IRI2038
FUTURES
AUDIT

BIGGER CAPACITY | BIGGER TEAMS | BIGGER TARGETS
INTRODUCTION

The Industrial Research Institute commissioned the IRI2038 foresight project to research how developments in technology, business processes, regulations and other spheres will impact the art and science of research and technology management over the next 25 years. This project will develop provocative yet plausible views of the next 25 years’ events, developments and other change forces impacting research and technology management and how IRI can best respond to these alternate futures.

This Futures Audit Report is one of the first reports from the IRI2038 project. Its goal is to establish what IRI members and others in the research and technology management arena believe will be the expected future. The Weak Signals Report is a companion to this report and uncovers emerging patterns of change that may shift the baseline future in unanticipated directions. Critical trends and emerging issues from both reports will be extrapolated into the future in the next phase of the project and later used to develop alternative scenarios about the future of research and technology management.

Results from IRI2038 will be shared throughout the year and a final presentation will be facilitated at the IRI Future Summit (November 2013).

IRI2038 is made possible by member donations to the IRI Diamond Anniversary Campaign. Ted Farrington of PepsiCo Advanced Research, Christian Crews of AndSpace Consulting, and Jennifer Blenkle of IRI lead the project.

The Industrial Research Institute (IRI) is the nation’s leading association of 200+ companies and federal laboratories having a common interest in the effective management of technological innovation. IRI is the only cross-industry organization networking the world’s best practitioners and thought leaders to seek, share, learn and create. www.iriweb.org
ABOUT THE FUTURES AUDIT

The expected future is an important component of any foresight program. Each of us makes decisions every day based on an informal, tacit vision of the future. This mental model is developed over time and is very rarely consciously challenged or updated. As a result it tends to do a good job of incorporating the long-term trend drivers that will continue to have a strong influence, but blinds its holders to critical new emerging issues that may shift the baseline toward alternative futures. It is important to document this expected future, both to capture the major drivers of change underlying research and technology management, and to contrast it with new emerging issues that may move the future in new directions.

The Futures Audit attempts to map the current mental model of the future that exists among research and technology management professionals. It uses interviews with 38 leaders across many geographies and industries to discover the major trends impacting the field in the past, present, and what they believe will affect the future. While this is not a statistically representative sample, the shared beliefs about the core drivers of the future do point to an existing mental model of the future that is operant among research and technology management professionals. While past IRI conferences and Research Technology Management journals have popularized several of these drivers, open innovation for example, they were also present among the responses of non-IRI members interviewed. If the Futures Audit captured the current mental model of the future among R&D leaders, then nothing in this report should be a surprise. Drivers and trends mentioned should reaffirm the held beliefs about the future. As discussed above, it is important that the Audit is not the sole tool used for forecasting possible futures, and should be read alongside the Weak Signals Report, which provides emerging trends that will shift the baseline Audit view of the future along several potential alternative paths.

METHODOLOGY

The Audit interviews had four main sections (see Interview Protocol, in the appendix). The first established the prior experience of the interviewee and current role in the organization. The second section asked the interviewees to look back to identify the major changes in research and technology management over the course of their careers. These questions open up the participants to the realization that significant change can occur and allow them to be more open to speculating about future changes. The third section dealt with changes the interviewees were currently seeing in the field. The final section used a number of different approaches to unearth their existing views on the future, including asking about what would surprise them, and to offer a vision of working in research and technology management in 2038. Asking about surprise highlighted held convictions about the future that were previously tacit, and asking for a vision utilized the more generative than analytical brain activities.

The interviews were transcribed and coded to find trends impacting the past, present and future of research and technology management. The 38 participants identified over 80 trends (see Appendix B). This report discusses the top 22 trends in the research and technology management field mentioned by the interviewees: 6 from the past 25 years that created the present conditions; 6 that are currently shaping it; and 10 that are expected to create change in the future. These 22 trends are grouped by time (past, present, future) and by categories of change found in the Verge Ethnographic Futures Framework. Verge uses the different ways humans interact with their cultural touch points as an organizing frame. It is being used for this project for several reasons. First it portrays trends not as abstract ideas but actual changes in human behavior. Second, these changes in behavior can more closely map to impacts on the sociology of research and technology management, not just the technology em-
ployed. In this way Verge places softer social change on a level playing field with the powerful technologies impacting how research is done and how people are managed. This report is structured according to these Verge touch points:

- **Create:** How we invent and build products, services experiences, and knowledge
- **Consume:** How we acquire, use, and destroy the things we create
- **Connect:** How we communicate with people, places, and things
- **Relate:** How we affiliate with people, organizations, and social structures
- **Define:** How we explain the world around us through concepts, ideas, and paradigms.

**PARTICIPANTS**

Futures Audit participants come from a diverse background of industries, regions, and experiences. The IRI2038 team used a matrix to ensure a wide range of leaders participated in the interviews, including non-IRI member companies and leaders.

A full list of the companies that participated is available in appendix C.

Despite this broad diversity, analysis of the interviews revealed 22 trends that were mentioned with a high degree of frequency by the participants. The following section lists these common trends.

*Figure 1: Participant Demographics*
RESULTS

Interview participants identified 84 distinct trends and emerging issues impacting the future of research and technology management. Some of these trends, such as the rise of computation or the access to knowledge embodied by the Internet, were global drivers of change far beyond the world of research and technology management.

Others, such as the globalization of R&D or a strong connection of R&D to business strategy, are very specific to the field. Both types of trends and emerging issues are represented in the Futures Audit, since both types have significant bearing on the future of the field. Of the 84 trends, 22 had much higher percentages of participants mentioning them. This report will focus on these trends in more detail.
The 6 trends mentioned most that have shaped the last 25 years of research and technology management are strong drivers that are affecting change now and will continue to impact the future of the field.

They include:

• **Create: The power of computation.** The exponential increase in the power of computation and the simultaneous drop in costs have moved computation from the mainframe to the laptop.

• **Connect: Access to knowledge.** Intranets have given way to extranets and the Internet, and instant access to the most up-to-date knowledge available inside and outside the corporation has provided remarkable leverage to individual researchers.

• **Relate: Globalization of R&D.** Companies have established research centers closer to customer markets around the world, and emerging markets have begun educating the majority of science and engineering students.

• **Relate: Open innovation.** Companies have moved outside the walls for innovation, initially toward university labs, later opening innovation across the value chain and to customers themselves.

• **Define: Increased regulation.** Globalization and an enhanced understanding of downstream impacts have radically increased the number and complexity of regulations involved in new product offerings to the market.

• **Define: Shift from fundamental to applied research.** As areas for fundamental research shrink and companies operate with thinner overheads in a globally competitive marketplace, research investments have been directed toward innovations that directly result in new products for companies.

The global drivers give rise to the top 6 trends that are currently creating change mentioned most by participants:

• **Create: Shift of R&D toward Asia.** Local companies in emerging markets are investing heavily in R&D and Asian countries are educating a majority of science and engineering students.

• **Create: Project Speed.** Business needs to apply innovation quickly and the speed of the global market is radically speeding up the time research projects have to complete work.

• **Consume: Rising global standard of living.** A billion new consumers in emerging markets now have disposable income, radically changing what researchers work on.

• **Connect: Big data.** Data from sales, operations, and sensors are being connected into massive sets of information that can be analyzed with sophisticated qualitative and quantitative research techniques.

• **Relate: Shortage of technical workforce that is hard to retain.** This rise in consumers and number of viable markets is increasing the need for companies to find and retain educated workers.

• **Define: Rigorous connection of R&D to business strategy and consumer need.** The shift toward applied research requires R&D to be highly sensitized to the business strategy to best ensure innovation is applied at all inside the corporation.

Most of these trends are very specific to research and technology management, with the exception of the global rise in standards of living, which interviewees suggest will cause resource scarcity and lead to a greater emphasis on sustainability in the future.

The bulk of the interview topics were on the future, and 10 trends were selected across the Verge categories that represent the diversity of elements participants identified as impacting the next 25 years.
At least 22% of the respondents mention these top ten as important to the future:

- **Create: Simulation.** Companies are using the ability to visualize interactions from massive data sets and the application of stochastic and predictive modeling to problems too difficult to solve analytically.

- **Create: Robotics & automation.** The ability to automate experiments and use robotics to accurately perform repetitive and precise work is freeing researchers to spend more time on analysis.

- **Create: Sustainability.** The awareness of the need to manage human impact on climate change and the degradation of land and ocean habitats will create opportunities for new areas of research and product development.

- **Create: Biotech & Nanotech.** These often cited trends would finally begin to dramatically impact the business sector and become major engines of innovative products for consumers.

- **Consume: Resource constraints.** Raw materials for products, and food and water for people, will be harder to find, develop, and deliver to a burgeoning global population. This will create opportunities for research and technology management to find solutions.

- **Connect: Virtual workforce & labs.** Researchers and managers for particular projects may be spread across the globe, meeting in online lab spaces.

- **Relate: Global war for talent.** The drop in engineering and science degrees in the US and the rise of those enrolled in those degrees in Asia will create a competition by companies for the services of the best students and workers.

- **Relate: Value chain open innovation.** Open innovation is moving beyond university labs and supply chain partnerships to include customers and the entire value chain in the innovation process. Companies will compete on innovation found across their value chain, from raw materials to after sales service delivery.

- **Define: Freelance R&D.** Many of the best project researchers will be freelancers, working contractually with many different companies.

- **Define: Challenges to IP.** Intellectual property protections will come under threat from several quarters, either externally by countries ignoring patents or internally through a bureaucratic issue of understaffing patent offices for the demand.

This report will go into these trends in more detail. Readers should also pay attention to the shorter descriptions of other trends mentioned about the future, especially those with small percentages of mentions. These are categorized as fringe trends, but change often happens from fringe areas with low perceived probabilities of occurrence or impact. The charts below provide statistics for all of the trends mentioned by interviewees.
SUMMARY CONCLUSIONS

Despite the significant diversity of participants, including type of business, region of the world, and industry, there was a strong common agreement on the 6 drivers of change that shaped the past, the 6 trends impacting the field now, and the 10 that will shape the next 25 years. Many participants share 3 core beliefs about the impact of these trends on research and technology management.

1. Bigger Capacity: Technology tools and business models will dramatically increase the capacity of the individual researcher.

2. Bigger Teams: These researchers will increasingly be participating in temporary projects composed of representatives of the entire product or service ecosystem, some of whom will not be human.

3. Bigger Targets: These projects will often be trying to solve bigger problems affecting the entire ecosystem or global society.

Further steps in the IRI2038 foresight process will allow IRI members to bring these elements of the baseline future into contact with the weak signals of change identified in the IRI2038 Weak Signals Report. This confluence of the expected baseline trends with the weak signals will give rise to the scenarios of the future of research and technology management.
SECTION 1: LONG-TERM DRIVERS

Participants identified 6 major trends from the last 25 years that impacted the art and science of research and technology management. On examination, these trends continue to drive current and potential future change in the field. They are fundamental drivers behind many of the newer developments being seen now and what participants expect to see over the next 25 years.

Create: The power of computation

Interviewees began their reflections of the past 25 years talking about the incredible impact of Moore’s Law and the power of computation on research and technology management. The exponential increase in the power of computation per dollar allowed the migration of computing from mainframes to desktops to cell phones over the last 25 years. This accessibility to computing changed the workflow of research, allowing researchers to do more work on local machines, not just data analysis itself but more of the visualization of the results.

Connect: Access to knowledge

An immediate corollary with the advance of powerful computation in the hands of the researcher and manager was the access to knowledge it enabled. Internally, all of a company’s generated information became downloadable and searchable. Knowledge management moved from the corporate librarian to information technology departments, then to client-based software on laptops. While this migration increased the speed and effectiveness of researchers, it was the Internet that exploded the access to knowledge. Suddenly researchers could search all studies on a particular subject from all over the world, from their desktop. Interviewees cited the Internet’s ability to leverage a single researcher’s power through information and expected this leverage to continue to change the practice of research and technology management.

Relate: Globalization of R&D

The combination of distributed computation and Internet connectivity allowed research to be done much closer to the local markets products were intended for. Companies planted R&D centers in emerging markets as these regions grew into major strategic growth areas for mature market companies. Additionally, these R&D centers enabled companies to take advantage of the local scientific and engineering workforce, which grew significantly over the last 25 years in comparison with mature markets. As the emerging markets grew in size, local companies began performing a large amount of research, joining the broader research and technology management community. Interviewees were strongly in favor of moving research closer to customers, but many suggested this driver has increased the ability of local companies in emerging markets to compete.

Relate: Open innovation

Competencies built by companies to communicate and manage research projects among their campuses also created the ability to do the same thing with other partners beyond the company walls. Early examples of open innovation were restricted to specific projects with university or government labs, and then expanded to alliances or joint ventures with close partners. Later the skills of managing research beyond corporate boundaries expanded to a much broader definition as companies accelerated innovation that met customer demands by including consumers and the entire supply chain ecosystem in ideation. Participants were in favor of working and managing in an open innovation environment, but many mentioned the need for researchers to be coached or trained in skills necessary to work with customers and partners in identifying new product needs.
**Define: Increased regulation**

Advances in sensing and the globalization of operations have created a thicket of regulations for new products. The ability for governments to measure ingredients, outputs, and environmental and human impacts of substances and products has created an intimidating environment for companies to release new products. As one participant in the study suggested, “what can be measured, can be regulated”. Additionally, the globalization of the marketplace and the democratization of consumers around the world have created a maze of special interest led regulations. The result has been a more conservative approach to research and technology management, as the value of an innovation must be measured against the cost of bringing new products to market. Most participants expressed frustration in the limitations to research these regulations have caused, while some cited them as opportunities to design new products and services.

**Define: Shift from fundamental to applied research**

Almost all study participants mentioned the shift away from fundamental research over the past 25 years. While many suggested the move was positive and important for research and development to move closer to the operations of the business and its customers needs, some lamented the loss of the transformational power of innovation driven by fundamental research. There were many reasons provided for the shift. The global competitive environment has reduced the ability of companies to devote resources to pure research that may not return money to the business for many years. Many interviewees also mentioned the perceived understanding that the fields available for breakthroughs with pure research were more limited, and that much of the major elements of science were known. The confusing global regulatory environment has increased the cost and timing of bringing fundamental research to market.

**SECTION 2: TRENDS IMPACTING THE CURRENT ENVIRONMENT**

While participants mentioned many trends currently impacting the art and science of research and technology management, these 6 were cited most frequently. Many of these are a direct result of the drivers discussed in Section 1 and also contribute to the 10 trends most mentioned impacting the future.

**Create: Shift of R&D toward Asia**

Asian economies have exhibited consistently high growth rates even as mature markets remained flat or regressed during the last recession. This has prompted both mature market and local companies to increase investment in research and development programs in Asia. Many interviewees mentioned their companies having established R&D centers in Asia staffed increasingly by local talent. This talent is easier to find since Asian governments have emphasized science and engineering education, making skilled workforce more numerous in Asia. Study participants suggested this has resulted in a shift in the center of gravity for global R&D toward Asia. Mature markets will increasingly be served by research performed in Asia.

**Create: Project Speed**

Long-term drivers of computation and access to knowledge have dramatically increased the expectations of the business on the speed of research and development projects from inception to delivery. Companies now expect results in weeks or months rather than years, especially as the focus of R&D has moved from fundamental to applied research. Interviewees suggested the tools are there to support faster projects, but some lamented the lack of deeper thinking that could develop more breakthrough innovations.
**Consume: Rising global standards of living**

There are more consumers able to spend discretionary income on products and services as a percent of total population than at any time in the world, and over a billion consumers will be added to this group in the coming decade. Solutions targeting these new middle class consumers will become a major focus for companies and in turn their R&D departments. These cost effective solutions are challenging in non-traditional ways, in that solutions are often arrived at by removing ingredients, parts, or chemicals, emphasizing simplicity rather than luxury. Additionally, interviewees mentioned the challenge of thinking about the cost and availability of the commodities and energy necessary to build and deliver these products to new consumers.

**Define: Rigorous connection of R&D to business strategy and consumer need**

Most study participants cheered the tighter connection of R&D to business operations. Output from research was implemented more often and R&D departments were seen as a necessary part of business operations. This allowed many R&D groups to retain budgets and personnel more than expected during the last economic downturn. Many mentioned the cyclical nature of the focus for R&D, as companies shifted between highly tactical, incremental innovation, and a need for broader, transformational innovation. Several interviewees, however, asked the question of where truly breakthrough innovation would come from inside their companies, with most answering that question by suggesting it would come from outside start-ups almost exclusively.

Participants mentioned the trends above most when discussing today’s decisions for research and technology management. Just as the past drivers influenced these trends, today’s trends will give rise to many of the trends participants think will change the business landscape in the future.

**SECTION 3: TRENDS IMPACTING THE FUTURE OF RESEARCH AND TECHNOLOGY MANAGEMENT**

It is difficult for humans to think ahead 25 years. As Ray Kurzweil has noted, humans forecast at a linear rate of change, while many types of change are exponential in nature. However, social change moves much more slowly, and can take an entire human generation to spread far enough to impact society. This study used a protocol that started by asking interviewees to look...
back a generation before looking forward. This sense of perspective was useful in helping participants comprehend the awesome speed of technological change affecting research. It also helped ground them in some of the timeless facts of managing people in a technology field. This combination of slow and fast change provided a venue for participants to offer a realistic forecast of what trends will impact the future, and how they might do so.

**Create: Simulation**

Study participants discussed simulation in two ways. First, the current use of fast and increasingly inexpensive super-computing engines to simulate physical conditions, from turbulence to fundamental particles to biological systems, will expand in scope and frequency. Researchers will run thousands of experiments against these models in the time it used to take to perform one in the real world. This will dramatically speed up the time from idea to implementation, cutting the number of real world experiments and increasing their likelihood of success. Interviewees from pharmaceuticals, aviation, and chemical industries often mentioned this side of simulation. Second, consumer-facing companies looked to advances in simulation to better understand future consumer demands and marketplace shifts. Companies and researchers will increasingly use massive data sets and the application of stochastic and predictive modeling to find areas of innovation that will meet unseen current or perceived future consumer needs. Some suggested that no major business decisions would be made without first running stochastic risk models to identify potential impacts across an increasingly complex system.

For research and technology management, participants felt simulation would enhance the power of the individual researcher, but potentially add a layer of complexity to current business decisions. While some welcomed the rigor simulation might provide in implementing innovation, others argued this tool may become overused and take the place of the technology manager.

**Create: Robotics & automation**

As the cost of robotics drops and the capabilities increase, more and more lab work will become automated. Open source programming will allow faster and cheaper installation and re-tasking of robots as well. Interviewees see advances in robotics as a way for them to spend less time on tedious, repetitive tasks in the lab. Participants also see automation extending to the analysis of results. Expert systems or intelligent agents will sift through immense quantities of data to arrive at hypotheses for human review.

Researchers will need to develop a facility for working in environments with very few humans, and with working with intelligent agents that do a significant amount of work and thinking for the researcher. Managers will need to add the care and feeding of robots and intelligent agents to their skill-sets of managing humans. Done correctly, robotics and automation will maximize the effectiveness of the researcher, a potentially scarce future resource.

**Create: Sustainability**

Whether or not interviewees felt climate change was driven by human activity, they believed that the needs of the environment will increasingly become a part of the economy. Consumers will drive the first wave of this change, demanding thoughtful engineering and innovation to reduce environmental impacts for products they buy. Regulations will quickly follow to legislate the types of materials in products, seeking to maximize the recovery of non-renewable materials and mandate the percentage of renewable materials. While some interviewees saw this as a potential threat that would increase the cost of innovation, others see sustainability as a welcome challenge for research and technology management to add significant value to companies.
For researchers, an understanding of the entire value chain from origin of raw materials to re-use - cradle to cradle - will be necessary to innovate. Managers will need to spot opportunities created by consumer demand and government legislation while negotiating a confusing and contradictory global regulatory climate.

**Create: Biotech & Nanotech**

Predictions of biotech and nanotech becoming the main driver of change in innovation have been around for over 20 years. And while both areas have grown into global industries, neither has yet to replace information technology as the prime engine of change in innovation. Looking ahead, however, many respondents felt that the next 25 years would be the era of bio and nanotechnologies. Biotechnology will finally reach the sweet spot of the s-curve of adoption. Participants cited advances in the automation of genetic analysis, the prevalence of inexpensive lab equipment, and the rising ability to deliver products, health outcomes, and even energy as markers that biotechnology will significantly impact the research landscape in the next 25 years.

Dreams of functional nanotechnology from decades past seem to have come down to the earthly reality of pants that do not stain. The idea of a nanotechnology future in which molecules are put together like legos to create anything the researcher may desire was still not discussed by most participants even looking out 25 years. However, they did think that nanotechnology would become the basis for most new materials in the future, and that these new materials could enable transformational innovations.

For researchers the maturation of bio and nano technologies was significant. Imagining biological assays in the millions and 3D printers at the nano scale, participants suggested a new world of experimentation that exponentially increased the power and speed of the individual researcher to develop prototypes and instantiate ideas.

For the technology manager these technologies posed new complexities in navigating regulations about their application and use, as well as staffing challenges to find skilled workforce in the future.

**Consume: Resource constraints**

Interviewees saw a significant commodities crunch ahead as the future population reaches 9 billion. Raw materials for products, food, and water will be harder to find and develop. Energy constraints will make it more difficult to deliver products globally to customers. Some participants felt that strategies of localization, where companies learn to use inputs for products found in local markets, and efficiency gains in taking water and unneeded materials out of products, would go a long way in meeting this demand. Others felt that resource constraints would open new sources of revenue for companies willing to invest to find solutions. A few forecasted a major downturn in the global economy due to severe food and water shortages, with human suffering in low income areas to be extreme.

For researchers resource constraints provide new challenges for innovation: process innovation to make products as efficiently as possible; ingredients and manufacturing innovation to use locally sourced raw materials; and molecular manufacturing to solve the future food crisis. Technology managers will be concerned with the percentage of research and engineering effort needed in each project to deliver product innovations to market that solve for resource constraints, and the need to find technically trained researchers to apply this discipline.

**Connect: Virtual workforce & labs**

When participants were asked about a vision for a day in the future of research and technology management 25 years from now, almost all suggested a completely virtual work experience. The globalization of research and the sophistication and availability of video
conferencing technology will mean that most researchers and managers will be interacting with each other through high definition screens in their own homes, often performing research in physical labs using robotic proxies. Some interviewees went farther, suggesting researchers will meet and work together in entirely virtual lab environments, where simulations and data become physical objects to interact with. A fringe few suggested the Singularity, in which people and artificial intelligences would be connected in a merged virtual existence.

But many interviewees felt that some face-to-face interactions would still be required. For them, no amount of realism introduced to video or holographic communications would replace physically working together. Most also felt that physical labs would still be needed, as simulation would not be able to totally replace real world experiments.

Researchers will be free to live where they wish, and manage work and home life much more seamlessly. Managers will continue to develop their skills at managing different cultures across multiple time zones. Instantaneous language translation, perceived as both possible and necessary in this future, will help, but the complexities of managing schedules of researchers who all work variably on different days or times of day will create a significant burden on managers.

Relate: Global war for talent

The need for science and engineering workforce to have local contextual knowledge of their markets will be important for future success. However, outside of Asia there will be an increasing mismatch between areas that produce technical workers and those that need it. Mature markets will remain a major source of revenue for companies, yet are producing fewer and fewer science and engineering graduates. Africa is projected to be the major engine of new growth for the world’s economy, yet it will lag greatly in the education of scientists and engineers. Participants saw several impacts of this imbalance on research and technology management. As the shortage for technically trained workers grows, companies and countries will compete for talent anywhere they can find it.

While initially a boon to researchers in the pay they can demand, it will result in being put to work on projects all over the world. They will need to quickly absorb the local culture and business context for the customers they are innovating for, and may need to access and interpret sophisticated ethnographic research. For technology managers, costs for people will rise, and the challenges of creating culturally relevant innovation will only increase as they leverage a global workforce to invent local solutions.

Relate: Value chain open innovation

When interviewees reflected on the path of open innovation they perceived a new era in which a product’s entire value chain would participate in innovation. Looking back, open innovation began with companies collaborating with government and university labs, then expanded to joint ventures or alliances with single players in the value chain. Today’s definition brought in employees from across the company and customers into an intimate relationship of innovation. Looking ahead, participants see the definition of open innovation continuing to expand to include collaborations of players from across the value chain, in which teams that include multiple stakeholders -- from raw materials suppliers to original equipment manufacturers to sales channels to service providers to customers -- all working together to identify, ideate, and create products for quickly shifting future consumer wants and needs.
Researchers will need to develop skills for working across organizational boundaries. They will be beholden to many more stakeholders and will need to know when to cooperate and when to challenge. Managers must adjust their views on IP and recognize speed to market may require working efficiently with many diverse team players.

**Define: Freelance R&D**

Innovation resources continue to be located outside R&D or even company boundaries. Participants see the rise of freelance R&D professionals as the global war for talent increases the options of a technically trained and experienced workforce. Technologies such as a virtualized workforce, labs, and simulation will increase the abilities of individual researchers to perform highly complex research without the need of corporate infrastructure. Participants see all of these trends combining to produce a large cadre of freelance R&D professionals who work on temporary projects anywhere in the world. These individuals may be added to internal teams or form with other temporary workers to perform specific research. After the project is done they may move on to other companies or find new projects for the current client.

For researchers, this model provides flexibility to work on topics they love without the bureaucracy they do not. They will need to develop skills to quickly engage in projects and work independently over virtual connections. Technology managers will become the equivalent of Hollywood producers, finding and hiring a research team for each project like producers do for each movie. A comfort with contracting temporary workers, especially on payments, IP, and non-disclosure will be a critical tool for success.

**Define: Challenges to Intellectual Property (IP)**

Interviewees mentioned several challenges to intellectual property protection that will grow to significantly impact future decision-making, mostly driven by globalization.

As more companies around the world file for IP protections, the number and complexity of applications will overwhelm patent offices. This will cause a large delay, even more so than today, in the granting of patents. Globalization will speed up the competitiveness of markets, reducing the time companies can benefit from patents. By the time patents will be granted the customers will have moved on to new products and technologies. In emerging markets patents may afford little protection against infringement by local competitors, reducing the value of revealing innovation in patent filings.

Participants suggested their companies will file less patents, counting instead on trade secrets and know how to get to market first and capitalize on innovation before customers’ needs and wants shift again. Importantly, interviewees from pharmaceuticals and applied chemical industries, where foundational molecules or new materials could have very long lives in the market, indicated a need to continue investing in IP protections well into the future. These participants suggested hope that signs were pointing toward better enforcement of patents globally, as more nations recognize the critical role they play in innovation.

**CONCLUSION**

Later steps in the IRI2038 project will integrate trends from the Futures Audit and Weak Signals Report to develop future scenarios for research and technology management. Through the course of Audit interviews a collectively held view of the future of research and technology management did surface. While shared broadly, it represents a very different environment for the researcher and technology manager in 2038.

**Bigger Capacity**

Technology tools and business models will dramatically increase the capacity of the individual researcher. From access to supercomputing on demand in the cloud, to inex-
pensive high definition video conferencing, researchers and managers will be able to do an incredible amount of work in any location around the world. Simulation, expert systems, and robotics will also play a role to augment the future speed and effectiveness of the individual.

**Bigger Teams**

Research and technology managers will increasingly be participating in temporary projects composed of representatives of the entire product or service ecosystem, some of whom will not be human. Open innovation, the war for R&D talent, and the rise of freelance R&D will mean that research teams will form from across a product or industry ecosystem to identify and solve future consumer needs. As these projects move faster from idea to market, research and technology managers will often be forming and reforming new teams, to meet needs or manage difficulties of retaining talent long-term. Internal R&D departments will rely on corporate knowledge management systems to provide continuity of know-how and experience over time. These expert systems may evolve into intelligent agents able to participate fully in research teams, adding to the diverse global human members that managers will need to support, motivate, and lead.

**Bigger Targets**

These projects will often be trying to solve bigger problems affecting the entire ecosystem or global society. The complexity of future global markets will mean that the greatest leverage for value creation will be found in solving system-wide inefficiencies. Just as iTunes broke open the digital market for songs by solving many issues across the value chain, research and technology managers will be working in these temporary teams trying to solve very big problems. Some of these problems will ascend the industry, when companies look to create value for sustainability and resource constraints that will threaten the continued growth of the global economy. This future requirement to work on system-wide solutions will counter the current trend of companies focusing on more incremental rather than transformational innovation.

The next stage of the IRI2038 foresight project is to take many of these trends and insights and extrapolate them into the future to understand their impacts on the art and practice of research and technology management. These impacts will be integrated into several scenarios with the help of IRI members and delivered in May of 2013.
APPENDIX A: INTERVIEW PROTOCOL

Interviewee background

1. Can you briefly describe your current role?
2. How long have you been in the research field?

Historical and current view

3. Looking back on your experience, what are some of the major changes in the field since you began? These could include technology advances, regulatory changes, changes in the workforce or business use of research and technology.
4. What do you see as forces at work changing how you work right now?

Future Forces

5. Looking ahead, what technologies will impact the field of research and technology management?
   a. How will that change what you do or how you work?
6. How do you see globalization evolving and how might it impact research and technology management?
7. Do you foresee any changes in the regulatory or intellectual property arenas?
8. Any other major forces of change you think might arise in the future that will impact your work?
9. What about how people work and the nature of the workforce?

Opportunities, Threats, and Surprises

10. What trend do you see as the biggest opportunity for you to do your job better in the future?
11. What trend is the biggest threat to you to be able to be effective in your job?
12. What would surprise you the most to see actually impact the field of research and technology management?

2038 Vision

13. You’ve just come into work on a Monday morning in 2038. Tell me a story about what you’re doing, how you are doing it, and where you might be doing it....

Wrap-up

14. Are there others within your company that would be interested in participating in this project or to receive updates on progress? Appendix B: Futures Audit Participants
# APPENDIX B: FUTURES AUDIT PARTICIPANTS

Companies with leaders who participated in this study and their demographic information:

<table>
<thead>
<tr>
<th>Company</th>
<th>Industry</th>
<th>Channel</th>
<th>HQ Location</th>
<th>R&amp;D Location</th>
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APPENDIX C: ALL TRENDS MENTIONED BY PARTICIPANTS

Past
• Big data analysis
• Fear of science
• Miniaturization
• Video conferencing
• Computation
• Internet
• From transformational to incremental
• Increased regulation
• Open innovation
• Globalization of R&D

Present
• Social media
• Technology Convergence
• Intelligent systems
• Biomimicry
• Aging Population
• Energy costs and storage
• Patent Office jam
• Portfolio Management
• Urbanization
• Global cohorts
• Shift from industrial to service
• Innovation everyone’s job
• Connected World
• Personalization
• Sensors
• Rising Global standard of living
• R&D for organic growth
• Prototyping
• Big data analysis
• Consumer research
• Tech savvy mobile workforce
• Shortage of technical workforce
• Shift of global R&D to Asia
• Project speed
• Technology integrated into strategy and business plan

Future
• Genomics
• Biofuels
• Sea level rise
• Tissue engineering
• New global currency
• Value of diversity
• Speech recognition
• China falls apart
• Global warming tipping point
• Bureaucracy
• Resource shortages change balance of power
• Capital for organic growth
• Cross-discipline research
• Embedded communications
• Population Growth
• Modular hardware
• Cloud-based research
• China Obey’s IP protections
• Rise of Africa
• Limits to Information infrastructure
• Sensors
• Cybernetics
• Rising global standard of living
• Pure research R&D companies
• Accelerated learning
• Biomimicry
• AI
• Energy costs and storage
• Work/Life balance blurs
• Reverse innovation
• Energy breakthrough
• Social media
• Aging population
• Population growth
• 3D printing
• World’s problems create opportunities for research to solve
• Intelligent systems
• Global war for talent
• Biotech and Nanotech
• Resource Scarcity
• Less company loyalty and more freelance
• Robotics
• F2F still required
• Challenges to IP protection
• Simulation
• Global warming/sustainability
• Collaboration
• Automation
• Virtual Work and Labs