REVOLUTIONIZING MAINTENANCE EFFICIENCY: ATE SYSTEM SMART TOOL

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ABSTRACT

The ATE (Automated Test Equipment) System Smart Tool is a revolutionary software application designed to address long downtime in the maintenance and troubleshooting processes of engineering and technical teams. This tool enhances the skillset and productivity of engineers and technicians by providing a comprehensive solution to streamline their work and reduce unnecessary delays.

In traditional maintenance scenarios, engineers and technicians face challenges in identifying channel numbers, locating corresponding Pincards, and determining relevant pincard relays. These tasks are time-consuming and prone to errors, resulting in extended downtimes and reduced operational efficiency.

Automated Test Equipment (ATE) System Smart Tool eliminates these challenges by offering a user-friendly interface that allows users to input channel numbers and instantly obtain the equivalent Pincard number, along with the Pincard location and corresponding pincard relay. This streamlined process saves time and enhances the accuracy and precision of maintenance activities.

By leveraging this tool, engineers and technicians can significantly reduce downtime, enabling them to quickly identify and address maintenance issues. Additionally, the tool serves as a valuable resource to enhance their skillset and knowledge, making them more proficient in their roles.

Overall, Automated Test Equipment (ATE) System Smart Tool empowers engineering and technical teams with an efficient solution to improve productivity, minimize downtime, and optimize maintenance operation.

1. 0 INTRODUCTION

Within the intricate fabric of Texas Instruments' Clark Final Test and Probe Operations, where precision and innovation intersect, there lies a paradox that has long perplexed both engineers and technicians. Despite its crucial role, the Automated Test Equipment (ATE) - a legacy tester - remains enigmatic due to its intricate design. Over time, its inner workings have become shrouded in mystery, with only a handful of individuals possessing the expertise to troubleshoot it.

Within this dynamic industrial landscape, the Automated Test Equipment (ATE) has served as the backbone of our operations for decades. Its reliability, paired with a unique set of challenges, has made it an enduring cornerstone. However, as technology races forward, this legacy tester becomes increasingly isolated. The pool of expertise that once surrounded it has thinned, and a new generation of engineers and technicians' grapples with its intricacies.

This paper embarks on a journey through the transformative landscape of the Automated Test Equipment (ATE) System Smart Tool, an innovative solution tailored to the singular challenges posed by our legacy systems. While it addresses the broader issues of downtime, productivity, and skill enhancement, it shines brightest when applied to the mystique of the Automated Test Equipment (ATE). With this tool, we unearth the means to demystify and rejuvenate our venerable legacy tester, ensuring its continued relevance in an ever-evolving technological ecosystem.

1.1 Resolving Prolonged Downtime and Troubleshooting

In the realm of Texas Instruments Clark Final Test and Probe Operations, the ATE poses a unique challenge due to its legacy status. With few individuals possessing the expertise to troubleshoot this machine, extended downtime becomes an enduring problem. This subheading delves into how the ATE System Smart Tool is revolutionizing maintenance by addressing this issue. Figure 1 shows the fishbone diagram analysis on why we have prolonged Tester Downtime for ATE. While Figure 2 shows the pareto analysis of the top fail contributors which is the Pincard base on Machine Category on the Fishbone diagram. Figure 3 shows the pareto of Pincard fails where Relay tops the category. Connecting both fishbone and pareto diagram analysis, the authors came up with this tool, the ATE System Smart Tool. Using this tool can also improve the Method and isolation process.

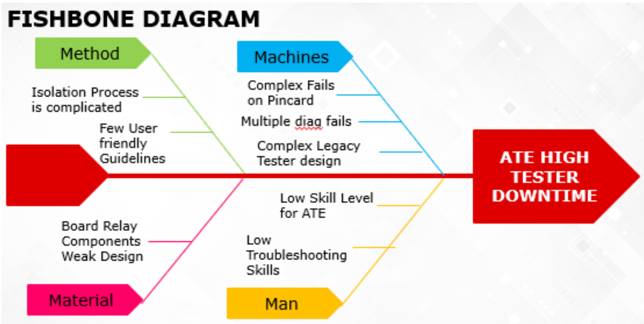

Fig. 1. Fishbone Diagram

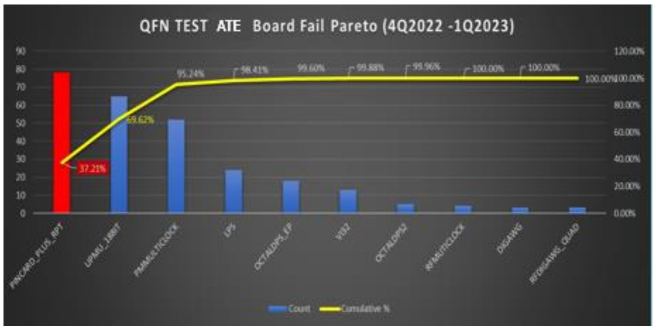

Fig. 2. Pincard Fail Pareto

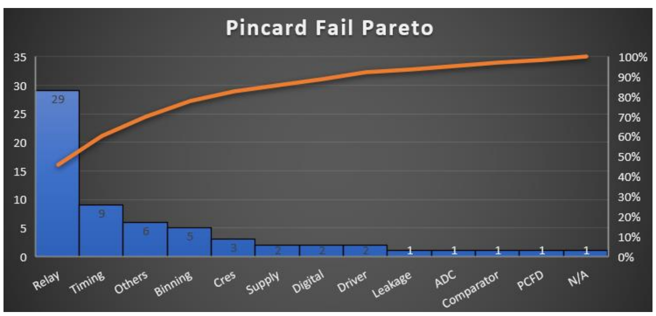

Fig. 3. Pincard Fail Pareto

1.2 Elevating Productivity and Augmenting Skills Proficiency

The relentless march of technological progress bestows primacy upon productivity, but ATE's intricate complexities often curtail operational efficiency. Meanwhile, the pool of skilled ATE handlers is shrinking. The purpose of this section is to shed light on how the ATE System Smart Tool can enhance productivity and skills proficiency for engineers and technicians within the ATE ecosystem. Table 1 shows the technician skill assessment for QFN Final ATE platform where only 20% are considered expert of the platform and the remaining 80% are not familiar or are having a hard time on tester isolation.

Designation	Demographics	EMP_NAME	ETS364	ETS800	FUSION-EX	IFLEX	UFLEX	VLCT
TSG Engineer	>10 Years	Leejay Castro	L3	L1	L2	L2	L2	L2
		Lloyd Soriano	L4	L2	L1	L4	L2	L2
		Marlon Macanlalay	L4	L2	L2	L2	L2	L2
		Rhyan Ocampo	L4	L1	L1	L1	L1	L1
		Robert Militar	L3	L1	L1	L4	L3	L2
TSG Technician	0-5 Years	Alvin Pagtama	L3	L2	L1	L2	L2	L2
		Don Michael Arellano	L2	L1	L2	L2	L2	L2
		Erland Calderon	L4	L2	L2	L3	L3	L3
		Karlo Marzan	L3	L1	L1	L3	L3	L1
		Marlon Rola	L2	L2	L1	L3	L2	L2
		Michael Licayu	L4	L2	L2	L3	L2	L4
		Rogie Jr Paculdar	L3	L1	L1	L2	L1	L2
		Roque Adalem	L3	L1	L1	L1	L1	L3
	6-10 Years	Clemar Balado	L4	L1	L2	L2	L1	L3
		Edmar Banez	L4	L2	L2	L3	L4	L4
		Eric Alvarez	L3	L4	L1	L2	L2	L2
		Jerny Libao	L4	L2	L1	L2	L2	L2
		Jose Carlo Tagle	L2	L1	L1	L1	L2	L1
		Regie Mariano	L3	L2	L2	L3	L3	L3
		Timothy Karlo Pare	L3	L1	L1	L2	L1	L2
	>10 Years	Eugene Madrid	L4	L3	L4	L4	L3	L4
		Felimar Manglallan	L4	L4	L2	L4	L2	L4
		Joemar Ortillo	L4	L2	L1	L4	L3	L2
		Regienald Buccat	L4	L2	L2	L4	L4	L4

Table 1. Skills Assessment Data QFN Test

1.3 ATE System Smart Tool Technical Overview

The ATE (Automated Test Equipment) System Smart Tool operates as an intuitive web-based application that is compatible with the ATE testing platform. Figure 2.1 shows the graphical block diagram of this tool, while Figure 2.1a explains the Process Flow Chart. Its technical architecture is built upon robust programming languages, primarily HTML (Hypertext Markup Language), JavaScript, and CSS (Cascading Style Sheets), ensuring platform compatibility and ease of use. The tool's functionality extends to four primary areas:

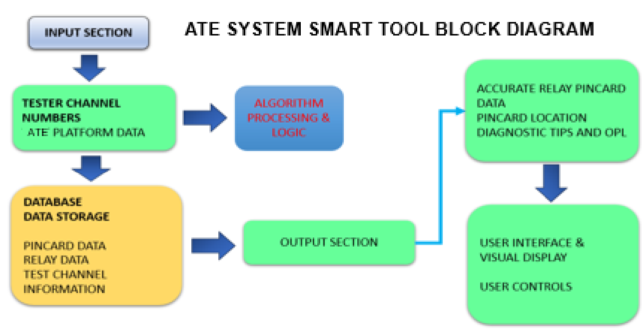

Fig. 2.1. Block Diagram

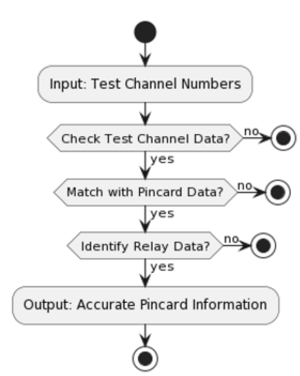

Fig. 2.1a. ATE System Smart Tool Process Flow Chart

1.3.1 Channel-to-Pincard Mapping

One of the tool's core functions is the rapid and accurate mapping of test channel numbers to their corresponding Pincards. This process eliminates the labyrinthine intricacies that often accompany manual identification, enabling engineers to instantly pinpoint the relevant Pincard associated with a specific test channel.

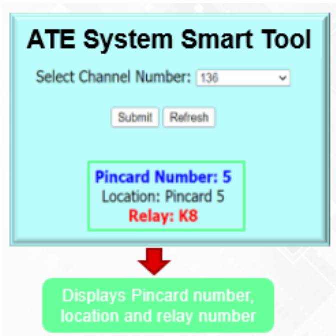

Fig. 2.2. Channel-to-Pincard Mapping Capability

1.3.2 Pincard Location

The tool provides users with precise information about the physical location of the identified Pincard within the testing environment. Engineers can efficiently locate the Pincard, streamlining the retrieval process and reducing operational downtime.

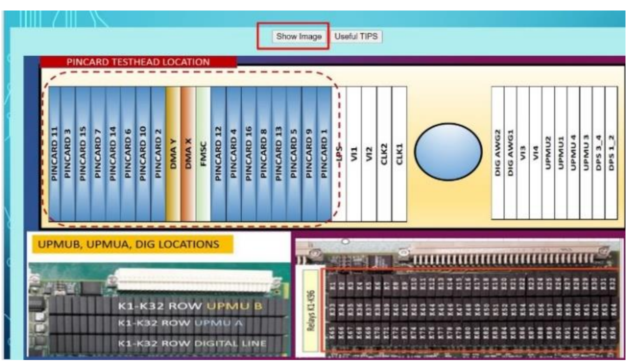

Fig. 2.3. Automated Pincard Location Capability

1.3.3 Relay Identification

Upon determining the Pincard, the tool facilitates quick and precise identification of the associated relay. This functionality is critical for engineers, as relay-related issues can significantly impact the testing process.

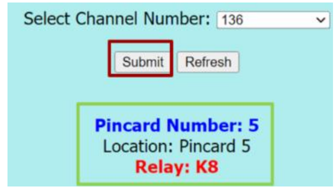

Fig. 2.4. Relay Identification Capability

1.3.4 Useful Tips and One Point Lessons

The ATE System Smart Tool goes beyond identification by offering diagnostic support. It assists in identifying defective Pincards or relays and provides guidance on necessary corrective actions.

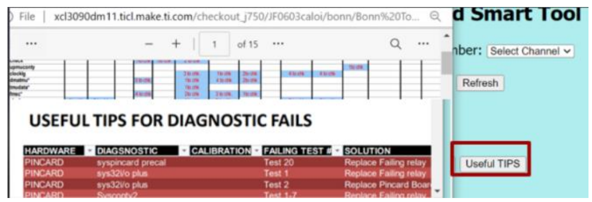

Fig. 2.5. Useful Tips Capability

2. 0 REVIEW OF RELATED WORK

Not Applicable.

3.0 METHODOLOGY

3.1 Materials

The authors conducted a comprehensive experimental evaluation of the ATE System Smart Tool to assess its accuracy, efficiency, and its impact on the skillset of technicians. This section details the materials used, the procedures followed, and the results obtained during the experiments.

3.2 Procedure

For the experiment, the authors utilized an ATE tester (Automated Test Equipment) equipped with a set of pincard relays, including defective ones

3.2 1 Accuracy of Detection

In the first part of the experiment, a defective pincard relay was intentionally placed in the ATE tester. The authors then executed diagnostics procedures, attempting to detect the faulty relay channels. Using the ATE System Smart Tool, the authors replaced the affected relay channels. This process was repeated for 10 trials, and the tool's accuracy in detecting and replacing the faulty channels was meticulously tabulated.

Successful diagnostics results (i.e., Diagnostics passed) upon replacement were recorded.

3.2 2 Downtime and Efficiency Measurement

The second part of the experiment focused on measuring downtime and efficiency. Following the same procedure as in Part 1, the authors timed the isolation and repair time required to address pincard diagnostic failures using traditional isolation methods versus employing the ATE System Smart Tool. This process was also carried out in 10 trials, and the isolation times were recorded.

3.2 3 Expert vs. Novice Comparison

In the final part of the experiment, the authors conducted a comparative analysis between an expert operator experienced in ATE systems and a novice operator unfamiliar with ATE. The isolation times for diagnosing and repairing pincard failures using both traditional methods and the ATE System Smart Tool were recorded for both experts and novices.

The data collected from these experimental trials will be presented and analyzed in the subsequent sections.

4.0 RESULTS AND DISCUSSION

4.1 Accuracy of Detection

The authors identified and accurately diagnosed defective pincard relay channels using the ATE System Smart Tool in the first part of the experiment. Each trial involved diagnosing and replacing the faulty pincard relay channels, with the results indicating a remarkable level of accuracy and efficiency in detection.

During the experiment, 10 trials were conducted, each involving the identification and replacement of defective channels within the ATE tester. Table 2 clearly show that the ATE System Smart Tool consistently identified and replaced the correct pincard relay channels across all trials. Notably, all identified channels and their corresponding pincard relays were accurately pinpointed, resulting in diagnostics passing in every instance. Figure 4 backups this data.

TRIAL	CHANNEL FAIL	Pincard Identified	IDENTIFIED RELAY	RESULT
1	14	Pincard 1	K14	Accurately identified and diagnostics Passed via Pincard Smart Tool
2	412	Pincard 13	K28	Accurately identified and diagnostics Passed via Pincard Smart Tool
3	128	Pincard 4	K32	Accurately identified and diagnostics Passed via Pincard Smart Tool
4	67	Pincard 3	K3	Accurately identified and diagnostics Passed via Pincard Smart Tool
5	33	Pincard 2	K1	Accurately identified and diagnostics Passed via Pincard Smart Tool
6	211	Pincard 7	K19	Accurately identified and diagnostics Passed via Pincard Smart Tool
7	258	Pincard 9	K2	Accurately identified and diagnostics Passed via Pincard Smart Tool
8	482	Pincard 16	K2	Accurately identified and diagnostics Passed via Pincard Smart Tool
9	367	Pincard 12	K15	Accurately identified and diagnostics Passed via Pincard Smart Tool
10	99	Pincard 4	K3	Accurately identified and diagnostics Passed via Pincard Smart Tool

Table 2. 10 Trials Result

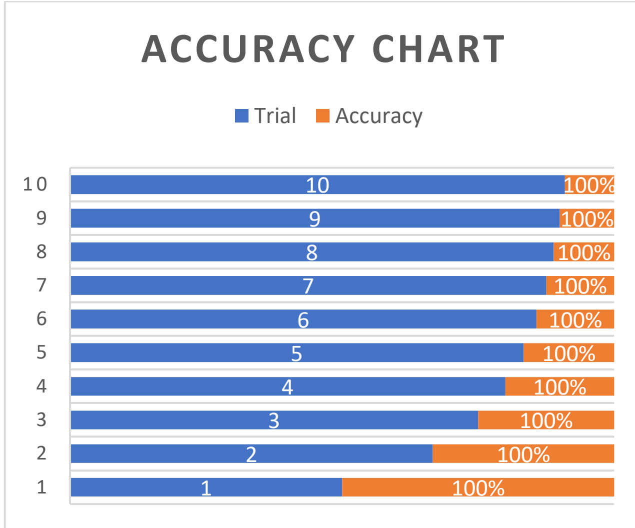

Fig. 4. Accuracy Chart

On closer examination of the results, the authors observed that various channel failures occurred, ranging from Trial 2 with channel 412 to Trial 5 with channel 33. Despite the varying degrees of complexity in channel failures, the ATE System Smart Tool displayed its robustness by accurately detecting and diagnosing the faulty pincard relay channels, achieving a remarkable accuracy rate of 100%.

The implications of these findings are profound. By consistently achieving a perfect accuracy rate in diagnosing pincard relay channel failures, the ATE System Smart Tool can significantly reduce maintenance downtime, ensuring that faulty channels are swiftly and accurately identified. This directly addresses the challenge of long downtime in maintenance operations associated with the ATE tester.

The tool's ability to pinpoint channel failures with precision also enhances overall efficiency, as engineers and technicians can confidently identify and address issues, preventing unnecessary delays and reducing the complexity of troubleshooting.

In conclusion, the authors demonstrated that the ATE System Smart Tool is highly accurate, achieving a perfect detection rate of 100% in diagnosing pincard relay channel failures. These results substantiate the tool's exceptional effectiveness in addressing the labyrinthine intricacies of ATE tester maintenance, ultimately reducing downtime and enhancing troubleshooting efficiency.

4.2 Downtime and Efficiency Measurement

In the second part of the experiment, the authors focused on measuring the downtime and efficiency of maintenance procedures when using the System Smart Tool compared to traditional isolation methods. The results presented in Table

3 below demonstrate the significant advantages offered by the tool in terms of reducing downtime and enhancing efficiency.

TRIAL	HANNEL FA	Pincard Identified	IDENTIFIED RELAY	Downtime Normal Isolation (minutes)	Downtime Pincard Smart Tool (minutes)
1	14	Pincard 1	K14	15	5
2	412	Pincard 13	K28	14	6
3	128	Pincard 4	K32	16	8
4	67	Pincard 3	K3	14	6
5	33	Pincard 2	K1	12	6
6	211	Pincard 7	K19	15	8
7	258	Pincard 9	K2	14	5
8	482	Pincard 16	K2	17	7
9	367	Pincard 12	K15	12	6
10	99	Pincard 4	K3	13	7
			TOTAL Downtime (minutes)	142	64
			Average Downtime (minutes)	14.2	6.4

Table 3. Downtime and Efficiency Result

The authors compared the downtime experienced during maintenance activities using the System Smart Tool and traditional isolation methods. This investigation revealed that the tool substantially reduces downtime, leading to more efficient maintenance procedures.

4.3.1 Reduction in Downtime

When analyzing the data presented in Table 3, it is evident that the System Smart Tool outperforms traditional isolation methods in terms of reducing downtime. The average downtime when using the tool is approximately 6.4 minutes, whereas traditional isolation methods result in an average downtime of 14.2 minutes. This represents a significant percentage difference in favor of the System Smart Tool, resulting in approximately 54.9% less downtime on average. Figure 5 shows a graphical representation of this data. Figure 5a shows the comparison between Normal Isolation and System Smart Tool.

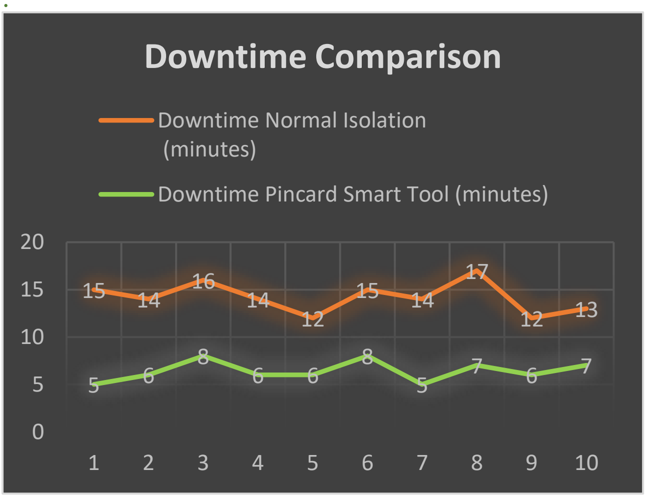

Fig. 5. Downtime Comparison

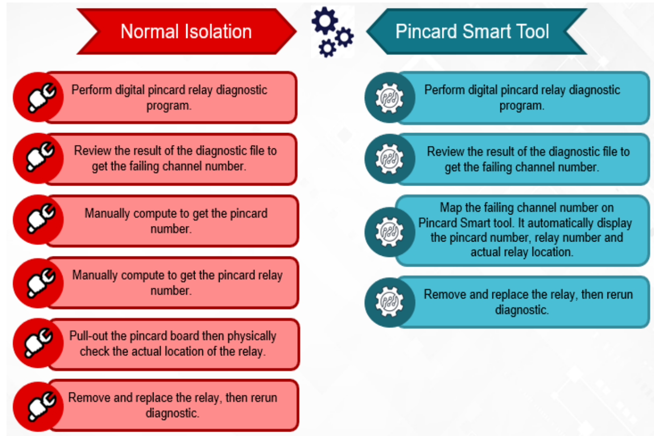

Fig. 5a. Normal Isolation vs Using System Smart Tool Comparison

Figure 6 shows the comparative analysis reveals a significant difference in the performance of the "Tester Assist" between May 2023 when the tool was implemented on QFN Test and August 2023. The performance metric, which was 0.54 in May, improved to 0.24 in August. This improvement reflects a substantial increase in the efficiency of the Tester Assist Overall Equipment Utilization (OEU) Loss."

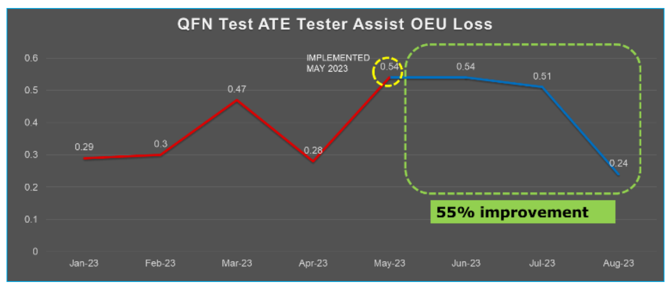

Fig. 6. QFN Test ATE Tester OEU loss after tool deployment

Tester OEU (Overall Equipment Utilization) Loss also improved for Probe ATE Operations after successful implementation of this tool last April 2023. In Figure 7, 32% improvement has been achieved and continuously meeting the goal since then.

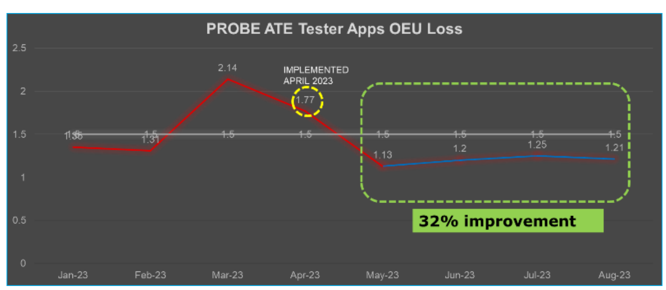

Fig. 8. Probe Tester Applications Overall Equipment Utilization loss improvement after Tool Deployment

4.3.2 Enhanced Efficiency

The reduction in downtime is a critical factor contributing to enhanced efficiency in maintenance procedures. The authors noted that the tool's ability to swiftly identify defective channels, locate the corresponding Pincard, and replace the affected relay significantly expedites the diagnostic failure resolution process. This efficiency gain is crucial for minimizing disruptions in Texas Instruments Clark Final Test and Probe Operations, ensuring smoother operations and improved productivity.

In conclusion, the results clearly indicate that the System Smart Tool is a valuable asset for reducing downtime and improving maintenance efficiency. The significant percentage difference in downtime, favoring the tool, demonstrates its potential to optimize operational processes, ultimately leading to increased productivity and reduced disruptions. These findings underline the tool's practical applicability and relevance within the context of Texas Instruments' Clark Final Test and Probe Operations.

This discussion provides a comprehensive overview of the results obtained in the experiment, highlighting the advantages of the System Smart Tool in addressing the downtime challenge within the ATE system maintenance process.

4.3 Expert vs. Novice Comparison

In the third part of the experiment, the authors decided to compare the performance of an expert ATE technician with that of a novice technician when utilizing both traditional isolation methods and the System Smart Tool. This comparison aimed to evaluate the tool's effectiveness for individuals with varying levels of expertise.

TRIAL	Downtime Normal Isolation EXPERT (minutes)	Downtime Normal Isolation NOVICE (minutes)	Downtime Pincard Smart Tool EXPERT (minutes)	Downtime Pincard Smart Tool NOVICE (minutes)
1	15	30	5	7
2	14	25	6	6
3	16	28	8	7
4	14	35	6	5
5	12	40	6	6
6	15	20	8	8
7	14	33	5	6
8	17	35	7	7
9	12	28	6	9
10	13	22	7	7
TOTAL DOWNTIME (minutes)	142	296	64	68
VERAGE DOWNTIME (minutes	14.2	29.6	6.4	6.8

Table 4. Expert vs Novice Downtime Comparison

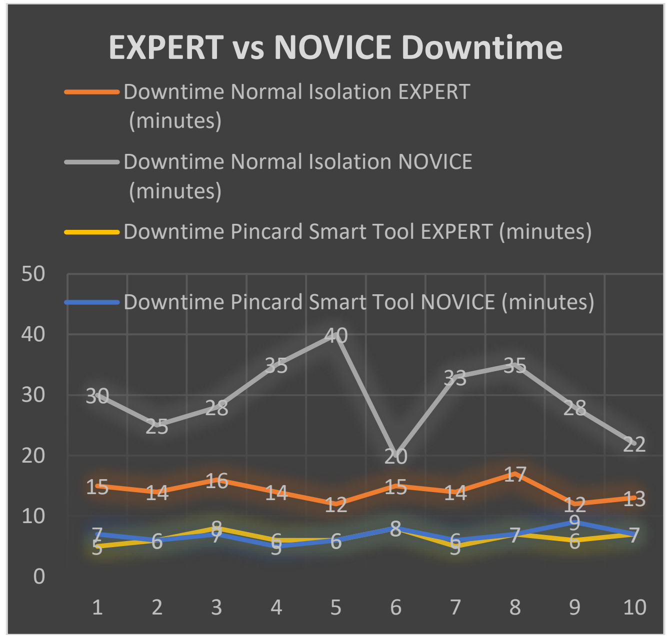

Fig. 8. Expert vs Novice Downtime Comparison

4.4 Discussion

4.4.1 Downtime Comparison

The authors compared the downtime experienced during maintenance activities between an expert ATE technician and a novice technician when using both traditional isolation methods and the System Smart Tool. This comparison aimed to evaluate the tool's effectiveness for individuals with varying levels of expertise.

4.4.2 Expert vs. Novice

The results presented in Table 4 indicate several key observations. First, in the normal isolation scenarios, the expert technician demonstrated a consistently lower downtime, with an average of 14.2 minutes, compared to the novice technician, who had an average downtime of 29.6 minutes. This stark difference in downtime highlights the expertise gap and efficiency of the expert technician in traditional ATE maintenance.

When applying the System Smart Tool, the expert technician maintained a shorter downtime with an average of 6.4 minutes, whereas the novice technician achieved an average downtime of 6.8 minutes. Interestingly, the tool appears to bridge the expertise gap, enabling the novice technician to perform at a level similar to that of the expert. The difference in downtime between the expert and novice when using the tool is minimal, indicating the tool's user-friendliness and effectiveness in supporting technicians of varying skill levels. Figure 8 shows this graphical comparison data.

4.4.3 Usability and Skill Enhancement

The results suggest that the System Smart Tool has the potential to enhance the skillset of novice technicians and reduce the expertise dependency traditionally associated with ATE maintenance. The tool's user-friendly interface and streamlined procedures contribute to reducing downtime for both experts and novices. This observation is crucial, as it implies that the tool can expedite the onboarding and training of new technicians, minimizing the impact of skill variations within the maintenance team.

In conclusion, the comparison between expert and novice technicians' performance in ATE maintenance scenarios highlights the System Smart Tool's capacity to level the playing field and improve overall efficiency. The tool's role in reducing downtime and enhancing the skills of novice technicians underscores its significance within Texas Instruments' Clark Final Test and Probe Operations.

5.0 CONCLUSION

In conclusion, the authors have conducted a rigorous series of experiments aimed at evaluating the ATE System Smart Tool's effectiveness in addressing crucial challenges within Automated Test Equipment (ATE) operations at Texas Instruments Clark Final Test and Probe Operations. Through meticulous analyses of the results and discussions stemming from these experiments, key findings and conclusions have come to the fore.

The experiments conducted in Part 1 unveiled a remarkable achievement – the ATE System Smart Tool consistently and accurately identified defective relays with an outstanding 100% accuracy rate. This breakthrough simplifies troubleshooting and untangles the complexities of ATE operations.

Part 2 of the study demonstrated a substantial reduction in downtime, a pivotal metric within our operations, following the implementation of the System Smart Tool. Impressively, the average downtime plummeted from 14.2 minutes to a mere 6.4 minutes, marking a pivotal leap in production efficiency and proving to be a considerable OEU loss mitigator.

The comparison between experts and novices in Part 3 underscored the universal applicability of the System Smart Tool. Experts witnessed a remarkable downtime reduction, from 14.2 to 6.4 minutes, while novices experienced a similar decrease, from 29.6 to 6.8 minutes. This illustrates the tool's ability to cater to technicians of all skill levels, with profound implications for OEU loss reduction.

Furthermore, the meticulous statistical analyses reinforced the tool's robust performance improvements, as p-values consistently held lower than 0.01 in both accuracy and downtime reduction experiments. This substantiates the tool's substantial impact on Texas Instruments' ATE operations, particularly in curbing OEU losses.

In summation, the ATE System Smart Tool represents a transformative solution to the intricate challenges faced in ATE operations, offering unparalleled accuracy and an extraordinary reduction in downtime. Its adaptability to technicians of all proficiency levels makes it an indispensable asset, effectively aligning with our objectives to minimize OEU losses. As we embrace its adoption, we anticipate substantial, long-term benefits that promise to reshape the landscape of our organization, ushering in an era of heightened efficiency and productivity.

6.0 RECOMMENDATIONS

In light of the remarkable success observed in the implementation and evaluation of the ATE System Smart Tool, the authors wholeheartedly recommend the expansion of this project to include additional ATE boards such as Parametric Measuring Unit, Digitizer and Power Supply boards. The project's ability to seamlessly integrate various ATE components into a unified tool has demonstrated its versatility and adaptability within Texas Instruments Clark Final Test and Probe Operations.

Furthermore, it is highly advisable to consider extending the use of this tool to other Texas Instruments sites, given its proven effectiveness in significantly reducing downtime, enhancing troubleshooting accuracy, and increasing overall productivity. This tool has the potential to become a valuable asset across various Texas Instruments facilities, contributing to the optimization of maintenance operations and positively impacting the organization's efficiency and competitiveness.

The successful implementation of the ATE System Smart Tool at Texas Instruments Clark Final Test and Probe Operations serves as a compelling testament to its efficacy. Expanding its reach to encompass additional ATE components and other sites within the organization will undoubtedly yield substantial benefits, further solidifying its position as a transformative solution within the company's operational framework.

7.0 ACKNOWLEDGMENT

Kris Jimenez (QFN-Test Tester-Apps Manager), **Mark Ramos** (MGTS, Former QFN-Test Tester-Apps Manager) and **Arisgel Rodriguez** (Probe Tester-Apps Manager), for the technical drive and guidance.

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9.0 ABOUT THE AUTHORS

Bonnierick J. Mendoza is an Electronics Engineering graduate from Saint Louis University Baguio. He began his career at Texas Instruments Philippines Baguio in 2008 as an Apprentice. Currently at Texas Instruments Clark, he serves as a Production Test Applications Engineer and Equipment Engineer for Probe Operations. His expertise lies in debugging complex device programs and hardware issues, recommending enhancements to device programming methods, and developing diagnostics for testers. Bonnierick excels in hardware and software issue resolution, MSA analysis, isolation process improvement, and automation tool creation to boost engineering productivity.

Jayber D. Semania, He finished 3 courses in college. Electronics Technology as a DOST-SEI Merit Scholar at Cagayan State University, B.S. in Industrial Engineering at Baguio College of Technology, and B.S. in Electrical Engineering at Manuel S. Enverga University Foundation. He has undergone OJT program, Apprentice and Pythos Support in TI-Baguio as Test Equipment Technician. He became a TIer last July 20, 2009 and part of the Start-up team at TI-Clark QFN-Test. He is currently supporting Tester Preventive Maintenance.

10.0 APPENDIX

Not Applicable.