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Managing Risk and Knowledge: Frameworks to Guide Knowledge-Enabled Technology Transfer

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Managing Risk and Knowledge: Frameworks to Guide Knowledge-Enabled Technology Transfer

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Abstract

Technology transfer is not only about the transfer of technology, but also about the transfer of knowledge, as evidenced by definitions of KM within the biopharma industry and beyond. However, knowledge transfer is often not well structured and its effectiveness – in particular for tacit knowledge (i.e., know how) – is an opportunity for improvement which can lead to many benefits. This article profiles recent research into the topic of improving knowledge transfer during technology transfer and presents several recently developed frameworks for improving such. The article furthermore explains how the frameworks can be co-deployed in support of robust knowledge transfer, supported by an illustrative case study.

1 Introduction

The introductory paper to this Level 3 special issue on steps toward digital transformation – **Knowledge enabled technology transfer** has covered in detail the important background for all four discrete articles. The points made in the Introduction are summarised below to help orient the reader:

- ICH Q10 provides guidance for the requirements of an effective pharmaceutical quality system (PQS), which includes recognizing quality risk management (QRM) and knowledge management (KM) as dual enablers to pharmaceutical quality.
- Technology transfer is not a one-time event as might be inferred from the ICH Q10 depiction of the PQS framework, but rather can happen many times in many different contexts across the pharmaceutical product lifecycle.
- Knowledge transfer during technology transfer is a risk to successful technology transfer and indeed to the goals of ICH Q10. Research suggests current effectiveness in the industry is an opportunity for improvement.

The sections following below present to the reader a series of frameworks which can be deployed to address the challenge of improving knowledge transfer during technology transfer.

2 Frameworks for Knowledge-Enabled Technology Transfer: One possible solution set

Recognising the importance of the transfer of knowledge across the pharmaceutical product lifecycle and in particular during technology transfer, the authors developed three frameworks over the course of their joint research study which can be applied to help guide knowledge-enabled technology transfer, and to more quickly realize the associated benefits. Understanding the role of QRM and the importance of knowledge in determining risk, the frameworks developed should be used in conjunction with the QRM process model [1], of which a version simplified by the authors shown below in Figure 1:

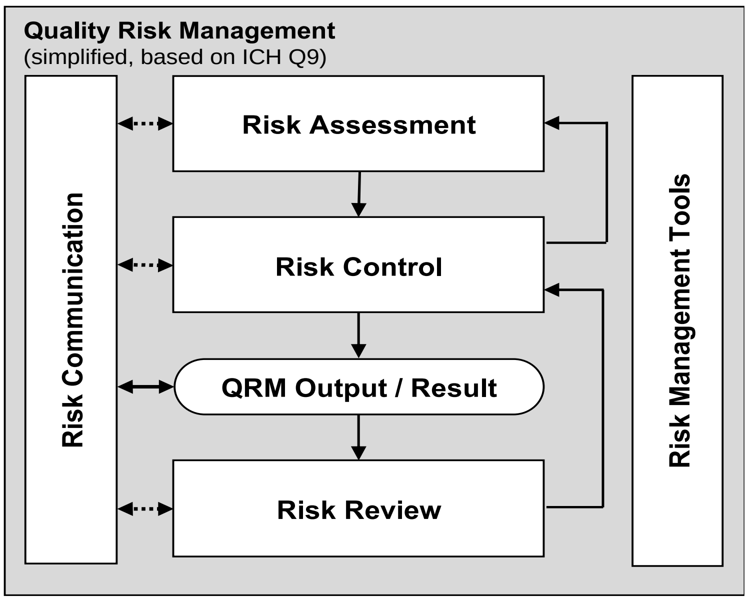

Figure 1 - The QRM Process Model (simplified) [1]

The frameworks developed to guide improvement of knowledge transfer effectiveness during technology transfer include the *Risk-Knowledge Infinity Cycle* (or *RKI Cycle*) and the *Knowledge Management Process Model*. Both of these can be applied through all the phases of the product lifecycle. The third framework developed, the *Knowledge Transfer Effectiveness Framework* (or *KT^E^ Framework*) is specifically designed to enhance knowledge transfer at technology transfer.

2.1 Framework Overview

Each of these three frameworks have been developed independently and published in different papers over the last few years. This Summer 2022 article presents each individual framework and demonstrates how they interact and be used collectively in support of a knowledge-enabled technology transfer. A brief introduction to each framework and supporting reference for further detail is as follows:

1. ***Risk-Knowledge Infinity Cycle* (*RKI Cycle*)**. This framework [2] is a framework to intentionally and methodically unite risk management and knowledge management, enhancing every PQS element, across every stage of the product lifecycle by ensuring the best knowledge is available to reduce uncertainty and inform risk management and risk-based decision making. The *RKI Cycle* is depicted in Figure 2.

Figure 2 - The RKI Cycle [2]

2. ***Knowledge Management Process Model***. This model [2] provides standard steps in the process of knowledge management to aid in the development of effective, robust and standardised KM approaches (e.g., KM strategies and plans, content management, taxonomy, search, knowledge capture and retention, tacit knowledge transfer, reflections, lessons learned, communities of practice, etc.). The *Knowledge Management Process Model* is depicted in Figure 3.

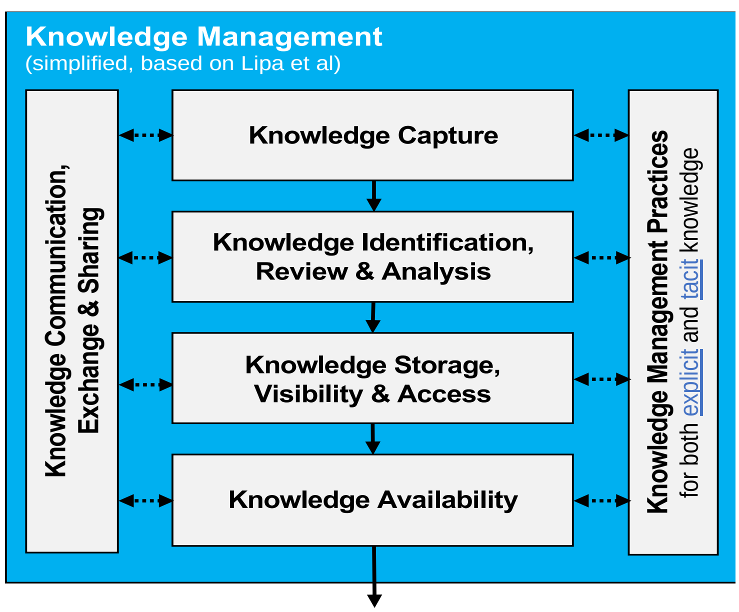

Figure 3 - The Knowledge Management Process Model (adapted) [2]

3. ***Knowledge Transfer Effectiveness (KT^E) Framework***. This framework [3] was intentionally developed to enhance knowledge transfer during technology transfer, following a simple 'plan-do-check-act' backbone, based on operational excellence practices. This steps in this framework are to plan for knowledge transfer (KT), execute KT, assess KT effectiveness, and deploy an action plan to ensure knowledge and learnings are shared forward (e.g., to control strategy) and backward (e.g., to upstream development). The *KT^E Framework* is depicted in Figure 4, and has been adapted in style representation only – the original concepts remain unchanged.

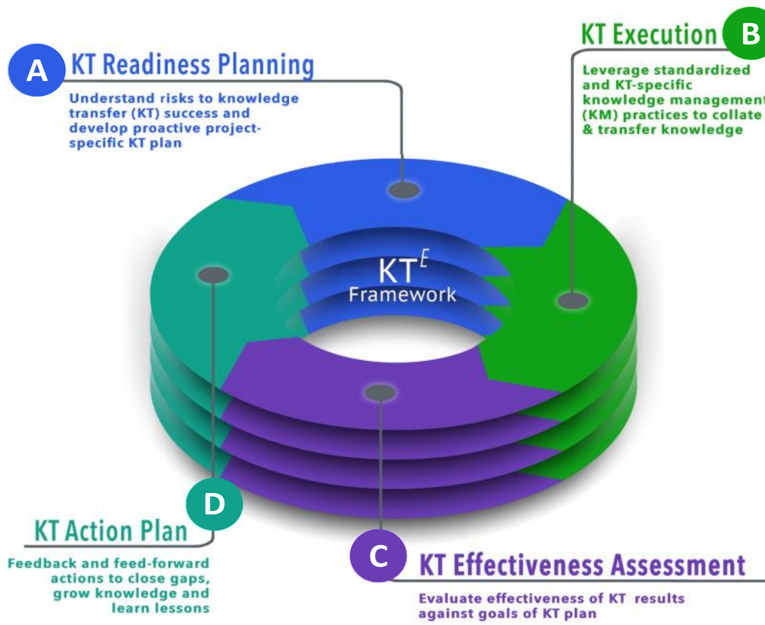

Figure 4 - The KT^E Framework (adapted) [3]

Figure 5 depicts these frameworks and how they overlay onto the PQS with the numbers corresponding to the descriptions above. The figure also depicts the bi-directional interdependency of technology transfer on knowledge management and quality risk management as established in ICH Q10 [4].

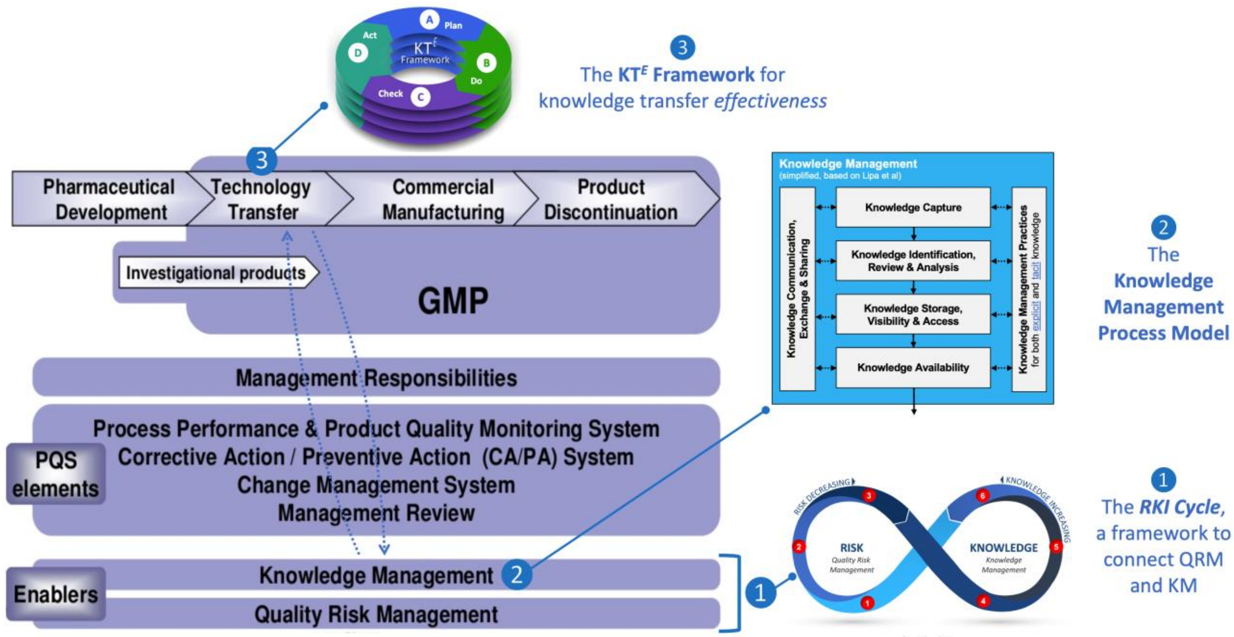

Figure 5 - Frameworks to enhance technology transfer knowledge transfer linked to the PQS

2.2 Framework Overview

To illustrate how these complimentary frameworks can be co-deployed as a robust solution to guide knowledge-enabled technology transfer, Figure 6 provides a summary of the progression from applying the *RKI Cycle*, supported by *QRM process model* [1] and *Knowledge Management Process Model* as QRM and KM are intrinsically linked [2], [5], and finally the *KT^E Framework*.

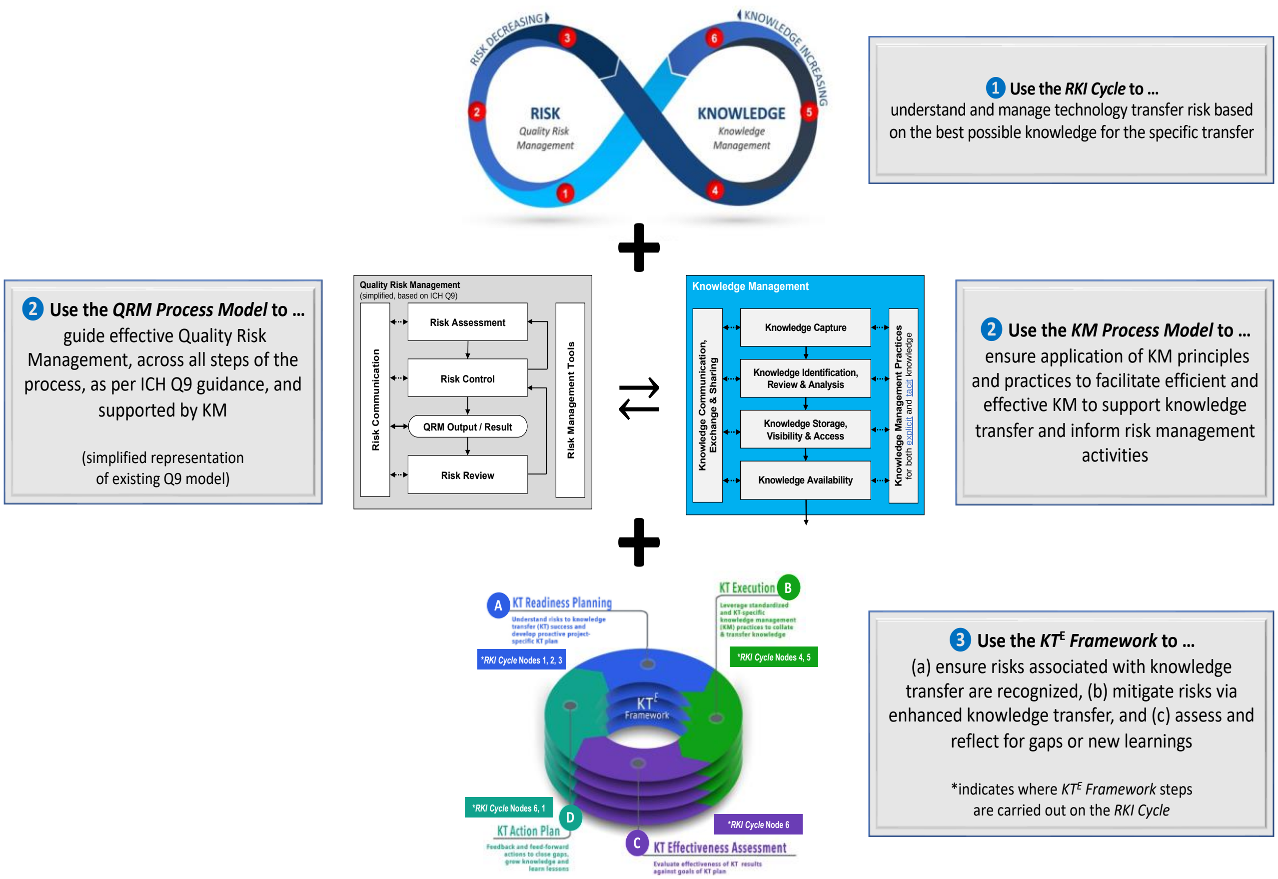

Figure 6 - Complimentary frameworks to support knowledge-enabled technology transfer

In summary:

- The ***RKI Cycle* guides the macro technology transfer process** of ensuring effective and connected risk and knowledge management (i.e., to inform decision making and the goals of the PQS)
- The ***QRM Process Model* guides effective risk management**
- The ***Knowledge Management Process Model* guides knowledge management**, to ensure existence of and application of standard and effective KM practices suitable for technology transfer
- The ***KT^E Framework* is used to tailor the *RKI Cycle* to meet the needs of the particular technology transfer and associated challenges and risks**. As further definition, the *KT*E *Framework* depicted in Figure 6 indicates which of its four steps (i.e., A (or 'Plan'), B (or 'Do'), C (or 'Check') or D (or 'Act') are carried out at specific nodes of the *RKI Cycle*.

In order to visualise how the frameworks are co-deployed, with the underpinning premise that knowledge and risk are intrinsically linked, the authors mapped the *KT^E Framework*, the *QRM Process Model*, and the *Knowledge Management Process Model* onto the *RKI Cycle*.

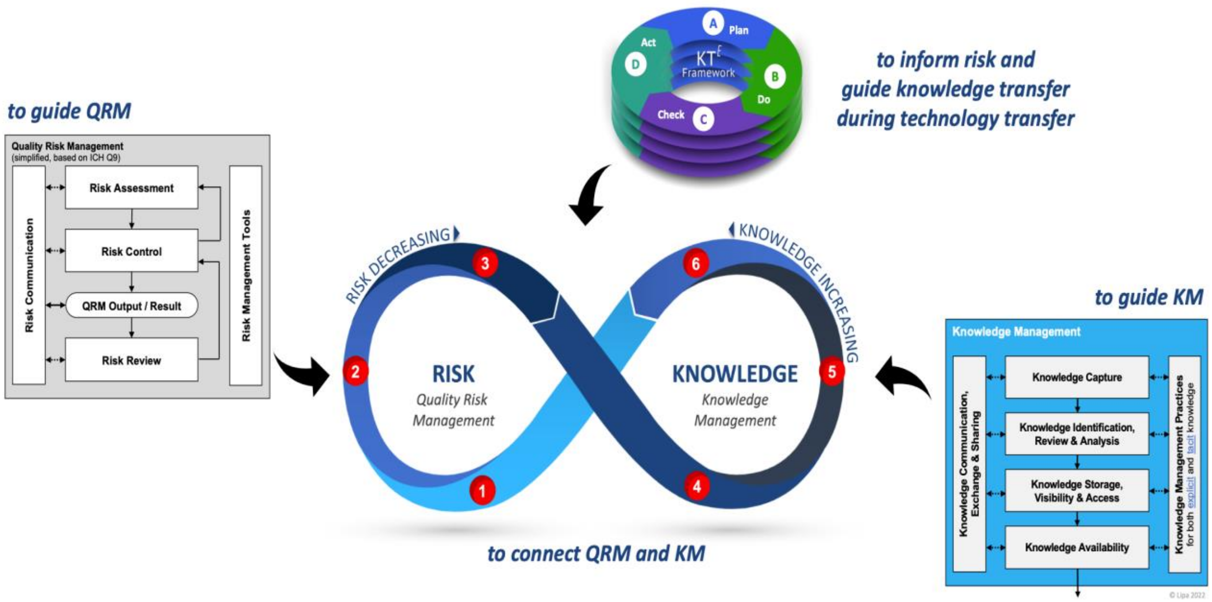

Figure 7 - Frameworks for knowledge-enabled technology transfer in unison

In aggregate, these frameworks can enable robust, effective risk management and knowledge transfer in support of a technology transfer project, while also creating a basis to realize the goals of ICH Q10 through minimizing risk and preserving knowledge.

3 Case Study

To illustrate how these frameworks work together, the following case study is presented.

Scenario

The scenario is for the technology transfer of an innovator vaccine product. The product has been designated as a breakthrough therapy, so all timelines for development, technology transfer and launch have been accelerated, and there is a push to get the product on the market. This is a new product introduction, from a development and commercialization facility in the USA (sending site) to an in-house manufacturing site in Asia (receiving site). The product is a multi-valent vaccine consisting of multiple serotypes. The receiving site has experience with biologics manufacturing, but not with vaccines. Furthermore, given a highly competitive labour market, talent turnover is high so the level of experience of personnel cannot be guaranteed.

In each of the following sections, one for each node on the *RKI Cycle* starting at node 1 as initiation point to prepare for the risk assessment(s), the baseline guidance for the *RKI Cycle* are shared followed by the additional considerations specific to technology transfer informed by the *KT*^{E} *Framework*.

3.1 Node 1 – Ensure the best available knowledge flows into QRM activities

Baseline *RKI Cycle* guidance	Use knowledge mapping or other techniques to ensure all requisite knowledge is available for technology transfer risk assessment • Informed by regulatory and industry guidance and local procedure • Include important tacit knowledge (e.g., know how, experience, history, etc.) • Include perspectives of both sending and receiving site (e.g., on availability of knowledge or who SMEs are – what may be obvious to the sending site may not be to the receiving site) • Prior knowledge (e.g., platform knowledge, lessons learned, knowledge from similar products / sites, continuous improvement of technology process, etc.)
Additional *KT*^{E} considerations	Anticipate risks specific to this technology transfer, and any additional knowledge required. For this case, this could include preparing for the following risks: • Accelerated development timeline (less experience with process, limited knowledge base) • Product type is new to the receiving site, and while the individual serotypes are similar this also poses a risk as there are minor differences which can easily be overlooked • Time pressure for accelerated launch, given breakthrough therapy status • Staff at receiving site is not highly experienced • Significant time zone change (e.g., experts may not be available in real time, lag time in getting documents, etc.) • Differences in culture (US to site in Asia)

3.2 Node 2 – Manage risk vis the QRM process

Baseline *RKI Cycle* guidance	Per the PDA Technical Report 65, Technology Transfer [6], *"The purpose of QRM applied to technology transfer is to review the proposed transfer of the manufacturing process to ensure that potential risks to the patient regarding the quality, safety, and efficacy of the drug product have been identified and are adequately controlled"* perform appropriate risk assessment(s) (e.g., stage of technology transfer planning and/or process readiness), using the *QRM process model* as a guide.
Additional *KT^E* considerations	Include additional risks for the technology transfer in the risk assessment, for which knowledge transfer may be at risk, and/or for where enhanced knowledge transfer may mitigate risks.

3.3 Node 3 – Use KM practices to capture the knowledge outputs of QRM

Baseline *RKI Cycle* guidance	Use KM practices and principles to recognize and capture valuable tacit knowledge from QRM activities, including decisions and supporting rationale, alternatives considered, what was known at the time, etc.
Additional *KT^E* considerations	Develop a *knowledge transfer plan*, outlining activities for knowledge transfer, including: • Effective and efficient knowledge transfer for technology transfer project success and long-term manufacturability • Mitigate risks identified during risk assessment (e.g., capability building for receiving site personnel) • Opportunity for learning from this technology transfer (e.g., to ensure a robust control strategy and to identify areas for further process characterization) • Information technology systems deployed at each site, including their use and interoperability during technology transfer

3.4 Node 4 – Ensure means to acquire, grow, capture & retain new knowledge

Baseline *RKI Cycle* guidance	Embed KM practices 'in the flow' of technology transfer processes and governance to ensure new knowledge is captured and retained, e.g., • Build tracking of knowledge transfer plan metrics into overall project monitoring • Embed KM practices into technology transfer milestones (e.g., codify use of after-action review at stage gate reviews) • Train personnel on good KM principles • Establish KM standards (e.g. guidance on where to store content, document trackers, decision trackers) and embed these into technology transfer standard process
Additional *KT^E^* considerations	The same general activities to embed KM practices 'in the flow' of technology transfer apply. Consider additional activities for this case and associated risks which could include: • "What if" assessment [7] as means for further risk identification and assessment of understanding and assumptions, and to explore for additional documents and knowledge to be transferred • Pre-job briefs and post-activity reflections to create situational awareness and enhance tacit knowledge transfer for personnel (build into daily readiness and issue management processes) [8] • Use of critical knowledge retention practices, if personnel transition during the project and/or at the completion of the process • Use of digital technologies, such as a *digital product profile*, and the role they can play in accelerating data and knowledge transfer as well as better understanding the interaction between parameters and process development history (for additional detail, see the paper 3 in this special issue) • Use of emerging technology, such as augmented reality or virtual reality can be applied to enhance tacit knowledge transfer for improved capability and process understanding for receiving site (for additional detail, see the paper 4 in this special issue)

3.5 Node 5 – Manage knowledge via the KM process

Baseline *RKI Cycle* guidance	Informed by the *Knowledge Management Process Model*, establish and ensure normalized use of a suitable set of KM practices, inclusive of both explicit and tacit knowledge. In accordance with good practice [9], these KM practices should be robust, addressing facets of people, process and technology. Furthermore, these KM practices should be enabled by training, sponsorship, organizational change management, roles, metrics, and governance.
Additional *KT^E* considerations	Ensure KM practices are in place (and 'in the flow' of the process as per node 4). Additional KM practices are adapted or created as required as dictated by technology transfer project risks (e.g., use of enhanced tacit knowledge transfer techniques, digital product profile, augmented reality, etc.).

3.6 Node 6 – Ensure all knowledge is available to QRM, PQS processes and all business processes

Baseline *RKI Cycle* guidance	Through use of standard KM practices to capture and retain knowledge, these KM practices should be codified for use 'in the flow' of other processes to create a 'pull' signal for knowledge (e.g., future technology transfer, change management, investigations, validation, etc.)
Additional *KT^E* considerations	Perform an assessment of knowledge transfer versus the original knowledge transfer plan, and a lessons learned or after-action review exercise. Ensure all learnings and open issues are properly prioritized and dispositioned by suitable governance (e.g., items from lessons learned, pre-job briefs and post-activity reflections, anticipated learning during this technology transfer project). These new insights should be acted on in both a feed*forward* (e.g., to the control strategy or body of knowledge about the product and process), and feed*back* basis (e.g., to development, to the business process of technology transfer, etc.)

4 Conclusion

As this article illustrates, knowledge transfer is a critical element of a successful technology transfer, yet the current state effectiveness of knowledge transfer leaves room for improvement. Such improvement through a more effective knowledge transfer which ensures the knowledge discontinuity of technology transfer does not adversely impact cost, quality and product availability. Each of the frameworks presented herein can be used individually to guide risk management, knowledge transfer during technology transfer, or effective knowledge management practices, but can furthermore be co-deployed to take knowledge transfer to the next level for technology transfer.

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