Preferred citation: J.D. Wright. The Future of Paper: plus ça change ..... – Prepared contribution. In **The Fundametals of Papermaking Materials**, *Trans. of the XIth Fund. Res. Symp. Cambridge, 1997*, (C.F. Baker, ed.), pp 1397–1424, FRC, Manchester, 2018. DOI: 10.15376/frc.1997.2.1397.

The Future of Paper: *plus ça change .....*

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Mr. Chairman, Members of the Organizing Committee, Ladies and Gentlemen. It is with great honour and pleasure that I accepted the invitation to open this 11th Fundamental Research Symposium in Cambridge. It brings me back to a university where I spent four extraordinary years as a student. The challenge to present an address to this organization with its remarkable history of keynote speakers was truly awesome.

Introduction

"Tradition has it that in 105, T'sai Lun first presented a sheet of paper to the Chinese Emperor as a substitute writing surface instead of silk or other cloth which had been used up to that time."[1] — a communications paper. By the fifteenth century we also saw paper used as a wrapping substance[2] — packaging. Even recycling started very early since a reference was made to wallpaper in about 1481.[3] It was habitually made from paper which had been used for books that had not sold, or were offensive to the political and religious leaders of the time.[4] Paper was reportedly used for sanitary purposes during the 9th century[5] — a consumer product. One of the first weekly newspapers, *Avisa Relation*, was published in

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[1] Hills, Richard L., 1988, p. 3, *Papermaking in Britain 1488 - 1988*, Athlone Press, London

[2] Ibid, p. 2

[3] Ibid, p. 81

[4] Ibid, p. 81

[5] Rennel, Jan, assisted by Aurell, Ron and Paulapuro, Hannu, 1984, p 33, *Future of Paper in a the Telematic World*, Jaakko Pöyry Oy 1984, Helsinki

Strasbourg in 1609,[6] newspapers first appeared in Britain in 1622, and a newsprint sheet made from mechanical pulp, was invented in Germany in 1840[7] — newsprint. It is not my intention in this presentation to review the history of paper, since that has been done in many well-known references. But, the four types of paper mentioned in these examples cover major product groupings that are still common today. If one looks at the range of products currently available there are about 457 paper grades in the marketplace in two broad categories, paper and paperboard. The split between these two is 55% and 45%, respectively.[8]

The age of our industry, and the fact that paper in so many forms is everywhere — indeed its very presence is ubiquitous — leads to some fascinating observations. As you read this presentation, you may be inclined to jot down your reactions through annotations in the margins. When was the last time you read an instruction manual on how to use pen and paper for this purpose? A.J. Sellon observes[9] that "for many years the paperless office has been held out as the goal for organizations," and "paper has obdurately remained a conspicuous fact in organization life." She says that, "Beyond all this, paper is an awkward subject to investigate since it is a symbol of the uninteresting past, not the exciting future."

Much has been written about the electronics age in which one purportedly can envision a future without paper. Most of these references seem to refer to paper on which one captures words or images, and hence may primarily refer to what we define as communications papers. However, it seems more positive to think of synergies between the electronics technologies and the paper world which are likely to coexist for some considerable time into the future. An intriguing example of this is described by The Institute for the Future in which marketplace information is sought through the power of the Internet. Having narrowed

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[6] Ibid, p. 34

[7] Hills, Richard L., 1988, p. 47

[8] IPP 1994, *International Pulp and Paper Directory*, Pulp and Paper International, Millar Freeman, San Francisco, CA

[9] Sellon, A.J. and Harper, R.H.R., 1997, Paper as an Analytic Resource for the Design of new Technologies, Proceedings of the CHI '97, Atlanta, GA

down one's search, for a particular automobile, for example, one receives from the manufacturer glossy brochures printed in full colour on high quality paper.[10] One can consider electronically, comparative pricing from potential suppliers over the Internet, but one may well wish to use more traditional media prior to making major investment decisions.

Where do we stand as an industry in the eyes of those who observe the innovations that drive our modern day economies? Utterback[11] writes eloquently about the history of innovation over the past 150 years, primarily from an American perspective. There is only passing reference to the process side of the pulp and paper industry, although a number of major breakthroughs which have had influence are described. Although he does not go as far as many authors, Utterback leaves the door open for technology to replace paper by some as yet unidentified technology breakthroughs. Negroponte[12] is more clear in arguing that paper will not be a part of the long-term future for information technology. In an earlier work, Foster[13] describes with some relish a visit to a paper mill in Alabama, where he saw an old mill, largely manually operated including its record keeping, alongside a new mill with banks of computer screens and no paper records in sight. He asked the mill manager, based on this observation, whether he thought that paper would be replaced by electronics. The reply was that "... this would never happen. Paper was too much a part of our lives. We needed to feel it and touch it. Without it we could lose the feeling of security, of possession that paper confers." Foster's comments were interesting. He felt "... as though I was talking to the captain of the Thomas Lawson. This manager didn't understand that the limits of printing on paper as a technology for conveying information were not far away and that electronic technology would soon be able to convey information more effectively and cheaply." The fascinating

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[10] Institute for the Future, p. 139, *1997 Ten-Year Forecast*, Corporate Associates Program Stanford, CA

[11] Utterback, James M., 1994, *Mastering the Dynamics of Innovation*, Harvard Business School Press, Cambridge, MA

[12] Negroponte, Nicholas, 1995, *Being Digital*, Alfred A. Knopf, New York, NY

[13] Foster, Richard, 1986, p. 33-34, *Innovation, the Attacker's Advantage*, McKinsey and Company, Summit Books, New York, NY

point to me is that all these authors seem to have a compelling need to write books on their theories and observations — on paper!

These various comments, plus the challenge from the Symposium organizing committee to present my own perspective on the future of paper, raised many questions in my mind. Where is the state-of-the-art in paper science and technology? What is happening as a result of new technologies, especially those from the world of electronics and information technology? What are the forces that will change or affect our industry? Are we like other industries? Which ones? Why? Will our industry disappear? Are we a sunset industry? Why will it survive? What are the challenges for the research community? This list of questions could very easily be expanded.

How does one discuss such a broad set of issues? With such a long and rich history, one can see enormous changes over nearly 20 centuries, and some underlying themes. First, *innovation* comes to mind. Hundreds of years of invention both in products and processes have led us to the present day. In response to opportunities, challenges and outside threats, generations of scientists, engineers, entrepreneurs, and businessmen have delivered new capabilities to meet the increasing demands for our products.

Change, or the impression of change, is another important unifying factor. But what is new? Perhaps the most powerful observation that one can make, and on which much has been written, is that the *pace of change* is accelerating.

These ideas of *innovation*, *change* and the *pace of change* will provide the framework for my observations about our industry, and the forces that play on the future directions of this long-standing supplier of products to the world. Experience has taught me that close coupling of business and technology factors will be critical for survival, and my analysis will include many different ideas, and I hope many questions will be raised.

Innovation — Where to Begin?

Innovation has played a critical role throughout the history of paper and paper products. These have been described in many references and histories of our technological and marketplace developments. Rather than try to repeat what has already been done so well, I want to focus on some areas where innovative new products have had major impact on our industry. I will not go back as far as Gutenberg!

A View of Office Technology Discontinuities

Because of the popular view that ultimately we will move towards the "paperless office" it is fascinating to look at a few of the significant office innovations of the past decades. Utterback[14] describes the invention and first commercial availability of the typewriter through the story of Samuel Clemens (Mark Twain). He was so impressed with the ability of the sales clerk to type 57 words per minute that he bought a machine. His letter to his brother describing it said, "TRYING TO GET THE HANG OF THIS NEW FANGLED MACHINE...[it] COSTS 125 DOLLARS. THE MACHINE HAS SEVERAL VIRTUES. I BELIEVE IT WILL PRINT FASTER THAN I CAN WRITE...IT PILES AN AWFUL STACK OF WORDS ON A PAGE." Perhaps the speed of writing or printing, was what seemed to be offered by this new technology, but the anecdote carries a powerful message that new technologies bring steep learning curves.

The development of the typewriter led to early word processors. The next pivotal office innovation was the invention of xerography by Chester Carlson in 1937 and its commercialization in 1959.[15] Xerography revolutionized the making of office copies, and essentially eliminated the need for carbon paper. Office paper usage grew at an astounding rate. Today Xerox is one of the largest distributors of cut-sheet paper in the world.

Laser printing was invented by Xerox in the mid 1970s, and subsequent developments in electronic imaging and printing represent another major milepost in office technology. These, combined with personal computers and powerful word processors continue the revolution. The concluding comments in Utterback's story of the typewriter are interesting.[16] "As a means of putting words on paper, the new computer technology represented a great advance over the crude mechanical instrument that Samuel Clemens .... encountered in 1874. A safe bet is that it will be displaced by something better in the future ... ." These very significant

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[14] Utterback, James M., 1994, p. 1-2, *Mastering the Dynamics of Innovation*, Harvard Business School Press, Cambridge, MA

[15] Dessauer, John H., 1971, *My Years With Xerox: The Billions Nobody Wanted*, Double Day, New York, NY

[16] Utterback 1994, p. 17

discontinuities have focussed on the way in which we put marks on paper, but not the fact that we seem to have an innate desire, or need, to use the paper.

Paper has traditionally been viewed as an archival medium. Properly stored, alkaline paper can last for hundreds of years. What electronic technology have we seen that easily reads documents created only a few years ago? Have you ever tried to open an early WordPerfect™ document with the current software? Can you retrieve, read, manipulate electronic documents that you created ten years ago? Where are they? I have paper files from 30-40 years ago but I certainly do not have an electronic document more than (optimistically) ten years old! The issue of storage ties closely to archival functions with an attribute of paper as an enduring medium. It is extraordinarily difficult to use old records retained on any other medium. Since magnetic media are not as durable as paper, and must be renewed approximately every ten years, and the software and systems to read it are even more volatile, this challenge becomes far more than a nuisance issue. It raises the whole question of librarian stewardship of information. A formal recommendation has now been accepted by the Council on Library Resources in the United States from the Commission on Preservation and Access[17] that updates become a formal responsibility of librarians.

One frequently reads about predictions of large declines in the use of paper for office functions. Certainly, the Internet and the World Wide Web with all the attendant technologies will have an impact, but what it will be is impossible to predict.

A View of Discontinuities in Major Industries

The evolution of an industry, beginning with an invention follows well-established patterns. The S-curve theory is one way of defining it. The first product often generates tremendous innovation from other inventors or potential suppliers of the new function. There is usually a period of intense invention of product attributes, refinements, and features which lead to increased competition for the new product. Companies grow, some survive, and some die, with variations depending upon the degree of protection of intellectual property that they have established.

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[17] Commission on Preservation and Access Newsletter, 1996, n. 85-94, Washington, D.C.

Later in the cycle, innovative companies focus on process improvements to increase their productivity or lower their costs. Some evolve as specialized niche market suppliers, with little potential for growth. Eventually, for products which may have utility on a world-wide basis, only a few large companies survive, and typically they will each have a significant percentage of the market share. In the pulp and paper industry, perhaps the integrated machinery suppliers provide an example of production equipment, and photographic papermakers an example of product. Is it likely, I ask you, that these forces will drive the paper industry to massive world-wide consolidation?

Finally, some industries disappear altogether because their products have been displaced by fresh innovations. Utterback, Foster and others who write on innovation touch on many examples that follow this pattern. Sailing ships have disappeared in favour of steam; ice as a refrigerant has largely disappeared. The original utilitarian purpose has been replaced by luxury or leisure-time niche market applications. Steam-driven locomotives have been replaced by diesel electric engines. Radial ply tires have replaced bias ply tires. How do we consider our industry in light of the changes implied by these examples? In most cases, the ultimate function has not changed, just the means by which it is delivered. Therefore, can we infer that paper will not change, or that it will not be replaced?

Where is Paper Science and Technology?

What can we possibly say about what is unknown in an industry that has existed and thrived for centuries? Where are we on that S-curve of paper science and technology? If we drew an S-curve or families of S-curves starting with the invention of paper, what would be the significant milestones and what would be radical discontinuities? Where are the areas of opportunity that provide options to leap to new S-curves? Surely they will include more than just the processes. Perhaps they will include designer fibres; unique combinations of fibres and composites; new linkages to printing and the distribution of printed documents, and to purveyors of information as a currency for ideas; limitless opportunities for communicating packages and consumer products — not to mention other totally different uses for paper products.

In his keynote lecture at the 1965 Fundamental Research Symposium, Professor C. Cherry speculated[18] that the paper and board industry was somewhere on the straight part of the sigmoid curve. His question at that time was "whither? Up, across, or down?" He highlighted the threats from radio, television, computers, etc., and identified many questions on recycling, packaging, and the physical properties of paper products. He even touched on some changes arising from the advertising world which he thought were unnecessarily showy and elaborate on packaging! If we were truly on the straight part of the S-curve then, where are we now in paper science and technology, after more than 30 years?

From my own view of this industry I tried to identify major product innovations over the past three decades. Certainly, in the broad product categories, there does not seem to be a sea-change in the list of innovative new products. The most significant from our perspective may be the development of thermo-mechanical pulp (TMP) and its use as 100% of the furnish in newsprint. It replaced groundwood pulp to make newsprint, removing the requirement to include sulphite pulp for strength, and it also enabled the use of chips and sawmill residues, replacing logs as the sole source of raw material. From a customer point of view, however, it is unlikely that this was seen as a new product, either by printers, or by readers of newspapers. When it comes to products, the list of breakthrough ideas is more limited. Foster[19] mentions the Proctor and Gamble development of Pampers™ which he says captured 35% of the 1985 market and accounted for 20% of Proctor and Gamble sales. Utterback[20] highlights Tetrapak™, an innovation for asceptic packaging, which when used with flash sterilization, removes the need for refrigeration of milk and fruit juices. The 3M. company tapped into the natural propensity we all have for writing thoughts on small pieces of paper when they invented Post-it Notes™ as a result of a development of a non-sticky

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[18] Cherry, C., 1965, pp. 1-10, The Humanity of Paper, *Consolidation of the Paper Web*, Edited by the Francis Bolam, Technical Association of the British Paper and Board Makers' Association, London, U.K.

[19] Foster, Richard, 1986, p. 38

[20] Utterback 1994, p. 146

glue for which there were no apparent or obvious uses.[21] From a different perspective we can also look at examples of products which were replaced by innovations, and which then reappear in new applications. For example, I am indebted to one of my colleagues for educating me about glassine. It was once used for such things as transparent envelope windows, bread-wrappings, and potato chip ("crisps" in the U.K.) bags. Having virtually disappeared it now finds major use as a component of the releasable backing papers for label technology, and has come back as recyclable windows in envelopes.

Clearly, there have been relentless improvements in the quality of paper products, and in the cost, quality, and speed of production processes. Again looking back only about three decades, my colleagues have mentioned some major process innovations. Twin-wire forming made possible almost a doubling of the speed of paper production, and new quality levels in sheet structure and formation. In the short term, the industry predicts process changes that will result in speed increases ranging from 18-23% for production of newsprint, tissue, fine papers, and linerboard from 1995 to 2000.[22] Bleaching technologies, including chlorine dioxide bleaching, chlorine-free bleaching, and a whole set of alternative strategies addressed both quality and significant environmental issues. Utterback[23] describes this example too, it being one of the few references to pulp and paper technologies in the general innovation literature. Another example is crown-compensated or variable-adjustment crown rolls, which enable much more flexible operation of the paper machine, as well as substantially wider webs. Finally, the range of on-line sensors, coupled with sophisticated control systems has had enormous impact. It is obvious that, incremental innovation integrated over time (in contrast with radical innovation),[24] can have overwhelming significance in reducing pulp and paper process costs and improving product quality.

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[21] Nayak, P. Ranganath and Ketteringham, John M., 1986, pp. 50-73, *Breakthroughs*, Arthur D. Little, Rawson Associates, New York, NY

[22] Pöyry, Jakko, Laine, Jakko E. And Jakko Pöyry Group, 1995, Jakko Pöyry Client Magazine

[23] Utterback, 1994, p. 133

[24] Ibid, p. 134

Change (plus ça change)

How has change — as distinct from innovation — affected our industry? Is it possible to make predictions about how change will affect it in the future?

Research, Management of Research, and Business

The traditional model of research has focussed on observation and literature searches, followed by hypotheses, and further research work and development: this in turn leading to publication of results and practical ends. The scientific research paradigm for many years has been to carry out the research, and then to write papers and patents. Is it going to be this way in the future? Will it change? If so, how? Dr. H.F. Rance, in his opening address to the 1977 Oxford Symposium,[25] argued eloquently in support of fundamental research which, he maintained, was critically important in order to make technological progress, and was distinct from academic research, which he said is "work carried out in cloistered seclusion, remote from the real world and in no way related to practical application." Industrial research requires solutions for some very difficult technical issues, setting the scene for conflict between business-oriented goals, and the traditional academic research goals. An example of this in our industry is that relatively little research has focussed on wet-end chemistry. This is a very complex problem with huge numbers of variables. To find solutions which will be necessary, and even of crucial importance, for closure of the systems in our manufacturing processes, both academic and industrial research work will need to be done.

Apart from the type of research, and the challenge as to whether fundamental research should or should not be carried out in industry as well as in the universities, there is the question of the effective composition of the research groups. My belief is that the best work, especially from an industrial point of view, comes from teams in which both fundamental and applied research are carried out. The presence of researchers who are keenly interested in fundamentals, challenges those who seek to innovate only from a practical perspective, leading to an understanding of the fundamentals of what is occurring. Similarly, the presence of applied researchers in a fundamental group often heightens the insight by showing that

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[25] Rance, H.F., 1977, pp. 2-7, Twenty Years On, *Fibre-Water Interactions in Papermaking*, Edited by the Fundamental Research Committee, Technical Division, The British Paper and Board Industry Federation, London, U.K.

something can be done without full understanding of basic mechanisms. The synergies of having the two types of research operating together are far more powerful than either is alone.

The real question is — how do we organize for creativity? It is *de rigueur* that we are expected to do more with fewer resources, and quicker, better, and cheaper. Speed is critical. The academic model of curiosity-driven research, despite its long history of producing serendipitous results, is inefficient. It is unlikely to endure unalloyed in tomorrow's speed-driven world. There is no doubt in my mind that universities will survive, but will there be generous support for the research programs? Emphatically, I believe the answer is yes. However, the reason may well be that universities, starved for funding, will adapt their research programmes to be more in line with industry requirements, and thus attract increasing revenues from this valuable source. Since we are in Cambridge, perhaps I might venture a further question: will Oxford, Cambridge, and their counterparts around the world, be able to escape this funding reality? How do we connect academic research, and also industrial research to the outside world, the world of our ultimate customers? Knowledge is "free" today. The value is in how one uses it.

The pulp and paper industry has often been focussed inwardly, at times ignoring advances in other fields. One important point relates to the power of synchronicity. How do we bring together related ideas and concepts efficiently? How do they get joined in different ways? Survival against threats from new alternatives needs ideas that are discontinuities or trend-breakers, that can move the industry from a current S-curve to a new base. Of importance to us is the fact that these ideas are often obtained outside one's conventional community. Paprican used a variant of the synchronicity idea by proposing, as part of the Canadian Mechanical Woodpulps Network of Centres of Excellence, a challenge to the academic community for solutions to the yellowing problem in newsprint made with mechanical pulps. For years, the problem remained unsolved within the pulp and paper research community, but by bringing in new skills — from organic- and photo-chemists — the mechanisms for this long-standing problem were understood, and this has opened doors for solutions.

Research management has changed radically over the decades from the hey-day of benevolent corporate research and development (R&D) spending typified by the early investments of AT&T Bell Labs, IBM, General Electric, Xerox, and many others. There are also pulp and paper industry examples of research laboratories where much fundamental and innovative research was carried out. I am less familiar with these but would offer the opinion that they

did not generate the same level of widespread international acclaim. From the early days, strategies have evolved: from technology as an asset produced (serendipitously) through R&D in isolation [*1st Generation*]; to links to business, and then technology/business integration [*2nd and 3rd Generation*]; from customers as an asset with strategic linkage to customer R&D [*4th Generation*]; and finally now extrapolated to knowledge as an asset and fully collaborative innovation systems [*5th Generation*]. The ideas lead to new concepts of a virtual R&D environment which may be critical for the survival of businesses or business enterprises dependent on new ideas to satisfy their customers and maintain their markets. These ideas are well documented by Rogers.[26] She states "In short, the rules have changed. The stage is set for a more integral role for research in sustaining profitable growth for a corporation, large or small, and the economic well-being of a nation or society." We are at the point where we must be concerned about strategically-driven research versus pure curiosity-driven academic research. I believe that it is easily possible to provide some gentle guidelines or directions to scientists so that the results of their free-thinking may actually contribute to a goal or mission of an organization. Further, entering the next millenium, we as scientists, should be concerned that these changes are understood. Either we will see some new ways of doing something in papermaking that has hithertofore been "impossible," or we may contribute to new product ideas which bring exciting value to customers. If we do not, we may reasonably expect that the support for basic or fundamental research will dwindle.

A brief look at changes in the world of business is appropriate. The simplest observation is that the world is shrinking and that businesses are becoming structures that can address global competition. This applies in particular to highly capital-intensive industries such as our own. I was fascinated to read recently[27] about a decision by British Steel to move a complete steel mill, piece by piece, from Hunterston, Scotland, to Alabama. The driving force was to move the source of manufacturing closer to the customer — in this case to address opportunities created by the wave of new investments by world-wide automotive companies in the southern United States. If steel mills move this way, why not paper mills?

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[26] Rogers, Debra M. Amidon, 1996, pp. 33-41, July/August Research Technology Management

[27] Wall Street Journal, Vol. CCXXX, No. 40, August 26, 1997, Steelmakers Scramble to Globalize

Utterback discusses business models from a different perspective.[28] In the evolution from a *fluid phase* of innovation, the beginnings of an industry are traced, through the *transitional phase* focussed on process changes with many competitors "but declining in numbers after emergence of dominant designs," to the final *specific phase*. In this latter state innovation is at best incremental for products and with cumulative improvements in productivity and quality; products are mostly undifferentiated and standard; production is capital intensive and rigid in large-scale plants; there are few competitors in a classic oligopoly with stable market shares; and the vulnerability is to technological innovations that present superior product substitutes. Does this portend massive consolidation in our industry on a world-wide basis, and condemn us to radical incrementalism as the most optimistic view of our research opportunities?

Markets, Advertising, and Consumers

Markets and marketing have changed enormously over the past decades. I will reflect a developed world perspective here; but opportunities for our industry to address the potentially emerging markets are there as developing countries advance their economies. Projections of growth rates for paper products are inevitably higher in those areas, compared with developed countries.

Fascinating books by Davis[29], Negroponte,[30] and Dertouzos[31] describe in vivid detail concepts such as mass customization, products moving from physical mass (atoms) to bits transmitted instantaneously, to virtual reality replacing travel and experiences. Negroponte, in particular, frequently refers to "newspapers" as a surrogate for atoms, but he still endorses the idea that the attributes of paper such as, feel, smell, large format, etc., are important. He also uses the metaphor of a newspaper to discuss his ideas on the display of information.[32]

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[28] Utterback, James M., 1994, pp. 79-102

[29] Davis, Stanley M., 1987, *Future Perfect*, Addison Wesley

[30] Negroponte, 1995

[31] Dertouzos, Michael, 1997, *What Will Be*, HarperEdge, New York, NY

[32] Negroponte, 1995, p. 188

While we may choose to accept these authors' predictions with some skepticism, the forces are relentless. Whatever the future holds, consumers are increasingly demanding and ever more discriminating. Quality, or perhaps more accurately the quality/cost ratio, increases relentlessly. Customer satisfaction is paramount. But there is a dichotomy between atoms and bits. One of my favourite examples is *Wired Magazine*, which despite the creators' initial intent that its contents be read electronically, finds a large customer base (including the computer whiz group) which delights in reading the paper version, printed on very high quality paper by a state-of-the-art 7-colour printing press!

Newspapers generally publish localized advertising supplements which can be customized down to the level of postal code areas within an urban community. Use of colour, targeted ads, special supplements in weekly newspapers, etc., are all evolving. Personalized ads frequently now appear in magazines. By contrast to conventional mass marketing techniques — the return rate from Publisher's Clearing House is less than 1% — Moore research has shown, using printers from Xeikon and Indigo, that magazines with profiled ads tailored to an individual's interests can be very hot sellers. Advertising touches almost 50% of the total production of paper products. How trends in the advertising industry develop will be critical for the consumer markets of the future. How will we change to follow these forces? How will paper maintain its major role?

The strong interplay of paper with marketing will continue. Recall, for example, the anecdote from the Institute for the Future of the car details first explored over the Internet, being followed by high quality glossy prints sent directly to the customer. Suppose one goes into a car dealership, defines the ideal car, and the salesman (who may not have such a car in stock) produces and sends to you personalized printed brochures, showing you sitting in your ideal vehicle with colour and options of choice. Would this not be enticing?

What do we do in our industry to adapt to the trends that are so evident in the marketplace? How do we reach out to our customers? How do we provide recognized value when so many of our products are only the input material, the carrier for the products that reach the ultimate customers. How will we organize to follow trends, particularly in advertising? Major publishers sell information; the product may be packaged in books or magazines, but

the substrate is paper. This point was made emphatically by Nehm[33] who also raised the connection by consumers of Springer Verlag information products, to the environment, through the substrate, paper! How will we change to meet these new customer needs?

The Pulp and Paper Industry

Typically, return on investment for the pulp and paper industry is abysmal. We seem to face the perennial inability to return the cost of capital. How can a highly capital-intensive industry survive under these conditions? Capital performance may well be the new discriminator. There are examples where process innovations in our industry result in higher quality at lower costs, and at significantly higher efficiencies. Not only can the capital costs be reduced, but operating costs can also be significantly lower. We may find that machine concepts will be developed by the "outside" community which, unconstrained by conventional wisdom, may make possible things that have been discounted by the "experts."

What will have to happen to the industry or its markets to change its performance? Consolidation may be one solution. Will we follow the examples set by "big oil" and "big auto"? It is significant that no integrated producer of pulp and paper in the world has much more than about 3% total market share. It is true that for selected product categories, some of the largest suppliers have a higher share. Abitibi-Consolidated, for example, in 1997 may have as much as 11% of the world-wide share of the newsprint markets.[34] In other industries, major suppliers dominate world markets, e.g., Boeing, Microsoft. If we follow other trends, some companies will stay as small niche market specialists, but overall, consolidation is inevitable. This will create a new landscape for looking at the quality/cost ratio. What will be the impact on sales and marketing of our products? What effects will this have on research investments?

What will happen in emerging markets, especially those of the Asian marketplace? How will new production capability in Indonesia and elsewhere affect our western markets? Will

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[33] Nehm, F., 1996, Environmental Credibility of the Paper Chain, European Conference on Pulp and Paper Research, Stockholm, Sweden

[34] Pulp and Paper Week, 1997, p. 7, Vol. 19, N0. 21, Abitibi-Stone Merger Easily Wins Approval: New Publication Papers Heavyweight, Pulp and Paper Week, Miller Freeman

plantation technology displace our natural forest resources? An idea, which could be interpreted as moving to new S-curves from a business perspective, comes from a new generation of non-traditional pulp and paper executives from Korea, China, and the Far East. They make decisions to invest billions of dollars for new pulp and paper mills in Indonesia. They do not seem to care that established industry executives are struggling with the problem of returning the cost of capital. Nor are they driven by quarterly Wall Street measures of performance, or by big pension fund or institutional investors — including those who play the cyclical nature of the pulp and paper commodity industry.

A discussion of change in our industry would be incomplete without a mention of the current growth projections. Jaakko Pöyry[35] expects newsprint to grow 2.4% per year from 1994 to 2010, and uncoated woodfree is expected to grow 3.6% per year in the same time frame. In 1994 newsprint held 12% of the total market and uncoated woodfree held 15%. Irrespective of threats from the information technology world, these are still large numbers, given the volumes of production.

Often our industry is viewed in total as a supplier of commodities. This may well be true for traditional market pulps and communications papers. However, specialties are very innovative and very competitive. Examples include laminates, non-wovens, industrial papers, some packaging, many consumer products, etc. A concern has been expressed in recent times that fibre supply will be an ever-increasing issue. What would be the effects of this constraint on our industry? Will the industry be forced to move to higher value-added (more profitable) uses of an increasingly valuable raw material? If so what changes will be required of our research community? My own belief is that if fibre supply really becomes a severe restriction, the creativity within our industry would solve the problems of how to use alternative sources of fibre to supply our customers with the valuable products they demand. For fibre supply and new product opportunity issues, we must not lose sight of the importance of volume in considering any possible changes. The biggest question is — in what directions should we be moving?

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[35] Jaakko Pöyry, 1997, Trends in Global Cost Competiveness, from a presentation at the Institute for Paper Science and Technology, Atlanta, GA

Change and the Pace of Change (ça va vite)

As we have seen, change is everywhere. What is also increasingly evident is that the pace of that change has accelerated far beyond levels predicted even a few years ago. Nowhere is this more true than in the newest of the major society-level revolutions — the Information Age.

Information Technology and Communications

Information technology and communications are changing with incredible speed. The compression of time to create and transmit ideas, new development tools, new ways of tapping and massaging information has led to current jargon couched in terms of "internet time." In a more derogatory sense, one hears of "dog time" — the compression of human life span to dog life spans for product cycles. I will not summarize in a paragraph or two the effects of all of the computer and communications or information technology developments we have seen over the past few years. Suffice it to say that in the computer and software industries, the product development cycles are incredibly short. Even in the computer processor business, which is capital intensive (of the order of $1B per fabrication plant, replaced about every two years), the cycles are short. Many books and references are available to describe these revolutionary technology-enabled functions.

I will address, instead, a few of the changes which touch our industry most closely. The 1984 Jaakko Pöyry review[36] on the Future of Paper does this in considerable detail. If anything, some of their predictions have already been exceeded by the electronics technologies, but overall the impact on paper has been much as they predicted. Their book presents some interesting S-curves[37] on the speed of communications, showing the percentage of news served within one day by various means, the percentage served within one hour, and finally the percentage served within one second.

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[36] Rempel, Jan, Aurell, Ron, and Paulapuro, Hannue, 1984, *Future of Paper in a the Telematic World*, Jaakko Pöyry Oy 1984, Helsinki

[37] Ibid, p. 44

In a more futuristic context, Negroponte[38] describes the changes from moving mass or material to moving bits of information. In the business of pulp and paper, as much as from customer demands, it is the speed of communications around the world that has forced the pace. Prices, ordering, the way in which our competitors respond, have been enormously affected. In general terms, many aspects of business operate at the speed of the fastest link, now literally seconds, anywhere in the world. Looking back to 1995, were the rapid rises in prices for our mainline products implemented by marketing executives steeped in old ways of communication. And were the customer responses a result of their speed of assessment of what the industry was doing? How we respond to an instantaneous order to deliver hundreds of tonnes of product around the world in any reasonable period opens many questions. Massive capital plants in some industries have given way to distributed plants to serve customers better such as mini-mills in the steel industry. Global companies, like those in the automobile industry, have distributed plants around the world for local manufacture. One might argue that we, too, are modelling our business this way.

In considering the extreme views of what information technologies might make possible, one scenario, counter to the common view, is that for a variety of social, political, and other reasons (pornography, security, etc.) the projected explosive growth of the Internet for commerce will not happen. The Internet would become the world's greatest source for high quality digital pre-press images, and this would be exploited by printing onto paper documents. In this scenario, paper wins because at present, it is undoubtedly the world's most cost-effective, high quality, display medium.

When it comes to putting ink on paper, the world of documents has changed enormously. Even in recent times, given advanced word processors and publishing software, we have moved from printing and publishing houses to the point where every author can also be a publisher. The emergence of a networked world has enabled a move from centralized to distributed printing — a paradigm shift in the way people use paper, or more specifically, produce and deliver paper-based documents. The insurance industry was one of the first to do this, delivering insurance policy documents to their customers from distributed printing bases. Discussion today of Web access for information in the home, with down-loading of desired information, is a major shift in who pays for the final documents. Conceptually,

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[38] Negroponte, 1995

information vendors extend the print-and-ship model to one where the individual user pays for prints including both toners or inks and paper.

Communication is greatly enhanced through the use of colour and "visual depth" dimensions. Thus the advent of low cost colour printing technologies has begun a trend to greater use of colour in everyday documents. Tufte[39] gives a rich description of the power of colour in communications. Many of the new digital colour printing technologies — and here I am not referring to digital pre-press — require special papers to be able to function. The best example is the Indigo technology which requires a specially coated paper to produce good colour images, and indeed, even to transfer the ELID™ toner to the paper. Other technologies also need special paper properties. By contrast, printers using lithography and other traditional technologies sell image quality by emphasizing paper quality. Inks are relative constants for each of these technologies. When, how, and how quickly, will we be able to produce a range of papers with performance qualities that will work with digital technologies at even close to the same level that we have for lithography?

Costs per page of colour-printed documents are plummeting. A year ago it cost $1 per page on a Xeikon press (both sides). Today the cost is 20 cents per page. The breakpoint for equivalent costs for full colour printed by these new technologies compared with offset, is now approaching 3000-4000 pages whereas it used to be between 500-1000 prints. Why would anyone buy a lithographic press for the short-run colour business? Early adapters are already using this technology. It will only be a short time before it is in common use.

We are now in the information technology age. Our industry has grown through the invention of the printing press and xerography, and through the incredible changes in society driven by the advances of the Industrial Revolution, to those of today's Information Age. The "time compression" has been quantified in a book by Makridakas[40] where he asserts that the Information Revolution is progressing about four times faster than the Industrial Revolution. What will be critical to help us adapt to the rapid changes? No doubt we all believe that our industry will adapt, and that we shall define some research and technology

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[39] Tufte, Edward, R. 1990, *Envisioning Information*, Graphics Press, Cheshire, CT

[40] Makridakas, Spyros G., 1990, p. 84, *Forecasting, Planning and Strategy for the 21st Century*, The Free Press, McMillan Inc., New York, NY

areas that will aid this process. First, however, it is important be confident of our survival, and here is some fresh thinking on that subject.

Why Paper Will Not Disappear

Much has been written about paper, and its many forms. As I stated earlier, paper is ubiquitous. The Canadian Pulp and Paper Association entitled its 1993 Annual Report "Paper: positively everywhere," which captures the spirit of this incredible material. The range and quantity of products for very different functions ensures that ours is not a single-application industry.

Communications papers, including newsprint, comprise about 45% of the marketplace, and there are many opinions about this segment. In 1986[41] it was stated that "The real threat to the graphic arts is an increase in illiteracy in the civilized, industrial world." People "who cannot even read road signs will not buy magazines or newspapers." It is worth saying that this group will be highly unlikely to buy or use computers, either.

Many people express the concern that paper is being replaced by "electronic documents" — the "paperless office" — or by the Internet and all its affiliated technologies. An article on the growth of paper consumption captures the opposite point of view.[42] It states that, "these statistics speak for the inertial and convenient bond between humans and paper as a cultural carrier and long-relished print substrate." A more balanced, long-term perspective might be to consider the synergies of paper with electronics technologies, and the complimentary products that are produced from those synergies. The proliferation of "how-to" books on computer technology has burgeoned in the past decade. We are now into the age of "instant books" to explain how to use the latest software or hardware systems. There are other examples describing new markets for childrens' books based on the characters from electronic games.[43] These never existed before. These growth markets are not really manifestations of addressing new customer needs, so much as they are a way of addressing

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[41] The Power of the Printed Word, Australasian Printer, 7, no. 11: 22-3, 25 (Dec-Jan 1986-87)

[42] Paperless Office is a Fiction, APR Allg. Pap.-Rundsch. 118, no.1:21 (January 5, 1994)

[43] Future Awareness Committee, Interview Documents, Paprican, 1996

new opportunities driven by an ever-increasing standard of living in our western society. Perhaps the parallel will be the actual availability of books in the developing world.

The "concept of a book as an item of enduring value, not as a primary source of information, but as an artifact" was described by Trier.[44] For years, all the books I ever bought had enduring value, even my engineering books where many new advances have made them less valuable than before. By contrast, the generation of computer help books is the first one to be viewed as "disposable books." I have pangs of conscience every time I throw out a book of this type. It seems so contrary to the idea of a book. Will we move to bi-modal uses of paper for printed materials? Should we consider those that are disposable or transitory, where paper must look good but need not be durable, and those which are for pleasure and interest, not transitory; where we like to touch and feel, and experience the pages, the book, the words and images, and, most of all, the ideas?

The Institute for the Future[45] talks about synergies through their example of (in)direct advertising where the advantages of direct mail are combined with those of the Internet. "Separately, direct marketing and Web-based marketing are ineffective and inefficient. The first is overkill; the second wishful thinking. The answer is a hybrid approach,....." and "customers can download images and text to their hearts' content, but the resolution of a glossy brochure and the design and tactile properties of high-end, paper-based materials should not be underestimated."

Counter-examples are the focussed efforts of many corporations to radically reduce paper use. Companies like Boeing have worked hard to replace their colossal sets of maintenance manuals, which are updated on a quarterly basis by moving to CD-ROM technology. Conceptually, helmets with vision systems connected to these electronic manuals can give detailed 3D information for maintenance operations. On the other hand, even at Boeing there are some interesting contradictions. Having designed the 777 entirely electronically, using sophisticated and powerful simulations and begun the test flights on a CAD-CAM designed and built plane, Boeing did not trust electronic media for archiving the results of their designs and thus printed a full set of design drawings on paper! This is consistent with the thoughts

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[44] Trier, George, 1996 pp. 13-28, International Pulp Bleaching Conference, TAPPI Proceedings

[45] Institute for the Future, 1997, pp. 137-139, *10 year Forecast 1997*

already expressed on how to access electronically-stored information from the past decade. One generally cannot do it! The paradox of companies like Hewlett Packard is intriguing. There is a corporate focus to reduce paper use in their business, but billions of dollars are made selling laser and ink jet printers.

Look too, at Moore Corporation. It is one of the world's largest suppliers of paper-based forms for the office. To accommodate the use of imaging technologies and electronic printing, the industry developed sophisticated versions of carbonless paper that would perform well with xerographic printers. Given the move towards electronic data exchange (EDI) and Internet/Intranet technologies, one could consider Moore's eventual demise synchronized with the rise of Jetform, the world's market leader in electronic forms technology. It is therefore fascinating to note that Moore is a 10% owner of Jetform.

A refreshingly different view of why paper is not likely to disappear is captured in the work of Sellon and Harper.[46] They are amongst those who are studying the attributes of paper from a behavioural perspective in contrast to the more traditional economic, technological, and market trends viewpoints. They examine a set of paper properties that they define as "affordances," a word taken from the psychological literature to mean the possibilities or opportunities for human interaction offered by the nature of an object or medium. The attributes reflect the real value of paper in "documents" or in the way that documents are developed, delivered, and used. There appears to be clear evidence that the designers of electronic systems to replace paper documents have not understood the value that paper brings. These authors speak of the clear separation of a reviewer's annotations on a text from the original; the collaborations which occur around a paper document that is easily viewed by a number of people working together. The ability one has to physically hand-deliver a document is significant, symbolizing its importance, its tangibility, its personal nature; its utility for editing, drafting and document creation; the author's ability to retain control over changes; and its physical embodiment generally. Some of these affordances are emulated, in part, by electronic systems, but the authors argue convincingly that it will be a long time, if ever, before the full set can be delivered by electronics technologies. Their conclusions are perhaps best captured by the realization that "because of the sheer complexity

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[46] Sellon, A.J. and Harper, R.H.R., 1997

of the problem, we predict that paper in support of some kinds of reading tasks will be one of the hardest paper-based tasks to shift to the digital domain."

One fascinating observation is the number of software packages that attempt to give electronic documents the attributes of paper. Examples are the software "post-it notes" (they appear as yellow notes on the screen), Hallmark™ electronic cards, Microsoft equivalents, the "paper" fluttering between images of file folders on the computer screen or disappearing into the image of a fax machine, images where multiple pages of paper on the screen give the impression of a book, and so on. People clearly feel comfortable with the concept of paper!

If one wants to look at the affordances of paper, it may be the case that the world of digital documents, or even the world of paper documents such as those referenced in the studies of International Monetary Fund by Sellon et al, is a relatively small fraction of the total market. Advertising, newspapers, consumer products, and packaging may be very big segments for a long time.

Finally, there have been many attempts over the years to replace paper with substitutes. Some, like plastic bags in the supermarket, have had a large effect. On the other hand, attempts to invent plastic paper are included in lists[47] of "Predictions That Did Not Materialize or Whose Importance Was Highly Overestimated."

Implications for the Research Community?

The discussion has touched on many aspects of factors that will have far-reaching effects on our industry. The pertinent question for a research audience is "what does this mean for us?" First and foremost, I think that we must recognize where we are on that S-curve of pulp and paper technology.

We should question whether the world of pulp and paper is anachronistic when it comes to ideas of market-driven innovation? How do very old and traditional industries play in, or survive in, the world of fast-paced innovation? We must recognize the challenge of quicker, better, cheaper. Non-wood products may replace wood products, cut sheet paper may be replaced by roll fed paper, chlorine dioxide bleached kraft may be superseded by wood-

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[47] Makridakas, Spyro G., 1990, p. 94

containing papers. Fibre quality is more critical in more demanding grades. Light-weighting exemplifies the current quality push across many grades and has a quality/cost focus. The Jaakko Pöyry Quality Index shows that some products need the very best fibres — the key question is how to engineer them.

Industry researchers are strong in understanding paper properties, but very weak in what we can, could, or should do with that understanding. Research is focussed on a technology that has reached a plateau. The research that is featured at this Cambridge Symposium is based on the assumption that paper is interesting, that paper is worthy of deep, on-going scientific study. I suggest that not only will it continue to be interesting, but we must meet the challenge to stretch paper beyond its current limits. Notions of real "stretch goals" may be important. How about "zero-defect products," miss-registration problems in printing presses, linting issues, inks that do not fix properly, etc.? For paper physicists, the biggest challenges may be for zero-defect paper, and for ordered rather than random fibre organization. Over and above the concept of defect-free paper, what are the implications of defects and fractures? The challenge is to address what it is that discourages paper use. For example, moisture reactivity is the bane of existence in ink jet printing. We need to take a materials engineering approach as did Tabor,[48] in his Cambridge Symposium address when he described friction and tribo-electric properties.

From an information technology point of view, I suggest that there are two distinct approaches in the style of research today. The first is where computers have had enormous impact on data acquisition; the atomic force microscope is one such instance. Experiments can now be done that were impossible to even contemplate ten years ago, and they produce incredible new insights and understanding. The second is where computers are used for complex simulations. At times the simulations seem to be more for the benefit of researchers than for real understanding of complex phenomena. More than two thirds of research seems to be moving in this direction. What must not be lost is the opportunity for strong connections between the two approaches!

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[48] Tabor David, 1981, pp. 3-17, Fashions in Scientific Research, *The Role of Fundamental Research in Paper Making*, Edited by James Brander, Mechanical Engineering Publications Limited, London, U.K.

The opportunities presented to us by envisioning new S-curves must not be lost. We must manage the whole paper cycle, not just parts of it. The emergence of rapid rotation fibres could give real consistency to the papermaking feedstock. This could solve the difficulties present by the variable furnish for our mills. The areas of printing and distribution are vitally important. Paper is one of the printer's biggest costs, and the margins are very small, and there will continue to be enormous efforts to cut costs. Information technology will be applied by our customers, and we need to be aware of its implications. Short print runs, just-in-time delivery, print-on-demand, etc., all rely on IT. The use of IT to make business processes more effective is the driver, not just that this is an alternative medium (to paper). The very high newsprint costs in late 1995 caused permanent changes to the paper markets. Broadsheet sizes were reduced, type was changed, content was seriously reviewed, etc.

The concept of mini-mills in the steel industry were first resisted strongly by senior management who argued[49] that "the integrated steel-making process is the only right one" implying massive production scale plants. The maverick first applications of mini-mills produced reinforcing rod, a product which the major producers were content to lose. But now the quality improvements have made mini-mills extremely challenging players in the new dynamics of world markets. Where is the thinking in our industry on similar concepts? One answer surely would be similar to that from the generations of senior steel mill executives. Another more positive one, would reference the mini-mill concept currently used to recycle old corrugated container waste into linerboard on a scale of 250-500 tonnes/day located near large urban centres. Now comes the idea for a recycle mill to be located on Staten Island, that will produce newsprint for direct sale to the New York Times Co. and NewsCorp — it appears that this idea is under serious consideration.[50] Can we envisage appropriately scaled paper machines feeding directly into the presses of the Wall Street Journal?

We must seek new areas for synergies with electronics technologies. What could we do with ideas for paper products with intelligence, or those which communicate? Should an overly wet Pamper send a signal to the household information system that "It is time for a change, please." ? Could the business of UPS be enhanced by intelligent packages which record

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[49] Drucker, Peter, 1985, p. 39, *Innovation and Entrepreneurship*, Harper and Row, New York, NY

[50] Bronx Project Moves Ahead, 1996, p. 6, Vol. 7, No. 6, Paper Recycler, Miller Freeman, San Francisco, CA

shock, temperature history, dampness, acceleration, or which transmit exact location? When reviewing some of the process equipment used in our industry, I was fascinated to read about the contributions to papermaking by John Dickinson.[51] He patented a machine capable of inserting threads or other materials in such a way that they became an integral part of the paper, and which in newer embodiments, is the technology used for inserting wire threads into banknote paper even today. What have we done to consider manufacturing methods or new products that contain elements with functionality from the electronics and semiconductor world? Why, for example, could we not combine a narrow, continuous or batch paper machine, with technologies used for inserting electronics components on printed circuit boards? What other ideas do you have for entirely new product concepts like smart papers, sensor-containing packages?

What totally new product and process innovation ideas can we find to open up new markets or drive down new cost curves? Are there opportunities in health care? What about environmental issues related to spill stabilization or toxic site cleanup? What about innovations in process technology from other industries, like the use of oxygen-enhanced combustion in iron and steel and glass? Is there a use for nitrogen from an in-house oxygen plant which produces both peroxide and combustion oxygen? What about idealized process design considerations to re-engineer our entire plants? What about ideas of process ecology and process architectures?

A set of interesting challenges for researchers to investigate opens up the question of how and where will this work be carried out? Will paper companies have larger research and development laboratories? Will industry institutes provide the structure for major new research? Where will pilot plant work be carried out, if at all? How will universities, industry, and even governments organize to fund jointly and carry out the research? How will the virtual research networks, implied by 5th Generation research and development, operate? I do not have answers to these questions, but you can be assured that I and my colleagues around the world who worry about research management are thinking deeply about possible solutions.

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[51] Hills, Richard L., 1988, p. 118

Conclusions (n'est pas la même chose)

This presentation has been built around the themes of *innovation*, *change* and the *pace of change*. For an industry that has existed for 2000 years, it is hard to believe that the products we bring to the marketplace will easily be displaced. We have seen the impact of many innovations on society, and on our industry. Most, however, have only enhanced or consolidated the uses and functions of paper products. Can we be complacent? No! Should we be complacent? No! Will paper really be around forever? My answer is emphatically, "yes"!

The real issues, I believe, relate to our position on the current S-curve of paper science and technology. To grow, and expand, we need to discover new horizons, new applications, which will give growth and higher return on our massive investments. Thus, many of the research questions will relate to new product ideas, and performance and quality standards of existing products which surpass limits we now say are impossible. Stretch goals are *de rigueur*. What is impossible today is tomorrow's commodity.

Change, the pace of change, and the need to adapt to new ideas are all powerful forces. Complacency is dangerous. Radical change may not be the obvious solution. However, the pulp and paper industry is a slow-moving, incremental industry, and I believe with some conviction that it will have to speed up!

In closing may I return to the title of this presentation, The Future of Paper, which implied that we really have a situation in which *plus ça change, plus ç'est la même chose*[52] could easily be an assertion many of us would make. This may be a dangerous position — this quotation was written in a political journal apropos of revolutions.[53] Perhaps the better

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[52] Karr, Alphonse, 1890, Les Guêpes, France, 1959, The Oxford Companion to French Literature, Compiled and Edited by Sir Paul Harvey and J.E. Hesseltime, Clarendon Press, Oxford, U.K.

[53] The history is interesting. From a colleague in Grenoble, Les Guêpes was published for ten years (1839-1849). It was a monthly political journal. Alphonse Karr had observed that newspapers were not doing their jobs in describing society and politics, and thus he wanted to provide a free and tough look at the French scene. Les guêpes implies "let loose and sting" and the author, himself, had been stung — someone was unhappy enough to attack him with a knife. Les Guêpes attacks the inconsistency of French politics. Having 13 different forms of government in 38 years probably gave rise to this particular quotation.

description would be *plus ça change, plus ça va vite* and to find ways, ourselves, to move our industry to new opportunities and markets! This then is the challenge as we look forward to the next millenium. When this Symposium next meets, we will be in a new century. Meanwhile, as you proceed with the detailed presentations in the excellent Programme your organizers have put together for this week, I invite you to think about the opportunities which today's research will present. Join me in considering how each paper might lead to a new product or a radically different process. Our goal this week must be to set our sights firmly in the future.

Acknowledgments

In preparing this presentation I have benefited enormously from many conversations with my family, and with colleagues and friends both in the industry and around the world. Their wisdom and insight is gratefully acknowledged. Without their many thoughts, ideas and constructive suggestions, my task would have been much more difficult, if not impossible.

Transcription of Discussion

KEYNOTE ADDRESS

Dr Joseph Wright, CEO, Paprican, Canada

Patrice Mangin, CEO, Centre Technique du Papier, France

In your presentation I missed any discussion on the so-called 'generation gap' in relation to the future of paper. I don't know what the next generation will do. Any feeling about that?

Dr Joseph Wright

There has been much written and I think the most interesting part ties to the affordances, the work of Sellon that I referenced, and even the people doing research on the affordances of paper have identified younger generation computer science oriented, highly functional computer users, going back to the uses of paper for some of its functions. So I think that we will change a lot, we will find change in the uses of paper and maybe some of the nature of use will be transient, but it will exist. For those things where we definitely use the paper idea, I think it will be around for a long time. Of course it is important to observe that all of these references to the paperless office only look at a portion of our market place, and there are many other functions that will use paper for a long time as well.