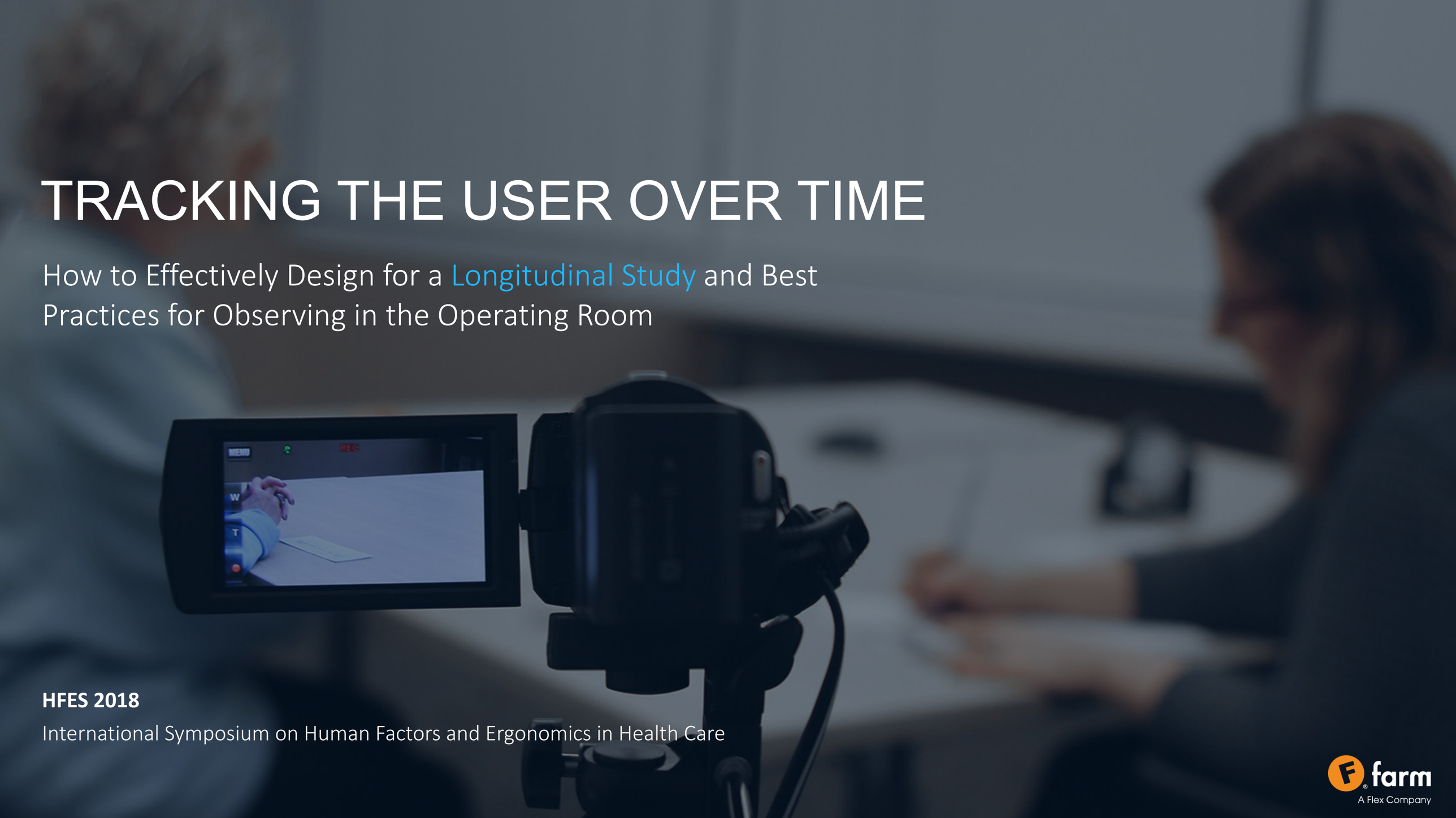
TRACKING THE USER OVER TIME

How to Effectively Design for a Longitudinal Study and Best Practices for Observing in the Operating Room



HFES 2018

International Symposium on Human Factors and Ergonomics in Health Care

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Kristyn Berry | Human Factors Engineer

As a human factors engineer at Farm, Kristyn supports the activities of the human factors team by designing and administering generative research, formative, and summative usability testing, moderating interviews, performing data analyses, recommending design refinements, presenting results to clients, and authoring proposals. Before working at Farm, Kristyn was a coordinator with the MIT Institute Events group where she was involved in every aspect of event planning and execution including content creation, marketing efforts, and managing volunteers and team members. Kristyn received a BS in biological sciences from MIT with a minor in psychology.

Laurie Reed | Human Factors Engineer

Laurie is the Senior Director of Human Factors Engineering at Farm Design, a southern NH-based full product development firm, where she has been an integral part of the human factors discipline for the past 7 years. Laurie leads the HF team, overseeing all user research that Farm conducts on behalf of its clients. Prior to Farm, Laurie worked as an independent HF contractor for a number of companies in both the consumer product and medical device space. Prior to that, Laurie started her career as a Research Associate at the American Institutes for Research based in Concord, MA. She holds a degree in Engineering Psychology from Tufts University and sits on an advisory panel for the Tufts HF program.

OUTLINE

Today's presentation will review techniques that can be employed to conduct a longitudinal study of an operating room technology.

1. Overview
2. Longitudinal Study Methodology
3. The Learning Curve
4. Management of Operating Room Observations
5. Prioritization Method for User Needs
6. Conclusions

1 OVERVIEW

FARM CONDUCTED A LONGITUDINAL STUDY OF A COMPLEX FIRST GENERATION TECHNOLOGY DESIGNED FOR USE IN THE OPERATING ROOM. THE GOAL WAS TO USE THE DATA FROM THIS LIMITED MARKET RELEASE TO INFORM SYSTEM REFINEMENT.

BENEFITS AND CHALLENGES OF LONGITUDINAL STUDIES

BENEFITS

- Assess learning over time.
- Detect connections between different events over a long period of time that might not otherwise be linked.
- Establish a sequence of events or a workflow/task assessment for a system.
- Detect market trends and measure customer satisfaction and engagement over time.
- For surgical observations especially, assess connections between surgical team familiarity and operative time.

CHALLENGES

- Although longitudinal data is collected at multiple, strategically planned points, researchers cannot assess what happens between those points.
- Follow-ups with participants can be challenging to execute (especially in a surgical environment), as researchers must work within the constraints of the facility and the surgeon's schedule.
- It is difficult to collect data in a complete and uninterrupted way, but it is important that data is consistent across users and across time.

LONGITUDINAL STUDIES, OFTEN PERFORMED THROUGH OBSERVATION, FOLLOW SPECIFIC INDIVIDUALS OVER PROLONGED PERIODS OF TIME.

2 | LONGITUDINAL STUDY METHODOLOGY

STUDY PARTICIPANTS

The longitudinal study was conducted as a **cohort** study, as participants all had a similar surgical background. However, in order to evaluate differences in interaction, usability, and learnability, the study included two sub-groups of users.

- Surgeons **experienced** with similar technologies
- Surgeons **inexperienced** with similar technologies

In order to define usability challenges and surgeon experiences across different types of surgeons, surgeons varied in:

- Number of years experience post-residency
- Predicate device experience
- Geographic location and hospital facility
- Number of procedures performed on a weekly/monthly basis

IN PLANNING FOR A LONGITUDINAL OBSERVATION OF SURGEONS, WHAT DATA SHOULD WE COLLECT AND HOW?

STUDY METHODOLOGIES

Our team employed the following research methodologies longitudinally:

- Observations of training and certifications of surgeons and staff
- Ethnography
  - Observational notes and video during procedures (anecdotal comments, use errors, close calls, usability or safety issues)
- Contextual inquiry among staff
  - One on one interviews: Questions and subjective assessments before and after surgical procedures
- Task analysis/procedure mapping/time stamping
- Diary studies (in the form of surveys)
- Critical incidence technique

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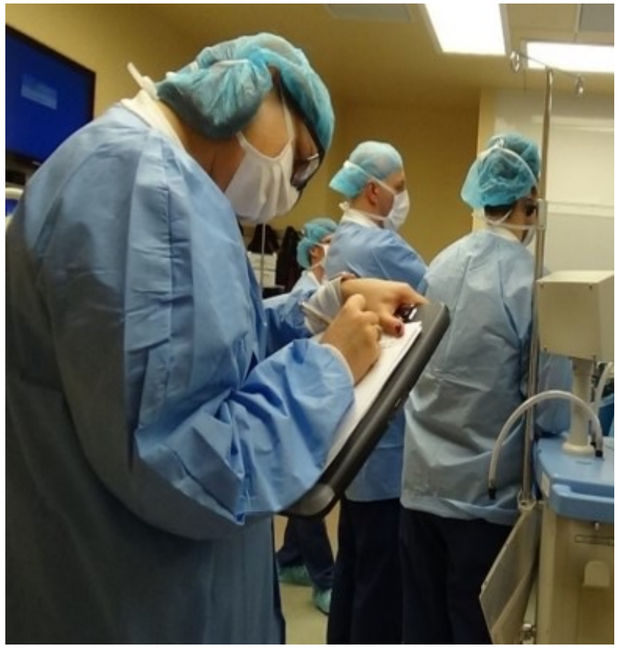
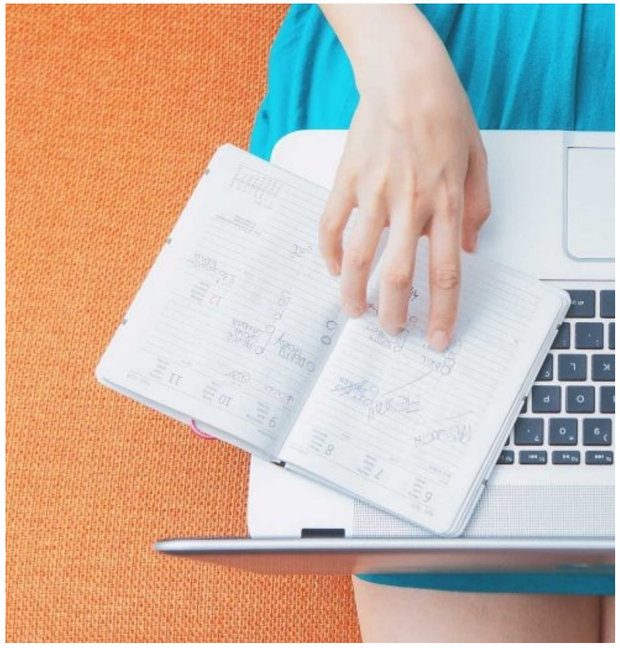
DATA COLLECTION

Because operating room observations (especially those conducted over multiple visits) consist of interactions with many team members, a rapid influx of information, data, and timing constraints, we aimed to collect as much information as possible throughout the duration of the entire procedure.



Raw data



Journals

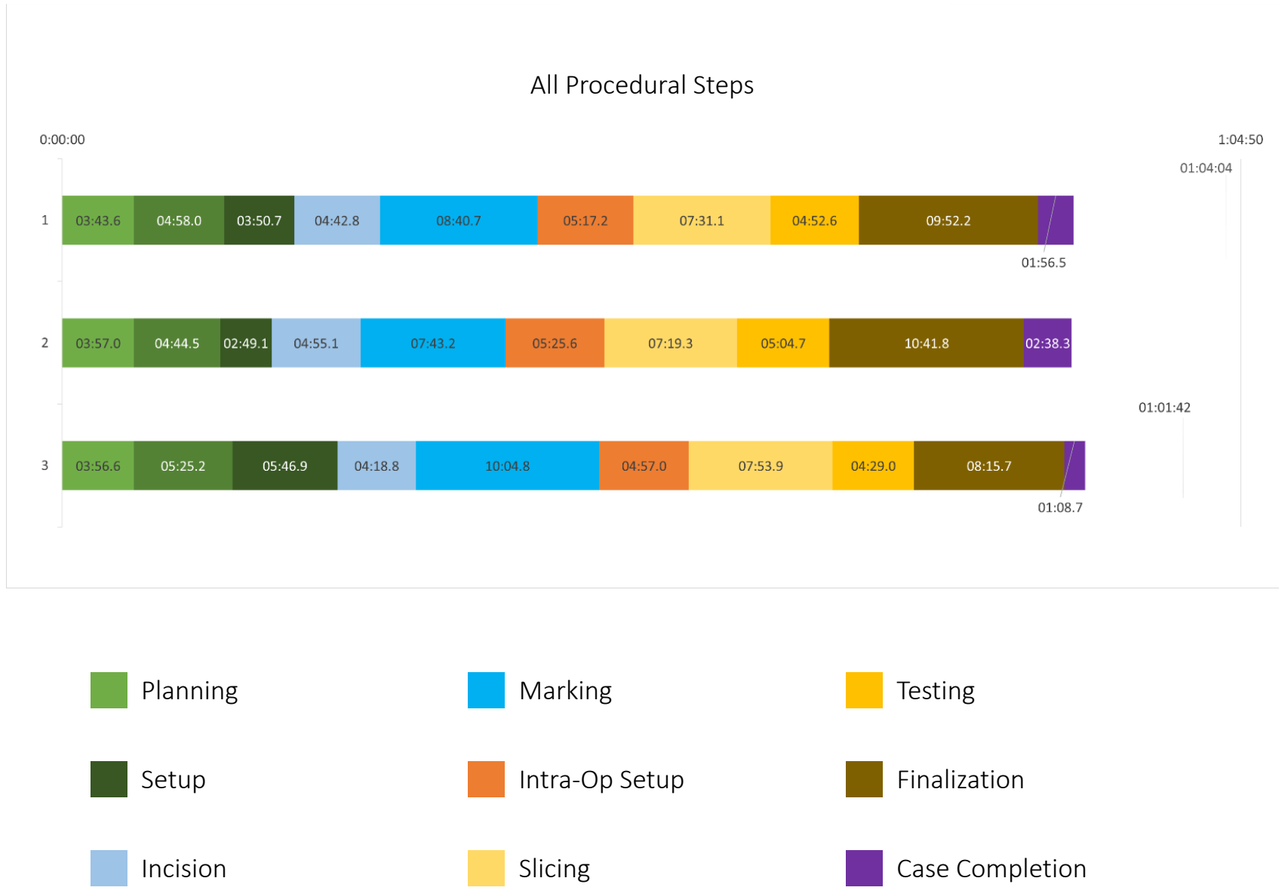
Video recording

System files

STUDY MATERIAL DEVELOPEMENT

After the initial observation of a surgical procedure, it may be necessary to adapt certain study materials. Study materials should be flexible to allow for potential changes that need to be made. For example, consider developing very open-ended observation guides.

- Organize the sections by primary procedural steps and subtasks, based on knowledge of the procedure.
- Enable flexibility in time stamping to reflect the possibility of different workflows.
- Prepopulate as much information as possible. For example, insert all of the expected OR layouts and enable the researcher to simply circle the one that applies.



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3 | THE LEARNING CURVE

SURGICAL EXPERIENCE LEARNING CURVES

The **Significance** of studying learning curves in surgery:

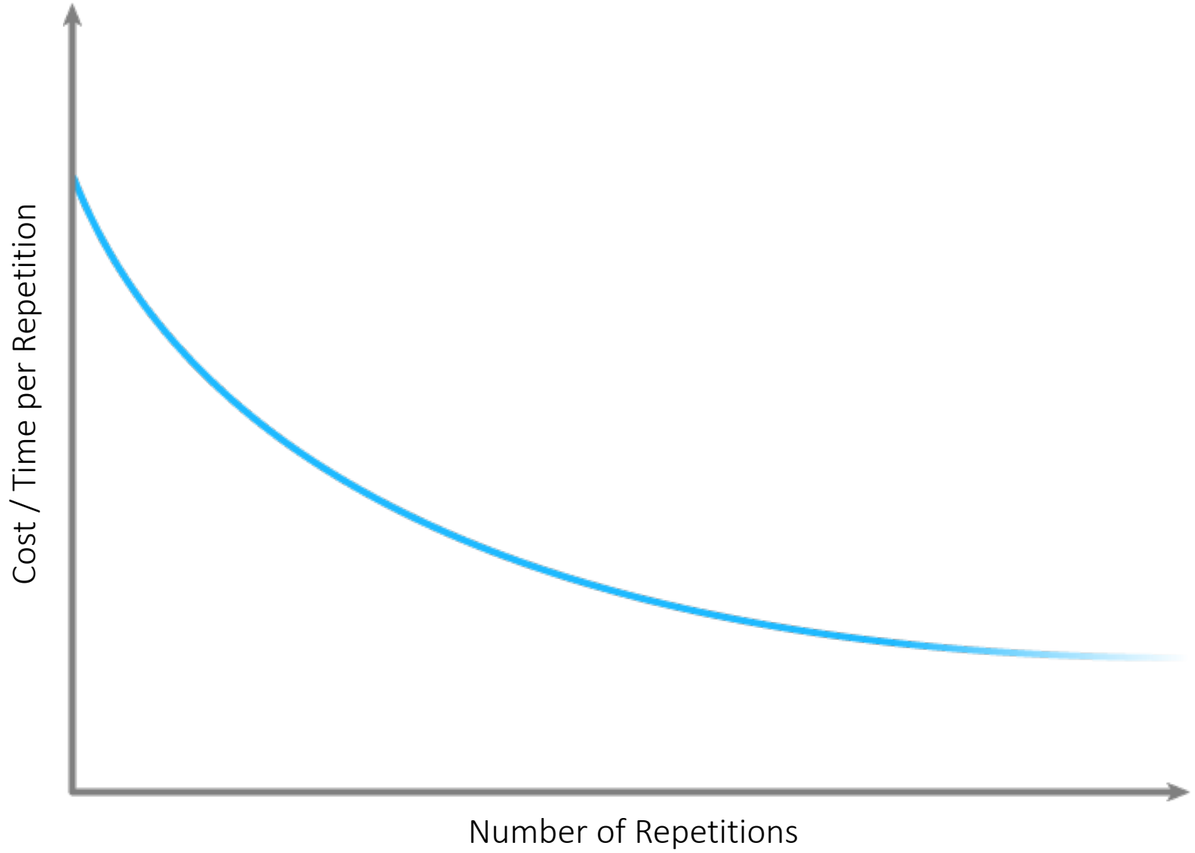
- There is a constant stream of new skills that must be acquired safely and efficiently
- Learning curve analysis can help develop and refine surgical training methods to protocols
- The development of experience-based learning curves can help keep track of individual surgical performance metrics over time and track progress of surgical personnel.
- Longitudinal studies with different surgeons can help in gaining data and insights on surgeon learnability, and hinder some of the challenges that researchers face.

WHEN CONDUCTING FIELD RESEARCH FOR A LONGITUDINAL STUDY, HOW CAN RESEARCHERS CAPTURE THE MOST RELEVANT DATA?

IN THE CASE OF OPERATING ROOM TECHNOLOGIES, HOW CAN RESEARCHERS PLAN TO BE PRESENT FOR THE MOST IMPACTFUL CASES?

SURGICAL EXPERIENCE LEARNING CURVES

A typical learning curve has the average cost/time per repetition plotted against the number of repetitions. For this study, the learning curve measurement “cost” was calculated based off of procedural time. This was calculated as total procedural time or procedural step time and the number of repetitions was based off of case number.



- The learning curve equation (Wright’s Model) is based off of fitting the data to an exponential equation in the form of y=ax^b
- Y = cumulative average time by unit [average time per procedure]
- X = cumulative number of units products [total number of procedures]
- A = time required to produce the first unit [time for surgeon to complete first procedure]
- B = learning curve coefficient [the log of the learning rate divided by the log of 2]

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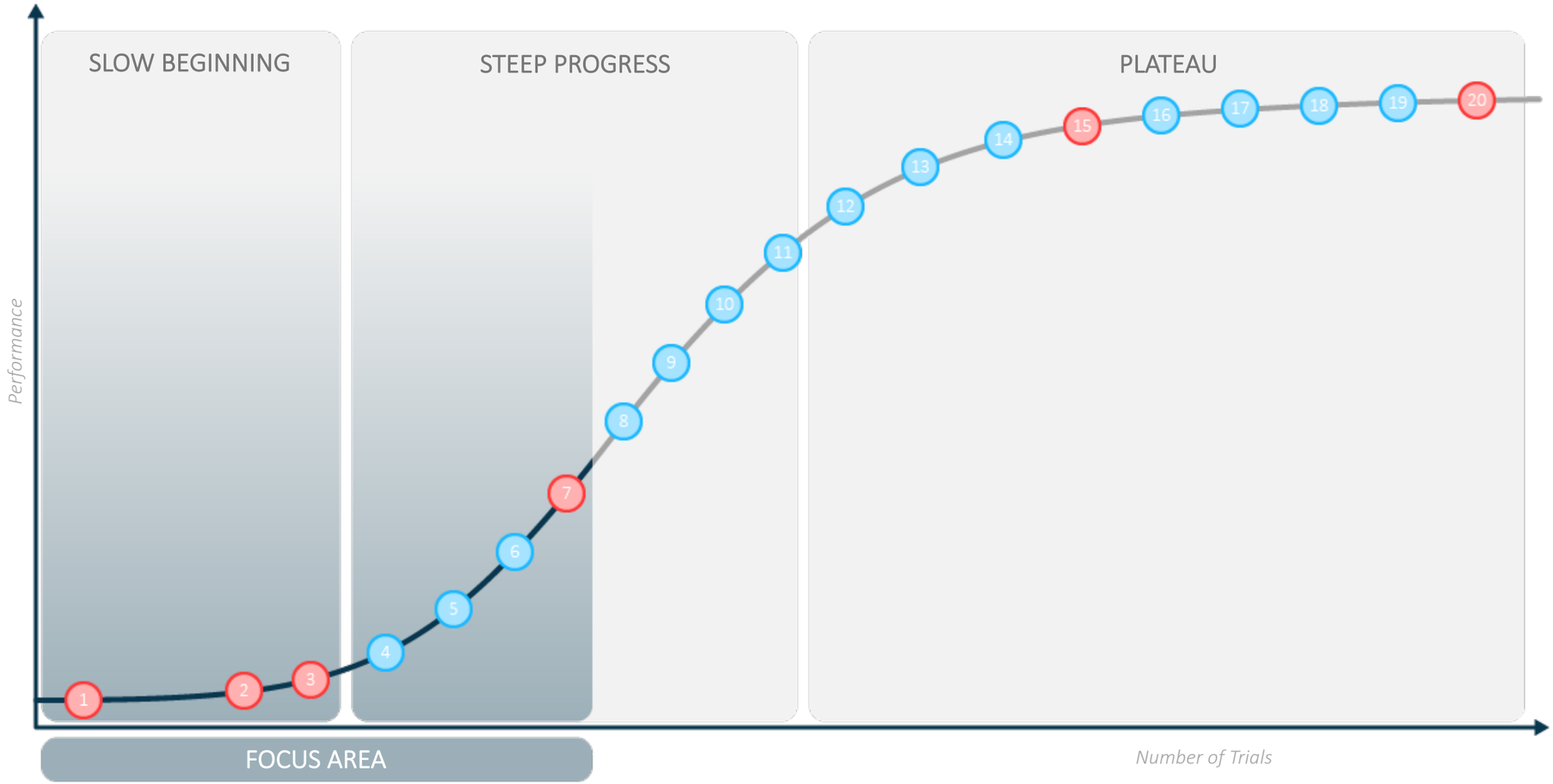
APPLYING KNOWLEDGE OF LEARNABILITY TO STUDY DESIGN

Farm interviewed product sales reps and stakeholders to help determine what case numbers would prove most impactful when collecting in-person information and gathering insights.



**The red markers distinguish what procedures were observed by our research team.*

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HOW CAN WE APPLY OUR UNDERSTANDING OF LEARNABILITY TO DATA ANALYSIS?

FACTORS IMPACTING THE LEARNING CURVE SLOPE

Level of Automation of a Technology or Task

An increase in task automation leads to a decreased likelihood of learning or improvement in efficiency.

Task Complexity

When tasks are highly customized for each attempt, the learning curve tends to approach 100%, or very little learning over time.

Operator's Level of Prior Experience

Experienced workers have lower first unit costs and higher learning curve coefficients than inexperienced workers.

Heritage Effect

Learning can also be "lost" when there is a break in activity repetition or the nature of the activity.

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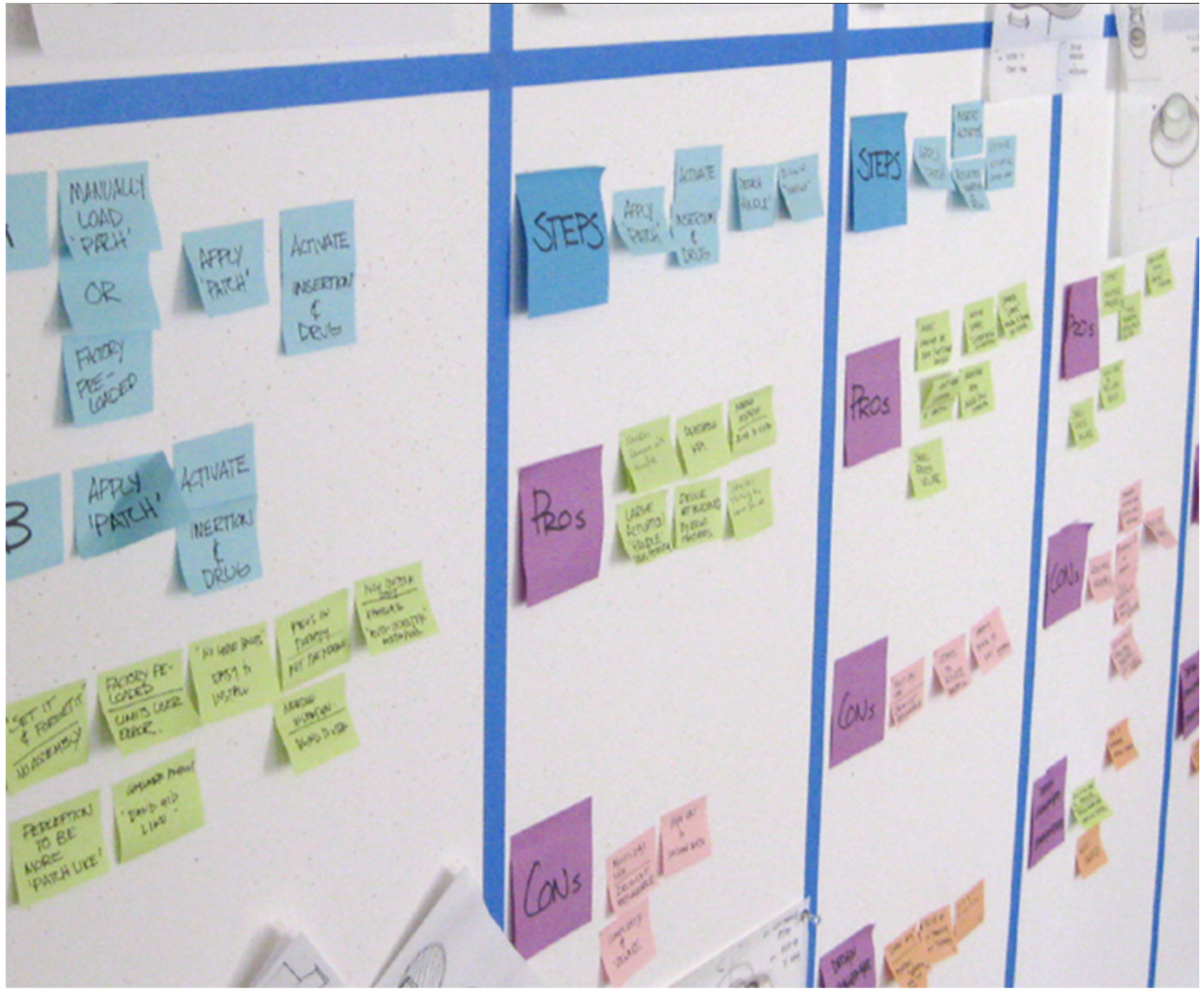
Heritage Effect

Learning can be "lost" when there is a gap in activity repetition or the type of activity being performed.

SURGICAL EXPERIENCE LEARNING CURVES

For our study, it was important to consider the following questions when planning for learning curve analysis:

1. Can we control the cadence of all surgeons' cases?
2. Is operating time measured by tourniquet time or from incision to wound closure? How might these vary across users?
3. How will variability in the following be handled?
    - Organizational factors
    - Surgical team familiarity
    - Case mix



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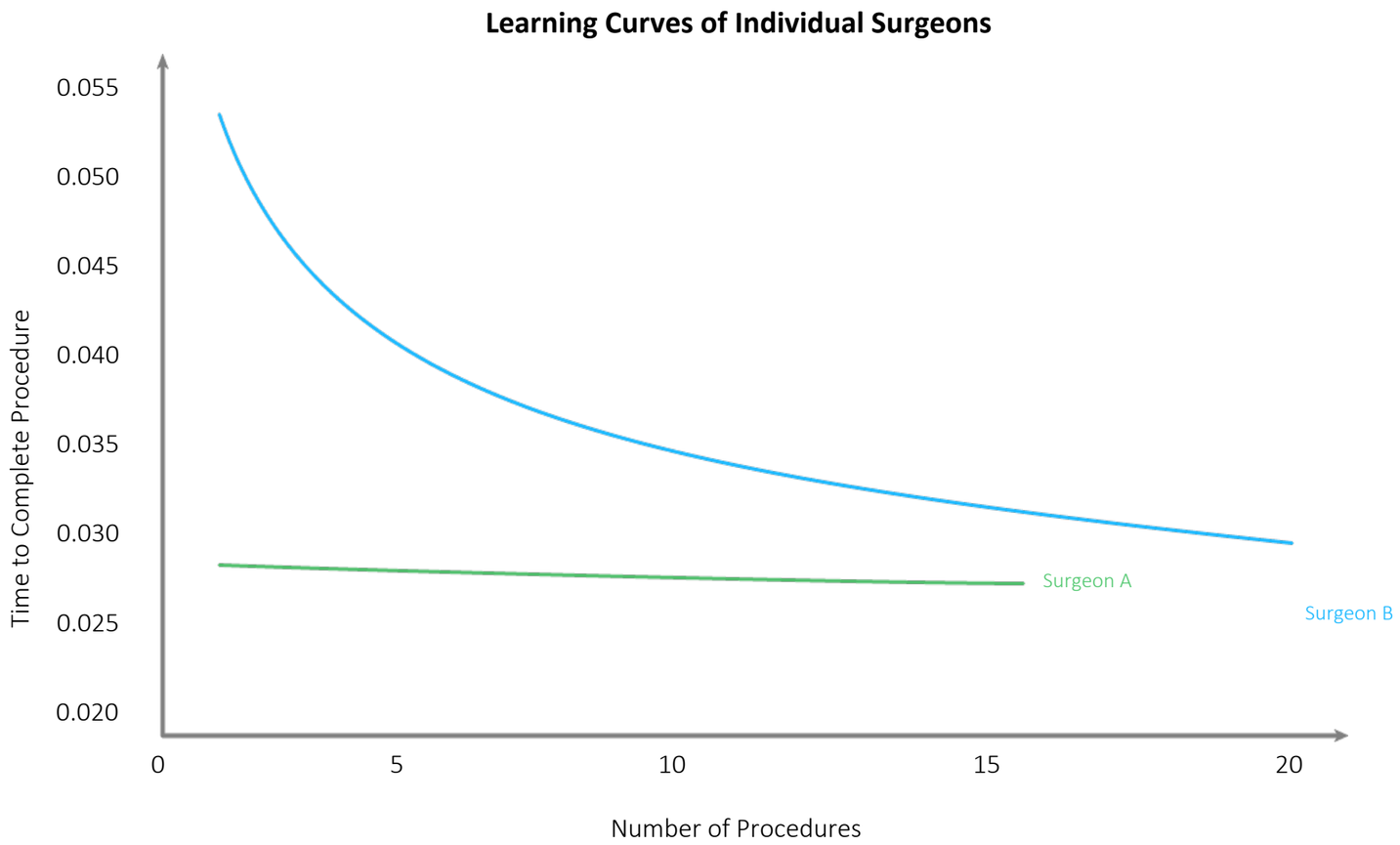
SURGICAL EXPERIENCE LEARNING CURVES



	Unit Number	y	a	x	b	Calculated Learning Rate
Surgeon A	1	-	-	-	-	-
	2	0:51:56	0:43:52	2	0.24377	**118%**
	3	0:51:18	0:43:52	3	0.14258	**110%**
Surgeon B	1	-	-	-	-	-
	2	1:13:19	1:14:15	2	-0.01841	**99%**
	3	1:03:30	1:14:15	3	-0.14244	**91%**

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4 | MANAGEMENT OF OPERATING ROOM OBSERVATIONS

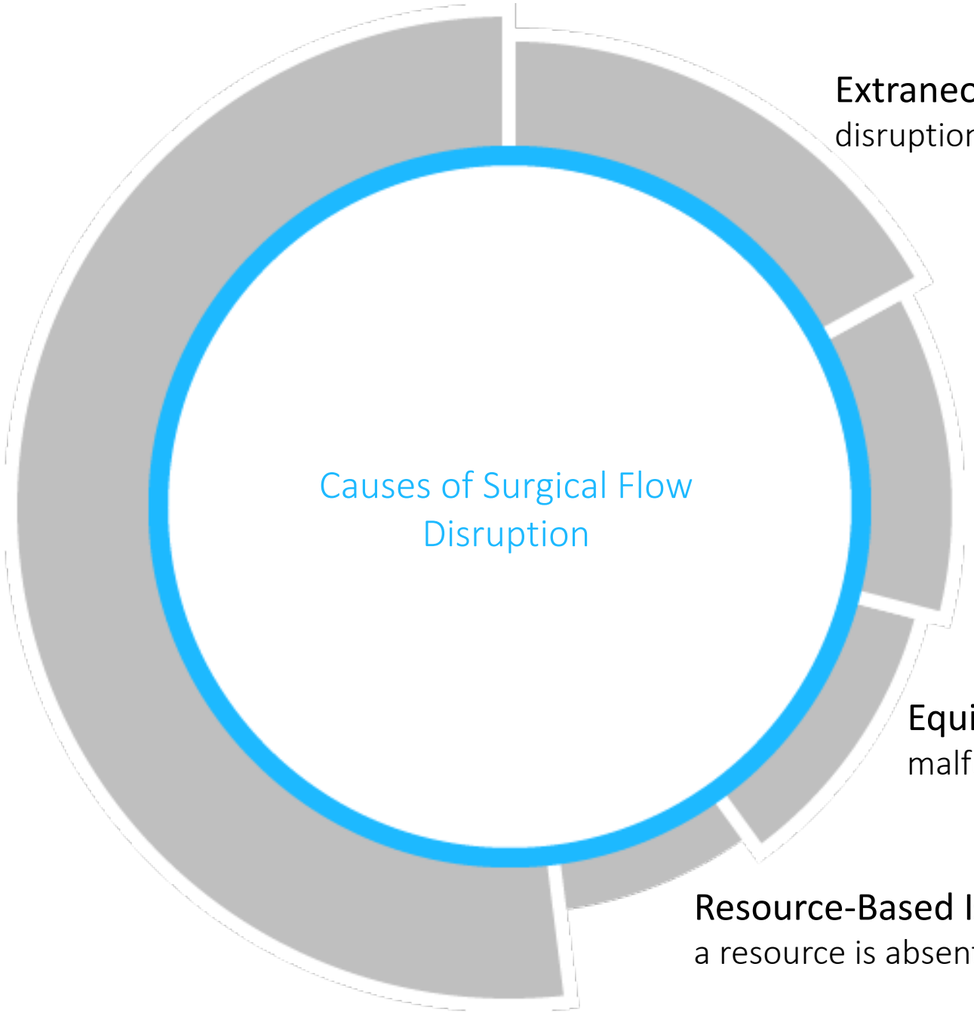
MANAGEMENT OF OPERATING ROOM OBSERVATIONS

The operating room can be a very challenging environment for conducting observations

- There are typically tight quarters since a number of people need to be in the room at once during a procedure.
- Based on the operating room layout and facility procedures, the sterile field may encompass a wide region of space and can make video recording challenging.
- The researcher should make their presence and purpose for being present aware to as many team members as possible to establish trust in the OR.
- Each team member plays a different role in interacting with the technology and they may have varying levels of training and experience. Some surgeons may use the same team members from procedure to procedure, while others may have a new team member during certain procedures.

WHILE PERFORMING RESEARCH IN THE OR, KEEP TRACK OF THE INTERACTIONS OF MULTIPLE SURGICAL TEAM MEMBERS DURING A PROCEDURE.

MANAGEMENT OF OPERATING ROOM OBSERVATIONS



Extraneous Interruption - 17%
disruptions during a procedure (not pain-treatment related)

Supervisory/Training Related Issues - 12%
management of personnel, guidance, or training of members of OR team

Equipment/Technology - 11%
malfunction of equipment or equipment design/performance

Resource-Based Issues - 8%
a resource is absent from the operating table

Teamwork - 52%
issues with communication, team coordination/familiarity, or team monitoring

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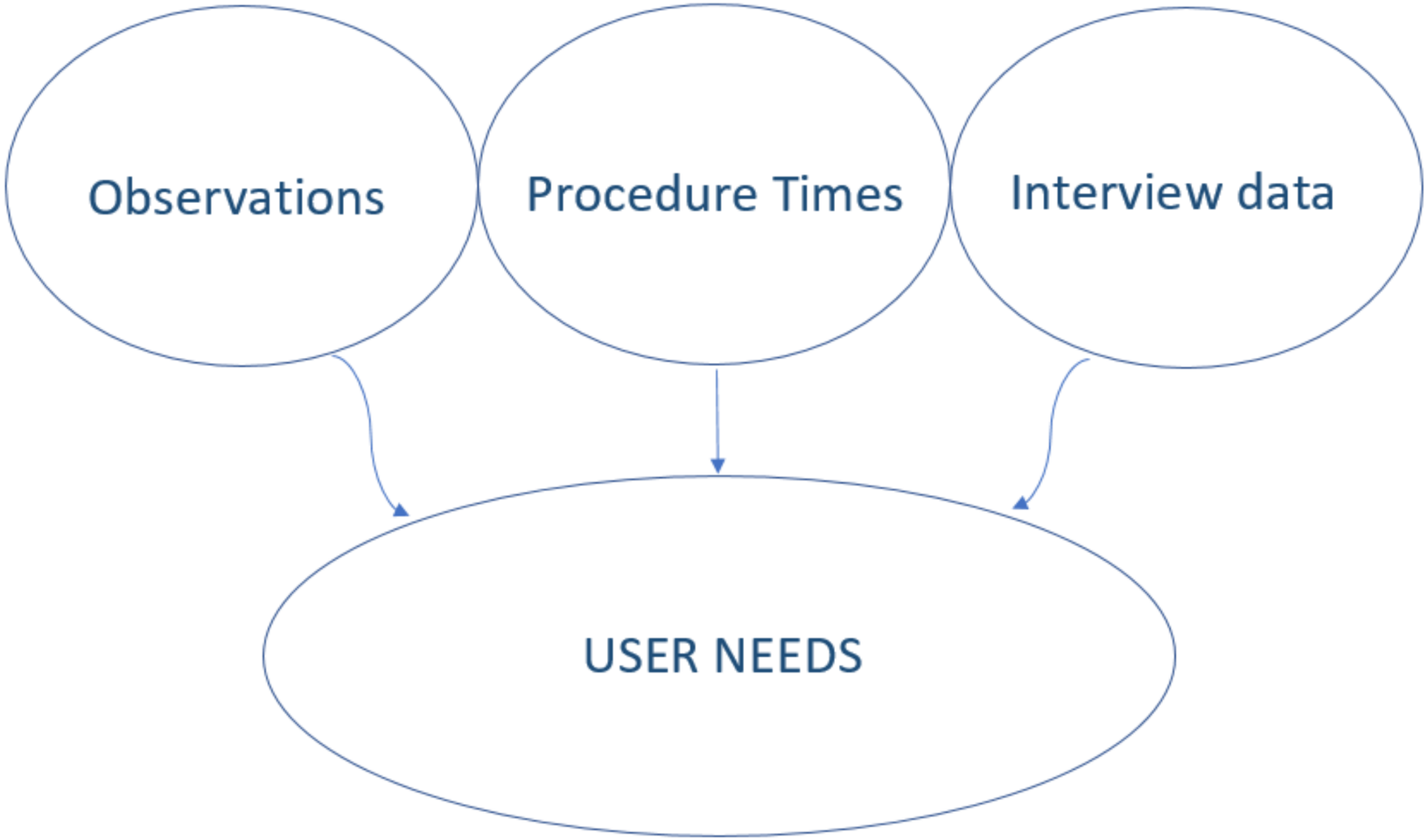
MANAGEMENT OF OPERATING ROOM OBSERVATIONS

- Monitor team movements during setup and the procedure.
- Note usability challenges encountered by any team member.
- Record methods of communication between the surgeon and other team members, as they can impact procedural efficiency in relation to technology interactions.
- Keep track of who is present in the OR at all times, and who performs what tasks.
- Monitor how room layout equipment impacts the flow in the OR. Does it restrict team interactions, performance, or increase distraction or tension?
- Conduct semi-structured interviews to collect information on:
    - Training
    - Task analyses
    - Job descriptions and functions
    - Knowledge, skills, abilities of staff members
    - Decision making and accessibility in the OR
    - OR team attitudes and surgeon leadership

5 | PRIORITIZATION METHOD FOR USER NEEDS

WITH THE COLLECTION OF LARGE AMOUNTS OF VALUABLE DATA FROM LONGITUDINAL RESEARCH, IT IS VITAL TO ORGANIZE THE DATA IN ORDER TO PRIORITIZE USER NEEDS THAT CAN HELP IMPROVE THE USER EXPERIENCE.

DEFINE USER NEEDS



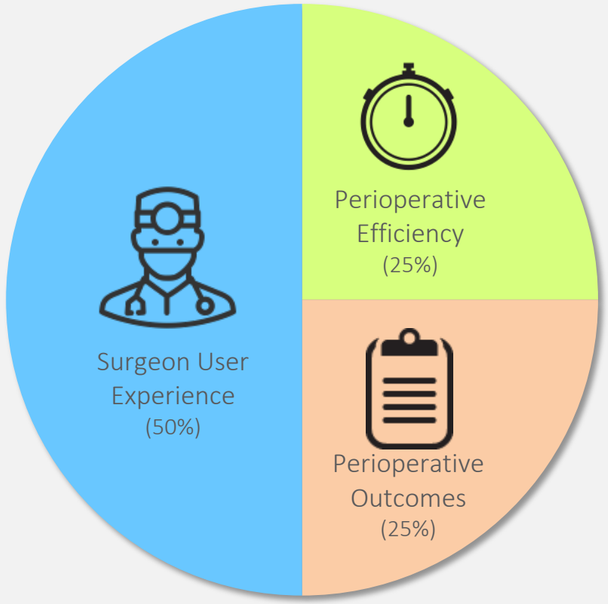
ORGANIZE USER NEEDS

ORGANIZE IDENTIFIED PAIN POINTS EXPERIENCED BY THE USER INTO OVERARCHING THEMES AND PROCEDURAL STEPS:

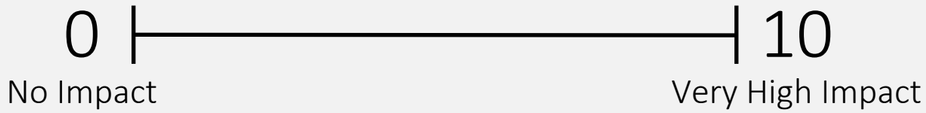
"The GUI does not give an option to customize the surgical plan based on differences in patient anatomy."

DETERMINE LEVEL OF IMPACT

1. Identify User Experience Parameters and Assign Weight



2. Researchers Assign Each User Need a Rating



3. Perform the Calculation:

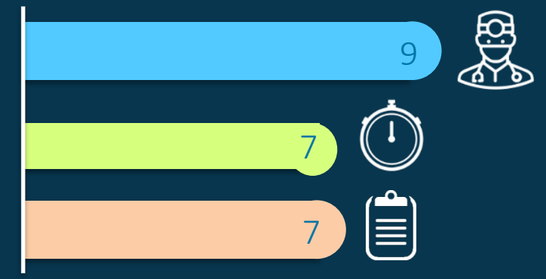
Impact score for surgeon user experience x 50%

Impact score perioperative efficiency x 25%

\+ Impact score for perioperative outcomes x 25%

TOTAL IMPACT

7.5 / 10



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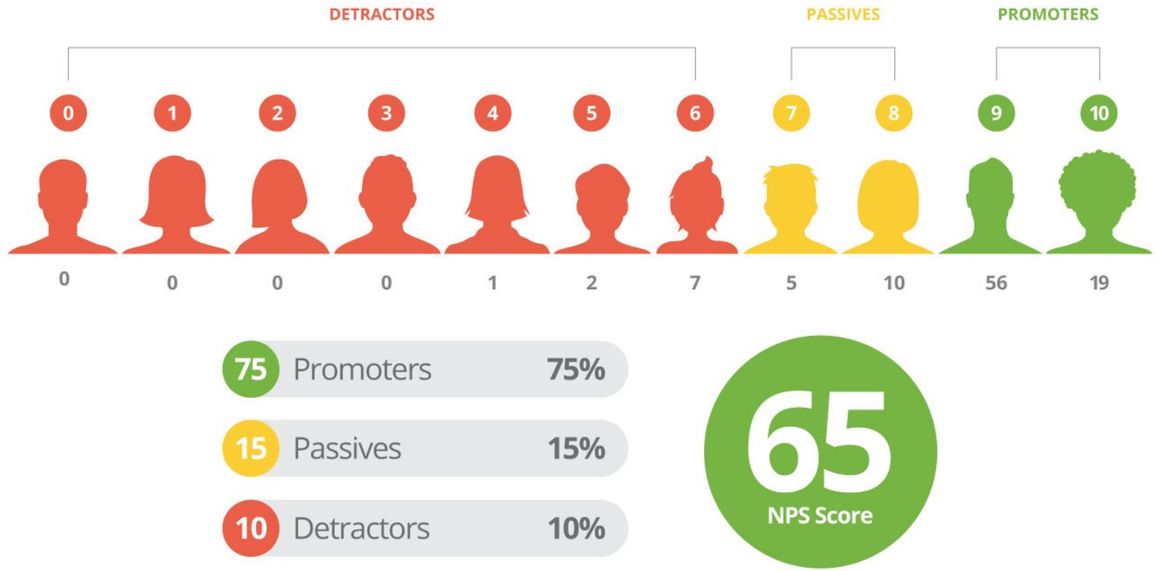
REVIEW SUBJECTIVE RATINGS

For this longitudinal study, our team assessed user satisfaction by collecting multiple subjective rating methods at each case:

- **Likert Scale Ratings** (How would you rate the ease or difficult of [X step in the procedure] on a scale of 1 to 5?)
- **Net Promoter Scores:** (How likely is it that you would recommend [the product] to a friend or colleague on a scale of 0 to 10?)



- **Promoters** (those who rate 9–10) are highly satisfied "loyal enthusiasts who will keep buying and refer others, fueling growth."
- **Passives** (those who rate 7–8) are "satisfied but unenthusiastic customers who are vulnerable to competitive offerings."
- **Detractors** (those who rate 0–6) are dissatisfied "unhappy customers who can damage your brand and impede growth through negative word-of-mouth."

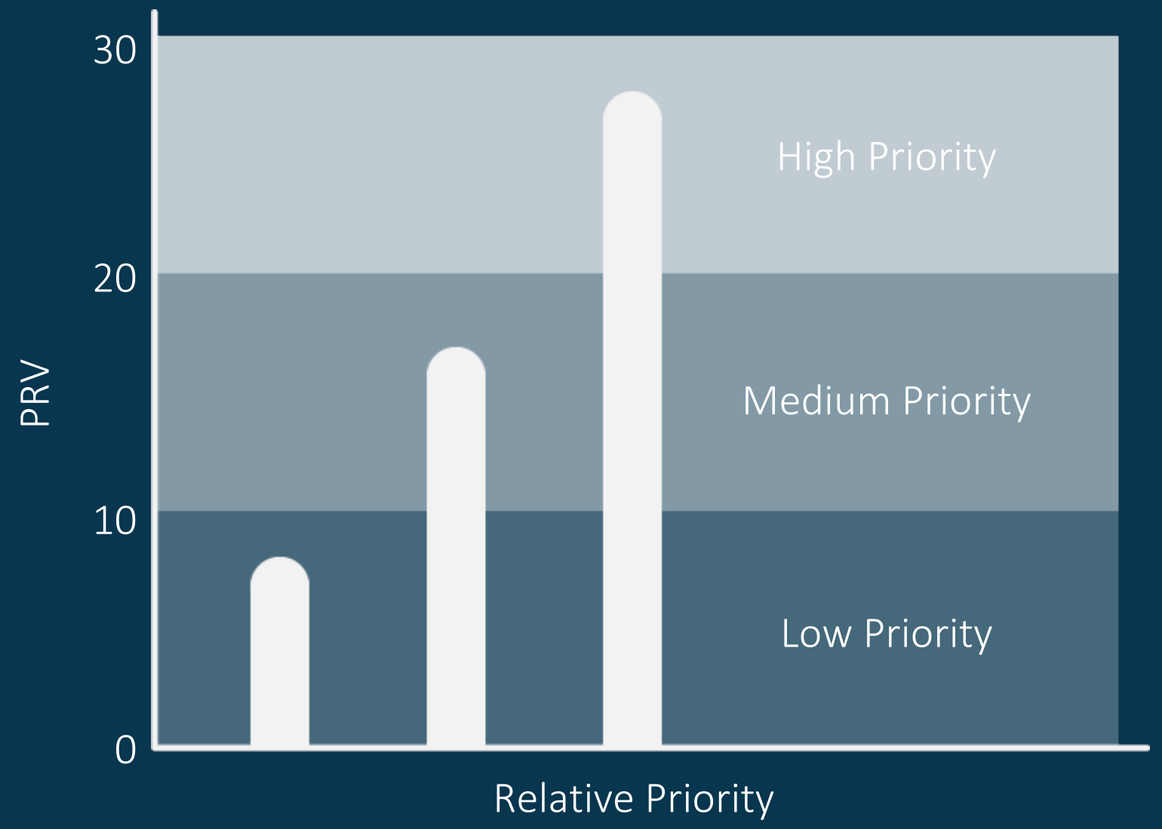
IDENTIFY STATISTICAL CORRELATIONS

WHICH STAGES OF THE SURGICAL PROCEDURE MOST INFORMED THE SURGEONS' NPS SCORES?

- Compare NPS scores to Likert Scale ratings (ANOVA, T-tests, Multiple regression)
  - Note linear relationships
  - The better/worse a surgeon's experience with [x step in the procedure] the higher/lower the NPS
- Categorize NPS priority:
  - 1 = user need has a non-significant correlation to NPS and low observed subjective correlation to user experience
  - 2 = user need has a non-significant correlation to NPS but high observed subjective correlation to surgeon experience
  - 3 = user need has a significant correlation to NPS and high observed subjective correlation to surgeon experience

CALCULATE PRIORITIZED RECOMMENDATION VALUE (PRV)

Impact Score x NPS Priority = PRV
(0 - 10) (1 - 3) (0 - 30)



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FINAL PRIORITIZATION TABLE

Each finding was organized by theme and included a recommendation, the associated procedural step, Impact (I) Score, Net Promoter Score (NPS) priority, and resulting Prioritized Recommendation Value (PRV).

Software Prioritized Recommendations

Theme	#	Finding	Recommendation	Procedural Step	I Score	NPS Priority	PRV
Software	2	The GUI does not give an option to customize the surgical plan based on differences in patient anatomy.	Ensure the system provides surgeons with tools in the GUI of the case planning screen that allow them to adapt surgical plan measurements based on differences in patient sizing and other differences in anatomy.	Planning	7.5	2	15

6 CONCLUSION

TAKEAWAYS FOR HF PRACTITIONERS

Longitudinal studies can be effective at assessing the usability challenges and user needs for a technology. This type of study is ideal for assessing how team dynamics and surgeon workflows will impact learning of a new technology.

When designing longitudinal studies, think critically about the factors that will influence your study and how to collect information:

Consider what and how many procedures your team will be present for by thinking about which procedures will give you the most impactful qualitative and quantitative data.

Take note of all interactions occurring in the operating room during a procedure.

Collect data for each user and map it to a learning curve in order to compare learning across different types of users and which procedural steps required the most learning.

Develop a prioritization system to efficiently organize all generative research gathered from your study.

Determine the most efficient methods for collecting data and be flexible!

Supplement all quantitative data with qualitative insights

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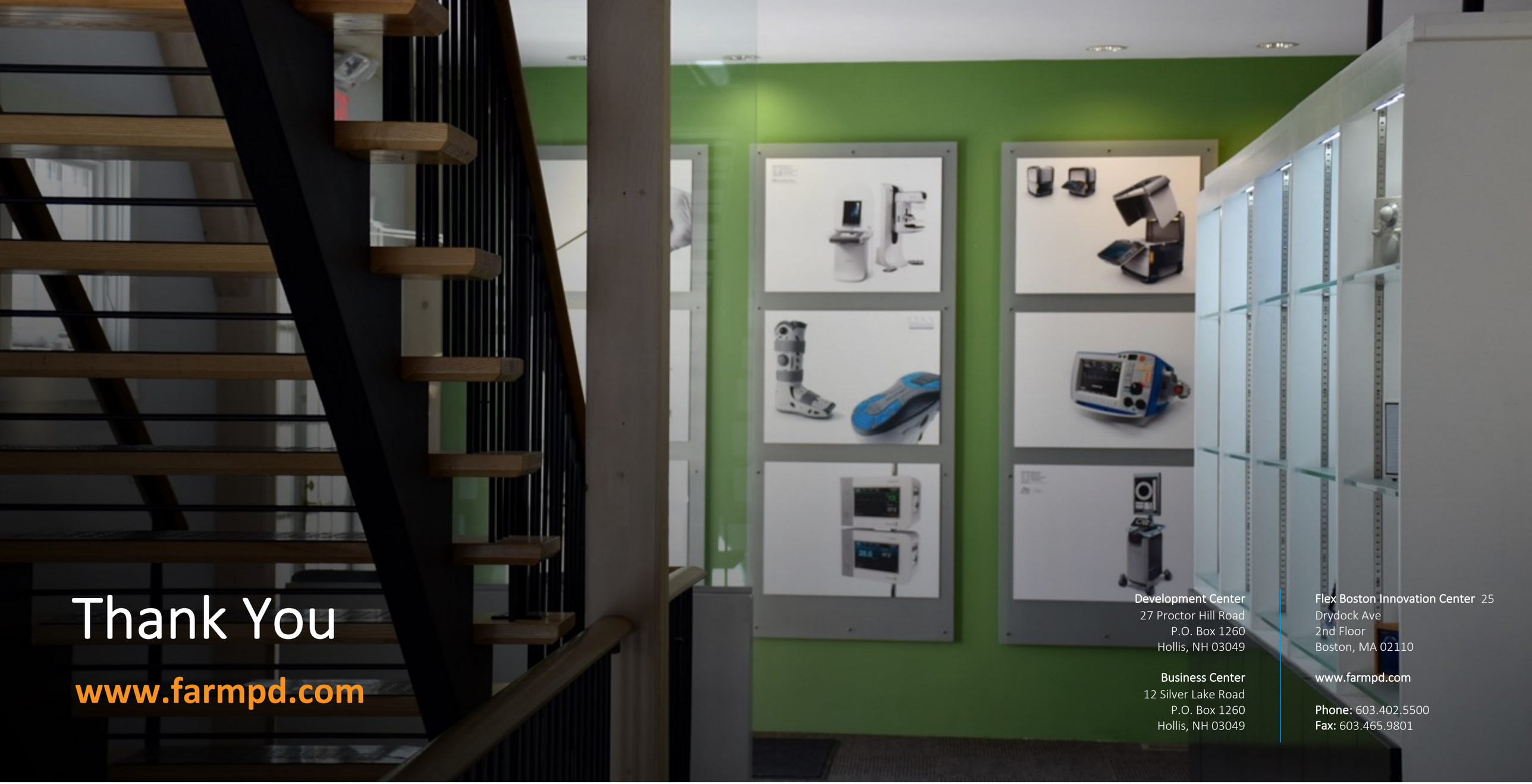

Thank You

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