

First Evaluation of the ASpecT, a New Automated Microbiology Plating Instrument  
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## ABSTRACT

Many laboratories are experiencing growing shortages of trained microbiology technologists and technicians. Consequently, there is considerable interest in new automation that could potentially lessen labor demands for specimen processing. In this study, we present the first published evaluation of a new microbiology instrument, the ASpecT (Automated Specimen Processor) manufactured by Copan, Inc. in which we evaluated cross-contamination, accuracy of plating, and quality of results. Absence of cross-contamination was demonstrated by plating a total of 200 alternating inoculated and sterile specimen tubes. The ability of the ASpecT to subculture enrichment broths was evaluated with 106 LIM broths, with results identical to routine testing. Plating of urine specimens with the ASpecT was compared to plating with the Dynacon Inoculab instrument. 300 specimens were plated in duplicate with both instruments using 1- $\mu$ l loops and 293 specimens were plated in duplicate on both instruments with 10- $\mu$ l loops. Results were compared between duplicate plating with the same instrument (replicate plating) and for consensus agreement between the two instruments. Replicate plating results were comparable for both instruments while the ASpecT had more specimens with significant results than the Inoculab with the 1- $\mu$ l loop only. Lastly, for plating of 113 ESwab specimens, the manual method and ASpecT plating each yielded 90 potential pathogens. In summary, we report a first evaluation of a new microbiology specimen-plating instrument, the ASpecT, which offers opportunities to automate the plating of microbiology specimens to an extent that has not been possible to date.

## INTRODUCTION

Clinical microbiology laboratories have largely been bypassed in the advances in automation that have benefitted other areas of the clinical laboratory in recent years. Continuously monitoring blood culture systems as well as automated microbial identification and susceptibility testing systems are widely utilized. However, the specific areas of specimen processing and culture workup remain manual tasks with few changes in the recent past. While some larger labs utilize urine-plating instrumentation, most microbiology laboratories have no automation in their processing areas. In this report, we present the results of a preliminary evaluation of a new microbiology plating instrument that offers the potential to automate the plating of a variety of liquid-based microbiology specimens.

## MATERIALS AND METHODS

**Overview of ASpecT.** The ASpecT (Automated Specimen Processor) is a new instrument manufactured in Italy for Copan Diagnostics (Murrieta, CA) that is designed to plate liquid specimens from a variety of different transport devices (See Figures 1 and 2). The ASpecT utilizes two Toshiba SCARA (selective compliant assembly robot arm) robots. The first robot moves specimens and plated media and takes specimens to the decapping device while the second robot does the actual inoculation and plate streaking. Barcode readers on the ASpecT scan the specimen tube, and a printer prints specimen information and a barcode on a label that is placed on the plated media. A 9-silo carousel holds 342 standard BD plates (Becton Dickinson Microbiology Systems, Cockeysville, MD) or 378 standard Remel plates (Remel, Lenexa, KS). Only transport devices with the specimen in a liquid phase can be processed on the ASpecT. With the exception of large urine cups (120 ml cups in our lab), all specimens are loaded on the ASpecT using special Teflon pallets that contain holes that are sized for specific containers. For example, one pallet holds 12 Vacutainer urine transport tubes, a different pallet holds 12 ESswabs, and a third type of pallet holds 6 enteric transport media tubes. Up to 6 pallets can be loaded on to the instrument at one time, resulting in a maximum load of 72 Vacutainers or ESswabs at one time. The ASpecT also has a vortex and a spinner/centrifuge that can be used to prepare specimens for plating. Actual plating is done by three metal loops incorporated in a triquetra (three cornered) loop inoculation tool (Figure 3). The loops are available in 3 sizes: 1 ul, 10 ul, and 30 ul. The ASpecT contains multiple sensors to verify proper operation including one sensor that is connected to a camera that verifies that the loop contains specimen after it is dipped into the specimen. A touch-screen computer facilitates selection of inoculation protocols, media, and streaking patterns, as well as other functions, and guides operation of the ASpecT.

This evaluation consisted of a preliminary evaluation of the first production version of a ASpecT in a clinical microbiology laboratory. At the time that this evaluation was performed, the ASpecT contained software to process only urine Vacutainer specimens, UriSwabs and ESswabs. Consequently, this evaluation was limited to those specimen transport devices.

**Cross-Contamination Studies.** To determine whether cross contamination occurs when streaking sequential specimens using the ASpecT instrument, studies were performed with both Vacutainer Urine C&S Preservative Plus Plastic Tubes (B.D.) and ESswabs (Copan). A fresh subculture of *Escherichia coli* (ATCC # 35218) was used to prepare a suspension equivalent to a 0.5 MacFarland standard in sterile saline. Dilutions were performed to obtain  $\sim 10^5$  CFU/ml and  $\sim 10^6$  CFU/ml organism suspensions.

Four ml of sterile saline was added to each of 50 Vacutainer tubes, and 4 ml of the  $10^5$  CFU/ml E. coli suspension was added to each of an additional 50 Vacutainer tubes. The tubes were then placed into the appropriate ASpecT pallet by alternating a tube filled with the E. coli suspension and a tube filled with sterile saline. The pallets were placed on the ASpecT instrument, and a standard urine-streaking pattern was selected that included a Blood Agar Plate (BAP) and MacConkey (MAC) Agar Plate for each of the 100 Vacutainers. All Vacutainer tubes were plated first using a 1 $\mu$ L loop and then retested using a 10 $\mu$ L loop. This yielded a total of 200 sets of plates: 100 sets inoculated with sterile saline and 100 sets inoculated with the E. coli suspension. Plates were incubated at 37°C and examined at 24 h for growth.

For testing of ESwabs, 0.1 ml of the  $10^6$  CFU/ml E. coli suspension was added to each ESwab tube (ESwabs contain 1 ml of liquid Amies transport media). The tubes were placed into the appropriate ASpecT pallet by alternating a tube inoculated with the E. coli suspension and a tube filled with only the transport media. The pallets were placed on the ASpecT instrument, and a 3-quadrant streaking pattern was selected that included a Blood Agar Plate (BAP) and MacConkey (MAC) Agar Plate for each of the 100 ESwab tubes. All ESwab tubes were processed first using a 10- $\mu$ L loop and then retested using a 30 $\mu$ L loop. This yielded a total of 200 sets of plates: 100 sets inoculated with sterile saline and 100 sets inoculated with the E. coli suspension. Plates were incubated at 37°C and examined at 24 h for growth.

**Enrichment broth subculture.** To verify the accuracy of the ASpecT for subculture of enrichment broths, testing was performed with LIM (Remel) broths. Routine LIM broths inoculated for prenatal group B strep screens from the Geisinger Microbiology Laboratory were used for this testing. Vaginal/rectals specimens are incubated in LIM broth for 18-24 h before subcultured for routine testing. After the routine testing was completed, LIM broth tubes were vortexed, and 1 ml was transferred to an empty, sterile ESwab tube. The ESwab tubes with LIM broth were subsequently subcultured to neomycin nalidixic acid (NNA) agar plates (BD) and BAP plates on the ASpecT using the 10- $\mu$ L loop. These cultures were read and worked up at 24h and 48h, and the results were compared with the routine culture results.

**Urine cultures.** The Dynacon Inoculab (Dynacon Inc., Mississauga, ON, Canada) is used for routine plating of urine cultures submitted in Vacutainer tubes to the Geisinger Microbiology laboratory. Plates on the Inoculab can be inoculated with either 1- $\mu$ L or 10- $\mu$ L loops. For this validation, routine urine specimens received in BD Vacutainers were first plated on BAP and MAC agar plates using a 1- $\mu$ L loop on the Inoculab for the routine microbiology lab culture, and these cultures were worked up and reported using standard Geisinger Microbiology Laboratory protocols. All specimens were then plated a second time with the Inoculab, and those plates were labeled for study purposes. The same specimens were then subsequently plated using a 1- $\mu$ L loop by the ASpecT on BAP and MAC plates in duplicate and identified for the study. This resulted in 4 total platings (2 times on Inoculab and 2 times on ASpecT ). Additional specimens were then 133 plated twice each on the Inoculab and the ASpecT using 10- $\mu$ L loops.

All plates were placed in a non-CO<sub>2</sub> incubator for a minimum of 16 hours. One set of the plates from the Inoculab inoculated with a 1- $\mu$ L loop was read and reported by a Geisinger Microbiology Technologist and the other sets of plates were read by one of us (BLS). Standard Geisinger microbiology laboratory procedures were used in the workup of all cultures. A senior technologist or one of us (PPB) reviewed all discrepant results.

**ESwabs.** Routine cultures from a variety of sources submitted to the laboratory in ESwabs were plated using the ASpecT. After routine manual plating was completed,

specimens were loaded onto the ASpecT and inoculated with a 3-quadrant streaking pattern, using BAP, MAC, 142 and CHOC agar plates. The ASpecT 30- $\mu$ l loop was used to inoculate all plates.

All cultures plated by the ASpecT were worked up independently of the manually plated cultures. Results were compared after all testing was completed on the manually plated and ASpecT plated specimens.

## RESULTS

**Cross-Contamination Studies.** 50 inoculated and 50 sterile Vacutainer tubes were alternately loaded on the ASpecT. They were plated with both 1- $\mu$ l and 10- $\mu$ l loops for a total of 200 cultures. No colonies were observed from the sterile tubes, and consistent streaking patterns were noted from the inoculated tubes. Similar results were observed with ESwab tubes for both the 10- $\mu$ l and 30- $\mu$ l loops with no growth from any of the sterile tubes and consistent streaking patterns from the inoculated tubes.

**Enrichment broth subculture.** 106 LIM broths were subcultured with the ASpecT. Preliminary studies (data not shown) indicated that the use of the 30- $\mu$ l loop did not result in a satisfactory number of isolated colonies. The use of the 10- $\mu$ l loop, however, produced consistent isolated colonies. Using the 10- $\mu$ l loop, there was 100% concordance with the routine culture method with each detecting 20 positive and 86 negative test results.

**Urine cultures.** A total of 300 specimens were processed in duplicate on the ASpecT and Inoculab using 1- $\mu$ l loops, while 293 specimens were processed in duplicate on both instruments using 10- $\mu$ l loops. The same specimens were not necessarily used for the 1- $\mu$ l loops and the 10- $\mu$ l loops so results were analyzed separately by loop size. Culture results were divided into those considered likely significant and those considered likely not significant.

For specimens plated with 1- $\mu$ l loops, single or multiple isolates with < 1000 CFU/ml and cultures with 3 or more organisms each with >10,000 CFU/ml (multiple flora) were considered not significant as were isolates of *Micrococcus* spp. and *Lactobacillus* spp. in any quantity. For the purposes of this study, coagulase-negative staphylococci and viridans streptococci were considered likely significant if present in a concentration of  $\geq$ 10,000 CFU/ml when present as a single pathogen or with no more than one other organism. For tabulation purposes, if a culture contained  $\geq$ 10,000 CFU of a potential pathogen (e.g. *E. coli*) and < 10,000 CFU/ml of one or two other organisms, the *E. coli* isolate was included with the significant isolates and the other organism(s) was included with the not significant isolates. For specimens plated with 10- $\mu$ l loops, results obtained were interpreted in a similar manner, accounting for the 10-fold difference in the dilution factor. Results obtained with the Inoculab and the ASpecT were evaluated in two ways. First, the replicate results were compared for each instrument. For example, the result obtained on specimen #1 plated with the ASpecT using the 1- $\mu$ l loop was compared with the second plating of specimen #1 on the ASpecT using the same size loop. Second, the recovery of significant isolates was compared between the two instruments.

The results of the replicate results for specimens with significant isolates are summarized in Table 1. Both instruments yielded similar results in replicate plating for significant isolates for both sized loops. Overall, for quantitation (same CFU/ml range, e.g. both replicates >10<sup>5</sup> CFU/ml), there were no significant differences between the results for the two instruments.

For cultures with non-significant results, there was agreement for the Inoculab between paired plates for the 1-ul loop for 184/223 results and 219/220 for the 10-ul loop. For the ASpecT, for specimens with non-significant results, there was agreement for the 1-ul loop for 192/220 results and 218/220 for the 10-ul loop. Most of the discrepant results involved specimens with no growth on one set of plates and < 10 actual colonies on the paired culture plates.

Results from ASpecT and Inoculab for specimens with significant results not in agreement are summarized in Table 2. From 74 specimens with significant results that were plated with 1-ul loops, there were 11 specimens with discrepant results. For 5 of the specimens, one of the Inoculab results was not in agreement with the 3 other results while for 1 specimen, one ASpecT result was not in agreement with the 3 other results. Four significant isolates were detected only by the two ASpecT cultures. Lastly, for one specimen, there was a difference in CFU/ml counts between the two ASpecT cultures and the two Inoculab cultures.

From 65 specimens with significant results that were plated with 10-ul loops, there were 7 specimens with discrepant results. One each of the ASpecT and Inoculab specimens was not in agreement with the 3 other results. For five specimens, there was a difference in CFU/ml counts between the two ASpecT cultures and the two Inoculab cultures.

**ESwab cultures.** A total of 113 specimens that were collected in ESwabes were plated on the ASpecT. These included 13 vaginal specimens and 100 routine cultures of mixed types (wounds, drainages, fluids, nares, skin, upper respiratory and others). All plates were inoculated using a 30-ul loop and read at 24 and 48 h of incubation. Manual and ASpecT plating both yielded 90 potential pathogens. The yield of normal flora (skin, vaginal, and respiratory) was also the same. One of the ASpecT cultures grew one colony of mold that was not detected on the manually plated culture.

## **DISCUSSION**

Many laboratories are experiencing growing shortages of trained microbiology technologists and technicians. This has been exacerbated not only by growth in routine testing but also by the demand for testing performed for epidemiological purposes, such as for MRSA (3). Consequently, there is considerable interest in new automation that could potentially lessen labor demands for specimen processing (7).

Current instrumentation available for microbiology processing includes streaking and plating instruments. There are 3 instruments currently available that can perform plate inoculation and streaking: The Dynacon Inoculab (LQ and LQH models); the bioMérieux MicroStreak instrument; and the ASpecT.

Inoculab instruments are designed to plate urine specimens of one specimen type. They plate specimens from one type of container that is selected at the time of instrument purchase. The Dynacon model LQH that we have in our lab holds a total of 38 uninoculated Remel plates, giving it a capacity of 19 specimens without reloading if two plates are used for each culture or 38 specimens if one plate is used. Since the LQH model has only one silo for uninoculated plates, if you use more than one type of plate for a culture, the plates must be intercalated in the stack. Inoculab instruments can also be used in a streak-only function.

The MicroStreak was released in 2008 (2). The MicroStreak requires a plugged disposable pipette tip for each specimen and one disposable plastic applicator for each plate. It can plate either single plates or biplates, and the applicator spreads the inoculum over the entire area of a standard 100 mm plate or a biplate. The smallest pipette that the MicroStreak can use is a 10-ul pipette and currently, the specimen top

must be removed at the time the specimen is placed on the instrument. If the residual specimen is to be saved, the specimen must be recapped after plate inoculation(2).

This study was designed to be a preliminary evaluation of a new instrument named the ASpecT. It was restricted to two container types-Vacutainers and ESwab tubes. Software that was not available when this study was performed will permit sampling of other specimen containers. We compared inoculation of urine Vacutainer specimens by the ASpecT and the Inoculab LQH instrument. We did not perform manual plating for this study as our in-house validation of the Inoculab instrument indicated that the Inoculab results were more reproducible than our manual plating method. Lue has also shown that the Inoculab was more accurate than manual plating in her lab using a 1-ul loop (5). Moreover, variability in manual specimen volume transfer for urine specimens has been demonstrated (1). We also evaluated the accuracy of the ASpecT to subculture Lim broths. Lastly, we compared manual plating of routine specimens collected in ESwabs with plating performed by the ASpecT.

Overall, the results obtained with the Inoculab and ASpecT for plating of urine specimens were comparable for specimens plated with 1-ul and 10-ul loops. Interestingly, there were 4 specimens plated with the 1-ul loop that grew a significant pathogen at a concentration of  $10^4$ - $10^5$  CFU/ml on both ASpecT cultures (2 with *Enterococcus* sp. and one each with *K. pneumoniae* and B-hemolytic *Streptococcus*) while the Inoculab culture was mixed or had multiple flora. Similarly, there was also one specimen plated with the 10-ul loop that grew *Enterococcus* sp. at a concentration of  $10^3$ - $10^4$  CFU/ml on both ASpecT cultures and mixed flora on the Inoculab culture.

There are several possible explanations for the different results between the ASpecT and Inoculab for these specimens: (1) random differences in CFUs near the breakpoints for reporting organisms; (2) failure of a loop to pick up specimen (loss of meniscus); and (3) more homogeneous specimen preparation with one instrument than the other. Differences between the operation of the Inoculab and ASpecT operation support the latter two possibilities. The ASpecT has a camera that detects the presence of a droplet inside the inoculating loop after the specimen is sampled. If no specimen is detected, the loop returns to the tube a second time and, if necessary, a third time. If the camera fails to again detect a droplet, the tube is moved to a discard bin. The Inoculab has no sensor to detect the presence of specimen in the loop. A second difference between the instruments is the preparation of the specimen prior to sampling. The instrument manual for the Inoculab states that the specimen should be agitated prior to placing it on the instrument but does not specify how that agitation should be accomplished. In contrast, the ASpecT has a vortex that vigorously mixes the urine tube prior to sampling. The exact reasons for the observed differences are clearly speculative on our part; nonetheless, the ability to verify the presence of actual specimen in the inoculating loop as well as vigorous vortexing prior to plating may offer more than a theoretical advantage for the ASpecT compared to the Inoculab instrument.

Clearly, there is a need for studies that will assess the speed, throughput, and labor savings of the ASpecT. At the time that this preliminary study was performed, the ASpecT required 27 min. to plate 24 Vacutainer tubes to two plates each while the Inoculab required 24 minutes to plate 24 Vacutainer tubes to two plates. We anticipate collecting more data once the Sunquest interface is fully validated and software upgrades have been installed.

There are also significant capacity differences between the Inoculab and the ASpecT. The Dynacon model LQH, which was used in our laboratory, holds a total of 38 uninoculated Remel plates compared to 378 Remel plates for the ASpecT. Since the Dynacon LQH model has only one silo for uninoculated plates, if you use more than one

type of plate for a culture, the plates must be intercalated in the stack. This would not be necessary if a single plate was used. The Dynacon Inoculab model LQ has 2 silos for uninoculated media that permits the use of one silo for each of two types of media for each specimen. The ASpecT has nine silos each holding 42 Remel plates, and one to nine types of media can be loaded at one time. More than one silo can be loaded with the same type of media. For example, if a lab uses a BAP for most specimen types, they might choose to load 3 silos with BAP and fewer silos with other types of media.

In our evaluation of the ASpecT for subculturing broths to plated media, we encountered no problems with the ASpecT. Using a 10-ul loop, the ASpecT consistently produced isolated colonies. For this study the Lim broths were transferred to empty ESwab tubes. We do not anticipate that labs would want to do this as a standard practice. The resolution to this issue could be the production of broths in smaller tubes either by Copan and or another manufacturer or software changes to the ASpecT to accommodate taller tubes.

Although our evaluation of the ASpecT for plating of routine cultures was limited to 113 specimens, results obtained were comparable to the manually plated cultures. We developed a 3-quadrant streaking pattern for use with the 30-ul loop that was used for all of these specimens. The ASpecT has the potential to process different size containers. The jaws on the robot have three settings to accommodate 3 sizes of containers. There are three docking stations (the docking station holds the bottom of the container during the uncapping process) that also accommodate 3 sizes of containers. The docking station can be easily swapped out. There are two decapping devices on the ASpecT. One is fixed and is designed for Vacutainer urine tubes. A variety of other decappers can be placed in the second decapping station including an ESwab decapper. For this study we used the decapper and docking station designed to hold ESwabs.

During this evaluation, we encountered no problems opening and closing either Vacutainers or ESwab tubes. Subsequent to the performance of this study, an interface was established between the ASpecT and the Sunquest Laboratory Information System. While now operational, it has yet to be fully validated. Unlike the MicroStreak, and similar to the Inoculab, the ASpecT requires no disposable products for plating. The option of plating urine specimens with 1-ul or 10-ul provides laboratories with flexibility to address clinical needs (4, 6).

The only mechanical (hardware) problem that we encountered during this study was a burnt out incinerator that we replaced. There were several software problems that were systematically addressed by Copan as they appeared. None of those problems persisted.

This study was designed to be a preliminary evaluation of a new instrument, the ASpecT. As we expand the use of the ASpecT to other specimen types, we are working to optimize the workflow pattern for each specimen type. In our routine use of ESwabs, specimens are manually plated using a disposable pipette that is manufactured to deliver approximately 28 ul/drop. Each piece of media receives one drop of the inoculum, and, for specimens requiring a Gram stain, one drop is placed on a slide. We envision a similar workflow with the ASpecT, with the preparation of any necessary slides occurring prior to loading containers onto the ASpecT for plating. It is important to understand that the only type of swab specimens that can be plated by the ASpecT is a swab that transfers the specimen to a liquid phase. ESwab is currently the only swab with that capability. ESwabs are more expensive than traditional wound swabs, and, for labs that are not using ESwabs routinely, this increase in cost should be included in the operational budget for the ASpecT.

We anticipate that the relative amount of specimens that a laboratory can plate on an ASpecT will be strongly influenced by specimen volume for a particular test and the media required for that particular specimen/test. For example, if a laboratory plants an average of 5 specimens each day of a particular specimen/test and that test requires media not used for other tests, adding and removing the required media from the silos may not be an efficient use of time. Importantly, the current operation of the ASpecT is designed for batch testing, not random-access testing.

In summary, we report a first evaluation of a new microbiology specimen-processing instrument, the ASpecT. We were satisfied by the performance of the ASpecT and believe that it offers opportunities to automate the processing of microbiology specimens to an extent that has not been possible to date. Additional studies by this and other laboratories are merited to test the full potential of the instrument.

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## Figure Legends

- Fig. 1. Front view of the ASpecT . The dimensions of the instrument are 75 inches wide, 75 inches high and 43 inches deep.
- Fig. 2. Top view of the ASpecT . The two SCARA robots are referred to as Tarzan and Jane.
- Fig. 3. Triquetra Loop. From left to right, 10-ul, 30-ul, and 1-ul loops.

Figure 1



Figure 2

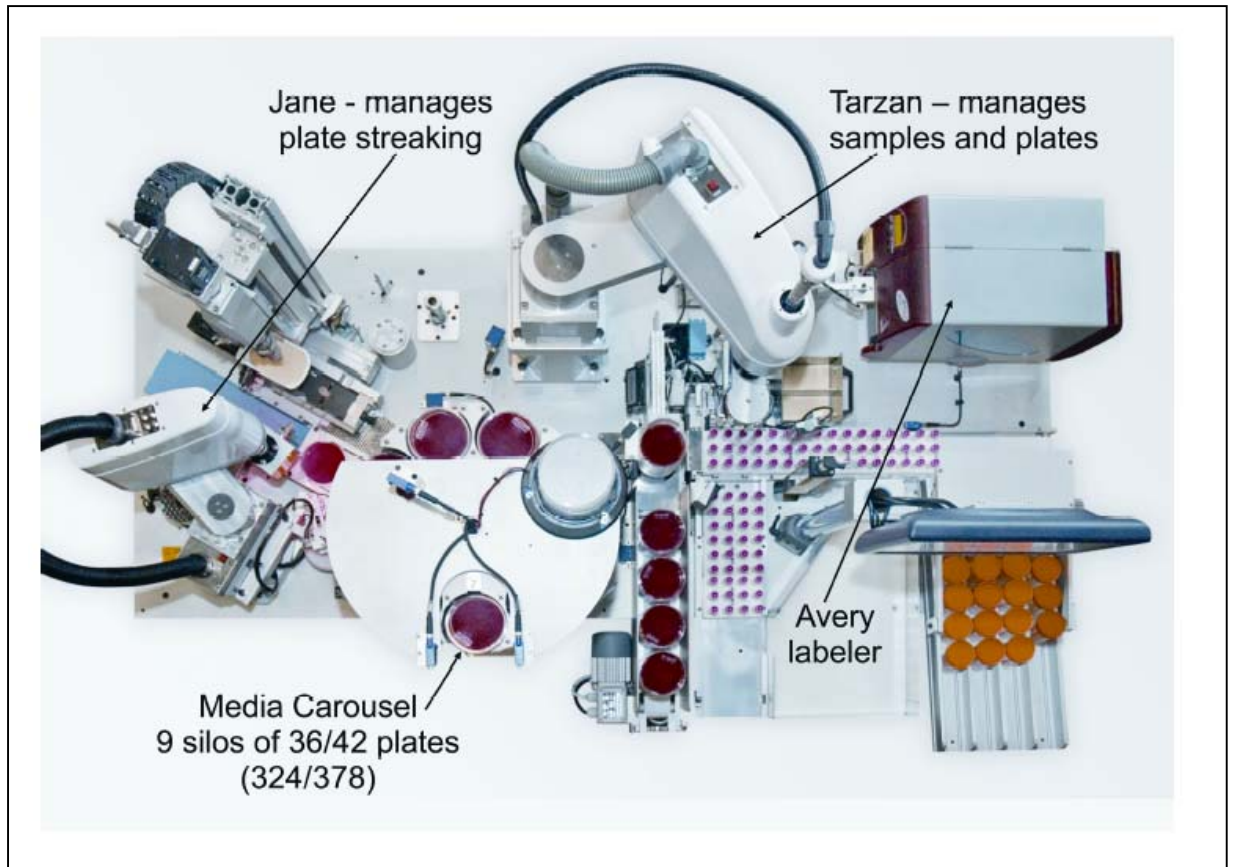


Figure 3

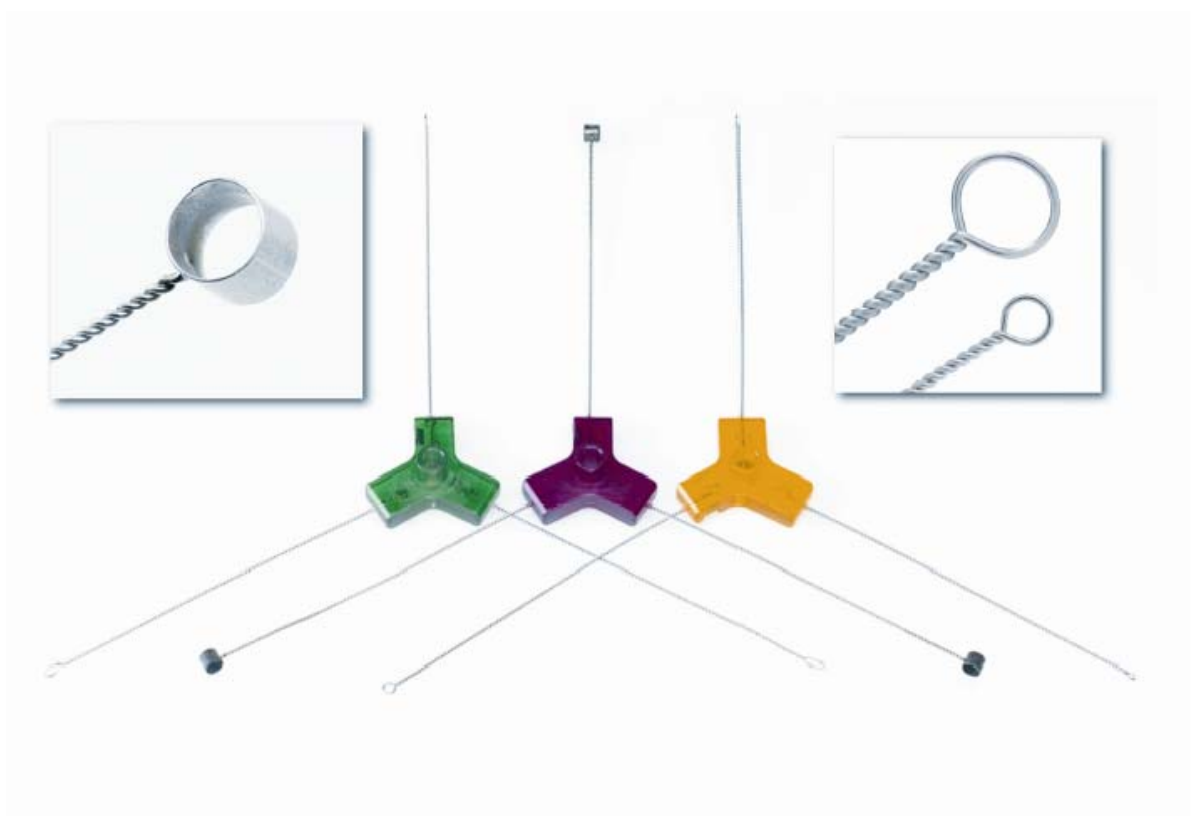


Table 1. Summary of replicate plating results for significant isolates.

	1-ul Inoculum		10-ul Inoculum	
	Total <sup>a</sup>	Same result <sup>b</sup> (same CFU range) <sup>c</sup>	Total	Same result (same CFU range)
Inoculab	80	80 (75)	71	71 (70)
ASpecT	81	80 (79)	70	70 (70)

<sup>a</sup> Total number of significant isolates for that instrument.

<sup>b</sup> Same result indicates same organism in replicate cultures with  $\geq 10^4$  CFU/ml for 1-ul inoculum or  $\geq 10^3$  CFU/ml for 10-ul inoculum.

<sup>c</sup> Same CFU range indicates results of both replicates had similar quantitation ( $10^3 - 10^4$  CFU/ml, or  $10^4 - 10^5$  CFU/ml or  $> 10^5$  CFU/ml)

Table 2: Results from ASpecT and Inoculab for specimens with significant results not in agreement<sup>a</sup>.

Inoculab			ASpecT	
Loop Size	Replicate 1	Replicate 2	Replicate 1	Replicate 2
1-ul	Multiple Flora	<10 <sup>4</sup> Mixed Flora	10 <sup>4</sup> -10 <sup>5</sup> Enterococcus <10 <sup>4</sup> 2 other orgs.	10 <sup>4</sup> -10 <sup>5</sup> Enterococcus <10 <sup>4</sup> 2 other orgs
	<10 <sup>4</sup> Mixed Flora	<10 <sup>4</sup> Mixed Flora	10 <sup>4</sup> -10 <sup>5</sup> Beta-strep	10 <sup>4</sup> -10 <sup>5</sup> Beta-strep
	<10 <sup>4</sup> 1 type	<10 <sup>4</sup> 1 type	10 <sup>4</sup> -10 <sup>5</sup> Enterococcus	10 <sup>4</sup> -10 <sup>5</sup> Enterococcus
	<10 <sup>4</sup> 1 type	No growth	10 <sup>4</sup> -10 <sup>5</sup> KI. pneumoniae <10 <sup>4</sup> 1 type	10 <sup>4</sup> -10 <sup>5</sup> KI pneumoniae <10 <sup>4</sup> 1 type
	>10 <sup>5</sup> E. coli	10 <sup>4</sup> 10 <sup>5</sup> E. coli >	10 <sup>5</sup> E. coli	> 10 <sup>5</sup> E. coli
	>10 <sup>5</sup> E. coli	10 <sup>4</sup> 10 <sup>5</sup> E. coli	> 10 <sup>5</sup> E. coli	> 10 <sup>5</sup> E. coli
	>10 <sup>5</sup> Beta-strep	10 <sup>4</sup> -10 <sup>5</sup> Beta-strep	>10 <sup>5</sup> Beta-strep	> 10 <sup>5</sup> Beta-strep
	10 <sup>4</sup> -10 <sup>5</sup> S. aureus	10 <sup>4</sup> -10 <sup>5</sup> S. aureus	>10 <sup>5</sup> S. aureus	10 <sup>4</sup> -10 <sup>5</sup> S. aureus
	10 <sup>4</sup> -10 <sup>5</sup> P. mirabilis	10 <sup>4</sup> -10 <sup>5</sup> P. mirabilis	>10 <sup>5</sup> P. mirabilis	>10 <sup>5</sup> P. mirabilis
	10 <sup>4</sup> -10 <sup>5</sup> NLF	> 10 <sup>5</sup> NLF	> 10 <sup>5</sup> NLF	> 10 <sup>5</sup> NLF
	10 <sup>4</sup> -10 <sup>5</sup> CNS	> 10 <sup>5</sup> CNS	> 10 <sup>5</sup> CNS	> 10 <sup>5</sup> CNS
	<10 <sup>4</sup> 1 O.T.	<10 <sup>4</sup> 1O.T.	<10 <sup>4</sup> 1O.T.	<10 <sup>4</sup> 1O.T.
	10-ul	Multiple Flora	Multiple Flora	10 <sup>3</sup> – 10 <sup>4</sup> CNS <10 <sup>3</sup> 1 O.T.
<10 <sup>3</sup> 2 orgs.		<10 <sup>3</sup> 2 orgs.	10 <sup>3</sup> – 10 <sup>4</sup> Enterococcus <10 <sup>3</sup> 1 O.T.	10 <sup>3</sup> – 10 <sup>4</sup> Enterococcus <10 <sup>3</sup> 1 O.T.
<10 <sup>2</sup> Mixed Flora		10 <sup>3</sup> – 10 <sup>4</sup> CNS <10 <sup>2</sup> 1 O.T.	10 <sup>3</sup> – 10 <sup>4</sup> CNS <10 <sup>3</sup> 1 O.T.	10 <sup>3</sup> – 10 <sup>4</sup> CNS <10 <sup>3</sup> 1 O.T.
10 <sup>3</sup> – 10 <sup>4</sup> E. Coli		10 <sup>3</sup> – 10 <sup>4</sup> E. coli	> 10 <sup>4</sup> E. coli	> 10 <sup>4</sup> E. coli
10 <sup>3</sup> – 10 <sup>4</sup> GBS		10 <sup>3</sup> – 10 <sup>4</sup> GBS	> 10 <sup>4</sup> GBS	> 10 <sup>4</sup> GBS
10 <sup>3</sup> – 10 <sup>4</sup> Enterococcus		10 <sup>3</sup> – 10 <sup>4</sup> Enterococcus	> 10 <sup>4</sup> Enterococcus	> 10 <sup>4</sup> Enterococcus
10 <sup>3</sup> – 10 <sup>4</sup> Vir. strep. <10 <sup>2</sup> 1 O.T.		10 <sup>3</sup> – 10 <sup>4</sup> Vir. strep. <10 <sup>2</sup> 1 O.T.	> 10 <sup>4</sup> Vir. strep. <10 <sup>2</sup> 2 O.T.	> 10 <sup>4</sup> Vir. strep. <10 <sup>2</sup> 1 O.T.

<sup>a</sup> O.T.= other type; GBS= Group B Streptococci; CNS= coagulase negative staphylococci; NLF= unidentified non-lactose fermenting Gram-negative bacilli.