Certfication
		3.3 Realiability	3.3.1 Technology Readiness Level
			3.3.2 Manufacturing readiness level
			3.3.3 Transfer of Technology
			3.3.4 Technology absoprption
		3.4 Specialized Skill manpower	3.4.1 Technical Skills
			3.4.2 Ability to Develop New Skill
			3.4.3 Availability
4	Technical (Govt Agency)	4.1 capability	4.1.1 Design
			4.1.2 Manufacturing
			4.1.3 Testing
			4.1.4 Integration
			4.1.5 Flight Testing
			4.1.6 Advanced Technologies
		4.2 Quality	4.2.1 Inspection methodology
			4.2.2 Total Quality Management
			4.2.3 Quality Standards
			4.2.4 Certification
		4.3 Reliability	4.3.1 Technology Readiness Level
			4.3.2 Manufacturing readiness level
		4.4 Specialized Skill manpower	4.4.1 Technical Skills
			4.4.2 Ability to Develop New Skill
			4.4.3 Availability
5	External facors	5.1 Sub Contracts	5.1.1 Requirements understanding
			5.1.2 Infrastructure
			5.1.3 Human resource
			5.1.4 experience
		5.2 Supply Chain	5.2.1 supply chain network
		5.3 Expert Availability	5.3.1 Domain Experts
			5.3.2 Knowledge Transfer
		5.4 Advanced Technology	5.4.1 Proven Advanced technology
			5.4.2 Ability to develop Advanced Technology
		5.5 Experience	5.5.1 International Collaboration
		5.6 Communication	5.6.1 Ability to communicate
		5.7 Quality	5.7.1 Quality Systems
			5.7.2 Quality Standards
		5.8 Certification	5.8.1 Guidelines
			5.8.2 Implementation
6	Organizational	6.1 Organizational Policy	6.1.1 Policy
			6.1.2 Rules & Regulations
		6.2 Organizational structure	6.1.3 Decision Making Structure
		6.3 Infrastructure	6.1.4 IT Infrastructure

		6.4	Resource	6.1.5	Human Resource
7	Program Managemnt	7.1	Planning	7.1.1	Acquisition plan
				7.1.2	Functional plan
		7.2	Controlling	7.2.1	Activities coordination
				7.2.2	Communication
		7.3	Organizing	7.3.1	Resources
		7.4	Leading	7.4.1	Direction
				7.4.2	Coordination
		7.5	Knowledge Management	7.5.1	tangible Knowledge
				7.5.2	Intangible Knowledge

Brief description of Major Risk Areas

International Aircraft House: International Aircraft House is Leading Fighter Aircraft development center. The Major risk area for this arrangement is a Government policy of that country towards joint venture, and ease of doing business. It is expected that JV formation should be a smooth affair without many hassles. Diplomatic Relationship is another major risk area which has to be analyzed properly before forming JV. These factors play a vital role in JV formulation. This JV assumed to be formed at the Government level. This may help smooth functioning of the JV.

Indian Partner (Government Agency): JV partner from Indian side is Government agency. Major risk areas are Government policy towards JV formulation, the time required to obtain Government clearance etc.

Domestic Aircraft House: Major risk elements are Design Capability (experience/expertise), investment ability, infrastructure etc.

Technical (IAH): Technical Capability and ability to develop advanced technologies for the fifth generation fighter aircraft (Advanced fighter aircraft) are major areas of risk Availability of skilled manpower is another major risk area that needs to be considered for risk analysis. Ability to provide consultancy if chosen as a consultant is another important risk area apart from nurturing the transferred technologies.

Technical (Government Agency- Indian Partner): The major areas of concern are a Technical capability in the areas of design, manufacturing, testing, quality, flight testing etc. Ability to build the required infrastructure to develop advanced fighter aircraft and expertise for serial production is a major requirement.

Availability of skilled manpower in required numbers is another major factor which needs to be addressed

External Factors: Many external factors influence the design & development of advanced fighter aircraft. Main risk areas are subcontracted, supply chain, domain expert's availability etc.

Organizational: Organizational structure of both IAH & Indian partner play as vital role. The major risk factor is compatibility between organizations in terms of policies, resource availability, structure etc

Program Management: Program management plays a vital role in successful development of advanced fighter aircraft. The major risk elements are planning, controlling, knowledge management both tangible & intangible.

Strategic Option 2: Risk Break down structure for Joint Venture with International Aircraft House (IAH) & Domestic Aircraft House (DAH)

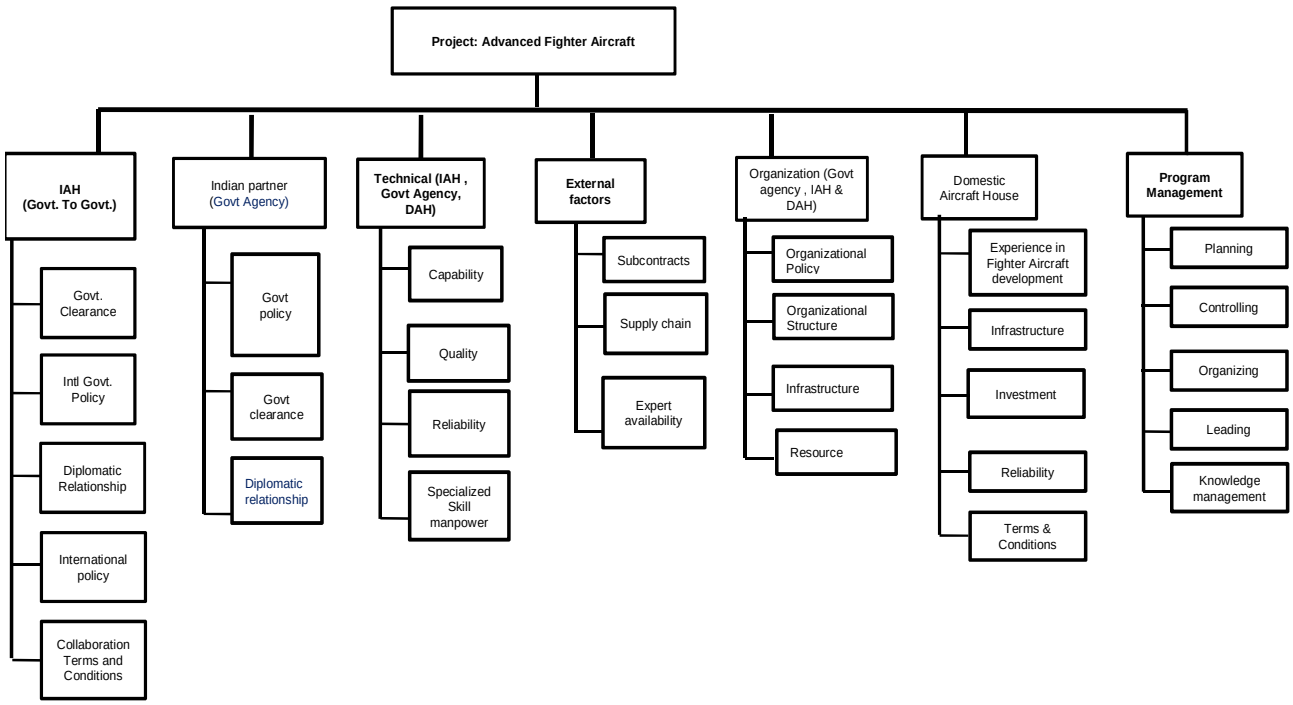

Figure 4

Major Risk Areas & Associated Risk Elements

Table 3

Sl. No	Critical Risk Areas	Risk Elements	
1	International Aircraft House	1.1 Govt Policy (intl)	1.1.1 Restrictions
			1.1.2 Stringent Guide Lines
			1.1.3 FDI
		1.2 Intl Govt Clearance	1.2.1 Single Window Clearance
			1.2.2 Multilple window clearance
			1.2.3 Bureaucracy
		1.3 Diplomatic Relation ship	1.3.1 Moderate
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			1.4.3 Human Resources
		1.5 Collaboration Terms & conditions	1.5.1 MOU
			1.5.2 NDA
			1.5.3 Violation
2	Indian Partner (Govt Agency)	2.1 Govt Policy	2.1.1 Restrictions
			2.1.2 Stringent Guide Lines
			2.1.3 FDI policy
		2.2 Govt Clearance	2.2.1 Single Window Clearance
			2.2.2 Multiple window clearance
			2.2.3 Bureaucracy
		2.3 Diplomatic Relation ship	2.3.1 Moderate
			2.3.2 Good
			2.3.3 Very Good

3	Technical (IAH)	3.1 capability	3.1.1 Design
			3.1.2 Manufacturing
			3.1.3 Testing
			3.1.4 Integration
			3.1.5 Flight Testing
			3.1.6 Advanced Technologies
		3.2 Quality	3.2.1 Inspection methodology
			3.2.2 Total Quality Management
			3.2.3 Quality Standards
			3.2.4 Certfication
		3.3 Realiability	3.3.1 Technology Readiness Level
			3.3.2 Manufacturing readiness level
			3.3.3 Transfer of Technology
			3.3.4 Technology absoprption
		3.4 Specialized Skill manpower	3.4.1 Technical Skills
			3.4.2 Ability to Develop New Skill
			3.4.3 Availability
4	Technical (Govt Agency) & DAH	4.1 capability	4.1.1 Design
			4.1.2 Manufacturing
			4.1.3 Testing
			4.1.4 Integration
			4.1.5 Flight Testing
			4.1.6 Advanced Technologies
		4.2 Quality	4.2.1 Inspection methodology
			4.2.2 Total Quality Management
			4.2.3 Quality Standards
			4.2.4 Certification
		4.3 Reliability	4.3.1 Technology Readiness Level
			4.3.2 Manufacturing readiness level
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			4.4.2 Ability to Develop New Skill
			4.4.3 Availability
5	External factors	5.1 Sub Contracts	5.1.1 Requirements understanding
			5.1.2 Infrastructure
			5.1.3 Human resource
			5.1.4 experience
		5.2 Supply Chain	5.2.1 supply chain network
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		5.5 Experience	5.5.1 International Collaboration
		5.6 Communication	5.6.1 Ability to communicate
		5.7 Quality	5.7.1 Quality Systems
			5.7.2 Quality Standards
		5.8 Certification	5.8.1 Guidelines
			5.8.2 Implementation
6	Organizational(IAH, DAH,Govt agency)	6.1 Organizational Policy	6.1.1 Policy
			6.1.2 Rules & Regulations
		6.2 Organizational structure	6.2.1 Decision Making Structure
		6.3 Infrastructure	6.3.1 IT Infrastructure
		6.4 Resource	6.4.1 Human Resource
7	Program Managemnt	7.1 Planning	7.1.1 Acquisition plan
			7.1.2 Functional plan

		7.2 Controlling	7.2.1 Activities coordination
			7.2.2 Communication
		7.3 Organizing	7.3.1 Resources
		7.4 Leading	7.4.1 Direction
			7.4.2 Coordination
		7.5 Knowledge Management	7.5.1 tangible Knowledge
			7.5.2 Intangible Knowledge
8	Domestic Aircraft House	8.1 Experience in Fighter Aircraft Development	8.1.1 Approval from Certification Agencies
			8.1.2 Efficiency
			8.1.3 Brand value
			8.1.4 Expertise
		8.2 Infrastructure	8.2.1 Plant & Machinery
			8.2.2 Human Resource
			8.2.3 Ability to expand
			8.2.4 Spare capacity
		8.3 Investment	8.3.1 Capability
			8.3.2 working Capital
			8.3.3 expansion
		8.4 Reliability	8.4.1 Product delivery
			8.4.2 Design, manufacturing & testing
			8.4.3 Quality Control
		8.5 Terms & conditions	8.5.1 MOU
			8.5.2 NDA
			8.5.3 Violation

Strategic Option 3: Risk Break Down Structure for Joint Venture with Domestic Aircraft House & International Aircraft House as Consultant

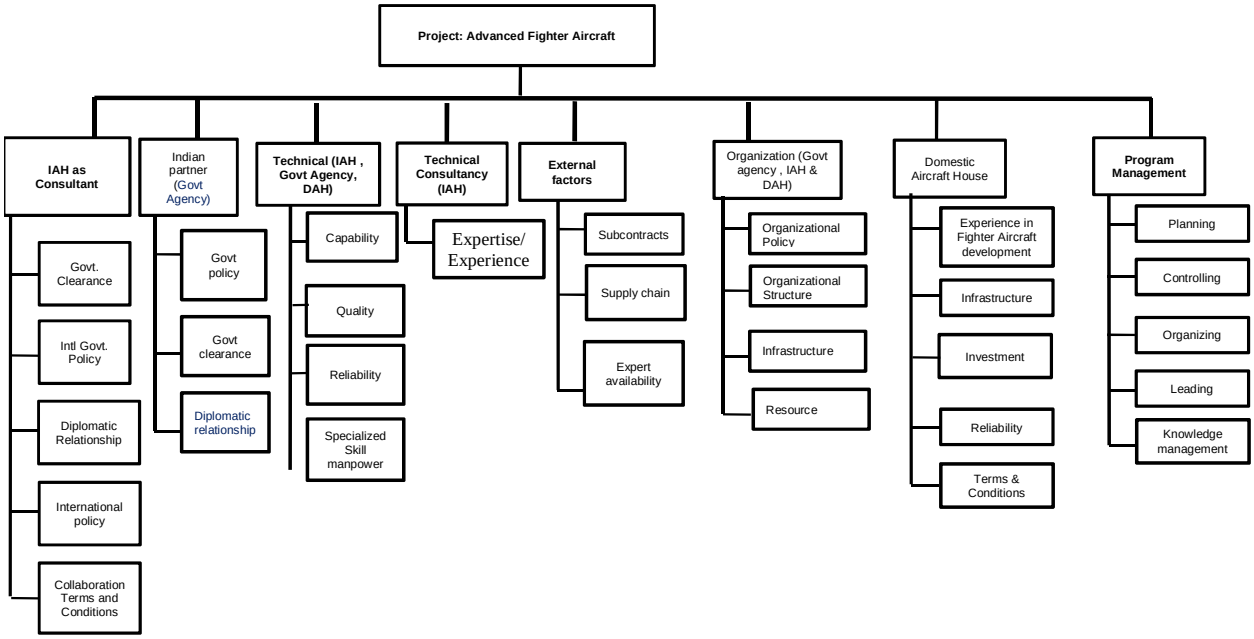

Figure 5

Major Risk Areas & Associated Risk Elements

Table 4

Sl. No	Critical Risk Areas	Risk Elements	
1	International Aircraft House as Consultant	1.1 Govt Policy (intl)	1.1.1 Restrictions
			1.1.2 Stringent Guide Lines
		1.2 Intl Govt approval	1.2.1 Single Window Clearance
			1.2.2 Multiple window clearance
			1.2.3 Bureaucracy
		1.3 Diplomatic Relation ship	1.3.1 Moderate
			1.3.2 Good
			1.3.4 Very Good
		1.4 International Policy	1.4.1 Developed Countries / Developing countries
		1.5 Consultancy Terms & conditions	1.5.1 MOU
			1.5.2 NDA
			1.5.3 Violation
			1.5.4 Accountability
2	Indian Aircraft House (Govt Agency)	2.1 Govt Policy	2.1.1 Restrictions
			2.1.2 Stringent Guide Lines
		2.2 Govt Clearance	2.1.1 Single Window Clearance
			2.1.2 Multilple window clearance
			2.1.3 Bureaucracy
		2.3 Diplomatic Relation ship	2.3.1 Moderate
			2.3.2 Good
			2.3.3 Very Good
3	Technical Consultancy (IAH)	3.1 Expertise / Experience	3.1.1 Design
			3.1.2 Manufacturing
			3.1.3 Testing
			3.1.4 Integration
			3.1.5 Flight Testing
			3.1.6 Advanced Technologies
4	Technical (Govt Agency) & DAH	4.1 capability	4.1.1 Design
			4.1.2 Manufacturing
			4.1.3 Testing
			4.1.4 Integration
			4.1.5 Flight Testing
			4.1.6 Advanced Technologies
		4.2 Quality	4.2.1 Inspection methodology
			4.2.2 Total Quality Management
			4.2.3 Quality Standards
			4.2.4 Certification
		4.3 Reliability	4.3.1 Technology Readiness Level
			4.3.2 Manufacturing readiness level
		4.4 Specialized Skill manpower	4.4.1 Technical Skills
			4.4.2 Ability to Develop New Skill
			4.4.3 Availability
5	External facors	5.1 Sub Contracts	5.1.1 Requirements understanding
			5.1.2 Infrastructure
			5.1.3 Human resource
			5.1.4 experience
		5.2 Supply Chain	5.2.1 supply chain network
		5.3 Expert Availability	5.3.1 Domain Experts
			5.3.2 Knowledge Transfer
		5.4 Advanced Technology	5.4.1 Proven Advanced technology
			5.4.2 Ability to develop Advanced Technology
		5.5 Experience	5.5.1 International Collaboration

Sl. No	Critical Risk Areas	Risk Elements	
		5.6 Communication	5.6.1 Ability to communicate
		5.7 Quality	5.7.1 Quality Systems
			5.7.2 Quality Standards
		5.8 Certification	5.8.1 Guidelines
			5.8.2 Implementation
6	Organizational(IAH, DAH,Govt agency)	6.1 Organizational Policy	6.1.1 Policy
			6.1.2 Rules & Regulations
		6.2 Organizational structure	6.2.1 Decision Making Structure
		6.3 Infrastructure	6.3.1 IT Infrastructure
		6.4 Resource	6.4.1 Human Resource
7	Program Managemnt	7.1 Planning	7.1.1 Acquisition plan
			7.1.2 Functional plan
		7.2 Controlling	7.2.1 Activities coordination
			7.2.2 Communication
		7.3 Organizing	6.2.1 Resources
		7.4 Leading	7.4.1 Direction
			7.4.2 coordination
		7.5 Knowledge Management	7.5.1 tangible Knowledge
			7.5.2 Intangible Knowledge
8	Domestic Aircraft House	8.1 Experience in Fighter Aircraft Development	8.1.1 Approval from Certification Agencies
			8.1.2 Efficiency
			8.1.3 Brand value
			8.1.4 Expertise
		8.2 Infrastructure	8.2.1 Plant & Machinery
			8.2.2 Human Resource
			8.2.3 Ability to expand
			8.2.4 Spare capacity
		8.3 Investment	8.3.1 Capability
			8.3.2 working Capital
			8.3.3 expansion
		8.4 Reliability	8.4.1 Product delivery
			8.4.2 Design, manufacturing & testing
			8.4.3 Quality Control
		8.5 Terms & conditions	8.5.1 MOU
			8.5.2 NDA
			8.5.3 Violation

Strategic Option 4: Risk Break down structure for International Aircraft House as consultant

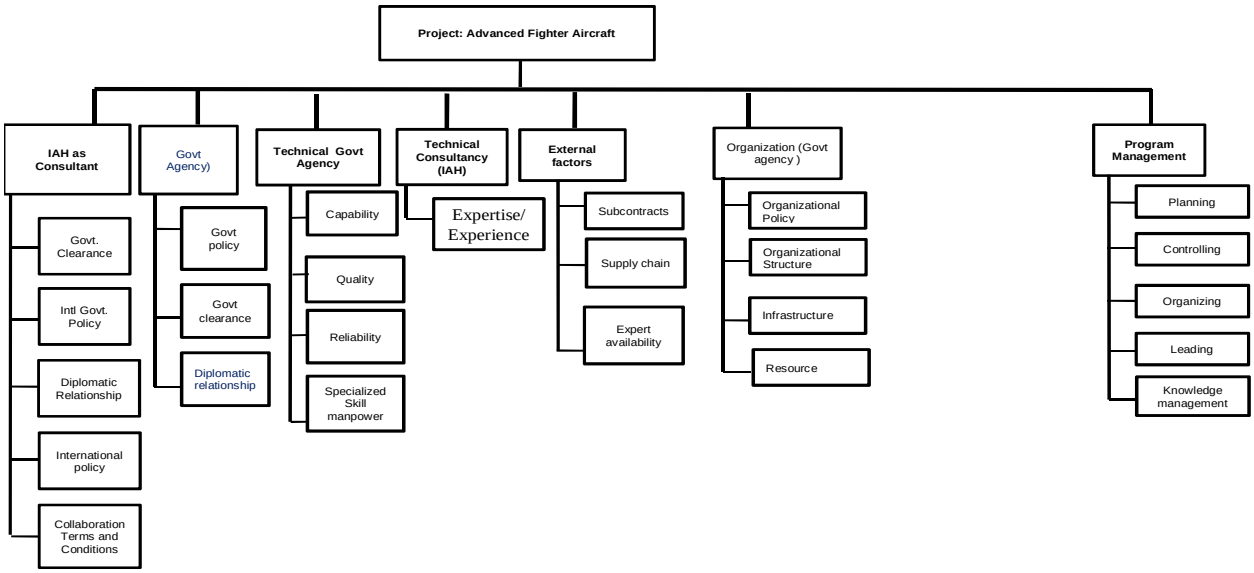

Figure 6

Major Risk areas & associated Risk elements

Table 5

Sl. No	Critical Risk Areas	Risk Elements	
1	International Aircraft House as Consultant	1.1 Govt Policy (intl)	1.1.1 Restrictions
			1.1.2 Stringent Guide Lines
		1.2 Intl Govt approval	1.2.1 Single Window Clearance
			1.2.2 Multiple window clearance
			1.2.3 Bureaucracy
		1.3 Diplomatic Relation ship	1.3.1 Moderate
			1.3.2 Good
			1.3.5 Very Good
		1.4 International Policy	1.4.1 Developed Countries / Developing countries
		1.5 Consultancy Terms & conditions	1.5.1 MOU
			1.5.2 NDA
			1.5.3 Violation
			1.5.4 Accountability
2	Indian Aircraft House (Govt Agency)	2.1 Govt Policy	2.1.1 Restrictions
			2.1.2 Stringent Guide Lines
		2.2 Govt Clearance	2.2.1 Single Window Clearance
			2.2.2 Multilple window clearance
			2.2.3 Bureaucracy
		2.3 Diplomatic Relation ship	2.3.1 Moderate
			2.3.2 Good
			2.3.3 Very Good
3	Technical Consultancy (IAH)	3.1 Expertise / Experience	3.1.1 Design
			3.1.2 Manufacturing
			3.1.3 Testing
			3.1.4 Integration

			3.1.5 Flight Testing
			3.1.6 Advanced Technologies
4	Technical (Govt Agency) & DAH	4.1 capability	4.1.1 Design
			4.1.2 Manufacturing
			4.1.3 Testing
			4.1.4 Integration
			4.1.5 Flight Testing
			4.1.6 Advanced Technologies
		4.2 Quality	4.2.1 Inspection methodology
			4.2.2 Total Quality Management
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		4.3 Reliability	4.3.1 Technology Readiness Level
			4.3.2 Manufacturing readiness level
		4.4 Specialized Skill manpower	4.4.1 Technical Skills
			4.4.2 Ability to Develop New Skill
			4.4.3 Availability
5	External factors	5.1 Sub Contracts	5.1.1 Requirements understanding
			5.1.2 Infrastructure
			5.1.3 Human resource
			5.1.4 experience
		5.2 Supply Chain	5.2.1 supply chain network
		5.3 Expert Availability	5.3.1 Domain Experts
			5.3.2 Knowledge Transfer
		5.4 Advanced Technology	5.4.1 Proven Advanced technology
			5.4.2 Ability to develop Advanced Technology
		5.5 Experience	5.5.1 International Collaboration
		5.6 Communication	5.6.1 Ability to communicate
		5.7 Quality	5.7.1 Quality Systems
			5.7.2 Quality Standards
		5.8 Certification	5.8.1 Guidelines
			5.8.2 Implementation
6	Program Managemnt	6.1 Planning	6.1.1 Acquisition plan
			6.1.2 Functional plan
		6.2 Controlling	6.2.1 Activities coordination
			6.2.2 Communication
		6.3 Organizing	6.3.1 Resources
		6.4 Leading	6.4.1 Direction
			6.4.2 coordination
		6.5 Knowledge Management	6.5.1 tangible Knowledge
			6.5.2 Intangible Knowledge
			6.5.3 Violation

CONCLUSIONS

Risk management is an important programme Management tool. Risk management plays a crucial role in the complex program like design & development of advanced fighter aircraft.

Effective risk management requires a clear understanding of risk faced in design & development of advanced

fighter aircraft. Risk identification at the beginning of the program is very essential and it minimizes schedule risk and thereby prevents cost escalation.

Risk Break down structure could be used as a program management tool to identify the risks. A complex program like design & development of fighter aircraft involves multiple criteria. It is necessary to adopt suitable execution model at the start of the program for the design & development. Wrong selection of execution model leads to schedule risk & cost escalation Due to time delay there could be technological obsolescence of the program. There is a high risk of the program may be abandoned due to huge cost escalation. RBS helps to identify the risks in each of the program execution models and it would be easy for the experts to make a judgment with the help of RBS to take appropriate decision to select the most preferred execution model. RBS helps Multi-criteria decision Analysis technique to identify the risks and make a proper judgment to take an appropriate decision based on the scorecard for each of the feasible execution models. In this paper, an attempt has been made to demonstrate the application of RBS as a program management tool in design & development of advanced fighter aircraft

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