MetaSystems White Paper

# ECONOMIC AND ERGONOMIC BENEFITS OF THE AUTOMATED GRAM SCANNER

## The Macro Problem in Micro

The USA healthcare system is suffering from a medical technologist (MT) shortage. According to the Bureau of Labor Statistics (BLS), the projected demand for MTs is going to increase by 11% by 2028, while the average increase for other occupations will only rise by 5%[1]. This decline in much needed personnel is due to several factors: (1) The graduation rate from accredited MT programs does not surpass the vacancy rate. In fact, a survey conducted by the American Society of Clinical Pathology (ASCAP) reported that ~6% of positions in microbiology laboratories remain vacant[2]. This lack of skilled labor is further evident in nearly ~40% of hiring managers for laboratories reporting that applicants do not have the necessary training and expertise to effectively execute the work[2]. (2) Expertise is further leaving the laboratory workforce through retirement; in the microbiology field, 20% of personnel are expected to retire by the year 2022[2]. (3) The increasing frequency of the spread of communicable diseases along with the steady growth in the vulnerable senior populace has resulted in additional specimens that need to be evaluated by clinical, especially microbiology, laboratories[3]. Over the next 10 years, there is an anticipated 10-15% upsurge in testing volumes[4].

Due to a diminishing labor force that encompasses a number of workers with little clinical laboratory experience and an increasing demand for laboratory services, qualified MTs very often have to work double shifts or overtime to not negatively affect patient care[3]. However, extended work hours have been linked to decreased sleep intervals, which in turn leads to fatigue. Studies show that fatigue impairs judgment and increases worker error[5]; thus, MTs working extended hours could very well negatively affect patient outcomes. To avoid injury, the CDC advises to keep manual microscope utilization to 5 hours a day, however, studies have shown that microscope users are working longer hours[6,7]. In fact, 100% of workers who spent 30 hours or more at the microscope per week suffered from some form of musculoskeletal problem[7]. Amongst microbiologists, the most common reported problems due to prolonged microscope use were neck/back related (70%) and eyestrain/headache (14%)[8]. Consequentially, 22.6% of lab workers have reported even being treated for or hospitalized for musculoskeletal injuries[7]. This further attributes to the lack of qualified personnel and thus impacts the quality of results that microbiology labs can provide.

## Gram Stain: First Line of Defense

Even with escalating expenditures and a dwindling workforce, microbiology laboratories are still expected to meet the demand for prompt and accurate test results at low costs. The Gram stain is an essential test of clinical microbiology. With its swift and simple execution, the Gram stain serves as the first critical step in providing clinicians with results that drive antibiotic therapy and determine if subsequent testing is necessary. Conversely, as aforementioned, utilizing standard manual microscopy to assess Gram-stained slides is distressing, tedious work that is prone to human error due to its redundancy. It takes an MT approximately 4.2 minutes to analyze one Gram slide, with an estimated 100 Gram slides analyzed daily. Due to this process still being 100% manual, analyzing Gram slides costs microbiology laboratories an average of $30.49 an hour for MTs[9]. This highly specialized personnel time could be more effectively spent with the implementation of a more ergonomic and cost-effective, automated microbial workflow.



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## Gram Scanner: The Automated Solution

To meet this challenge, MetaSystems developed the Gram Scanner, a fully automated walk-away microscope scanning and imaging system, depicted in **Figure 1.** With some simple modifications, the Gram Scanner can also be used as a solution for automatically imaging acid-fast bacteria (AFBs, such as mycobacteria) and for ova and parasites (O&Ps).

## Time Study

With time efficiency being crucial to laboratories under extreme stress due to workforce shortages or a public health crisis such as the 2020 COVID-19 pandemic, the automation feature of the Gram Scanner was developed to allow technicians to image slides and walk away to simultaneously engage in other vital laboratory tasks. MetaSystems has focused, in this time study, on utilizing Gram-stained slides due to the Gram assay being the first step in the microbiology patient care pathway. In an earlier collaborative study with TriCore Reference Laboratories (Albuquerque, NM), the Gram Scanner saved technicians an average of 1.15 minutes in slide review time for blood, respiratory, wound swabs, and bodily fluid samples. In order to assess the total amount of technologist time, as well as laboratory costs that the Gram Scanner can save a microbiology laboratory, an internal study was conducted with blood Gram-stained slides (prepped from positive blood cultures) that were evaluated utilizing the standard manual workflow and our automated workflow.

## Methodology

Gram-stained blood slides were scanned automatically with the Gram Scanner (MetaSystems Group, Inc., Newton, MA) as well as evaluated manually through the oculars of a Zeiss AxioImager Z2 (White Plains, NY) (**Figure 1**). For the manual workflow, 10 fields of view (FOVs) of each slide were first viewed under a 10x objective, and then each slide was analyzed under a 100x–oil immersion objective, viewing 10, 20, 40 and 50 FOVs. Slide results were entered into Excel to mimic LIS data entry. For the automated workflow, the sample area of each slide was scanned at 10x to determine the best regions for image capture. The regions identified during the prescan were then scanned with a 63x oil immersion objective, capturing 10, 20, 40, or 50 FOVs. Slides were evaluated by viewing the digitized images captured in the Metafer (imaging software) gallery and results were entered into the Field Review 2 function and reported out in the scanning platform's advanced data management software (Neon), with integrated reporting tools and automated lab workflow state assignments.

***Figure 1**. Gram Scanner instrumentation equipped with a Zeiss Axioimager Z2 microscope, CoolCube color camera, slide feeder, and magazines.*

To determine the financial benefits of the Gram Scanner, we developed a return on investment (ROI) economic model compromised of the following parameters: the number of staff in a microbiology lab, salaries, fringe benefit rates, average number of slides processed daily, and equipment cost including a service contract. Assumptions to the ROI model were based on known average wages and fringe benefit rates for medical technologists[9].

## Results

The overall findings confirmed that the Gram Scanner lessens the time as well as the financial burden for microbiology laboratories. When separating the automated workflow time into the time that a technologist is required to physically interact with the microscope or computer (hands-on time) and the time in which the system is independently performing a task (automation time), it was found that the automated workflow required significantly less technologist time in comparison to the standard manual workflow. In fact, the automated workflow was comprised of a mere 0.5-0.9 minutes of hands-on time in comparison to 3.2-5.4 minutes of hands-on time comprising the manual workflow (**Figure 2**). By reducing the amount of time that technologists are tethered to the microscope during slide examination, the Gram Scanner saved ~85% of tech time in comparison to the manual method (**Table 1**). Lastly,



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an ROI analysis of the Gram Scanner demonstrated a breakeven at 1.3 years, saving laboratories scanning an average of 3,000 slides monthly over $1 million in 5 years (**Figure 3**).

## Conclusions

Using the Gram Scanner, microbiology lab directors can significantly reduce the time their MTs spend at the microscope, increasing the overall efficiency of the lab through more cost-effective use of technicians' time. This new advanced strategy can even have a direct, positive impact on MT's health. Additionally, with the Gram Scanner's pre-scan capability of automatically selecting suitable sample areas for imaging and analysis, the quality of microbiology lab results improves as selection does not depend on individual experience and assessment; thus the Gram Scanner further aids in alleviating some of the issues seen in the decline of available expertise in the MT labor market as aforementioned. Moreover, the advantages of the Gram Scanner divulged in this study are not only applicable to Gram-stained slides, but can also save microbiology laboratories time in analyzing Ziehl-Neelsen or Auramine O-stained slides. The Gram Scanner is an ergonomic investment in full lab automation that leads to faster patient results and thus permits laboratories to scale up production without increasing their labor force.

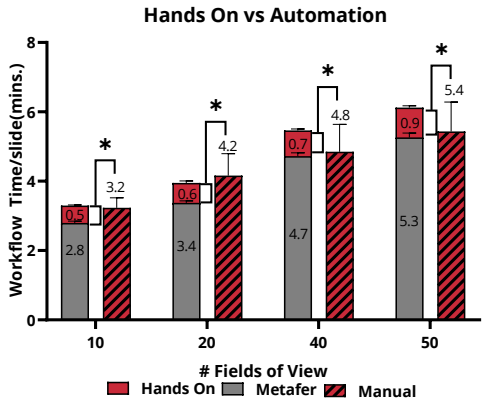


***Figure 2**. Automation through the Gram Scanner results in significantly less time compared to the manual method in which technologist are required to be at the microscope or computer. Data expressed as mean ± SD. Statistical significance, * p< 0.05, determined by two-way ANOVA with Tukey's post-hoc test, n=5 slides per group.*

| # FOVs | % Decrease in Hands on Time |
|---|---|
| 10 | 84 |
| 20 | 86 |
| 40 | 85 |
| 50 | 84 |

***Table 1**. Percentage decrease in hands on time for automated workflow in comparison to manual workflow.*

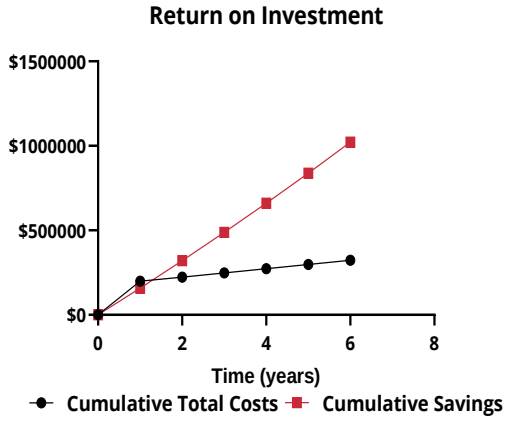


***Figure 3**. Gram Scanner investment costs and savings in labor over a 5-year period.*



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