From Implementation to Innovation: Digital Pathology Infrastructure and Cost

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Memorial Sloan Kettering Cancer Center

DIGITAL PATHOLOGY DPA ASSOCIATION

Digital Pathology Central Role In Pathology
Specific Infrastructure Needs and Resources

Digital pathology evolution from minor technology to becoming the core of modern pathology workflows, connecting analog pathology, slide scanning, data storage, and case management.

- Large academic medical center
- Large private pathology practice
- Reference laboratories
- Research institution
- Small pathology practice
- AI/Tech

…and more- no two institutional needs will be alike

Dr. Orly Ardon

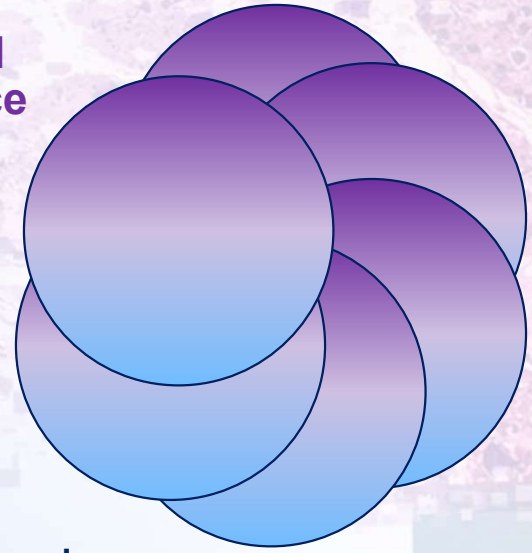
Needs of a Digital Pathology Program

Sponsorship from Leadership

Vision and resources

Service and maintenance

Internal
External



Scanners

Digital workflow infrastructure: capacity, speed, image quality, barcode reader LIS integration

Space

For coordinated workflows: accessible, turnaround time, quality and maintenance

Servers and storage

IS and IT infrastructure and software

Staffing

Trained and aligned with laboratory activities

IT support

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Contents lists available at ScienceDirect

Journal of Pathology Informatics

journal homepage: www.elsevier.com/locate/jpi

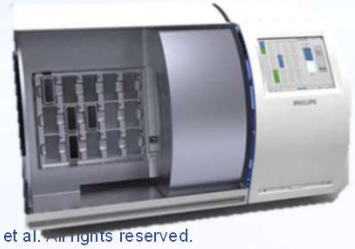
ELSEVIER

Digital pathology operations at a tertiary cancer center: Infrastructure requirements and operational cost

Orly Ardon *, Eric Klein, Allyne Manzo, Lorraine Corsale, Christine England, Allix Mazzella, Luke Geneslaw, John Philip, Peter Ntiamoah, Jeninne Wright, Sahussapont Joseph Sirintrapun, Oscar Lin, Kojo Elenitoba-Johnson, Victor E. Reuter, Meera R. Hameed, Matthew G. Hanna *

Successful Quality Digital Pathology Ecosystem: “The 6 Ss”

Whole Slide Scanners



Hardware Publications of Interest (partial list)

Review Article

Contemporary Whole Slide Imaging Devices and Their Applications within the Modern Pathology Department: A Selected Hardware Review

Ankush Patel[1], Ulysses G. J. Balis[2], Jerome Cheng[2], Zaibo Li[1], Giovanni Lujan[1], David S. McClintock[2], Liron Pantanowitz[2], Anil Parwani[1]

[1]Department of Pathology, The Ohio State University, Columbus, Ohio. [2]Department of Pathology, University of Michigan, Ann Arbor, Michigan, USA

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JPI https://doi.org/10.4103/jpi.jpi_66_21

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Measuring digital pathology throughput and tissue dropouts

George L. Mutter [a,b,*], David S. Milstone [a,b], David H. Hwang [a,b], Stephanie Siegmund [a,b], Alexander Bruce [a]

https://doi.org/10.4103/jpi.jpi_5_21

Pathology - Research and Practice

Volume 253, January 2024, 155028

Complete digital pathology transition: A large multi-center experience

Benzion Samueli [a b 1 6], Natalie Aizenberg [a b 2 6], Ruthy Shaco-Levy [a b c], Aviva Katzav [d], Yarden Kezerle [a b 3], Judit Krausz [e 4], Salam Mazareb [f], Hagit Niv-Drori [g h], Hila Belhanes Peled [e], Edmond Sabo [f i], Ana Tobar [g h], Sylvia L. Asa [j 5]

Journal of Pathology Informatics

Volume 12, Issue 1, January–December 2021, 25

Original Article

Comparative Assessment of Digital Pathology Systems for Primary Diagnosis

Sathyanarayanan Rajagopalan [1], Rajiv Kumar [1], Vidya Rao [1], Trupti Pai [1], Neha Mittal [1], Ayushi Sahay [1], Santosh Menon [1], Sangeeta Desai [1]

Journal of Pathology Informatics

Volume 12, Issue 1, January–December 2021, 39

Original Article

Testing of Actual Scanner Performance in a High-loaded UNIM Laboratory Environment

Mikhail Yurevich Genis [1], Alexey Igorevich Remez [1], Maxim Ivanovich Untesco [1], Dmitrii Anatolevich Zhakota [2]

Journal of Pathology Informatics 18 (2025) 100446

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Digital slide scanning at scale: Comparison of whole slide imaging devices in a clinical setting

Orly Ardon [a,b,*], Allyne Manzo [a], Jamaal Spencer [a], Victor E. Reuter [a,b], Meera Hameed [a,b], Matthew G. Hanna [a,b,1]

Pathology and Laboratory Medicine International

Dovepress

REVIEW

Whole slide imaging in pathology: advantages, limitations, and emerging perspectives

This article was published in the following Dove Press journal: Pathology and Laboratory Medicine International 11 June 2015

Number of times this article has been viewed

Navid Farahani[1] Anil V Parwani[2] Liron Pantanowitz[2]

[1]Department of Pathology and Laboratory Medicine, Cedars-Sinai Medical Center, Los Angeles, CA, USA; [2]Department of Pathology, University of Pittsburgh School of Medicine, Pittsburgh, PA, USA

Abstract: Significant technologic gains have led to the adoption of innovative digital imaging solutions in pathology. Whole slide imaging (WSI), which refers to scanning of conventional glass slides in order to produce digital slides, is the most recent imaging modality being employed by pathology departments worldwide. WSI continues to gain traction among pathologists for diagnostic, educational, and research purposes. This article provides a technologic review of WSI platforms and covers clinical and nonclinical pathology applications of these imaging systems. Barriers to adoption of WSI include limiting technology, image quality, problems with scanning all materials (eg, cytology slides), cost, digital slide storage, inability to handle

https://doi.org/10.2147/PLMI.S59826

Digitization of Pathology Labs: A Review of Lessons Learned

Lars Ole Schwen[a,*], Tim-Rasmus Kiehl[b], Rita Cavalho[b], Norman Zerbe[b], André Homeyer[a]

[a]*Fraunhofer Institute for Digital Medicine MEVIS, Max-von-Laue-Str. 2, 28359 Bremen, Germany*

[b]*Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin and Humboldt Universität zu Berlin, Institute of Pathology, Charitéplatz 1, 10117, Berlin, Germany*

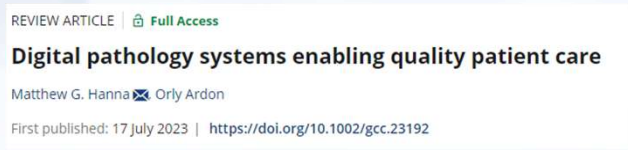
Lab Invest. 2023 Nov;103(11):100244. doi: 10.1016/j.labinv.2023.100244.

REVIEW ARTICLE

Integrating digital pathology into clinical practice

Matthew G. Hanna [1 &], Orly Ardon [1], Victor E. Reuter [1], Sahussapont Joseph Sirintrapun [1], Christine England [1], David S. Klimstra [1] and Meera R. Hameed [1 &]

Modern Pathology (2022) 35:152–164; https://doi.org/10.1038/s41379-021-00929-0



REVIEW ARTICLE | Full Access

Digital pathology systems enabling quality patient care

Matthew G. Hanna | Orly Ardon

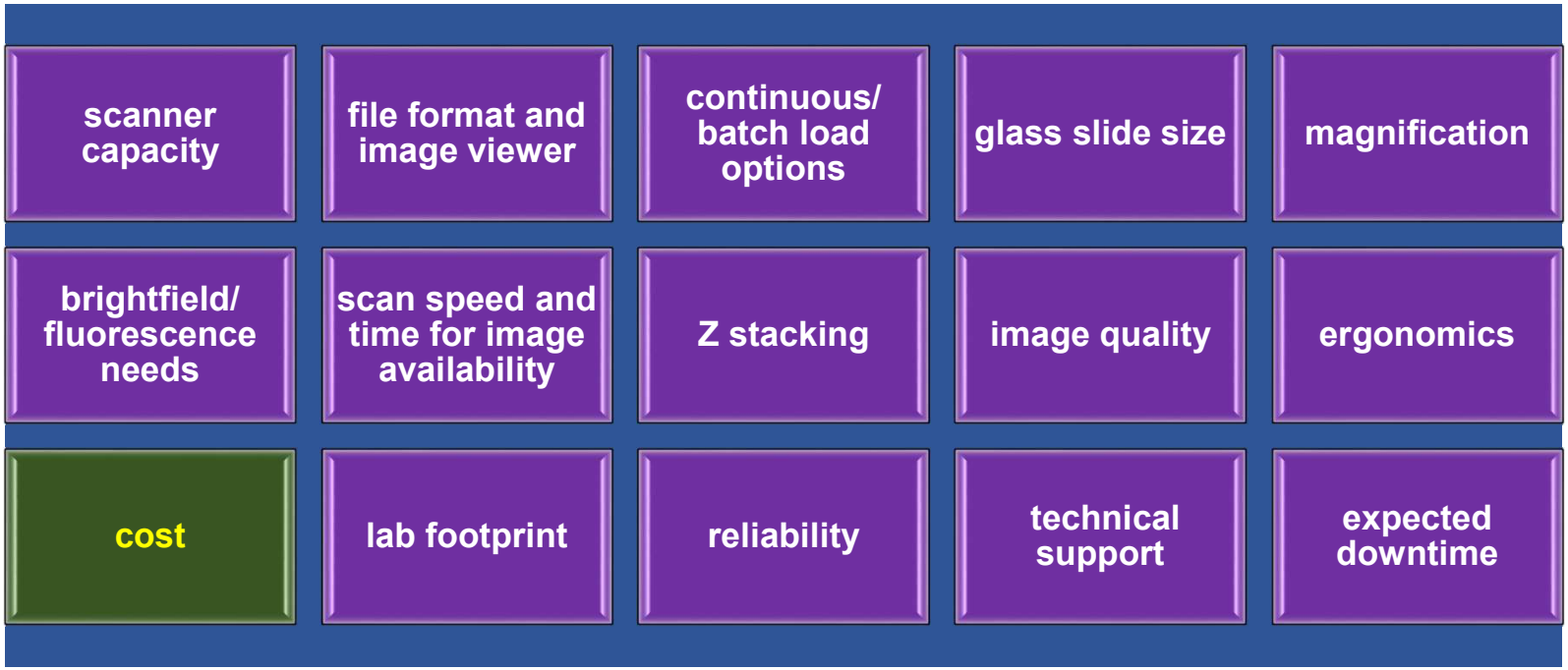
First published: 17 July 2023 | https://doi.org/10.1002/gcc.23192

Institutions May Have Multi-Vendor Operations

- Need to identify best technology for specific intended uses
- No/little interoperability
- Different technologies, potentially different use cases
- Internal and external technical support is a necessity
- Software application specific to vendor

Whole Slide Imaging System selection:
The right scanner for the right use case and operational need

The goal is to optimize operational efficiency and quality



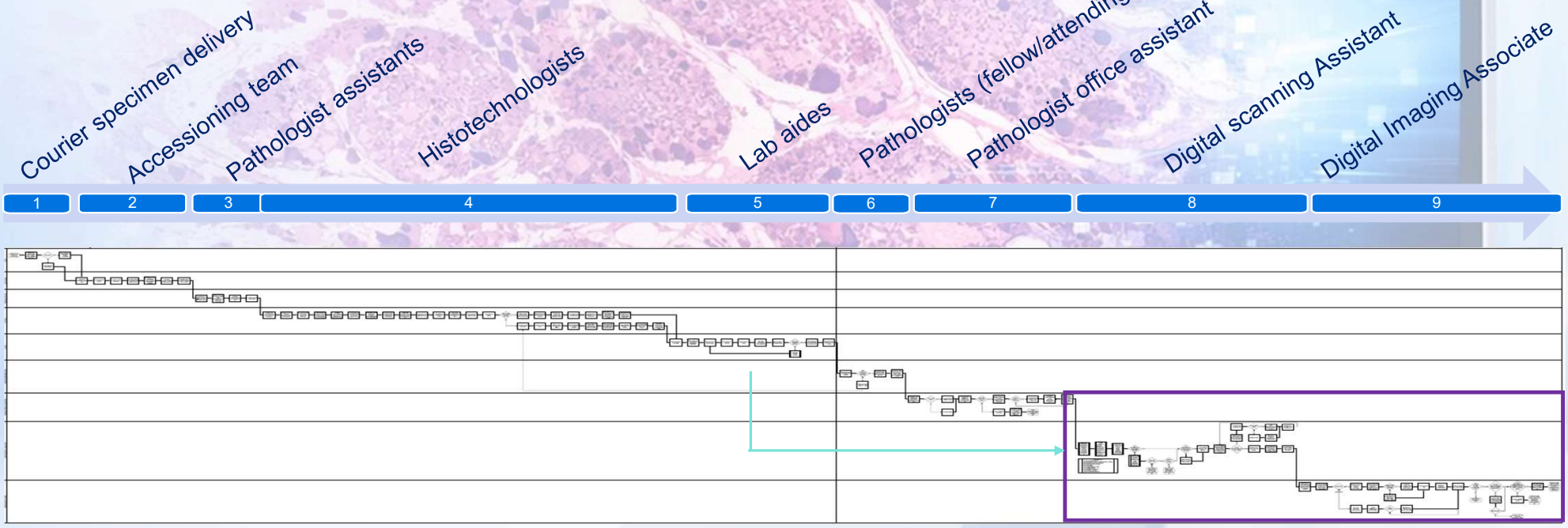
After Ardon et al. https://doi.org/10.1016/j.jpi.2023.100318

Successful Quality Digital Pathology Ecosystem: “The 6 Ss”

Staffing

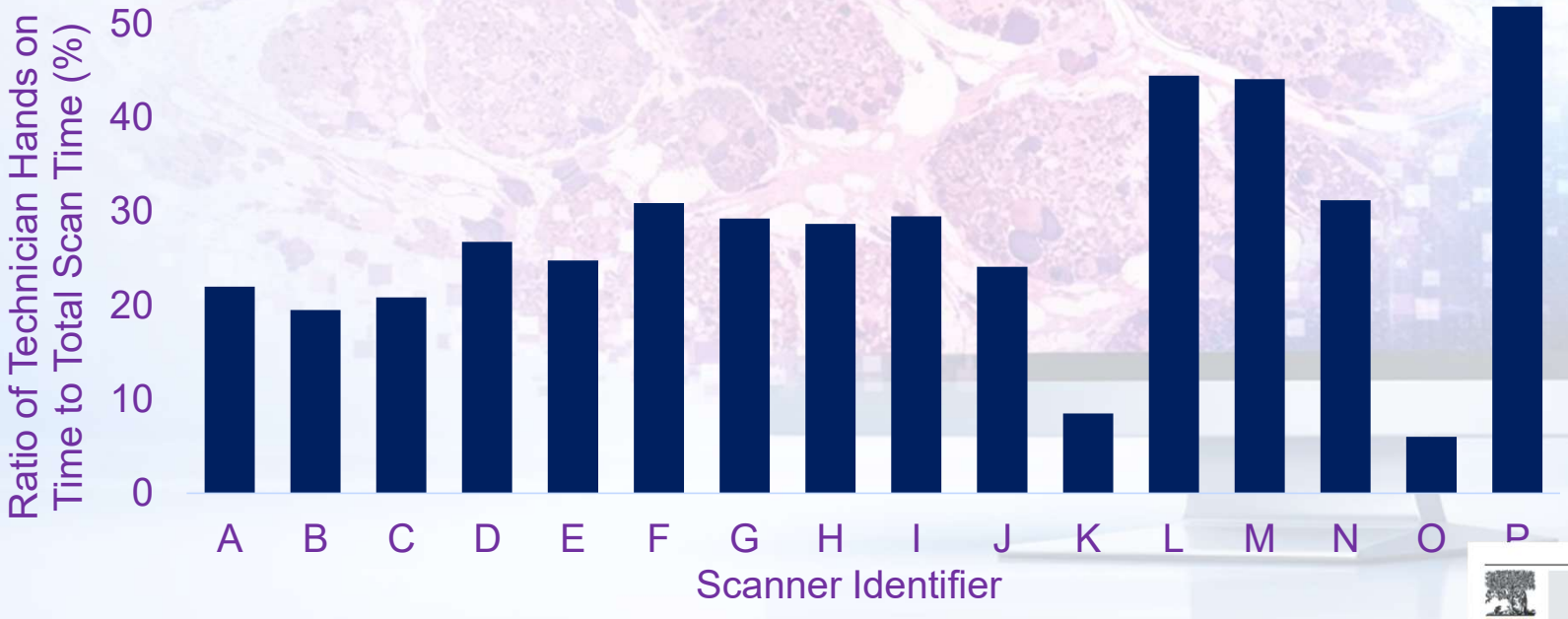
- Trained and aligned with laboratory activities
- IT support

Digital Pathology Involves All Teams in Pathology



Scanners Have Variable Technician Hands On Requirement

Technician time is essential for optimized scan mode and for image review.
In this study, it ranged from 5% to 51% of the total run time.




Journal of Pathology Informatics

Digital slide scanning at scale: Comparison of whole slide imaging devices in a clinical setting

Quality and Cost

Quality control systems are designed to minimize operation errors and are required for patient care

Tradeoff between cost and risk to patients

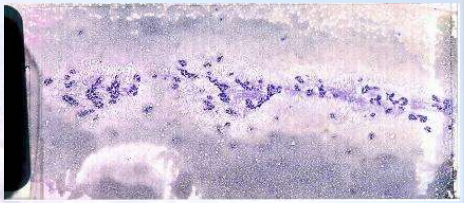
Reducing errors reduces operation costs

- Cost of Quality: cost of conformance and cost of failure

Quality Assurance in the WSI Process

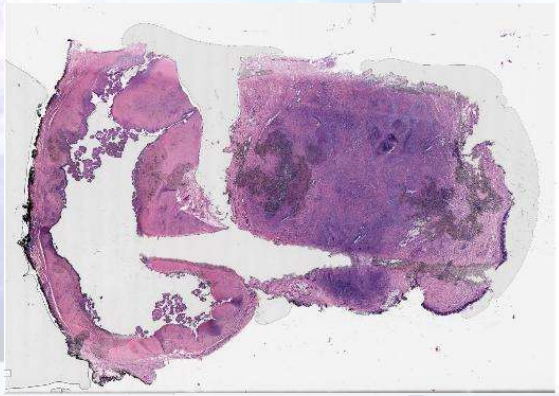
Pre-Analytical

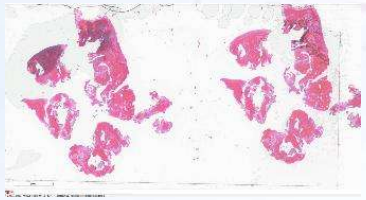
- Specimen collection and transport to pathology
- Specimen receipt and accessioning
- Grossing
- Tissue processing
- Tissue embedding
- Microtomy
- Staining, coverslipping and drying



Analytical

- Scanner load
- Digital imaging
- Digital image upload to LIS
- Digital image quality review



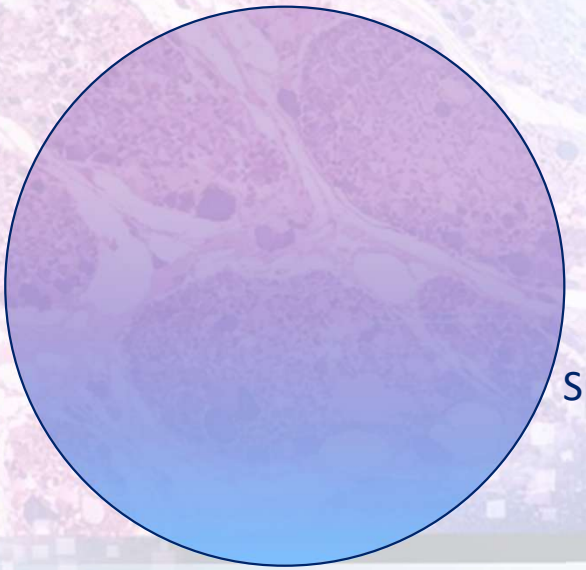


Post-Analytical

- Image analysis
- Pathologist review and reporting
- Data storage
- Glass slide storage

Ardon et al. 2023. https://doi.org/10.1016/j.labinv.2023.100246

Successful Quality Digital Pathology Ecosystem: “The 6 Ss”



Space

For coordinated workflows: accessible, turnaround time, quality and maintenance

Dedicated Scanning Operations Space: Design and Modularity














Successful Quality Digital Pathology Ecosystem: “The 6 Ss”

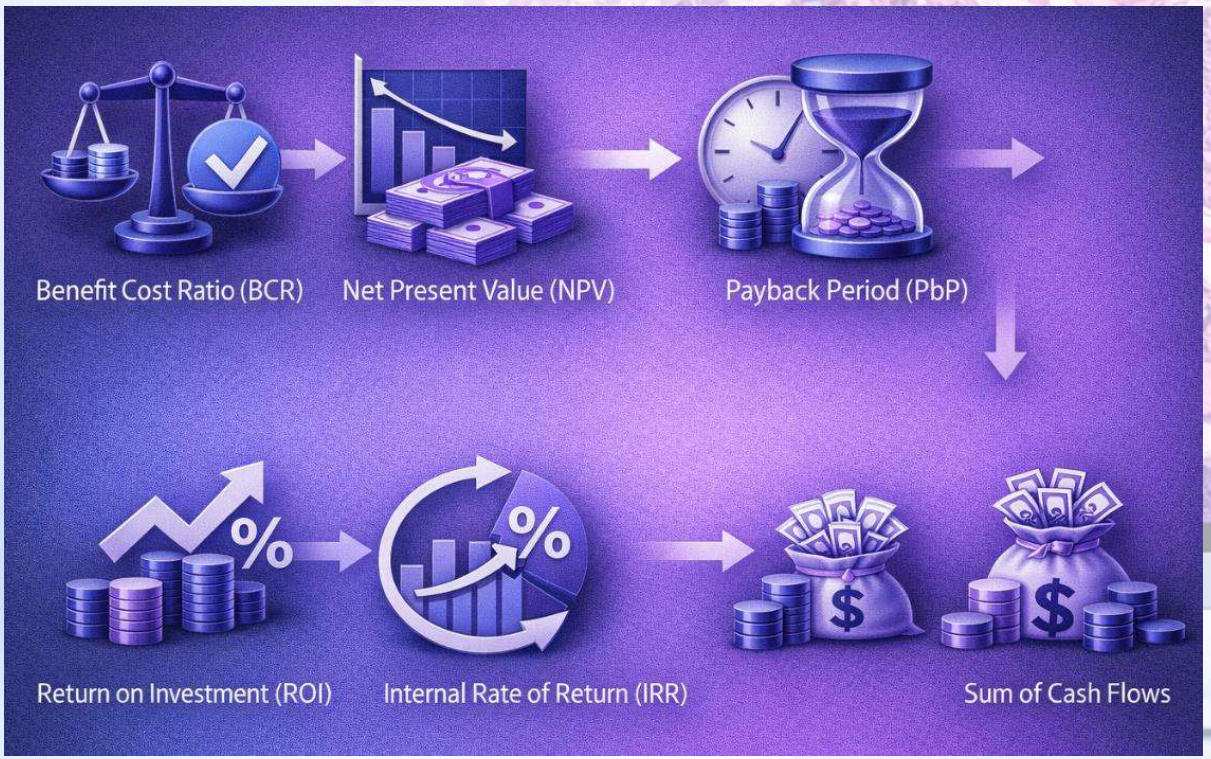
Servers, storage, LIS

- IT infrastructure
- HPC cluster
- LIS integration
- Vendor agnostic IMS
- Interface engines and middleware
- Deidentification system
- Data management tools
- Workstations and monitors

- Cybersecurity and compliance
- Audit support
- Data storage lifecycle
- Interoperability
- Downtime procedures
- Workflow redesign
- DevOps and platform engineers
- Data scientists/AI engineers

Multimillion $ investment in enterprise data storage needs
Ongoing need for tool development, updates, planning and technical support

The Business Case for Digital Pathology



Organizations need to establish cost benefit analysis of expected qualitative and financial benefits of digital pathology project(s) using one or more of these calculations.

After https://project-management.info/cost-benefit-analysis-business-cases/

Why Do We Need to Calculate Costs?

This is true for any business plan or innovation effort: if you don't understand the finances, everything feels like a barrier.

Once the costs are visible and measurable, many of these challenges become planning and resourcing questions rather than reasons not to move forward.

How do we start?

- Evaluate whether a digital pathology transition is feasible
- Compare alternative infrastructure and workflow models
- Support internal and external funding proposals
- Build a defensible business case
- Gain leadership and stakeholder buy-in
- Enable scalable digital pathology operations
- Respond to finance teams' requests for quantitative justification
- Or simply to better understand the true cost landscape

Calculating Cost and Cost Avoidance of Digital Slides

Data will be gathered from institutional department(s), vendors, professional societies, peer institutions, publications, available online resources and calculators.

Will differ among institutions and accounting practices

Should include all scanning operations components and manual steps that may get replaced

Hardware cost includes annualized scanner cost* and maintenance

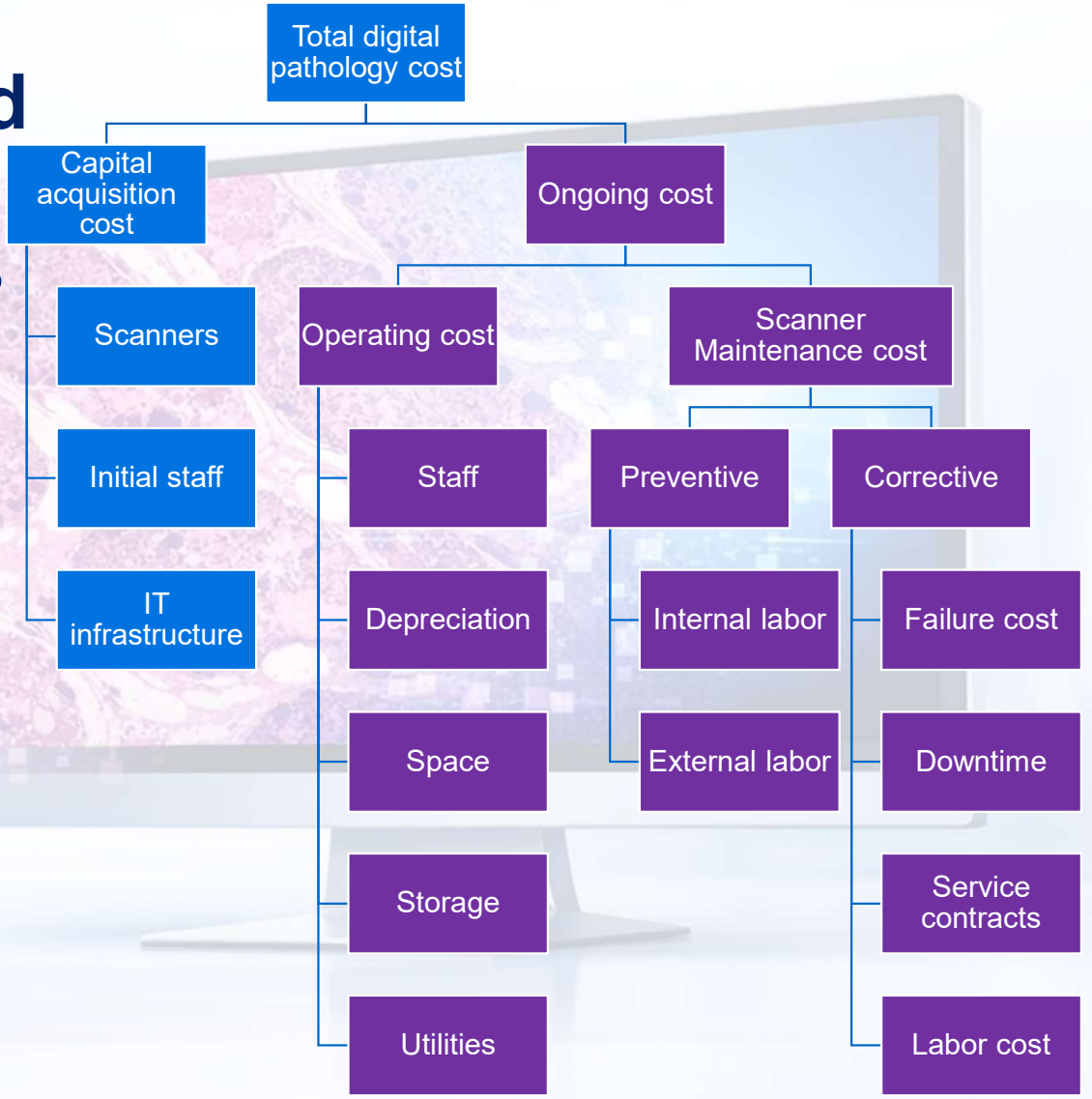
Labor includes scanner operator and all additional staff involved in digital operation

Data storage and all software needed for the operation should be added

*Annual cost of scanner is fixed, the number of slides scanned is variable and will affect cost/slide. Maximizing scanner usage will drive down cost/slide.

Breakdown of Capital and Operational Costs of Clinical DP Operations

- Understanding the cost of DP operations is essential for the development of business plans for institutional investment in the technology
- Breakdown of cost categories simplifies required data collection

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Digital pathology operations at a tertiary cancer center: Infrastructure requirements and operational cost

Universal Digital Pathology Specific ROI Calculator for Customized Financial Planning

The DPA developed a Return on Investment (ROI) calculator as a companion tool to provide an exhaustive list of the necessary concepts needed when assessing the financial implications of transitioning to a digital pathology system.

This dynamic ROI calculator integrates relevant cost and cost-saving components associated with digital pathology implementation and maintenance. Considerations include factors such as digital pathology infrastructure, clinical operations, staffing, hardware and software, information technology, archive and retrieval, medical-legal, and potential reimbursements.

The ROI calculator offers a comprehensive, customizable tool for institutions to assess their anticipated upfront and ongoing annual costs as they start or expand their digital pathology journey. It also offers cost savings analysis based on specific user case volume, institutional geographic considerations, and actual costs.

This tool is intended to estimate the potential costs and cost savings resulting from the transition to digital pathology for business plan justifications and return on investment calculations.

Disclaimer: The DPA ROI Calculator is for educational purposes only. The results are estimates based on the information you provide and may not reflect actual results. The results of the calculations are not a promise or guarantee for a specific product or service. The Digital Pathology Association is not responsible for the content, results, or accuracy of the information on the calculators. The calculations are hypothetical examples designed to illustrate the impact of digital pathology. The examples are not representative of any specific company or product. Actual results will vary.

Select Country/Currency:

AUSTRIA (Euro - EUR)

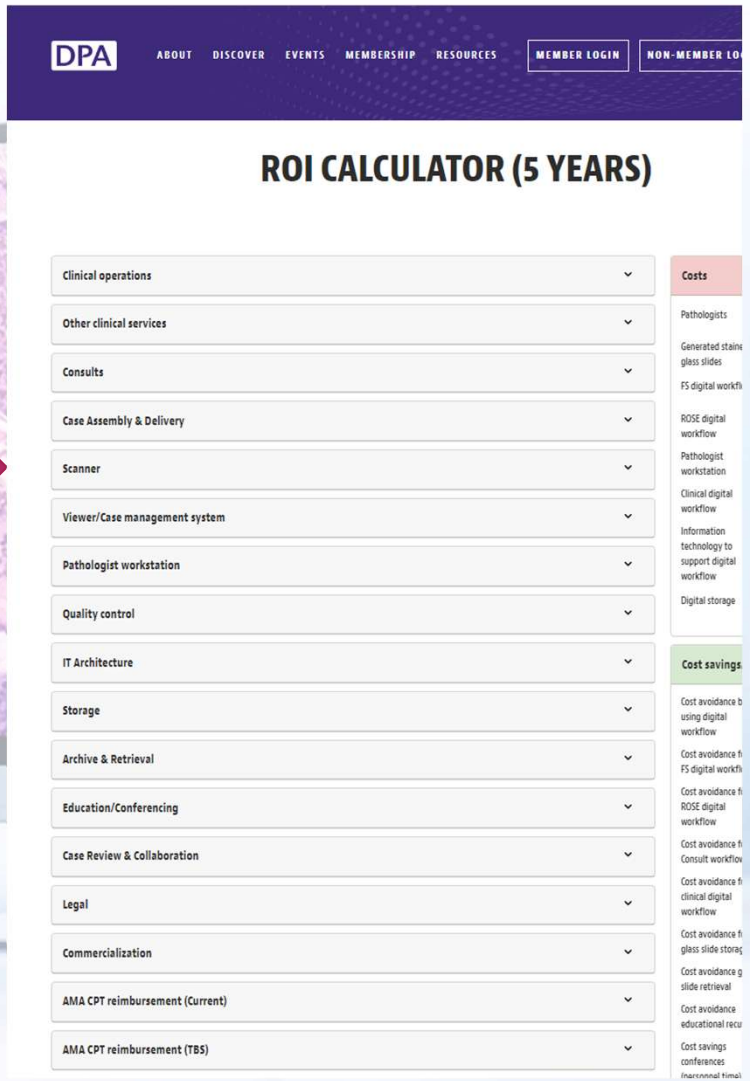
https://digitalpathologyassociation.org/roi-calculator

Calculator Categories

Costs
Annual cost pathologists
Cost to generate stained glass slides per year
Cost for FS digital workflow
Cost for ROSE digital workflow
Cost Pathologist workstation
Cost for clinical digital workflow
Costs for information technology to support digital workflow
Costs for digital storage

Cost savings/avoidance
Cost avoidance by using digital workflow
Cost avoidance for FS digital workflow
Cost avoidance for ROSE digital workflow
Cost avoidance for Consult workflow
Cost avoidance for clinical digital workflow
Cost avoidance for glass slide storage
Cost avoidance glass slide retrieval
Cost avoidance educational recuts
Cost savings conferences (personnel time)
Cost savings Case Review & Collaboration
Cost avoidance Legal

Revenue
Additional consultation practice
Data commercialization
Computer assisted quantification reimbursement
Future CPT reimbursement



https://digitalpathologyassociation.org/roi-calculator

Clinical Operations

	Year 1	Year 2	Year 3	Year 4	Year 5
Number of stained slides generated/year	800 000	1 000 000	1 100 000	1 100 000	1 200 000
Number of days operating per week	5	5	5	6	7
Number of operation weeks per year	52	52	52	52	52
Estimated stained slides generated per day	3 076	3 846	4 230	3 525	3 296
Cost to generate glass slide from laboratory	$ 5	$ 6	$ 10	$ 12	$ 12
# of pathologists	100	105	110	115	120
Avg FTE cost/annual salary for Pathologist ($)	$ 250 000	$ 260 000	$ 270 000	$ 280 000	$ 290 000
# of pathologists using digital	1	5	10	20	50
Anticipated producitivity gain per Pathologist using digital (%)	5 %	5 %	5 %	10 %	15 %
Avg FTE cost/annual salary for Technologist ($)	$ 80 000	$ 80 000	$ 80 000	$ 80 000	$ 80 000
Average number of Technologist hours worked per shift (hours)	8	8	8	8	8
Avg FTE cost/annual salary for Admin	$ 50 000	$ 51 500	$ 53 045	$ 54 636	$ 56 275
Average number of Admin hours worked per shift (hours)	8	8	8	8	8

https://digitalpathologyassociation.org/roi-calculator

Return on Investment (ROI) Estimator/Calculator

Costs		
Pathologists	$	25 000 000
Generated stained glass slides	$	20 000 000
FS digital workflow	$	250 000
ROSE digital workflow	$	300 000
Pathologist workstation	$	98 900
Clinical digital workflow	$	79 329 564
Information technology to support digital workflow	$	1 823 276
Digital storage	$	252 000 00(

+

Cost savings/avoidance		
Cost avoidance by using digital workflow	$	2 947 500
Cost avoidance for FS digital workflow	$	305 000
Cost avoidance for ROSE digital workflow	$	227 500
Cost avoidance for Consult workflow	$	3 343 695
Cost avoidance for clinical digital workflow	$	353 043 729
Cost avoidance for glass slide storage	$	75 000
Cost avoidance glass slide retrieval	$	887 227
Cost avoidance educational recuts	$	41 000
Cost savings conferences (personnel time)	$	1 461
Cost savings Case Review & Collaboration	$	3 226
Cost avoidance Legal	$	2 100 000

+

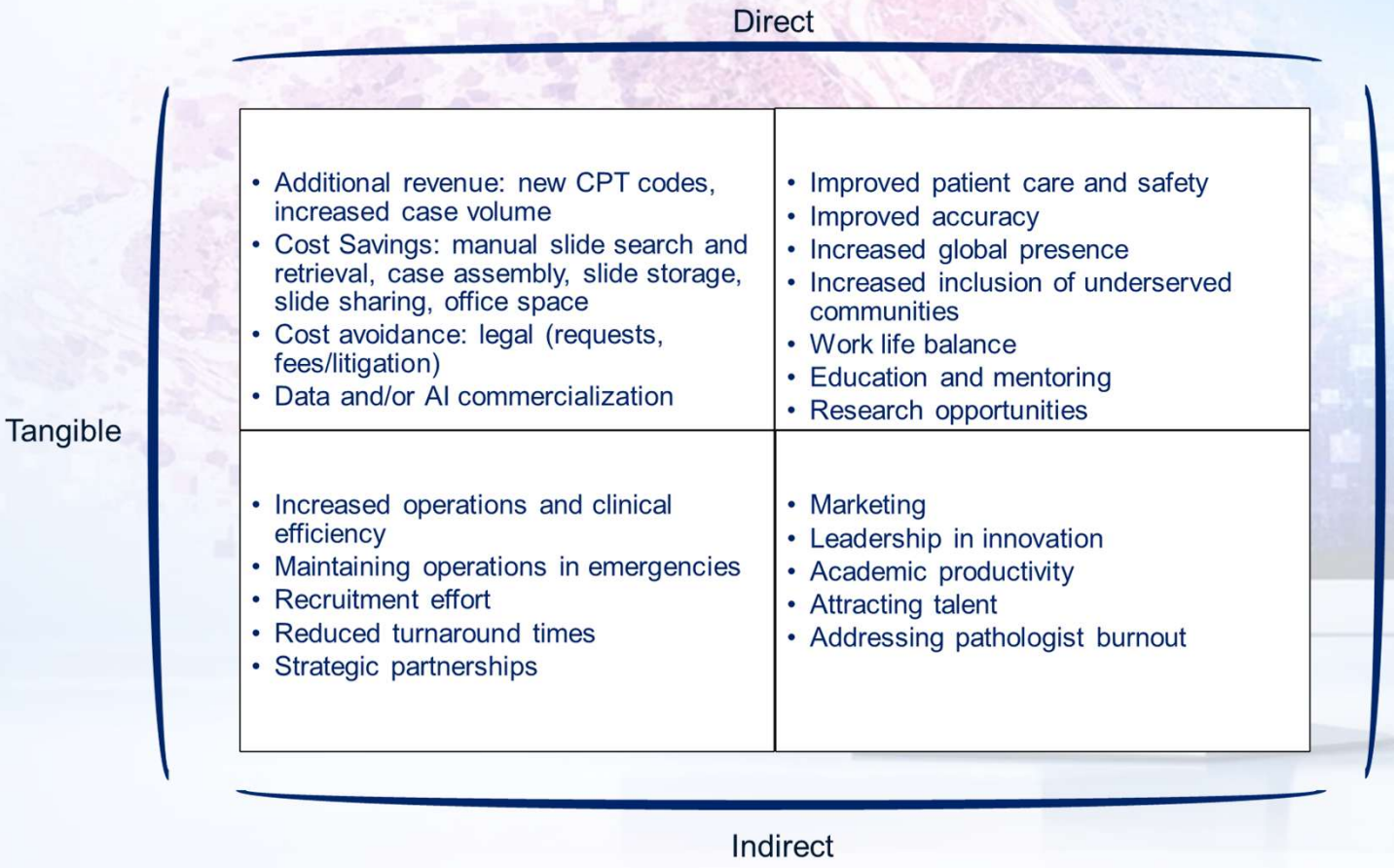
Revenue		
Additional consultation practice	$	12 162 000
Data commercialization	$	500 000
Computer assisted quantification reimbursement	$	92 000
Future CPT reimbursement	$	94 750 000

=

RESULTS		
Costs	$	333 801 740
Cost savings/avoidance	$	362 975 341
Revenue	$	107 504 000
Total Revenue + Cost savings	$	470 479 341
ROI is calculated as	%	140.94

https://digitalpathologyassociation.org/roi-calculator

Digital Pathology Benefits



Benefits impact patients, as well as staff, pathologists, department and institution.

Ardon et al 2023 https://doi.org/10.1016/j.jpi.2023.100318

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