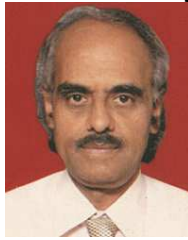


R&D - Another Oxymoron ?



*Dr Raja Manuri Venkata Gopala Krishna Rao, FNAE
Research Advisor and Technology Consultant
(Formerly Scientist, Founder and Head, FRP Division, NAL-CSIR)*

PREAMBLE

Research and Development is today's buzz-word. In the Technological World these two activities are construed as inseparable. What I intend articulating herein, are my thoughts on this fondly debated topic today, engulfed by my experiences in the emerging areas of Composite-Materials Science and Technologies that I pursued, in a highly demanding Aerospace Engineering Environment. It is a recall of what exactly these two terms meant to me, when I had to handle them in parallel (riding two horses at the same time), when I faced a dilemma (not a confusion) when to do the Research and when to do the Development. I also tried to figure out, what type of Research I was in, falling in between the Fundamental and the Frontier. There I realized that, what I did could be most aptly termed the "Concurrent Research-Development Driven-RDD", running in parallel with the project objectives that I was to meet. What resulted therein, were a host of Scientifically Substantiated and externally funded Application Specific Indigenous Products, using Home-Grown Technologies. Publications, Patents, Academic Guidance, Technical Training to Technology Transfer (TOT), were the byproducts that came out in an "Engineering Sciences Laboratory", established under the prestigious CSIR-Umbrella. Being a Chemical Engineer basically, seems to have provided me the much needed "Multifunctional Character of an Interfacial Engineer", destined to work in a Multidisciplinary, if not an alien Environment.

PASSION AND PURPOSE - THE TWO HORSES

As I was trying to get over the R&D Syndrome, two questions stared at me with implicit answers, "Is Research for Research Sake? with a "No", and is Development at the cost of Research? with a "Not at all". What dawned onto me was that, these are like two horses one can ride with pride, when handled with both a passion to do so and a purpose in doing so, by walking that extra mile. Soon, it turned out that, these two are in a way inseparable (when the deliverable was a visible Hardware, to be scientifically substantiated), but not interchangeable or synonymous (a misnomer, when the term R & D is used casually). As a Scientist designate in a Premier National Laboratory, mandated to take the Engineering Sciences to Industrial Applications, it then appeared a daunting task in a situation wherein, the primary responsibility was to deliver the externally funded Hardware, rather than pursuing a Passionate Research. And my conscience all the while haunted me," Lo, you are the Scientist First". So, there was a conflict between Science and Conscience.

RESEARCH- DIFFERENT DIMENSIONS

The field “Research” as such is variously viewed as Pure/Fundamental/Basic, Applied/Application Oriented, the Forward Looking/Futuristic, or the Frontier, leading to Cutting Edge Technologies. So, where does one stand in this galaxy of terminologies? If “Research” were to mean mere exploration of the fundamentals of Pure Science, the outcome may remain dormant until it is exploited for practical use, but not necessarily meaning that it has no societal bearing. The best it can do is to inspire many who venerate and value Research in its pristine form. The Researcher pursues what he enjoys passionately and it is for others to reap the benefits out of the resulting Publications/Academic Guidance/Talks/Celebrations and so on, the hallmarks of his achievements. Also, it may have emerged out of curiosity to know why, as a cure for boredom. There is no cure for curiosity, it is said.

The Applied Research with an implied end use has a different connotation in that, the pursuer has an inherent interest in “Research”, but an obligation to apply his results, remaining a driving force, if not a compulsion. This may even result in a Forward Looking Research (fanciful or purposeful again). The Researcher here has an objective, with a hope that someday down the line someone may use his results for practical applications. Here, the Research - outputs are either widely published with adequate experimental data for posterity or Patented or protected for commercial exploitation (as in a Corporate R&D). Further, this may turn out to be a Frontier Research, if the topic is on the cutting edge front, or treading into areas left out or un contemplated, but highly promising from a futuristic application view point.

In between coming next is the Research Application Oriented, wherein the Researcher, has clearly a process/product in mind, awaiting development, but delayed for want of decision makers and support (Minds and Funds). Here, when pursued with limited or no funds, his results will be “Relevant and Ready to use” in developing an End Product with well defined Performance Specifications. In a way, this is a vision. This way, the Research output does form a precursor of the Product- yet to be borne, without having to start the Development Cycle from scratch, saving enormously on Effort, Time and Costs (in a way not amounting to treading into the unknown, even while undertaking a totally new or novel developmental task). The concept of pre-project funding worked handy on such occasions, proving an excellent example of the Forward looking R&D. An in-house project funding; however small it is, also helps in supplementing the sponsored research project requirements well in advance. This was very effectively proved yet times, in the author’s experience.

Now, about the Concurrent Research (Research Development Driven-RDD)- This is the case when a commitment is made to a Sponsor with funding to develop and deliver a product, scientifically substantiated with well identified and defined performance specifications, Quality, Time Frames and Estimated Budgets (deadlines) hanging over the R & D Head like a Damocles Sword, with no room for temporal or spacial slips, time-schedules and cost over runs for instance. In a way, the hardware sets the fixed boundary conditions (like in a linear analysis model) for the Research minded Head. Thus, a passionate Researcher has to put the Product above the Paper. This is in contrast to the “Sponsored Research”, a term used to Research Carried out under sponsorship, but not necessarily having resulted in an End-Product.

R&D PERFORMANCE - YARD STICKS

Doing the “R” for R sake (Publications) and the D for D sake (Products), is a thing very clear with no ambiguities and its own visibilities, leaving no room for misgivings. Doing the R&D in a Scientific and

Industrial Environment, is understandable, only by setting certain yard sticks or performance parameters, when it comes to evaluating one's performance. These constitute publications, presentations, patents, invited talks, seminar lectures, academic guidance for the R-Component, while the Product- Delivered with attendant progress reviews/dead lines, certification and acceptance by the sponsor constitute those of the D-Component. Then, how much the R&D Scientist needs to score on both these counts is a question. This turns out to be a gray/grey area, governed with both subjectivity and objectivity, with no exact formula being applicable. Different perceptions naturally emerge here. For some ,it is difficult to publish because of the classified nature of their work and patenting becoming even more difficult when the sponsor's endorsement/clearances is an issue , thereby deterring them from doing enough in terms of meeting the yard sticks of the R & D put together. It may be like having variables more than the equations. Also, time is seen to be a constraint, since one has to develop the hardware in return to the price attached to it, and yet take time off to "indulge in publishing", of what they can and what they cannot. But, for one who feels immensely burdened with the feeling that being a scientist and more so when he has an innate obsession for scientific research/publications (not for publication or publicity sake, but for placing in public domain to share his experiences for posterity) , riding the proverbial two horses mentioned herein become relevant. Else, such a scientist can end up with a tendency of tilting towards an industrial type of activity and drift away from what might be called losing his moorings with Science or blunting his Scientific Temper, which he has.

If an R&D Organization leans gradually towards Hardware Development (for whatever justifiable reasons), the evaluation of a Scientist-Designate often if not invariably, is by what one delivers against External Cash Flow-ECF (another new buzz-word) ,the sort of R – Component yard- sticks mentioned above, not holding much water. But for those, not in a position to bring in ECF by the very nature of their specialization with attendant limitations to generate/rope in funds, the R – Component yard- sticks become relevant or come handy, but the question one may face is, "At whose cost the Research is done". In case of Hardware development the ECF can take the precedence, for reasons obvious. But, for one whose conscience is in balancing between the R and the D , undoubtedly, it is walking on the sword's edge with the risk of doing neither or sacrificing one for the other, even to the extent of missing timely returns for his efforts, a price one must be prepared to pay, for doing the R & D in parallel.

R & D MANAGEMENT & CULTURE

Well, typically in a scientifically managed R&D set up, the R&D Managers are self made and they evolve within the organization. In extreme cases, the criteria of how R & D personnel is assessed, can resonate in between, by what he develops and delivers against ECF and against exclusive Research resulting in publications, presentations, patents, books and so on. Here, two distinct class of people emerge (though may not be by design), viz. the Researchers and the Developers, analogous to Thinkers and Doers (a once hotly debated issue in one of Country's Premier Organization, when it got into a dilemma as to who should to head and lead it?). Often, there can be little or inadequate overlap of their philosophies driving respective activities within the same organization; the passions, commitments and out puts however, remaining undoubtedly clearly visible in their own way. Herein crops up the issue regarding the Manifesto or Charter of an R&D Organization?, as expounded by its Founders , bringing into picture, its attitude and the environment it creates and provides for these two class of people, by inspiring, motivating encouraging the personnel with R&D potentials and credentials, on board. The Managers are the higher order R&D personnel, having reached the level, meant to visualize and draw the Road Maps for the immediate, near and far futuristic programs that while generating a sound

economy for the organization, also sustain it in a highly challenging and rapidly changing Techno-Scientific environment. In this context, what is needed is an effort on how to "Preserve and Perpetuate continuity to the Scientific Culture", in the Organization as a whole. The Role of an R&D Manager in such an Organization is paramount and got to be versatile and unique, unlike what exists in an Industrial R & D (with Motto of Return on Investments). He has to lead from the Front/Rear, Plead when needed (generating funding, to support the Organization, from within and outside) and bleed often (in a situation of do or die, having committed to deliver a visible End-Product to the sponsor, on behalf of his organization). It is a different matter that, it is the organization which is ultimately accountable to the sponsor, no matter who stays and who leaves. The Manager has to take along all concerned at all levels and be the anchor, synergizing and normalizing their Strengths and Weaknesses. Building and Maintaining the "Research Reserves", is like keeping the OH- Water Tank full all the while so to say, in order that the taps do not go dry, one day.

The role of the Captains of the R & D Organization is vital as its watch dog all the time, in enabling and facilitating the right output from groups/teams of diversified disciplines, much like in a sport. But, what is missed out often is, how to enlighten and align the Research minded ones with the Development savvy, make them admire each other's compulsions, yet retaining their individual core competences, as one cannot afford to have in an R&D of this kind, either of them exclusively. Even the academic institutions are realizing the importance of having both, but with discretion. Coming back, both the R and the D groups have to rub shoulders, each respecting and supplementing the other's efforts, and share the Fruits of the R&D Success collectively. The Binding Matrix undoubtedly is the R&D Manager, but the Captains are the Eye in the Sky. Often it is a testing time for the Manager, especially when he on his own volition or under compulsion accepts the R&D responsibility of leading a Group with diversified potentials, disciplines and attitudes. Here, he should willfully create an interface among his Team members with different domain knowledges, rather than being preferential to some and not being so to some. Hierarchy and Ranks should not come in the way, when it comes to giving due credit, if not undue elevation. However, if some outperform in Research/Academics despite project pressures showing their extra-abilities, the organization should not miss spotting them, and reward them, either by giving them independent responsibilities and/ or, promote them suitably. If the system has limitations, it should find ways out (if not out of the way), or "Effect reforms, to reward them", (example, technical vs scientific cadres). Protecting and preserving such Scientific Minded Professionals (need not be not an OXYMORON), will be an asset to the organization in the long run, recognizing that, Passionate R & D Scientists are usually if not necessarily born and created or made. Often he (the Manager) may need to even learn, where it is not his domain of expertise or of no interest to him inherently. But having "accepted the responsibility" for whatever reasons, he has to Lead, Plead and Bleed. Once he likes doing it, the results are fantastic, but first the "EGO must GO". A Bottom up Top Down approach (willingness to learn even from below when needed with humility and managing the Equals and Superiors at the top with courage) enables the Manager rise like a Phoenix, pledging his long experience maturity and wisdom. Often, the Ombudsmen of the R & D Organization, may need to help the Captains make mid course corrections, if need be, to ensure smooth running of the R & D Band Wagon. If this is not done, it may lead to depletion of the Research Reserves, in the long run. The Scientific R&D Institutions are Custodians of the National Public Trust, respecting and nurturing the High Science and High Technology Areas in contemporary and fast emerging fields. They should have strong Research Inclinations side by side the Product Indigenization Goals and Responsibilities, at the same time be the Beacon, or a hope for the Country's NEXGEN (eg, the have not's from the educational sector).

CONCURRENT RESEARCH (THE RDD or R2D)

The Concurrent Research or the Research Development Driven (RDD) is need based and carried out mostly in parallel and occasionally in tandem with the Development programs, committed with the Sponsor's funding, time line and specifications clearly identified right at the beginning. The RDD thus is linked with a product from the beginning much like (if not in Toto) in a **mission-mode**. Again, the task of the R&D Manager is to deliver what was promised, standing under a Damocles Sword.

This is a very challenging situation, since the "Research here is Application Oriented" and Contemporary, to be carried out on well defined and directed project relevant topics not necessarily linked to his passion, with the expected results to feed into the end product, continuously. And, it is time bound since it has to run in parallel with the development cycle; but, such Research should not be **co-terminus** with the product delivery, paving the way to forward looking or the futuristic R&D Road Maps. That is when the term R&D represents two sides of an R&D coinage, since the research results have to be compulsively fed into the Product under development, making it scientifically substantiated and technically sound. Yet it is a kind of Business and a win-win situation, both for the Donor (of challenge) and the Receptor (of opportunity). Here, the direct deliverable is most often a hardware (can be a software too if linked and adequately demonstrated on an application platform) and the implied one always is the research, supporting the former. That is where the Nation is benefitted, as the Research Funding is no issue and the Development invariably turns out to be indigenous and one can see "**Made in India**", on every product used not only in India, but elsewhere as well. It is a charm, ultimately to do this kind of RESEARCH that results in an end product, and the Researcher is at no one's mercy for funding, only rider being, "Are you willing to ride two horses, and walk that extra mile"? In this case, there is nothing like, someone questioning for accountability, the promised and delivered (promised deliverable) speaking for itself. The Project Documents (Technical, Scientific, Reviews, Sponsor's Acceptance/Satisfaction Indices,, Publications in Open Literature, Patents, TOT Records, supplemented by Academic Guidance), all stand as a testimony to the R&D Performance of the Organization as a whole. It is important to recognize that, both these activities are inherently dissimilar in nature, resonating between those of a "Research Passionate Scientist" and a 'Hard Core Development Engineer'. That brings us into the concept of doing both the R and the D, in a hardware development-dominated environment (when it tends to be so), leaving little or no room for a passionate/fanciful Research, or an attitude, "I did my job, it is for you to do what you want to do with that". But then these two horses need to be handled and harnessed with both willingness and commitment. This though is a challenging and often conflicting situation for a Research Minded Scientist, it is a win-win situation, as the Scientist gets the funding support and the sponsor gets his end product —sort of you can have the cake and eat it too. Question is how many wish to take them as Thrills in Chills and Charms in Challenges.

THRILL, CHILLS, CHARMS AND CHALLENGES - Some Case Studies

The best example here, is, development of an end product, with novel/new materials, new processes, and acceptance methods specific to the novelty (first time done, and none else can do). That was when my mind wandered in a wonder-world called the "Composite Materials", especially when the products to be developed were as diversified as a 2-seater all composite aircraft-HANSA (for pilot-training), and Radomes"(Radar Domes for protecting ground based Radars for disaster warning/management and for flight vehicles), both having a very close link to the societal needs. They called for interdisciplinary participation (Materials, Processes, Technologies, Manufacturing, Mechanical Design/Structural Analysis, Fluid Mechanics, Electromagnetics, and Engineering Services and what not).

In essence, the HANSA demanded formulation and execution of Applied Research Programs on customized composite material formulations, their characterization, , multi-level testing , their certification/qualification and acceptance, concurrently with development of inexpensive indigenous Production Processes/Fabrication Technologies (emphasis being on easy absorption by a small scale private sector), bringing together “Basics of Polymer Science” and different disciplines of “Engineering and Engineered Sciences” and realization of a certificated light trainer aircraft of world class with a stringent weight-budget (All Up Weight- AUW within 750 Kg, vide the JARVLA regulations- not a gram exceeded, reminding the Act from The Quality of Mercy of the Shakespearian Drama, the Merchant of Venice). Many who worked in the program either lost or maintained their BMIs in the process The “RADOME” provided yet another case of a challenging R&D venture to indigenously build the Next-Generation (NEXGEN) product for protecting the Doppler Weather Radars (the ground installed DWRs, used for coastal disaster management), and many Air Borne Radomes for the Fire Control Radars on JAGUAR Maritimes and the Weather Radars on NAL,s - SARAS . In this case, the subject Electromagnetics turned out to be a crucial design driver, and the last word in the acceptance of the product by the sponsor.

Coming back to the HANSA and the RADOMES Episodes , these facilitated bringing into play, a gamut of technical, scientific and engineering aspects like, materials, choice, characterization/testing (coupons to component levels ,invoking spectroscopic, thermal ,mechanical, structural and electromegnetics analyses, including the Customized Engineering Services) before and after rigorous exposure to application specific service environments , optimization of parameters for material-formulations development and composite-cure chemistry, also in parallel addressing the scientific topics like Synthesis and Kinetics of Cure and optimization.

The concept of the “Glass Transition Temperature-Tg” as a crucial measure of the degree of cure as well as a service temperature index for this Composite Aircraft took the centre stage of material certification and acceptance. It is no hype if said that, at one point of time, this parameter (as a design driver and a research topic), became the most debated with unabated breath, overshadowing many other issues , till the DGCA accepted and certified a RT-Cured Epoxy Composite system for the airframe. Selection and certification of a Flame retardant Resin System for the Engine Cowling, replacing the conventional Aluminum Alloy was another another excitement.

Environmental Research Studies carried out included, Hygrothermal Effects (combined Humidity and Temperature Effects).This led to extensive studies on Hot-Wet property Degradation trends (very specific to the Polymer Composite Materials) that led to generation of material specific Design Allowable(A Basis and B Basis) and data generation, so crucial for the structural Engineers for their optimum Design and Analysis efforts, to evolve a safe design for the structure on Field (in flight for the aircraft and on ground and in flight for different class of Radomes).Other important issues addressed were the , repair and requalification methodologies, NDT qualification and a host of allied topics. All these exercises demanded generation of accurate data for the structural designers on the top-floor on one hand, and the process-sheets for the product development Teams to ensure repeatability and reliability of the process followed at the shop-floor, on the other. These Products so developed, had to be ultimately certified for their compliance for functionality, safety of performance and service life, constantly involving collective efforts from Teams of various Disciplines. All these culminated in Prototype development, and finally the Type Certification of a full-scale product (Flying in case of

HANSA and the Onsite Installable 12.88 m diameter Dome in case of the Radome for the DWRs, by respective certification agencies), to say the least.

THE BEARER OF THE R&D MANTEL

Here emerges the main question, how and who, should find the time or scope to do the Research and the Development in parallel. This is here that, a passion or obsession of a scientist (the Author) gave the clue that led to identification of myriads of project specific topics ‘for short term, medium term and long term Research opportunities for Under Graduate, Post Graduate and Doctoral Programs, and generated hundreds of trained students/scholars/faculty both from within and outside the Organization. Colleagues/Researchers, Scientists, Technicians and Shop Floor work force ,had all to come together, so that everyone in the “TEAM” was exposed to the technoscientifics and significance of the product development program, irrespective of their qualifications/background/ divisional affiliations etc. Superimposed on all these, is the Certification mandates imposed by the ISO Certification System in place from within, demanding transparency (Do what you say and say what you do) and the DGCA (for the civil aircraft-HANSA) and the CEMILAC (for airworthiness of the Line Replaceable Units-LRUs of the Fighter Aircraft- Jaguar), as well as the respective sponsors of these products, from outside .This is not at all a comfortable and if at all the most scaring situation for a Scientist, wishing to be left alone as an independent Researcher, if there was a choice.

Very often, one encounters a situation to provide a proof of concept (POC) to a new idea, make a representative article or a prototype and finally to realize the full scale functional product. The all composite (non-metallic) HANSA first of its kind and in its class, provided the best example as we succeeded in the program with a range of versions (the proof of concept version/the experimental version by a mouldless route to win the confidence of higher ups that be, the pre-production version through a mould-route for an industry-friendly version, the Series Production Versions for repeatability of a qualified process, and finally the Technology Transfer version (TOT version) for commercial exploitation, with Post-TOT service support mandates. The HANSA first production prototype with an all up weight of 750 kg had its maiden flight test on 11, May,1998 (The Technology Day) creating a great excitement among all those involved. The CSIR newsletter described HANSA as the most-researched aircraft in its class. The certification for series production by DGCA in 2002/03 gave a sigh of relief to the TEAM-HANSA dedicated to the project for more than a decade and a half. The DWR-Radome was an equally if not a lesser significant example that culminated in the TOT to the End User /Sponsor, after more than 2 years of rigorous EM and Structural Tests on ground, before acceptance for its maiden installation (MARK I) at the Satish Dhawan Space Centre-SDSC, Sriharikota for ISRO, the sponsor. Soon followed the MARK II version with less number of larger panels, the technology of which was finally transferred to the sponsor identified PSU (BEL)

Indigenization and certification (by CEMILAC) of a flight worthy Nose Radome for the Jaguar Maritime fighter aircraft, closely followed by its TOT to the sponsor (HAL, to be inducted into the Air Squadrons), was another example of achieving, “The Mission Impossible”. The success story of this High-Temperature Resistance Composite Radome for a high speed flight Vehicle has many twists, excitements and all the ingredients of an R & D Venture, in its development in a record time, that ultimately, established a “Template for Radome Indigenization Programs”, with in the country, to say the least.

The aforesaid products and many of their predecessors/successors not covered herein for want of brevity, were an off shoot of the Applications Related Research Activities pursued concurrently with the product development (e.g., the Composite - Rocket Launcher Tubes replacing the imported heavy steel tubes, the 300KW and 500KW wind turbine blades under a NIMITLI enabled PPP Program, and a Bus Body for the mobile speech and Hearing Unit- to name a few and all again the firsts in the country).

Now, taking a breath, the question to be asked is, who, how and where else can a passionate scientist, function with such challenges, except in an Engineering Sciences Lab, that could give all the freedom/flexibility to him (leading from front in some programs and from the rear in some) and his team, allowing him to create a conducive platform to perform the Feat in an R&D mode, in “an environment, that prevailed at that time”. And above all, the Organizations’ stand that, the Lab-Facilities are public funded and hence have got to be liberally thrown open for the needy student community on one hand (human resource development) and the greedy scientific researchers (intellectual manpower development) on the other, the project specific services having the top most priority, of course.

THE AFTER EFFECTS OF A PASSIONATE R & D AND THE ROAD MAP

During my three and half decades of professional life (1973-2007/2008) and later over the past 7 years as a retired (but not tired yet) scientist of a prestigious National Laboratory, I tried very hard to understand the similarities and disparities between the R and the D. I struggled first as a scientist-in-charge of a pilot plant (just as a little manager) only with a good number of unskilled, semi- skilled and skilled work force (masters in their own art), and practically no technically or scientifically qualified man power, then getting an opportunity to elevate it to an independent Unit and finally to a full- fledged scientific division, which has today, highly qualified human-power .Thanks to all my peers who gave me the mandate ,trusted in me and watched me critically all the time, as I tirelessly tried to Ride these R&D Horses, that provided me and my Team, a golden opportunity and maneuverability like that needed for an unstable fighter aircraft.

The “FRP-DIVISION” that I was destined to create and groom (out of a Pilot Plant), before calling it a day in 2007/2008, has today many Doctorate – Scientists including enviable number of Women Scientists, mostly who rose from a technical to the doctoral level, while supporting the projects, and International Publications in its basket, (Missing a century by the Division was not regretful, since I could for once “discover an excuse” that there was “no time” to hit a century, for records sake). All along, it had been my endeavor to strike a judicious-balance between the R and the D, by interweaving these two in the warp and weft directions (akin to a planar bidirectionally woven fabric of glass or carbon reinforcement used in a polymer matrix of a composite material), and often by stitching them vertically (like in a 3D composite preform), to ensure the “R&D Structural Integrity”, invoking liberally the pressures from peers and demands of sponsors, and kindling their passions for research. In the process, a platform got created intentionally or unintentionally, wherein I could play my role at will in synergizing these two activities, Research outputs supporting the product development and Products developed and delivered for a price, nourishing and nurturing the former. The Division (or the legacy if I may say so),that I left behind with a vision, had both the technically qualified and trained staff rubbing shoulders with scientifically enabled / qualified staff, all the time, with the emphasis that “we were all made for one another and one none has existence without the rest” . The Road Map, I laid for this Division, had also made its forays into the frontier fields of the S & T, like the Nano -

Composites, High Performance Polymer Matrices, Radiation Cure Processes, Resin Infiltration Techniques (superior to conventional Resin Impregnation techniques), Jip- Preps (Just in time prepregs, all set to replace the expensive imported Prepreg Technologies), and many allied advances for the Composite Product Development Programs, all Scientifically, Technologically, Ecologically and Socially significant.

At the end of the day, I got a semblance (Saakshaatkaaram) of what an R & D could be made to look like (if not exactly what it can or should be- still I am pondering over), thanks to the organization which gave me the freedom, to pursue research with handful of students, staff, faculty of educational institutions and so on, of course walking those extra miles during extra hours, with a responsibility of having to deliver the end product to the sponsor (the customers or our GODS), who gave us the funds in good faith. While doing the R & D, to meet what the industry wanted, I and my colleagues enjoyed (and toiled) in “Taming the R & D Horses”, we could develop many a concept into realities through innovative ideas.

Looking back, there is some sense of fulfillment, if not to the extent that I would have liked. All said and done, “R & D” continues to remain an “OXYMORON”, when the Research is done with mere Passion as the purpose, and the Development carried out sans Research.

Tail Piece One thing, I can say for sure is that, for a scientist of an Engineering Sciences Laboratory under the CSIR umbrella,”Research should be his soul and substance whereas Development should be his bread and butter”. In this article, I tried to summarize in tit-bits, my R & D Trials and Tribulations , the HR-Experiences, as a Scientist, Engineer and finally the Technologist (the Trinity of modern R & D), that too as a chemical engineer in an Aerospace Laboratory. Thanks to the material I worked with, the composite material, and the Environment I was blessed with to play my Role. First I felt, it was a gross Misadventure, and looking back, I feel it would have been a missed Life Time- Opportunity in my Profession, had I not taken it up willfully with a passion and bowing to it in all humility. Soon I realized that given everything else, it is my basic curriculum-driven instinct, that goaded me all through, as the activity I handled, called for an “Interfacial Engineer” that I became ultimately (not a jack of all trades any way).

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