



CTA in E/Affect Stage One Report

March 2023



INTRODUCTION

Improving personnel performance is perhaps the most critical requirement for the success of any organization. Particularly in high-stakes, dynamic environments, the workforce must be equipped with knowledge and skills—the cognitive tools—to do their job effectively, efficiently, and safely.

Unfortunately, many organizations underachieve because they lack their own set of tools for understanding and enabling proficient cognitive performance.

Cognitive Task Analysis (CTA) is a proven—though underused—suite of methods that get at expert performance. CTA unpacks how experts think—findings that in turn can be used to fill knowledge gaps, reduce risks, and improve proficiency.

By focusing on the expertise, CTA can serve as an engine to boost performance in workers, organizations, and even entire industries. Realizing such performance gains has the potential to create tangible, societal-level effects, including productivity and the earning potential of an expertise-charged workforce.

Sponsored by Schmidt Futures, the NDMA is coalescing experts in CTA to demonstrate this potential through our *CTA in E/Affect Initiative*.

Stage One of the *Initiative* welcomed submissions of case studies from practitioners applying CTA in a variety of domains. As this report demonstrates, these submissions strongly support the return on investment for the application of CTA methods, showcasing the benefits that CTA has brought to organizations in many diverse industries.

As you read about these success stories, think about what CTA can do for you and your workforce.

CONTENTS

KEY TAKEAWAYS	4
CHAPTER 1: WHAT IS CTA?	6
CHAPTER 2: CASE STUDIES	8
KNOWLEDGE MANAGEMENT	9
INSTRUCTIONAL SYSTEM DESIGN	11
COGNITIVE SYSTEMS ENGINEERING	17
CONCLUSION	19
CTA IN E/AFFECT SUBMISSIONS	20

Visit naturalisticdecisionmaking.org for an interactive version of this report.

KEY TAKEAWAYS

1

CTA IS CREATING VALUE IN DIVERSE INDUSTRIES.

- Healthcare
- Defense and Security
- Biotechnology Manufacturing and Shipping
- Elite Performance Sport/Coaching
- Military
- Financial Services Employment Support
- Petrochemical Engineering
- Crime Scene Examination
- Prospect Vetting
- Social Services
- Visual Automotive Damage Assessment
- Child Welfare
- And more...

2

MANY CTA METHODS ARE BEING PUT TO USE.

- Critical Decision Method
- Team CTA
- Applied Concept Mapping
- Knowledge Audit
- Goal-Directed Task Analysis
- Concepts, Processes and Procedures
- Precursor, Action, Result, Interpretation
- Task Diagrams Cognitive Demands Table
- And more...

3

CTA IS ENABLING A SPECTRUM OF APPLICATIONS.

- Training programs
- Simulation exercises
- Instructional design curriculum
- AI system development
- Mental model refinement
- User Journeys and UI/UX designs
- Organizational redesign
- And more...

4

CTA IS AT WORK GLOBALLY.

- United States
- United Kingdom
- Germany
- Taiwan
- Romania
- Singapore
- Philippines
- Indonesia
- Thailand
- And more...

KEY TAKEAWAYS

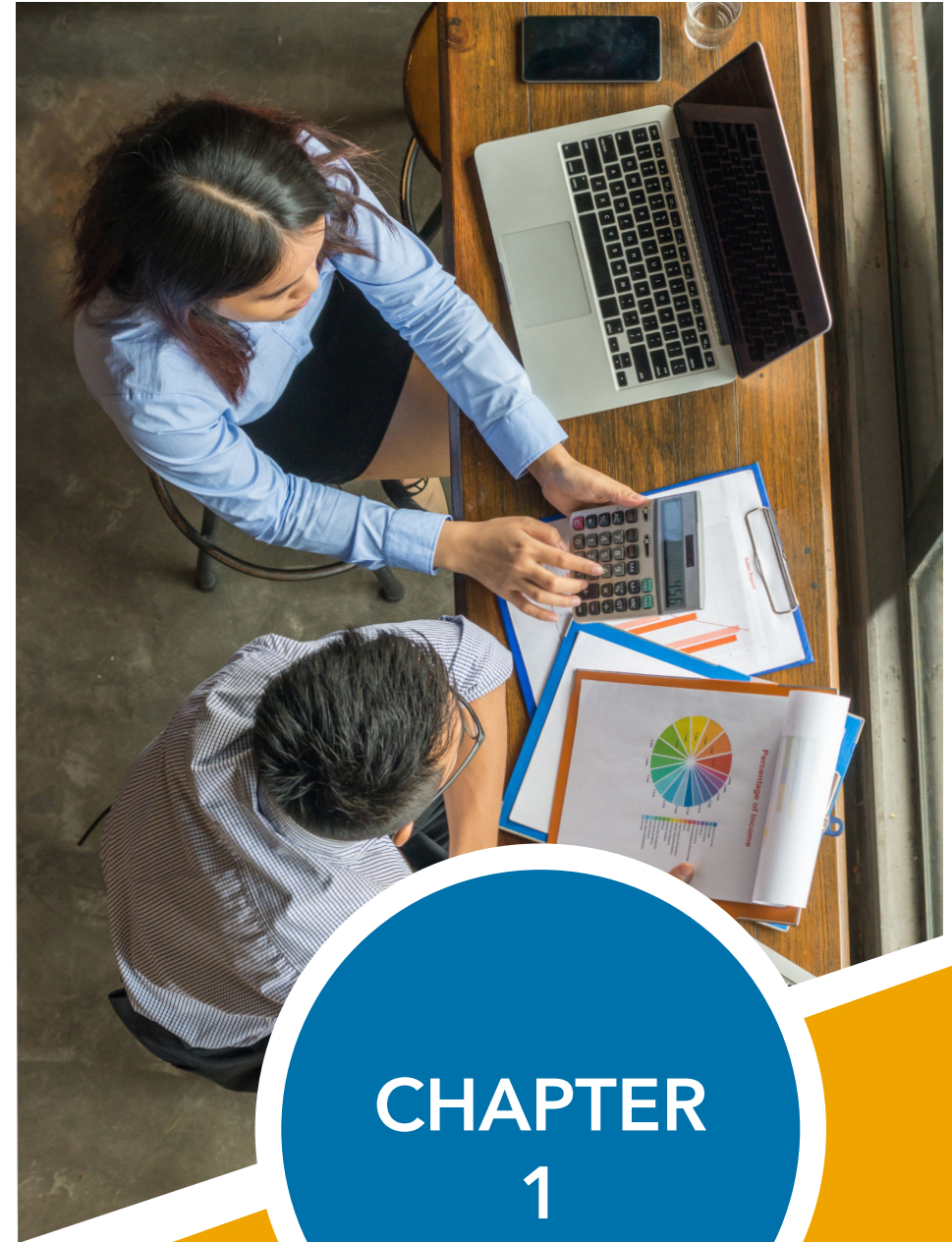
5

THE RETURNS ON INVESTMENT IN CTA ARE SIGNIFICANT.

- Decrease Training Time
- Olympic & Paralympic Medals
- Reduced Backorders
- Heightened Recognition Skills
- Rapidized Onboarding
- Reduced Errors
- Increased Valuation
- Increased Preparedness
- New Tool Designs
- Decrease in False Alarms
- World Records
- Enhanced Analytic Abilities
- Hastened Hiring Decisions
- Reductions in Cost
- New Corporate Functions
- Policy & Culture Change

WHAT IS CTA?

*CTA practitioners
“get inside the heads”
of performers to reveal the
nature of their expertise*



CHAPTER 1

WHAT IS CTA?

Cognitive Task Analysis is a toolkit used by NDM researchers and practitioners to understand proficient performance and how people achieve expertise.

Studies by NDMA members have found that traditional training programs often cover only a fraction of the skills that workers actually need to succeed in a given role.

CTA practitioners “get inside the heads” of performers to **reveal the nature of their expertise**, such as how experts:

- Make accurate decisions
- Make sense of data
- Avoid or recover from mistakes
- Create efficiencies
- Manage risk
- Adapt to changing conditions
- Trade-off resources.

Such findings can be translated into learning experiences and tools that accelerate the achievement of expertise in others—acceleration that has been demonstrated empirically.

CTA offers many use cases for improving performance through application of findings, including:

- Knowledge management: Capturing the knowledge of workers with key knowledge and skills so that novices can accelerate their own expertise;
- Instructional system design: Ensuring that training programs are based on what workers actually need to know and be able to do; and
- Cognitive systems engineering: Designing tools to support proficient performance and augment human capabilities.

With CTA, performance improvements come rapidly, reduce the gap in performance between experts and novices, and can change the trajectory of entire organizations.



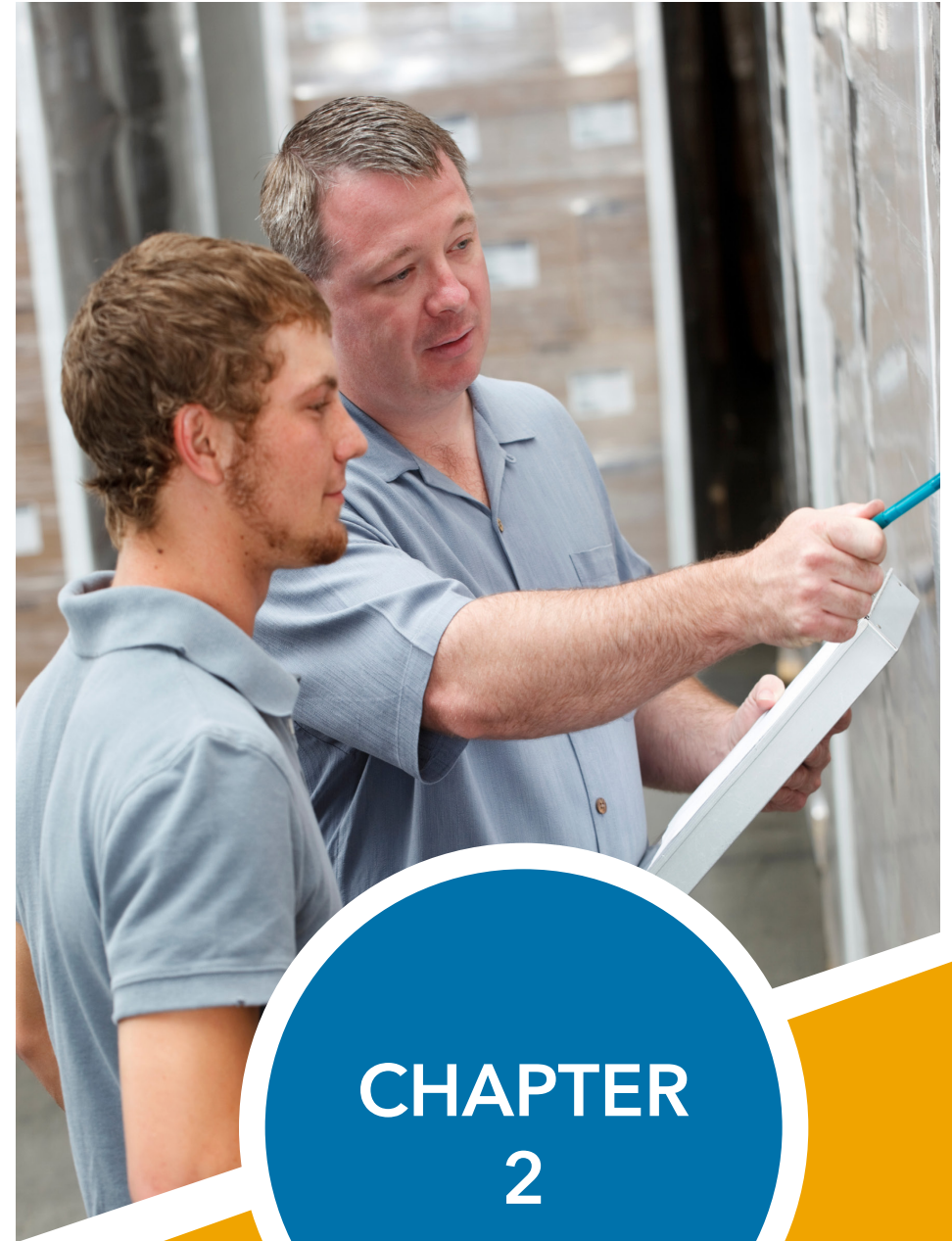
The diversity of methods, applications, domains, geographic locations, and outcomes in CTA research supports the usefulness and applicability of CTA in all kinds of real-world environments.

CASE STUDIES

KNOWLEDGE
MANAGEMENT

INSTRUCTIONAL
SYSTEM DESIGN

COGNITIVE SYSTEMS
ENGINEERING



CHAPTER 2



KNOWLEDGE MANAGEMENT

Capturing the knowledge of workers with key knowledge and skills so that novices can accelerate their own expertise.



KNOWLEDGE MANAGEMENT

Employment Support

This study used Applied Cognitive Task Analysis and the Critical Decision Method to understand how highly effective employment support advisers operate to identify some of the core mindsets, rules of thumb, and other 'workarounds.' Task diagrams, cognitive demands tables, insight stories and extracts from the Knowledge Audit interviews were produced and shared via a 60-page report. As a result, the sponsoring organization used the findings to reconsider a larger change to the roles and responsibilities of employment support professionals as part of an innovative, transformative re-think.

Petrochemical Engineering

After assessing organizational needs via a pilot study, this organization briefed and trained a diverse range of engineering employees on how to conduct Applied Cognitive Task Analysis with the goal of eliciting and sharing engineering expertise. The study focused on accurately capturing individual cognition to maintain continuous knowledge transfer within this highly qualified workforce. The organization went on to build its own in-house training presentations, produced cognitive demands tables, and developed a Tips Guide for ACTA. Furthermore, the workplace developed a common language to 'think like an expert' and enhanced knowledge transfer and communication with early career and novice employees.

"'Seeing the big picture' and 'tricks of the trade' are often taken for granted by experts. Eliciting these aspects adds power to the technique as it is not just applicable to purely technical challenges, but to most things we do."

- Petrochemical Engineer Professional



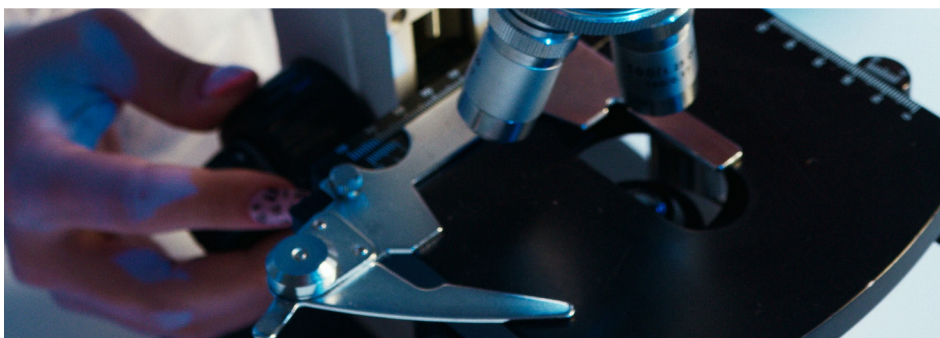


INSTRUCTIONAL SYSTEM DESIGN

Ensuring that training programs are based on what workers actually need to know and be able to do.



***“The results have been game changing, making us a prime acquisition target compared to our competition.”
- Biotechnology Manufacturing and Shipping Manager***



INSTRUCTIONAL SYSTEM DESIGN

Clinical Health Care

This study used a problem-solving decision framework to create an instructional design curriculum to achieve mastery in recognizing and managing hereditary colorectal cancer and familial colorectal cancer. The study used a collection of de-identified authentic clinical cases and images of varying complexity to simulate common clinical scenarios for learners to practice decision making with feedback and create mental representations and maps for these conditions. At the end of the course, all learners met or surpassed the Minimum Passing Standard, and the mean scores significantly increased from pretest to the initial post-test and from the initial post-test to the final post-test.

Biotechnology Manufacturing and Shipping

This manufacturing company utilized Team Cognitive Task Analysis, Critical Decision Method, and Applied Concept Mapping to understand and combat problems with on-time delivery. The study targeted front line production workers as the critical Subject Matter Experts for solving this problem. Researchers designed a FutureView™ Rehearsal exercise for 120 front line lab workers in manufacturing based on the results of the Cognitive Task Analysis. This led the teams to insights into the work practices and decisions that were leading to the company's problems. The company had no significant backorder problem within 3 months of doing the exercise and implementing the solution discovered in the rehearsals.



“ACTA is a valuable asset in the examination of performance and as a reflective tool to shape an individual’s professional learning.”

- High Performance Sport and Elite Coaching Customer



INSTRUCTIONAL SYSTEM DESIGN

Sepsis Recognition in Children

This study conducted 14 Critical Decision Method interviews with four novices (interns), four senior trainees (senior residents), and six faculty (expert) physicians. The interviews yielded 23 real-world incident accounts, which were analyzed for cue recognition. The findings were used to inform a set of six complementary training scenarios that combined sepsis-related cues in a variety of contexts. A validation study showed compelling evidence that experienced physicians were more likely to recognize sepsis in the simulated scenarios than residents—suggesting that the scenarios provided practice at thinking like an expert in realistic, challenging situations.

High Performance Sport and Elite Coaching

This project conducted Applied Cognitive Task Analysis for the purpose of professional development and the creation of Shared Mental Models among elite coaches, sport scientists, and practitioners within the UK high-performance system. The study resulted in coaching education resources, the development of SMMs across a high-performance management team, and enhanced understanding of knowledge, cognition, and skills needed to execute tasks within athletic performance. This research contributed to one Olympic medal and Olympic Record, seven Paralympic medals and four World Records at the Tokyo Games, and 52 Individual World Championship, European Championship and World Cup medals across the Tokyo cycle.

"We have been able to harmonize our initial approach to complex and major incidents which has strengthened and simplified team-working dynamics and improved effective deployment of resources from different areas [and] has standardized our contribution to the Police investigation, [as] evidenced by positive feedback from our Criminal Justice partners."

- Head of Scene Examination



INSTRUCTIONAL SYSTEM DESIGN

Landmine Detection

A military research office identified two expert handheld detection equipment operators. Cognitive Task Analysis helped develop cognitive process models of expert operator's skill. The models then served as blueprints for designing operator training for each device. Three field tests employing army combat engineers showed that the prototype PSS-12 training program produced substantial gains in detection performance. Detection rates increased from a pretest level of roughly 15-17% to 87% after 15 hours of training per soldiers. Overall aggregate detection performance ultimately rose to 97% and trainees successfully found 100% of the most-challenging mines in the final tests.

Crime Scene Examination

This study used Applied Cognitive Task Analysis to develop a scenario-based training tool for crime scene examination staff. This research not only raised understanding of the cognitive demands in crime scene examination, but led to cultural and policy changes, particularly around the training of scene examiners. The study increased the level of preparedness of 120 crime scene examiners. Since 2018, the forensic services unit has delivered cognitive bias and strategy setting within its Level 1 and Level 2 courses with elements of scenario-based training.



“By codifying the intuitive knowledge of our account executives about our market into formal training material, we were finally able to better train our existing BDRs who often felt lost because they had no process for orientation for their prospecting meetings. The training material also sped up onboarding of new sales employees. In addition, we clearly communicated factors that make a prospect not a fit to the marketing team to disqualify prospects as early as possible on our website.”

- Head of Growth

INSTRUCTIONAL SYSTEM DESIGN

Prospect vetting for SaaS-developer/provider

A Goal-Directed Task Analysis and Knowledge Audit was performed with two Business Development Representatives of the vetting process, followed by a GDTA, KA and Critical Decision Method with three Accounting Executives working at different stages along the three-staged vetting sales funnel. The findings resulted in a heuristic process of the standard procedure of prospect-vetting in the organization, which was used to train BDRs to disqualify prospects as early as possible in the vetting process. The research helped reduce the number of people disqualified with the reason “no prospect fit” from 53 to 17.

Supplemental Nutrition Assistance Program (SNAP) Case Workers in Social Services

This project included a Cognitive Task Analysis-derived branching decision tree with criteria for decisions, along with updated training materials that incorporated the decision tree and other CTA-derived content for SNAP case workers. The sponsoring organization offered the training experience to 23 employees who had been hired within the previous six months. Overall, CTA-based training required six fewer hours of training than the control version. The CTA-based training cohort performed significantly better on the post-training assessment. The CTA-trained group was significantly less likely than the control group to make errors over time, resulting in fewer cumulative errors during the audit period.



“The changes implemented based on the training course and recommendations made in Phase 1 enabled a transition of the damage type identification task from industry experts with decades of damage assessment experience to novices with up to 7 months of prior experience.”

***- Visual Automotive Damage Assessment
Sponsoring Customer***

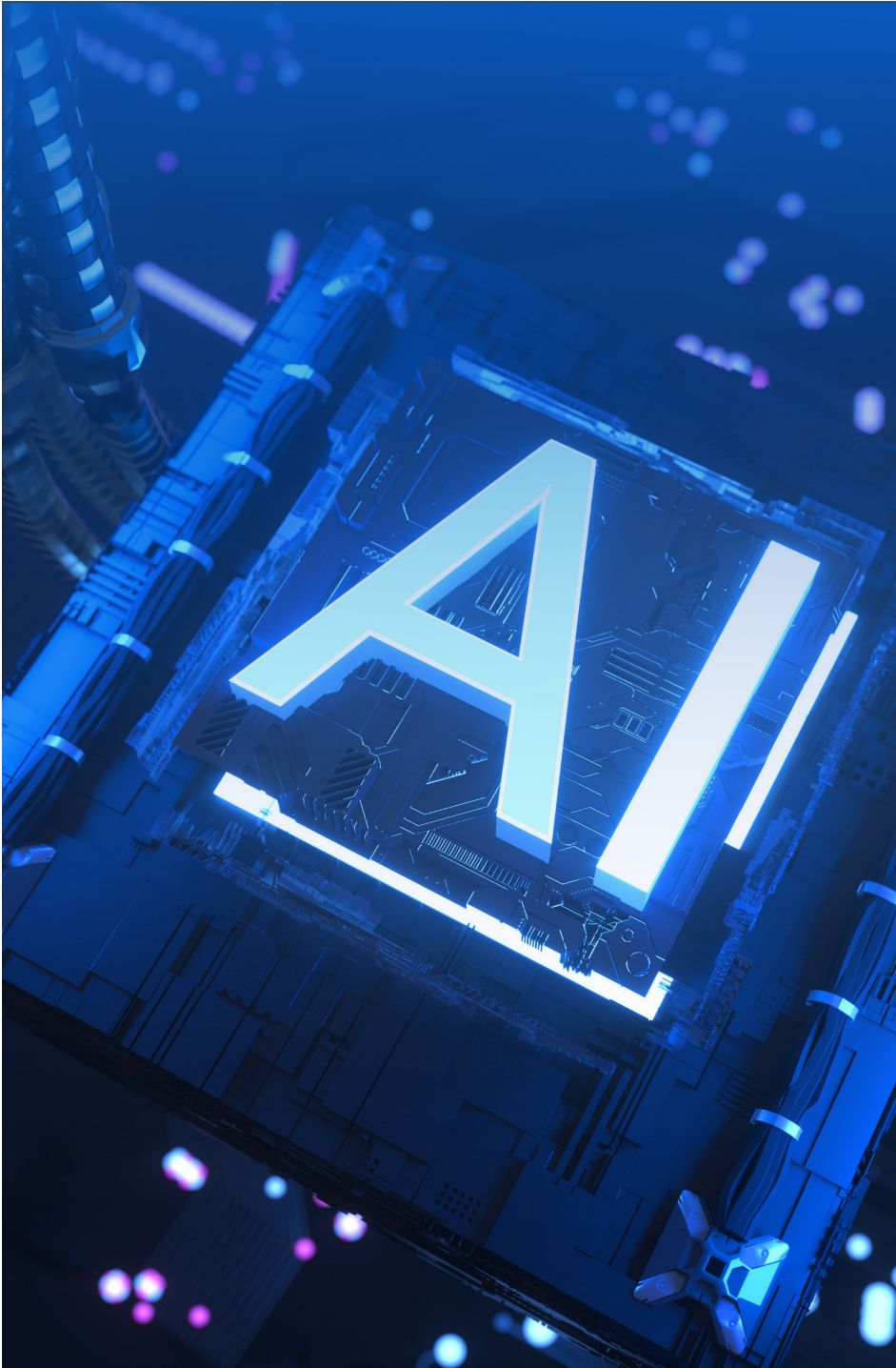
INSTRUCTIONAL SYSTEM DESIGN

Visual Automotive Damage Assessment

This study used a simulation interview technique from Applied Cognitive Task Analysis during which experienced assessors were presented pictures of damaged vehicles with varying levels of damage. The interviewees described the cues and strategies they used to classify damage. Then, the second phase involved developing and evaluating training materials based on findings from the simulation interviews. A comparative analysis of novice performance data before and after receiving the training indicated that performance improved dramatically on damage labeling tasks. Following a training period of 2-3 weeks, the organization successfully scaled its pool of available annotators by 4x whilst simultaneously reducing average annotation cost by 30%.

Child Welfare Investigations

Researchers conducted 15 Critical Decision Method interviews with experienced child welfare workers. CDM interviews produced decision requirements and expert strategies that provided a knowledge basis for critical decisions in welfare. The researchers extended interview findings (incidents and decisions) into 23 text-based training scenarios. Training was delivered in groups of 8-12 child welfare professions and featured peer-to-peer discussion about every decision point. A paired sample t-test compared pre-test scores to post-test scores indicated that performance significantly improved from the pretest to the post-test.



COGNITIVE SYSTEMS ENGINEERING

*Designing tools to support
proficient performance and
augment human capabilities.*



“In our evaluation, we found both qualitative and quantitative evidence that the design of the system provided effective transparency across all three levels of the Situation-Awareness Transparency model.”
- Defense and Security CTA Practitioner

COGNITIVE SYSTEMS ENGINEERING

Defense and Security

A national defense agency sponsored research to conduct multiple applications of CTA to inform the design of an AI system for intelligence analysis. The Critical Decision Method was used to elicit analyst expertise about a memorable investigation they were involved with. Then, CTA was used to evaluate the provision of transparency by the system with 10 expert criminal intelligence analysts. The initial study informed the design of the intent architecture of a conversational AI system. The research enhanced the ability of analysts to construct explanatory hypotheses and direct their inquiries. The conversational system has been deployed for experimentation in numerous domains across the government.

Market Abuse Surveillance in Capital Markets, Financial Services

The Critical Decision Method and the Card Sort exercise were used to capture relationships between tasks conducted, information available and methods of accessing information among participants from a global bank and a global asset management firm. From this work, User Journeys and UI/UX designs were created as cognitive support tools. These methods have continued to be used in several high challenge projects to deliver new insights and pathways for product development and are regarded as part of their R&D toolkit.



CONCLUSION

As organizations navigate challenging workforce trends, such as losing expertise to retirement and broadscale upheaval in education, CTA methods offer an effective and efficient approach for developing and enabling cognitive skills that improve performance.

The case studies from Stage One of the *CTA in E/Affect Initiative* demonstrate the diversity of domains, methods, applications, and outcomes already realized by CTA practitioners. By investing in CTA, these sponsoring organizations have uncovered insights that have directly strengthened their workforce.

The potential for CTA remains mostly untapped. Many sectors have yet to realize its benefits. Building on Stage One of the *CTA in E/Affect Initiative* and working across numerous sectors in Stage Two, the NDMA will identify high-value targets for applications of CTA that offer potential for industry-level improvements.

We have much more work to do to capitalize on the possibilities of CTA.
We hope you'll join us.

CTA IN E/AFFECT INITIATIVE: STAGE ONE



The NDMA received 14 submissions a diverse set of domains, reinforcing the benefits and applicability of CTA for any working environment across the global economy.

NDMA members voted for the most compelling success stories, which are denoted.





SUBMISSIONS

CTA in E/Affect Submissions

Domain	Participants	Methods & Applications	Value-Add
<p>Landmine detection</p> 	<p>Total Number of Participants = 20 novice trainees engaged in assessment of prototype training programs</p>	<ul style="list-style-type: none">• Naturalistic multi-modal observation• Behavioral analysis• Concurrent verbal protocol analysis• Experimentation• Cognitive modeling• Operational field-testing assessment• Cognitive process models of expert operator's skill → blueprints for designing operator training for each device• Improvised Explosive Device detection training	<p>Substantial gains in detection performance without an increase in false alarms; aggregate detection performance rose to 97%</p>
<p>Healthcare</p> 	<p>Total Participants = 14 (4 novices (interns), 4 senior trainees (senior residents), 6 faculty (expert) physicians)</p>	<ul style="list-style-type: none">• Critical Decision Method• Simulation-based training curriculum	<p>Improved training program for residents, resulting in a curriculum with 24 different scenarios; validation study showed that experienced physicians were more likely to recognize sepsis in the simulated scenarios than residents</p>

CTA in E/Affect Submissions

Domain	Participants	Methods & Applications	Value-Add
Defense and Security 	<p>Total Number of Participants = 18</p> <p>Total Number of Proficient Performers = 18</p>	<ul style="list-style-type: none"> • Critical Decision Method • AI system development 	<p>Enhanced ability of analysts to construct explanatory hypotheses and direct their inquiries</p>
Financial Services 	<p>Total Number of Participants = 11 (7 experts and 4 journeymen from a global bank and global asset management firm)</p>	<ul style="list-style-type: none"> • Critical Decision Method • Card Sort exercise • Cognitive demand table • User Journeys • UI/UX designs 	<p>Establishment of a new Research & Ideation function working across behavioral, data and computer science with the product teams; methods continued to be used in a number of high challenge projects to deliver new insights and pathways for product development and are regarded as part of their R&D toolkit</p>
Biotechnology Manufacturing and Shipping	<p>Total Number of Participants = 120 front-line workers</p> <p>Total Number of Proficient Performers = 20</p>	<ul style="list-style-type: none"> • Team CTA • Critical Decision Method • Applied Concept Mapping • Workplace ethnographic study • Simulation exercise 	<p>The company had no significant backorder problems within 3 months of doing the simulation exercise and implementing the solution discovered in the rehearsals</p>

CTA in E/Affect Submissions

Domain	Participants	Methods & Applications	Value-Add
Petrochemical Engineering	Total Number of Participants = 32 engineering professionals	<ul style="list-style-type: none"> • Applied CTA • In-house training presentations • Cognitive demands table • Tips guide for ACTA 	Developed a common language to 'think like an expert;' enhanced knowledge transfer and communication with early career and novice employees
Elite Performance Sport, Elite Coaching	Total Number of Participants = 8 (3 Olympic Coaches, 3 Paralympic Coaches, 2 Inter-disciplinary Specialist Coaches)	<ul style="list-style-type: none"> • Applied CTA • Shared Mental Model development • Coach education resource development 	Contributed to one Olympic medal and Olympic Record; seven Paralympic medals and four World Records at the Tokyo Games; 52 Individual World Championships
Crime Scene Examination	Total Number of Participants = 12 Scene Examination Supervisors	<ul style="list-style-type: none"> • Applied CTA • Cognitive demands table • written reports and presentations • Guidance documents • Scenario-based training tool 	Increased understanding of the cognitive demands in crime scene examination; cultural and policy changes around the training of scene examiners; increased level of preparedness of 120 crime scene examiners
Visual Automotive Damage Assessment	Total Number of Participants = 10 employees (7 proficient motor engineers and 3 not proficient employees)	<ul style="list-style-type: none"> • Applied CTA • Training course (PowerPoint format) supplemented by a decision aid 	Improved performance on damage labeling tasks; successfully scaled the pool of available annotators by 4x while simultaneously reducing average annotation cost by 30%

CTA in E/Affect Submissions

Domain	Participants	Methods & Applications	Value-Add
Employment Support	Total Number of Participants = 4 Employment Support professionals	<ul style="list-style-type: none"> • Applied CTA • Critical Decision Method • Cognitive Audit method • Task diagrams • Cognitive demands table • Insight stories and extracts from the Knowledge audit interviews were produced and shared via a 60-page report 	Transformative re-think of roles and responsibilities of ES professionals; provided helpful insights into Employment Support expertise within the organization
Prospect Vetting	Total Number of Participants = 5 (2 business development representatives and 3 accounting executives)	<ul style="list-style-type: none"> • Goal-Directed Task Analysis • Knowledge Audit • Critical Decision Method • Heuristic process of the standard procedure of prospect-vetting used for training business development representatives 	Improved training; enhanced disqualification effectiveness; sped up onboarding of new employees
Clinical Health Care	<p>Group A Total Number = 18</p> <p>Total Number of Proficient Performers = 18</p> <p>Group B Total Number = 23</p> <p>Total Number of Proficient Performers = 23</p>	<ul style="list-style-type: none"> • Problem-solving decision framework • Instructional design curriculum 	Mean scores significantly increased from pretest to the initial post-test and from the initial post-test to the final post-test on the Simulation-Based Mastery Learning method for assessment among learners

CTA in E/Affect Submissions

Domain	Participants	Methods & Applications	Value-Add
Social Services	Total Number of Participants = 23 employees hired within the previous six months Total Number of Proficient Performers = 23	<ul style="list-style-type: none">• Concepts, Processes, & Procedures (CPP)• Precursor, Action, Result, Interpretation (PARI)• Decision tree• Editable electronic versions of the agency's standardized training	Decreased training time; improved post-training assessment scores; fewer cumulative errors during the audit period
Child Welfare	Total Number of Participants = 15 child welfare professionals	<ul style="list-style-type: none">• Critical Decision Method• Text-based training scenarios	Significantly improved scores from the pretest to the post-test among child welfare professionals