Virtuoso Project Teams: Beyond High Performance, a Case Study of the Teaming Success of the Motorola Satellite Communications System IRIDIUM® Program

Abstract

High performance teaming has always been the gold standard for project management in general and new product or new system generation in particular. Within the realm of high performance, however, there are special factors that must come together in both temporal aspects and technical content to be truly accomplished. These project teams may be referred to as virtuoso teams.

As an illustration of the principles of high functioning teaming, it is helpful to look back at one of the systems projects of the last century considered to be a hallmark of technical success and examine, from a behavioral perspective, what principles illustrate this "best of the best" teaming genre. The Motorola IRIDIUM® Satellite Communications System is one such project. Through published memoirs, case studies and retrospective articles, recent publications, personal notes and documentation, and unpublished project artifacts, aspects of the project team are examined to illustrate some of the theoretical principles of high performance teaming.

Preface

The logistics of launching 72 satellites in 12 months and 12 days through 22 successful launches on three different types of rockets in three countries (US – Vandenberg AFB, Russia – Baikonur, and China – Taiyuan) were, for a cellular telecommunications system designer, almost mind-boggling. To do what had not been done before required project team innovation, creativity and some measure of bravado. Motorola's manager for satellite manufacturing had to deal with extremely short cycle times and doing what others considered impossible as a matter of course:

*"**He challenged the launch team to develop test processes and equipment that would allow them to place test equipment into the overhead compartment of commercial aircraft. As for the complexity of the launch site, he recalled saying, 'It's like a rock concert. There is a lot of money at stake, a lot of technology involved, a high penalty of failure and you have a very tight timeframe in which to operate. You arrive at 10 o'clock at night on Thursday, your show is on Friday, and you have to be somewhere else on Saturday.'**
The launch team took [his] idea and sent a team to observe and document the processes that were used by The Rolling Stones [during an actual concert tour]. They came back with clever ways to streamline the logistics of their launch processes, contributing to setting records that may never be broken." [20, p. 132].*

1. Introduction

In the Information Systems field, the use of case studies as a valuable tool with the intention to reveal phenomena within their context has been suggested for the past three decades. [4]. What follows is not a research study *per se;* rather it is an examination of events *in situ* that may retrospectively inform us through analysis of the context in which project team members experience project teaming.

It is my bias that there are endeavors that push forward new developments in science and human affairs that can clearly only be accomplished by very large teams. The realization of new paradigms breaks with past limitations and quantum leaps in human endeavors may only be accomplished over the short term by large teams, often supported by an even larger infrastructure with the financial and relational leverage to achieve groundbreaking results. This is true for a number of industries concerned with what is termed "new product development" whether the industry is pharmaceuticals, civil engineering, critical information systems or aerospace, among others. Breaking new ground requires project teams that have the skill sets to work with highly technical, highly complex systems that require the highest performance of team members in order to realize the project goals. High performance teaming is a much-studied aspect of project management. Virtuoso teams are unique among project teams as models of high performance. These teams are the result of unique circumstances that combine a contextual prism of generous funding, top organization support, opportunity, location and team leadership with the

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temporal aspects of teams. These temporal aspects go beyond a set schedule for delivery. Not only is time of the essence, but the feeling that *this* same team, *this* same opportunity, that *these* team members may never pass this way again – is the 'once in a lifetime' factor that drives individuals to savor every aspect of the working relationships.

1.1 The idea, the goal

The idea that Motorola needed to create the largest communication satellite project in the history of the world was a theoretical one: develop a constellation of 77 satellites that essentially "flipped" the engineering model for terrestrial cellular telephony. Instead of having base stations on earth in many geographic locations to provide coverage everywhere (except the poles), including oceans, small islands, rough terrain, mountain ranges and other areas where base stations were not realistic, Motorola would put the base stations in the sky. This "network in space" would link a cellular phone user on the ground to other users or networks through satellite cross links that created a planetary network all while moving in a geosynchronous orbit at 16,000 miles per hour. Cellular calls would link to the terrestrial infrastructure through gateways on the ground that contained switching stations to transfer call through the land-based networks and terrestrial cellular networks. The gateways were planned to be owned and operated by various consortia in global locations that represented every continent, except Antarctica. The system would operate 24/7 for 365 days per year everywhere. [5]. The entire complex program was the concept of three men, all extraordinary in their fields – an engineer, a mathematician, and a retired Air Force officer - who would eventually lead a program with over 1500 team members spanning 10 years at an estimated total cost of over $3.5 billion. These individuals, with the support of a general manager of the Motorola Government Systems group, sold the idea to the CEO with the target of full operation of the entire constellation by November 1998, a goal that was technically accomplished. [20]

1.2 Technical triumph, commercial disaster

For a decade after the 2000 corporate bankruptcy and near-decommissioning of the satellite system by the constellation owners, the name IRIDIUM was the posterchild for bad business cases. Virtually every case study regaled the strategic folly of the investment of Motorola and its partners. In engineering and technical circles, however, the astounding software and hardware accomplishments of the project team were still recounted with reverence though typically asterisked by the business case failure. [7], [13], [22]. What has not been thoroughly examined is how well the entire project was run. Almost two decades after the delivery of the project mission, those involved are being recognized as trailblazers. A closer look at the project reveals how it exemplifies the highest performance in project teaming.

2. Theoretical background

The epistemological framework for selecting this case analysis is based upon the fundamentals of Appreciative Inquiry as a platform for " the discovery of what gives 'life' to a living system when it is most effective," through " the art and practice of asking questions that strengthen a system's capacity to apprehend, anticipate, and heighten positive potential."[10, p. 3]. The theoretical creation of Appreciative Inquiry comes from the social constructionist approach to organization development. This framework has not been part of traditional Project Management scholarship. One viewpoint, however, may be that consideration of the contextual enhances the standard practice of conducting post-project lessons learned, and the ability to reflect on 'what went well' in practice. The processes associated with this theoretical approach include interviewing and storytelling practices to tease out the appreciation of what historically has been a best practice aimed at developing information that is informative and applicable to future organizational endeavors. A major activity associated with this approach is to spur collaborative inquiry into phenomena associated with the discovery of value.

3. Methodology

The use of case study as a methodology for inquiry has been established as a legitimate qualitative method of study to test a theory, in this case the elements of virtuoso project team performance, and/ or to describe phenomenological events from the perspective of the participants or observers. [42]. The case study methodology is appropriate for this retrospective for at least two critical reasons. First,

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the investigation of phenomena in their contextual framework is an important strength that is aptly applied to individual projects. Secondly, the project management discipline itself requires that lessons learned – a retrospective analysis of what went wrong, as well as what went right - is considered to be a professional best practice. [34], [32]. Sources for triangulation of data informing this paper came from a variety of journal articles retrospectively published in both the business technology domains, other published literature, published memoirs of participants verified by the author as an eyewitness to certain events described by the writers, the author's archival notes, and unpublished Motorola internal use documentation from the program procedures. [16]. The test of time has not diminished the technical and engineering accomplishments of the Iridium Communication Systems and the Program that designed, developed, tested and produced it. To those who would say that this example is from the late 1990's and may no longer be relevant, a number of the scholarly case studies in project management and some of the seminal work in organization development and project teams was developed during that same era [22]. The aging process does not diminish the value of the vintage perspective. Accordingly, my ability to reflect on my experiences of being a part of this accomplished team without romanticizing, and to view in hindsight what was accomplished through theoretical models and the narratives of others helps to ground this retrospective case beyond any one individual's recollections.

4. Case study literature on the IRIDIUM Satellite System

A literature review of current case studies and retrospectives on the Motorola program from the perspective of teaming and organizational behavior, not from a commercial or business case perspective is difficult to find in current published journal articles. From a technical and engineering standpoint, the numerous patents associated with the program and many scientific papers on the satellite constellation and the ground network have been published over the years. From the business and strategic perspective, a number of top –ranked universities have published cases recounting the negative results of the commercial endeavor – from the high cost of the satellite phones to the inescapable truth that the entire business and marketing plan for IRIDIUM LLC was

deficient. Harvard, Kellogg School of business at Northwestern, and MIT, have all published case studies and/or theses about the IRIDIUM story [6], [12], [35], [38].The bankruptcy of the company within a year after full operation of the constellation has most often been attributed to Motorola Corporation; however there were numerous other actors that played a part in the eventual commercial collapse of the venture. [5]

4.1 Review from a commercial and strategic business perspective.

Esty's Harvard Business School case provides a thorough critique of the satellite communications industry's lack of solid strategy or business case. This case presents many of the negative financial impacts with exhibits depicting revenue projections, satellite configuration data, and capitalization tables. There is no review of the project team and its accomplishments in terms of the project management triad of quality and schedule adherence. Cost and budget are reviewed and the negative impact of overspending is emphasized. [12].
Similarly, Lim et al provide a case study of the entire satellite phone industry using the IRIDIUM system as the primary example for recounting lessons learned. The lessons include faulty commercialization, disconnects between satellite communication technology and the terrestrial mobile communications technologies that evolved, signal quality and roaming fees and the failure to target additional marketing niches (however, the niches described would not have been able to meet the cost of entry so it remains an open point) [25]. The Daneke and Dooley case study for IEEE critiques the IRIDIUM project as follows: "Given its scale and notoriety, IRIDIUM is one of the more discussed corporate fiascos." While acknowledging that the system "was a colossal undertaking and significant engineering accomplishment", no mention of the project team, its leadership or developmental expertise was included in the study. The authors reference other case studies on the system noting that the large capital outlays made on the gamble that the system would be profitable should have been curtailed early on. The case study is interesting as it also describes the failure of the commercial deliverable as due to an inadequate stage transition in the invention, business planning, and business execution model. [11]. In another Harvard Business review article, Carroll and Mui use

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the IRIDIUM Program as their primary example of making the wrong bets on technology through reliance on breakthrough innovation which over – rode marketing strategy.

Finkelstein and Sanford provide a number of direct quotes in their case study of IRIDIUM. From analysts calling the system "a multibillion dollar science project" to the IRIDIUM LLC CEO stating , "We're a classic MBA case study in how not to introduce a product," the authors go on to state that "IRIDIUM will go down in history as one of the most significant business failures of the 1990's." [6] The forces of faulty IRIDIUM LLC leadership, escalating financial commitment and lack of board oversight are clearly outlined, however no mention is made of the developers and engineering teams that designed, developed and implemented the system.

4.2 Review from a project management methodology perspective

Case studies from project management and various aerospace symposia and technical conferences are equally negative in terms of the final outcome of the project and the lack of strategic foresight. Kerzner develops the most comprehensive case study from a project management perspective, yet there is no mention of the project team's work in terms of matrixed organization, team accomplishments or team dynamics. [22]. Beesemyer *et al* discuss the IRIDIUM System in terms of "epoch shifts" that occurred during the development stages from the 1980's through 2000's. [3]

5. The evolving model of project teaming.

For the majority of new development work performed by organizations, the scholars writing in this century have moved towards teams and team success as evolutionary and related to team response to external change. Colwill notes that Kerber and Buono in "Rethinking Organizational Change," present a grid for describing organization change along the dimensions of organizational complexity and technical uncertainty that distinguishes the constraints that teams must deal with depending upon the organizational context. [9]. Kerber and Buono define the guided approach to change as more unconstrained in its approach. Why is this befitting of team considerations? Because higher performance and highly skilled knowledge workers that are often

hand-picked for a specific program (e.g. the Manhattan project), need intellectual flexibility to problem-solve within the technical space.

5.1 From high performing teams to high performing systems

Peter Vaill's chapter in the *Handbook for Strategic HR* [41] is based on observations that provide clarity on the behavior of high performance systems. The contention is that, if we apply Vaill's examples of "work systems" to work teams or team behaviors, we may be able to test them empirically against the narrative histories of actual high performance teams. [41]. Vaill provides eight key assumptions as a preface for an astonishing 44 hypotheses relate to the high performance of systems; however is it beyond the scope of this paper to enter into an in-depth discourse on all of them.

The eight assumptions that underlie Vaill's hypotheses, generalized here, can be paraphrased as follows:

a. Subjects of performance studies generally are not volunteers, but rather are acting out of individual needs to work for their self-interest.

b. Most of the high performance systems research has been related to problems and problem solving. In other words, Appreciative Inquiry as a methodology of approaching high performance teams has not been an integral part of many studies.

c. The study of less-than-successful performance usually leads to cause-and-effect diagnoses of what could have, potentially, enhanced performance.

d. Typically, systems that are considered to be effective (i.e., successful in their mission), have been used as comparators for systems that are judged to be ineffective.

e. When it comes to the investigation of system performance, studies of teams tend to either center on human resources dimensions, or on technical resource dimensions, but not both together to form a true systems approach to analysis.

f. The definition of what comprises a system for study has been generally accepted as it has been defined by organization management, not by third parties or external observers.

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g. Researchers tend to report their findings as the juxtaposition of what *should* occur versus what is *actually observed* to be occurring.

h. It is considered axiomatic that boundary-spanning between a given system and external elements should be improved via the interfaces between the system and its environment.

Vaill contends that human resources and technological resources should be "jointly optimized" [41, p. 235], in order to achieve higher performance. This optimization of work applies to external tools as well as to humans in large groups, small groups as well as triads and dyads. The principles of human behavior must be blended with the principles of physics, mathematics, chemistry, and other physical sciences to create a fully and optimally-functioning system. Within this context it is interesting to review some of Vaill's key hypotheses of interest as they can inform us of why certain projects are successful: [41, p. 235-240]:

a. No one kind of behavior dominates the system.

b. Failure to achieve the right arrangement of environmental conditions is sometimes cause for system members to fail.

c. A private language and a set of symbols arise among members of the system for talking about its conduct and problems.

d. Members evolve a set of indices of system performance which are systems specific and which may not relate easily to any other system.

e. When there are three or more people involved in a particular high performance system, a set of explicit values and ideologies about what the system does and why will tend to arise.

f. Members will report "peak experiences" in connection with their participation in the high performance system.

g. Performance breakthroughs in systems development occur in unplanned ways.

h. The inanimate elements of the system are often anthropomorphized by members of a high performance system. Machines become people.

i. Observers may come to feel that, members "live, eat, sleep, and breathe" their work activity.

j. External controls on the activity of the high performance system are seen by members as, at best, irrelevant.

k. Leaders in high performance systems will tend to be persons who are perceived by members as experts. Leaders' initial status, influence, credibility, and prestige will derive from the demonstration of their expertise.

l. Members of a high performance system may tend to have a powerful aesthetic experience regarding the inanimate objects of the system and/or the system's operation.

m. When a person has been the leader of a high performance system for an extended period, s/he will become a quasi-mythical figure in the eyes of the team members.

n. High performance systems will pay more attention to the initiation processes of new members than will comparable systems.

Vaill's contention is that, by studying systems [teams, organizations] that do these things well, we can impact the management and leadership practices of such teams/ organizations in the future. Examples of the observations made by Vaill abound in the technology and aerospace industries. Two retrospectives on high performing systems that illustrate this are Tracey Kidder's Pulitzer prize-winning book about the development of a new computer by Data General, *The Soul of a New Machine*, [23] considered a computer industry classic from the early 1980's, and John Bloom's recently published historical work on Motorola and the IRIDIUM Satellite Systems, *Eccentric Orbits: The Iridium Story* [5]. Both projects were made up of team members that were extremely skilled with disparate personalities. In many cases, the Motorola team contained some of the most unique subject matter experts in some of the most specialized areas (K-band radio frequencies, low earth orbitology, etc.), that have ever been gathered on one project. To say that "no one kind of behavior was dominant" is, in retrospect, truthful because the skill sets of the individuals far outweighed any personal tendencies toward the harmonization of behavior. The acronyms and jargon developed for one-of-a-kind technology projects with cocooned teams is brilliantly recounted by Kidder [23].

"To almost everything they touched the Microteam attached their prefix. The office that four of them shared, sitting virtually knee-to-knee, has a sign on the door that said 'THE MICROPIT'; the room in which they held their weekly meeting was the Micro-Conference Room. They gave out Microawards and Carl Alsig had his Microporch. One of them owned a van which became the Microbus." [23, p.154]

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Team members of high performance systems teams do march to their own drummer and frequently refuse to compare their performance to any other known index because of the specialness perceived. For the Motorola IRIDIUM Project team members there was a refusal to compare their systems with any other planned or proposed constellation of satellites because they were creating something newer, bigger, better, greater. Indeed, it was not uncommon to hear team members wax poetic about the minutiae of satellite technologies in ways that only insiders and scientific experts could hope to comprehend. This obviously draws a unique boundary around the team members and encourages them to create their own world, separate from other organizational teams, family members, friends, industry connections and the rest of the world. Sitting together in a group in an airport lounge speaking in what others would term gibberish: "The GEPA contract for IITL is really going to make GSM's target," is something that others would consider speaking in tongues. It is part of a bonding process that high performance teams pride themselves upon. To say that the technology becomes anthropomorphized is evident even in the title of Tracey Kidder's nook: *The Soul of a New Machine.* [23]. Many Motorola IRIDIUM Team members referred to the satellites as the "birds" or even "my birds," with admiration for the beauty of a piece of space equipment that few external stakeholders could begin to appreciate. The initiation process of the Motorola team members on the IRIDIUM project was well crafted and made for indoctrination and immersion. It began with a week-long class introducing the various elements of the project, the organization, the particulars of the satellite systems, the mission, the object, and included three days of team training developed by Belgard, Fisher, and Rayner and used by Motorola's Satellite Communications Systems in-house Organization Development and Human Resources Departments, and included a face-to-face question and answer meeting with Durrell Hillis, the President of the Motorola Division responsible for the IRIDIUM Program. This specialized initiation training was replicated over a period of years for over 1500 team members. Vignettes about heroic activities that demonstrated the team work abound. Anecdotes about individual managers and contributors take on mythic proportions.

5.2 The best of the best: Virtuoso teams

Fischer and Boynton wrote an article published in Harvard Business Review in 2005, entitled "Virtuoso Teams" [14]. Their description of virtuoso teams is fascinating because, just as there are high performance teams, these are the *highest* performance teams – the best of the best – and the authors seek to define and describe the epitome of these elite groups. "Virtuoso teams comprise elite experts in their particular fields and are specially convened for ambitious projects." [14, p. 149]. *Virtuoso* is a term most often used for orchestral and musical endeavors. For anyone that has played in an orchestra or sung with a choir, the ability to synchronize across different "functions" (instruments or vocal registers) is s special brand of teaming. If each performance were a "project" then virtuosity would be the culmination of "peak performance" by teams that appear to go beyond time and space to totally immerse themselves and transcend the normal group experience. For authors Marotto *et al*, it is a team version of what Mihayli Csikszentmihalyli termed "flow" in his 1990 description of what occurs when a person is so engaged in what they are doing that nothing else matters in temporal reality. Marotto *et al* suggest that collective virtuosity is flow at a group level. For a project team to be able to exhibit this level of performance over a sustained period of time, especially at the program level, is indeed rare and worth studying. [27]. Ordinary teams may get along better and prove less difficult for management oversight but the results will not approach the outstanding or astonishing magnitude of teams especially picked to push the envelope. These virtuoso teams are formed around high risk missions, hence, these teams develop an intense need to beat the odds and move the needle on challenges. High-stakes virtuoso teams are different: the entire team is hand-picked and singled out, not just the leadership or a sprinkling of resident gurus. Like artistic virtuosos, however, these teams cannot really be managed in the traditional sense. Just as with operatic legends such as Enrico Caruso and Maria Callas, these star performers, or divas, may not in fact fit in with the larger organization. Often they are accommodated, left alone, or segregated to perform their work. It is typical of "skunk works" teams operating under the corporate radar to develop a new idea to become the nucleus of a virtuoso team. It is when the virtuoso teams become large enough to

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accomplish an entire mission or project that corporate organization experiences the highest performances possible. This is not a recent phenomenon. Doris Kearns Goodwin's *Team of Rivals* described how Abraham Lincoln hand-selected unique star performers as the best people for his Presidential Cabinet, knowing that he would not create a cohesive group, but rather a team that would have the fortitude and intelligence to counter him if needed. [18]. Other virtuoso teams could rightfully include Oppenheimer's team on the Manhattan Project, Watson and Crick in the discovery of the double-helix structure of DNA, and more recently, the combined team that mapped the human genome. Fischer and Boynton also note that organizations willing to create virtuoso teams must understand that this is not the place for what is commonly described as good team behaviors: the best way to cater to solo performers with big egos is to build what they term the "group ego" [14, p. 151]. This can be accomplished, they suggest by encouraging a passionate focus on the team's ultimate goal, fostering a 'bigger than life" vision for the end result and allowing the team to disagree and attempt the impossible. In order to achieve superior goals with the panoramic vision that exceeds expectations and create sea change, virtuoso team members must be able to work on their own terms to develop ideas and create products and services that today we call "disruptive technologies."

5.3 Superordinate goals: the key to higher performance?

More recently Sue-Chan *et al* developed a theory that posits that teams with superordinate goals, defined as a mission that is "bigger' than the project itself, is a precursor to greater collaboration within teams, which in turn is a precursive trait for higher performance teaming based on their studies. [39]. If this is the case, then the IRIDIUM Satellite System, a program to create a cellular base stations using satellites for global cellular communications coverage to first develop the most complex communication system in the history of the world served as a superordinate goal that focused over 1500 team members across multiple sub teams towards collaboration required for successful performance qualifies as a project with superordinate goals as perceived by its team members.

6. Findings

6.1 The real-life virtuoso team.

The Motorola support of the IRIDIUM Program Team created a virtuoso team using the Fischer and Boynton principles over ten years *before* the authors produced their paper. All of the key tenets of the authors were put into practice for this Program by Motorola as early as 1988: [14, pp. 152-3]:
"Assemble the stars.
Build the group ego.
Make work a contact sport.
Respect the customer's intelligence.
Herd the cats"
How do these principles manifest in real-life virtuoso teams such as the Motorola IRIDIUM Program Team?
a. Hire the best, the brightest, the craziest people- the outliers, the big names, the rising stars. Put them all into the mix.
b. Don't worry if they don't behave like "team players." Let them compete, wrangle with each other, and duke it out, but keep their eyes on the prize.
c. Nothing is better than face-to-face contact and co-location. Virtuoso teams are not virtual teams. If you have to build a new facility to house the team, then do it, if you have to spend a fortune on international travel for team members , do it, but get them into the same space as often as possible for as long as possible.
d. Aim for the most sophisticated customers, users, and buyers that are available for your product. Play to the best audiences. Do not reach down, reach up.
e. Herding the cats is the role of the program managers. In every virtuoso team there need to a few people who understand how to work with star performers and corral them when needed; someone to watch the clock and the budget, but with the flexibility to understand what it takes to manage this special culture.

6.2 Setting up for success: starting at the top

Chapter 1 of Durrell Hillis' collection of IRIDIUM Program memoirs and interviews is entitled, " 'A' Players Only and the Culture that Resulted." As one former Motorola team member put it: "When I came to the program I was immediately overwhelmed,

amazed and delighted a) to be part of this enterprise, and b) to be surrounded by such an incredible group of people." Another team member recollected: "On the front end, we were allowed a lot of freedom in setting boundary conditions…. Allowing teams to work that out amongst themselves was a really, really innovative way of getting the Program off and running. I think that it was a powerful enabling construct." [20, p. 67-9].

8. Discussion

For those who experience the pinnacle of team work, the virtuoso team experience can be life-changing: As Hillis concludes, "I've heard over and over from people on the program that they consider it the peak of their career experience both professionally and personally. I have no expectations that I'm going to equal or surpass that experience…The ground has been broken and the trail's been blazed and the existence theorem of proof is there…That's the real legacy, but there were times during the Program when you wondered if it was all worth it." [10, p. 69-70]. In Deborah Colwill's model of the 4th generation of organizations, the future may indeed fully develop an "Energy Wave" paradigm whereby group accomplishment will be achieved by large unknown groups, perhaps not even teams, that have virtual access to each other and the ability to craft something lasting and beneficial through the relatively uncoordinated efforts of countless and often anonymous thousands of people. [9].Wikipedia is an example of this. Open sourcing and other virtual endeavors on a global scale may portend examples of large new product development efforts that are more the norm on the coming decades. Whether they constitute a true "group" or "team" is something to be researched and explored. The next generation of breakthroughs may indeed be developed and realized by anonymous conglomerations of human minds that are focused virtually on a similar objective. Networks of networks, rather than nested teams, may be the newest horizon. I would submit that this may be the next frontier of groups dynamics and is worthy of further study by both scholars and practitioners alike. The concept of virtuoso teaming can be evidenced across a variety of projects: challenging civil projects, pharmaceutical discovery projects, and other frontier expanding endeavors. Case studies cannot provide all of the historical data that internally and externally impact a project team. As with many

retrospective analyses, the passage of time provides ample opportunity to gain a different perspective. Virtuoso teaming is still possible within large technology projects today. The foundational importance of incorporating an appreciative assessment within the traditional lessons learned after a project is completed but prior to disbanding of the team may provide some guidance as to the best ways to incorporate some qualitative data on the lived experiences of project team members and project team leadership.

9. Critical evaluation

One possible critique of the virtuosity teaming concept is that many IT and IS projects are not "pushing the envelope" in terms of creating the conditions for virtuosity in team performance. I believe that is a different question from whether the study and practice of conditions for virtuosity in teaming are valuable. The goal of this paper was to present retrospective data to capture the contextual complexity of the virtuoso team in a setting of over 1,500 project team members. Undoubtedly there are many limitations of the case study methodology and this study in particular. There are no data presented to quantify the internal and external conditions that beget virtuosity in project teams. This case study presents no reproducible formulae for creating those conditions. Nor is there any suggestion that virtuosity in teaming can or should apply to all future instances of IT or IS project work. Although this paper is not intended to be standard research, there may be a contribution to applied project management which could be valuable for the practitioner engaged in project leadership. The conditions that create a project team at a particular point in time for a particular project deliverable are never really duplicated. The fact that we never step into the same river twice does not mean, however that we cannot extract the value of this retrospective learning, if only to help recognize project team virtuosity *during* its time and not almost twenty years later. One theoretical contribution is the application of qualitative Appreciative Inquiry to the project management practice of lessons learned. Qualitative work has not been systematically embraced within the project management academic literature as much as practitioners seem to recognize its value, in my experience across multiple industries. Certainly, there is some archival value in capturing the

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phenomenology of the project team that created the world's largest satellite system. Most of the senior project leaders of the original Motorola IRIDIUM Satellite System Program are probably in the neighborhood of sixty to eighty years of age as of this writing. Considering all of the negativity in many of the aforementioned case studies, is it not about time to recognize these leaders for what was *valuable* about the project – aside from the fact that the satellite constellation is still operative long after its expected life?

10. Suggestions for further investigation

Examples of current projects in IT, IS and related software disciplines continue to push known boundaries; technology for driverless cars, applications for 3-D printing and the ubiquitous use of software and systems for the support of biomedical research and development easily come to mind.
For the future application of qualitative project management team study, some intriguing questions may be summed up as follows:
1. Can the qualities of high performance and virtuoso teaming be developed and applied to non-boundary pushing projects?
2. How can we create the team focus of having a superordinate mission on other projects that are *not* "first in the world" endeavors?
3. What effects do unconditional support of senior leadership and related financial and infrastructure support have on the psychological safety of the project team? And, does this psychological safety then permit a higher degree of team virtuosity? How would we measure this? Examination of these questions may help to inform us of ways to enhance high performance of project teams as well and the quality of work-life for our colleagues.

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Virtuoso Project Teams: Beyond High Performance, a Case Study of the Teaming Success of the Motorola Satellite Communications System IRIDIUM® Program

Abstract

High performance teaming has always been the gold standard for project management in general and new product or new system generation in particular. Within the realm of high performance, however, there are special factors that must come together in both temporal aspects and technical content to be truly accomplished. These project teams may be referred to as virtuoso teams.

As an illustration of the principles of high functioning teaming, it is helpful to look back at one of the systems projects of the last century considered to be a hallmark of technical success and examine, from a behavioral perspective, what principles illustrate this "best of the best" teaming genre. The Motorola IRIDIUM® Satellite Communications System is one such project. Through published memoirs, case studies and retrospective articles, recent publications, personal notes and documentation, and unpublished project artifacts, aspects of the project team are examined to illustrate some of the theoretical principles of high performance teaming.

Preface

The logistics of launching 72 satellites in 12 months and 12 days through 22 successful launches on three different types of rockets in three countries (US – Vandenberg AFB, Russia – Baikonur, and China – Taiyuan) were, for a cellular telecommunications system designer, almost mind-boggling. To do what had not been done before required project team innovation, creativity and some measure of bravado. Motorola's manager for satellite manufacturing had to deal with extremely short cycle times and doing what others considered impossible as a matter of course:

"He challenged the launch team to develop test processes and equipment that would allow them to place test equipment into the overhead compartment of commercial aircraft. As for the complexity of the launch site, he recalled saying, 'It's like a rock concert. There is a lot of money at stake, a lot of technology involved, a high penalty of failure and you have a very tight timeframe in which to operate. You arrive at 10 o'clock at night on Thursday, your show is on Friday, and you have to be somewhere else on Saturday.'
The launch team took [his] idea and sent a team to observe and document the processes that were used by The Rolling Stones [during an actual concert tour]. They came back with clever ways to streamline the logistics of their launch processes, contributing to setting records that may never be broken." [20, p. 132].

1. Introduction

In the Information Systems field, the use of case studies as a valuable tool with the intention to reveal phenomena within their context has been suggested for the past three decades. [4]. What follows is not a research study *per se;* rather it is an examination of events *in situ* that may retrospectively inform us through analysis of the context in which project team members experience project teaming.

It is my bias that there are endeavors that push forward new developments in science and human affairs that can clearly only be accomplished by very large teams. The realization of new paradigms breaks with past limitations and quantum leaps in human endeavors may only be accomplished over the short term by large teams, often supported by an even larger infrastructure with the financial and relational leverage to achieve groundbreaking results. This is true for a number of industries concerned with what is termed "new product development" whether the industry is pharmaceuticals, civil engineering, critical information systems or aerospace, among others. Breaking new ground requires project teams that have the skill sets to work with highly technical, highly complex systems that require the highest performance of team members in order to realize the project goals. High performance teaming is a much-studied aspect of project management. Virtuoso teams are unique among project teams as models of high performance. These teams are the result of unique circumstances that combine a contextual prism of generous funding, top organization support, opportunity, location and team leadership with the

temporal aspects of teams. These temporal aspects go beyond a set schedule for delivery. Not only is time of the essence, but the feeling that *this* same team, *this* same opportunity, that *these* team members may never pass this way again – is the 'once in a lifetime' factor that drives individuals to savor every aspect of the working relationships.

1.1 The idea, the goal

The idea that Motorola needed to create the largest communication satellite project in the history of the world was a theoretical one: develop a constellation of 77 satellites that essentially "flipped" the engineering model for terrestrial cellular telephony. Instead of having base stations on earth in many geographic locations to provide coverage everywhere (except the poles), including oceans, small islands, rough terrain, mountain ranges and other areas where base stations were not realistic, Motorola would put the base stations in the sky. This "network in space" would link a cellular phone user on the ground to other users or networks through satellite cross links that created a planetary network all while moving in a geosynchronous orbit at 16,000 miles per hour. Cellular calls would link to the terrestrial infrastructure through gateways on the ground that contained switching stations to transfer call through the land-based networks and terrestrial cellular networks. The gateways were planned to be owned and operated by various consortia in global locations that represented every continent, except Antarctica. The system would operate 24/7 for 365 days per year everywhere. [5]. The entire complex program was the concept of three men, all extraordinary in their fields – an engineer, a mathematician, and a retired Air Force officer - who would eventually lead a program with over 1500 team members spanning 10 years at an estimated total cost of over $3.5 billion. These individuals, with the support of a general manager of the Motorola Government Systems group, sold the idea to the CEO with the target of full operation of the entire constellation by November 1998, a goal that was technically accomplished. [20]

1.2 Technical triumph, commercial disaster

For a decade after the 2000 corporate bankruptcy and near-decommissioning of the satellite system by the constellation owners, the name IRIDIUM was the posterchild for bad business cases. Virtually every case study regaled the strategic folly of the investment of Motorola and its partners. In engineering and technical circles, however, the astounding software and hardware accomplishments of the project team were still recounted with reverence though typically asterisked by the business case failure. [7], [13], [22]. What has not been thoroughly examined is how well the entire project was run. Almost two decades after the delivery of the project mission, those involved are being recognized as trailblazers. A closer look at the project reveals how it exemplifies the highest performance in project teaming.

2. Theoretical background

The epistemological framework for selecting this case analysis is based upon the fundamentals of Appreciative Inquiry as a platform for " the discovery of what gives 'life' to a living system when it is most effective," through " the art and practice of asking questions that strengthen a system's capacity to apprehend, anticipate, and heighten positive potential."[10, p. 3]. The theoretical creation of Appreciative Inquiry comes from the social constructionist approach to organization development. This framework has not been part of traditional Project Management scholarship. One viewpoint, however, may be that consideration of the contextual enhances the standard practice of conducting post-project lessons learned, and the ability to reflect on 'what went well' in practice. The processes associated with this theoretical approach include interviewing and storytelling practices to tease out the appreciation of what historically has been a best practice aimed at developing information that is informative and applicable to future organizational endeavors. A major activity associated with this approach is to spur collaborative inquiry into phenomena associated with the discovery of value.

3. Methodology

The use of case study as a methodology for inquiry has been established as a legitimate qualitative method of study to test a theory, in this case the elements of virtuoso project team performance, and/ or to describe phenomenological events from the perspective of the participants or observers. [42]. The case study methodology is appropriate for this retrospective for at least two critical reasons. First,

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the investigation of phenomena in their contextual framework is an important strength that is aptly applied to individual projects. Secondly, the project management discipline itself requires that lessons learned – a retrospective analysis of what went wrong, as well as what went right - is considered to be a professional best practice. [34], [32]. Sources for triangulation of data informing this paper came from a variety of journal articles retrospectively published in both the business technology domains, other published literature, published memoirs of participants verified by the author as an eyewitness to certain events described by the writers, the author's archival notes, and unpublished Motorola internal use documentation from the program procedures. [16]. The test of time has not diminished the technical and engineering accomplishments of the Iridium Communication Systems and the Program that designed, developed, tested and produced it. To those who would say that this example is from the late 1990's and may no longer be relevant, a number of the scholarly case studies in project management and some of the seminal work in organization development and project teams was developed during that same era [22]. The aging process does not diminish the value of the vintage perspective. Accordingly, my ability to reflect on my experiences of being a part of this accomplished team without romanticizing, and to view in hindsight what was accomplished through theoretical models and the narratives of others helps to ground this retrospective case beyond any one individual's recollections.

4. Case study literature on the IRIDIUM Satellite System

A literature review of current case studies and retrospectives on the Motorola program from the perspective of teaming and organizational behavior, not from a commercial or business case perspective is difficult to find in current published journal articles. From a technical and engineering standpoint, the numerous patents associated with the program and many scientific papers on the satellite constellation and the ground network have been published over the years. From the business and strategic perspective, a number of top –ranked universities have published cases recounting the negative results of the commercial endeavor – from the high cost of the satellite phones to the inescapable truth that the entire business and marketing plan for IRIDIUM LLC was

deficient. Harvard, Kellogg School of business at Northwestern, and MIT, have all published case studies and/or theses about the IRIDIUM story [6], [12], [35], [38].The bankruptcy of the company within a year after full operation of the constellation has most often been attributed to Motorola Corporation; however there were numerous other actors that played a part in the eventual commercial collapse of the venture. [5]

4.1 Review from a commercial and strategic business perspective.

Esty's Harvard Business School case provides a thorough critique of the satellite communications industry's lack of solid strategy or business case. This case presents many of the negative financial impacts with exhibits depicting revenue projections, satellite configuration data, and capitalization tables. There is no review of the project team and its accomplishments in terms of the project management triad of quality and schedule adherence. Cost and budget are reviewed and the negative impact of overspending is emphasized. [12].
Similarly, Lim et al provide a case study of the entire satellite phone industry using the IRIDIUM system as the primary example for recounting lessons learned. The lessons include faulty commercialization, disconnects between satellite communication technology and the terrestrial mobile communications technologies that evolved, signal quality and roaming fees and the failure to target additional marketing niches (however, the niches described would not have been able to meet the cost of entry so it remains an open point) [25]. The Daneke and Dooley case study for IEEE critiques the IRIDIUM project as follows: "Given its scale and notoriety, IRIDIUM is one of the more discussed corporate fiascos." While acknowledging that the system "was a colossal undertaking and significant engineering accomplishment", no mention of the project team, its leadership or developmental expertise was included in the study. The authors reference other case studies on the system noting that the large capital outlays made on the gamble that the system would be profitable should have been curtailed early on. The case study is interesting as it also describes the failure of the commercial deliverable as due to an inadequate stage transition in the invention, business planning, and business execution model. [11]. In another Harvard Business review article, Carroll and Mui use

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the IRIDIUM Program as their primary example of making the wrong bets on technology through reliance on breakthrough innovation which over – rode marketing strategy.

Finkelstein and Sanford provide a number of direct quotes in their case study of IRIDIUM. From analysts calling the system "a multibillion dollar science project" to the IRIDIUM LLC CEO stating , "We're a classic MBA case study in how not to introduce a product," the authors go on to state that "IRIDIUM will go down in history as one of the most significant business failures of the 1990's." [6] The forces of faulty IRIDIUM LLC leadership, escalating financial commitment and lack of board oversight are clearly outlined, however no mention is made of the developers and engineering teams that designed, developed and implemented the system.

4.2 Review from a project management methodology perspective

Case studies from project management and various aerospace symposia and technical conferences are equally negative in terms of the final outcome of the project and the lack of strategic foresight. Kerzner develops the most comprehensive case study from a project management perspective, yet there is no mention of the project team's work in terms of matrixed organization, team accomplishments or team dynamics. [22]. Beesemyer *et al* discuss the IRIDIUM System in terms of "epoch shifts" that occurred during the development stages from the 1980's through 2000's. [3]

5. The evolving model of project teaming.

For the majority of new development work performed by organizations, the scholars writing in this century have moved towards teams and team success as evolutionary and related to team response to external change. Colwill notes that Kerber and Buono in "Rethinking Organizational Change," present a grid for describing organization change along the dimensions of organizational complexity and technical uncertainty that distinguishes the constraints that teams must deal with depending upon the organizational context. [9] Kerber and Buono define the guided approach to change as more unconstrained in its approach. Why is this befitting of team considerations? Because higher performance and highly skilled knowledge workers that are often

hand-picked for a specific program (e.g. the Manhattan project), need intellectual flexibility to problem-solve within the technical space.

5.1 From high performing teams to high performing systems

Peter Vaill's chapter in the *Handbook for Strategic HR* [41] is based on observations that provide clarity on the behavior of high performance systems. The contention is that, if we apply Vaill's examples of "work systems" to work teams or team behaviors, we may be able to test them empirically against the narrative histories of actual high performance teams. [41]. Vaill provides eight key assumptions as a preface for an astonishing 44 hypotheses relate to the high performance of systems; however is it beyond the scope of this paper to enter into an in-depth discourse on all of them.

The eight assumptions that underlie Vaill's hypotheses, generalized here, can be paraphrased as follows:

a. Subjects of performance studies generally are not volunteers, but rather are acting out of individual needs to work for their self-interest.

b. Most of the high performance systems research has been related to problems and problem solving. In other words, Appreciative Inquiry as a methodology of approaching high performance teams has not been an integral part of many studies.

c. The study of less-than-successful performance usually leads to cause-and-effect diagnoses of what could have, potentially, enhanced performance.

d. Typically, systems that are considered to be effective (i.e., successful in their mission), have been used as comparators for systems that are judged to be ineffective.

e. When it comes to the investigation of system performance, studies of teams tend to either center on human resources dimensions, or on technical resource dimensions, but not both together to form a true systems approach to analysis.

f. The definition of what comprises a system for study has been generally accepted as it has been defined by organization management, not by third parties or external observers.

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g. Researchers tend to report their findings as the juxtaposition of what *should* occur versus what is *actually observed* to be occurring.

h. It is considered axiomatic that boundary-spanning between a given system and external elements should be improved via the interfaces between the system and its environment.

Vaill contends that human resources and technological resources should be "jointly optimized" [41, p. 235], in order to achieve higher performance. This optimization of work applies to external tools as well as to humans in large groups, small groups as well as triads and dyads. The principles of human behavior must be blended with the principles of physics, mathematics, chemistry, and other physical sciences to create a fully and optimally-functioning system. Within this context it is interesting to review some of Vaill's key hypotheses of interest as they can inform us of why certain projects are successful: [41, p. 235-240]:

a. No one kind of behavior dominates the system.

b. Failure to achieve the right arrangement of environmental conditions is sometimes cause for system members to fail.

c. A private language and a set of symbols arise among members of the system for talking about its conduct and problems.

d. Members evolve a set of indices of system performance which are systems specific and which may not relate easily to any other system.

e. When there are three or more people involved in a particular high performance system, a set of explicit values and ideologies about what the system does and why will tend to arise.

f. Members will report "peak experiences" in connection with their participation in the high performance system.

g. Performance breakthroughs in systems development occur in unplanned ways.

h. The inanimate elements of the system are often anthropomorphized by members of a high performance system. Machines become people.

i. Observers may come to feel that, members "live, eat, sleep, and breathe" their work activity.

j. External controls on the activity of the high performance system are seen by members as, at best, irrelevant.

k. Leaders in high performance systems will tend to be persons who are perceived by members as experts. Leaders' initial status, influence,

credibility, and prestige will derive from the demonstration of their expertise.

l. Members of a high performance system may tend to have a powerful aesthetic experience regarding the inanimate objects of the system and/or the system's operation.

m. When a person has been the leader of a high performance system for an extended period, s/he will become a quasi-mythical figure in the eyes of the team members.

n. High performance systems will pay more attention to the initiation processes of new members than will comparable systems.

Vaill's contention is that, by studying systems [teams, organizations] that do these things well, we can impact the management and leadership practices of such teams/ organizations in the future. Examples of the observations made by Vaill abound in the technology and aerospace industries. Two retrospectives on high performing systems that illustrate this are Tracey Kidder's Pulitzer prize-winning book about the development of a new computer by Data General, *The Soul of a New Machine*, [23] considered a computer industry classic from the early 1980's, and John Bloom's recently published historical work on Motorola and the IRIDIUM Satellite Systems, *Eccentric Orbits: The Iridium Story* [5]. Both projects were made up of team members that were extremely skilled with disparate personalities. In many cases, the Motorola team contained some of the most unique subject matter experts in some of the most specialized areas (K-band radio frequencies, low earth orbitology, etc.), that have ever been gathered on one project. To say that "no one kind of behavior was dominant" is, in retrospect, truthful because the skill sets of the individuals far outweighed any personal tendencies toward the harmonization of behavior. The acronyms and jargon developed for one-of-a-kind technology projects with cocooned teams is brilliantly recounted by Kidder [23].

"To almost everything they touched the Microteam attached their prefix. The office that four of them shared, sitting virtually knee-to-knee, has a sign on the door that said 'THE MICROPIT'; the room in which they held their weekly meeting was the Micro-Conference Room. They gave out Microawards and Carl Alsig had his Microporch. One of them owned a van which became the Microbus." [23, p.154]

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Team members of high performance systems teams do march to their own drummer and frequently refuse to compare their performance to any other known index because of the specialness perceived. For the Motorola IRIDIUM Project team members there was a refusal to compare their systems with any other planned or proposed constellation of satellites because they were creating something newer, bigger, better, greater. Indeed, it was not uncommon to hear team members wax poetic about the minutiae of satellite technologies in ways that only insiders and scientific experts could hope to comprehend. This obviously draws a unique boundary around the team members and encourages them to create their own world, separate from other organizational teams, family members, friends, industry connections and the rest of the world. Sitting together in a group in an airport lounge speaking in what others would term gibberish: "The GEPA contract for IITL is really going to make GSM's target," is something that others would consider speaking in tongues. It is part of a bonding process that high performance teams pride themselves upon. To say that the technology becomes anthropomorphized is evident even in the title of Tracey Kidder's nook: *The <u>Soul</u> of a New Machine.* [23]. Many Motorola IRIDIUM Team members referred to the satellites as the "birds" or even "<u>my</u> birds," with admiration for the beauty of a piece of space equipment that few external stakeholders could begin to appreciate. The initiation process of the Motorola team members on the IRIDIUM project was well crafted and made for indoctrination and immersion. It began with a week-long class introducing the various elements of the project, the organization, the particulars of the satellite systems, the mission, the object, and included three days of team training developed by Belgard, Fisher, and Rayner and used by Motorola's Satellite Communications Systems in-house Organization Development and Human Resources Departments, and included a face-to-face question and answer meeting with Durrell Hillis, the President of the Motorola Division responsible for the IRIDIUM Program. This specialized initiation training was replicated over a period of years for over 1500 team members. Vignettes about heroic activities that demonstrated the team work abound. Anecdotes about individual managers and contributors take on mythic proportions.

5.2 The best of the best: Virtuoso teams

Fischer and Boynton wrote an article published in Harvard Business Review in 2005, entitled "Virtuoso Teams" [14]. Their description of virtuoso teams is fascinating because, just as there are high performance teams, these are the *highest* performance teams – the best of the best – and the authors seek to define and describe the epitome of these elite groups. "Virtuoso teams comprise elite experts in their particular fields and are specially convened for ambitious projects." [14, p. 149]. *Virtuoso* is a term most often used for orchestral and musical endeavors. For anyone that has played in an orchestra or sung with a choir, the ability to synchronize across different "functions" (instruments or vocal registers) is s special brand of teaming. If each performance were a "project" then virtuosity would be the culmination of "peak performance" by teams that appear to go beyond time and space to totally immerse themselves and transcend the normal group experience. For authors Marotto *et al*, it is a team version of what Mihayli Csikszentmihalyli termed "flow" in his 1990 description of what occurs when a person is so engaged in what they are doing that nothing else matters in temporal reality. Marotto *et al* suggest that collective virtuosity is flow at a group level. For a project team to be able to exhibit this level of performance over a sustained period of time, especially at the program level, is indeed rare and worth studying. [27]. Ordinary teams may get along better and prove less difficult for management oversight but the results will not approach the outstanding or astonishing magnitude of teams especially picked to push the envelope. These virtuoso teams are formed around high risk missions, hence, these teams develop an intense need to beat the odds and move the needle on challenges. High-stakes virtuoso teams are different: the entire team is hand-picked and singled out, not just the leadership or a sprinkling of resident gurus. Like artistic virtuosos, however, these teams cannot really be managed in the traditional sense. Just as with operatic legends such as Enrico Caruso and Maria Callas, these star performers, or divas, may not in fact fit in with the larger organization. Often they are accommodated, left alone, or segregated to perform their work. It is typical of "skunk works" teams operating under the corporate radar to develop a new idea to become the nucleus of a virtuoso team. It is when the virtuoso teams become large enough to

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accomplish an entire mission or project that corporate organization experiences the highest performances possible. This is not a recent phenomenon. Doris Kearns Goodwin's *Team of Rivals* described how Abraham Lincoln hand-selected unique star performers as the best people for his Presidential Cabinet, knowing that he would not create a cohesive group, but rather a team that would have the fortitude and intelligence to counter him if needed. [18]. Other virtuoso teams could rightfully include Oppenheimer's team on the Manhattan Project, Watson and Crick in the discovery of the double-helix structure of DNA, and more recently, the combined team that mapped the human genome. Fischer and Boynton also note that organizations willing to create virtuoso teams must understand that this is not the place for what is commonly described as good team behaviors: the best way to cater to solo performers with big egos is to build what they term the "group ego" [14, p. 151]. This can be accomplished, they suggest by encouraging a passionate focus on the team's ultimate goal, fostering a 'bigger than life" vision for the end result and allowing the team to disagree and attempt the impossible. In order to achieve superior goals with the panoramic vision that exceeds expectations and create sea change, virtuoso team members must be able to work on their own terms to develop ideas and create products and services that today we call "disruptive technologies."

5.3 Superordinate goals: the key to higher performance?

More recently Sue-Chan *et al* developed a theory that posits that teams with superordinate goals, defined as a mission that is "bigger' than the project itself, is a precursor to greater collaboration within teams, which in turn is a precursive trait for higher performance teaming based on their studies. [39]. If this is the case, then the IRIDIUM Satellite System, a program to create a cellular base stations using satellites for global cellular communications coverage to first develop the most complex communication system in the history of the world served as a superordinate goal that focused over 1500 team members across multiple sub teams towards collaboration required for successful performance qualifies as a project with superordinate goals as perceived by its team members.

6. Findings

6.1 The real-life virtuoso team.

The Motorola support of the IRIDIUM Program Team created a virtuoso team using the Fischer and Boynton principles over ten years *before* the authors produced their paper. All of the key tenets of the authors were put into practice for this Program by Motorola as early as 1988: [14, pp. 152-3]:
"Assemble the stars.
 Build the group ego.
 Make work a contact sport.
 Respect the customer's intelligence.
 Herd the cats"
How do these principles manifest in real-life virtuoso teams such as the Motorola IRIDIUM Program Team?
a. Hire the best, the brightest, the craziest people-the outliers, the big names, the rising stars. Put them all into the mix.
b. Don't worry if they don't behave like "team players." Let them compete, wrangle with each other, and duke it out, but keep their eyes on the prize.
c. Nothing is better than face-to-face contact and co-location. Virtuoso teams are not virtual teams. If you have to build a new facility to house the team, then do it, if you have to spend a fortune on international travel for team members , do it, but get them into the same space as often as possible for as long as possible.
d. Aim for the most sophisticated customers, users, and buyers that are available for your product. Play to the best audiences. Do not reach down, reach up.
e. Herding the cats is the role of the program managers. In every virtuoso team there need to a few people who understand how to work with star performers and corral them when needed; someone to watch the clock and the budget, but with the flexibility to understand what it takes to manage this special culture.

6.2 Setting up for success: starting at the top

Chapter 1 of Durrell Hillis' collection of IRIDIUM Program memoirs and interviews is entitled, " 'A' Players Only and the Culture that Resulted." As one former Motorola team member put it: "When I came to the program I was immediately overwhelmed,

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amazed and delighted a) to be part of this enterprise, and b) to be surrounded by such an incredible group of people." Another team member recollected: "On the front end, we were allowed a lot of freedom in setting boundary conditions…. Allowing teams to work that out amongst themselves was a really, really innovative way of getting the Program off and running. I think that it was a powerful enabling construct." [20, p. 67-9].

8. Discussion

For those who experience the pinnacle of team work, the virtuoso team experience can be life-changing: As Hillis concludes, "I've heard over and over from people on the program that they consider it the peak of their career experience both professionally and personally. I have no expectations that I'm going to equal or surpass that experience…The ground has been broken and the trail's been blazed and the existence theorem of proof is there…That's the real legacy, but there were times during the Program when you wondered if it was all worth it." [10, p. 69-70]. In Deborah Colwill's model of the 4th generation of organizations, the future may indeed fully develop an "Energy Wave" paradigm whereby group accomplishment will be achieved by large unknown groups, perhaps not even teams, that have virtual access to each other and the ability to craft something lasting and beneficial through the relatively uncoordinated efforts of countless and often anonymous thousands of people. [9].Wikipedia is an example of this. Open sourcing and other virtual endeavors on a global scale may portend examples of large new product development efforts that are more the norm on the coming decades. Whether they constitute a true "group" or "team" is something to be researched and explored. The next generation of breakthroughs may indeed be developed and realized by anonymous conglomerations of human minds that are focused virtually on a similar objective. Networks of networks, rather than nested teams, may be the newest horizon. I would submit that this may be the next frontier of groups dynamics and is worthy of further study by both scholars and practitioners alike. The concept of virtuoso teaming can be evidenced across a variety of projects: challenging civil projects, pharmaceutical discovery projects, and other frontier expanding endeavors. Case studies cannot provide all of the historical data that internally and externally impact a project team. As with many

retrospective analyses, the passage of time provides ample opportunity to gain a different perspective. Virtuoso teaming is still possible within large technology projects today. The foundational importance of incorporating an appreciative assessment within the traditional lessons learned after a project is completed but prior to disbanding of the team may provide some guidance as to the best ways to incorporate some qualitative data on the lived experiences of project team members and project team leadership.

9. Critical evaluation

One possible critique of the virtuosity teaming concept is that many IT and IS projects are not "pushing the envelope" in terms of creating the conditions for virtuosity in team performance. I believe that is a different question from whether the study and practice of conditions for virtuosity in teaming are valuable. The goal of this paper was to present retrospective data to capture the contextual complexity of the virtuoso team in a setting of over 1,500 project team members. Undoubtedly there are many limitations of the case study methodology and this study in particular. There are no data presented to quantify the internal and external conditions that beget virtuosity in project teams. This case study presents no reproducible formulae for creating those conditions. Nor is there any suggestion that virtuosity in teaming can or should apply to all future instances of IT or IS project work. Although this paper is not intended to be standard research, there may be a contribution to applied project management which could be valuable for the practitioner engaged in project leadership. The conditions that create a project team at a particular point in time for a particular project deliverable are never really duplicated. The fact that we never step into the same river twice does not mean, however that we cannot extract the value of this retrospective learning, if only to help recognize project team virtuosity *during* its time and not almost twenty years later. One theoretical contribution is the application of qualitative Appreciative Inquiry to the project management practice of lessons learned. Qualitative work has not been systematically embraced within the project management academic literature as much as practitioners seem to recognize its value, in my experience across multiple industries. Certainly, there is some archival value in capturing the

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phenomenology of the project team that created the world's largest satellite system. Most of the senior project leaders of the original Motorola IRIDIUM Satellite System Program are probably in the neighborhood of sixty to eighty years of age as of this writing. Considering all of the negativity in many of the aforementioned case studies, is it not about time to recognize these leaders for what was *valuable* about the project – aside from the fact that the satellite constellation is still operative long after its expected life?

10. Suggestions for further investigation

Examples of current projects in IT, IS and related software disciplines continue to push known boundaries; technology for driverless cars, applications for 3-D printing and the ubiquitous use of software and systems for the support of biomedical research and development easily come to mind.
For the future application of qualitative project management team study, some intriguing questions may be summed up as follows:
1. Can the qualities of high performance and virtuoso teaming be developed and applied to non-boundary pushing projects?
2. How can we create the team focus of having a superordinate mission on other projects that are *not* "first in the world" endeavors?
3. What effects do unconditional support of senior leadership and related financial and infrastructure support have on the psychological safety of the project team? And, does this psychological safety then permit a higher degree of team virtuosity? How would we measure this? Examination of these questions may help to inform us of ways to enhance high performance of project teams as well and the quality of work-life for our colleagues.

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