From Concept to Market: Linking Research, Development and Production Activities

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Learning Objectives

1. Participants will be able to distinguish between *three* Methodologies (scientific research, engineering development, industrial production), and contrast the *three* States of Knowledge they generate.

2. Participants will be able to discuss examples of literature supporting each of the *nine* Activity Stages and *nine* Decision gates, and explain why Stages have multiple steps.

3. Participants will be able to name and describe at least one technical analysis tool and one market analysis tool relevant to each of the three Phases of activity.

Need to Knowledge Model*

A Prior to Grant Perspective for S&E R&D and Technological Innovation

**Learning Objective 1*

Range of Public Support for S&E Activity

- ***Grant-based Scientific Research*** – Exploration to discover new knowledge about physical world (NSF/NIH) – *Works well!*
- ***Sponsored R&D for Innovation*** – Application of S&E outputs for commercial exploitation intended to generate socio-economic impacts – *Lots of Problems!*
- ***Contract R&D for Production*** – Application of S&E outputs to deliver specified products with national value (DoD/DoE) – *Works well!*

Sponsored R&D Programs with Innovation/Impact intent

- **All US Agencies**: SBIR/STTR Programs.
- **NSF** – Engineering Research Centers (ERC); Industry/University Cooperative Research Centers (I/U CRC); Innovation Corps (I-Corp).
- **NIH** – Program on Public/Private Partnerships.
- **NIST** – Technology Innovation Program (TIP).
- **USDE** – Rehabilitation Engineering Research Centers (RERC); Field Initiated Development (FID).
- **Canada** – Natural Science and Engineering Research Council (NSERC); Canadian Institutes for Health Research (CIHR).
- **European Union** – Research Framework Programme; Competiveness & Innovation Framework Programme.

Innovation & Impact

- Traditionally, each sector defined terms in own narrow context, unconcerned with downstream market activities or broader societal benefits, comfortable in status quo budgets and paradigms. But that applecart is tipping . . .
- National Science Board (2012) – "*Innovation is defined as the introduction of new or significantly improved products (goods or services), processes organizational methods, and marketing methods, in internal business practices or in the open marketplace.*" (OECD/Eurostat, 2005).

“Translating Three States of Knowledge: Discovery, Invention & Innovation”

Lane & Flagg (2010)

Implementation Science

http://www.implementationscience.com/content/5/1/9

Clarification: 3 States of Knowledge

- Scientific Research methodology ►

  Conceptual Discovery

- Engineering Development methodology ►

  Prototype Invention

- Industrial Production Methodology ►

  Market Innovation

Discovery State

- ✓ Scientific Research methods create new to the world knowledge.
- ✓ Process – Empirical analysis reveals novel insights regarding key variables, precipitated by push/pull.
- ✓ Output – **Conceptual Discovery** expressed as manuscript or presentation.
- ✓ Legal IP Status – Copyright protection.
- ✓ Value – **Novelty** as first articulation of new concept as contributed to knowledge base.

Invention State

- ✓ Engineering Development methods combine and apply knowledge as functional artifacts.
- ✓ Process – Trial and error experimentation and testing demonstrates proof-of-concept, initiated through supply/demand forces.
- ✓ Output – **Prototype Invention** claimed and embodied as operational prototype.
- ✓ Legal IP Status – Patent protection.
- ✓ Value – **Novelty** of conceptual discovery **+ Feasibility** of tangible invention.

Innovation State

- ✓ Industrial Production methods codify knowledge in products/components positioned as new/improved.
- ✓ Process – Systematic specification of components and attributes yields final form.
- ✓ Output – **Market Innovation** embodied as viable device or service in a defined context, initiated through a commercial market opportunity.
- ✓ Legal IP Status – Trademark protection.
- ✓ Value – **Novelty + Feasibility** + **Utility** defined as revenue to company and function to customers.

Importance of Untangling Terms

- *Each Method has own rigor and jargon.*
- *Actors are trained and operate in one method and tend to over-value that method.*
- *Academic & Government sectors dominate "STI" policy at the expense of Industry – the only sector with time and money constraints. . .*
- *Methods are actually inter-dependent, while traditional dichotomies are all complementary factors supporting innovation outcomes.*

Way Forward: Integrate Conceptual but Differentiate Operational

- *Consider three distinct states:* Know role of Research, Development and Production methods in context of each project – plan and budget accordingly.
- *Engage Industry early:* Government/Academic projects intended to benefit society fail to cross gaps (death valley vs. Darwinian sea) to business & open markets.
- *Apply evidence-based framework:* Link three methods; Communicate knowledge in three states; Integrate key stakeholder who will determine eventual success.

Outputs/Outcomes/Impacts from R or D Methods are distant from Socio-Economic Impacts

Milestones	Research	Development	Production
Identify Opportunity	Knowledge Gap in Literature	Supply Push or Demand Pull	
Project Output	Journal Publication	Patent Issued	
Stakeholder Outcome	Discovery Use & Citation	Practice / License	
Claim Impact			Societal QoL & Industry Economic Stature

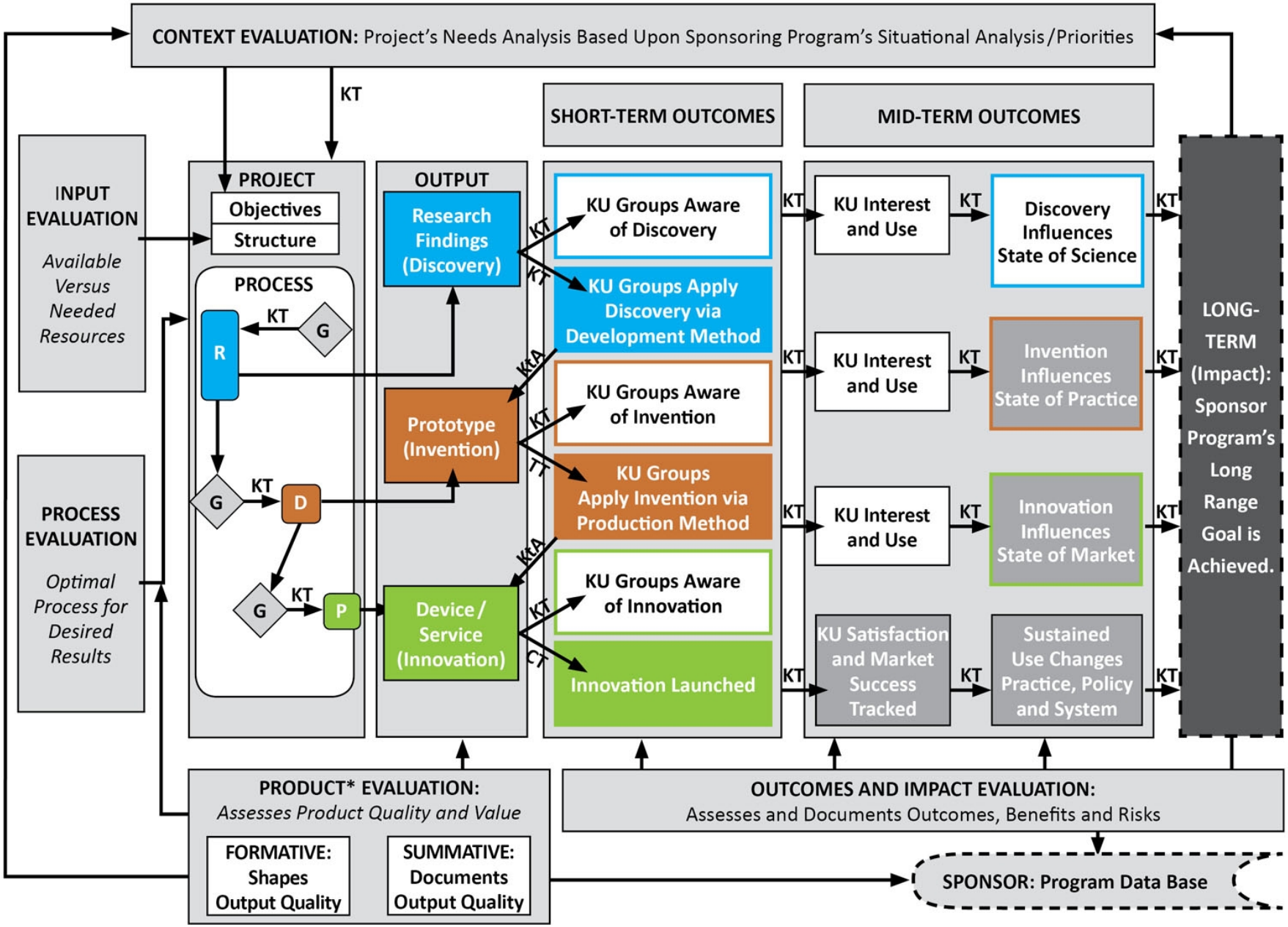
“Modeling Technology Innovation: How the integration of science, engineering and industry methods combine to generate beneficial socio-economic impacts.”

Stone & Lane (2012).

Implementation Science

http://www.implementationscience.com/content/7/1/44/

Figure 7. Planning and Evaluating Technology-Based R&D: Role of KT from Beginning to End



Elements of NtK Model

- Full range of activities includes 3 Phases, 9 Stages & Gates, Steps, Tasks and Tips.
- Supported by primary/secondary findings (scoping review of 250+ research and practice articles), and A/T case examples.
- Logic Model orientation – “Begin with the end in mind” (Stephen Covey), and work backwards through process to achieve it.

Evidence Milestones	*Research Discovery*	*Development Invention*	*Production Innovation*

Need to Knowledge (NtK) Model for Technological Innovations

Phases	Stages and Gates
Discovery (Research)	Stage 1: Define Problem & Solution
	👍 👎 ?
	Stage 2: Scoping
	👍 👎 ?
	Stage 3: Conduct Research and Generate Discoveries → Discovery Output!
Invention (Development)	*Communicate Discovery State Knowledge* 👍 👎 ?
	Stage 4: Build Business Case and Plan for Development
	👍 👎 ?
	Stage 5: Implement Development Plan
	👍 👎 ?
	Stage 6: Testing and Validation → Invention Output!
Innovation (Production)	*Communicate Invention State Knowledge* 👍 👎 ?
	Stage 7: Plan and Prepare for Production
	👍 👎 ?
	Stage 8: Launch Device or Service → Innovation Output!
	Communicate Innovation State Knowledge 👍 👎 ?
	Stage 9: Life-Cycle Review / Terminate? 👍 👎 ?

Need to Knowledge (NtK) Model

- ***Orientation*** – Actors engaged in innovation "need to know": Problem/Solution; Methods/Outputs; Stakeholder roles; and Goal in context of beneficial socio-economic impacts.
- ***Integration*** – Product Development Managers Association (PDMA) New Product Development practices (implementation); Canadian Institutes of Health Research (CIHR) Knowledge to Action Model (communication).
- ***Validation*** – Stage-Gate structure populated with supporting evidence (1,000+ excerpts) from scoping review of academic and industry literature , along with links to tools for completing recommended technical and market analyses .

Need to Knowledge Model

http://kt4tt.buffalo.edu/knowledgebase/model.php

NtK Model Key Findings

Evidence base of Academic and Industrial Literature since 1985

Learning Objective #2

Objective 2: Lessons from Literature

- Literature from both Industry and Academia converge on “Best Practices” in New Product Development, where due diligence supplants *ad hoc* approaches and tests assumptions.
- Steps/Activities/Tips all point toward Best Practices validated through numerous iterations under a variety of field conditions.
- Stage/Step level activity do not require a linear progression, but Decision Gates cannot be properly addressed without them.

PDMA NPD Handbooks

Stage/Gate Structure

CIHR KTA Model

Scientific Method

Need to Knowledge (NtK) Model

Literature Review to Identify Supporting Evidence

Keyword Searches: **12,692 articles**

Inclusion Criteria Applied: **298 articles**

Review of Abstracts for Relevance: **212 articles**

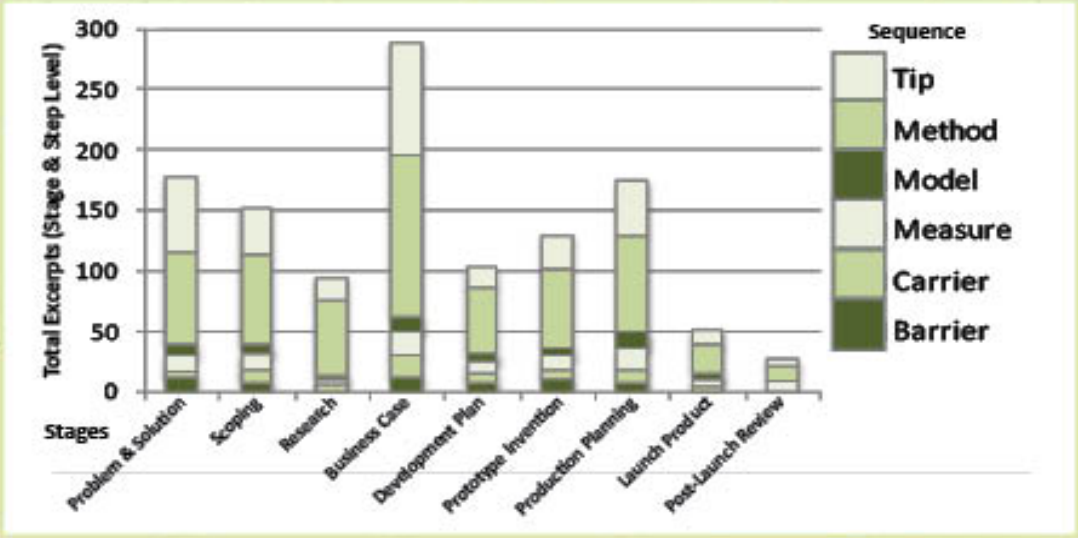
Review of Articles for Key Lessons: **1208 excerpts**

Information Gathered from Each Article

- Citation, Annotation, Potential User Groups
- Relevant work settings, Study methodology
- Excerpts classified by:
  - Placement within NtK model
  - Type of information: method, model, measure, barrier, carrier or tip
  - Primary Excerpts: Author's conclusions
  - Secondary Excerpts: Paraphrased conclusions from prior publications

NtK Model Components

- **3 Phases -** represent activities/decisions to generate outputs in three states
  - **9 Stages and 9 Gates** (537 excerpts)
  - **58 Steps** (674 excerpts)
  - **70 Tips** (71 excerpts)
- **3 KTA cycles** (264 excerpts) - stakeholder mechanisms for moving knowledge from one state to another



TOOLS
Embedded at Step level

RESOURCES
- Publications
- Tech Transfer Template
- Modules/Guides

CASE EXAMPLES
Embedded at Stage level

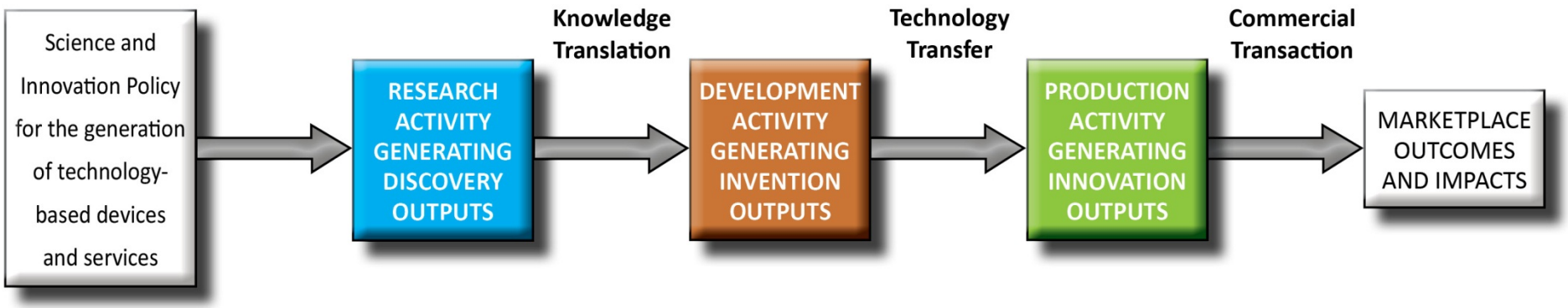
Knowledge Base

- Search for citations or excerpts
- Search by: Keyword, Knowledge User Group or Settings

In the past year, NtK Model Used/Noted by:

- PDMA - The Source
- Technology Transfer Tactics
- NIDRR Grantees
- AAATE, ATIA, CIHR

Knowledge Communication – 3 Strategies for 3 States



Delivering Solutions to Problems involves progress across three Knowledge States

Research ⟶ ***Discovery*** ⟶**Translation** ⟶ **Utilization** ↓

Development⟶ ***Invention***⟶ **Transfer**⟶ **Integration** ↓

Production ⟶ ***Innovation*** ⟶ ***Transaction*** ⟶ Lif**ecycle** ↓

Evidence from Scoping Review

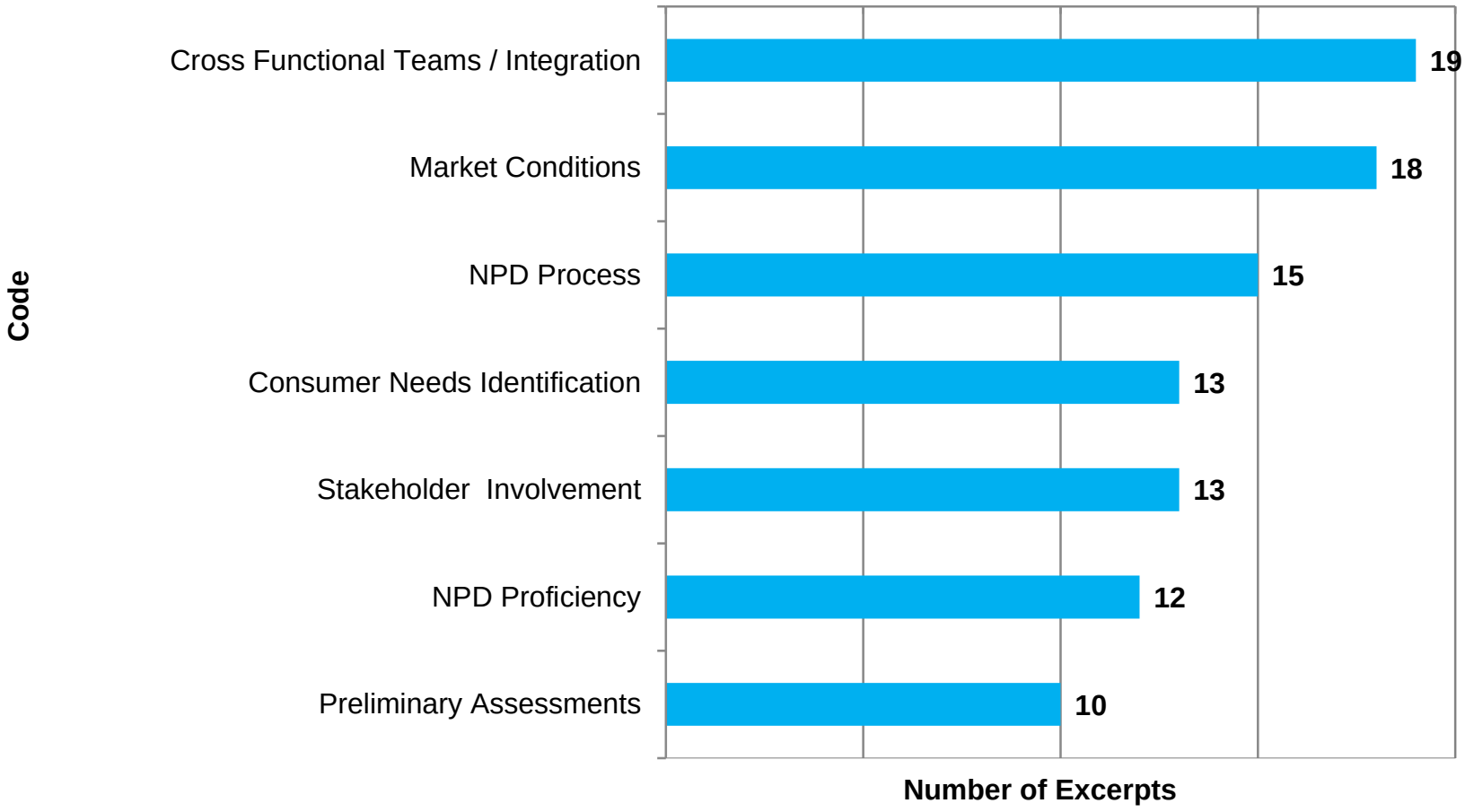
- *Literature Search; Scoping Review & Narrative Synthesis.*
- *Over 800 excerpts from over 200 academic and industry journal articles substantiate stage/gate model.*
- *Excerpts cluster differently for each Phase of R/D/P.*
- *Review aggregated findings: http://kt4tt.buffalo.edu/knowledgebase/research.php?model=3*

Search Evidence Base

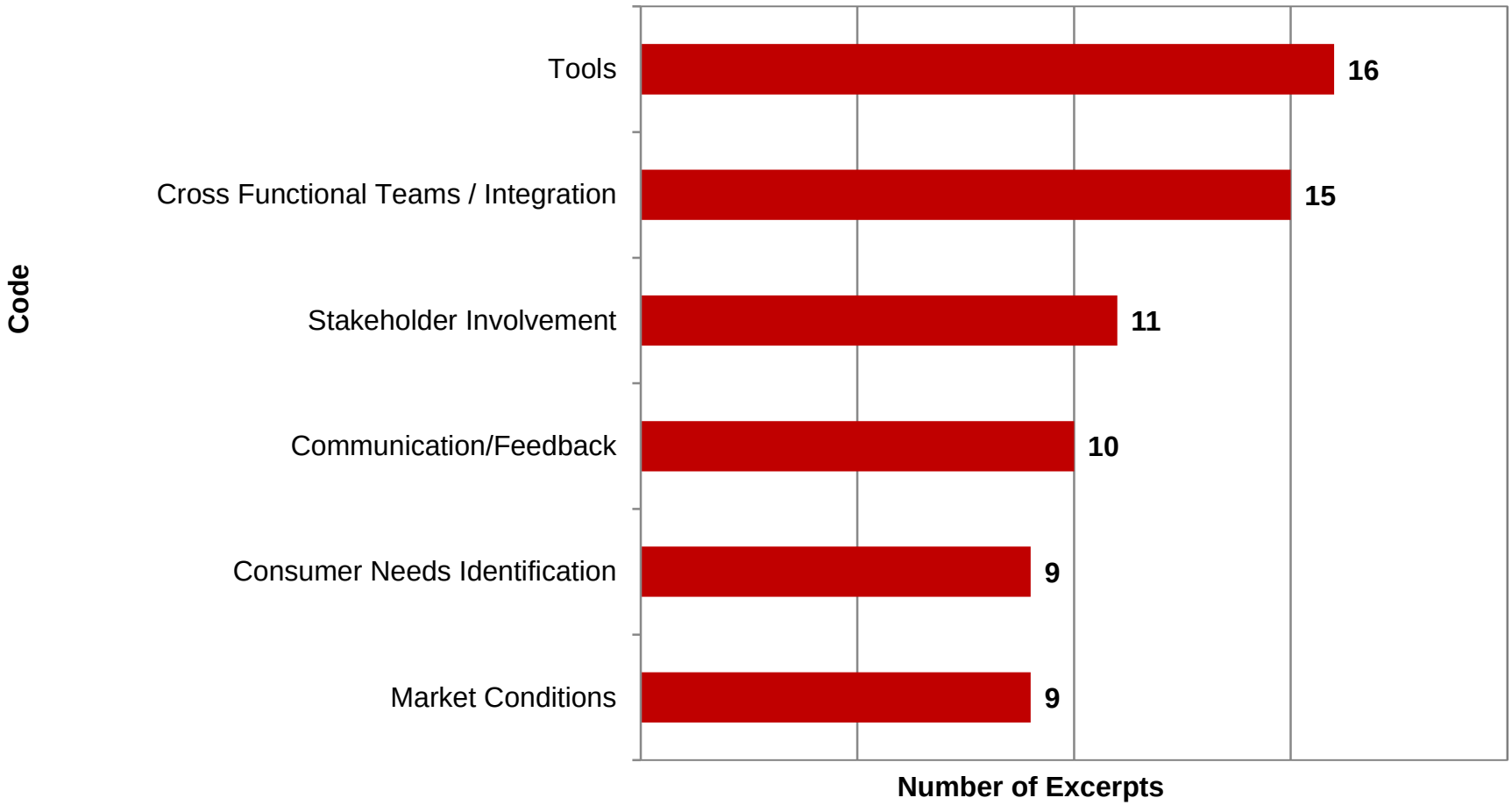
- *Search evidence base by keyword:*

http://kt4tt.buffalo.edu/knowledgebase/search.php

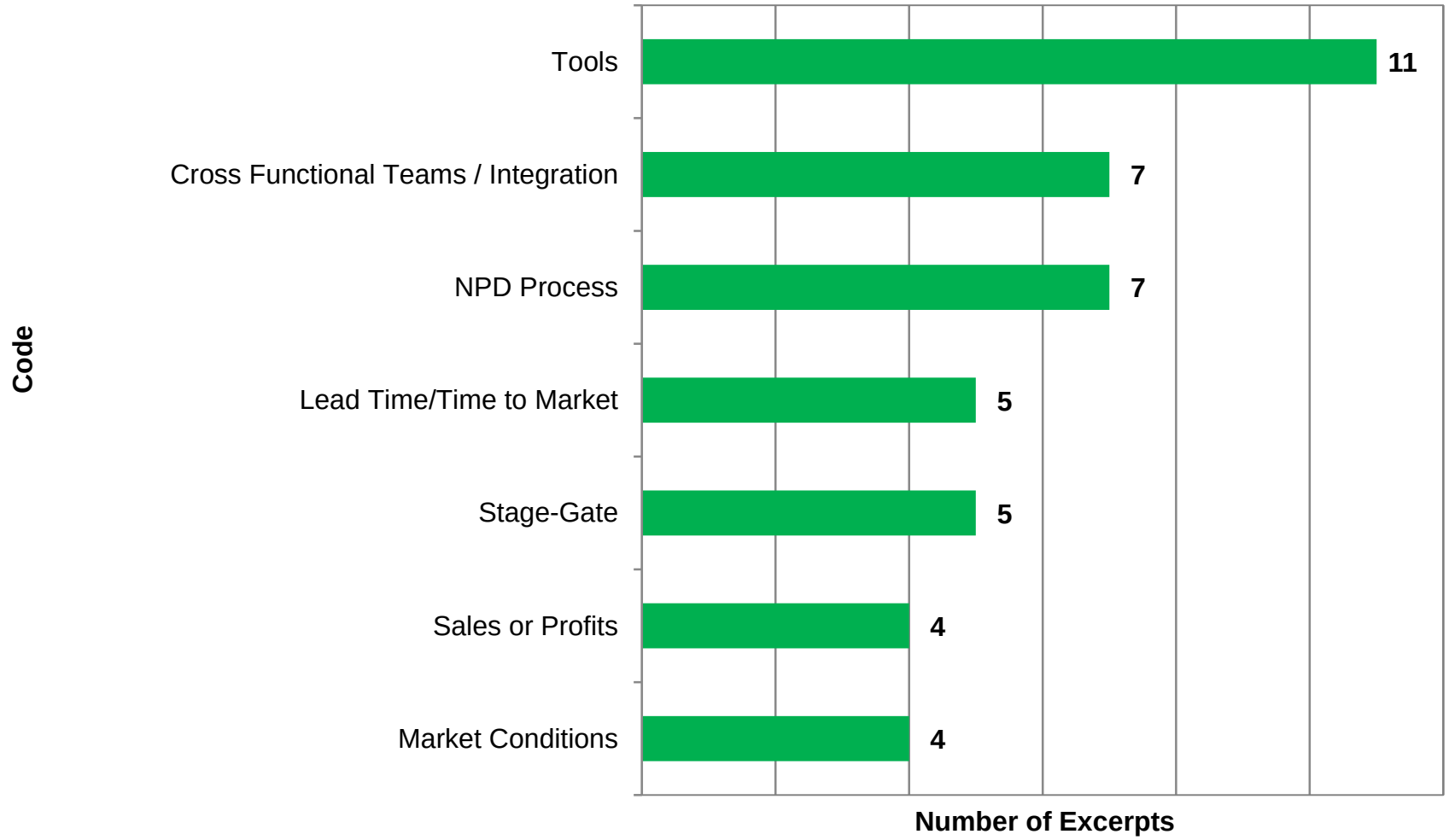
Number of Excerpts by Code in the Research/Discovery Phase



Number of Excerpts by Code in the Development/Invention Phase



Number of Excerpts by Code in the Production/Innovation Phase



NtK Model's Toolbox

Tools for Technical, Marketing and Customer Analyses

Learning Objective #3

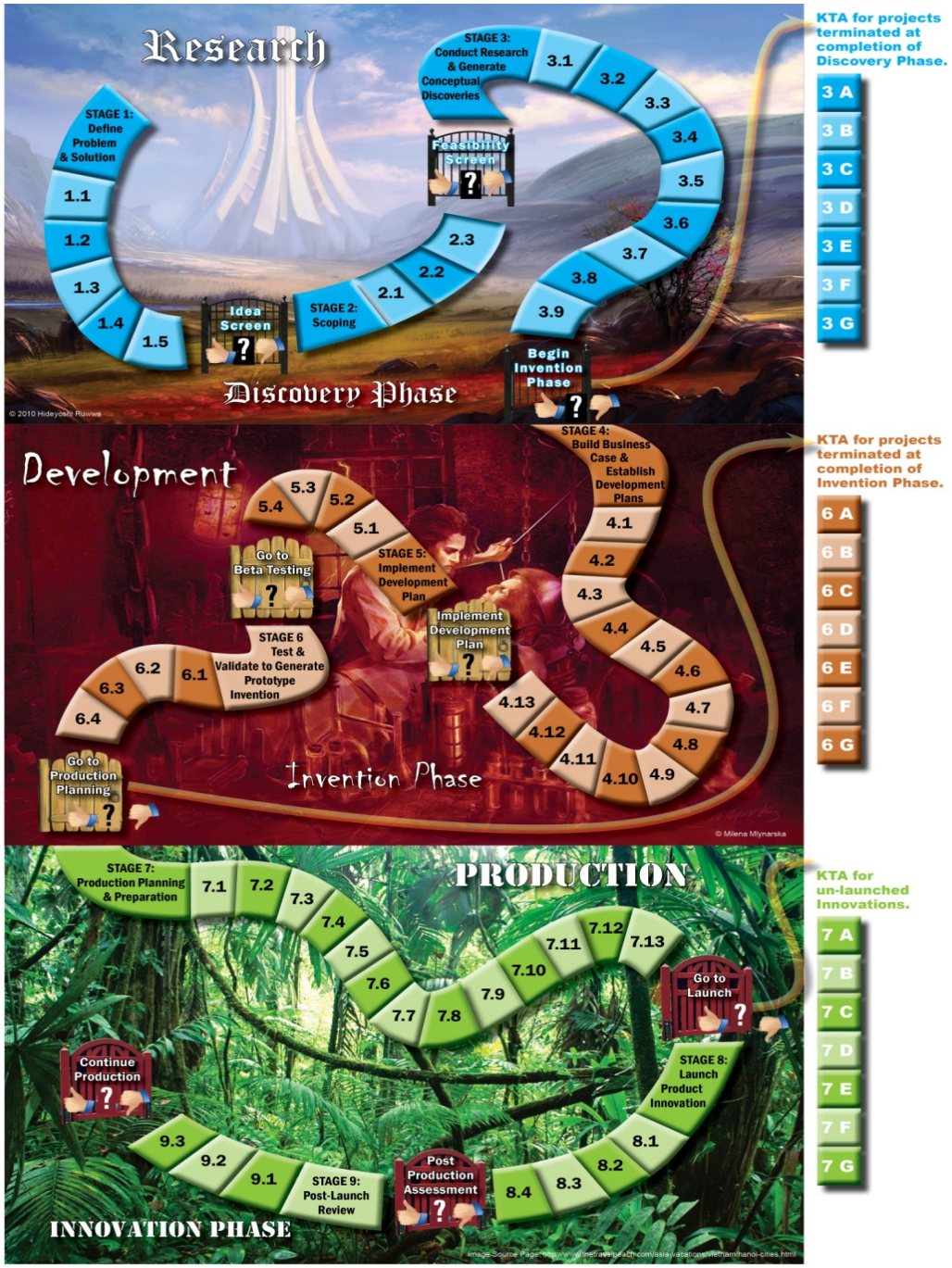
Objective 3: Requirements for Technical & Marketing Analysis

- Analyses are required throughout all three Phases, while Grantees are only familiar with a sub-set of them.
- Technical, market and customer analyses address three different yet equally critical issues for technological innovation.
- Knowing what you don’t know but need to do is critical to creating a successful team.

Knowledge Translation
KT4TT
Technology Transfer

“Gamification” of Technological Innovation

Progress through three Methods of Knowledge Generation, and the effective Communication of three Knowledge States, may be circuitous and iterative, punctuated and prolonged, risky and unpredictable, yet still be planned, implemented and accomplished through the deliberate and systematic efforts of key stakeholders.



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NtK Model's Toolbox

Go to tools for Technical, Marketing and Customer Analyses

http://kt4tt.buffalo.edu/knowledgebase/model.php

Summary: NtK Model Utility

- Clarifies processes and mechanisms underlying technology-based Innovation, by integrating academic & industry literature.
- Establishes linkages between three distinct methods and their respective knowledge outputs for implementation/communication.
- Offers structure to sponsors & grantees for program/project planning, implementation, monitoring and evaluation.

Summary: NtK Model Value

- **Technology Grantees:**
  - Proposal structure – Review Panel liked.
  - RERC Tech Transfer/ SBIR Phase III Plans.
- **Program Sponsors:**
  - Assess proposals; Track progress.
  - Compliance enforced – Funding continuation?
- **Organizations:**
  - PDMA's "The Source"; Tech Transfer Tactics;
  - CIHR; CEUD; DIT; ATIA; AAATE.

Knowledge Translation
K T 4 T T
Technology Transfer

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