Implementation Guide

How to use an index like ForATE may seem like a trivial detail, but misuse of a tool, however powerful, could give managers the wrong direction and lead to bad decisions. Here are the recommendations for the judicious use of the ForATE index in your organization.

1.1.1 Generalities

First, note that setting up and using the ForATE index within your organization will require a good distribution of responsibilities. Indeed, it is recommended that the index be a tool for simplifying and synthesizing scientific information from the field to management. It could become very counterproductive for your organization if the tool were used by managers, to impose a vision based only on budget at the expense of scientific common sense. Yes, the result of the ForATE must support the manager in his decision, and this decision may lead the manager, for various reasons external to the index, not to invest, despite a favorable message. On the other hand, it is important that a scientist can collate the data, interpret the results, and use the ForATE index to support the manager. If the structure of your organization allows it, we suggest using the mini-PTA model (Beaudoin A. , 2009) which relies on a chief scientist who can supervise the collection, as well as adequately support and explain the conclusions that can be drawn from the ForATE index to the manager. The scientific-managerial bond of trust that is created with such an arrangement makes it possible to establish a synergy favorable to optimization and innovation in the scientific field (Beaudoin A. , 2009).

In addition, this model will make it possible to support the manager less versed in science on the relevance of the comparison of techniques. Comparing any techniques together, without making a scientific connection between them is questionable. We do not question here the comparison in its essence, but only the excessive or inappropriate comparison. The manager is not necessarily able to distinguish between, for example, a method of developing fingermarks on porous surfaces, and another method for non-porous surfaces… The comparison of two techniques targeting two types of different surfaces

with ForATE makes little sense since the latter are in no way in competition. The greatest value of ForATE is achieved when evaluating similar techniques and can avoid a lot of talking when replacing an old technique with a new one that is overall better on all dimensions measured by the index. The chief scientist will be able to guide the manager to avoid pitfalls and ensure judicious use of the index.

It should also be noted that the ForATE index makes it possible to compare techniques, from a relative point of view, without taking into account the treatment sequences or the particularity of each specific case encountered in the field ... This approach is completely logical, considering that management consists of processing flows, budgets, etc. The index is built on making sense in terms of management. The contribution of the scientist supporting the manager is very important to provide the nuances necessary to obtain a complete overall portrait. Despite the decisions that may be made based on the processing flow in relation to the results of the ForATE index, it is important to note that one can always come back to consider the individual case depending on the circumstances. Thus, a method set aside for routine processing, following comparison with the ForATE index, could on the other hand be retained for specific cases (for example, for major crimes), where the investment would be quite justifiable.

Over time, it may also become necessary to revise the ForATE assessment of a technique or technology to take into account developments of science or technology in the field. Indeed, as science evolves, the assessment of the risk of a technique may change with the understanding of the impacts of certain products on human health. It is also possible that the advent of certain technologies will influence the appreciation we may have. Imagine, for example, the arrival in the community of a new technologically very advanced magnifying glass which would make it possible, according to the CAST development assessment scale, to make usable, not only the traces with values of 3 and 4, but also the traces of value 1 and 2. The evaluation of the techniques previously analyzed would then become obsolete, and it would be necessary to revisit the previous ForATE indices to determine if the addition of the traces of values 1 and 2 could change our perception of efficiency.

Finally, we recommend that managers set up a follow-up of the results obtained with each of the techniques implemented within their organizations to know the operational development success rate, the type of surface giving the best results, etc. Although completely optional, this suggestion will allow you, in the medium / long term, to analyze the trends and reveal the obvious facts that could allow you to optimize the ways of doing things in your organization. Although this advice is completely independent of the index we are talking about in this manuscript, the data collected will be, for the manager, an interesting source of information that will perfectly complement his toolbox when scientific-managerial decisions must be taken.

1.1.2 Specifications for the efficiency index

The key to accurately assess the efficiency is to analyze exactly what you want to buy. Indeed, if an organization wishes to implement the Physical Developer (PD) technique in its laboratory, and thinks of using ready-made preparations already available on the market (recognized as being less effective in the field), the effectiveness must be evaluated on this very precise product… Same thing if the intention is to use, for example, the PD recipe of the Sûreté du Québec (SQ) in your laboratory; you should not do your pseudo-operational study with the US Secret Service (USSS) recipe (two recipes using different products). This warning may seem trivial, but the differences between a pre-mixed product in the store and two separate recipes can completely change the analysis we can draw from it ... In short, we are always testing what we want to buy!

As part of the efficiency index, we strongly recommend the use of phase 3 pseudo-operational study. We invite you to take the time to read the entire article which explains in detail the prerequisites sought (International Fingerprint Research Group, 2014). Below, you will find a summary of the main points to observe.

When preparing your pseudo-operational study, you must take into account the environmental conditions in which you will have to use the technique, plan for the aging of the fingermarks which represents your operational reality and plan for the storage

conditions of the samples (especially during the aging) which is in line with your organization's procedures for preserving exhibits.

The substrates chosen for your study are also important because the mode of manufacture, the brand, and the post-manufacturing particularities can have an impact on the results that will be obtained (for example, from one country to another, the methods of coating paper are different, and these may affect the efficiency of the techniques). When choosing your substrates, you must ensure that you have representativeness of the type of substrate generally encountered in your regional situation in your operational files (International Fingerprint Research Group, 2014).

For donors, the IFRG recommends the use of fingermarks from volunteers representing the population of your region. To have a statistically significant donor count, the IFRG recommends a minimum of 20 fingermark donors for your study. Natural fingermarks should be favored for the collection of samples, with the minimum of intervention by the researcher (no heavy traces by passing the finger over the forehead, no washing of hands before the tests, etc.). On the other hand, it is extremely important to know exactly how many fingermarks have been deposited on the surface (essential for the use of the index). Thus, you will be able to determine the number of fingermarks expected (deposited) and the number of fingermarks obtained (effectively developed by the technique). It is suggested to opt for a collection of fingermarks by depletion (subsequent deposition of fingermarks from the same finger on the substrate), to be able to benefit from a gradual reduction of deposited material ... This allows you to obtain an evaluation of the efficiency taking into account the sensitivity of the technique according to the variation of material to be detected.

The evaluation of the fingermarks development results should be done by an expert in fingerprint identification. They can properly assess the possibilities of exploiting the fingermarks in the context of a potential identification. We will use an absolute scale like the CAST one (Bandey & Gibson, 2006) to assess each location where a fingermark has been left by the volunteers. For the CAST scale, grade 3 and 4 fingermarks will be counted as a development allowing identification (therefore positive), the others as a non-development. For each of the samples (depending on the donor, aging, substrate), the

development data will be entered into the automated calculation application of the ForATE-Tech Chem or ForATE-Light Source, depending on the situation, which is available free of charge for users (http://alexandre.beaud0in.net/ForATE.htm). Note that we are not testing the sequential treatment here since we want to get the absolute effectiveness value of a technique on its own. However, we recommend that you test the effectiveness of the techniques in sequence when you have decided to invest in its acquisition, to optimize your Standard Operating Procedures.

1.1.3 Specification for the Health risk index

The health risk index is very important. This is a precautionary index here, to take into account the impact on the health and safety of your staff, which is one of the most important resources of an organization. When analyzing this index, we recommend that you take out all the safety data sheets (MSDS) of the products used (or retrieve the classification according to international standards IEC 60825-1: 2014 and IEC 62471: 2006 or IEC 60825 -1: 2014 Ed.3.0 if it is a forensic light source). It is in these sheets that you will find the H phrases (which are now mandatory) allowing you to assess the dangerousness of the products. If your safety data sheets do not contain H-phrases (or contain R-phrases), then they are not up-to-date or legal ... We recommend that you obtain new ones. It is also recommended to use the safety data sheets from your suppliers, to make sure that you have the information related to the right product, and not an alternative product with a similar name whose manufacturing conditions are not the same.

Note that if the health risk index is high, it is extremely important to see this result as a red flag for the technique evaluated… Indeed, the calculation of the Risk Index must make it possible to determine the acceptable level of risk (Persoons, Dumas, Stoklov, & Maître, 2005) :

Acceptable risk = $I_R < 4$

Intermediate risk = $4 \leq I_R \leq 40$

Unacceptable risk = $I_R \geq 40$

If the chief scientist collating the information realizes that the technique presents an unacceptable risk (above 40), it should be discussed with the manager. This is an alarm that may mean that the technique is too dangerous, or that the laboratory and employees do not have the appropriate protective equipment to use certain products. Either way, the manager will have to make a decision. As much, a method that does not give results, however good for the health, is of no interest to the organization; a method, no matter how good it is, that would put employees at risk of death would pose a major ethical problem that would be just as bad for the organization. The risk index should become, for your organization, a limit value in your assessment of techniques and technologies (cut-off value).

1.2 Possibility of cost-efficiency analysis with ForATE

We must be careful with the principle of cost-benefit analysis. This kind of analysis normally expresses costs and benefits in monetary terms, where the profitability of an intervention is assessed by placing a financial value on the results. (Champagne, Contandriopoulos, Brousselle, Harty, & Denis, 2011). With the ForATE, we recommend more specifically the cost-efficiency analysis using the costs of a technique (or technology) and the results of ForATE, in an attempt to assess the efficiency of the latter by a ratio of perceived forensic benefits over costs (Kobus, Houck, Speaker, Riley, & Witt, 2011). With the current context of scarcity of resources, the need to control spending, and the need to be accountable to the population, it remains very important for the manager to be able to justify acquisition decisions, not only with a composite index. , but also by associating the associated monetary impacts. We will therefore look at three studies produced from the thesis on ForATE to establish a cost-efficiency analysis for each of them. For this evaluation, we will use the prices in Canada of the different methods (Latent Forensic Services, 2020).

1.2.1 IND/Zn vs DFO

In the study between IND / Zn and DFO, we obtained ForATE indexes of :

- IND/Zn = 559,35
- DFO = 390,95

In terms of costs, we received a quote for equivalent quantities of products (already fully prepared) which corresponds to :

- IND/Zn = 65,59$ for 100 ml
- DFO = 53,99$ for 100 ml

So :

$$IND = \frac{559{,}35}{65{,}59\$} = 8{,}48/\$$$

$$DFO = \frac{390{,}95}{53{,}99\$} = 7{,}24/\$$$

Thus, by calculating, we obtain an efficiency per dollar invested of :

- IND/Zn = 8.53 ForATE ratio (perceived forensic profits) per dollar invested per 100 ml
- DFO = 7.24 ForATE ratio (perceived forensic profits) per dollar invested per 100 ml

Note that to simplify the calculation of this ratio, the price of ready-made solutions was used. The cost of producing such a solution in your laboratory is usually much lower. For the sake of transparency, here is what the same analysis could have given by purchasing all the necessary products individually from Sigma-Aldrich (2021) in Canadian dollars.

Table 1: IND/Zn prices and recipe

Qty	Name of the product	Price at Sigma-Aldrich in Canada	Cost per unit	Cost per recipe
1 g	Zinc chloride	99,20$ per 5 g	19,84$/g	19,84$
50 ml	Glacial acetic acid	94,30$ per 2500 ml	0,0377$/ml	1,89$
1 g	Indanedione	115$ per 1 g	115$/g	115$
400 ml	Ethyl acetate	134$ per 2500 ml	0,0536$/ml	21,44$
4000 ml	HFE 7100	325$ per 1000 ml	0,325$/ml	1300$
4450 ml	Recipe cost			1458,17$
100 ml	Cost for 100 ml			32,77$

Then, we reduce the cost according to the proportions used (in our case, 100 ml), and we obtain a cost per 100 ml of $ 32.77. If we compare with the cost of the ready-made solution sold by a supplier ($ 65.59 per 100 ml), it becomes clear that it is worth to go for mixing the chemical in your laboratory, if possible.

The cost-efficiency analysis, therefore, becomes for the IND / Zn 17.07 ratio of ForATE (perceived forensic benefits) per dollar invested per 100 ml (instead of the 8.53 previously calculated with premixed products).

If we do the same calculation for DFO:

Table 2: DFO prices and recipe

Qty	Name of the product	Price at Sigma-Aldrich in Canada	Cost per unit	Cost per recipe
2 g	DFO	760$ per 1 g	760$/g	1520$
80 ml	Glacial acetic acid	94,30$ per 2500 ml	0,0377$/ml	3,02$
160 ml	Purified methanol	192$ per 4000 ml	0,048$/ml	7,68$
3760 ml	HFE 7100	325$ per 1000 ml	0,325$/ml	1222$
4000 ml	Recipe cost			2752,70$
100 ml	Cost for 100 ml			68,82$

Then, we reduce the cost according to the proportions used (in our case, 100 ml), and we obtain a cost per 100 ml of $ 68.82. If we compare with the cost of the ready-made solution sold by a supplier ($ 53.99 per 100 ml), it becomes obvious that it is more profitable to opt for the purchase of this ready-made solution in this specific case. (possibly related to the very high cost of DFO, caused by the small quantity purchase available from Sigma-Aldrich).

The cost-efficiency analysis, therefore, becomes for the DFO 5.68 ratio of ForATE (perceived forensic benefits) per dollar invested per 100 ml (instead of the 7.24 previously calculated with premixed products).

In the end, the calculation of the “homemade” recipe accentuates the lead of the IND / Zn in terms of cost-efficiency.

The manager could therefore use these conclusions to justify a decision to implement IND / Zn to the detriment of DFO, considering the reality of the costs associated with the two methods in his country. This conclusion supports the decision of several laboratories.

1.2.2 ORO vs PD

In the study between the ORO and the PD, we obtained the following ForATE indexes :

ForATE index for 0 to 14 days	ForATE index for 15 to 30 days
- ORO = 293,97 - PD = 276,88	- ORO = 262,13 - PD = 261,63

In terms of costs, we received a quote for equivalent quantities of products (already fully prepared) which corresponds to :

- ORO = 88,74$ for 1000 ml
- PD = 94,49$ for 1000 ml

Thus, by calculating, we obtain an efficiency per dollar invested of :

- Between 0 to 14 days
    - ORO = 3.31 ratios of ForATE (perceived forensic profits) per dollar invested per 1000 ml
    - PD = 2.93 ratios of ForATE (perceived forensic profits) per dollar invested per 1000 ml

- Between 15 to 30 days
    - ORO = 2.95 ratios of ForATE (perceived forensic profits) per dollar invested per 1000 ml
    - PD =2.77 ratios of ForATE (perceived forensic profits) per dollar invested per 1000 ml

This would mean, for the manager, that he gets more for his money with the ORO than with the PD in his country. The manager could therefore use this conclusion to justify a decision to implement the ORO. This conclusion could suggest to the manager that it would be preferable to implement the ORO compared to the PD ... but that both methods present a fairly low rate of forensic profits (in the sense of ForATE) per dollar invested. By linking with the previous cost-efficiency analysis, it would be preferable to invest primarily in IND / Zn than in these two techniques currently analyzed.

1.2.3 IND/Zn vs Nin

In the study between IND / Zn and DFO, we obtained the following indexes :

ForATE index :

- IND/Zn = 420,70
- Nin = 341,48

Note that this was a study with a proof of concept design (Phase 1) (International Fingerprint Research Group, 2014), and that the use of pseudo-operational Phase 3 studies for ForATE is recommended. Let's see the impact of this study while using a design that was not recommended. Quickly, we see that the IND / ZN, unsurprisingly, has a better ForATE than the Nin.

In terms of costs, we received a quote for equivalent quantities of products (already fully prepared) which corresponds to :

- IND/Zn = 65,59$ per 100 ml
- Nin = 38,40$ per 100 ml

Thus, by calculating, we obtain an efficiency per dollar invested of :

- IND/Zn = 6,41 ForATE ratios (perceived forensic profits) per dollar invested per 100 ml
- Nin = 8,89 ForATE ratios (perceived forensic profits) per dollar invested per 100 ml

This would mean, for the manager, that he gets more for his money with Ninhydrin than with IND / Zn in his country. Isn't that amazing? Although proof of concept clearly shows that one method offers better efficiency than the other at first glance, the fact remains that the effect calculated by the efficiency index is underestimated. , since the proof of concept does not take into account the potential variation of the substrates (tests carried out on the preferred substrate of Ninhydrin in this case), a sufficient number of participants, etc. The weak design of the IND / Zn vs Nin study produces a ForATE that is not representative of the operational effectiveness of these two methods. The cost-effectiveness analysis allows us to observe that the effectiveness of IND / Zn was underestimated (when compared to the pseudo-operational study). This effect is even clearer when one refers to the Canada-wide study which compared DFO and Ninhydrin (Wilkinson, Rumsby, Babin, Merritt, & Marsh, 2004). Indeed, DFO alone allowed, according to this article, to develop more than twice as many fingermarks as Ninhydrin alone (an increase of 105%). Considering that the results obtained with the comparison of IND / Zn and DFO (where IND / Zn showed a 42% increase in fingermark development compared to DFO), it is evident that the effectiveness of IND / Zn was underestimated by the proof of concept study. If we take the cost-efficiency analysis of the IND / Zn - DFO study (more robust, pseudo-operational phase 3 study), at the level of the ForATE of the IND / Zn, and that we keep the ForATE of Nin in this study, the substrate of which favors its efficiency (white paper), to make a comparison again, we notice that IND / Zn and Nin are now face to face.

- IND/Zn = 8,53 ForATE ratios (perceived forensic profits) per dollar invested per 100 ml
- Nin = 8,89 ForATE ratios (perceived forensic profits) per dollar invested per 100 ml

But what's the impact of the product supplier? In our case, we have already observed that the supplier of products prepared in advance (Latent Forensic Services, 2020) had a rather high price for IND / Zn (possibly due to a small amount of preparation). If we repeat the exercise using laboratory recipes, locally the IND / Zn would have a cost per 100 ml $ 32.77. For Ninhydrin, we would obtain (Sigma-Aldrich, 2021) :

Table 3: Ninhydrin prices and recipe

Qty	Name of the product	Price at Sigma-Aldrich in Canada	Cost per unit	Cost per recipe
100 g	Ninhydrin	332$ per 100 g	3,32$/g	332$
200 ml	Glacial acetic acid	94,30$ per 2500 ml	0,0377$/ml	7,54$
400 ml	Ethanol	181$ per 2500 ml	0,0724$/ml	28,96$
4000 ml	HFE 7100	325$ per 1000 ml	0,325$/ml	1300$
4700 ml	Recipe cost			1668,50$
100 ml	Cost for 100 ml			35,50$

The cost-efficiency ratio would be recalculated as follows.

Using the underestimated IND / Zn ForATE, and laboratory preparation costs, locally:

- IND/Zn = 12,84 ForATE ratios (perceived forensic profits) per dollar invested per 100 ml
- Nin = 9,61 ForATE ratios (perceived forensic profits) per dollar invested per 100 ml

Using the IND / Zn ForATE following a pseudo-operational study, and the costs of preparation in the laboratory, locally :

- IND/Zn = 17,07 ForATE ratios (perceived forensic profits) per dollar invested per 100 ml
- Nin = 9,61 ForATE ratios (perceived forensic profits) per dollar invested per 100 ml

This example demonstrates the impact of local costs on a cost-efficiency analysis. In the end, the practical application of proof of concept was made to demonstrate the dangers of using a bad study design to compensate for a pseudo-operational study (International Fingerprint Research Group, 2014), a cost-benefit or cost-efficiency analysis with ForATE without taking the time to analyze the situation and take all the necessary precautions to get as close as possible to the true value of forensic techniques or technologies, as well as to those of cost-efficiency analysis where prices can have a major impact on the appreciation of a technique. And if it becomes necessary to use, under certain circumstances, a meta-analysis to measure effectiveness, it will become imperative to be very careful with the inclusion and exclusion criteria of studies from the literature to be included.

2 References

Bandey, H. L., & Gibson, A. P. (2006, Février). The Powders process, Study 2. *HOSDB Fingerprint Development and Imaging Newsletter: Special Edition*, pp. 1-13.

Beaudoin, A. (2009). *Analyse des stratégies d'évaluation des technologies des corps policiers canadiens: le cas de l'identité judiciaire, Thèse de Master.* Montréal: Université de Montréal. Récupéré sur http://hdl.handle.net/1866/3606

Champagne, F., Contandriopoulos, A.-P., Brousselle, A., Harty, Z., & Denis, J.-L. (2011). L'évaluation dans le domaine de la santé. Dans A. Brousselle, F. Champagne, A.-P. Contandriopoulos, & Z. Harty, *L'évaluation: concepts et méthodes* (éd. 2e, pp. 49-70). Montréal: Les Presses de l'Université de Montréal.

International Fingerprint Research Group. (2014). Guidelines for the assessment of fingermark detection techniques. *Journal of Forensic Identification, 64*(2), 174-200.

Kobus, H., Houck, M., Speaker, P., Riley, R., & Witt, T. (2011). Managing performance in the forensic sciences: Expectations in light of limited budgets. *Forensic Science Policy and Management, 2*, 36-43.

Latent Forensic Services. (2020, Dec 23). *Chemistry*. Consulté le Dec 23, 2020, sur Latent Forensic Services: https://www.latentforensics.com/

Persoons, R., Dumas, L., Stoklov, M., & Maître, A. (2005). Développement d'une nouvelle méthode d'évaluation des risques chimiques: application dans les laboratoires hospitaliers. *Archives des Maladies Professionnelles et de l'Environnement*, 326-334.

Sigma-Aldrich. (2021, Mar 20). *Sigma-Aldrich*. Récupéré sur Millipore Sigma: https://www.sigmaaldrich.com/canada-english.html

Wilkinson, D., Rumsby, D., Babin, B., Merritt, M., & Marsh, J. (2004). The Results of a Canadian National Field Trial Comparing 1,8-Diazafluoren-9-one (DFO) with Ninhydrin and the Sequence DFO Followed by Ninhydrin. *Identification Canada Journal, 27*(3), 10-24.