IISE ANNUAL CONFERENCE & EXPO 2017

Addressing Capacity Constraints through Linear Optimization of Provider Schedules

Manny Hill

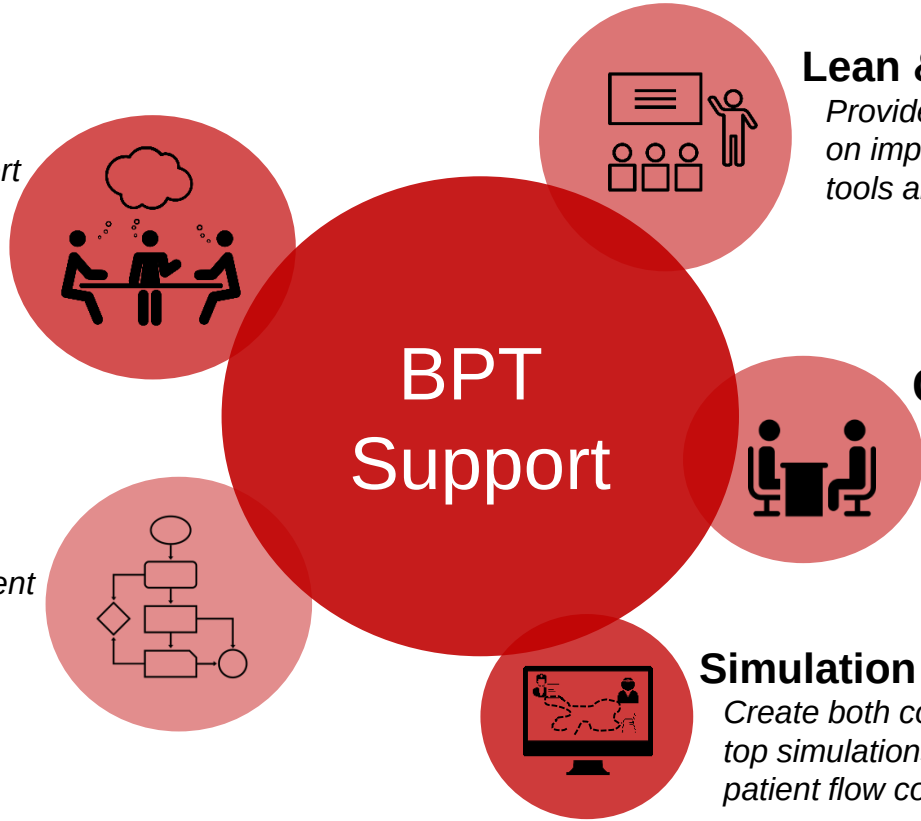
Business Process Engineer, Texas Children's Hospital

Texas Children's®

Business Process Transformation

Manny Hill, Business Process Engineer

Business Process Transformation



Strategic Facilitation
Assess needs and provide support for large scale strategic and operational initiatives

Lean & Six Sigma Training
Provide training to staff and leaders on improvement methodologies, tools and principles

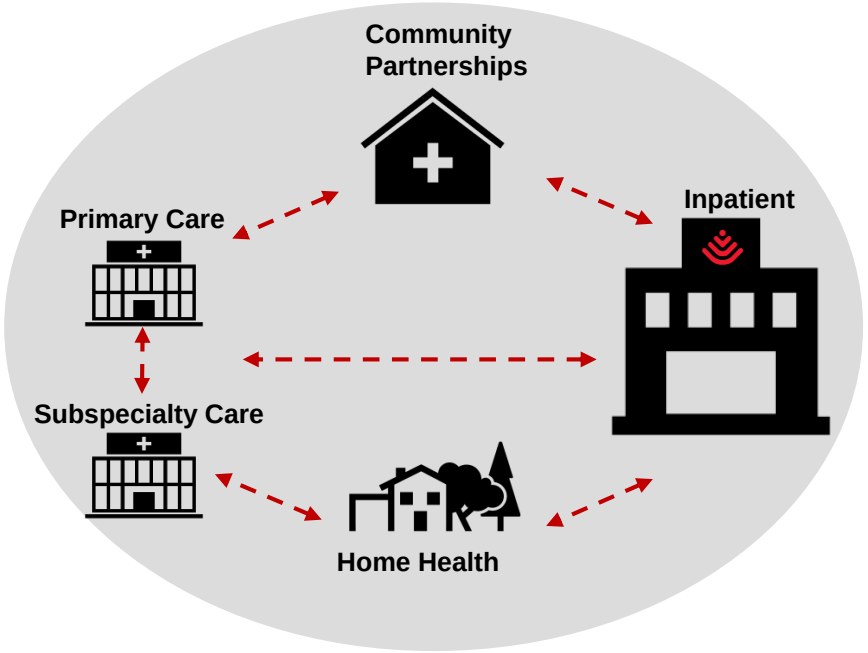
Coaching/Mentoring
Coach/Mentor LSS students as well staff throughout the organization in implementing successful project

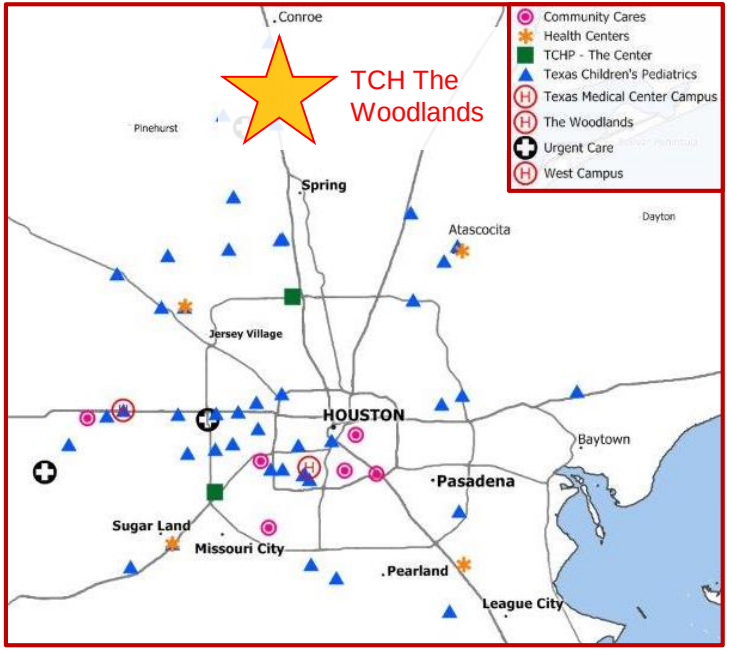
Process Improvement
Assist teams in process refinement and development to improve effectiveness and efficiency

Simulation Modeling
Create both computer and table top simulations to evaluate patient flow concerns

Texas Children's is a comprehensive system in Houston TX

Texas Children's is comprised of 70+ patient care locations and a network of partnerships that treat women and children across the care continuum.





Texas Children's Hospital

Texas Children's Hospital The Woodlands

25+ Subspecialties

25 Emergency Center Rooms

4 Operating Rooms

32 Acute Care Beds

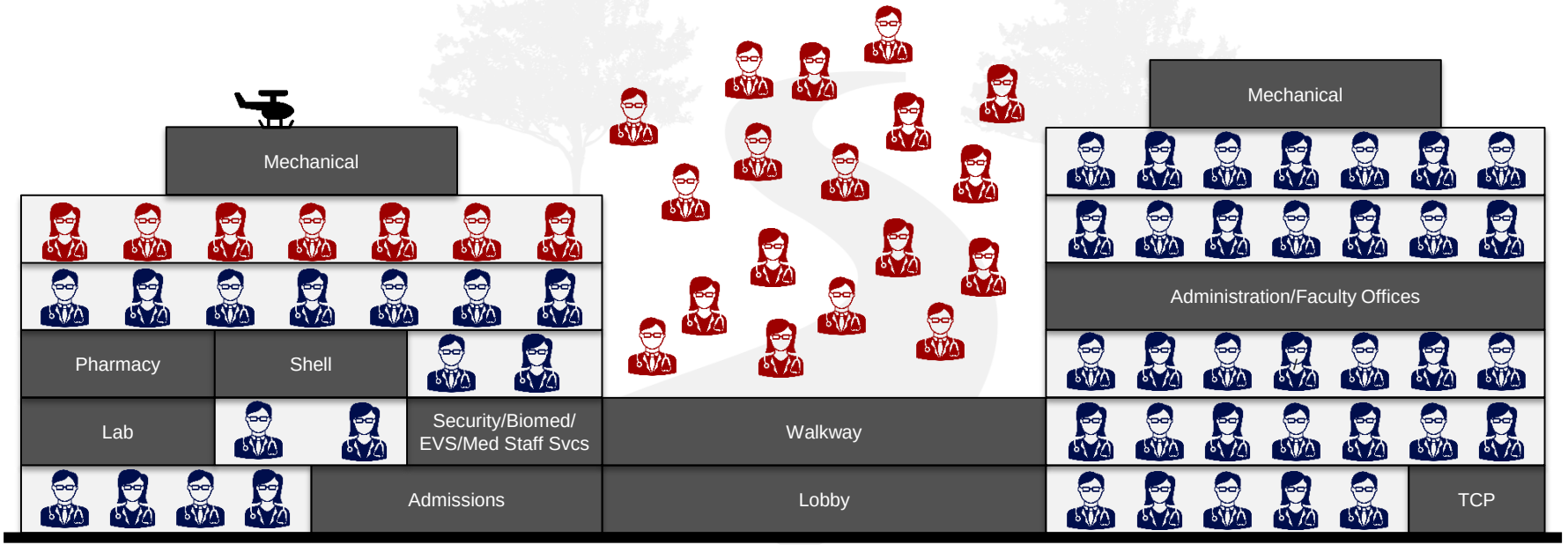
14 NICU Beds

14 PICU Beds

& Room to Grow

Texas Children's Hospital

Dedicated Provider Model & Implications

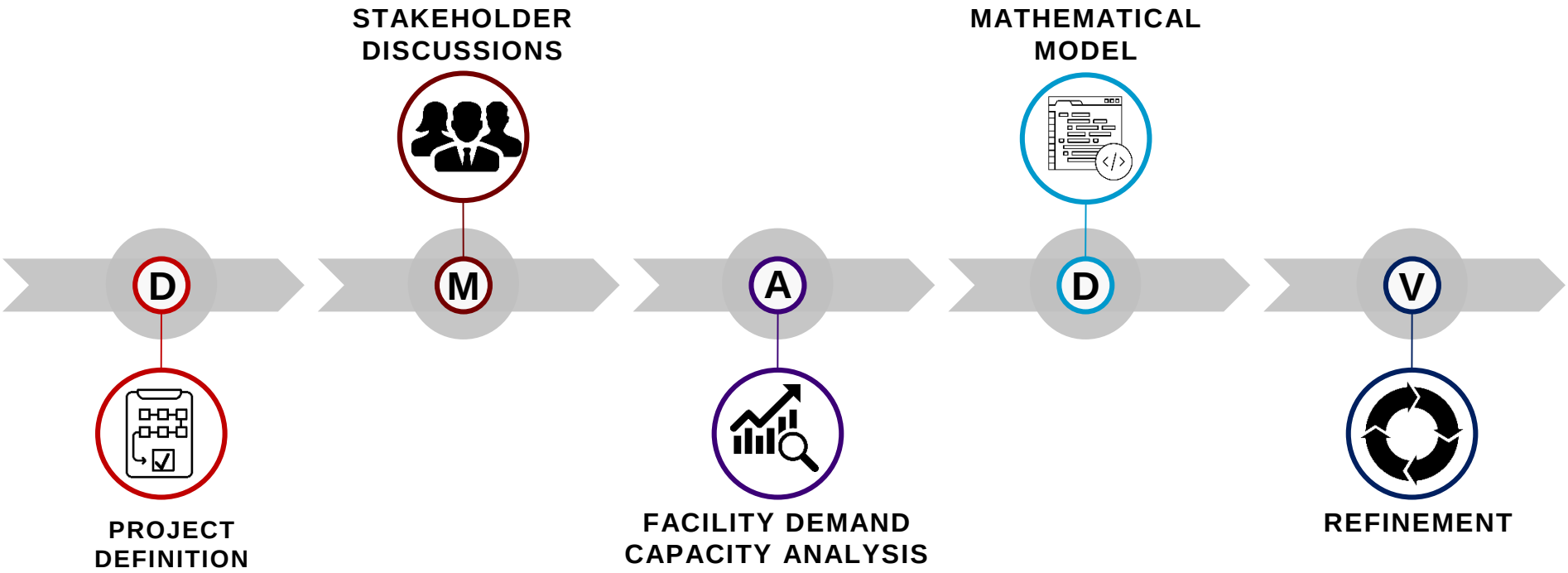


Hospital Building

Outpatient Building

Texas Children's Hospital

A Systems Engineering Approach to Provider Scheduling



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A brief look back on the Woodlands Lean Journey

Establishing project context, developing tangible goals, and brainstorming the project plan

D

PROJECT DEFINITION

STAKEHOLDER DISCUSSIONS

M

A

FACILITY DEMAND CAPACITY ANALYSIS

MATHEMATICAL MODEL

D

V

REFINEMENT

TCH The Woodlands

Surgical

- Ophthalmology
- Otolaryngology
- Pediatric Surgery
- Plastic Surgery
- Urology
- Pediatric Gynecology
- Dental w/in procedure rooms

Other

- Sports Medicine
- Emergency Medicine
- Pediatric Hospital Medicine
- Pathology
- Critical Care
- Radiology

Medical

- Adolescent Medicine
- Allergy & Immunology
- Behavioral & Developmental
- Cardiology
- Dermatology
- Endocrine/Diabetes
- Genetics
- Gastroenterology & Nutrition
- Hematology/Oncology
- Neurology
- Physical Medicine & Rehab
- Pulmonary Medicine
- Rheumatology
- Travel Medicine
- Transition Medicine

A novel dedicated provider model was adopted to ensure full-time coverage of consistent providers across both outpatient clinics and inpatient services.

Traditional Scheduling Planning

When initially planning the space, the project manager used excel tables to manually assign providers to a clinic slot and specific rooms.

Floor 1	ORTHO		SPORTS MEDICINE	
	MD	APP	MD	APP
Targeted Number of Providers	2	2	2	-
Targeted Number of Sessions	6	2	7	-
Targeted Total Sessions	12	4	14	-

Traditional Scheduling Planning

Traditional scheduling methods become difficult when resource demand approaches capacity

Floor 1					ORTHO		SPORTS MEDICINE			
Exam Room	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM
1	Ortho2	Ortho1	Ortho1	Ortho1	Ortho2	Ortho1	Ortho1	Ortho1	Ortho2	SM1
2	Ortho2	Ortho1	Ortho1	Ortho1	Ortho2	Ortho1	Ortho1	Ortho1	Ortho2	SM1
3	Ortho2	Ortho1	Ortho1	Ortho1	Ortho2	Ortho1	Ortho1	Ortho1	Ortho2	SM2
4	SM1	Ortho2	Ortho2	SM1	SM1	Ortho2	SM1	SM1	SM1	SM2
5	SM1	Ortho2	Ortho2	SM1	SM1	Ortho2	SM1	SM1	SM1	
6		Ortho2	Ortho2			Ortho2				
Targeted Number of Providers					2	2	2	2		
Targeted Number of Sessions					6	12	7	14		
Targeted Total Sessions					12	24	14	28		

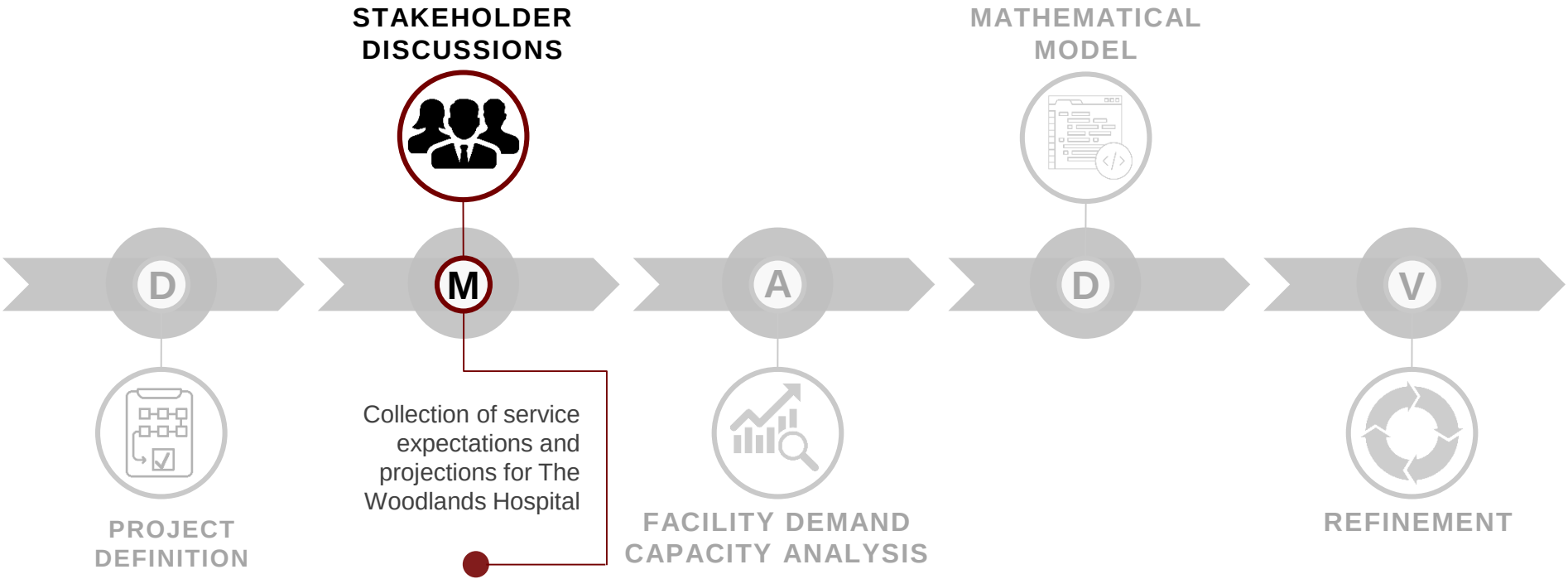
Linear Programing

Optimization method using a mathematical model

- Minimizing or maximizing *something*
  - Typically cost, profit, or utilization of resources
- Subject to constraints
  - Typically resource limitations, availability, etc.

We used Matlab to code the optimization objectives & constraints and excel to store the data.

A brief look back on the Woodlands Lean Journey



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Voice of the Customer

"Providers are assigned a certain number of clinic sessions which are determined by their contract"

"Providers/managers have also requested a OR time based on expected volumes"

"When West Campus opened we had an issue with providers being scheduled in the clinic & OR during the same time slot"

"All of our providers won't fit in the space, but we aren't sure how to determine who needs to stay at the Health Center"

"What if we reduced the number of rooms?"

"Could evening sessions fix the problem?"

Translation to Critical Customer Requirements (CCR)

"Providers are assigned a certain number of clinic sessions which are determined by their contract"

Number of sessions required per week

"Providers/managers have also requested a OR time based on expected volumes"

Number of OR blocks requested

"When West Campus opened we had an issue with providers being scheduled in the clinic & OR during the same time slot"

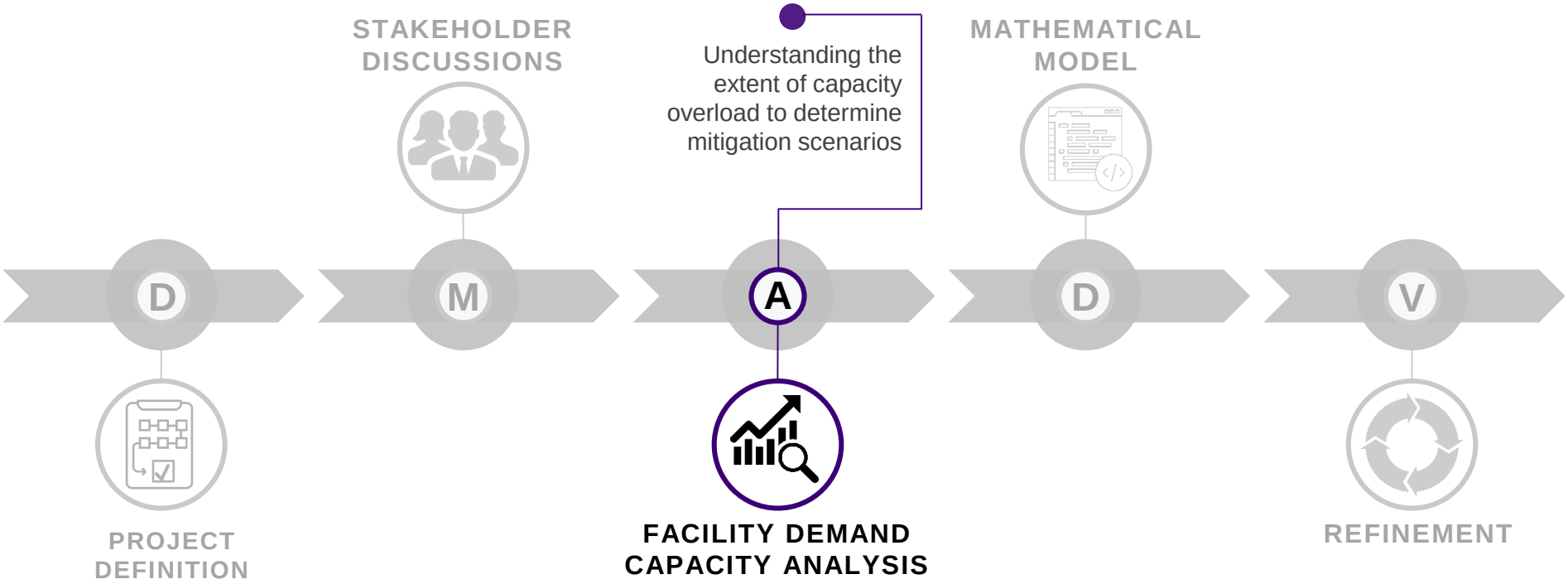
"All of our providers won't fit in the space, but we aren't sure how to determine who needs to stay at the Health Center"

"What if we reduced the number of rooms?"

Number of rooms used per clinic session

"Could evening sessions fix the problem?"

A brief look back on the Woodlands Lean Journey



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Demand Capacity Calculations

Demand per Floor: $\sum_{n=1}^{j} S_R * R_A = D_F$

Provider		Request # Clinic Sessions	Request # Rooms	Request Set schedule?	Request Late Start Date?	Demand per Provider	Demand per Service
SPORTSMED1	Ernest	7	3			21	45
SPORTSMED2	Santana	8	3			24	
ORTHO1	Shilt	3	3	Yes		9	
ORTHO2	Rosenfeld	1	3	**Yes**		3	
ORTHO3	Fracture PA	4	2			8	
ORTHO4	Gerow	2	3	**Yes**		6	77
ORTHO5	Kushare	5	3			15	
ORTHO6	new	6	3		Yes	18	
ORTHO7	new	6	3		Yes	18	

Demand Capacity Calculations

Capacity per Floor: $R_E * S_W = C_F$

Floor	Pod	Number of Exam Rooms	Exam Rooms
1		10	Ortho, Sports Medicine
3		12	Pedi Surg, Plastics, Derm, Pedi Gyn, Uro, Renal
5	A	12	A&I, Rheum, Infectious Disease
5	B	10	Endo, NGI
6		12	Pulm, PM&R, Genetics

10
Available Clinic Rooms

Clinic Sessions per Week

5 Days per Week X 2 Sessions per Day = 10 Clinic Sessions Per Week

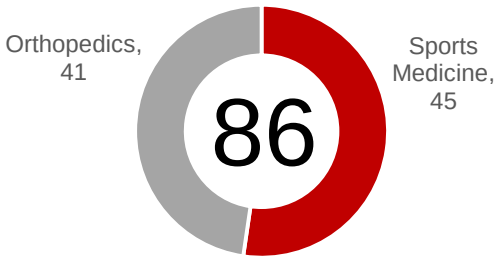
Overall Available Rooms = 100

Demand Capacity Analysis
Outpatient Building Floor 1

Provider		Request # Clinic Sessions	# Rooms	Set schedule?	Late Start Date?
SPORTSMED1	Ernest	7	3		
SPORTSMED2	Santana	8	3		
ORTHO1	Shilt	3	3	Yes	
ORTHO2	Rosenfeld	1	3	**Yes**	
ORTHO3	Fracture PA	4	2		
ORTHO4	Gerow	2	3	**Yes**	
ORTHO5	Kushare	5	3		
ORTHO6	new	6	3		Yes
ORTHO7	new	6	3		Yes

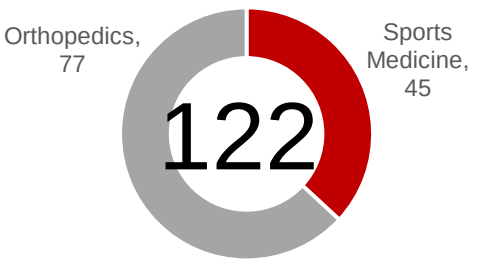
Recruitment by October 2016

Requested Rooms Per Week



Maximum Recruitment

Requested Rooms Per Week



Capacity

10 Available Clinic Rooms

10 Clinic Sessions Per Week

Overall Requested = 86
Overall Available = 100

Overall Requested = 122
Overall Available = 100

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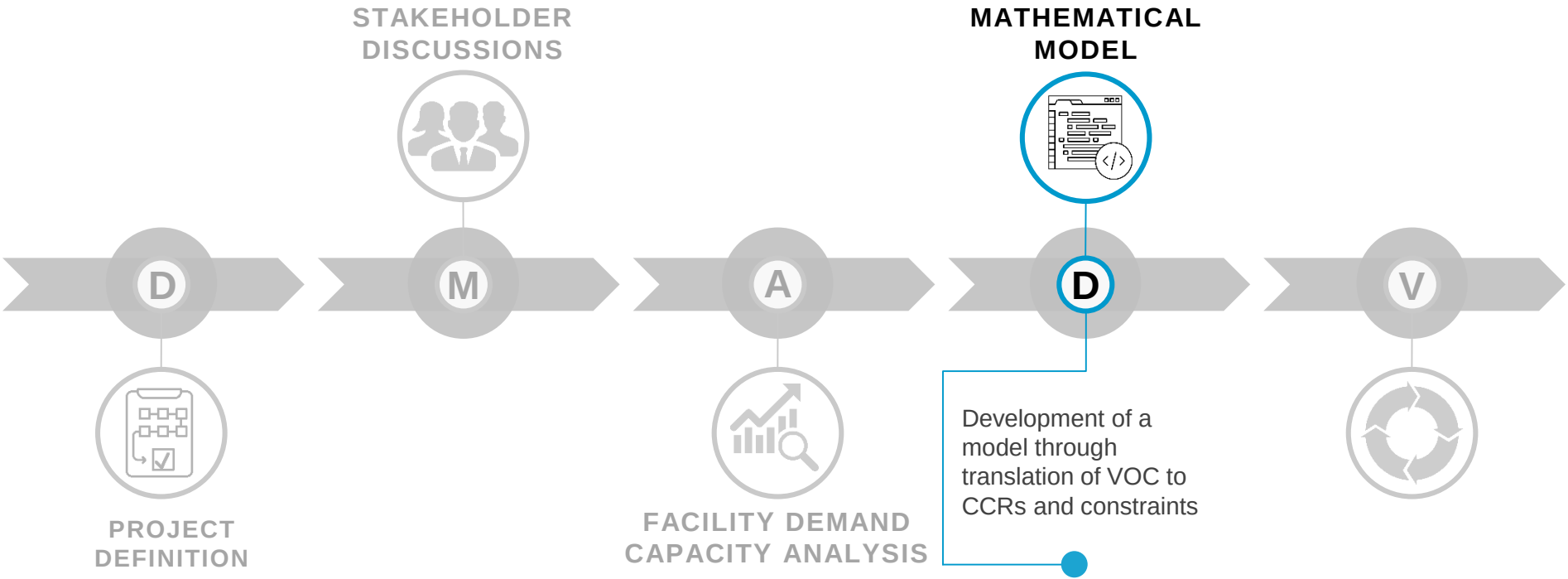
A brief look back on the Woodlands Lean Journey



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Linear Programing Design Process – Starting with the Data

Number of OR blocks requested

Service coverage preferences

Provider start date

Number of rooms used per clinic session

Number of sessions required per week

Provider schedule preferences

Exam rooms per floor

Number of ORs

Number of providers per service

Floor preferred for each service

Linear Programing Design Process – Starting with the Data

Number of OR blocks requested

Service coverage preferences

Number of sessions required per week

Provider start date

Number of rooms used per clinic session

Provider schedule preferences

Exam rooms per floor

Number of ORs

Number of providers per service

Floor preferred for each service

Linear Programing Design Process – Starting with the Data

Hospital Level

Number of OR blocks requested

Number of ORs

Number of providers per service

Service coverage preferences

Provider Level

Number of rooms used per clinic session

Number of sessions required per week

Provider start date

Service Line Level

Provider schedule preferences

Exam rooms per floor

Floor preferred for each service

Linear Programing Design Process – Starting with the Data

Facility	Number of clinic Floors	Number of ORs	Days Open	Sessions / Blocks per Day

Floor	Number of Exam Rooms	Services

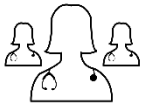
Service	Number of Providers	Coverage Preferences

Provider	Number of Clinic Sessions	Number of OR blocks	Rooms per Clinic Session	Preferences	Service

Linear Programing Design Process – Starting with the Output

OR Schedule

OR	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM
1	PROV4									
2				PROV2			PROV3			
3							PROV4			
4				PROV1					PROV5	

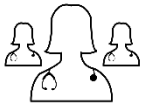


Clinic Schedule

Providers	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM
PROV1	C	C			OR					
PROV2				OR			C	C	C	C
PROV3	C		C					OR	C	C
PROV4		OR	C	C			OR			
PROV5						C	C		OR	OR
…										

Linear Programing Design Process – Starting with the Output

How can we include the Hospital & Service Level data such as rooms per floor and service floor preferences, etc.?

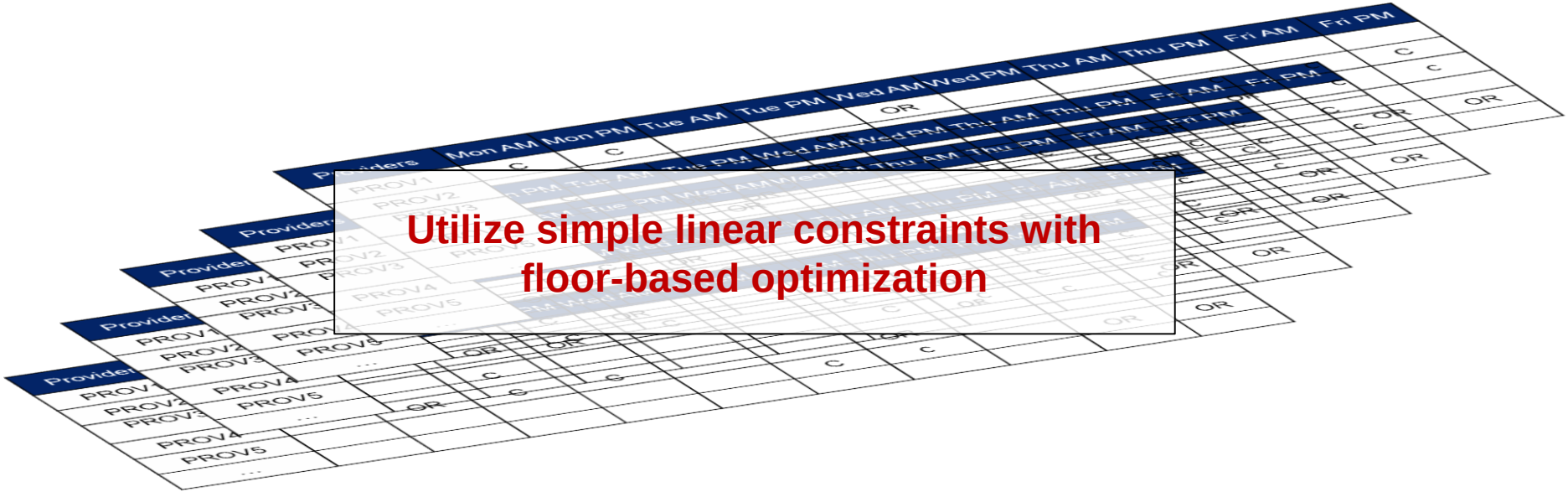


Clinic Schedule

Providers	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM
PROV1	C	C			OR					
PROV2				OR			C	C	C	C
PROV3	C		C					OR	C	C
PROV4		OR	C	C			OR			
PROV5						C	C		OR	OR
…										

Linear Programing Design Process – Starting with the Output

How can we include the Hospital & Service Level data such as rooms per floor and service floor preferences, etc.?



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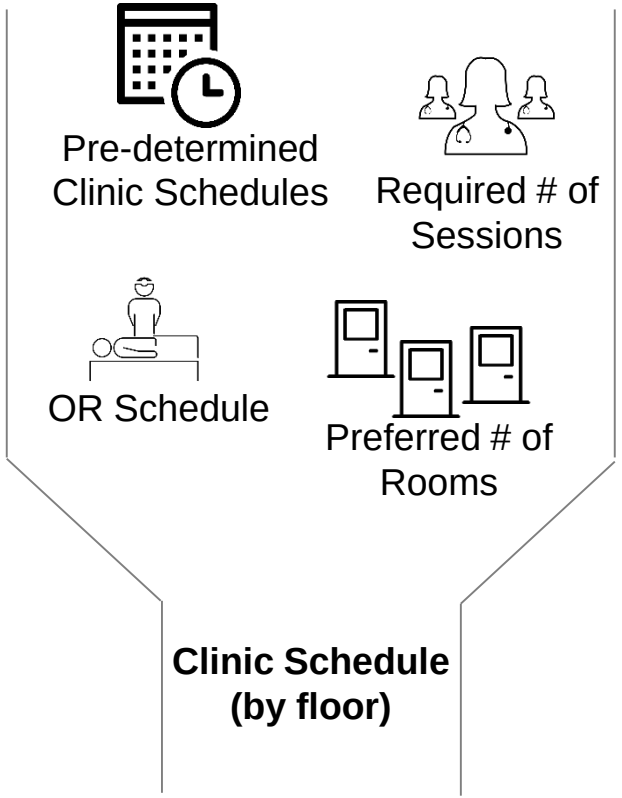
Woodlands Clinic Scheduling Optimization

Constraints:

- Providers must meet the required number of clinic sessions
- The number of exam rooms available on a floor is already defined
- The provider's clinic schedule must not conflict with the OR blocks assigned to their service line
- Whenever possible provider preferences should be met (days in clinic / OR)
- Providers will not be given more rooms than requested

Objective: To maximize the number of rooms a provider is allocated



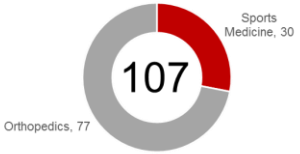
How it works

1 Analyze Provider Information

Floor 1 Overview

	Provider	Request # Clinic Sessions	# Rooms preferred	Set schedule?	Late Start Date?
SPORTSMED1	Ernest	7	2	Yes	
SPORTSMED2	Santana	8	2		
ORTHO1	Shilt	4	3		
ORTHO2	Rosenfeld	1	3	**Yes**	
ORTHO3	Fracture PA	4	2		
ORTHO4	Gerow	2	3	**Yes**	
ORTHO5	Kushare	4	3		
ORTHO6	new	6	3		
ORTHO7	new	6	3		

Requested Rooms Per Week



10 Available Clinic Rooms

10 Clinic Sessions Per Week

Overall Requested = 107
Overall Available = 100

2 Input into Excel

	#Rooms =	10			Pre-determined OR schedule										Pre-determined Clinic Sessions									
	#Providers =	9																						
	Name	# perferred rooms	# sessions	Weights	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM
1	SPORTSMED	2	7	1													1	1	1	1	1		1	
2	SPORTSMED	2	8	1																				
3	ORTHO1	3	4	1	1				1															
4	ORTHO2	3	1	1																	1			
5	ORTHO3	2	4	1																				
6	ORTHO4	3	2	1															1	1				
7	ORTHO5	3	4	1			1			1														
8	ORTHO6	3	6	1				1					1											
9	ORTHO7	3	6	1							1			1										

3 Validate Results & Discuss Options

Full Recruitment Anticipated in October 2016

Floor 1

Option 1: Room Reduction

	Draft First Floor Clinic Schedule										Non-Ideal
Provider	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM	
SPORTSMED1	2		2	2	2	2	2		2		
SPORTSMED2	2	2	2	2	2		2		2	2	
ORTHO1	OR				OR		2	2	3	3	2
ORTHO2							2				1
ORTHO3	2					2		2		2	0
ORTHO4					3	3					0
ORTHO5	2	2	OR	3		OR		3			2
ORTHO6		3	3	OR	3		2	3	OR	3	1
ORTHO7	2	3	3	3		3	OR		3	OR	1
Total	10	10	10	10	10	10	10	10	10	10	7

Options:

- Room Reduction (shown here)
- Saturday Morning Clinic

Providers would be allocated less rooms than requested for 7 sessions (of 42).

Matlab Executable

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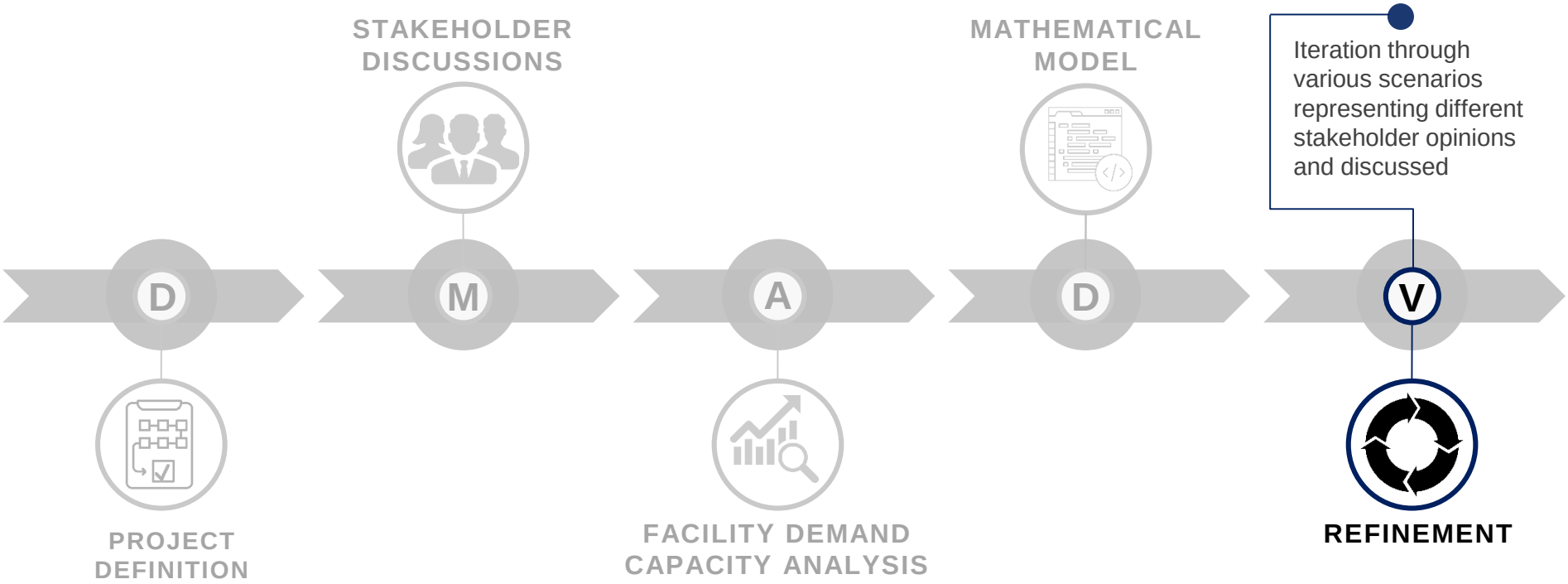
A brief look back on the Woodlands Lean Journey



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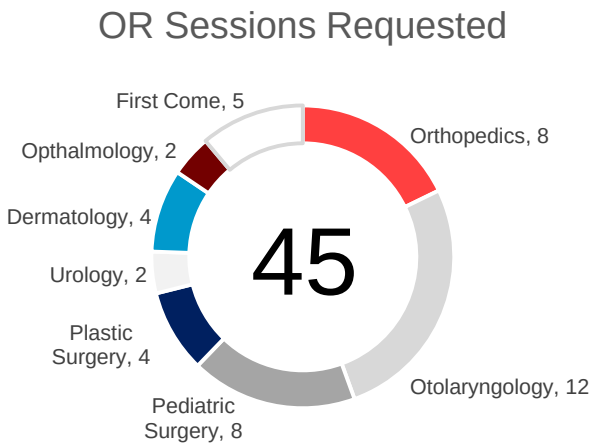
Determining the OR Schedule



Service Line	Requested OR Space			Recommended OR Space Allocation		
	# Providers with OR Blocks	Blocks Per Provider	Total	# Providers with OR Blocks	Blocks Per Provider	Total
ORTHO	4	2	8	4	2	8
OTO	3	4	12	3	3	9
PEDISURG	2	4	8	2	4	8
PLASTICSURG	1	4	4	1	3	3
URO	1	4	4	1	4	4
DERM	1	2	2	1	1	1
OPTH	1	2	2	1	2	2
FCFS	-	-	5	-	-	5
Total			45			40

Overall Requested = 45
Overall Available = 40

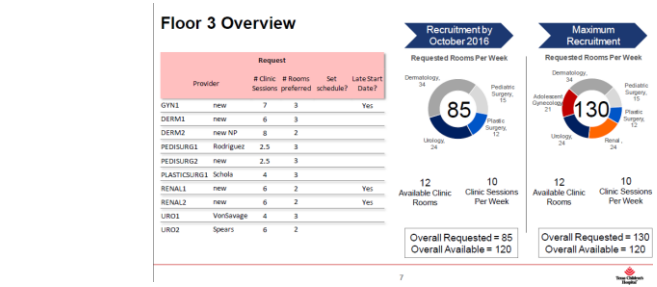
**For the initial schedule review, providers were assigned OR blocks without preference. Blitz sessions will be held in June 2016 to discuss preferences with Surgeons for final schedule.*

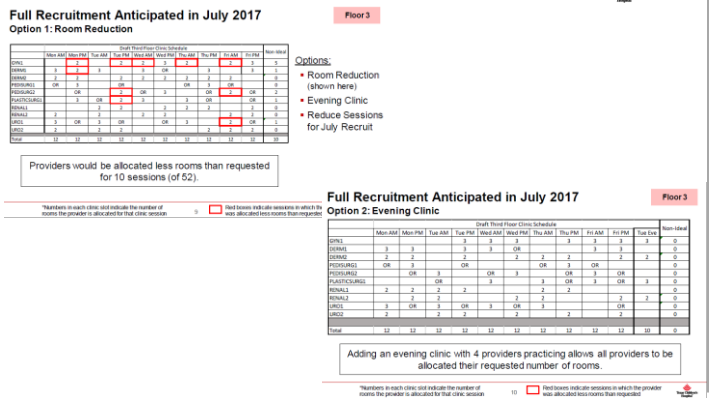
Space Analysis & Scheduling Proposal

Outpatient Building Summary

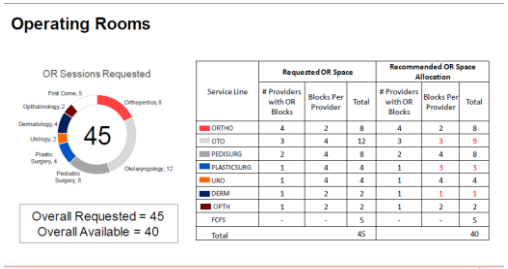
While our analysis was driven by a rooms requested per week metric, Woodlands leadership & providers are more familiar with sessions per week, so a summary of the analysis with “sessions short [per week]” was included

Floor by Floor Analysis & Schedule Proposal





OR Analysis & Schedule Proposal



Draft OR Schedule
(Based on Recommended OR Space Allocation)

	Monday AM	Monday PM	Tuesday AM	Tuesday PM	Wednesday AM	Wednesday PM	Thursday AM	Thursday PM	Friday AM	Friday PM
OR Room 1	OTO1	OTO4	OTO3	OTO4	OTO1	OTO3	OTO4	OTO3	OTO1	ORTHO7
OR Room 2	ORTHO1	URO1	ORTHO5	ORTHO6	ORTHO1	ORTHO5	ORTHO7	PLASTICSURG1	ORTHO6	PLASTICSURG1
OR Room 3	PEDISURG1	PEDISURG2	PLASTICSURG1	PEDISURG1	PEDISURG2	URO1	PEDISURG1	PEDISURG2	PEDISURG1	PEDISURG2
OR Room 4	FC	OPTO1	FC	URO1	FC	DERM1	FC	OPTO1	FC	URO1

Texas Children's Hospital

By The Numbers…

21 Sub-specialties Included

75 Providers

99% Exam room utilization by Sept 2017

The Woodlands Outpatient Building
Provider Room Allocation

Floor 1 Schedule

Providers		Num of Sessions Requested	Num of Sessions in MOB	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM	Evening
Orthopedics Total		27	24	8	9	3	9	6	9	3	3	6	9	
ORTHO1	Shilt	3	1	KW			3	KW/OR ?	KW/OR ?	MAC1	MAC1			
ORTHO2	Rosenfeld	1	1											
ORTHO3	Comeaux (PA)	4	4	2	3	KW	3	KW	KW(2,4)	KW	2?		3	
ORTHO4	Gerow	2	0					MAC1	MAC1					
ORTHO5	Kushare	5	6	3	3	KW/OR?	OR	3	3	KW/OR?		3	3	
ORTHO6	new	6	6	3	3	OR	3		3		3	OR	OR	3
ORTHO7	new	6	6	OR	OR	3		3	3		OR	3	3	3
Sports Medicine Total		15	15	4	2	3	3	3	3	6	3	6	3	
SPORTSMED1	Ernest	7	7	2		3	3	3	3	3		3		
SPORTSMED2	Santana	8	8	2	2	KW	KW			3	3	3	3	
Total		42	39	12	11	6	12	9	12	9	6	12	12	6

Floor 3: General Surgery Pod

Providers		Num of Sessions Requested	Num of Sessions in MOB	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM	Evening
Pediatric Surgery Total		11	9	2	3	3	0	3	2	3	2	3	3	
PEDISURG1	Rodriguez	2.5	2	OR	OR	3	KW	OR	OR				3	
PEDISURG2	new	2.5	2		3	OR	OR	3		OR	OR			
PEDISURG3	new	-	-									OR	OR	
PEDISURG4	new PA	6	5	2		with Rodriguez			2	3	2	3	with Rodriguez	
Plastic Surgery Total		5	8	5	3	3	3	0	2	2	2	0	0	
PLASTICSURG1	Olorunnipa	5	4	3	3	3	3	OR	OR			OR	3?	
PLASTICSURG1	new (PA)	-	4	2						2	2			
Urology Total		6	9	3/5	0/2	2	2	3/5	3	0	3	5	3/5	
URO1/3	Seth/new	2/6	6	3		OR	OR	3	3	OR	3	3	3	
URO2	Spear (PA)	6	3	KW(1,3,5)/ WO(2,4)	KW(1,3,5)/ WO(2,4)	2	2	CCC(1,3,5) /WOO(2,4)	CCC(1,3,5)/ Admin(2,4)	CyFair	CyFair	2	Admin(1,3,5) /WOO(2,4)	
Additional Space Total		14	12	0	3	4	6	3	3	5	5	3	0	
PROV2	new GYN	7	6		3	2	3			2	3	3	OR	
PROV3	new GYN	7	6			2	3	3	3	3	2		OR	
Total		43/47	38	10/12	9/11	12	11	9/11	10	10	12	11	6/8	

Floor 3: Ophthalmology

Providers		Num of Sessions Requested	Num of Sessions in MOB	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM	Evening
Ophthalmology Total		27	11	6	3	6	6	6	6	6	6	3	3	
OPHTH1	Coats	3	0	OR	3(2,4,5)									
OPHTH2	Herce	2	2					3	3					
OPHTH3	Yen	1	1							3				
OPHTH4	Paysee	3	0			3(1,3,5)	3(1,3,5)							
OPHTH5	Tung	7	5	OR	OR	3		3	3	3	3	Med Ctr	Med Ctr	
OPHTH6	Kelinski (Optometrist)	4	0	3(1,3)	3(1,3)									
OPHTH7	Morrison (Optometrist)-New	7	3			3(2,4)	3(2,4)				3	3	3	
Total		27	11	3	3	6	3	6	6	6	6	3	3	

Floor 3: OTO Pod

Providers		Num of Sessions Requested	Num of Sessions in MOB	Mon AM	Mon PM	Tue AM	Tue PM	Wed AM	Wed PM	Thu AM	Thu PM	Fri AM	Fri PM	Evening
Otolaryngology Total		35	13	3	3	6	3	3	3	6	6	6	0	
OTO1	Hughes	5	3	OR	OR	OR	OR	Cy-Fair	Cy-Fair	3	3	3		
OTO2	Roper (PA)	10	9	3	3	3	3	3	3	3	3	3		
OTO3	new	5	0					OR	OR	OR	OR			
OTO4	new	5	0			OR	OR					OR	OR	
OTO5	new (PA)	-	-											
OTO6	new	5	0	OR	OR			OR	OR					
OTO7	new	5	0							OR	OR	OR	OR	
OTO8	Giannoni	-	1			3								
Total		35	13	3	3	6	3	3	3	6	6	6	0	

Texas Children's Hospital

A Systems Engineering Approach to Provider Scheduling

D — **PROJECT DEFINITION**

Establishing project context, developing tangible goals, and brainstorming the project plan

M — **STAKEHOLDER DISCUSSIONS**

Collection of service expectations and projections for The Woodlands Hospital

A — **FACILITY DEMAND CAPACITY ANALYSIS**

Understanding the extent of capacity overload to determine mitigation scenarios

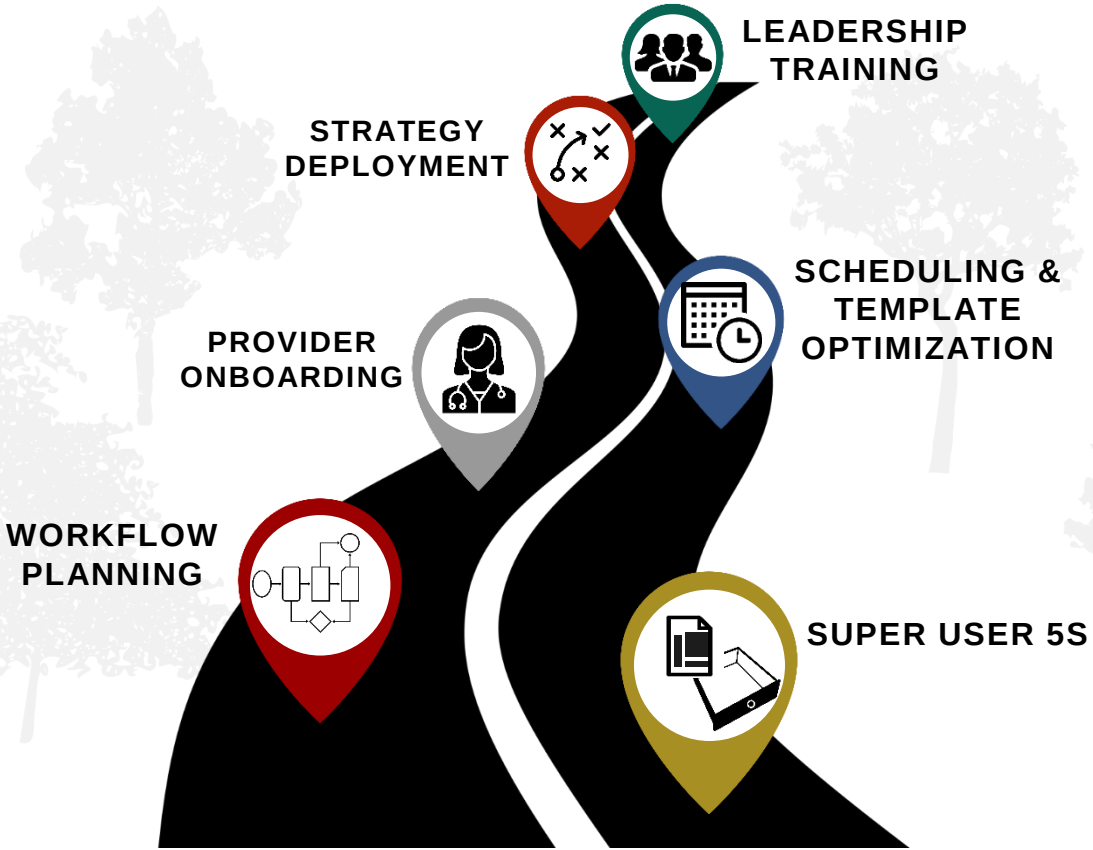
D — **MATHEMATICAL MODEL**

Development of a model through translation of VOC to CCRs and constraints

V — **REFINEMENT**

Iteration through various scenarios representing different stakeholder opinions and discussed

The Woodlands Lean Journey



Thank You!

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