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Technology Intelligence in Action

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TECHNOLOGY INTELLIGENCE IN ACTION

1. **Introduction**

Technology Intelligence (TI) is one of the many ways of applying Competitive Intelligence (CI)(NIKOLAOS; EVANGELIA, 2012). Since Ansoff (1975), authors have discussed the need to monitor new technology development to avoid surprises and to take actions to reduce risks. Most recently, authors are looking at TI as an important activity for companies face growing rivalry in a highly dynamic market (KIM et al., 2012; LICHTENTHALER, 2003, 2004, 2007; RAU; HAEREM, 2010). As CI, TI intends to detect and process weak signals in order to identify opportunities and threats and provide actionable information (LICHTENTHALER, 2003; NOSELLA; PETRONI; SALANDRA, 2008; ROSSEL, 2012)

Companies have been trough three generations of Technology Intelligence, described by Lichtenthaler (2003), which varies intensity, scope and strategic effectivity of TI. The first generation is characterized by a low or no connection between company strategy and technology strategy, studies that are intensive in technology and do not influence in strategic planning. The second generation is characterized by a higher degree of synchronization between company and technology strategies and by communicating studies' results in long written reports that may or may not be considered for strategy formulation by the higher administration. The third generation is characterized by the highest synergy between R&D department and the overall company's strategy. Intelligence analyst participates actively in the strategic planning and is involved in important decisions.

The Intelligence cycle, as summarized by Herring (1999), starts with the Key Intelligence Topics (KITs) identification, which will provide information for Planning and Direction process. Second, the process of Information Processing & Storage creates the Knowledge Base. Data Collection, Analysis and Production processes then collect, report and make the intelligence actionable and understandable for Dissemination process for the Users and Decision Makers. Choo (2001) describes the same process as being composed of three main steps: Information Needs Assessment, Information Seeking and Information Use.

Here we will analyze two cases of application in order to understand the Technology Intelligence process, identify the main tools that are used by companies and map the main sources of information. The cases were selected to verify differences and similarities in two different situations: when the TI is made by a third party (a Research Institute) based on a client's needs; and when the company uses its own personnel and assets to perform the project. The article begins with a literature review, then discuss the methods that were used, present the cases and then discuss and conclude with the main findings.

2. **Literature Review**

2.1 Competitive Intelligence

To start defining Competitive Intelligence, we will look at the work from Nikolaos and Evangelia (2012), who made a literature review on concepts and context of CI. For them, CI is a way for Companies to anticipate and react to changes inside and outside their industries in a world that is driven by hyper-competition. For Miller (2002), CI is the act of collecting, analyzing, and application, legal and ethically, information regarding the capacities, vulnerabilities and intentions of a company's competitors, and monitoring facts of the competitive environment.

The main objectives are to help companies to be in the competitive frontier of the advances (MILLER, 2002), provide help in decision-making and provide competitive advantage (PELLISSIER; NENZHELELE, 2013). To do so, CI relies on a myriad of methodologies that are mostly a variation of the process described by Choo (2002), composed by a cycle of Information needs, Information acquisition, Information organization and storage, Information products and services, Information distribution and Information use, creating Adaptive behavior. See Figure 1 for details on these phases of the cycle.

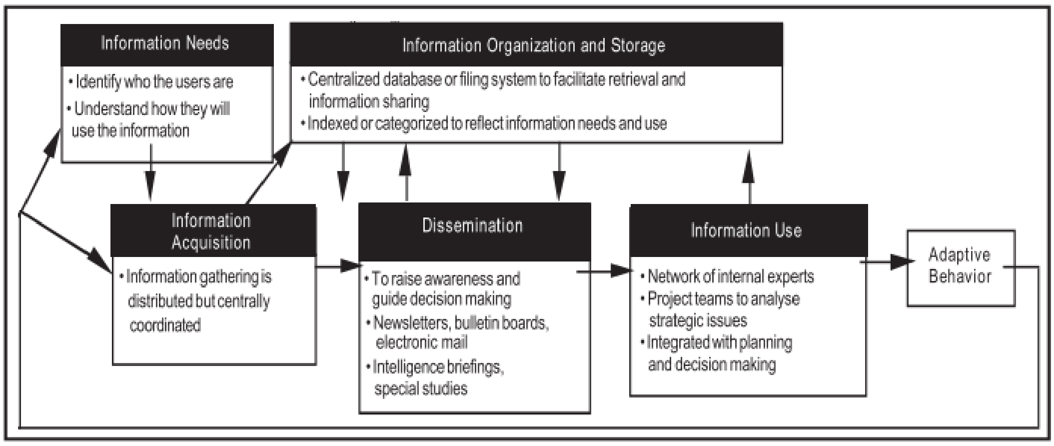

Figure 1: Steps for Competitive Intelligence. Source: Choo (2001, p. 237)

Herring (1999) adapted the National Intelligence Topics (NIT), a government intelligence model, into the Key Intelligence Topics (KIT), in order to be used by companies in order to produce information that management can actually act on, which he calls Corporate Intelligence. According to him, corporate intelligence might be reactive or proactive. By being proactive, one might provide the information by one's own judgement or ask the management what decisions and action they are working on. As he suggests the latter is the best option, he provides an interview protocol to identify the main information needs.

Intelligence needs might generally be categorized in three functional types:

> - Strategic decision and action, including the development of strategic plans and strategies;
> - Early-warning topics, including competitor initiatives, technological surprise, and government actions;
> - Descriptions of the Key Players in the specific marketplace, including competitors, customers, suppliers, regulators and potential partners.
> (HERRING, 1999, p. 6)

2.2 Technology Intelligence

Authors have cited Technology Intelligence (TI) concepts since the first appearance of CI in the literature with Ansoff (1975). One of the earliest appearances of the term Technology Intelligence was in Cooper and Schendel (1976), when the authors studied companies that face threats from new technology. Since then, technology surprises have been discussed by authors such as Herring (1999), who was already presented and discussed in the last section; Choo (2001), who cited Christensen's (1997) book about how technology strongly affected the hard disk industry as an example of technology surprise; Lichtenthaler (2003, 2004, 2007), who analyzed the way companies organize their Technology Intelligence efforts, studied the application of TI in context of radical innovation and compared TI organization in different times and stages of maturity; among others (ITTIPANUVAT et al., 2014; JOUNG; KIM, 2017; KIM et al., 2012; MORTARA, 2011; VEUGELERS; BURY; VIAENE, 2010; YOON et al., 2015) that contributed to TI discussion.

Prescott and Miller (2002) named “Technical Competitive Intelligence” the exercise of avoiding surprise by the technical advances of competitors through technology monitoring in its many forms. In their book, they present a series of case studies in order to fulfill a gap that exists in literature regarding this subject. Savioz (2002 apud SCHUH; GRAWATSCH, 2004, p. 3) defined Technology Intelligence as “activities that support decision-making of technological and general management concerns by taking advantages of a well timed preparation of relevant information on technological facts and trends (opportunities and threats) of the organisation’s environment by means of collection, analysis and dissemination”.

Lichtenthaler (2004) developed a framework to study Technology Intelligence process. His framework is composed by two steps, the first for the scanning and the second for monitoring. During the first step, employees become aware of a new technology and communicate it to the top management, who will discuss its relevance. The second step, monitoring, may be run several times as the now known technology is observed and new trends are being identified. See Figure 2 for Lichtenthaler’s framework.

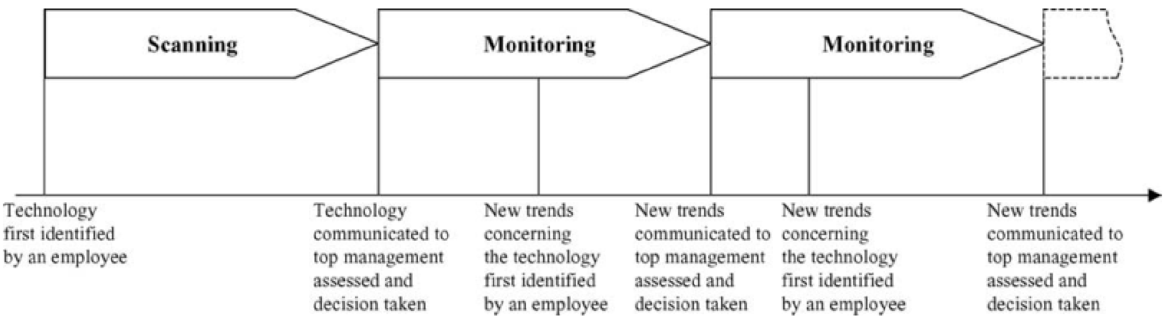

Figure 2: Technology Intelligence process framework. Source: Lichtenthaler (2004, p. 334)

The organization of the TI sector in the company affects directly its outcomes. Technology Intelligence may be organized in three ways: (1) hierarchically, (2) participatory and (3) hybrid (LICHTENTHALER, 2007). When the TI is organized hierarchically, awareness of the new technology is made by individual researchers, who will proactively test it. Then, the new trend is informed to Technology Intelligence specialists or directly to top management for decision making. This model emphasizes scientific aspects of the technology and usually over or under evaluates technologies. The participatory model, mid management strongly participates in the technology discussion with the researcher. Only after this discussion the matter is taken to the top management. Often, this model does not communicate intelligence results to top management efficiently. The third model, hybrid, is a mixture of the latter two. Trends are communicated to top management with TI experts’ support, assessed in mid management and decision is made upon the knowledge created. This model leads to quick and optimal decisions.

A variation with a higher detailed view, brought by Mortara et al. (2009), situates the TI in the context of Decision Making. On this model, decision makers provide guidelines on how to direct search and information needs assessment. These guidelines are used in the intelligence cycle, which will feedback decision makers with information for decision. See Figure 3 for their model.

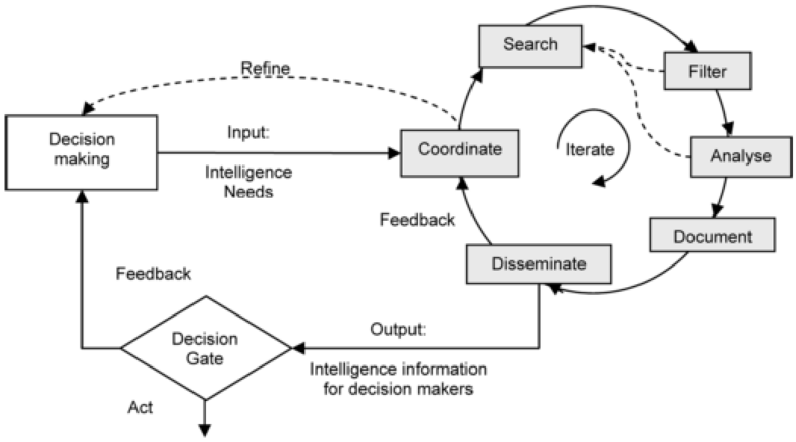

Figure 3: Technology Intelligence in the context of Decision Making.
Source: Mortara et al. (2009, p. 118)

Historically, methods based on expert-based analysis were used in classic technology management, however, with Technology Intelligence dealing with a greater amount of information every day, Information Technology (IT) is playing a growing role in corporations. In this context, there is an increasing number of researchers working on methodologies based on TRIZ, a Soviet inventive problem solving system (SCHUH; GRAWATSCH, 2004; YOON, 2008). Technology Planning is usually cited as a strategic outcome of Technology Intelligence (JOUNG; KIM, 2017; MOMENI; ROST, 2016; SCHUH; GRAWATSCH, 2004; WANCURA et al., 2013). A framework for applying TRIZ-based Technology Intelligence and relating it to Technology Planning is shown in Figure 4.

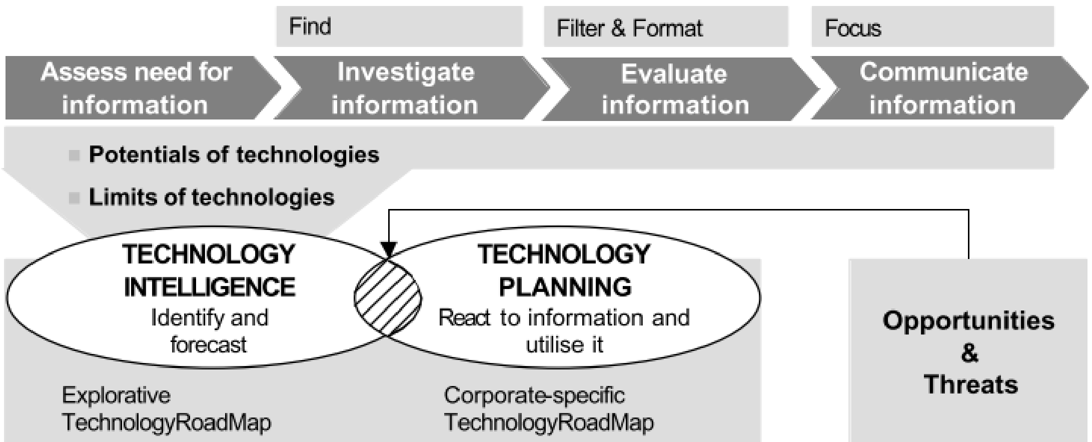

Figure 4: TRIZ-based Technology Intelligence framework.
Source: Schuh & Grawatsch (2004, p. 4)

Castellanos & Torres (2010) cite most common TI tools and methods as being Technological Assessment, Benchmarking, Technology Prospective and Technology Surveillance. According to them, the main attributes of the information are time (past, present, future), dynamics (a specific moment or a changing environment), uncertainty (formal or informal sources) and origin (primary or secondary sources). Schuh & Grawatsch (2004) lists methods such as S-curve Analysis, Ideality (Ideal product assessment) and Trends of Technological Evolution Analysis.

We could not find works regarding a comprehensive study on tools and methods used on TI projects, neither a great number of case studies regarding this subject. In this matter, an interesting case was reported by Tessun (2002), who described how Daimler-Benz Aerospace used Scenario Analysis to build its Technology planning. Scenario Analysis is based on creating future alternatives and assessing probabilities for each uncertainty, then creating strategies for each resulting scenario from the combination of all uncertainties. At Chevron, Ransley (1996) reported that, in many contexts, TI activities are outsourced.

3. **Research Question and Objectives**

After going through the literature review, we could see that, as Miller (2002) pointed out earlier, there is still a gap in reported cases of companies actually applying Technology Intelligence. This article intends to help covering this gap by answering the research question: **How companies build an actionable technology intelligence project?**

More specifically, we want to answer: What companies want when building such a project? What are the main steps taken during the process? Which tools are applied? Which sources of information are used? How companies deal with the final result? Who is responsible for such a project?

We have, as general objective, to describe application cases of technology intelligence focusing on tools and process. As specific objectives, we have:

a) To describe cases of technology intelligence projects;
b) To describe the process used from project request to decision making;
c) To identify tools and sources of information used during the process; and
d) To describe the allocated team's competencies.

4. **Methods**

We used Case Study approach for this research. Case study is a method used when the research question requires a deep diving into the subject (EISENHARDT, 1989; YIN, 2015) While quantitative methods focus on literal replications to enhance the conclusions, qualitative methods rely on theoretical replication (EISENHARDT, 1989; THEÓPHILO; MARTINS, 2009; YIN, 2015).

For data collection, as one of the authors participated in the projects described here, we used Participant observation, as part of an Action-research method. Differently from other methods, Action-research is a proactive way of doing research, applying concepts from literature and looking at the results enlightened by a research objective. “The goal is to make that action more effective while simultaneously building up a body of scientific knowledge” (COUGHLAN; COGHLAN, 2002, p. 223).

Two cases were selected, one from a public research institute that made a technology forecast project of a new technology for a client from the petrochemical industry. The second from a private company from the chemical industry who made a landscape scanning project on a specific technology of interest. We did not describe the technologies or the companies due to compliance issues. We did, however, describe the process and the tools used in the studies.

In each case, we followed Choo's (2001) generic process of Competitive Intelligence (Information needs, Information acquisition, Information organization and storage, Information products and services, Information distribution, Information use) so that the comparison could be made in the same base even for distinctive companies and cases.

5. **Two application cases**

In this section, we describe two application cases: we will firstly look at a public research institute that was using its competencies and structure to support a client from the petrochemical industry that was deciding whether or not to invest in a new technology; then, we review the work of a private chemical company that was interested in getting a first snapshot of a certain technology's landscape.

5.1 Case 1: Technology Intelligence at a Public Research Institute

This case happened at a Brazilian Public Research Institute (which we will refer as RI), who was contacted by a large company in the Petrochemical industry. The client was deciding whether or not to invest in a technology that was being offered by two different companies, each with its own pros and cons, and each exploring different biochemical routes to achieve the same goal: to substitute oil-derived raw materials for a determined chemical application.

RI team was composed by two technology specialists (who were PhDs in Chemical Engineering), one Technology Intelligence expert (PhD in Business Administration) and one Technology Intelligence analyst (Bs in Business Administration). The project took about eight months to complete.

5.1.1 Information needs

The RI team, then, started to assess what exactly was the main issue that was blocking the decision making. For that, the team used meetings with the client's specialist to understand the decision modeling. It was then understood that the main trigger for decision was the final cost per liter of the resulting product. In other words, if the final product costs more than the traditional technology, they were not to invest in this new technology. So, there were two questions to answer: Will this technology outperform traditional petrochemical-based products in 5 years? If yes, in which company should we invest?

Table 1 correlates the questions, its aspects and the methods used to answer:

Table 1 – Questions, aspects and methods for Technology Intelligence at RI

Question	Aspect	Method
Will this technology outperform traditional petrochemical products in 5 years?	1. Comparison with similar technology development from the past	S-curve analysis Literature and patentes review
	2. New technology present performance assessment	Literature and patents review
	3. New technology rival routes analysis	Literature and patents review
	4. Main uncertainties for the future assessment	Delphi
	5. Future performance assessment	Linear regression Scenario analysis
	6. CAPEX, OPEX and Final product cost	Modeling and simulation
	7. Suggested decision	Decision analysis
In which company should we invest?	8. Differences between companies identification	Companies' material analysis

Question	Aspect	Method
	9. Decision modeling for company	Decision analysis
	10. Suggested decision for company	Decision analysis

Source: Original data

After understanding the needs, deciding the methods that were to be used, and the main performance indicator for the decision, the Information needs assessment phase was concluded and RI team moved on to the next step.

5.1.2 Information acquisition

Once the needs were mapped, the team started to acquire information from Databases. Table 2 shows the sources of information used for each method from Table 1.

Table 2 – Sources of information for each method.

Method	Sources
S-curve analysis	Past projects from IR
Literature and patents review	Derwent patent database; Web of science
Delphi	Technology experts
Linear regression	Performance reported on articles and patents
Scenario analysis	Technology experts
Modeling and simulation	SRI reports on industry investments
Companies' material analysis	Companies' websites
Decision analysis	All gathered information for the project

Source: Original data

It is important to note that, during the project, new sources of information were added. For this case, when analyzing the differences between the companies' technology, it was noted that, for company A, the raw material would be sugar cane sucrose, while for company B, corn syrup glucose. Hence, for Decision analysis regarding aspect 10 (Decision for "In which company should we invest?"), projections for future prices of these raw materials were added to the model. The need for downstream processes after production were also included, as Company B needed an extra step by the end of the process, which increased its CAPEX and OPEX.

5.1.3 Information organization and storage

All information were stored in RI's internal network, in a folder that was accessible for every team member. For each aspect, a folder was created to gather all information that supported the conclusions.

For Articles recovered from Web of Science, the team used the cloud-based software Endnote web to organize and analyze data. Modeling and simulation for the production plant was done using the software ASPEN. Decision modeling was made on DPL and Microsoft Excel.

5.1.4 Information Dissemination

There were bi-weekly meetings with the client to present advances and discuss key aspect of the project. Important decisions were made during these meetings, such as the addition of Utilities as a variable in the economic modeling (which shown itself later as a variable of very low significance), and the choice for abandoning company B's technology when the price projections shown that in every scenario the cheapest technology would be A's.

By project completion, there was a formal presentation of the results in the client's headquarters, with the presence of the decision makers and the project's team. The suggested decision was to not invest in the technology, as it would not be cheap enough in their required timespan. The RI team's conclusion was that this technology would only be viable for high aggregated value applications.

5.1.5 Information use

After project completion and final presentation, the board of decision makers gathered and decided to follow RI's team suggestion. The company did not invest in the technology for their final product price would be much more competitive using traditional petrochemical routes.

As this project happened in 2010, we now know that this decision was right. We can judge from two different points of view. Firstly, the pessimistic, by the extreme drop of oil prices that happened after 2014, which was not forecasted by RI's team. Secondly, the optimistic: the team did forecasted that the technology would not perform sufficiently in productivity, yield of raw materials and percentage of extracellular final product, forcing a downstream process after production. After five years of technology development, every forecast became a reality.

5.2 Case 2: Technology Intelligence at a Private Company

This case was happened at a Brazilian Chemical Industry that is its way to internationalization. This company has assets in Brazil, Latin and North America, Europe and Asia. We'll call this company "Chemical". At Chemical, there is a constant need for exploring new technologies to increase its Innovation KPIs. Most of times, the company calls "new" something that its competitors are exploring, but Chemical is not. This is the case we're studying in this section.

The team for this project was composed by one Technology Intelligence analyst (MSc in Business Administration) helped by one intern (Materials Engineering student). The whole project took about two weeks.

5.2.1 Information needs

The need arose from noticing that Chemical's competitors are exploring successfully a technology. This technology is very close to the traditional that Chemical dominates and could be a natural evolution, as it takes advantage of the existing assets and competences. This new technology is a slightly different form of copolymerization of monomers that Chemical understands how to manipulate. The novelty is in the fact that these monomers must be strictly controlled to achieve the desired results.

To define the problem, the company's internal Technology Intelligence analyst gathered with the Innovation manager. Using an interview protocol, key questions were formulated and methods chosen. The key questions are: What are the applications for this technology? Who is investing in researching this technology? Which are the ongoing partnerships? Where is this technology being developed? Table 3 shows the questions, aspects for each of them and methods used to answer.

Table 3 – Questions, aspects and methods for Technology Intelligence at Chemical

Question	Aspect	Method
What are the applications for this technology?	1. Main applications	Patents, articles and deep-web documents review
	2. Main advantages	Patents, articles and deep-web documents review
	3. Main disadvantages	Patents, articles and deep-web documents review
Who is investing in researching this technology?	4. Main players	Patents review
	5. Classification in competitors and customers	Patents review and market review
Which are the ongoing partnerships?	6. Identification of partnerships	Patents review
Where is this technology being developed?	7. Countries	Patents review

Source: Original data

For this project, there was no KPI to trigger a decision. The need was for a first look at the technology landscape.

5.2.2 Information acquisition

As we did with the first case, we'll show in Table 4 the data sources for each method presented in Table 3.

Table 4 – Sources of information for Technology Intelligence at Chemical

Method	Sources
Patents review	Thomson Innovation; IHS Engineering Workbench; CAS SciFinder
Articles review	IHS Engineering Workbench; CAS SciFinder
Deep-web documents review	IHS Engineering Workbench
Market review	Market specialists

Source: Original data

For this case, Market specialists were not allocated to the project, hence it was necessary to schedule interviews with them to identify customers and competitors. This is a common fact in Chemical's IT projects.

5.2.3 Information organization and storage

As with the RI's case, there was a network folder where all information was stored and accessible for the TI area. Much of the data organization was made using the source softwares, such as Thomson Innovation (Thomson), CAS SciFinder (CAS) and IHS Engineering Workbench (EWB). These are softwares that offer an Artificial Intelligence (AI) interface to help users, however, one is not required to use such algorithms. AI was heavily used in EWB, due to the ability of accessing Deep-web documents, but was not used at all when searching Thomson or CAS. For these, boolean controllers were used.

However, not every needed information could be taken from the default analytical capabilities of each software. For those analysis, Microsoft Excel was used. No specific software for Decision Analysis was used.

5.2.4 Information dissemination

There was only one meeting before the start of the project and one after for presenting the results to the Innovation manager, who firstly ordered the project. All data was gathered in a Microsoft Powerpoint presentation and made available.

5.2.5 Information use

Information was used to enhance a set of knowledge that arrived from other areas, such as R&D, Engineering, Field Marketing and third-party Consultants. There is no record of decisions made upon the material created in the project.

6. **Discussion**

After seeing Technology Intelligence in action in such distinct cases, we can draw some inferences about how it is actually applied on corporations. When we compare TI as a service for third-parties with TI as a featured sector in the company, it is clear a difference in three aspects: timing, deepness, and team expertise.

Timing is a direct consequence of the deepness of the project itself. We can hypothesize that when a company outsources its Intelligence, it becomes natural to expect a deeper, more complex and comprehensive work. As the price for such project becomes more apparent and, probably, it went through an internal process of approving the budget for outsourcing, decision makers want a final report that uses the most tools and sources of information as possible. On the other hand, when the company has internally a dedicated resource for Intelligence, decision makers will have the tendency of demanding more projects, with much lesser budget and with a stricter deadline.

When looking at the results under the prism of Lichtenthaler (2003), it seems that the company that outsourced the study in the first case is operating on the third generation of TI, while Chemical, with its science-centered view and low connection between technology and company strategies, is yet operating in the first generation. Besides that, when taking Lichtenthaler (2007) as a model, RI's customer seem to be organized in a hybrid way, while Chemical is organized in a participative way, hence the lack of top management participation in the dissemination phase of TI, and the size and expertise of the team allocated in the project.

The iterative process described by Mortara et al. (2009) was not observed in any of the cases, as the conclusions seemed to not represent an input for new TI projects. As this is not an issue on the first case, once the customer could proceed with the study internally, this is something to be aware on the second. Chemical seems to be in a very initial maturity level for Technology Intelligence and this cycle has not yet been initiated.

When looking at the framework from Schuh & Grawatsch (2004), we could not detect in any of the cases a connection with Technology Planning. This is something that simply might have not yet happened at Chemical, and is certainly something to be observed further. At RI's customer, it is natural that we did not have access to this outcome, but it is natural to assume that this specific project is part of some kind of technology planning.

While this might seem an argument for companies outsource all of its Intelligence projects, there is also another observation to be made before reaching such a conclusion: Companies seem to now know how to deal with Technology Intelligence. When outsourcing, they are more willing to pay for an extremely comprehensive project that not necessarily needs to be so deep and complex. When doing it internally, decision makers are not willing to wait and give the TI analysts resources to conduct a project in the right deepness and complexity. We can not yet fully affirm this, but it seems like a “goldilocks problem” applied to Technology Intelligence: for which types of TI project should the company rely on outsourcing? For which types should the decision makers empower an internal TI area? How companies can estimate the value of TI, so that they won’t over or underpay for such projects?

7. **Conclusion**

We’ll present our conclusions by answering each research question presented earlier. The main question of this article was: How companies build an actionable technology intelligence project? In order to answer this general question, we answered the following more specific questions:

1. What companies want when building such a project?

As Herring (1999) had already described for Competitive Intelligence, we can consider the possible information needs for Technology Intelligence in three main categories:

> - Strategic decision and action, including the development of strategic plans and strategies;
> - Early-warning topics, including competitor initiatives, technological surprise, and government actions;
> - Descriptions of the Key Players in the specific marketplace, including competitors, customers, suppliers, regulators and potential partners.
> (HERRING, 1999, p. 6)

We could not find any other category to question Herring’s work.

2. What are the main steps taken during the process?

We still could not find any significant difference from the process described by Choo (2001). So, the steps that are taken during a Technology Intelligence process are:

1. Information needs assessment
2. Information acquisition
3. Information organization and storage
4. Information dissemination
5. Information use

Not every IT project, however, becomes actionable, so not every process will reach Information Use step.

3. Which tools are applied?

We could compile a list of tools companies use for conducting Technology Intelligence projects. See Table 5 for this compilation.

Table 5 – Used tools for Technology Intelligence

Tool	Sources of information	Observed in
Derwent Patent Database	Patents	RI
Web of Science	Articles	RI
Technology reports (ie. SRI)	Consulting companies	RI
Endnote web	Patents	RI
DPL	Data input from user	RI

Tool	Sources of information	Observed in
IHS Engineering Workbench	Patents, Articles and Deep-web documents	Chemical
CAS SciFinder	Patents and Articles	Chemical
Thomson Innovation	Patents, Articles, News	Chemical
Microsoft Excel	Data input from user	Chemical

Source: Original data

4. *Which sources of information are used?*

We have already answered this question on Table 5.

5. How companies deal with the final result?

When there is already a decision to be made, the final result covers gaps and decision makers use the information to base their settlements. The final decision is, then, a function of the decision makers' willingness for taking risks.

However, when there is not a decision at the genesis of the project, the final result is read and archived. The information made available does not affect directly a technology decision, however we can not say that the information is useless: it contributes to a better understanding of the environment and might be basis for a more specific question for TI in the future.

6. Who is responsible for such a project?

The typical team for Technology Intelligence project is composed by at least one analyst, who has to dominate the methods and have access to the tools and sources of information. It is desirable to have technology experts as well in order to have a deeper understanding of the technology itself. The availability of technicians will give the project a greater legitimacy and increase the probability of providing actual actionable intelligence.

References

ANSOFF, H. I. Managing Strategic Surprise by Response to Weak Signals. **California Management Review**, v. XVIII, n. 2, p. 21–33, 1975.

CASTELLANOS, O. F.; TORRES, L. M. Technology intelligence: Methods and capabilities for generation of knowledge and decision making. **PICMET ’10 - Portland International Center for Management of Engineering and Technology, Proceedings - Technology Management for Global Economic Growth**, p. 1176–1184, 2010.

CHOO, C. W. Environmental scanning as information seeking and organizational learning. **Information Research**, v. 7, n. 1, p. 1–37, 2001.

CHOO, C. W. **Information Management for the Intelligent Organization: The art of Scanning the Environment**. 3rd editio ed. New Jersey: Information Today, Inc., 2002.

CHRISTENSEN, C. **Innovator’s Dilemma: when new technologies cause great firms to fall**. [s.l: s.n.].

COOPER, A. C.; SCHENDEL, D. Strategic responses to technological threats. **Business Horizons**, v. 19, n. 1, p. 61–69, Feb. 1976.

COUGHLAN, P.; COGHLAN, D. Action research for operations management. **International Journal of Operations & Production Management**, v. 22, n. 2, p. 220–240, 2002.

EISENHARDT, K. M. Building theories from case study research. **Academy of Management Review**, v. 14, n. 4, p. 532–550, 1989.

HERRING, J. P. Key intelligence topics: A process to identify and define intelligence needs. **Competitive Intelligence Review**, v. 10, n. 2, p. 4–14, 1999.

ITTIPANUVAT, V. et al. Finding linkage between technology and social issue: A Literature Based Discovery approach. **Journal of Engineering and Technology Management - JET-M**, v. 32, p. 160–184, 2014.

JOUNG, J.; KIM, K. Monitoring emerging technologies for technology planning using technical keyword based analysis from patent data. **Technological Forecasting and Social Change**, v. 114, p. 281–292, 2017.

KIM, J. et al. Technology trends analysis and forecasting application based on decision tree and statistical feature analysis. **Expert Systems With Applications**, v. 39, n. 16, p. 12618–12625, 2012.

LICHTENTHALER, E. Third generation management of technology intelligence processes. **R&D Management**, v. 33, n. 4, p. 361–375, 2003.

LICHTENTHALER, E. Technological change and the technology intelligence process: A case study. **Journal of Engineering and Technology Management - JET-M**, v. 21, n. 4, p. 331–348, 2004.

LICHTENTHALER, E. Managing technology intelligence processes in situations of radical technological change. **Technological Forecasting and Social Change**, v. 74, n. 8, p. 1109–1136, 2007.

MILLER, S. H. Prefácio. In: PRESCOTT, J. E.; MILLER, S. H. (Eds.). . **Inteligência competitiva na prática: técnicas e práticas bem-sucedidas para conquistar mercados**. 1st. ed. Rio de Janeiro: Campus, 2002. p. 11–15.

MOMENI, A.; ROST, K. Identification and monitoring of possible disruptive technologies by patent-development paths and topic modeling. **Technological Forecasting and Social Change**, v. 104, 2016.

MORTARA, L. et al. Technology Intelligence practice in UK technology-based companies. **International Journal of Technology Management**, v. 48, n. 1, p. 115–135, 2009.

MORTARA, L. Communicating Technology: A practical Guide. 2011.

NIKOLAOS, T.; EVANGELIA, F. Competitive intelligence: concept , context and a case of its application. **Science Journal of Business Management**, n. 2, p. 1–15, 2012.

NOSELLA, A.; PETRONI, G.; SALANDRA, R. Technological change and technology monitoring process : Evidence from four Italian case studies. **Journal of Engineering and Technology ManagementTechnology Management**, v. 25, p. 321–337, 2008.

PELLISSIER, R.; NENZHELELE, T. E. Towards a universal definition of competitive intelligence. **SA Journal of Information Management**, v. 15, n. 2, p. 1–7, 2013.

PRESCOTT, J. E.; MILLER, S. H. Inteligência Competitiva Técnica. In: PRESCOTT, J. E.; MILLER, S. E. (Eds.). . **Inteligência competitiva na prática: técnicas e práticas bem-sucedidas para conquistar mercados**. 1st. ed. Rio de Janeiro: Campus, 2002. p. 293–294.

RANSLEY, D. L. Benchmarking the “external technology watching” process: Chevron’s experience. **Competitive Intelligence Review**, v. 7, n. 3, p. 28–33, 1996.

RAU, D.; HAEREM, T. Applying an organizational learning perspective to new technology deployment by technological gatekeepers: A theoretical model and key issues for future research. **Information Systems Frontiers**, v. 12, n. 3, p. 287–297, 2010.

ROSSEL, P. Early detection, warnings, weak signals and seeds of change: A turbulent domain of futures studies. **Futures**, v. 44, n. 3, p. 229–239, 2012.

SCHUH, G.; GRAWATSCH, M. TRIZ-based technology intelligence. **Triz Journal**, 2004.

TESSUN, F. Análise de cenários e sistemas de advertência antecipada na Daimler-Benz Aerospace. In: PRESCOTT, J. E.; MILLER, S. H. (Eds.). . **Inteligência competitiva na prática: estudos de casos diretamente do campo de batalha.** 1st. ed. Rio de Janeiro: Campus, 2002. p. 295–306.

THEÓPHILO, C.; MARTINS, G. Metodologia da investigação científica para ciências sociais aplicadas. **São Paulo: Atlas**, 2009.

VEUGELERS, M.; BURY, J.; VIAENE, S. Linking technology intelligence to open innovation. **Technological Forecasting and Social Change**, v. 77, n. 2, p. 335–343, 2010.

WANCURA, H. et al. Creating a Solid Base for Technology Road Mapping Using an Integrated Technology Monitoring and Assessment Tool. **Procedia - Social and Behavioral Sciences**, v. 75, p. 370–382, 2013.

YIN, R. K. **Estudo de Caso: Planejamento e Métodos**. 4a. ed. Porto Alegre: Bookman editora, 2015.

YOON, B. On the development of a technology intelligence tool for identifying technology opportunity. **Expert Systems with Applications**, v. 35, n. 1–2, p. 124–135, 2008.

YOON, J. et al. Technology opportunity discovery (TOD) from existing technologies and products: A function-based TOD framework. **Technological Forecasting and Social Change**, v. 100, 2015.