What if Our Clothes Could Show How Fast We Run?

Social Fabric Fitness:

The Design and Evaluation of Wearable E-Textile Displays to Support Group Fitness

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Michael Gubbels
Jon E. Froehlich

CHI 2104
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HCIL Human Computer Interaction Laboratory
COMPUTER SCIENCE UNIVERSITY OF MARYLAND
makeability lab
UNIVERSITY OF MARYLAND

21180
17273

Plethora of Run Trackers

Designed for the individual!

TEAM RED LIZARD
HOOD TO COAST RELAY

Carron et al., 1996; Hanc, 2005; Kolata, 2009;
Robbins, 2009; Youngren, 2009 Barder & Knight, 2010

Group Running Benefits

- Adherence to training
- Educational benefits
- Increases enjoyment
- Aids training intensity

Social facilitation theories posits: the presence of others can increase a person's drive and focus (*e.g.,* Carron, 1996; Strauss, 2002)

Carron et al., 1996; Hanc, 2005; Kolata, 2009; Robbins, 2009; Youngren, 2009 Barder & Knight, 2010

SFF: Theoretical Underpinnings

Social Facilitation: A Self-Presentational View

Charles F. Bond, Jr.
Connecticut College

This article offers a self-presentational account of performance in others' presence. The account attributes social facilitation to the performer's active regulation of a public image, and it attributes social impairment to embarrassment following loss of public esteem. Individuals lose esteem by making numerous errors on difficult tasks. This self-presentational analysis is tested in a study of context effects in verbal learning. Two tasks are studied: a difficult task that includes a few simple items and an easy task that includes a few complex items. Consistent with the self-presentational analysis (but not with drive theories of social facilitation), the presence of an observer impairs the learning of simple items if those items are embedded within a difficult task. Also, an observer's presence does not impair the learning of complex items if those items are embedded within an easy task. Questionnaire responses suggest a naturally occurring confound between task difficulty and perceived failure.

The influence of the presence of others on individual behavior, a classic topic in social psychology, was studied extensively in the early 1900s (Dashiell, 1935). Contemporary interest in the topic derives from Zajonc's proposal (1965) that the presence of others acts as a source of generalized drive (Spence, 1956), and energizes the dominant response tendency to the exclusion of competing responses. Cottrell (1972) amended Zajonc's theory, contending that the presence of others arouses apprehension over evaluations. He claimed evaluation apprehension as a source of generalized drive.

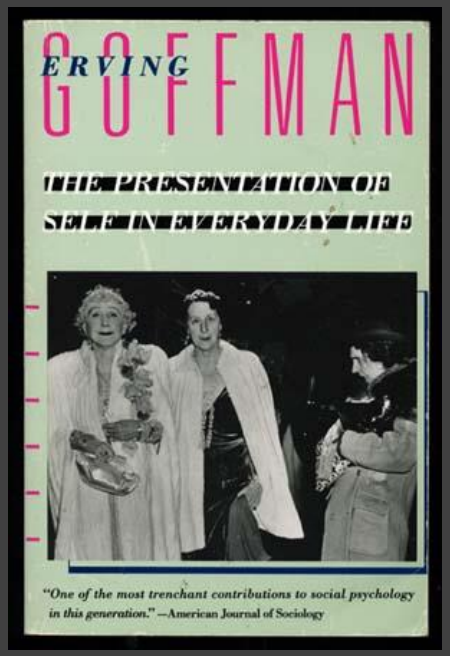
This article proposes an alternative analysis of behavior in others' presence. Following Cottrell, the analysis attributes the influence of others' presence to the potential that presence gives them for evaluation. But Cottrell seemed to ignore the fact that the object of evaluation is the individual's performance. The contingency of others' evaluation on the exhibited performance renders any *generalized* drive interpretation of their influence obtuse. Because a favorable evaluation could be secured or an unfavorable one avoided by competent performance, the nonactive presence of others provides an incentive for exhibition of socially valued behaviors (Geen, 1979). In addition the performance's status as the basis for evaluation gives that performance ongoing psychological significance for the performer. Lacking direct access to another's evaluation, the individual is left to infer it. The inference derives, in part, from a moment-by-moment retrospective self-evaluation that may influence subsequent behavior.

Erving Goffman elaborates related insights in his self-presentational analysis of social interaction (1959, 1967). Self-presentation theory depicts behavior in others' presence as attempts to control or reactions to a public self-image. According to Goffman when the individual appears before others, he or she will discover that an idealized self-image has been claimed. This acceptable image (called *face*) has a normative character. It obligates others to accord the individual the status claimed and obligates the

This article is based on a dissertation submitted to Duke University in partial fulfillment of the requirements for the PhD. I am grateful to Alan Levy, my dissertation adviser, for his guidance and to Mike Gottesman for help with this research.

Requests for reprints should be sent to Charles F. Bond, Jr., P.O. Box 1402, Connecticut College, New London, Connecticut 06320.

Journal of Personality and Social Psychology 1982, Vol 42, No. 6, 1042-1050
Copyright 1982 by the American Psychological Association, Inc. 0022/3514/82/4206-1042$00.75



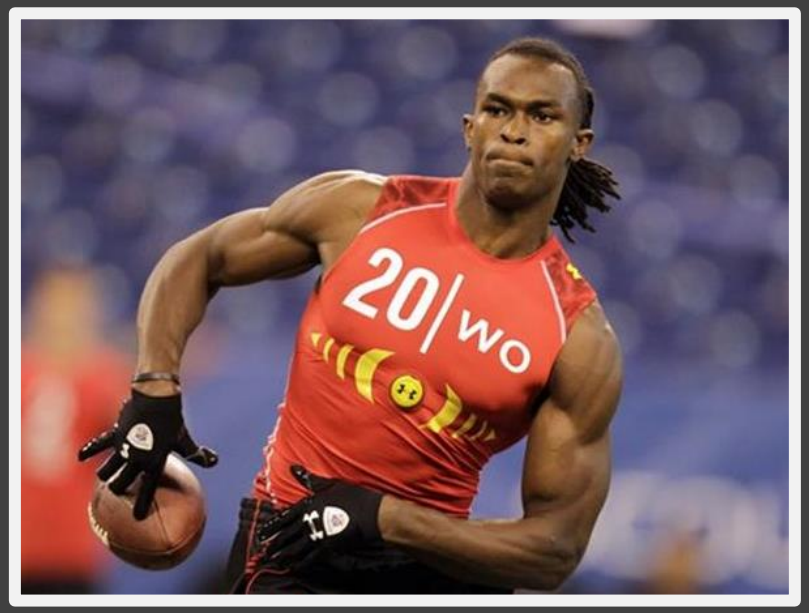
Bond reframes social facilitation in terms of Goffman's presentation of self.

Presence of others can motivate the individual to project image of competence.

For tasks perceived to be too difficult, however, performance may actually decline as individual becomes self-conscious

Potential Dichotomy
Increased motivation
vs. increased anxiety
SFF Externalizes
Performance

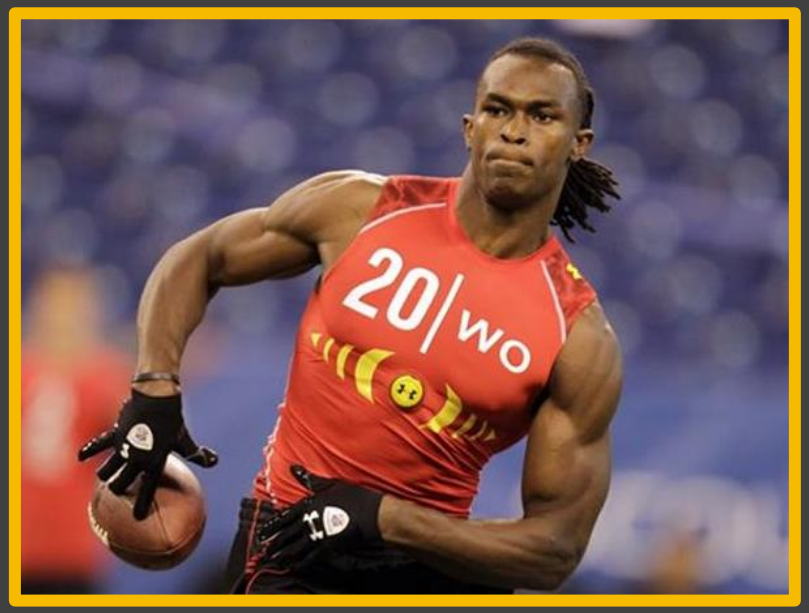
Wearables & Sports



Wearables for **Sensing**

Wearables for **Sensing & Visualization**

Wearables & Sports

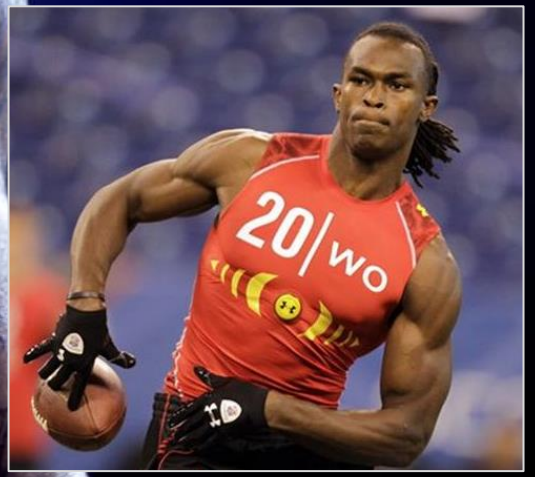


Wearables for **Sensing**

Wearables for **Sensing & Visualization**

Under Armour E39

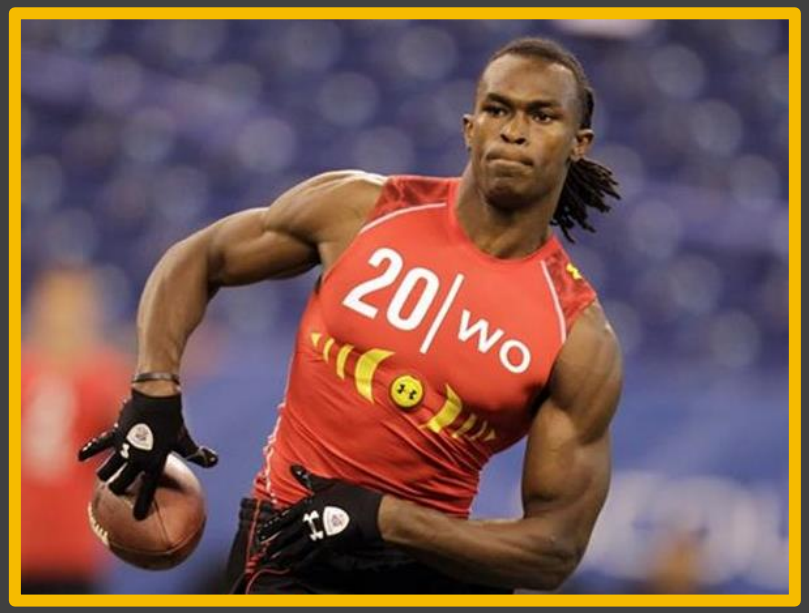
Real-time athlete monitoring



Adidas miCoach Elite

Real-time athlete monitoring

Wearables & Sports



Wearables for **Sensing**

Wearables for **Sensing & Visualization**

Wearables & Sports

Wearables for Sensing

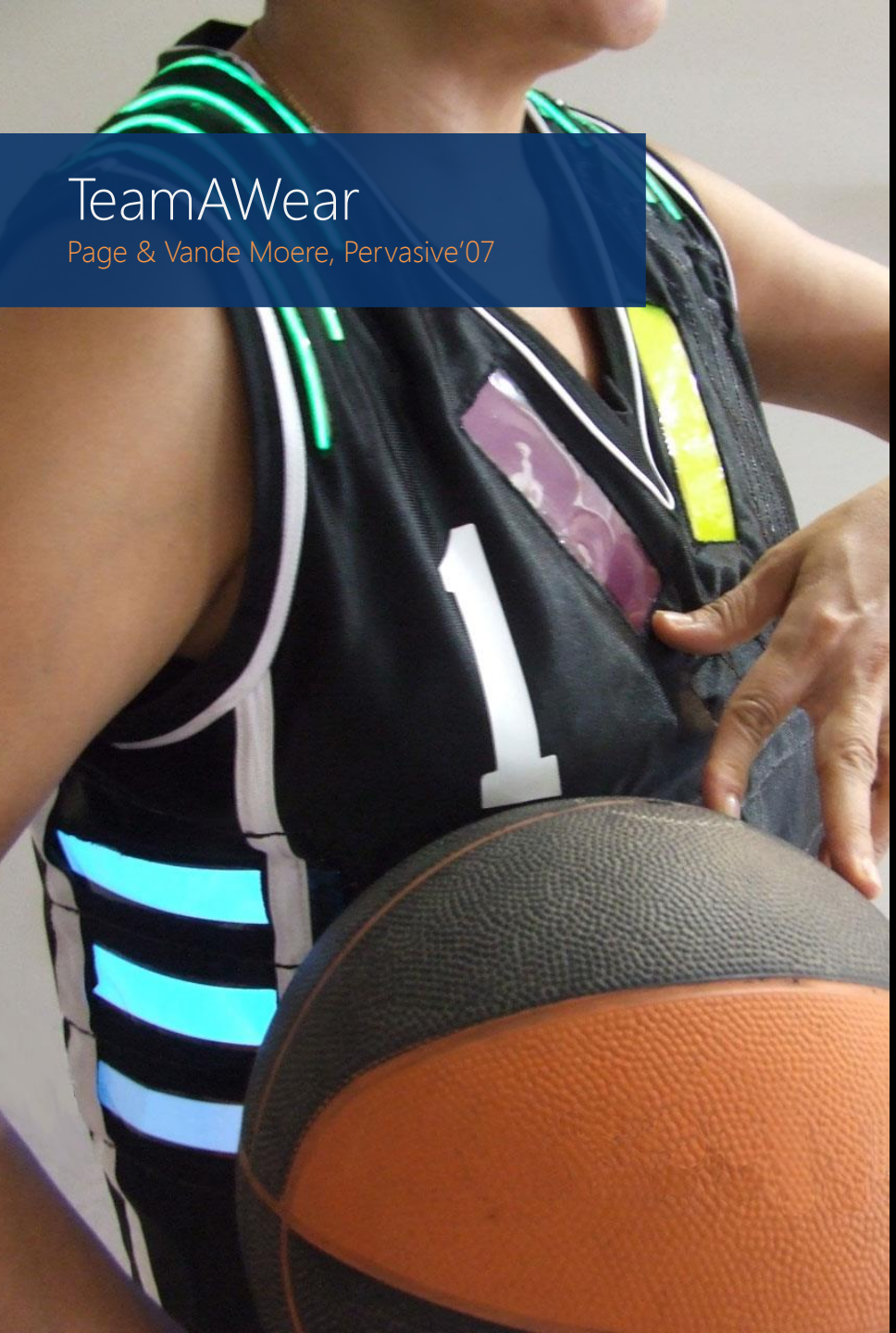
Wearables for **Sensing & Visualization**

Reebok Checklight

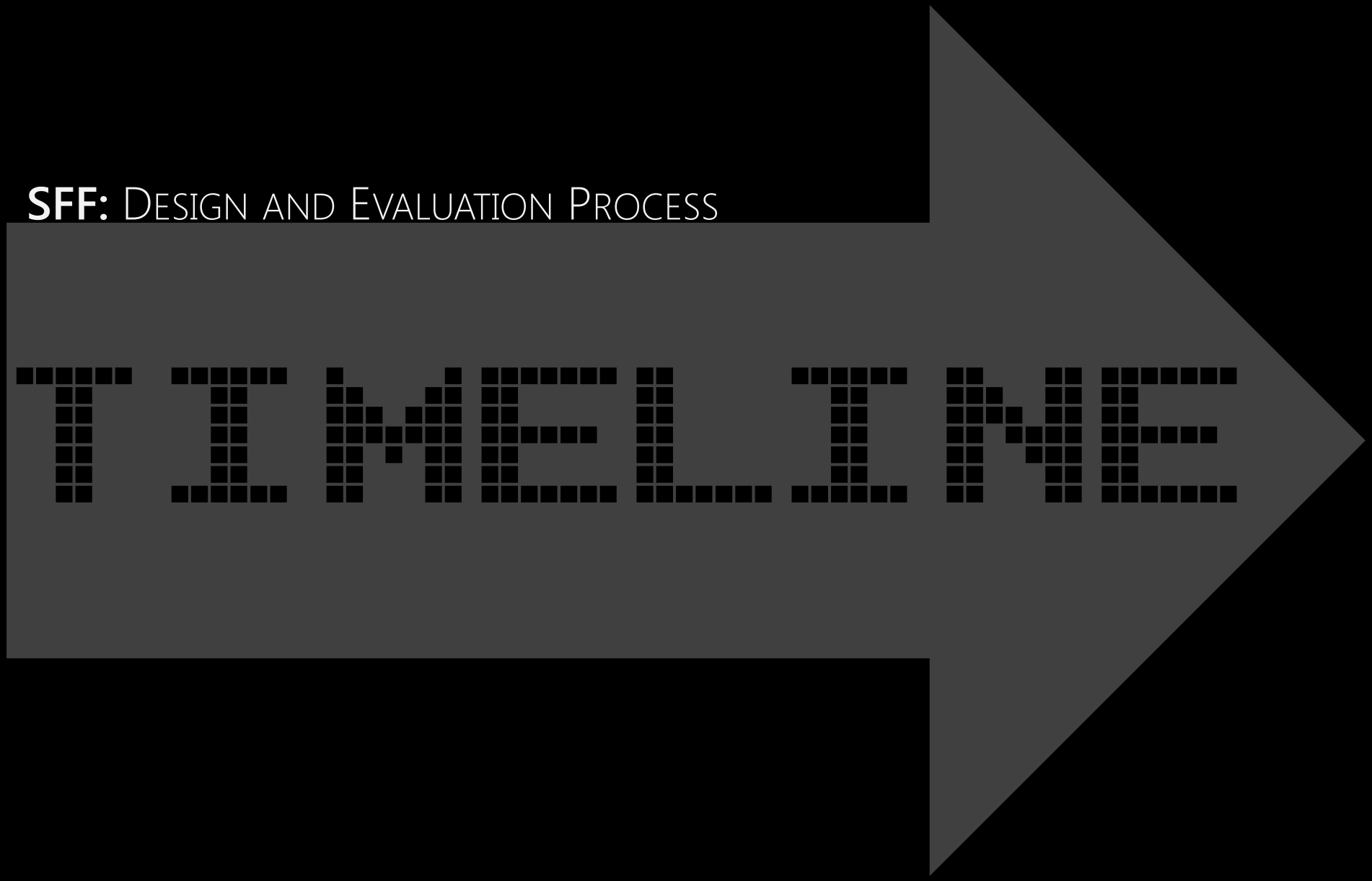
Co-located sensing & feedback on athlete

TeamAWear

Page & Vande Moere, Pervasive'07



SFF: Design and Evaluation Process



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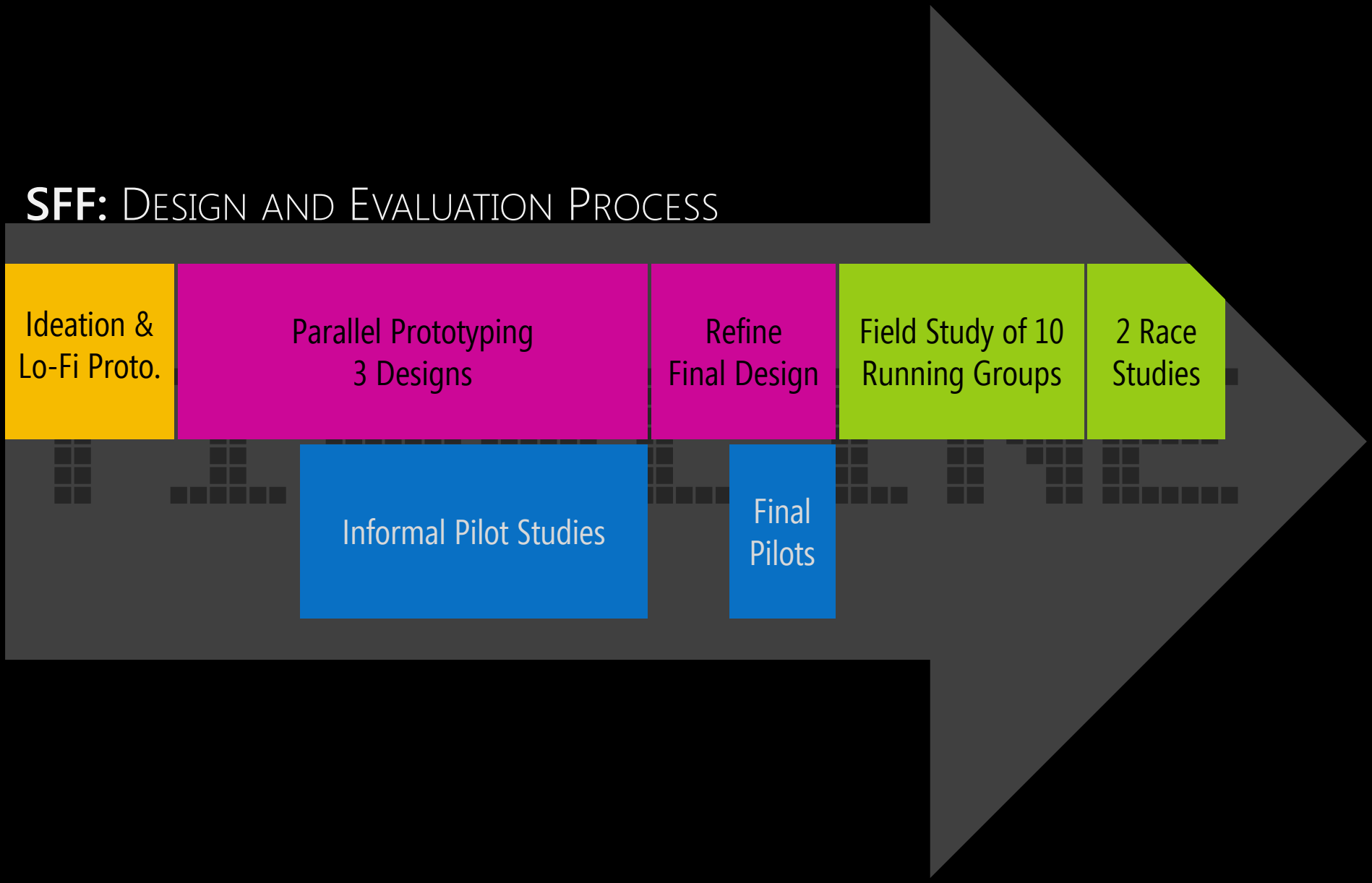

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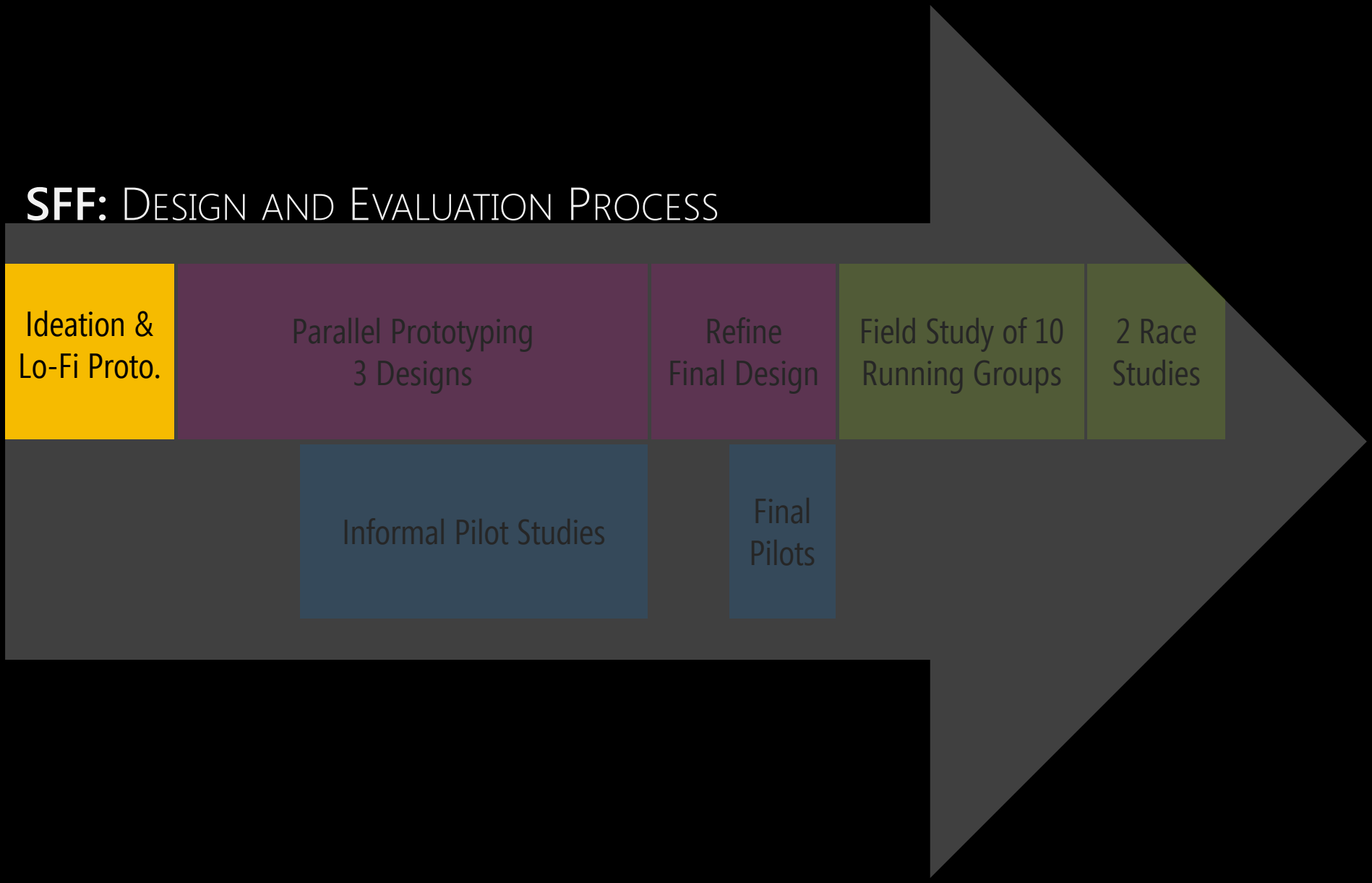
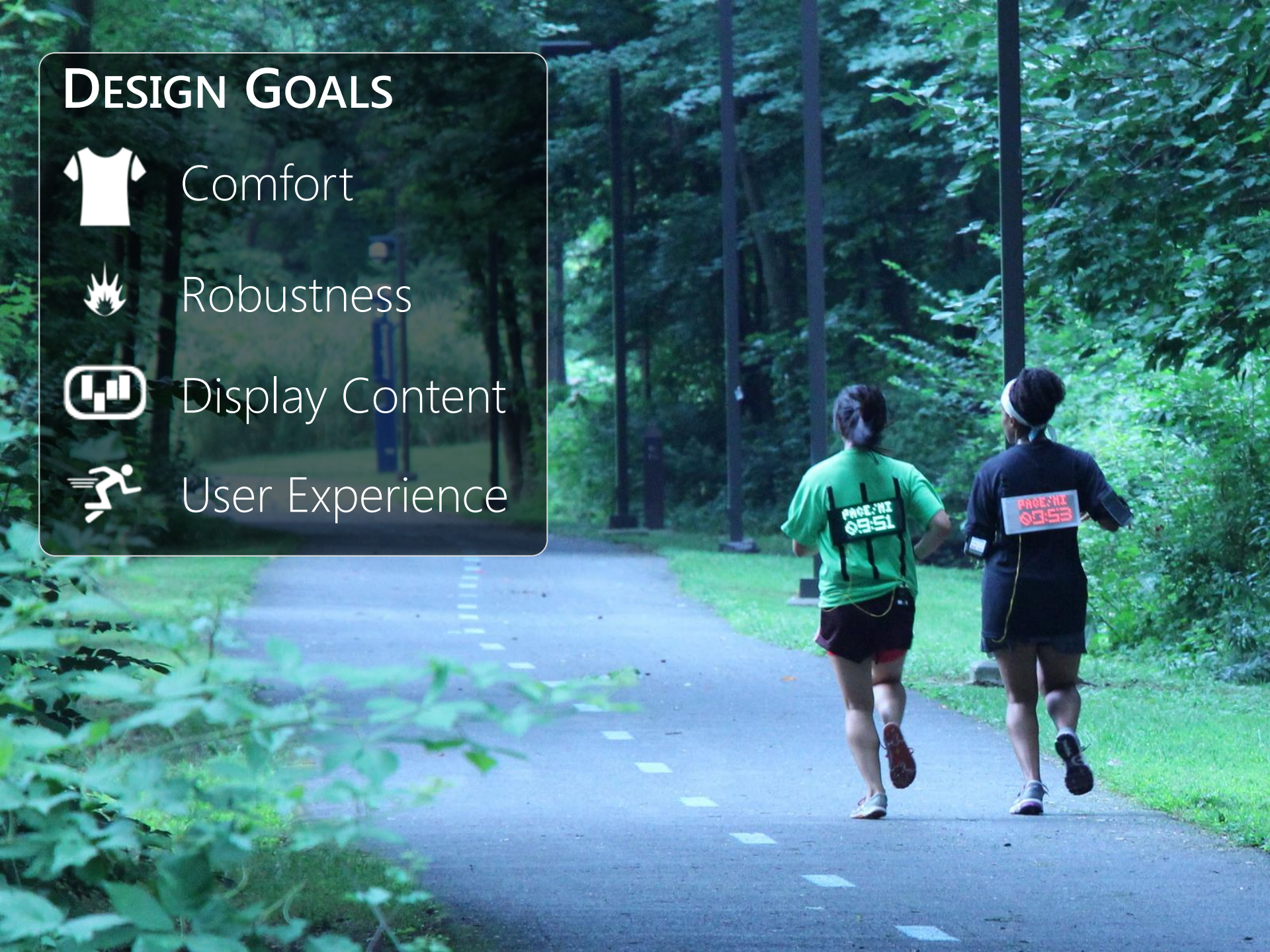
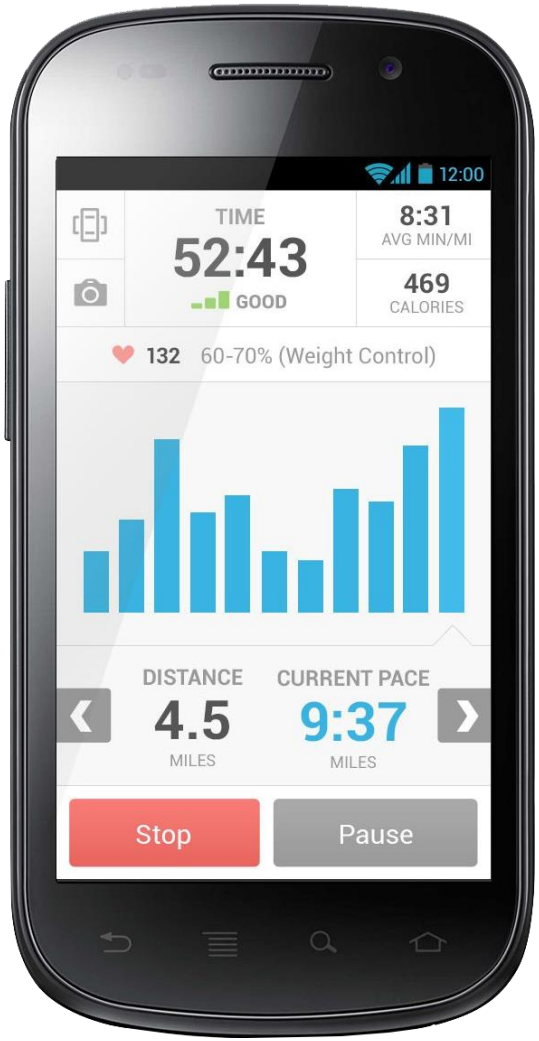



Design Goals
Comfort
Robustness
Display Content
User Experience

SFF: System Overview



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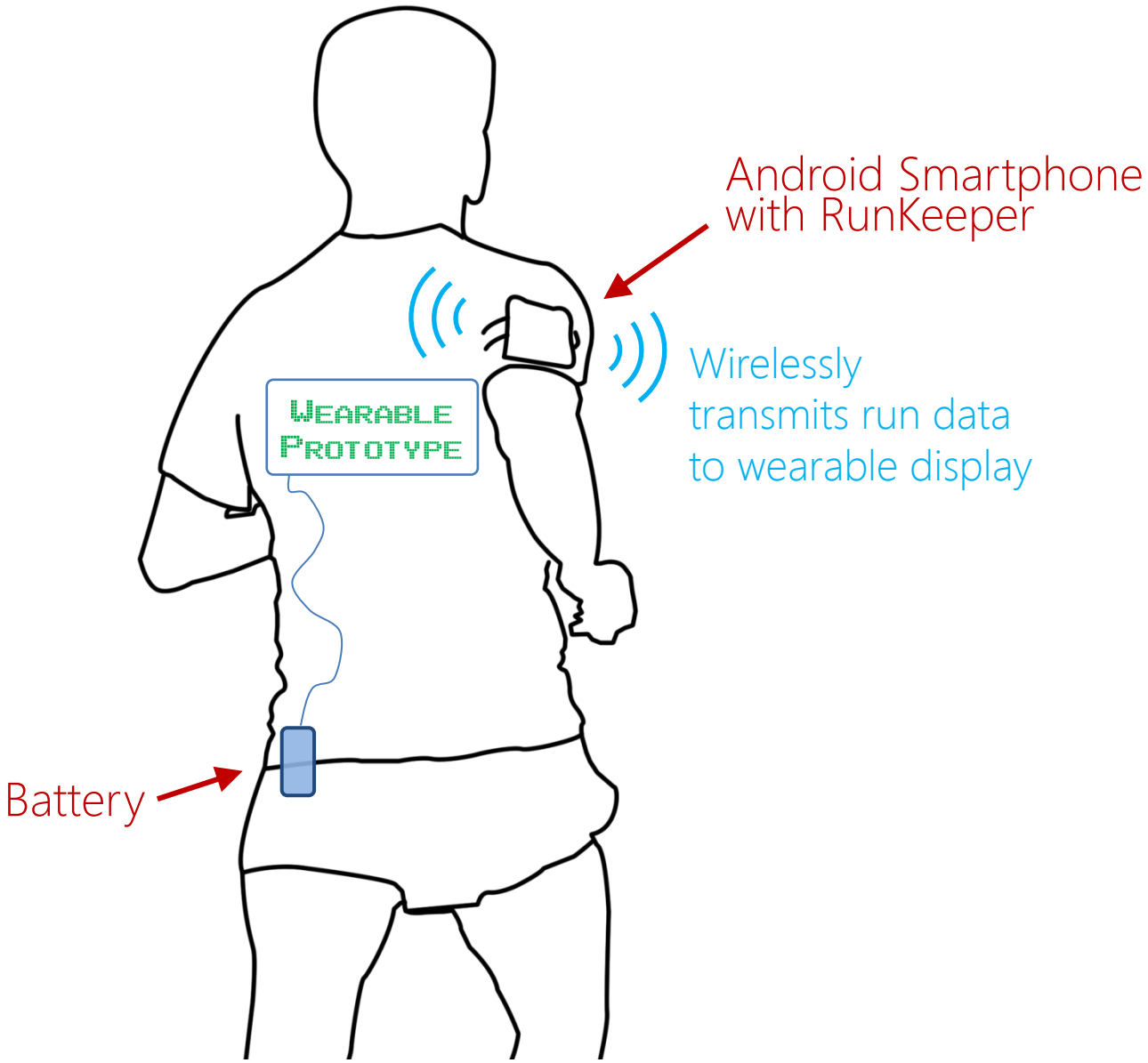
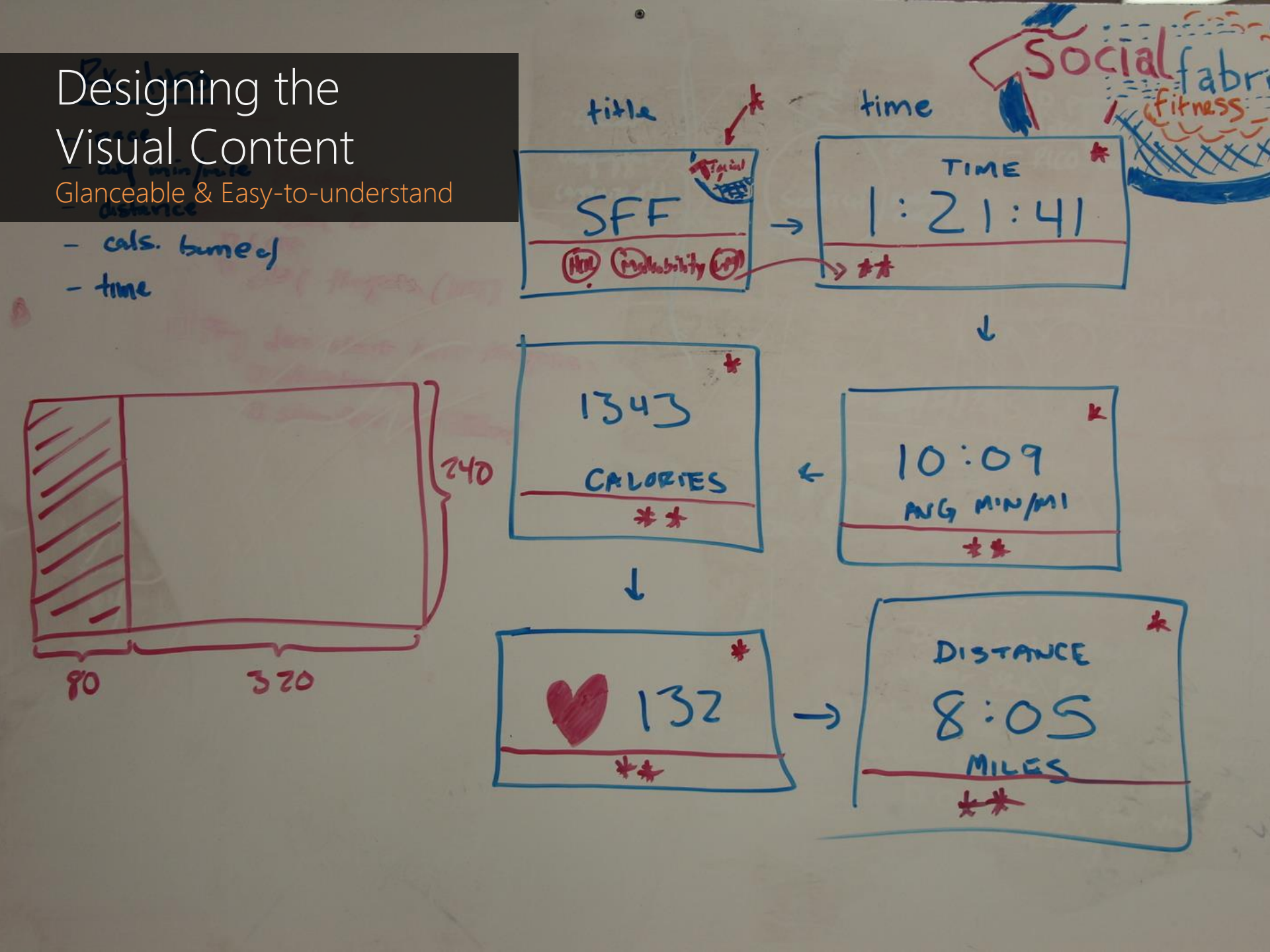
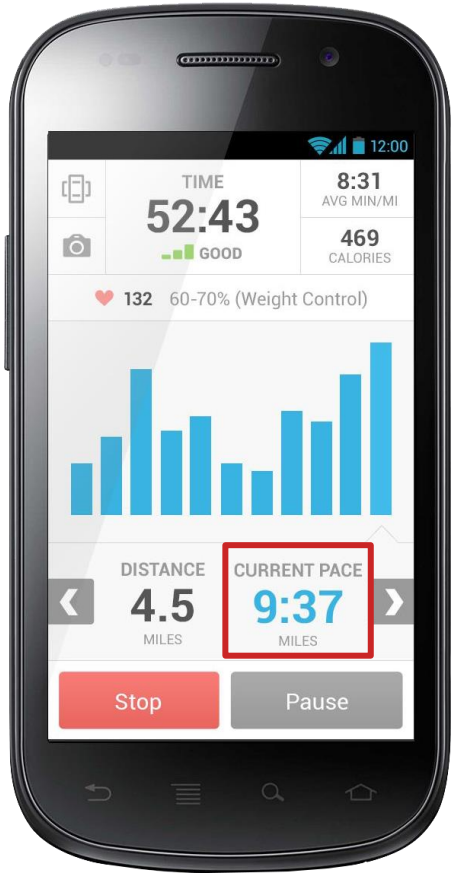


Designing the Visual Content

Glanceable & Easy-to-understand



SFF: Primary Visualizations



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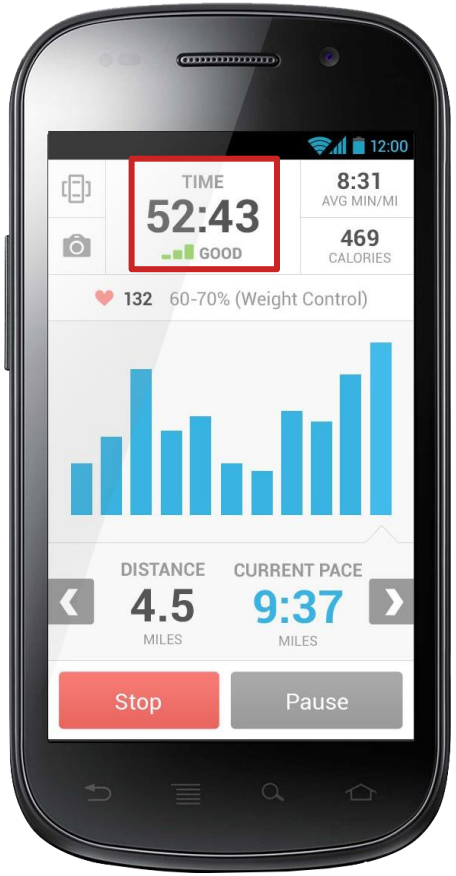

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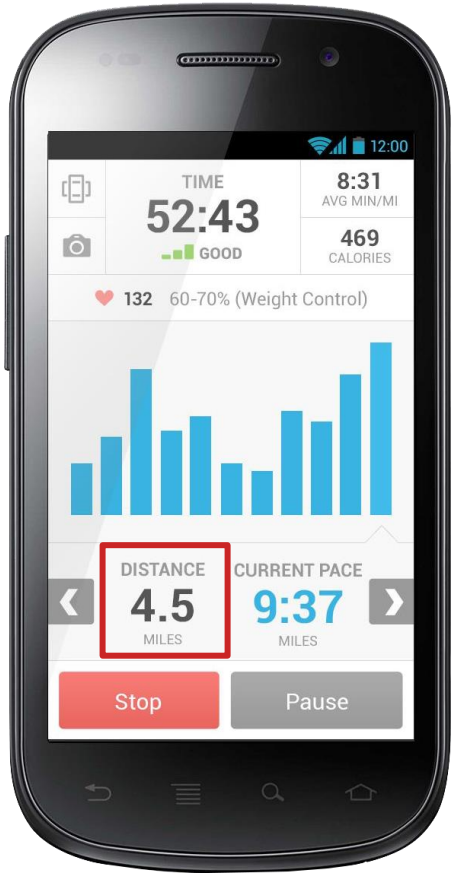
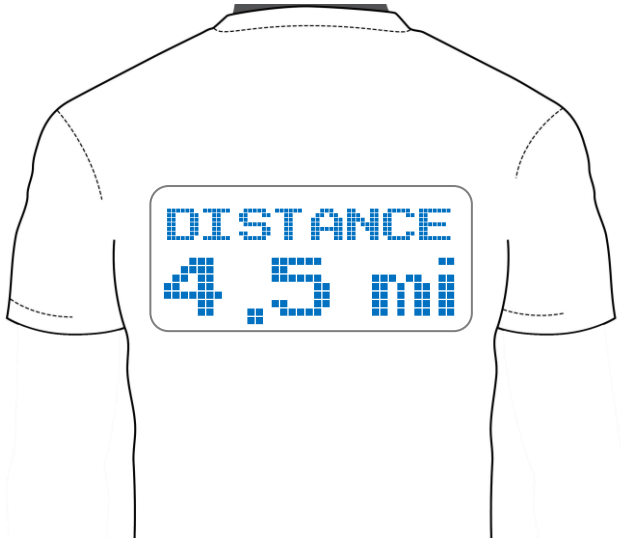
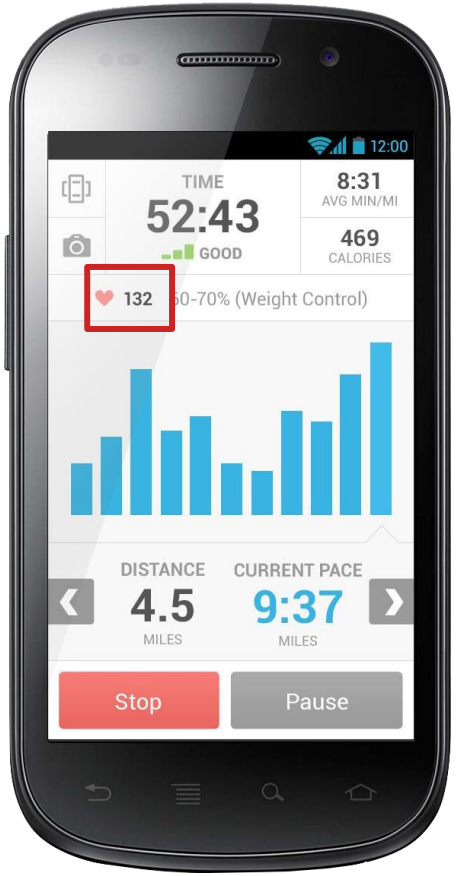
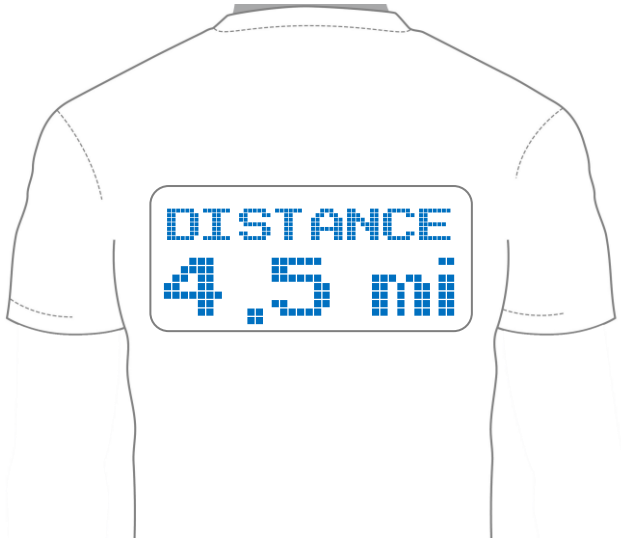


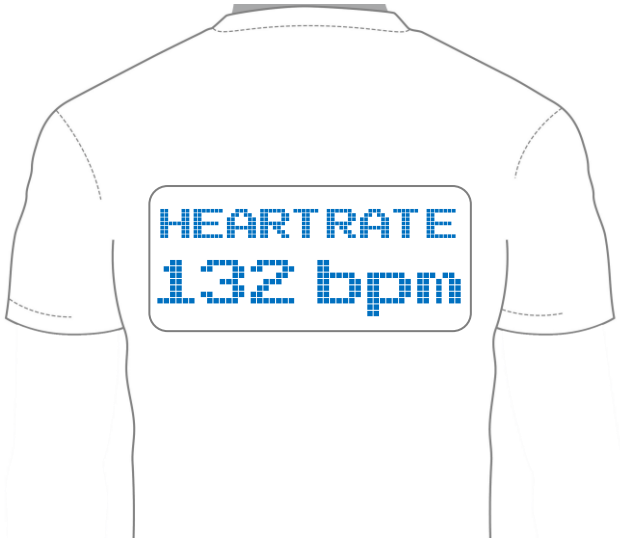


Although RunKeeper tracks a single user, these **measures are shared** across the running group as they run together.

SFF: Primary Visualizations

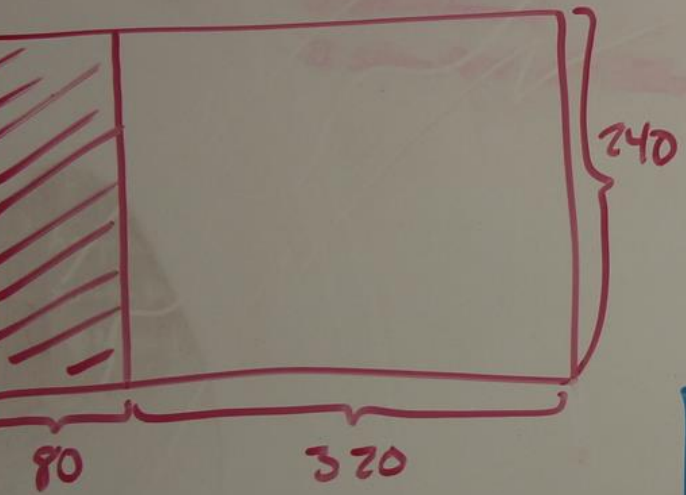


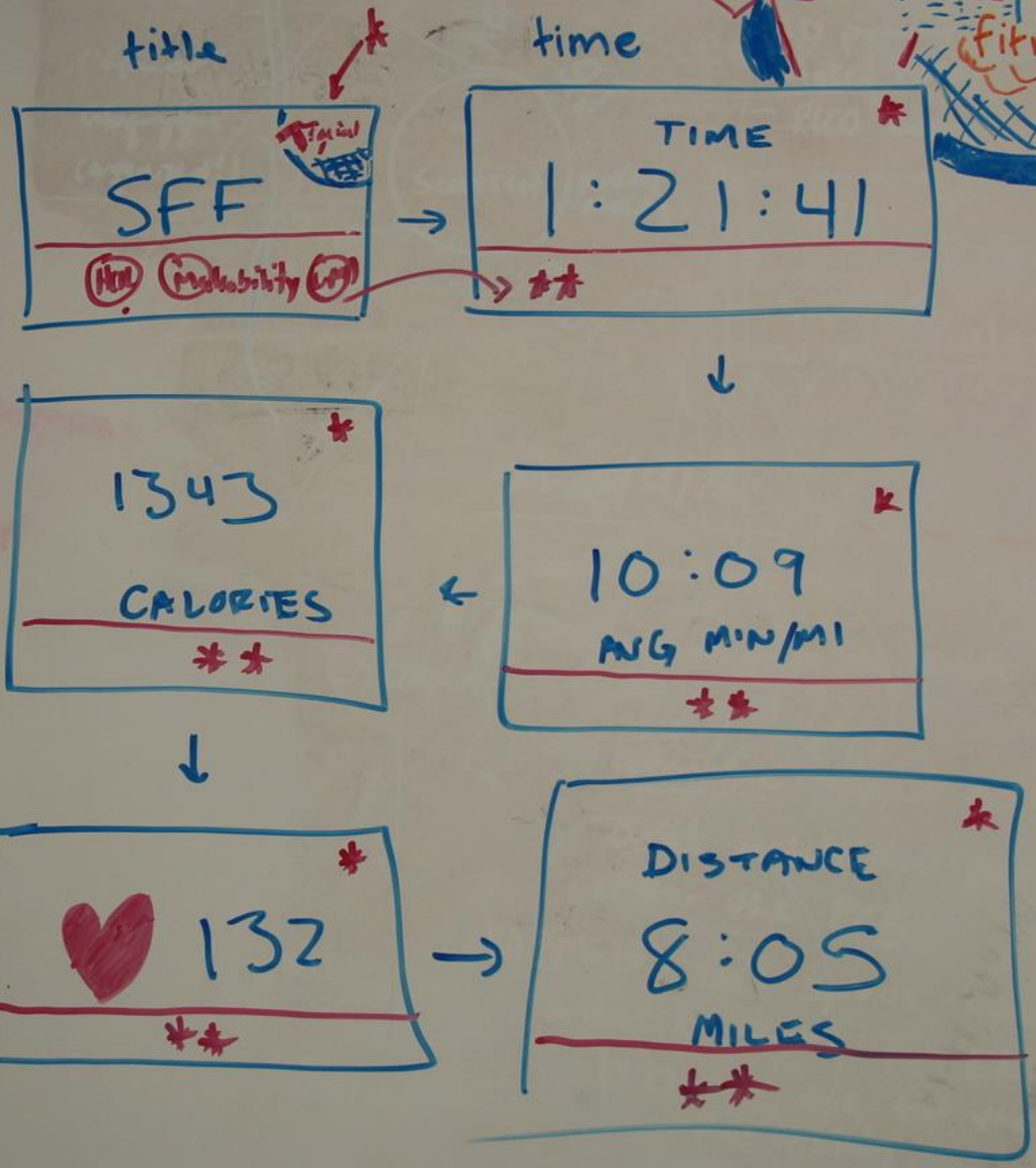




RK Info

- pace
- avg min/mile
- distance
- cals. burned
- time





Comfort

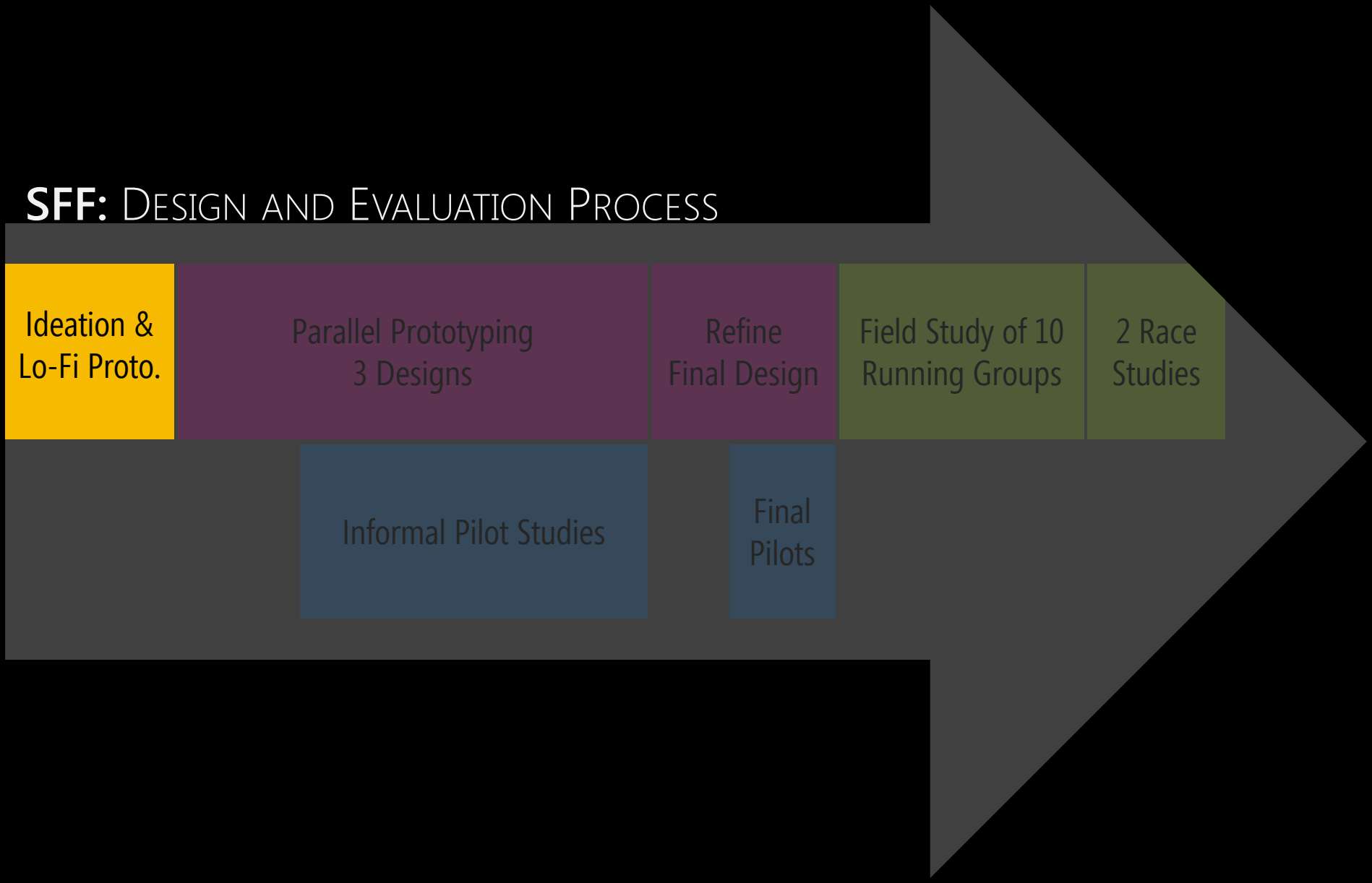
Low-Fidelity Prototypes

Crayola
MARKERS

Engineering

Responsive & Robust

SFF: Design and Evaluation Process



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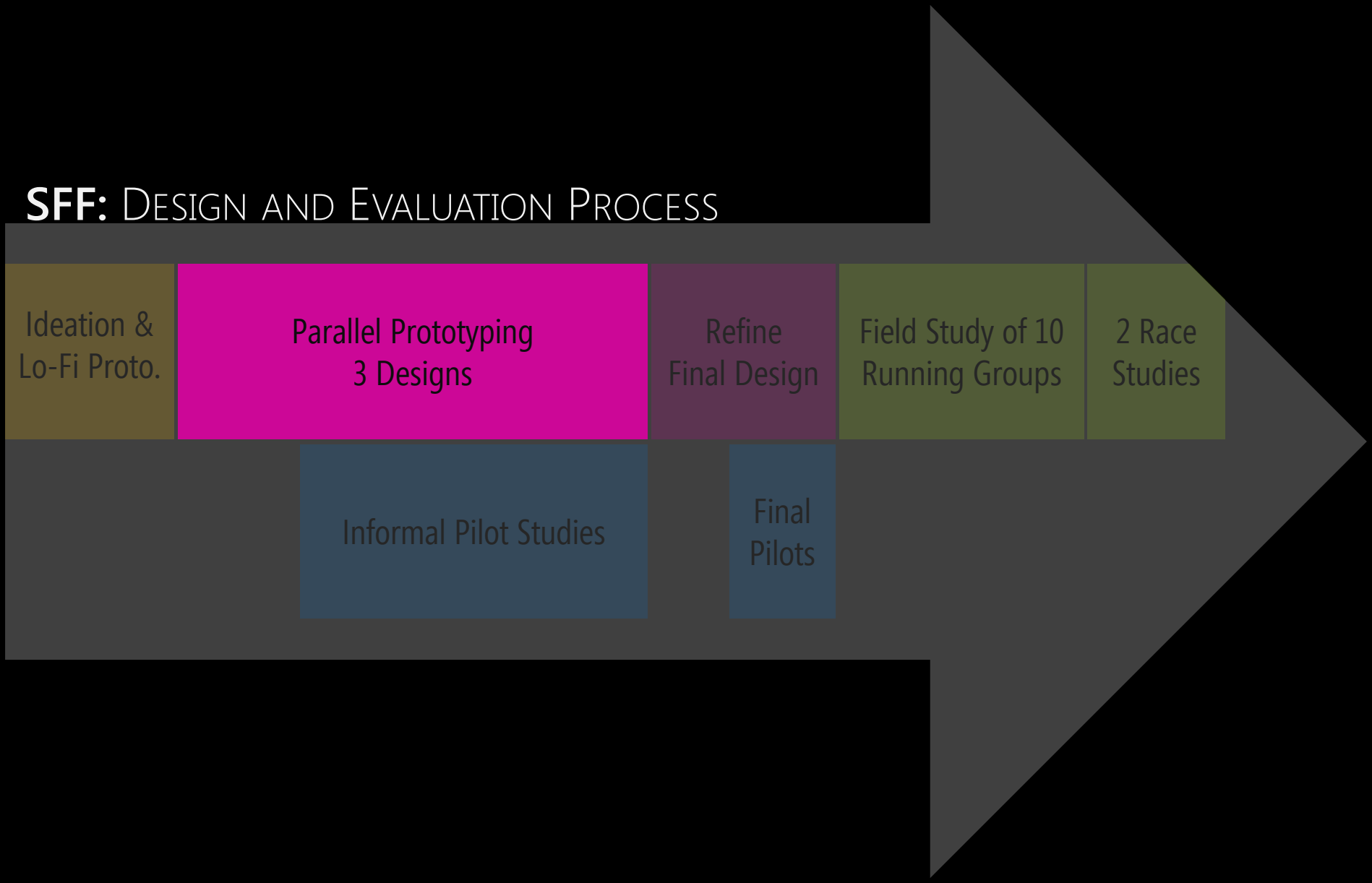
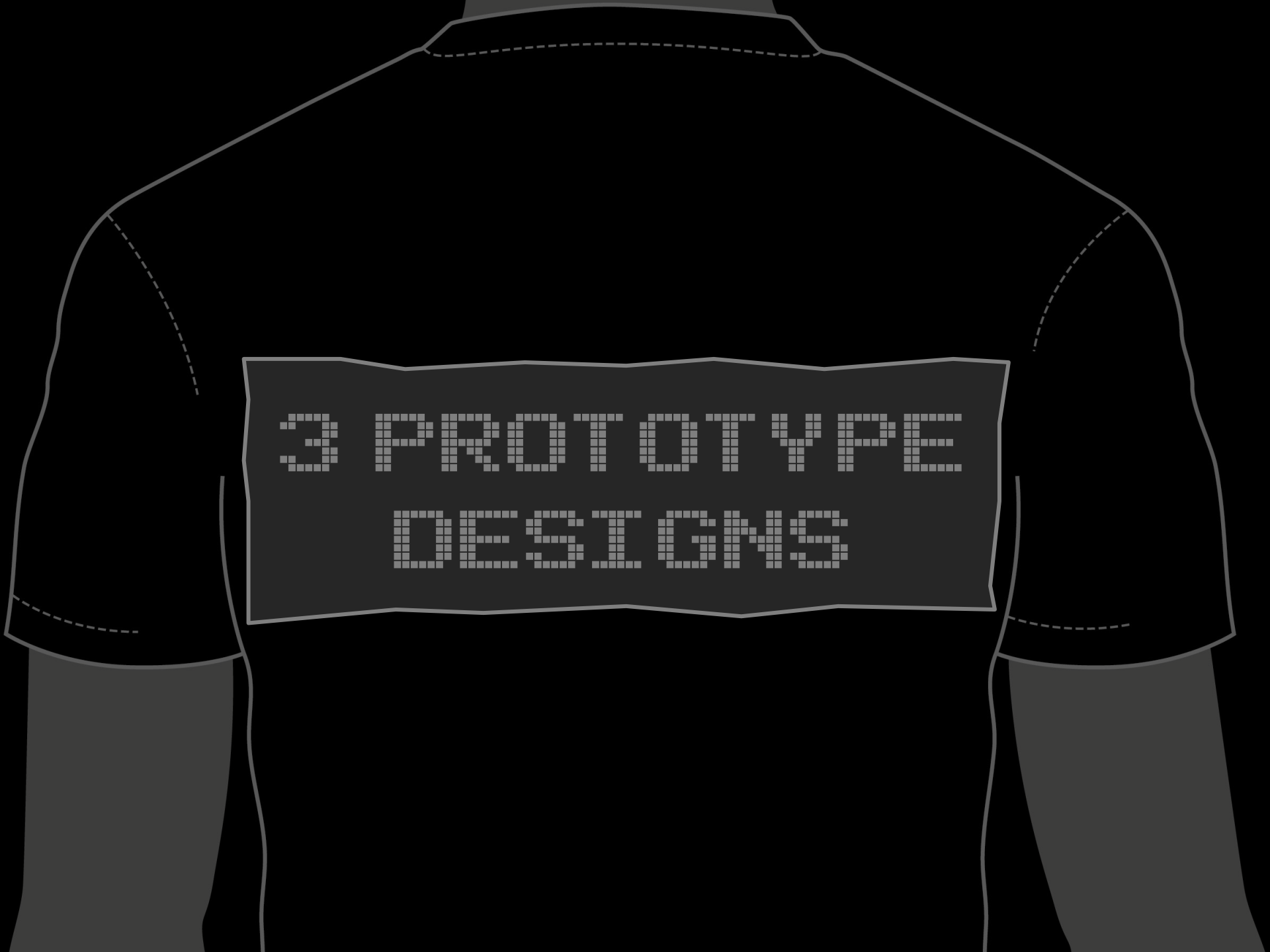



3 PROTOTYPE
DESIGNS

Prototype #1

Custom LED Matrix Display

Prototype #2

Electronic Ink Display

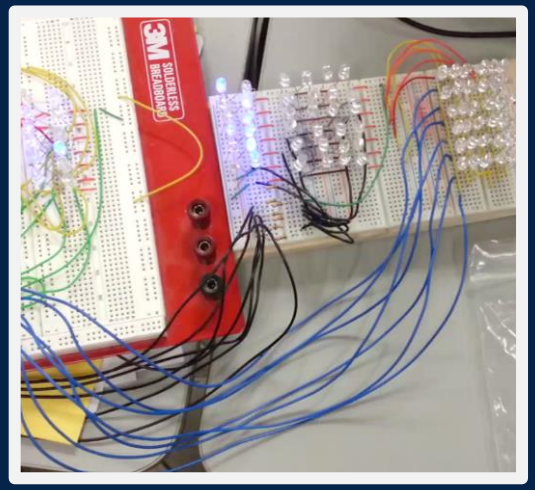
Prototype #3

Erogear LED Matrix Display

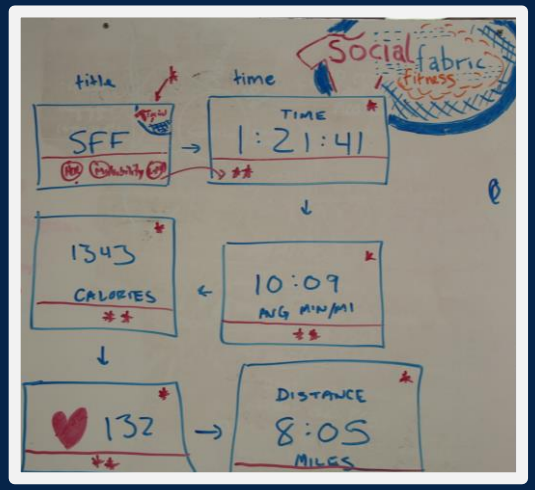
Prototype #1
Custom LED Matrix Display
PACE
7:44

Prototype #1

Three prototyping dimensions



Prototyping **Technology**

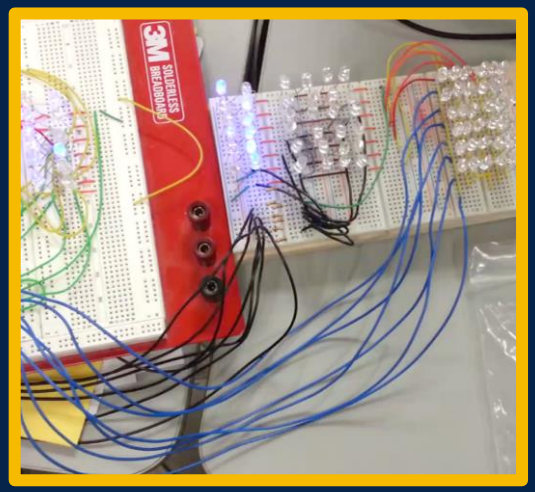


Prototyping **Visualization**

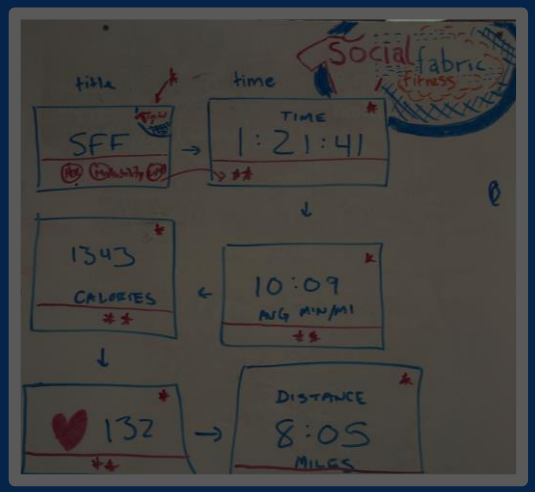
Prototyping **Materials**

Prototype #1

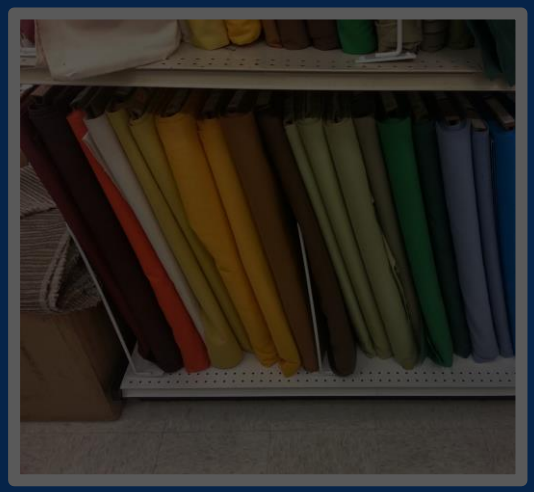
Three prototyping dimensions



Prototyping **Technology**



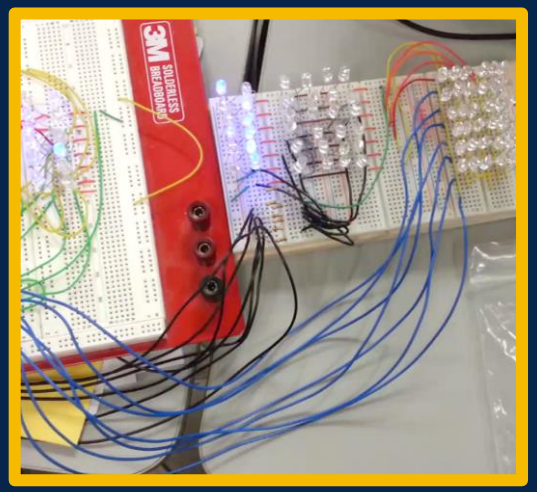
Prototyping **Visualization**



Prototyping **Materials**

Prototype #1

Three prototyping dimensions



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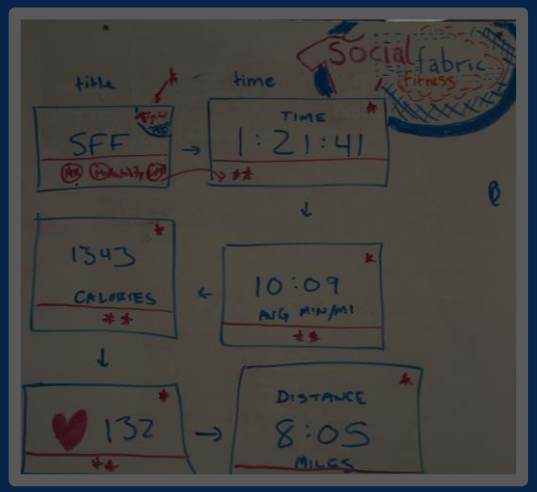
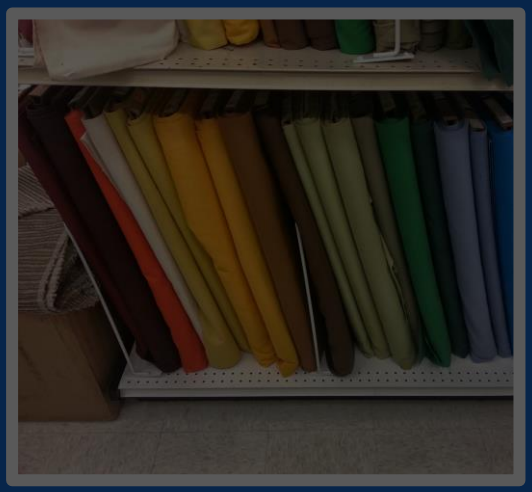


Prototyping **Visualization**



Prototyping **Materials**

1. Select MCU Platform
2. Prototype Circuit Designs
3. Build Software
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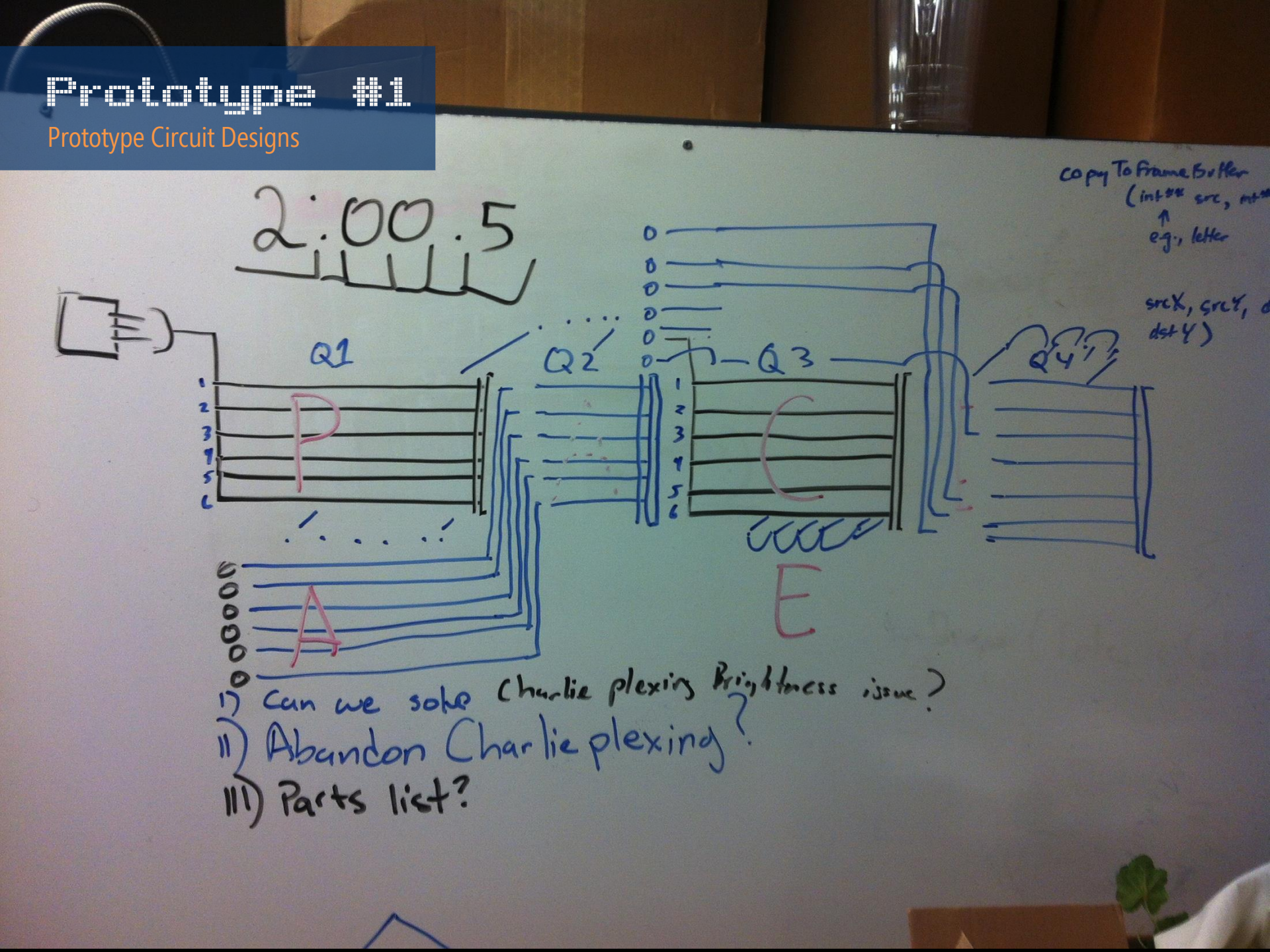
5. Manufacture PCB
6. Test Final PCB & Software

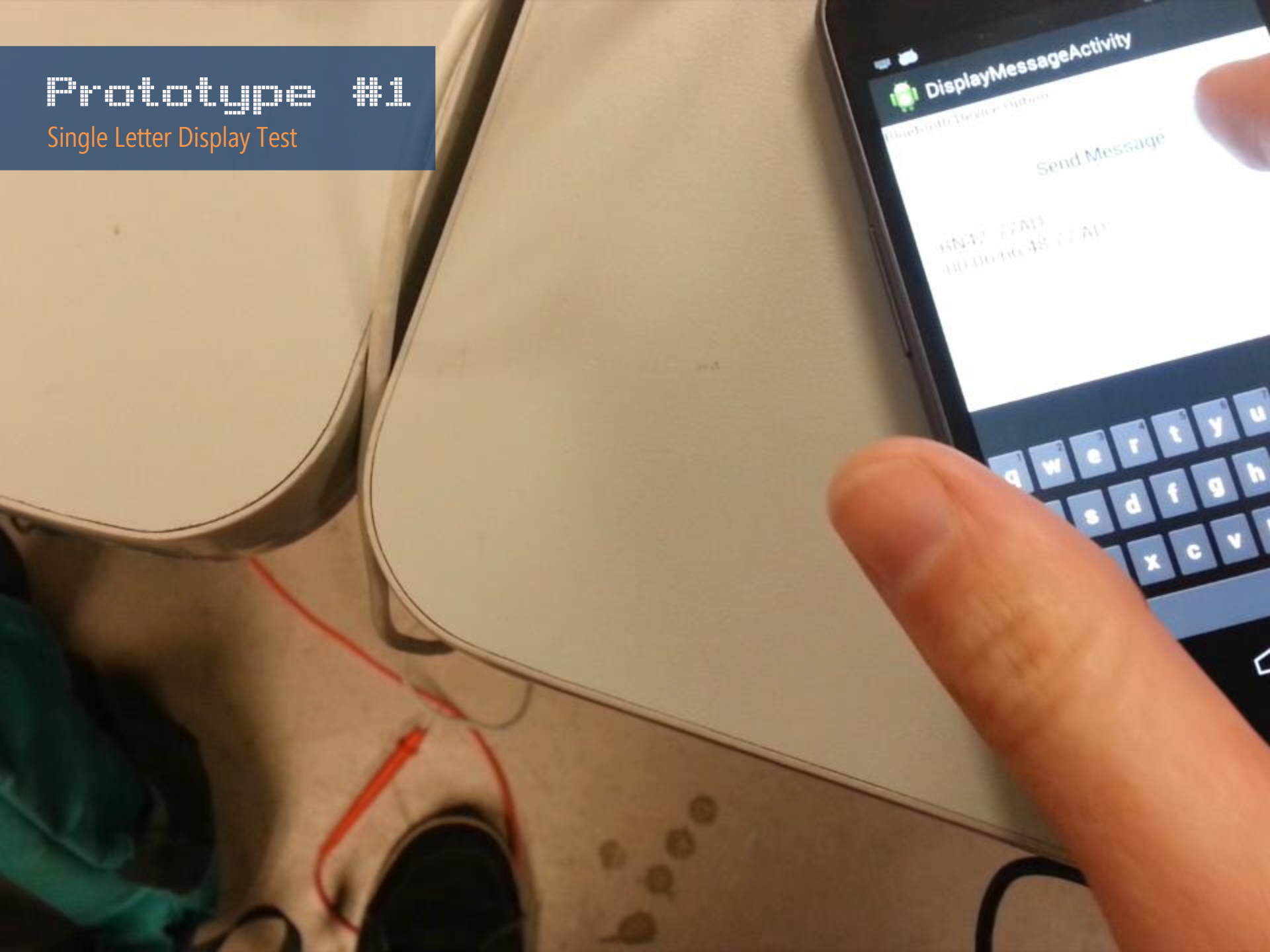
Prototype #1

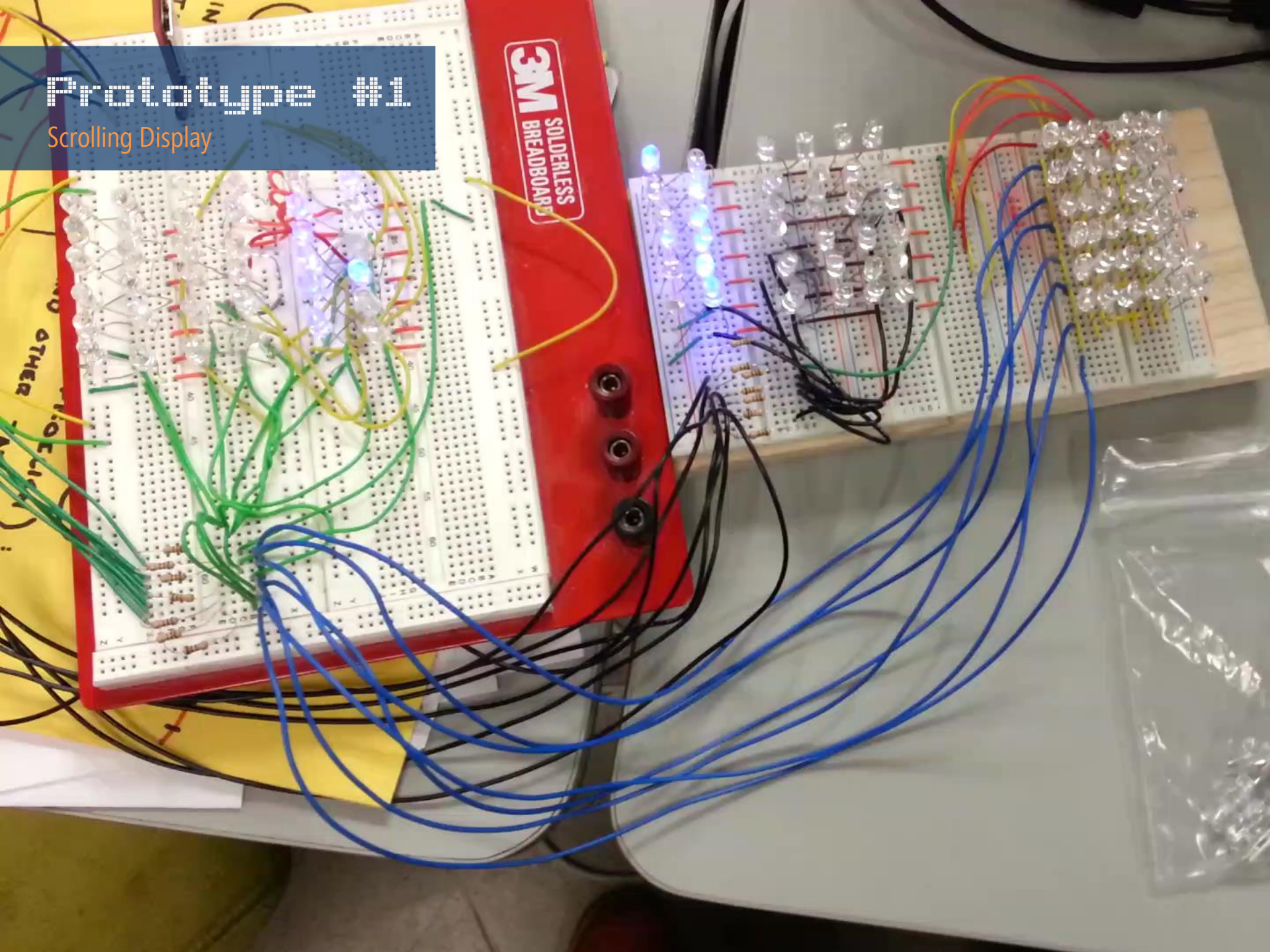
Prototype Circuit Designs



Prototype #1

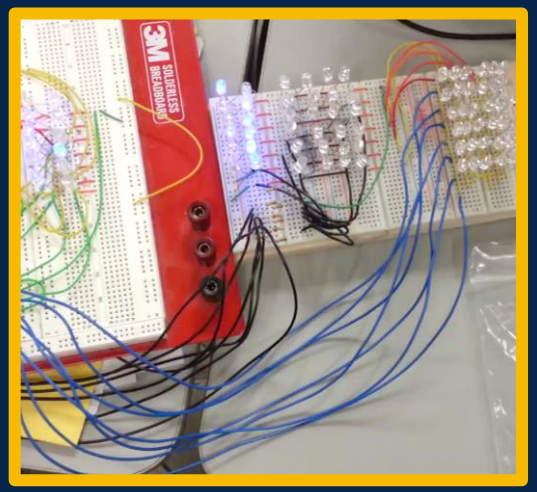
Single Letter Display Test



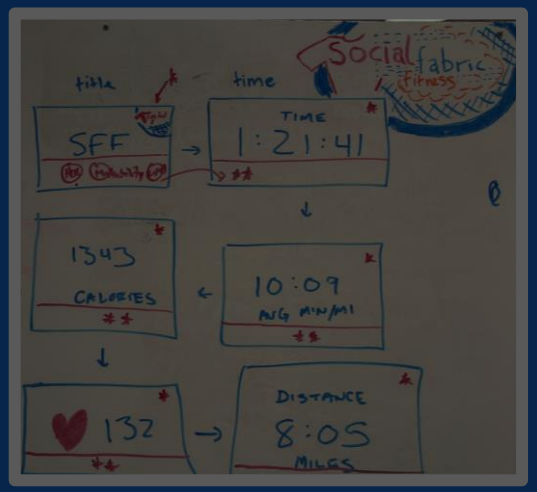

Prototype #1
Scrolling Display
3M SOLDERLESS BREADBOARD

Prototype #1

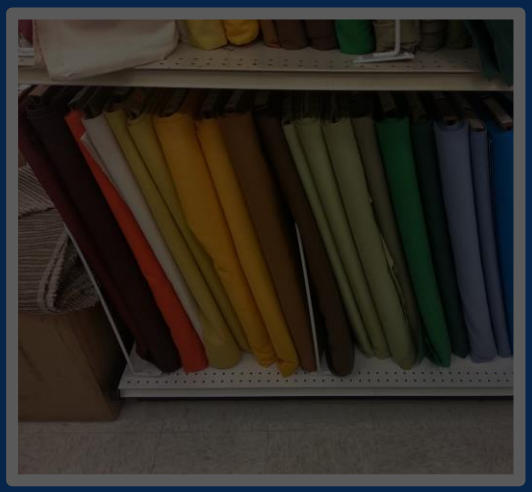
Three prototyping dimensions



Prototyping **Technology**



Prototyping **Visualization**



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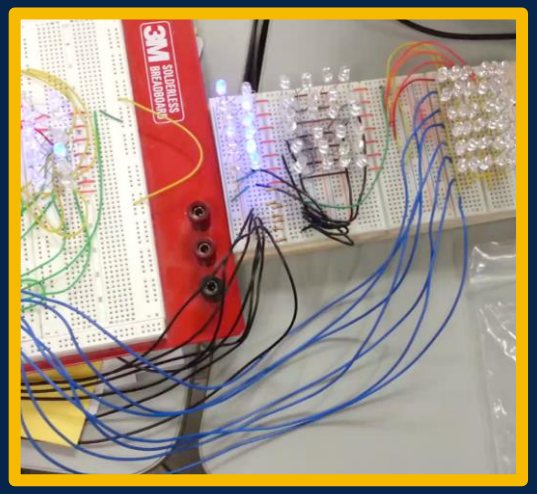
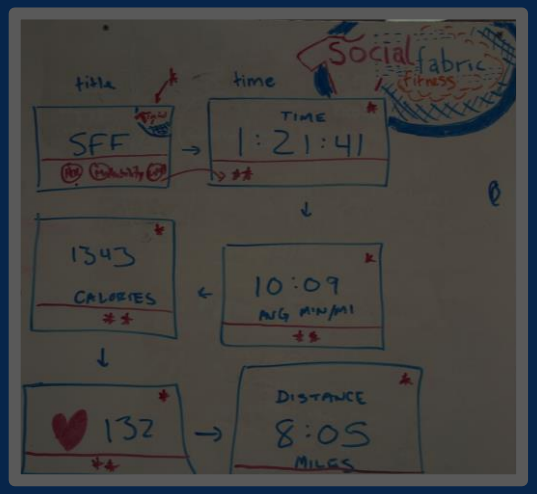
Prototype #1

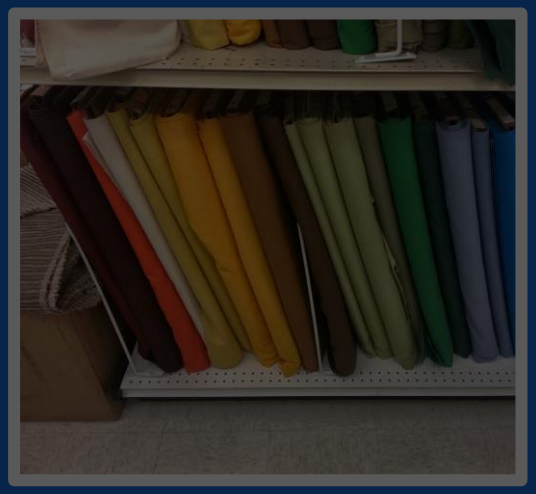
Three prototyping dimensions



Prototyping **Technology**



Prototyping **Visualization**



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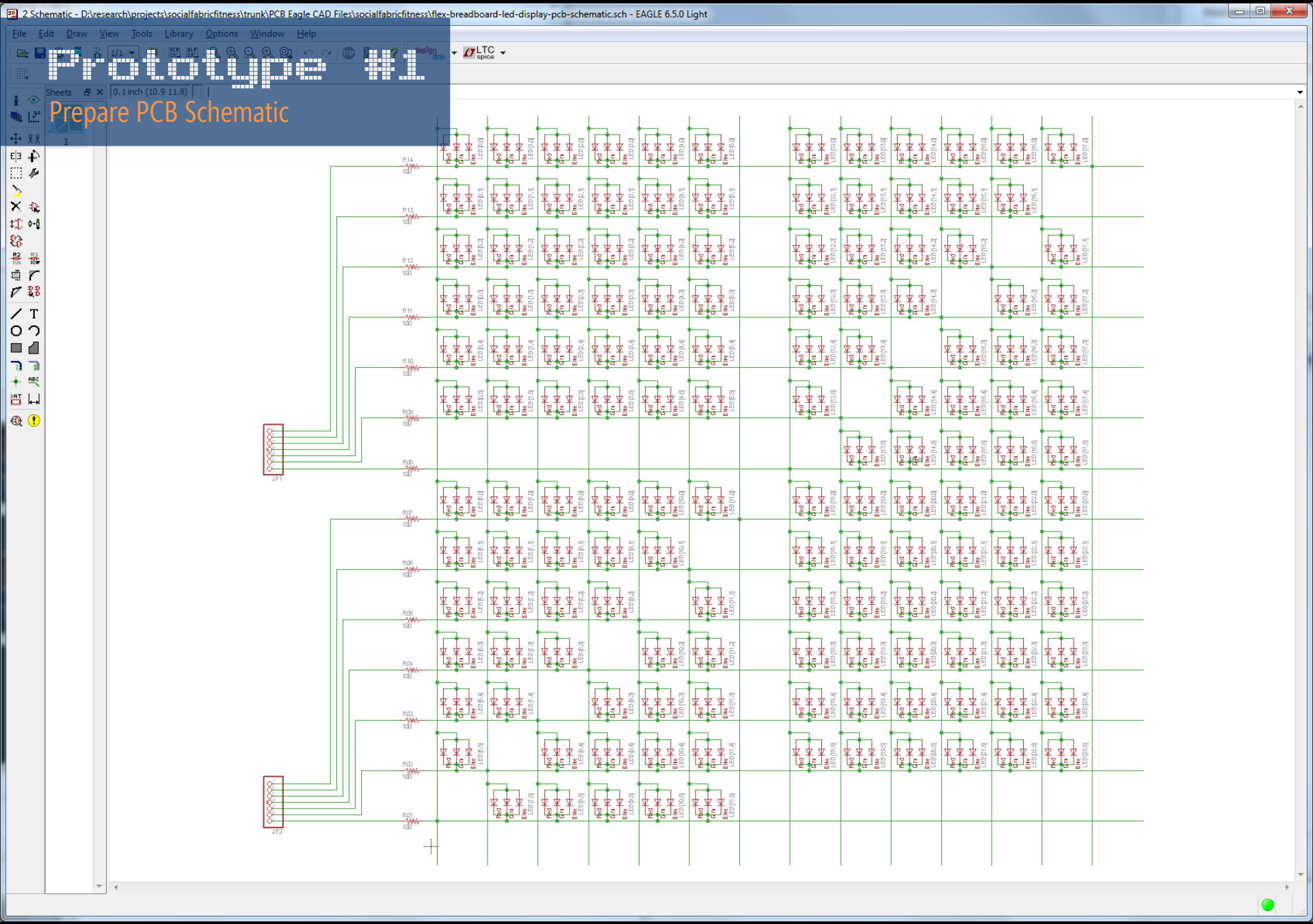
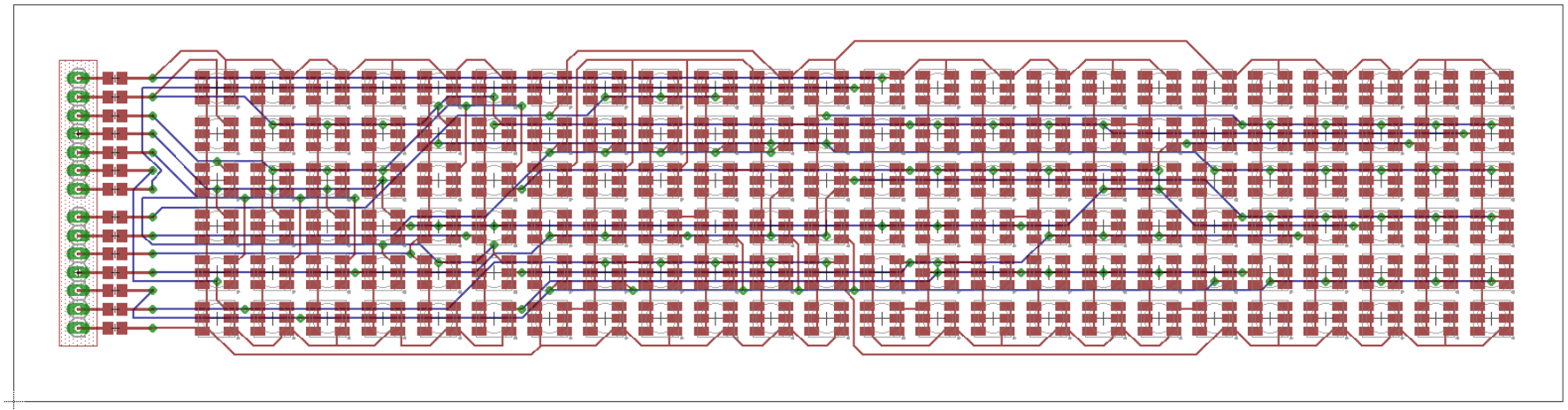
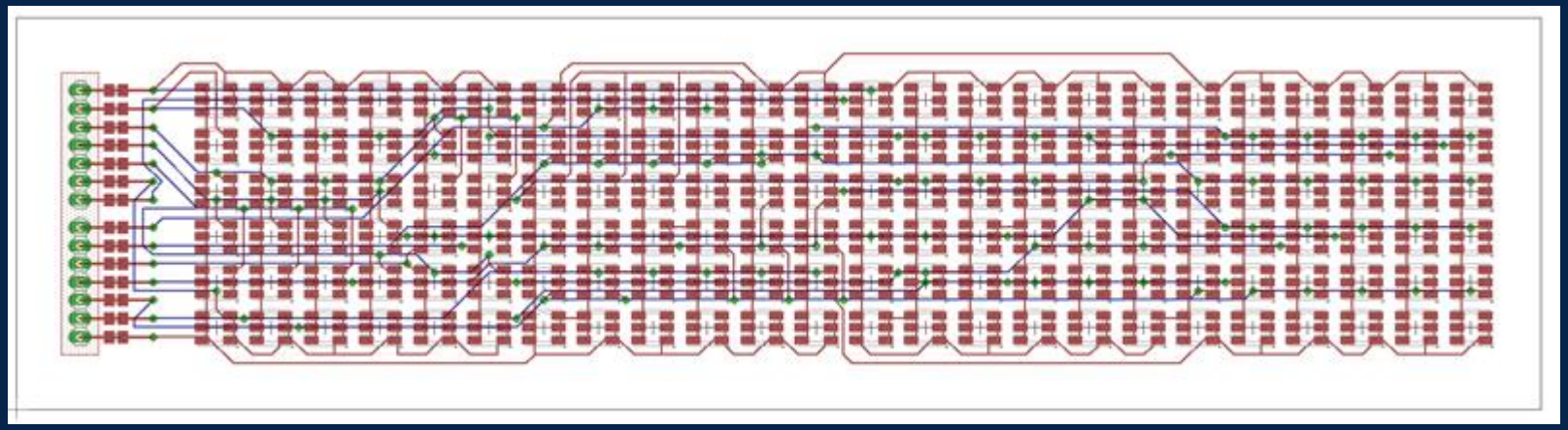

2 Schematic - D:\research\projects\socialfabricfitness\trunk\PCB Eagle CAD Files\socialfabricfitness\flex-breadboard-led-display-pcb-schematic.sch - EAGLE 6.5.0 Light
File Edit Draw View Tools Library Options Window Help
Prototype #1
Prepare PCB Schematic
Sheets
0.1 inch (10.9 11.8)

Prototype #1

Prepare PCB Schematic



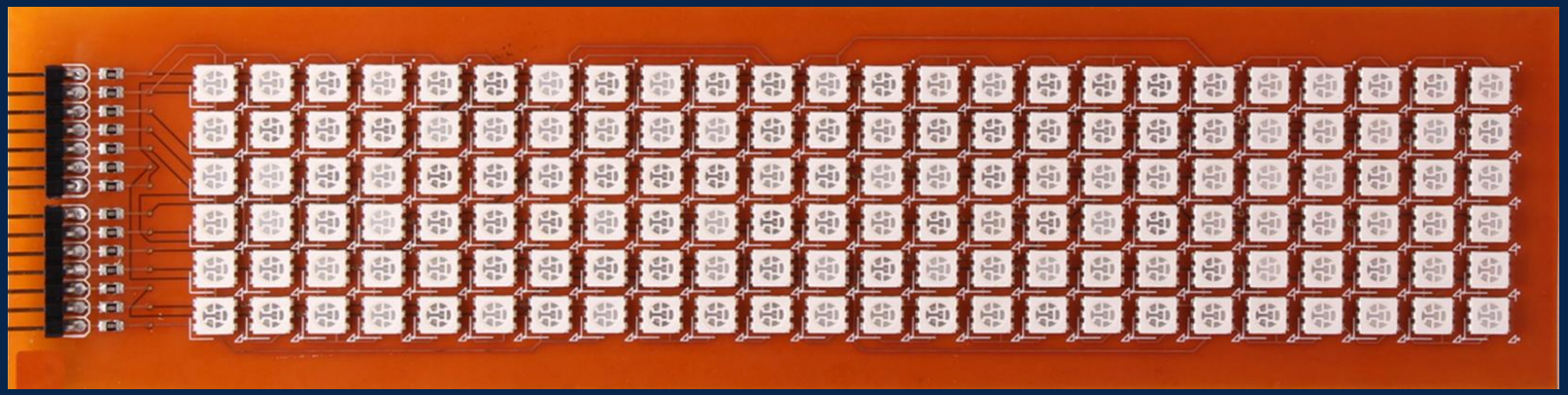


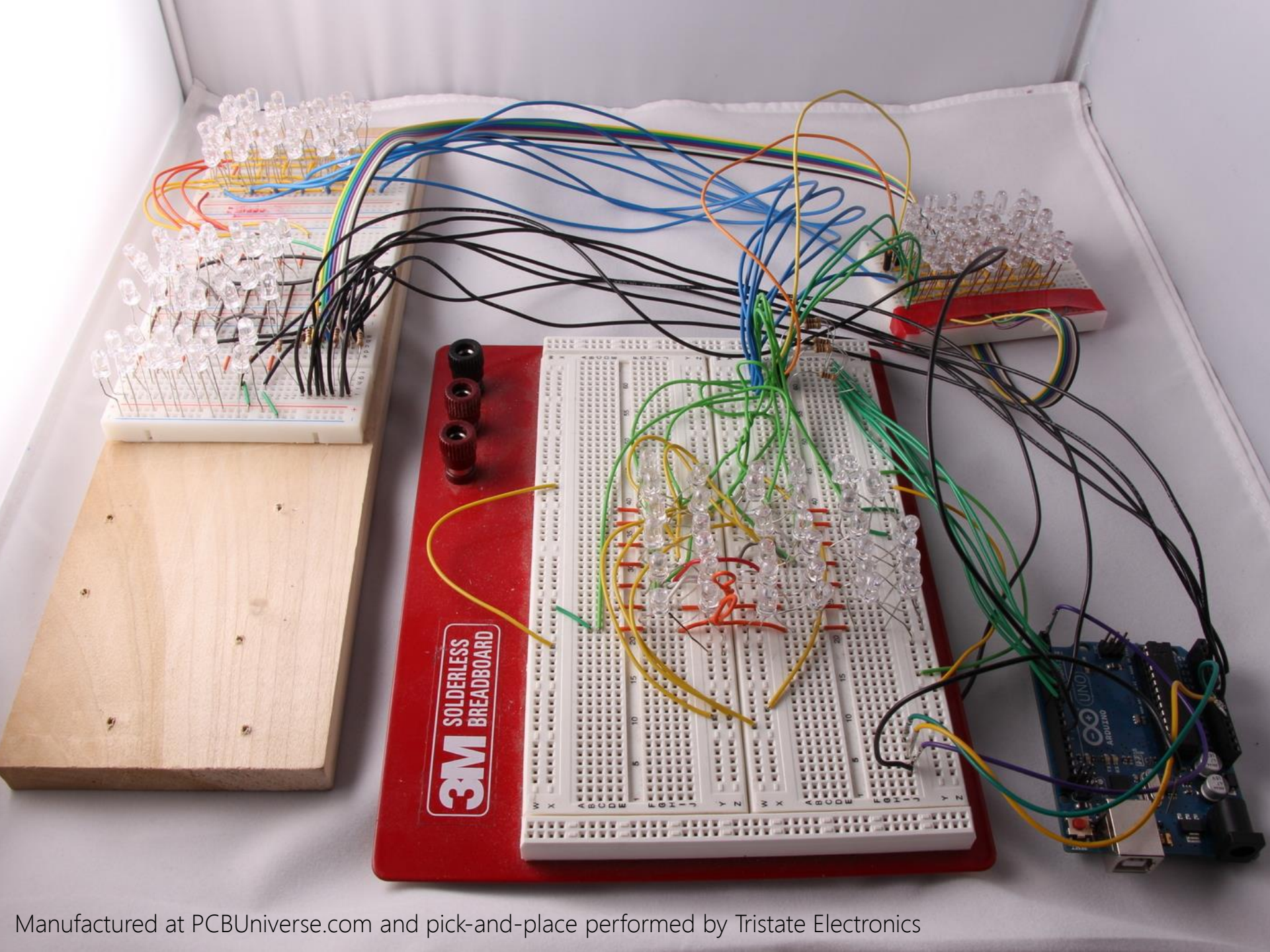
PCB UNIVERSE PRINTED CIRCUIT BOARDS

http://PCBUniverse.com

Tristate Electronic Manufacturing Inc.

http://tristateelectronicmfg.com





Manufactured at PCBUniverse.com and pick-and-place performed by Tristate Electronics

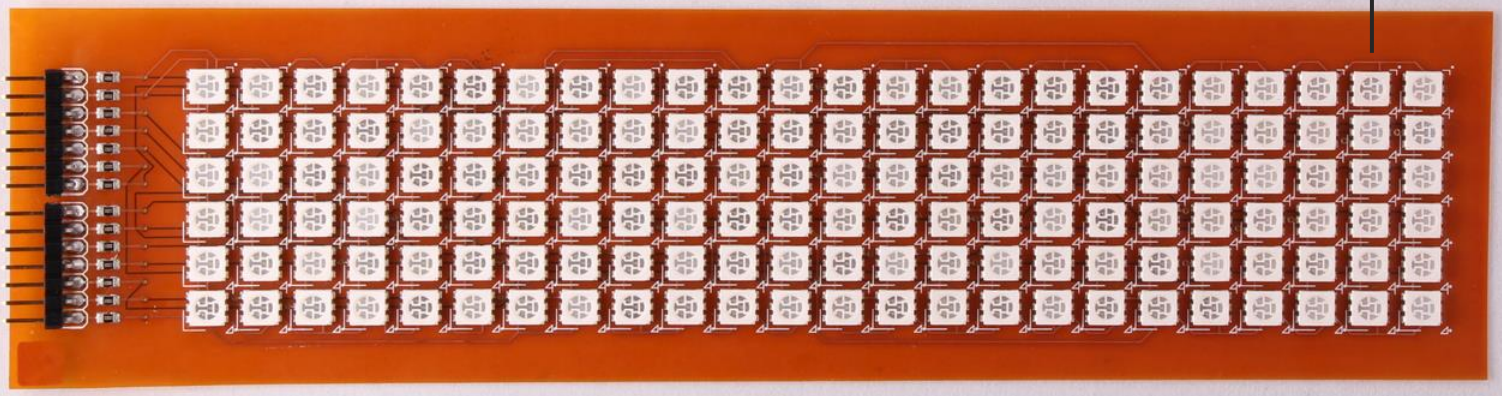
Prototype #1

Manufactured Flexible PCB

Flexible PCB

24 x 6 Matrix

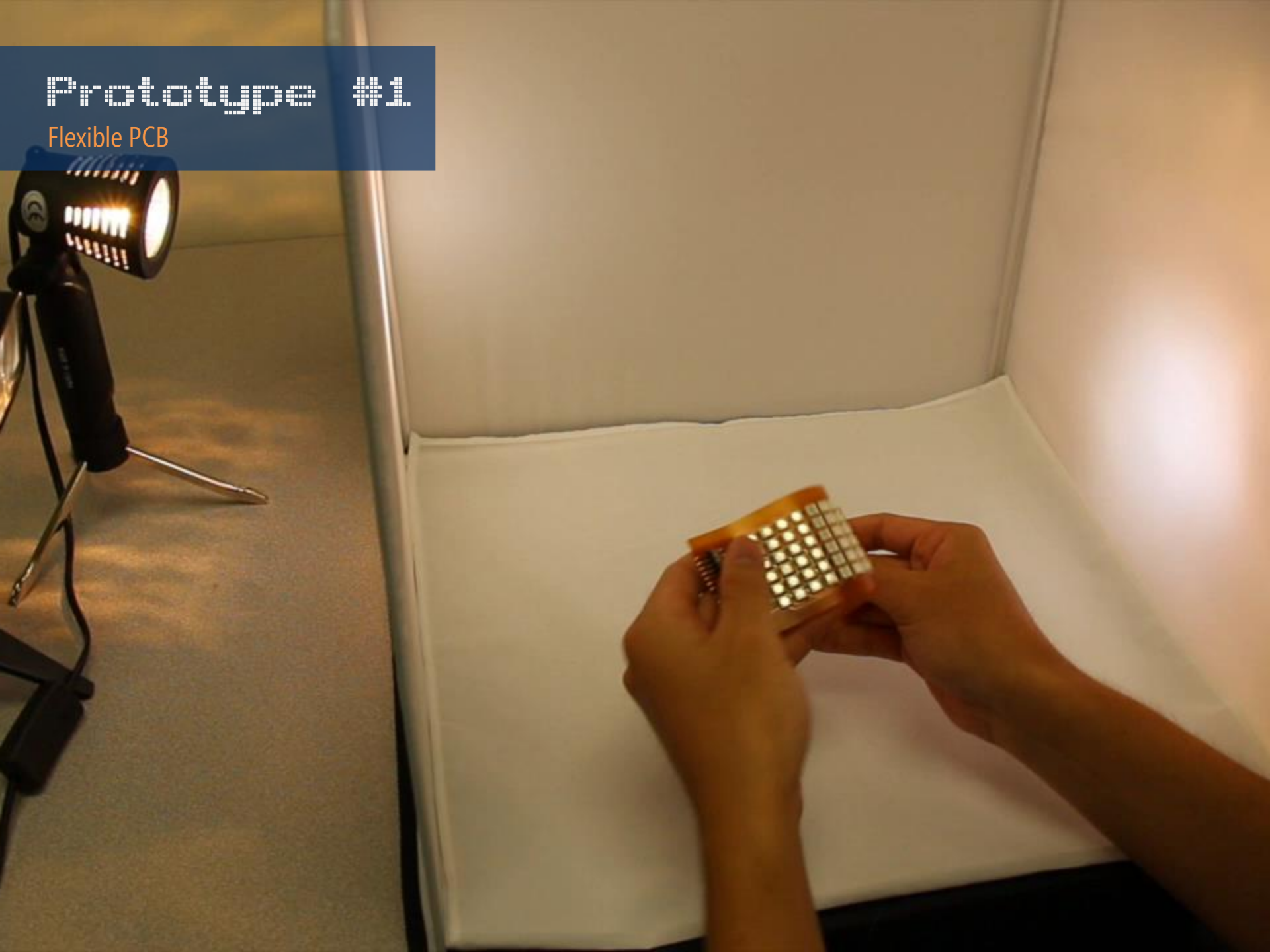
Green or **Blue** LEDs

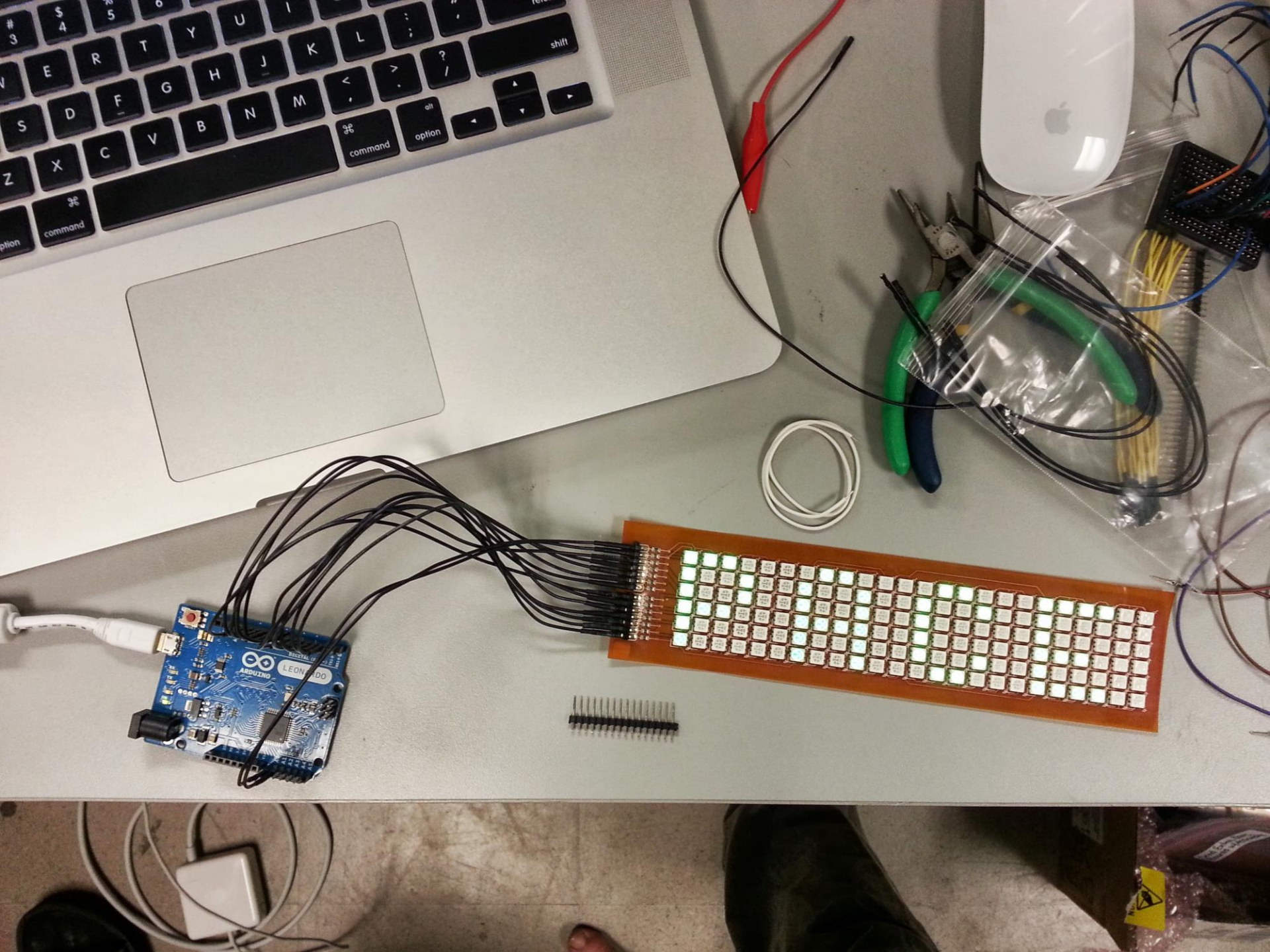


Manufactured at PCBUniverse.com and pick-and-place performed by Tristate Electronics

Prototype #1

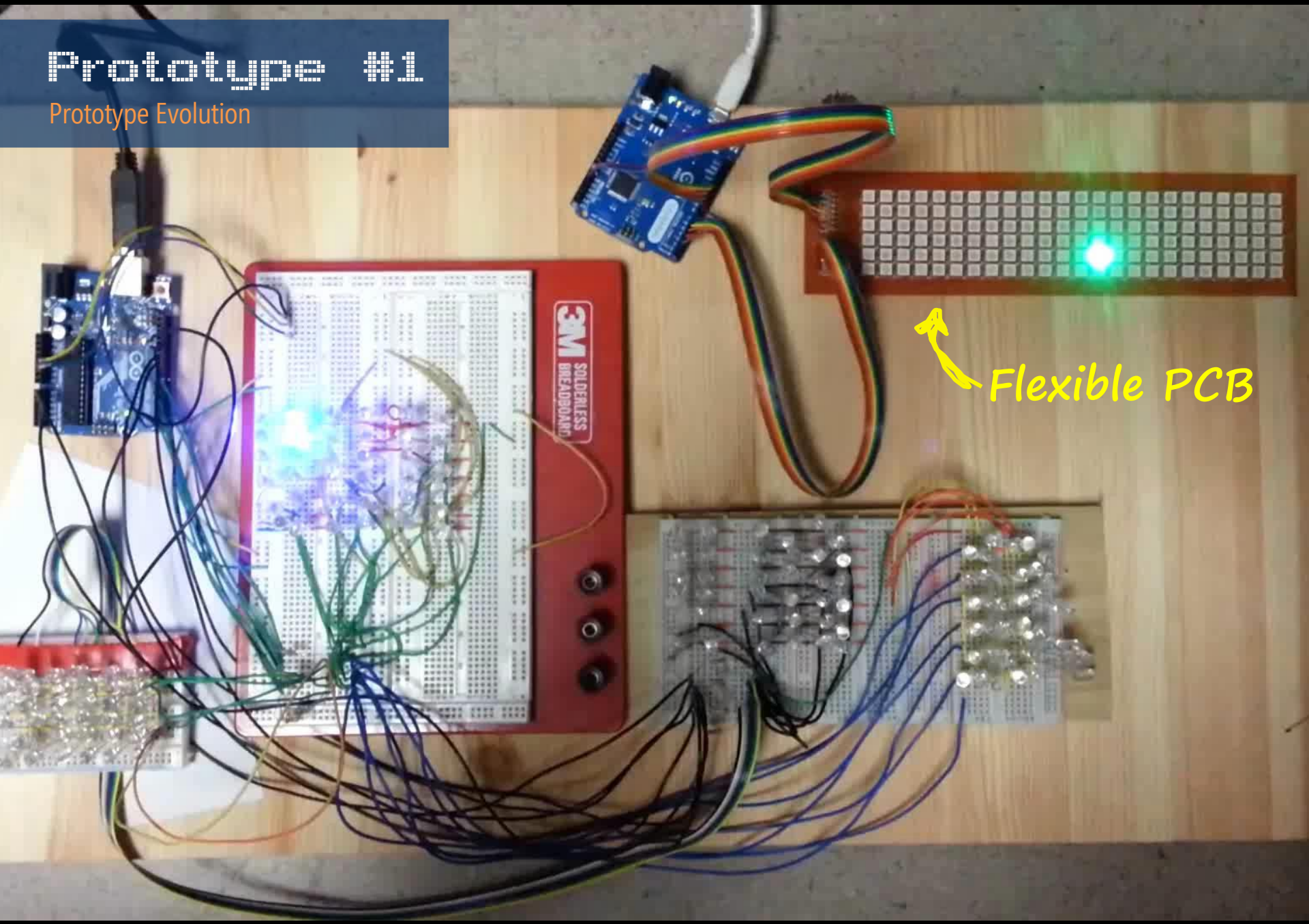
Flexible PCB




command
option
shift
ARDUINO
LEONARDO

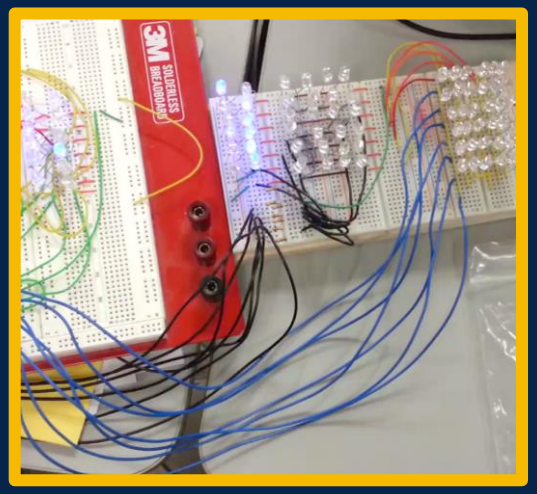
Prototype #1

Prototype Evolution

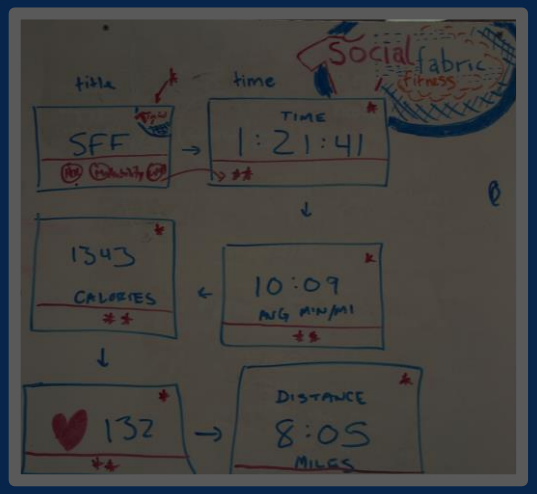


Prototype #1

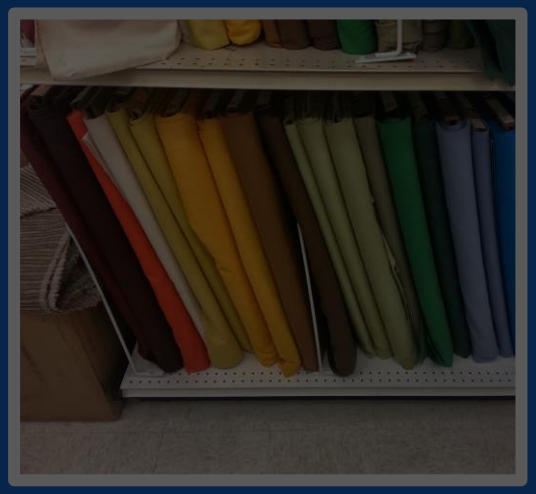
Three prototyping dimensions



Prototyping **Technology**



Prototyping **Visualization**

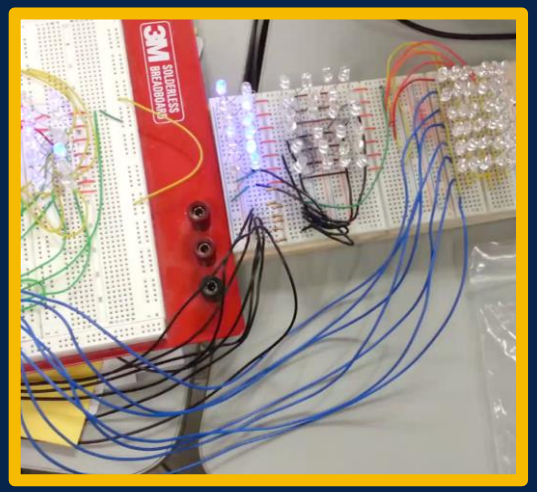


Prototyping **Materials**

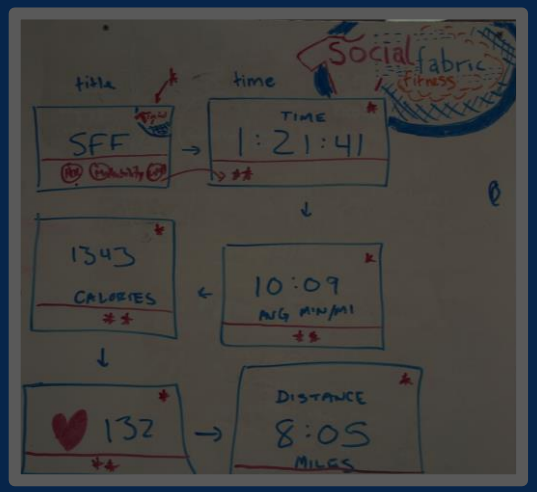
1. Select MCU Platform
2. Prototype Circuit Designs
3. Build Software
4. Layout PCB
5. Manufacture PCB
6. Test Final PCB & Software

Prototype #1

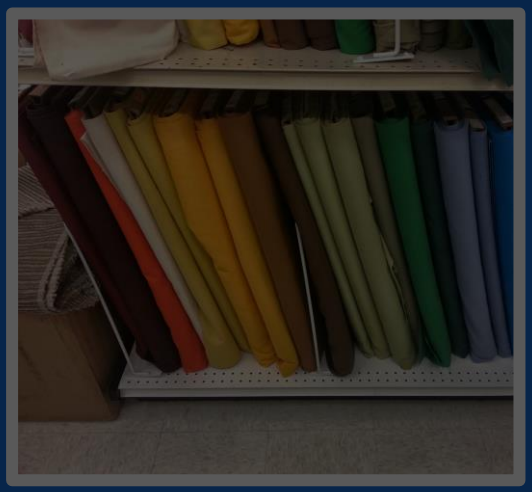
Three prototyping dimensions



Prototyping **Technology**



Prototyping **Visualization**

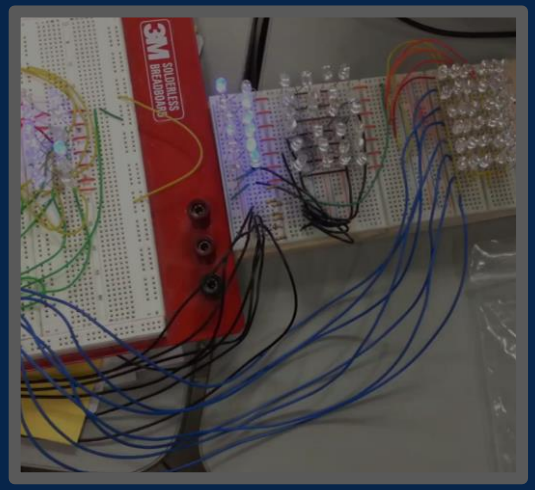


Prototyping **Materials**

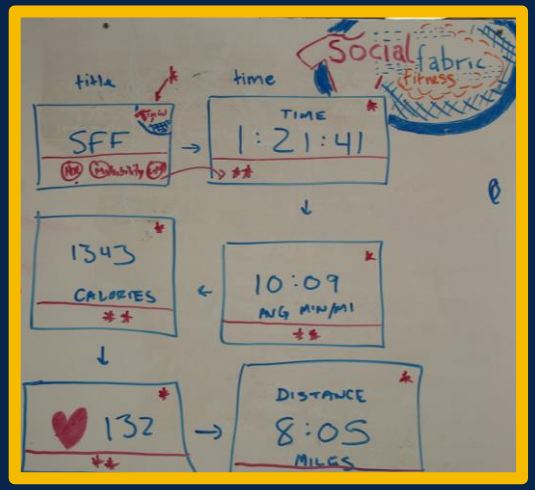
1. Select MCU Platform
2. Prototype Circuit Designs
3. Build Software
4. Layout PCB
5. Manufacture PCB
6. Test Final PCB & Software

Prototype #1

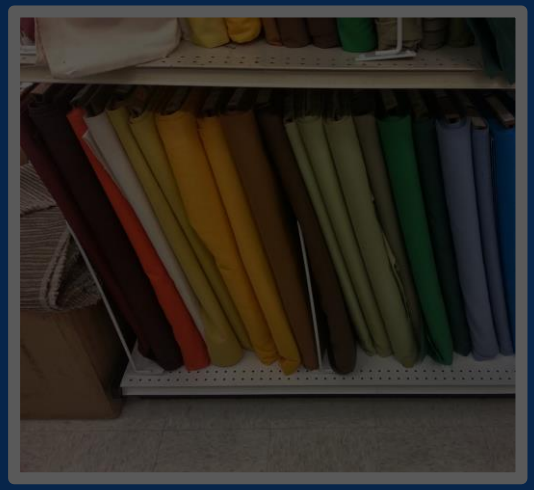
Three prototyping dimensions



Prototyping **Technology**



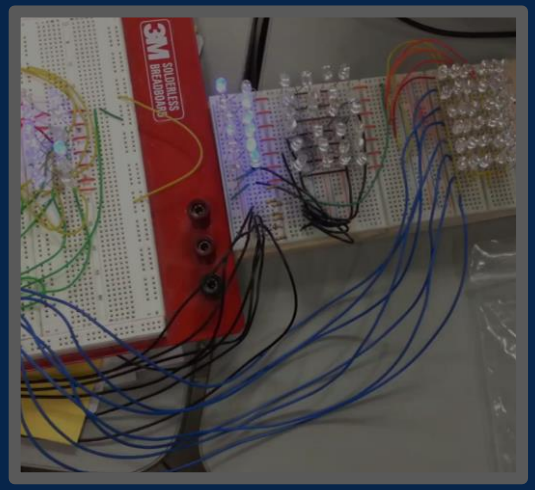
Prototyping **Visualization**



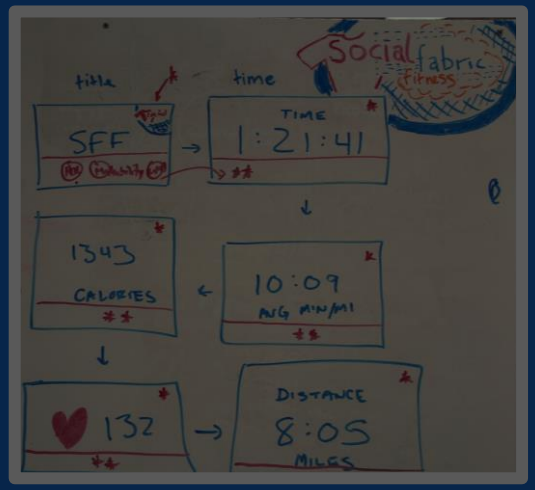
Prototyping **Materials**

Prototype #1

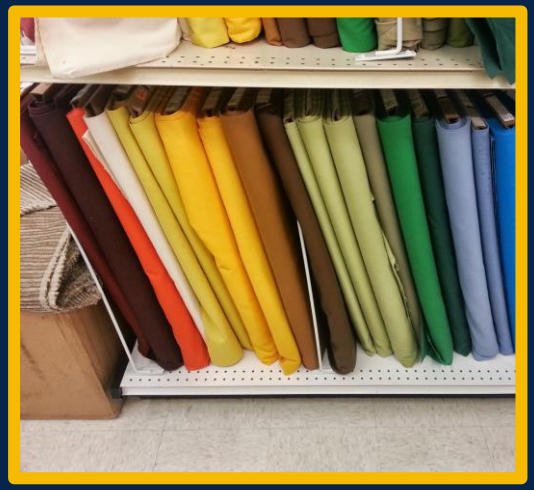
Three prototyping dimensions



Prototyping **Technology**



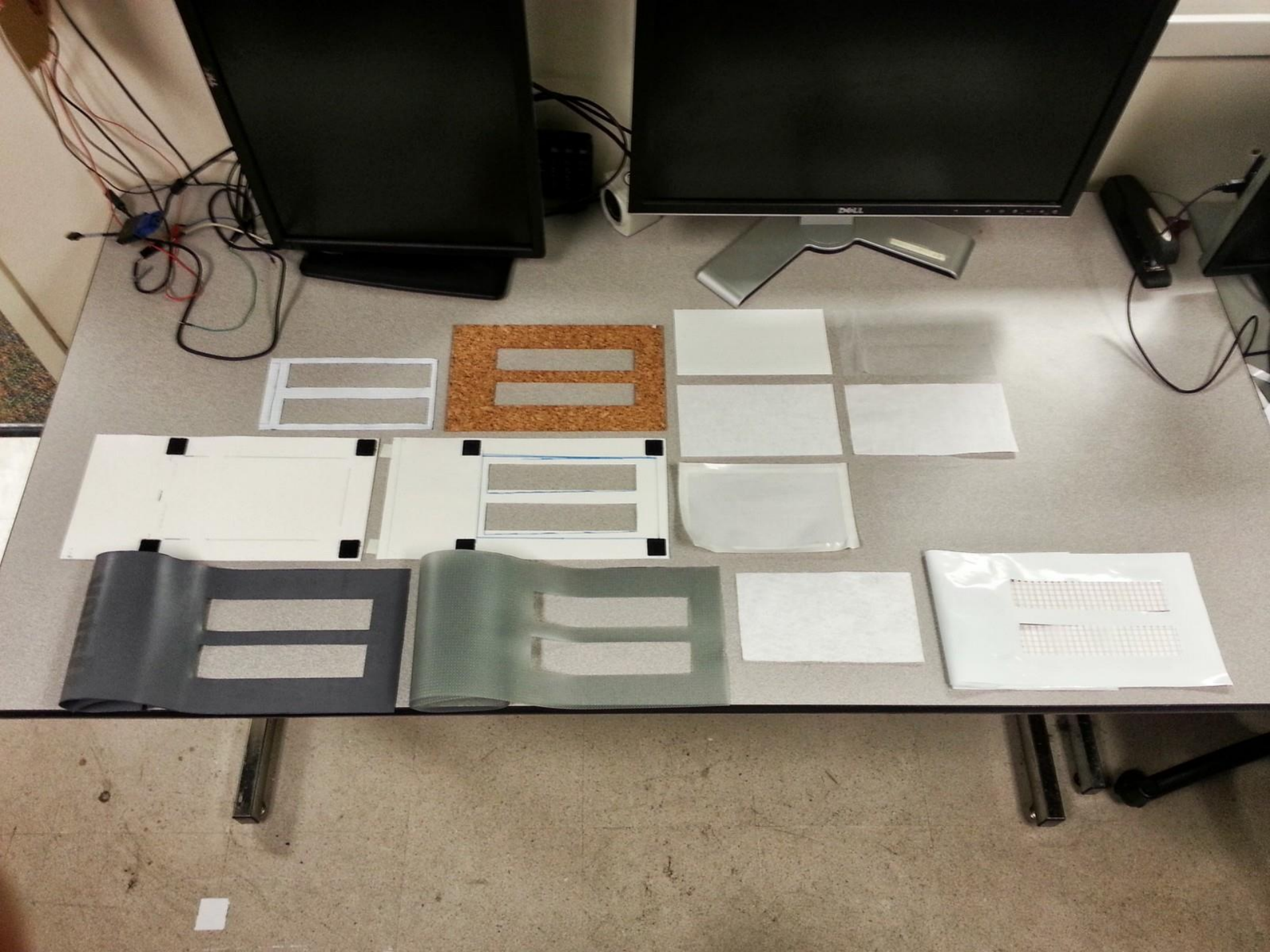
Prototyping **Visualization**

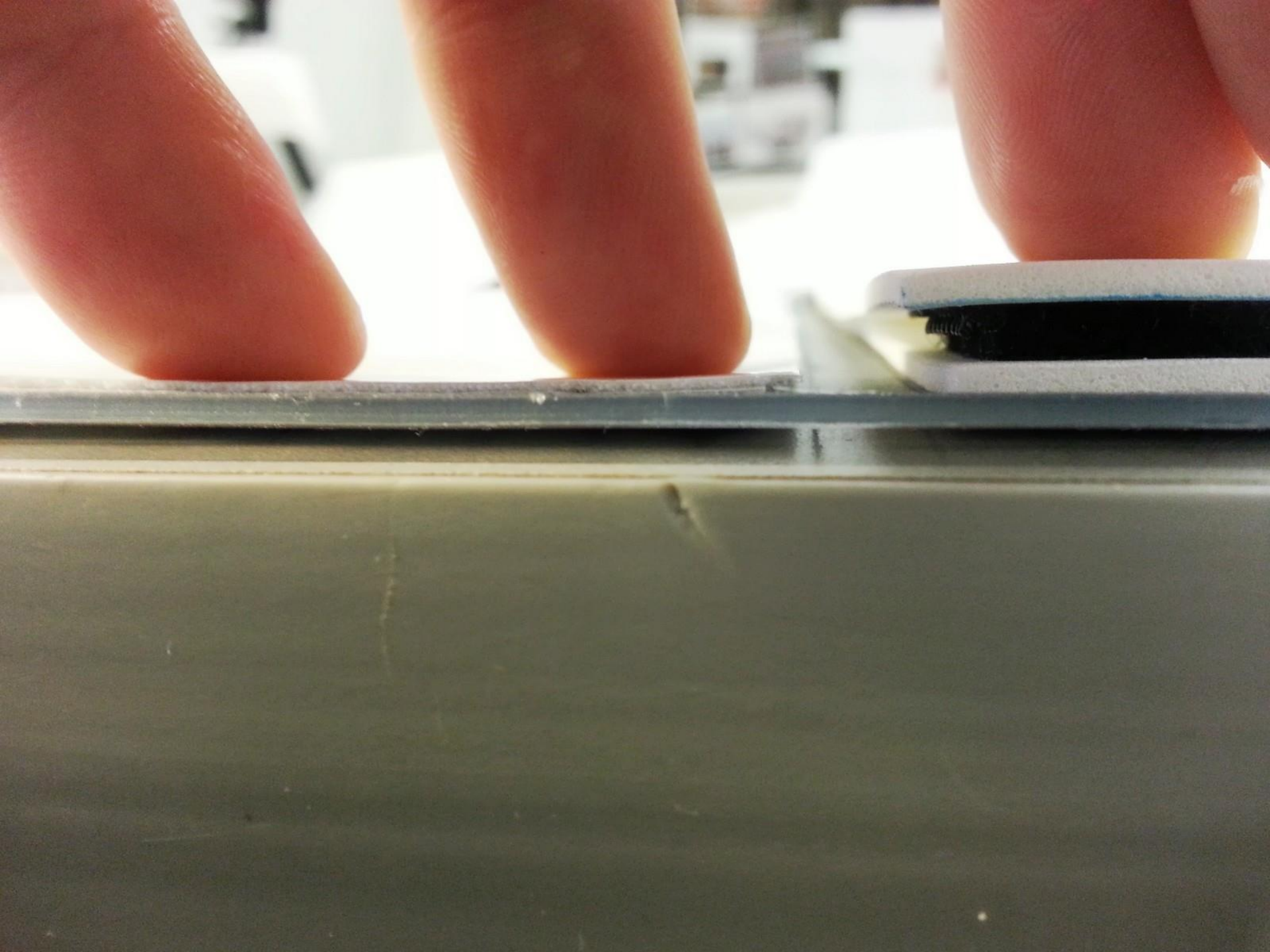


Prototyping **Materials**

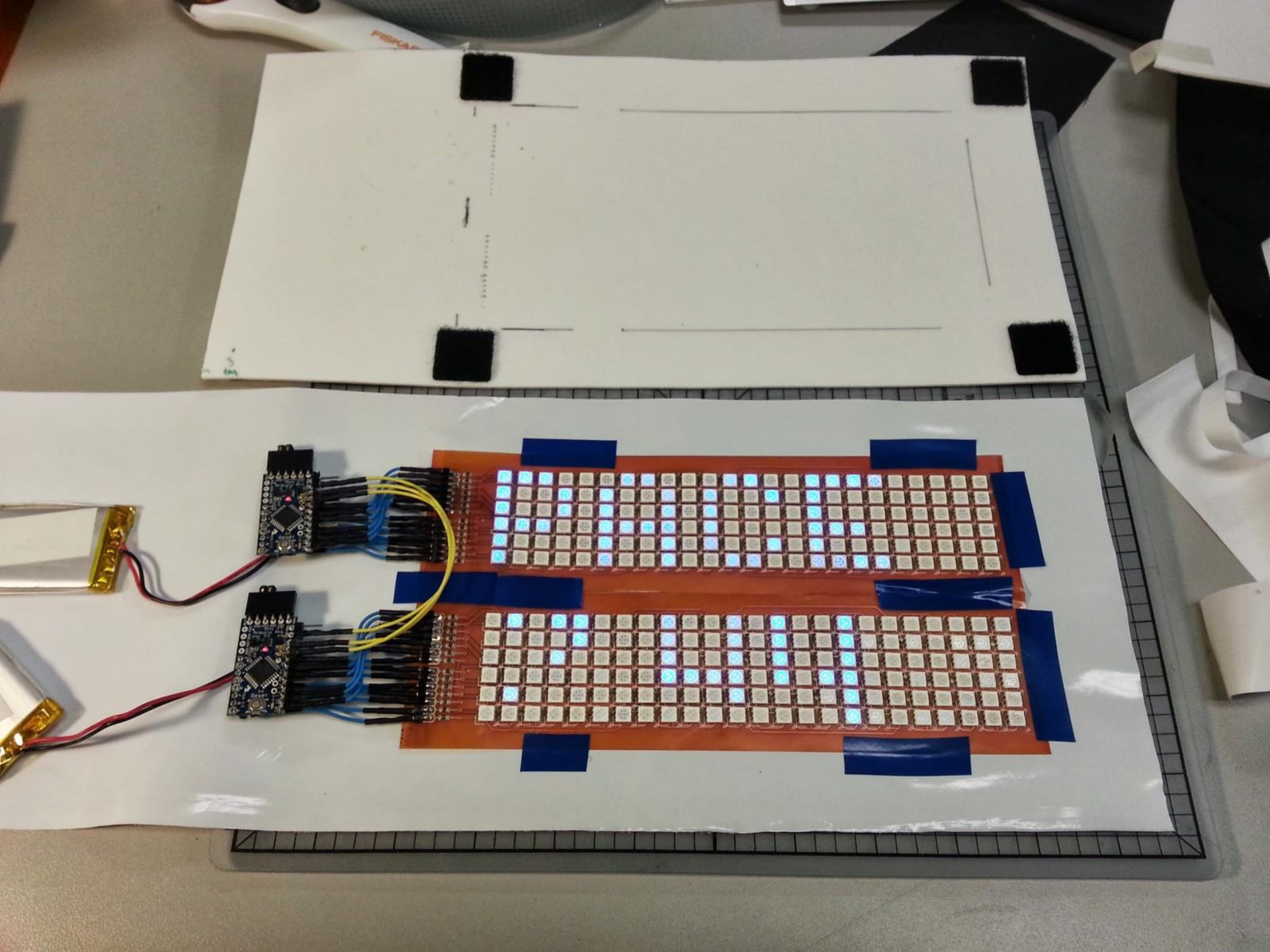
JOANN
fabrics and crafts
NO PARKING FIRE LANE

SewClassics
$8.99
263-7809
199-7162
$7.99
263-7783
$7.99





TRAINING
ADVANCED

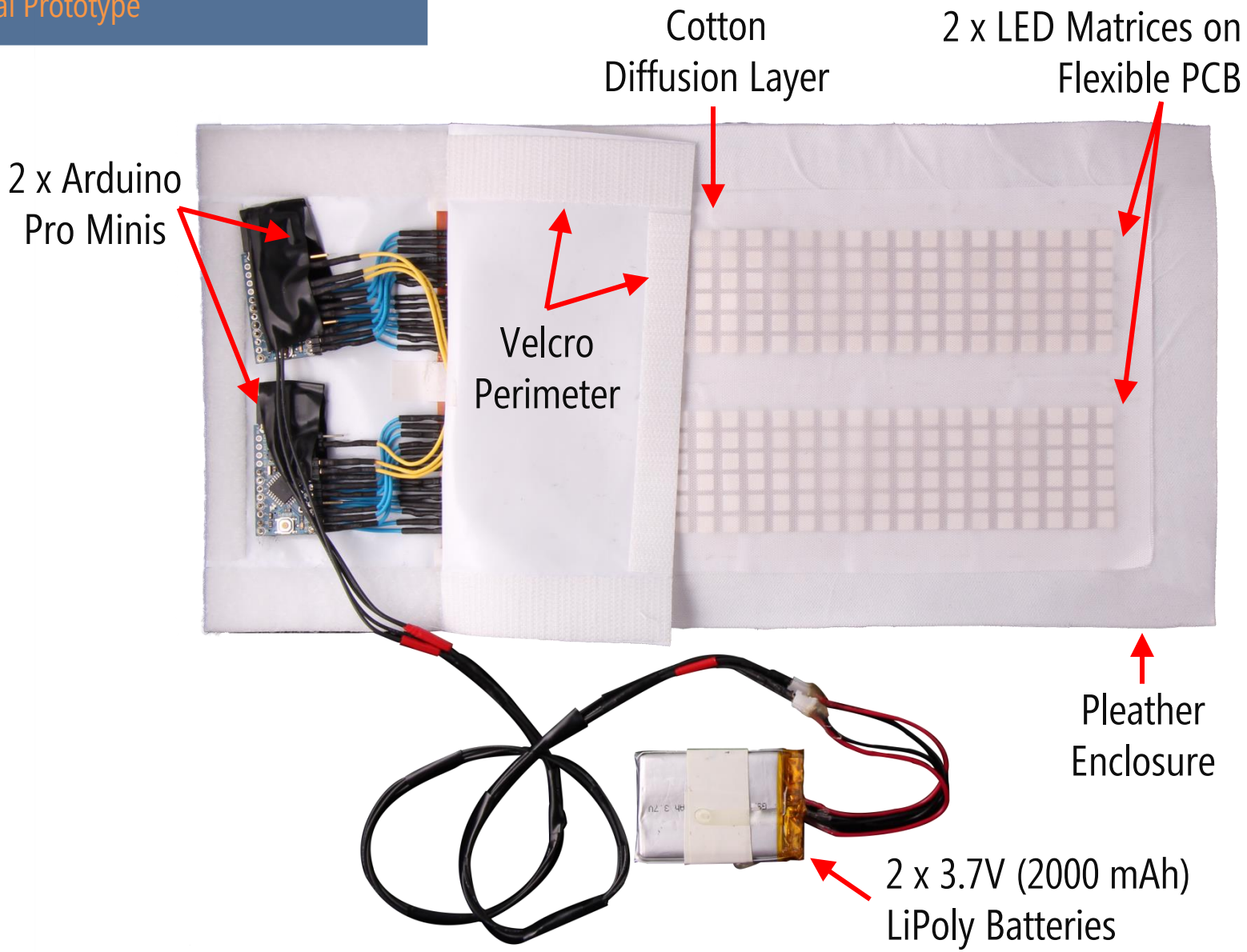


8
9
10

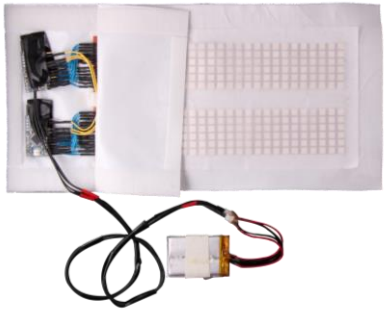
PACE
XLII

Prototype #1

Final Prototype



SFF: Three Prototypes



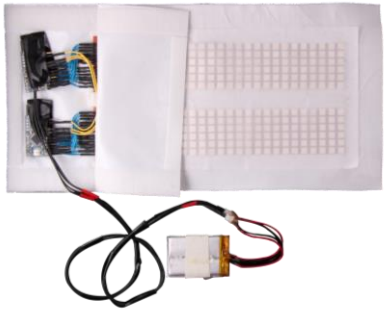
Prototype #1

Display Weight	66.9 g
Total Weight	152.9 g

As a comparison:
iPhone 4S = 140 g

* With enclosure

SFF: Three Prototypes



	Prototype #1
Display Weight	66.9 g
Total Weight	152.9 g
Pixels	24 x 12
Refresh Rate	5 Hz
Dimensions*	21.3 x 12.2 cm
Display Thickness*	13.5 mm

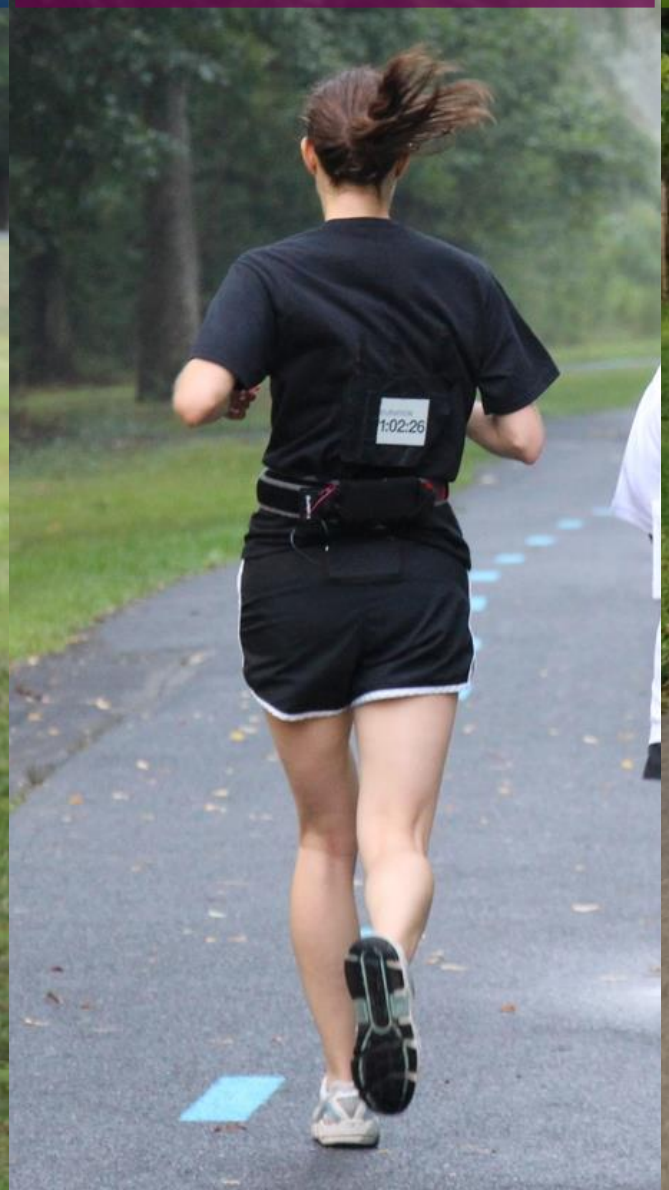
* With enclosure

Prototype #1

Custom LED Matrix Display

Prototype #2

Electronic Ink Display



Prototype #3

Erogear LED Matrix Display

Prototype #2
Electronic Ink Display
1:02:26

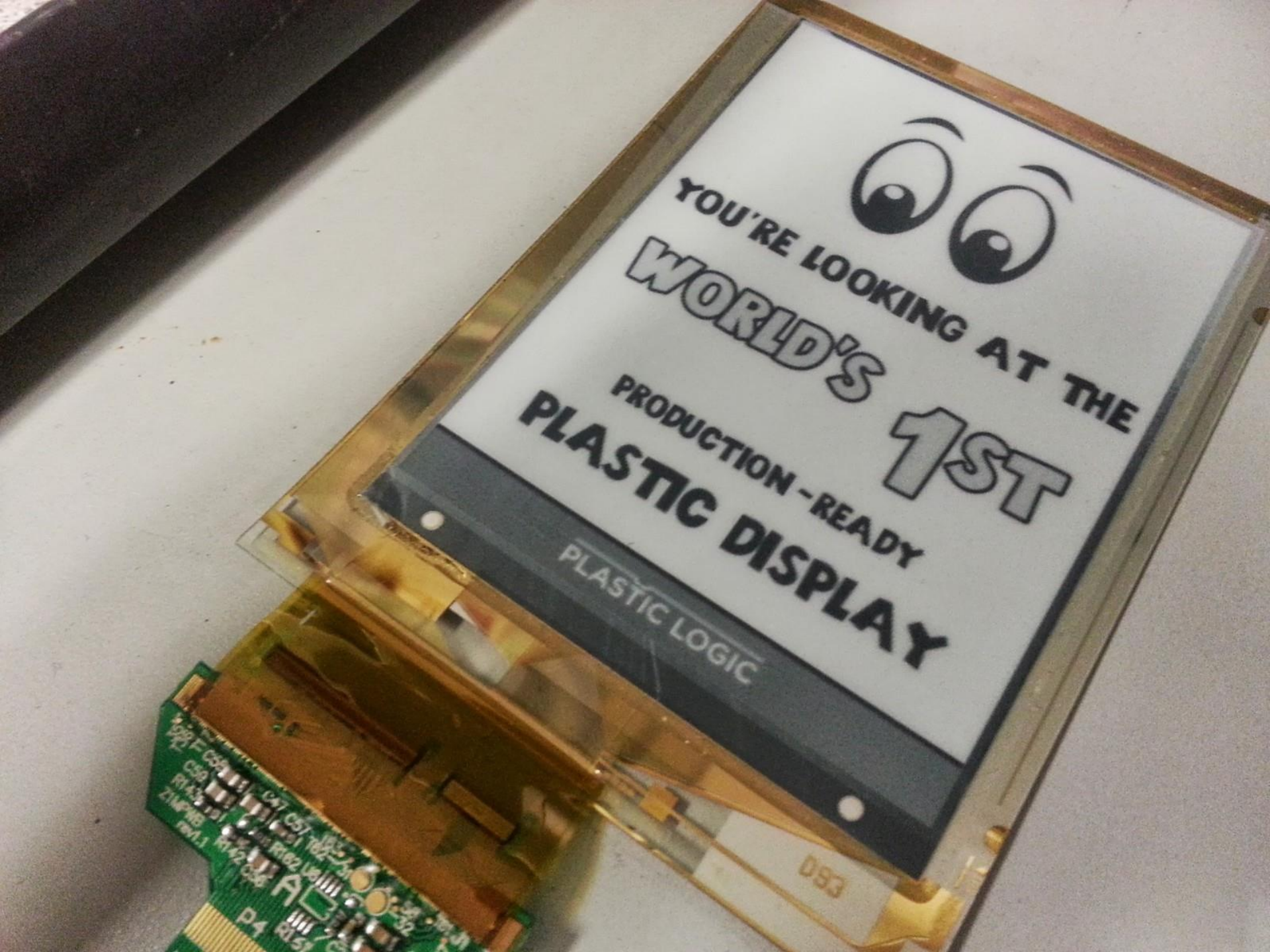
Prototype #2

Three steps

Find **Manufacturer**

Prototyping **Software**

Prototyping **Materials**

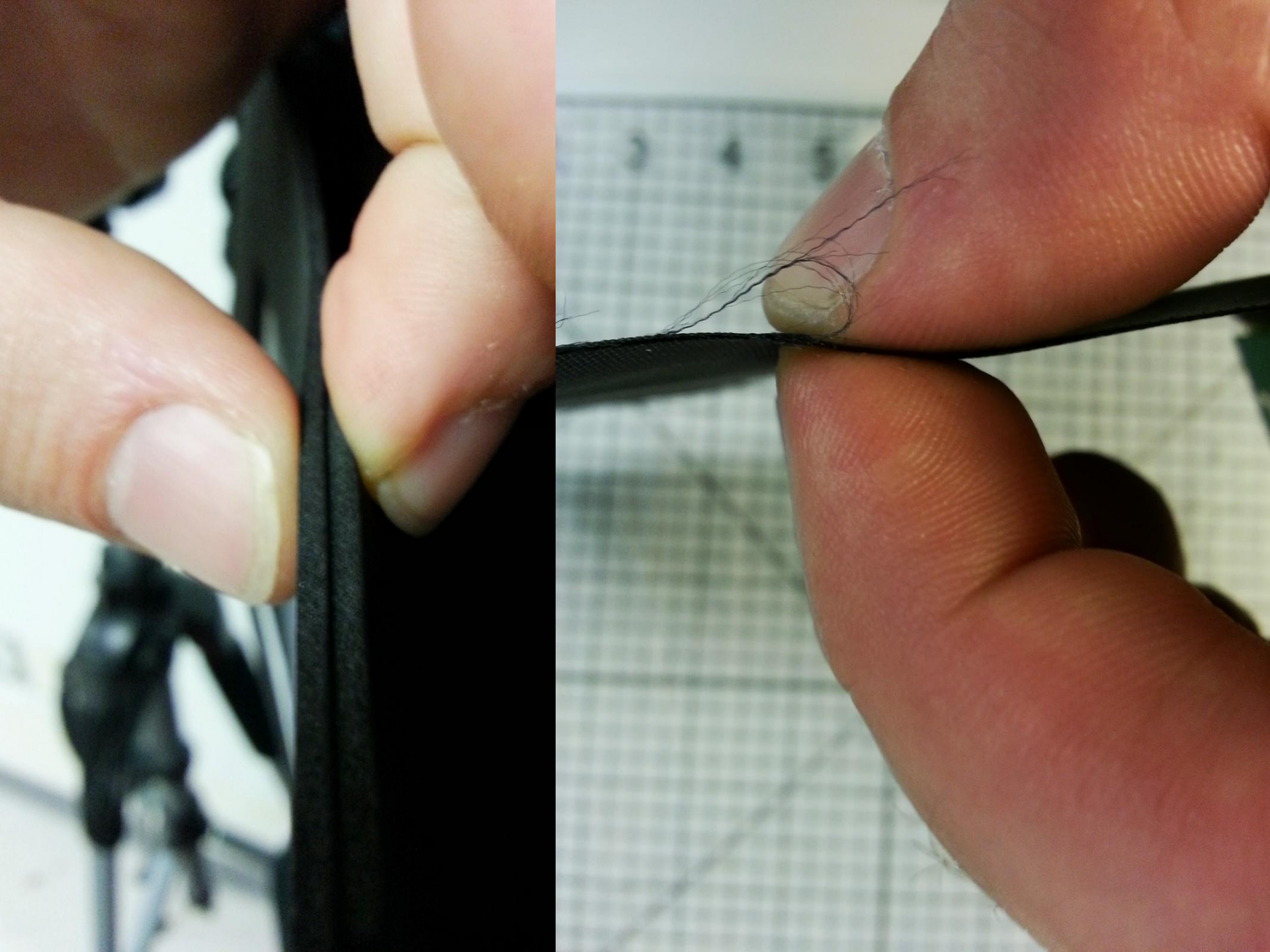

YOU'RE LOOKING AT THE
WORLD'S 1ST
PRODUCTION-READY
PLASTIC DISPLAY
PLASTIC LOGIC

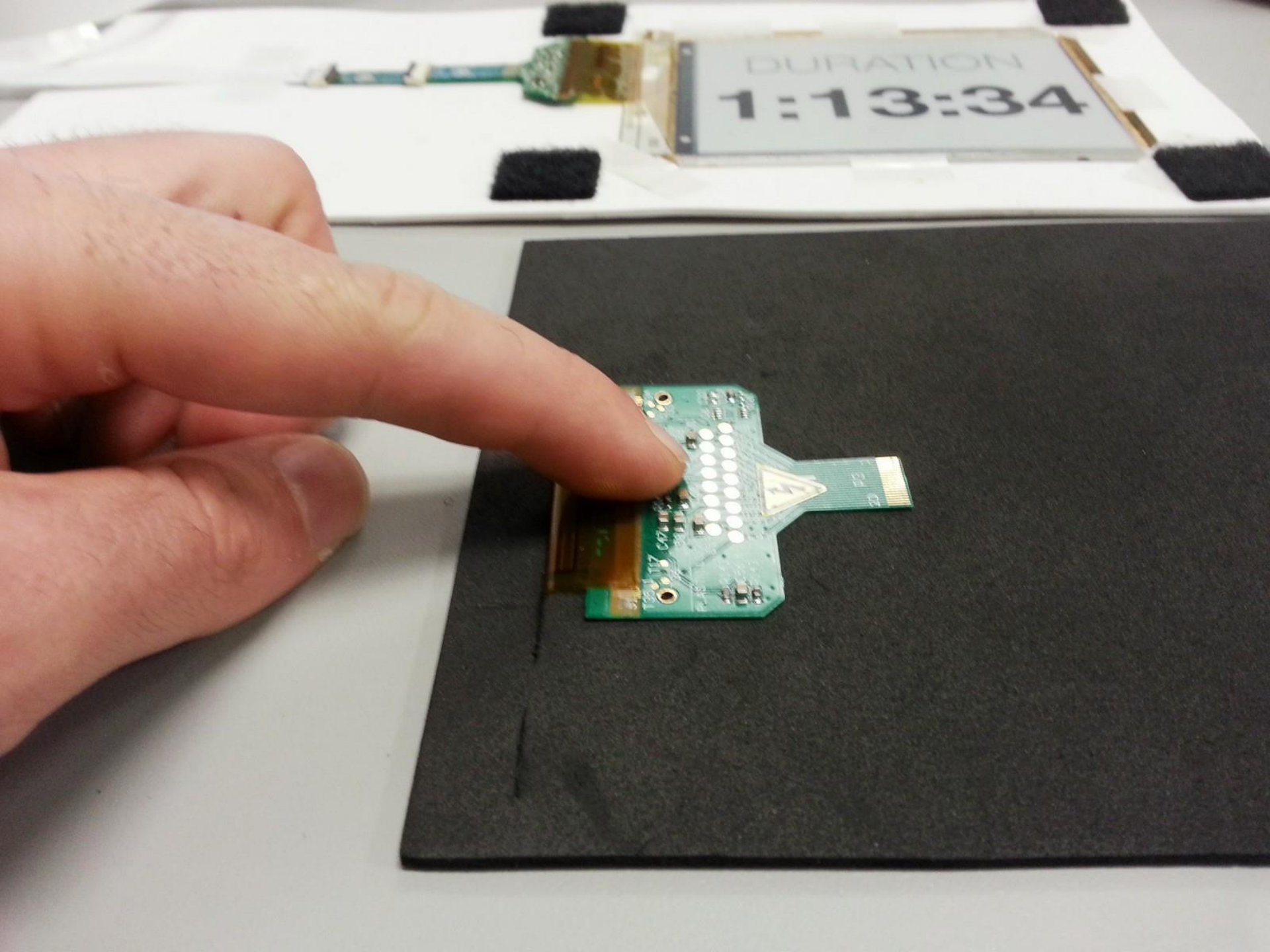
DURATION

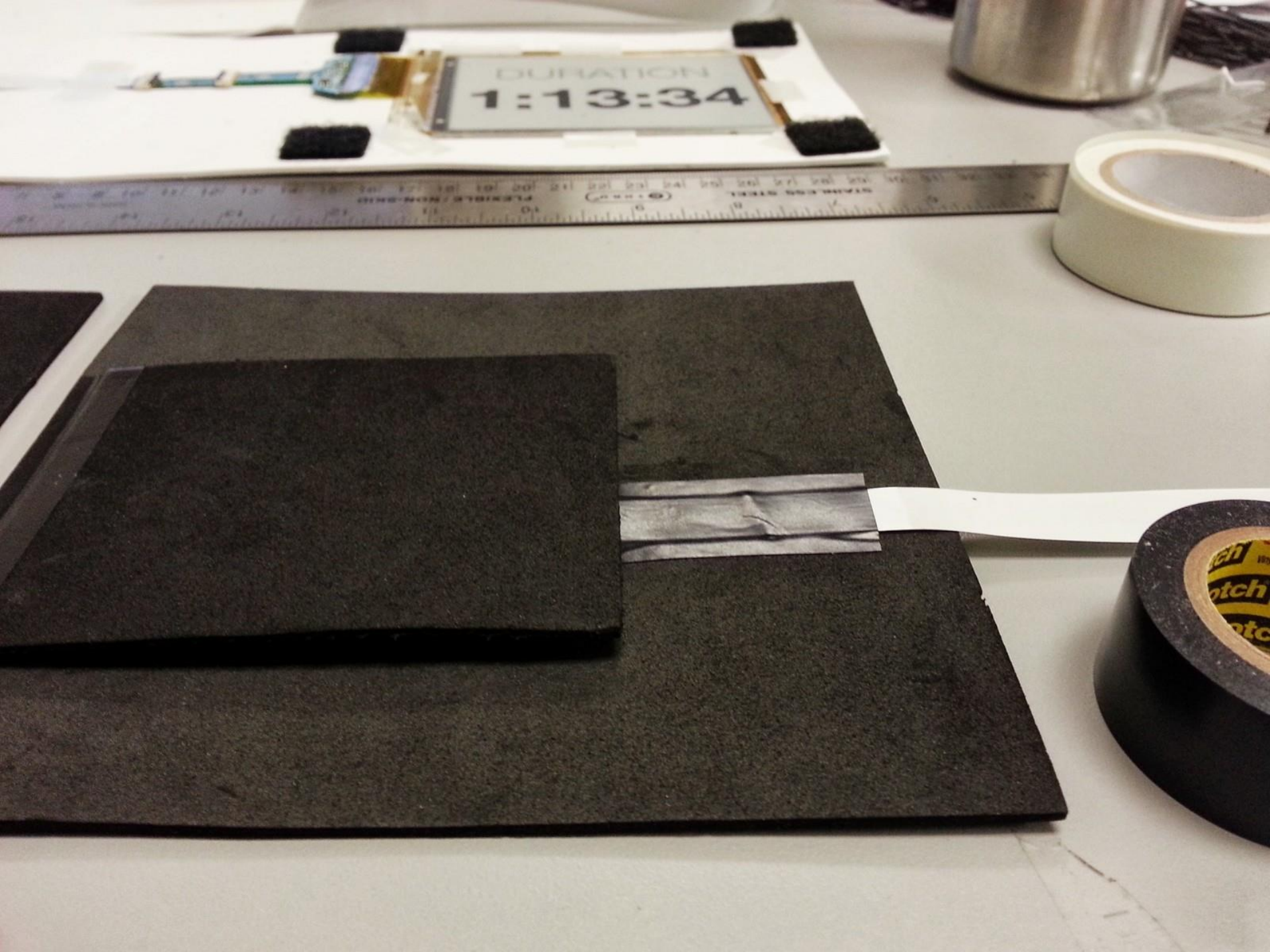
1:13:34

PLASTIC LOGIC

Z1 MPWB rev1.1




DURATION
1:13:34

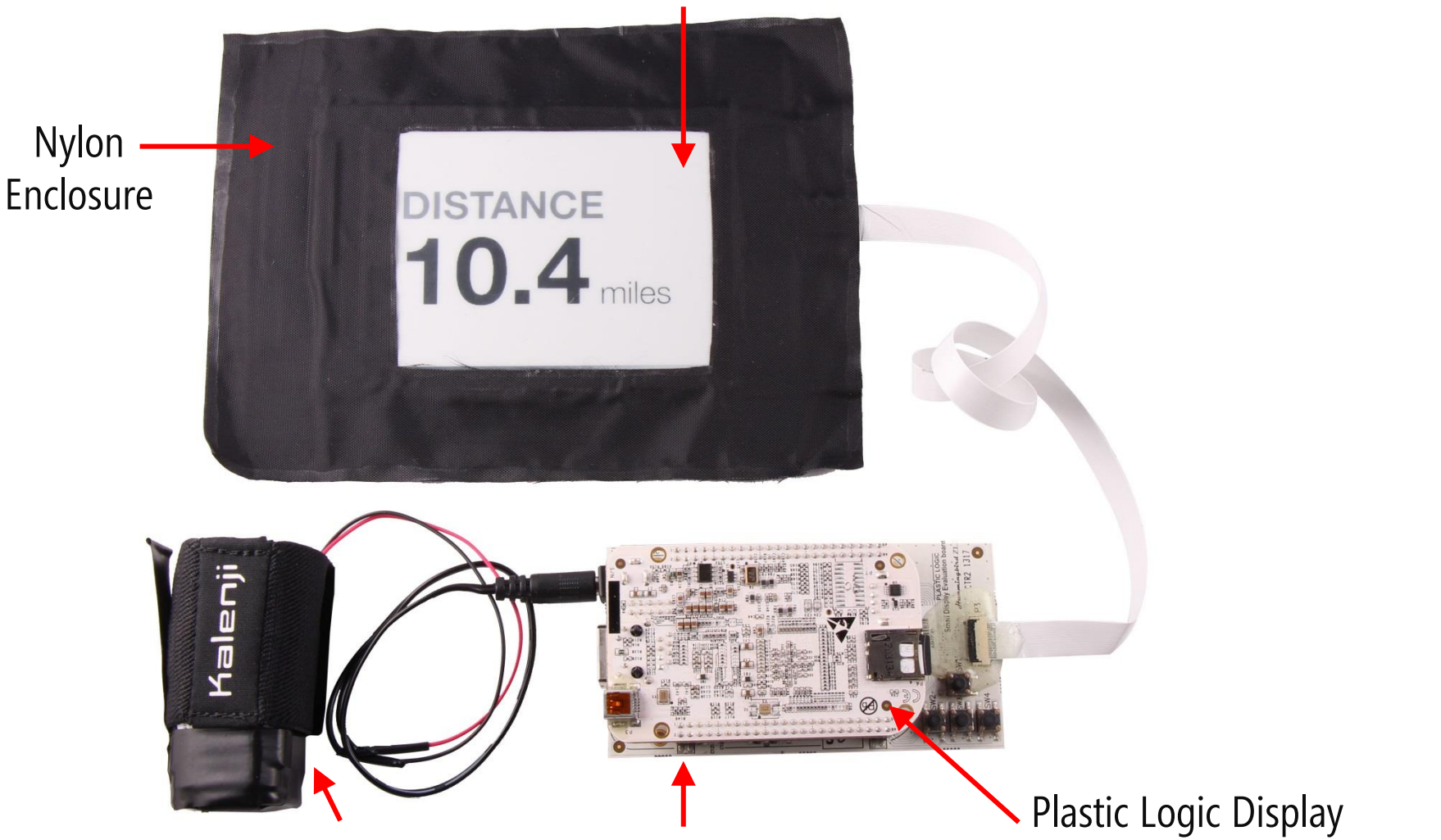

DURATION
1:13:34

MADE IN TAIWAN

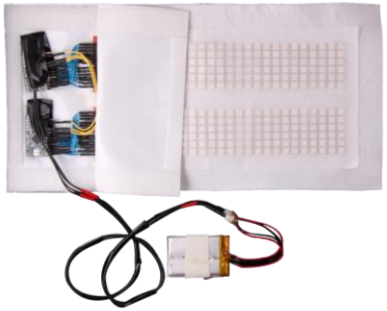
DISTANCE
10.4 miles

Prototype #2

Final e-Ink Prototype



SFF: Three Prototypes



	Prototype #1	Prototype #2
Display Weight	66.9 g	25.4 g
Total Weight	152.9 g	411.7 g
Pixels	24 x 12	320 x 240
Refresh Rate	5 Hz	1.1 Hz
Dimensions*	21.3 x 12.2 cm	18.4 x 14 cm
Display Thickness*	13.5 mm	4.9 mm

* With enclosure

Prototype #1

Custom LED Matrix Display

Prototype #2

Electronic Ink Display

Prototype #3

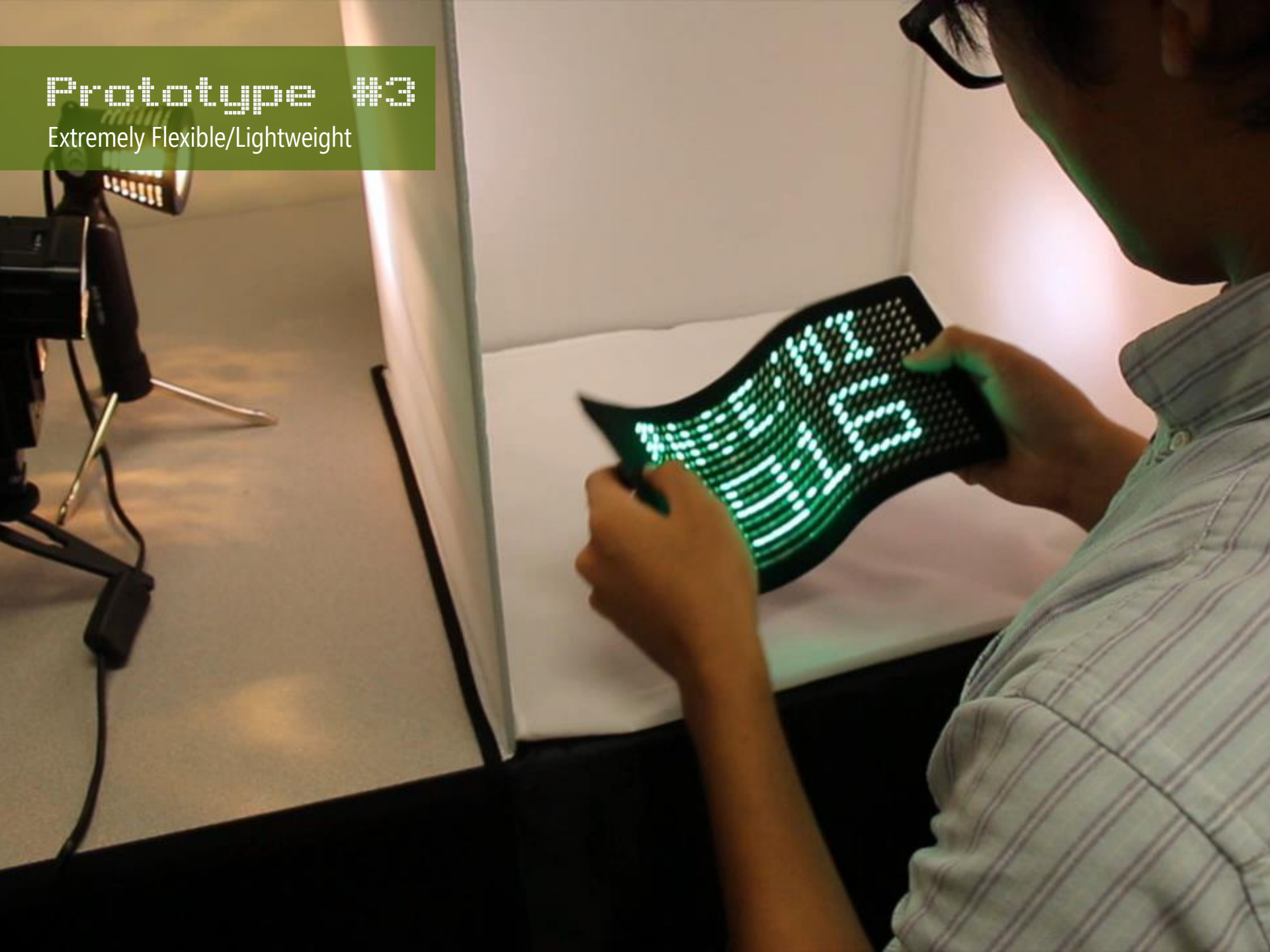
Erogear LED Matrix Display

Prototype #3

Erogear LED Matrix Display

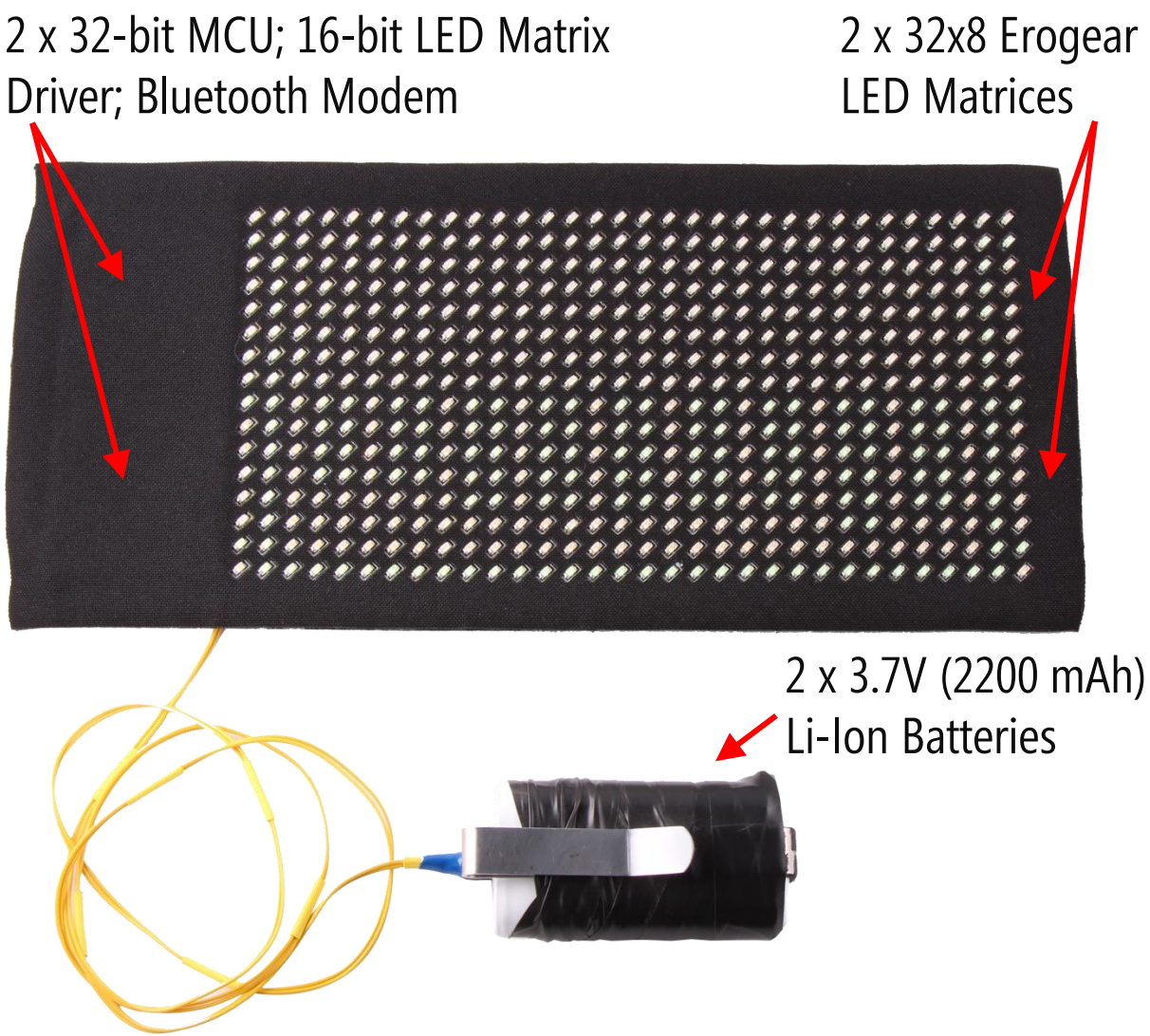
Prototype #3

Early Erogear Visualizations

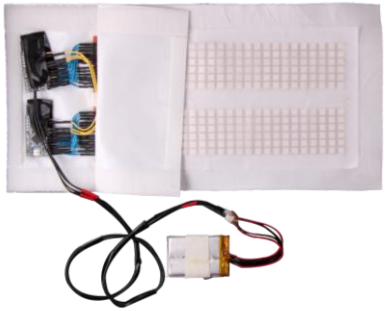

Prototype #3
Extremely Flexible/Lightweight

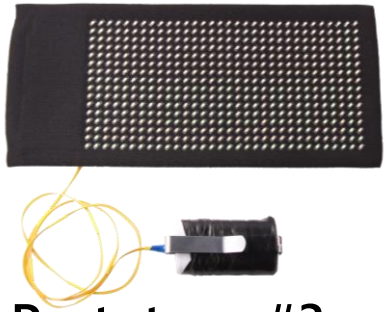
Prototype #3

Final Erogear Prototype



SFF: Three Prototypes

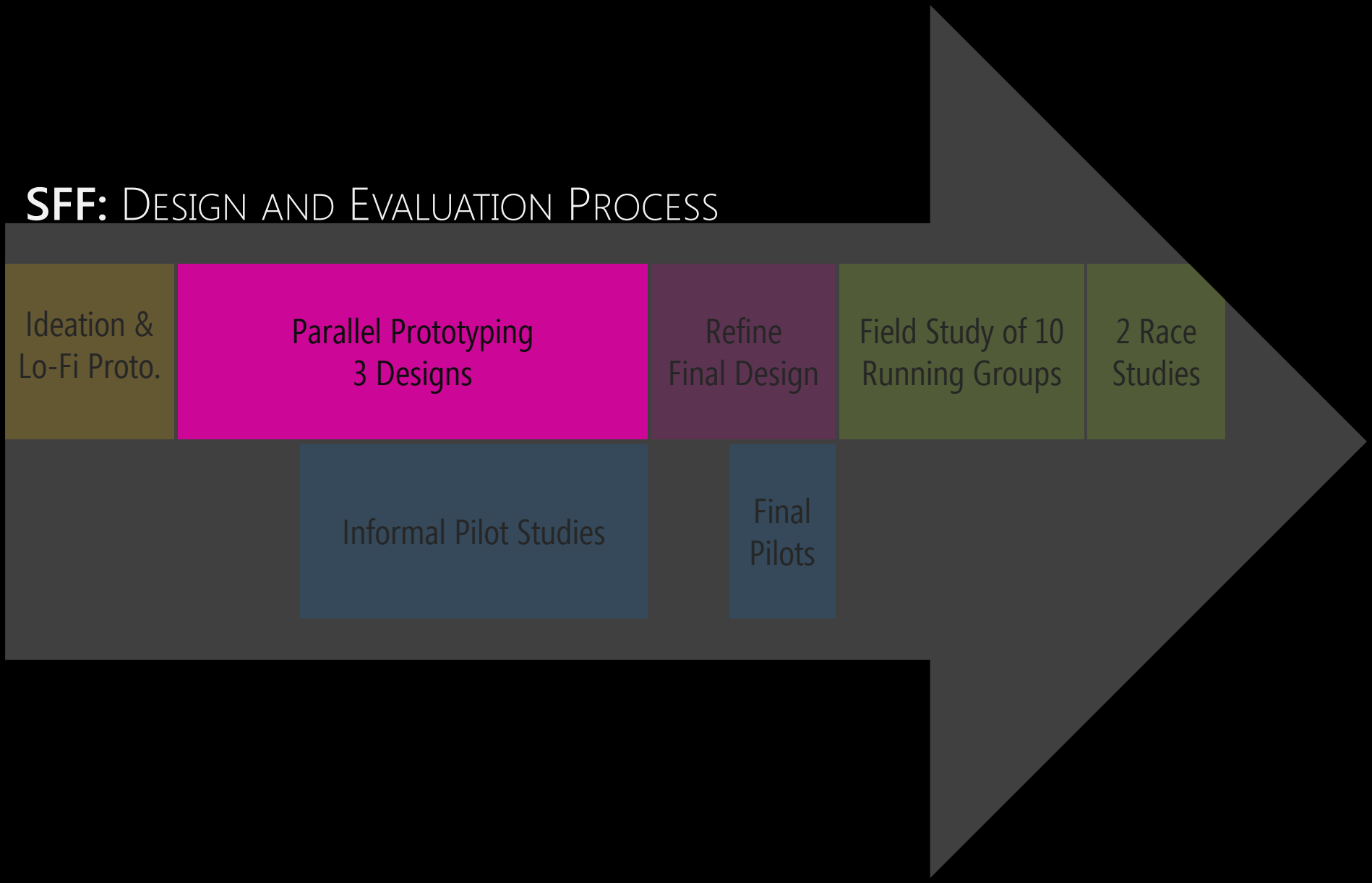




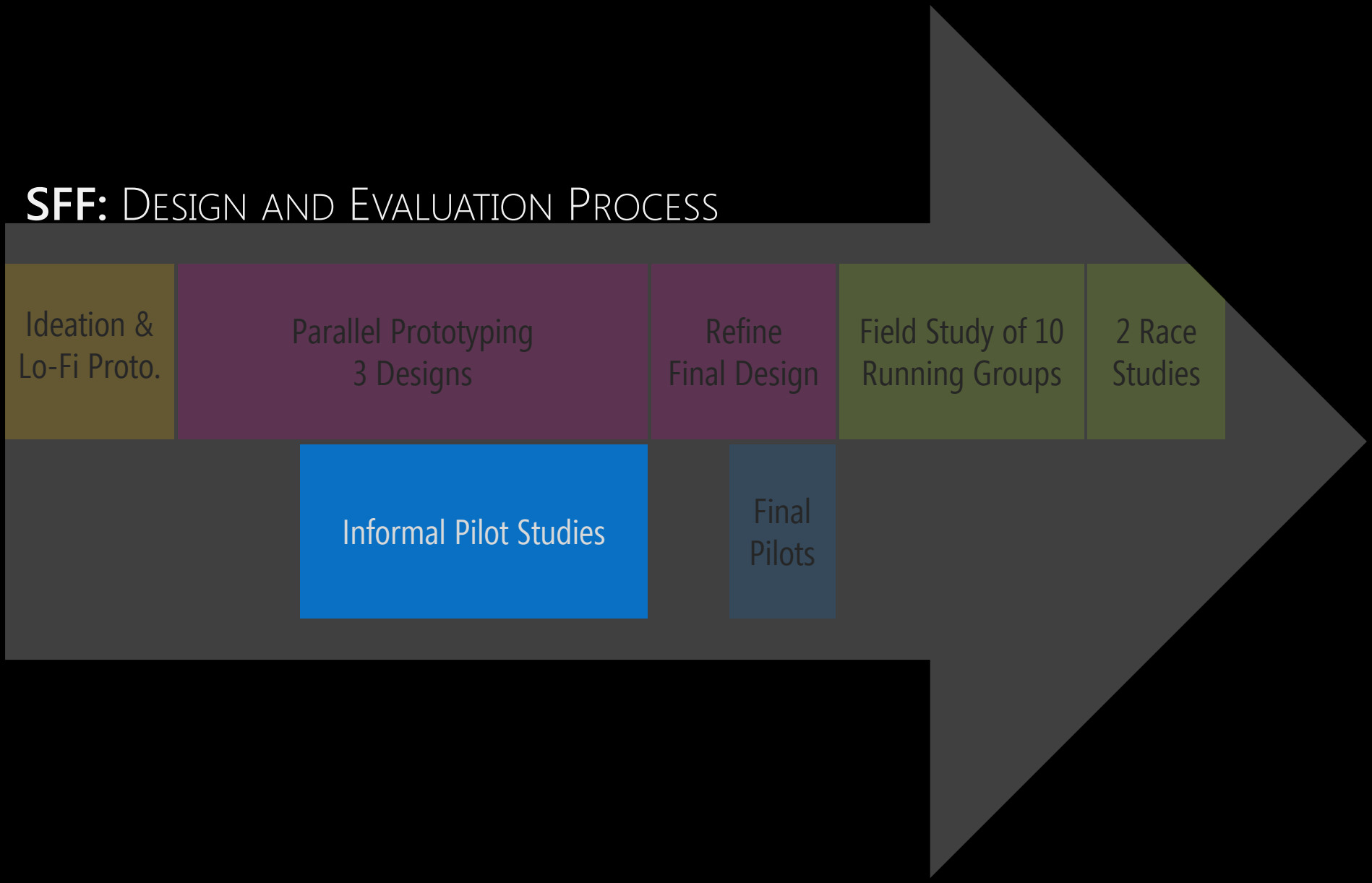
	Prototype #1	Prototype #2	Prototype #3
Display Weight	66.9 g	25.4 g	46.8 g
Total Weight	152.9 g	411.7 g	161.2 g
Pixels	24 x 12	320 x 240	32 x 16
Refresh Rate	5 Hz	1.1 Hz	38 Hz
Dimensions*	21.3 x 12.2 cm	18.4 x 14 cm	20.3 x 15.2 cm
Display Thickness*	13.5 mm	4.9 mm	4.8 mm

* With enclosure

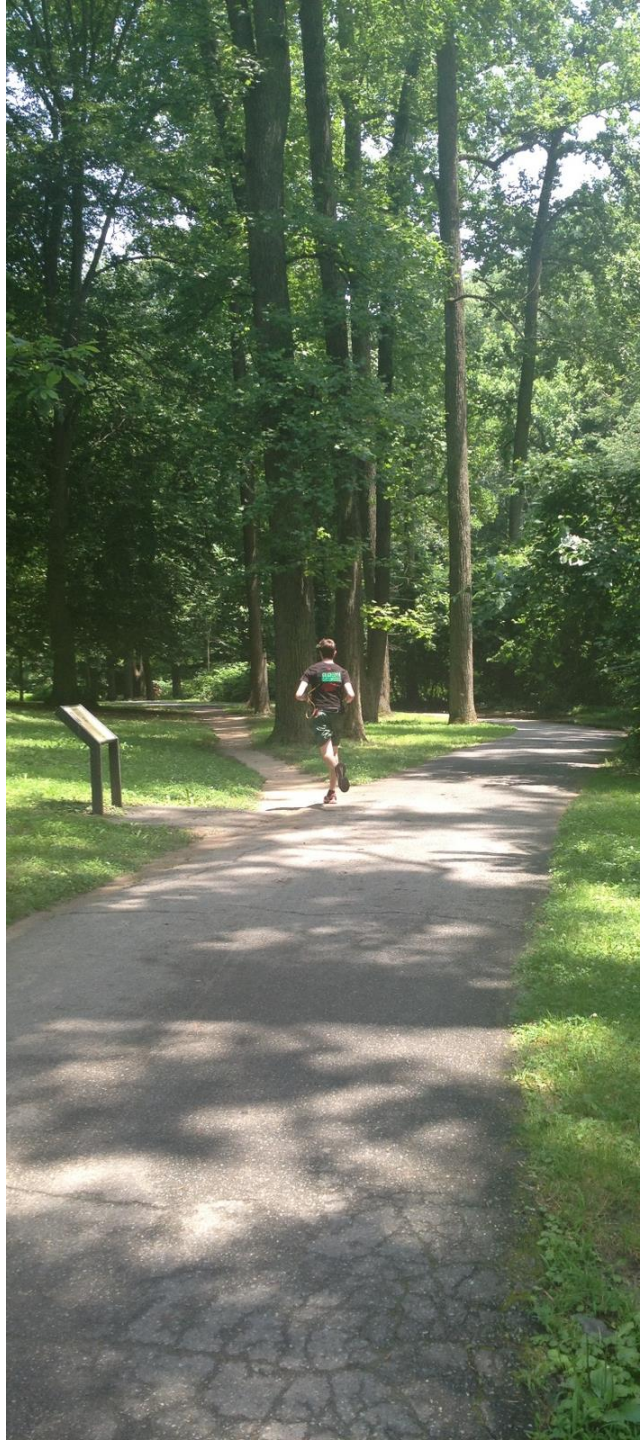
SFF: Design and Evaluation Process

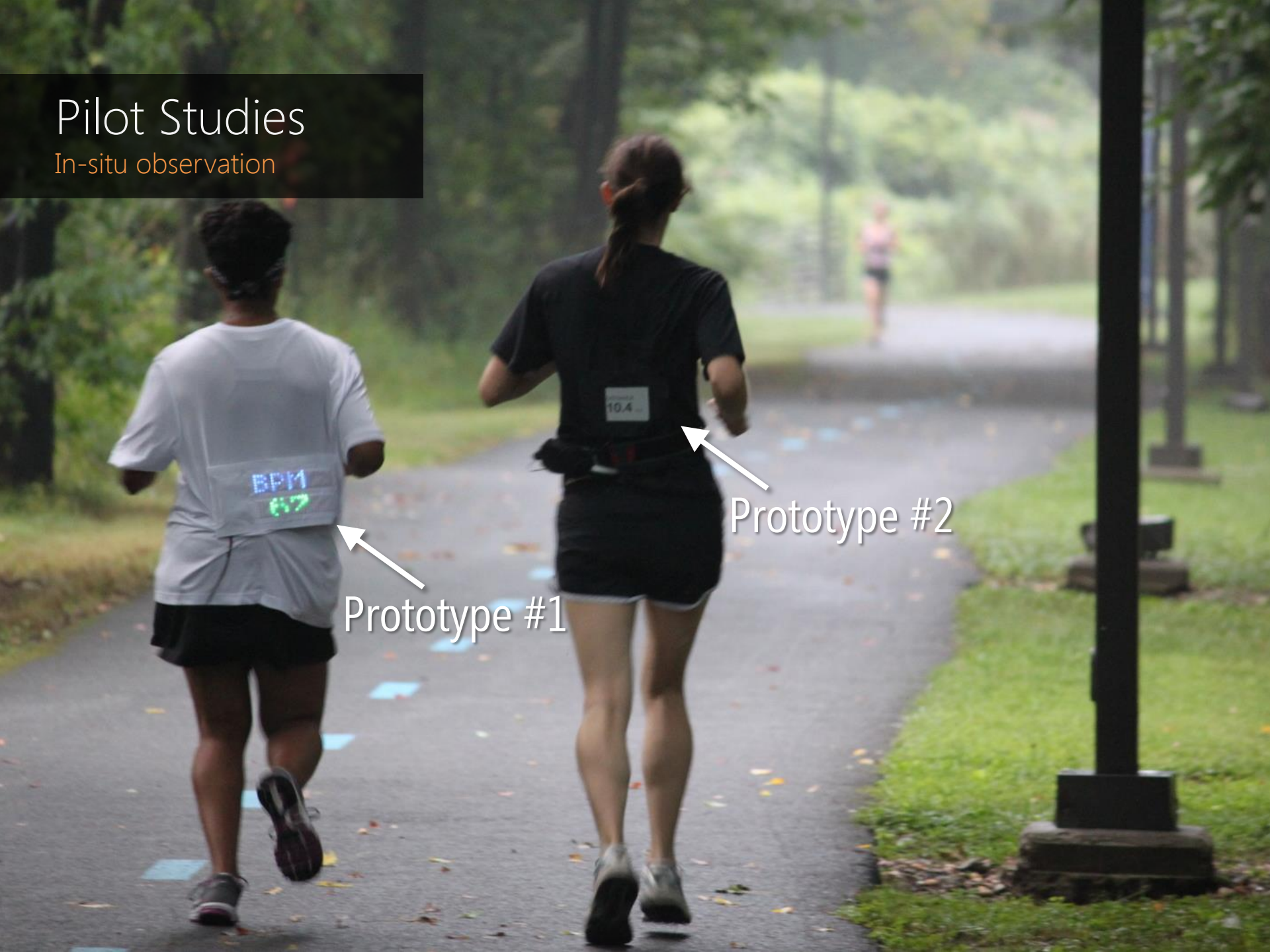


SFF: Design and Evaluation Process



Informal Pilot Studies
Evaluate Comfort
Examine Viewability
Investigate Robustness
Gain qualitative reactions
Prototype #3




Pilot Studies
In-situ observation
BPM
67
Prototype #1
Prototype #2

Data Collection

In-situ observation

Data Collection

In-situ observation

NICE
DAY!

Data Collection

Pre- and Post-Surveys

Analysis

Post-hoc review

Viewability

Examining Diffusion Layers

edX

Viewability

Prototype #1 & #2

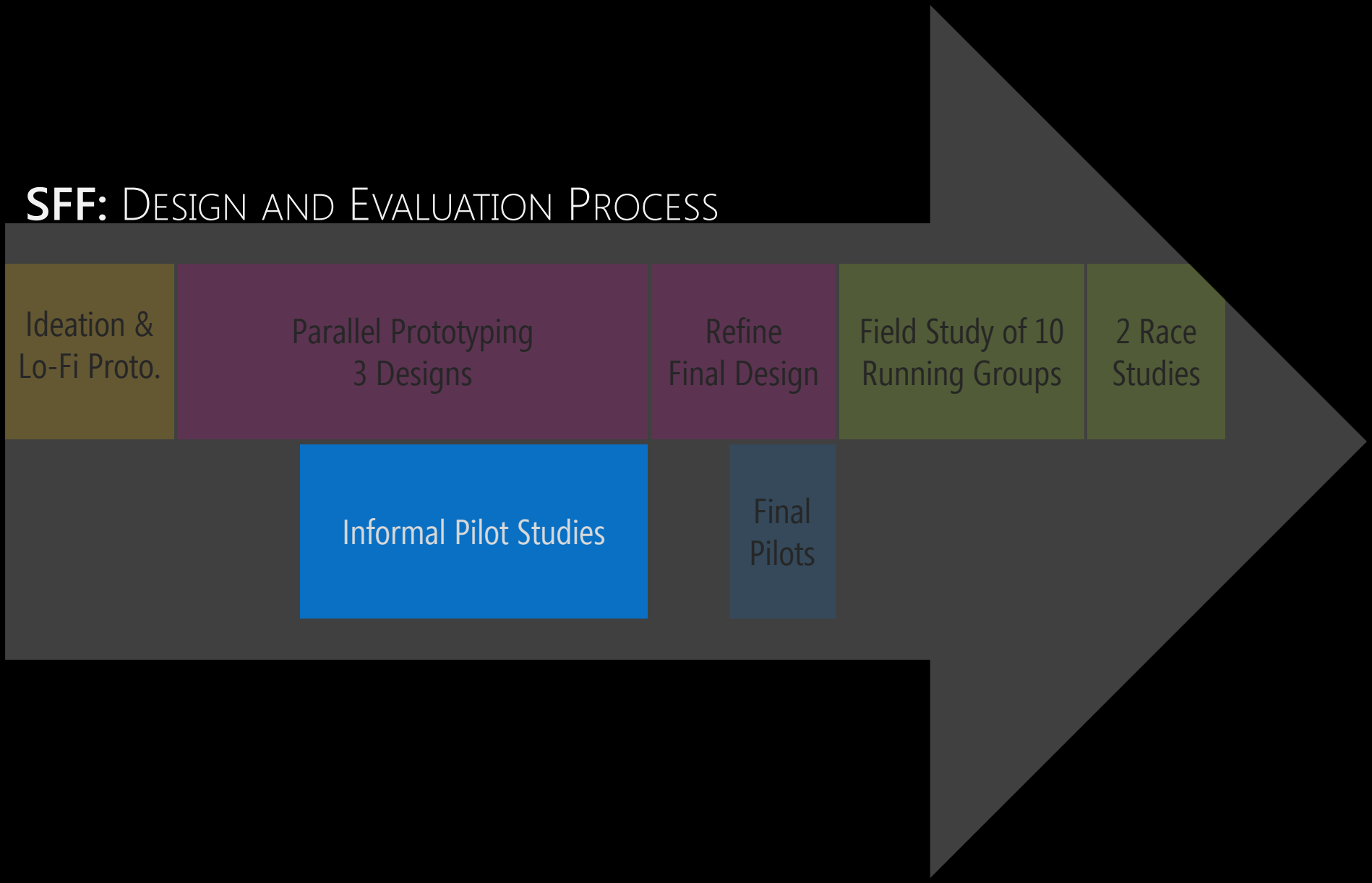
Viewability

Prototype #1 & #2

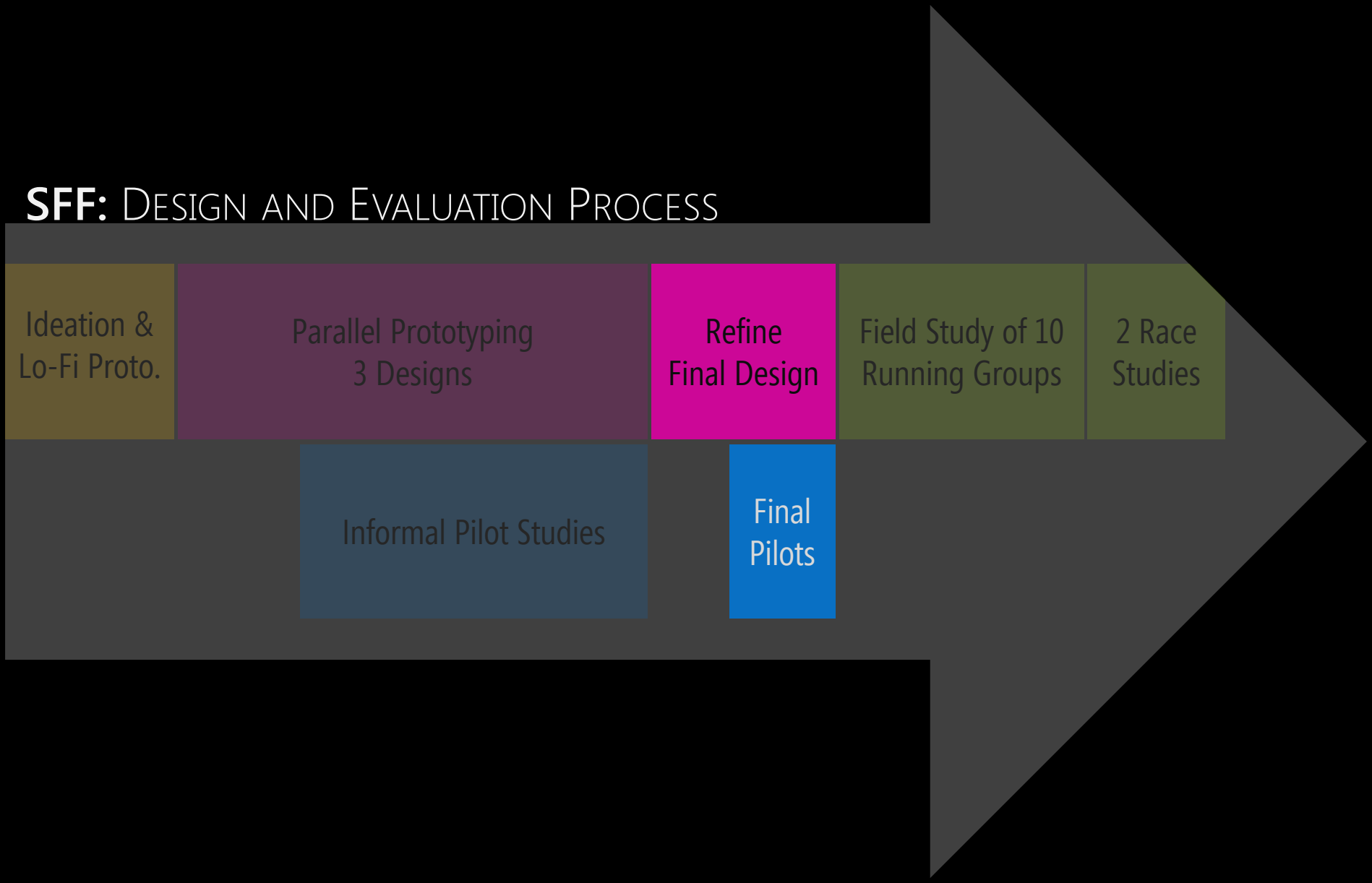
Viewability

Prototype #3: Lighting Conditions

SFF: Design and Evaluation Process



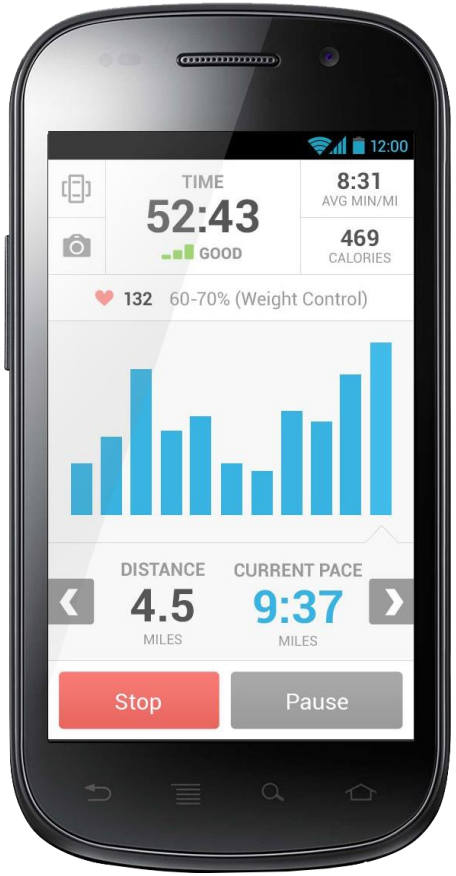
SFF: Design and Evaluation Process

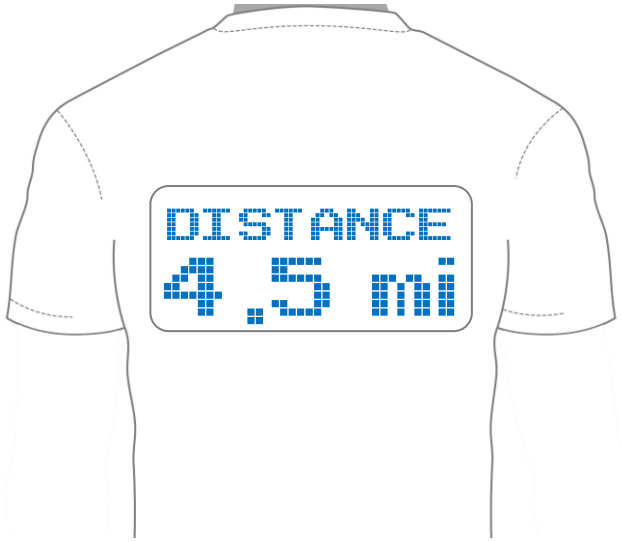


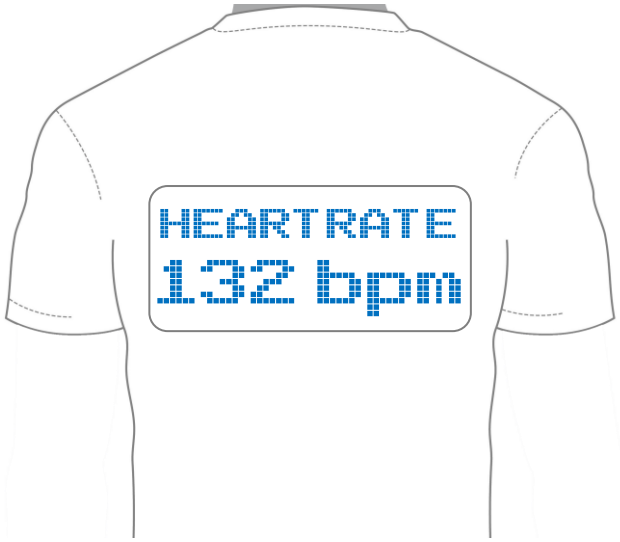
Prototype #3

Erogear LED Matrix Display

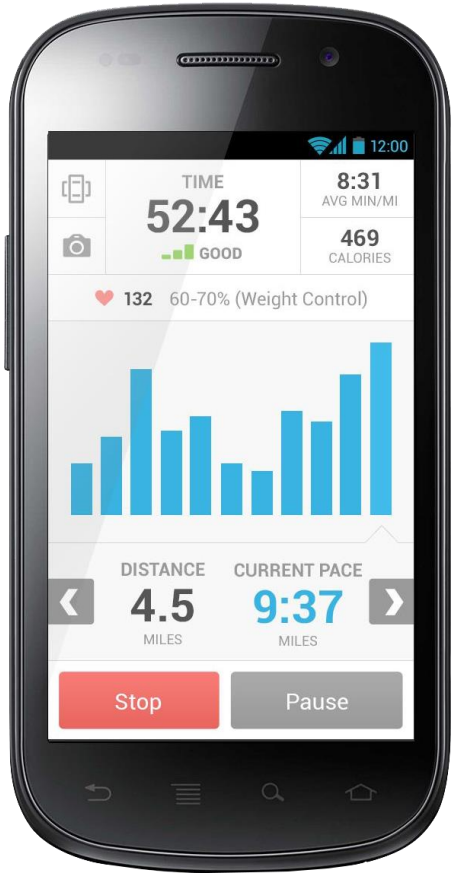
SFF: Primary Visualizations



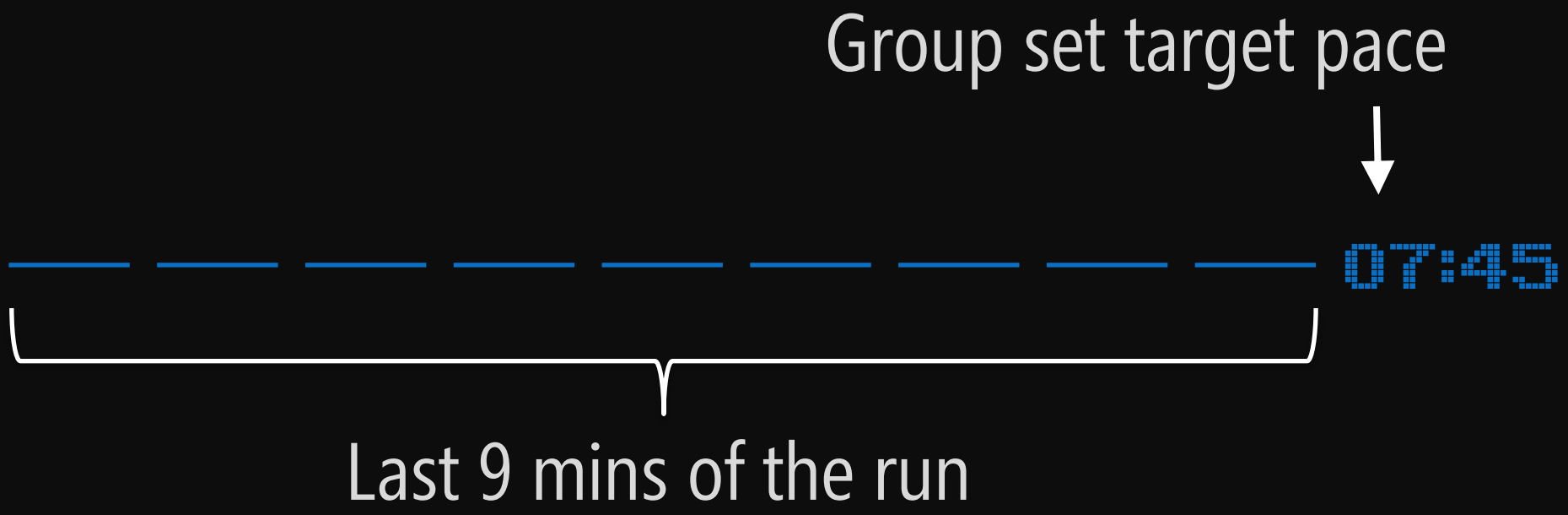




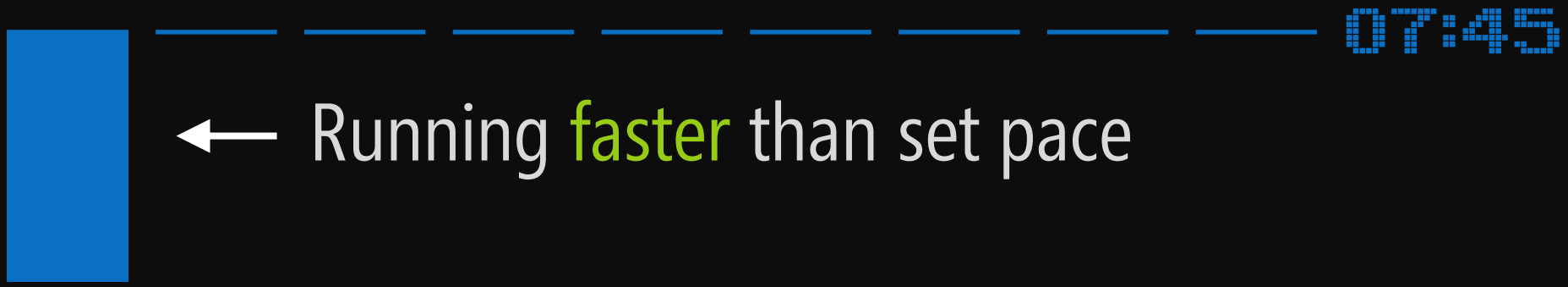
SFF: Final Visualizations



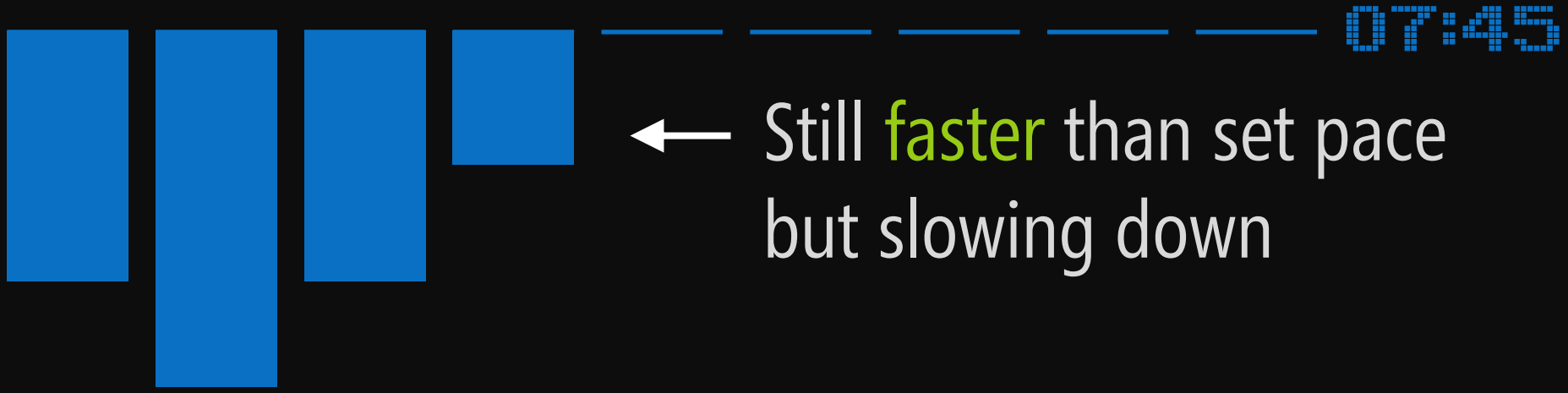
SFF: Shared Goal Visualization



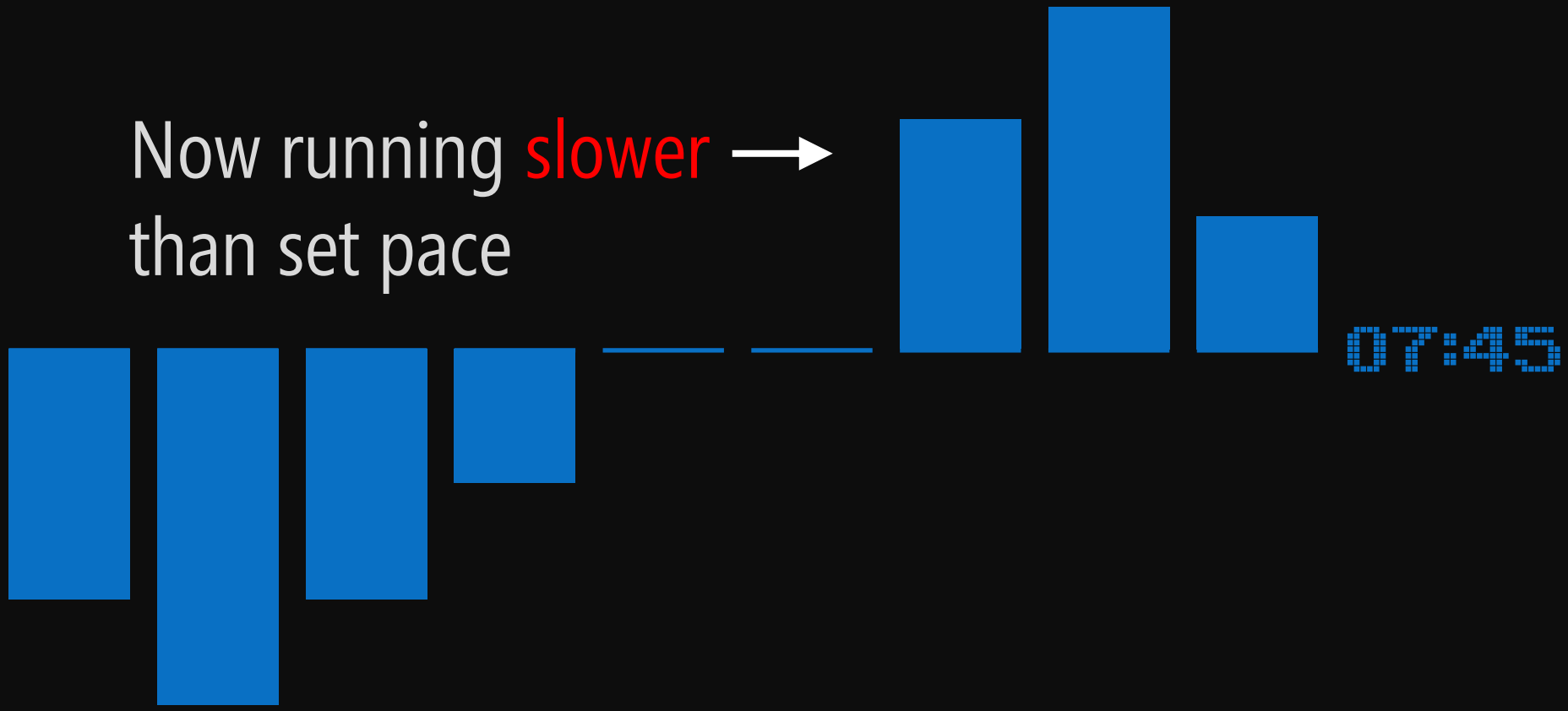
SFF: Shared Goal Visualization



SFF: Shared Goal Visualization



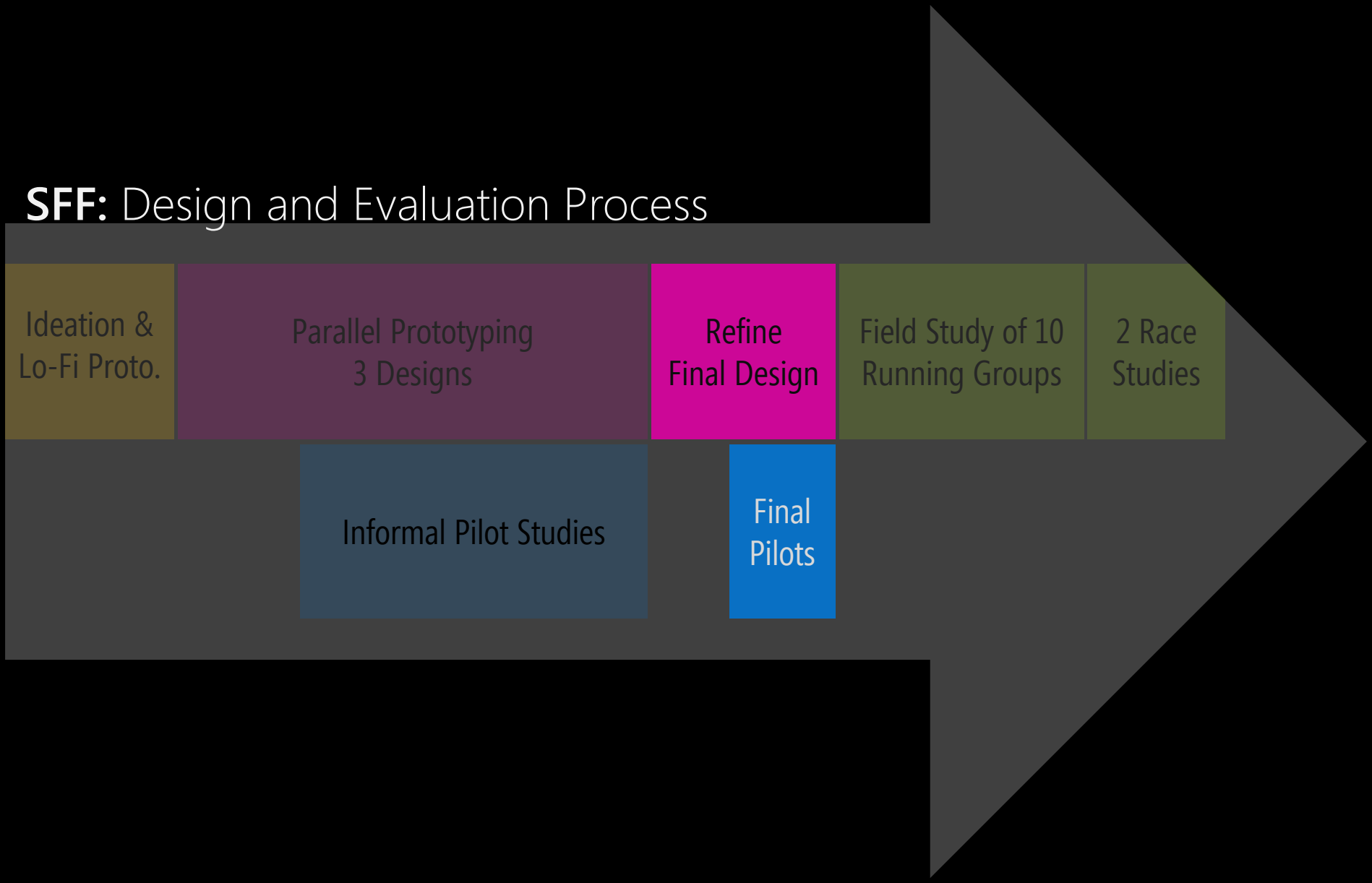
SFF: Shared Goal Visualization



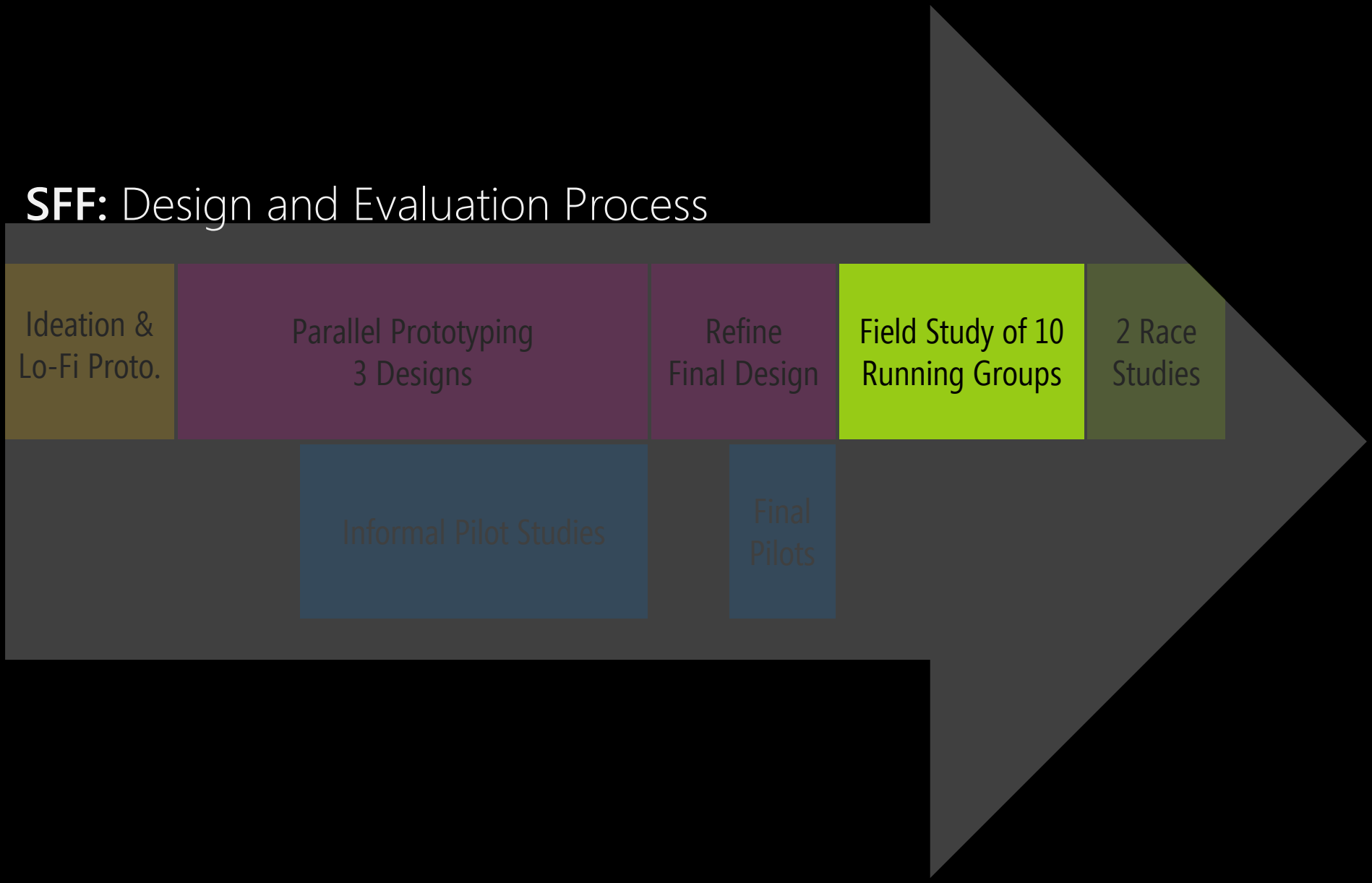
Final Prototype

Shared Goal Visualization

SFF: Design and Evaluation Process



SFF: Design and Evaluation Process



makeability lab

Running Groups Needed to Help Evaluate New Wearable Running Technology

Do you run? Do you run in groups? We need your help! In our study, we are looking for existing groups of runners (3 or more) to assist us as volunteers in a research project exploring e-textile athletic jerseys.

Specifically, we have designed and constructed prototype athletic jerseys that communicate running information such as pace, duration, and distance via a live, wearable display. As a participant, your role is to help us better understand how these jerseys impact your sense of the run activity and the runners around you.

For the study, we will ask you to first complete a short demographic and pre-activity survey. Then, you will perform a short running activity of 20 – 35 minutes (depending on your preference) with the group. One (or two) people in the running group will be wearing our e-textile jersey along with a provided mobile phone and arm strap. After completing the run, you will be asked to fill out a short survey about your experience. The entire session should last approximately 60 minutes.

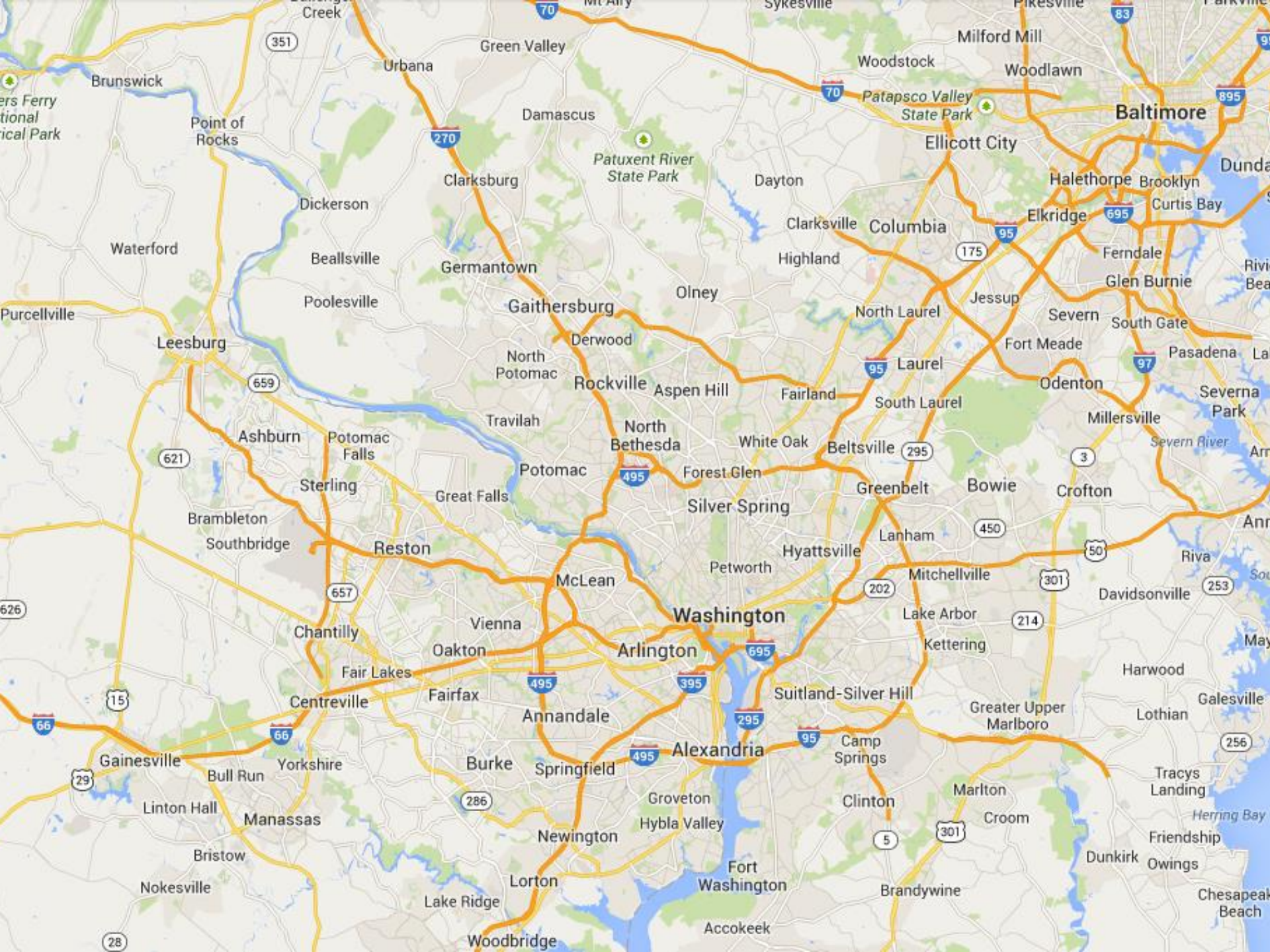
Participants will be reimbursed $20 per hour for their time. Study sessions will be conducted on the University of Maryland, College Park campus or, in some cases, at a specific physical location of your choice. All participants must be 18 years of age or older and be an active runner. Apart from that restriction, we encourage people of all genders and ethnicities to participate. If you are interested in participating, please email Matthew Mauriello (mattm@cs.umd.edu) the following information:

- How often you run (e.g., once a week, three times a week)
- How often you run in a group and the typical group size
- How you currently track your runs (e.g., Nike+, Runkeeper, paper + pen)

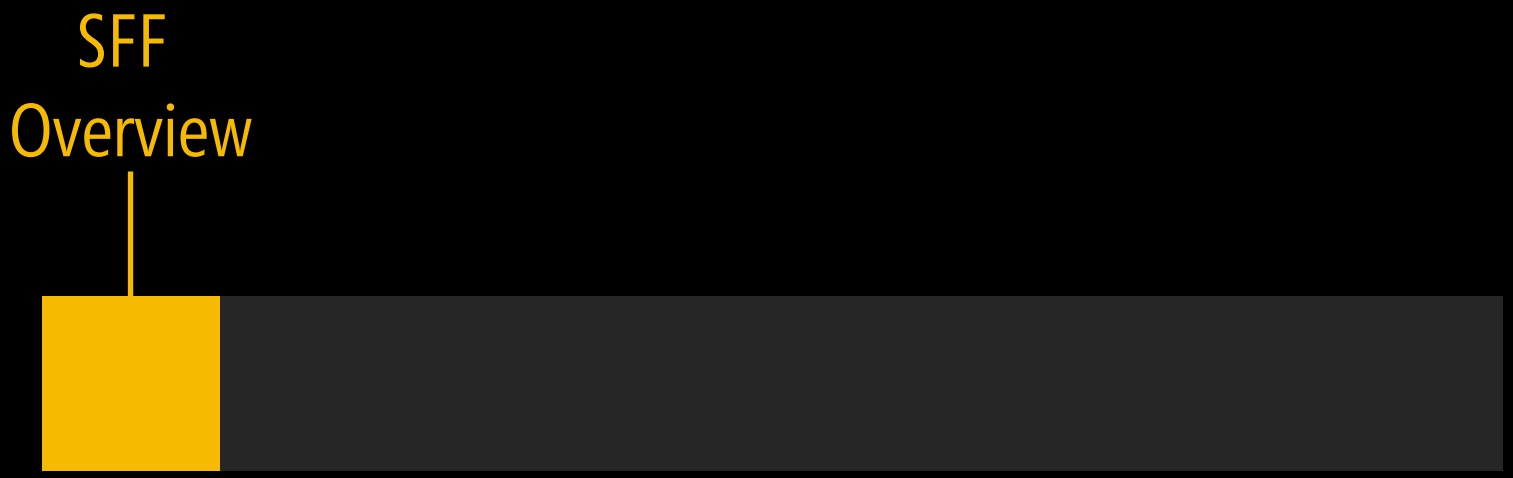
Feel free to take a look at our research lab's website to find out more about our research program: http://www.cs.umd.edu/hcil/. Please also feel free to redistribute this posting.

Sincerely,

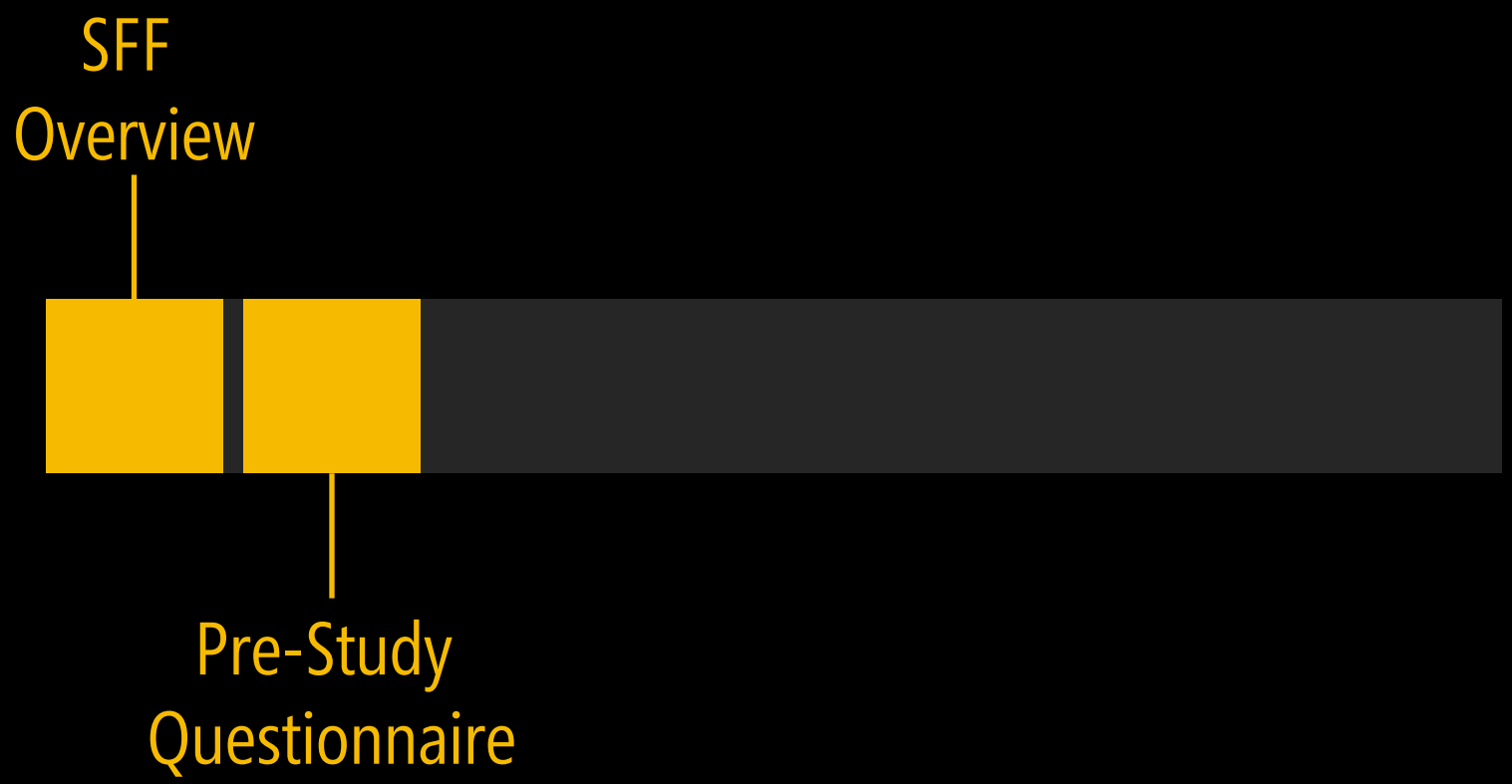
~Matthew Mauriello, MS
Department of Computer Science
University of Maryland
A.V. Williams Building, 4122
College Park, MD 20742
--
http://www.cs.umd.edu/~mattm/
Twitter @mattm401


Creek
351
Green Valley
Urbana
Milford Mill
Woodstock
Woodlawn
Brunswick
70
Patapsco Valley
State Park
Baltimore
895
Point of
Rocks
Damascus
270
Ellicott City
Patuxent River
State Park
Clarksburg
Dayton
Halethorpe
Brooklyn
Curtis Bay
Dickerson
Elkridge
695
Clarksville
Columbia
95
175
Waterford
Beallsville
Germantown
Highland
Ferndale
Glen Burnie
Olney
Jessup
Poolesville
Gaithersburg
North Laurel
Severn
South Gate
Purcellville
Derwood
Fort Meade
Leesburg
North
Potomac
Laurel
97
Pasadena
659
Rockville
Aspen Hill
Fairland
Odenton
Severna
Park
Travilah
South Laurel
Millersville
Ashburn
Potomac
Falls
North
Bethesda
White Oak
Beltsville
295
Severn River
621
3
Potomac
495
Forest Glen
Sterling
Greenbelt
Bowie
Crofton
Great Falls
Silver Spring
Brambleton
Lanham
450
Southbridge
Reston
Hyattsville
50
Riva
Petworth
Mitchellville
McLean
202
301
Davidsonville
253
657
Washington
Vienna
Lake Arbor
214
Chantilly
Oakton
Arlington
695
Kettering
Fair Lakes
Harwood
495
395
Fairfax
Suitland-Silver Hill
Galesville
15
Centreville
Greater Upper
Marlboro
Lothian
Annandale
295
66
66
95
Camp
Springs
256
Gainesville
Yorkshire
Burke
Springfield
495
Alexandria
Tracys
Landing
29
Bull Run
Marlton
Groveton
Clinton
Linton Hall
286
Herring Bay
Manassas
Hybla Valley
Croom
Newington
5
301
Friendship
Bristow
Dunkirk
Owings
Fort
Washington
Lorton
Nokesville
Brandywine
Lake Ridge
Chesapeake
Beach
Accokeek
28
Woodbridge

SFF: Study Procedure



SFF: Study Procedure



makeability lab

Human-Computer Interaction Lab

Participant ID: _____ Date: _____ Time: _____

Social Fabric Fitness

Pre-Study Questionnaire

Instructions to participants: This survey is for research purposes only. Your responses will be anonymized. We *will not* look at your responses until we get back to our research lab.

About Your Experience

Please answer the following questions openly and honestly. If something is not clear, please feel free to ask a research staff member for clarification.

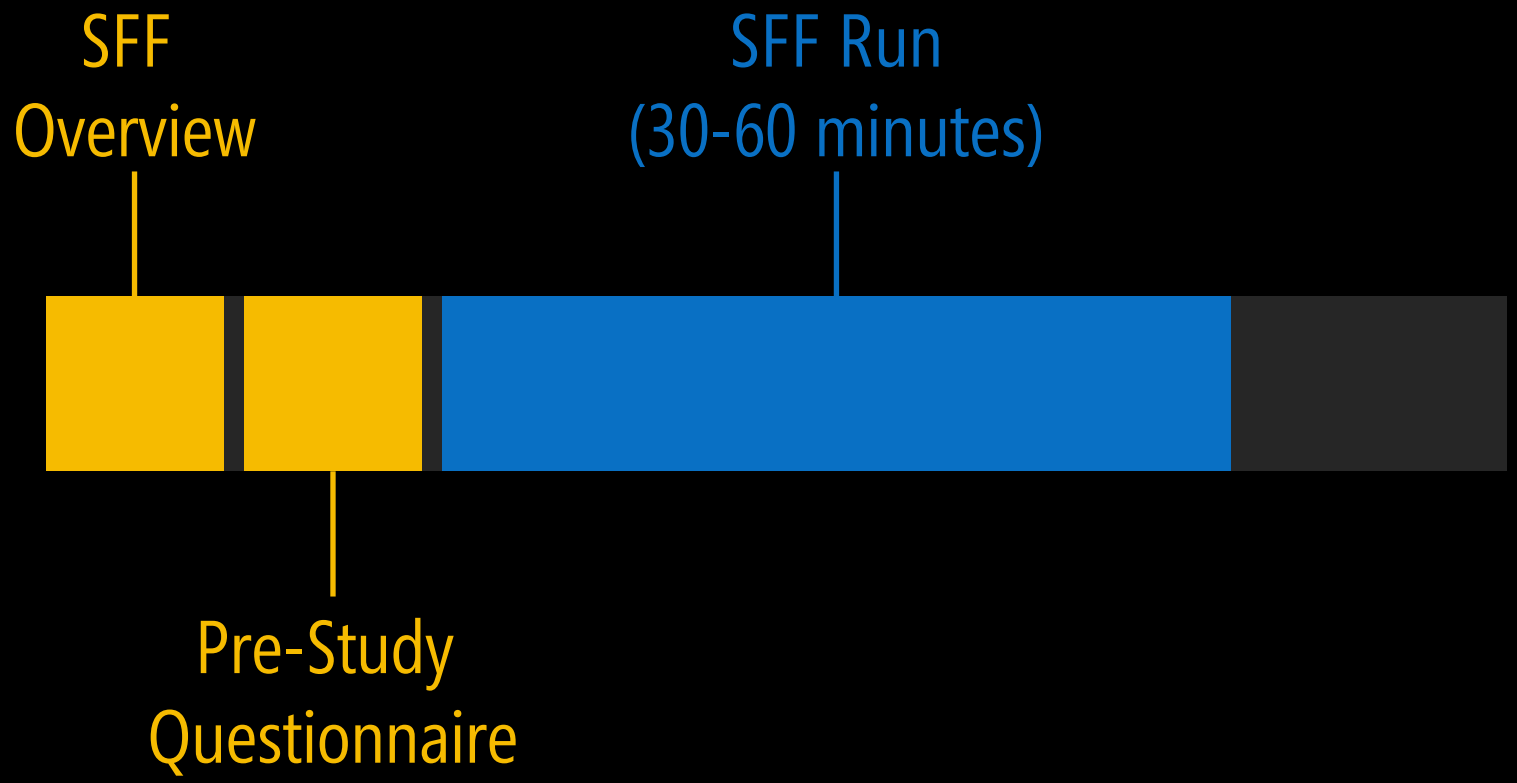
1. Your age:_____
2. Gender: Male_____ Female_____ Other_____
3. What is your profession? If you are currently a student, please indicate your current field of study:

   _____
4. In the last seven days, I have run _____ times.
5. In the last seven days, I have run with at least one other person _____ times.
6. My typical run is _____ (miles / kilometers), which lasts _____ minutes
7. I consider myself an active, fit person.

Neither agree

Strongly

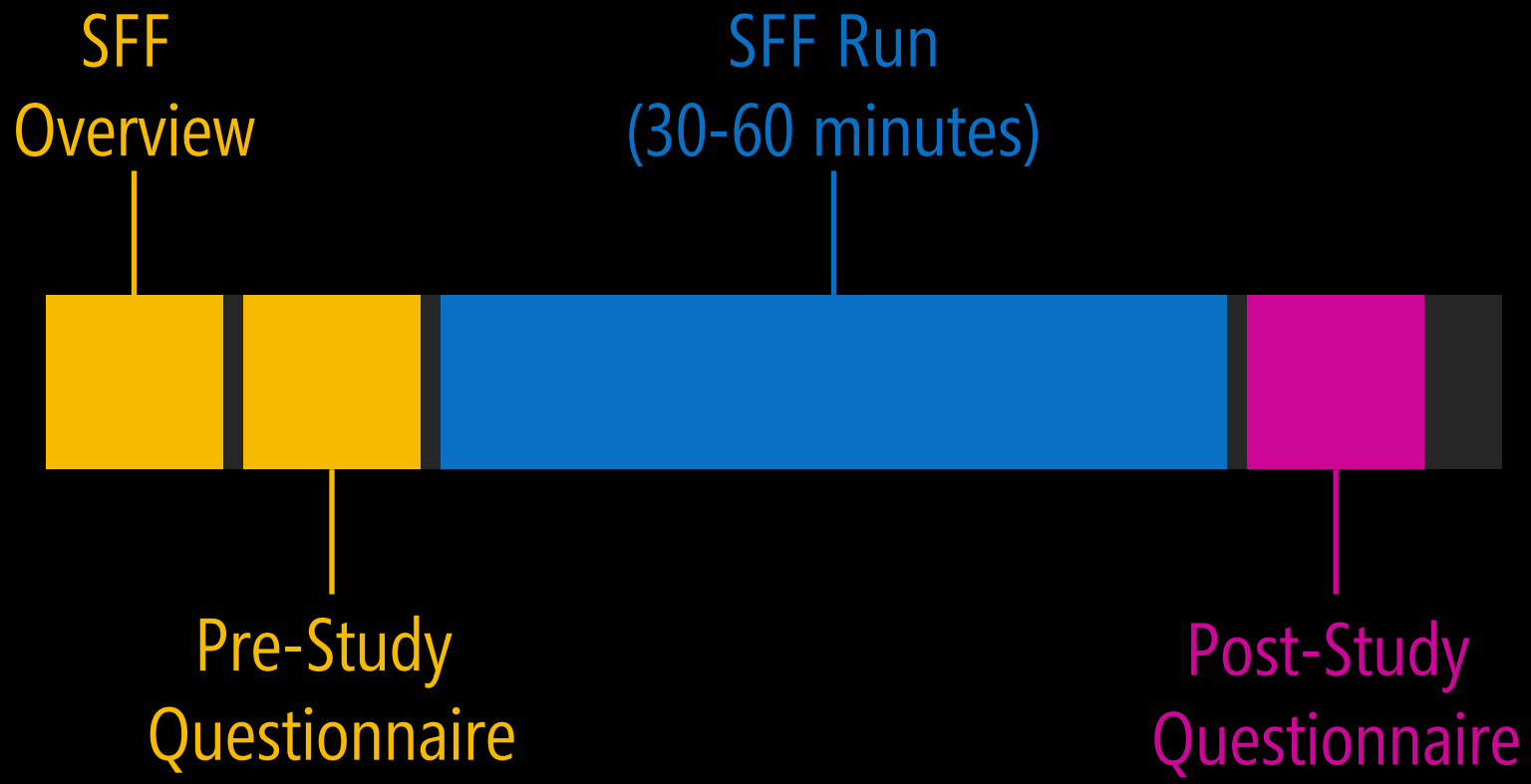
SFF: Study Procedure



DURATION
23:43

PACE
11.16
RUNNING STRONG
FOREVER

SFF: Study Procedure



makeability lab

Human-Computer Interaction Lab

Participant ID: _____ Date: _____ Time: _____

Social Fabric Fitness

Wearer Post-Study Questionnaire

Instructions to participants: This survey is for research purposes only. Your responses will be anonymized. We *will not* look at your responses until we get back to our research lab.

Devices and Comfort

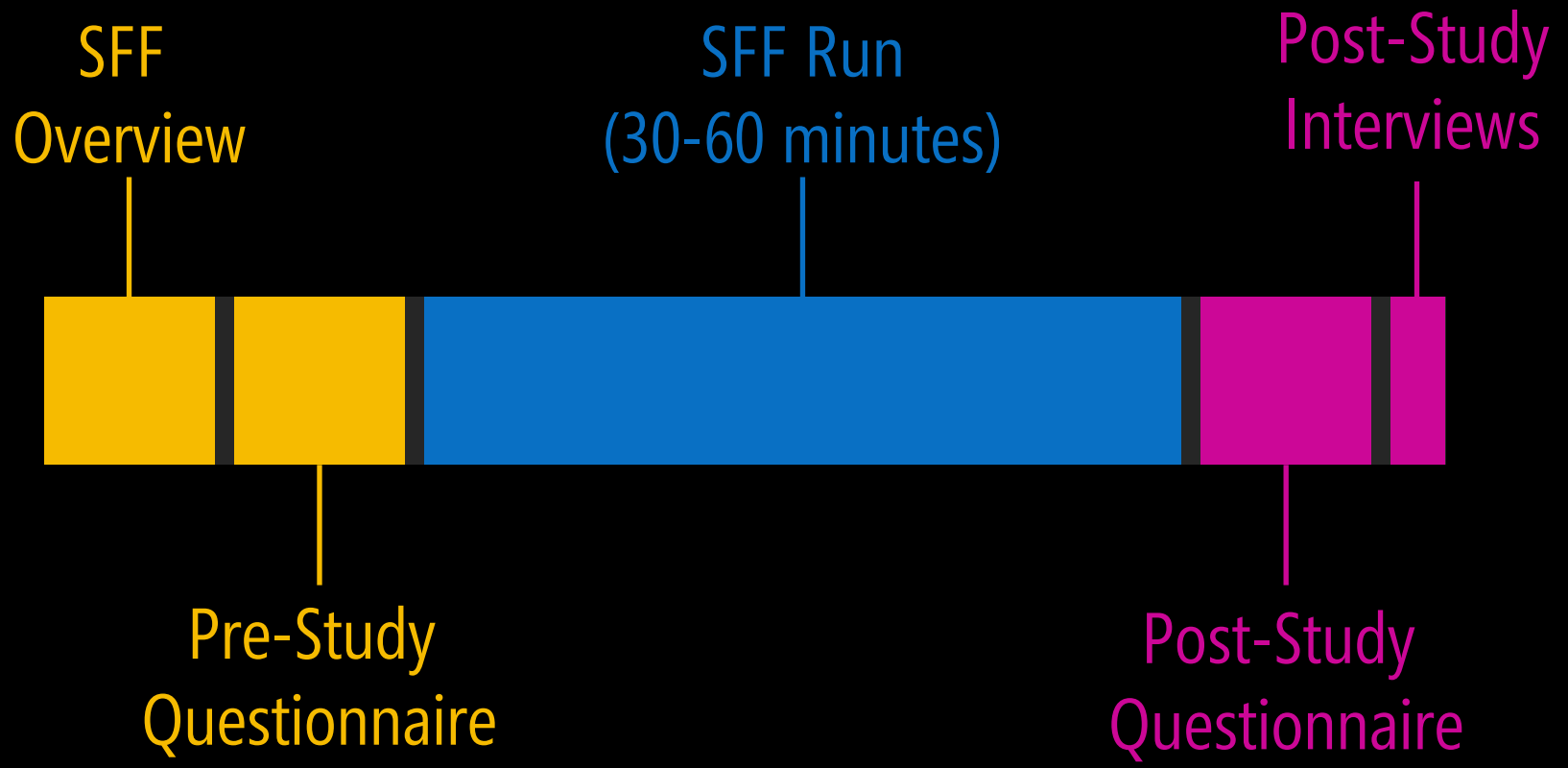
1. I wore the heart rate monitor (check one). Yes_____ No_____
    a. Please describe why you chose to wear it.

2. Briefly describe where you wore the battery and how this worked for you.

3. Briefly describe where you wore the armband and how this worked for you.

4. In terms of physical comfort, I did not notice the _____ during the run.

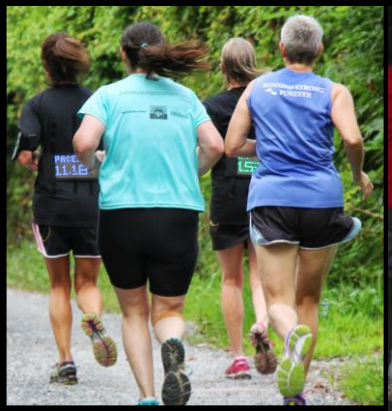
SFF: Study Procedure



5:30AM
Obligatory Red Bull

Field Study Participants

10 Groups; 52 Individuals (35 Female)



Avg Group Size:

5

Avg Age:

40.7

Avg Target Pace:

10:14

Avg Distance:

3.5 mi

SFF: Analysis

We analyzed the Likert scale survey data to uncover trends and use the interview and open-form data to provide context.

SFF: Field Study Results

Comfort

User Experience

Display Content

Cohesiveness

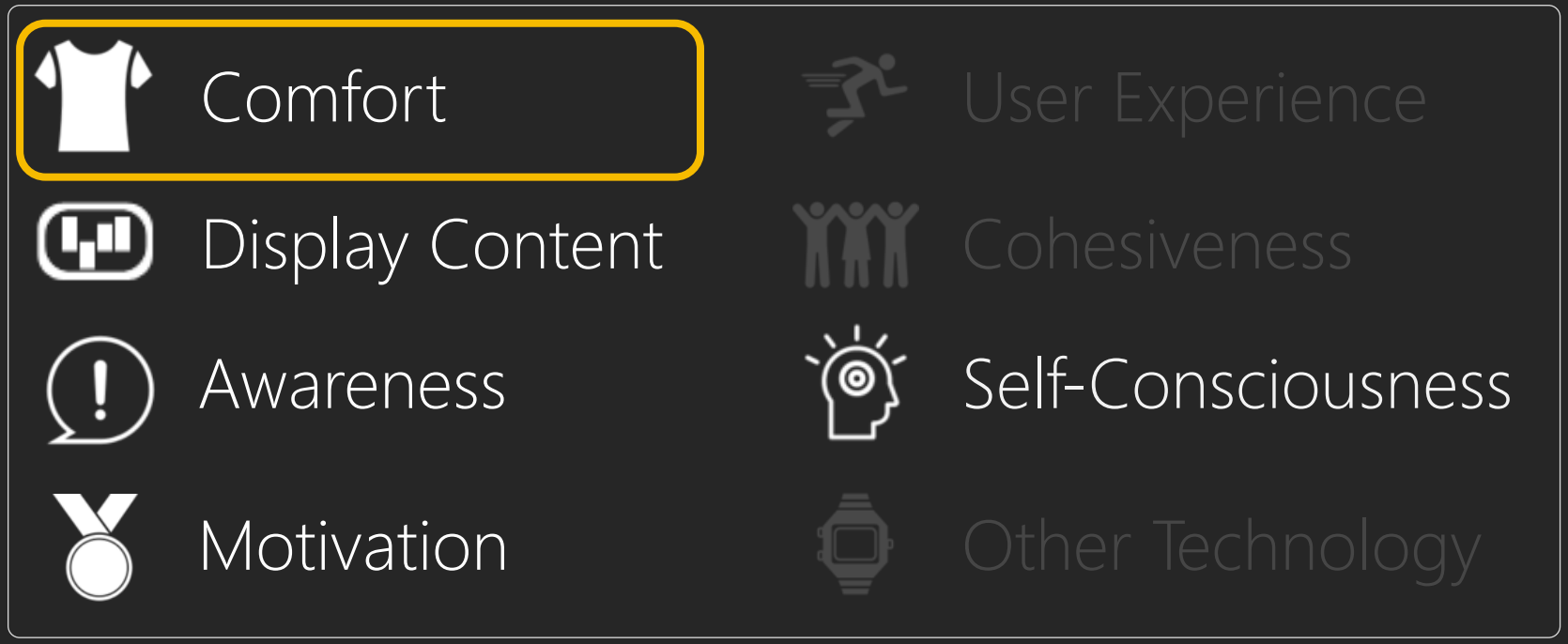
Awareness

Self-Consciousness

Motivation

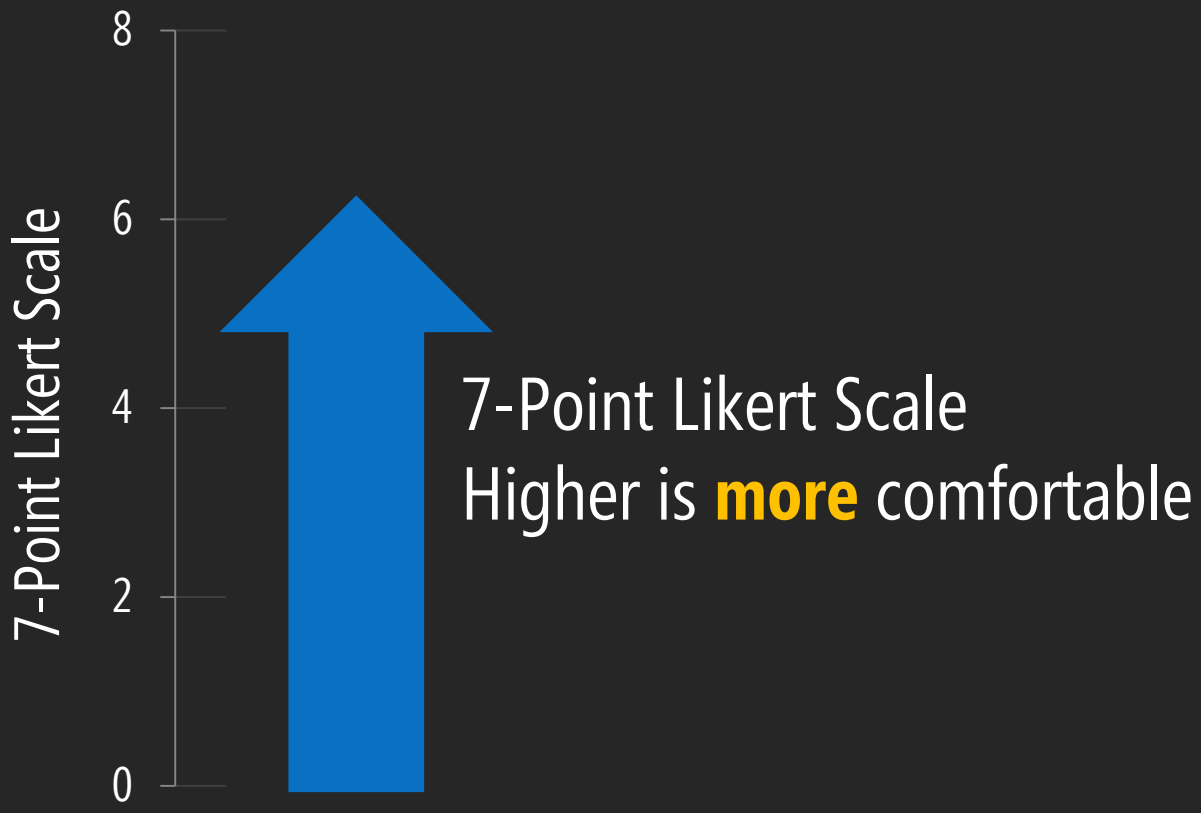
Other Technology

SFF: Field Study Results



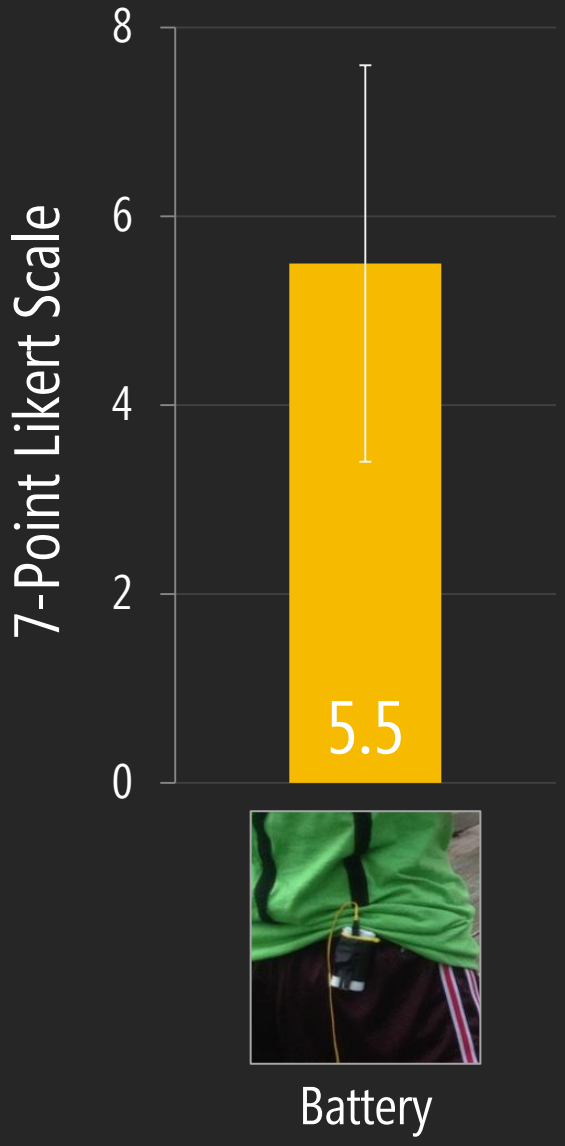
Field Study Results

Comfort; Wearers (N=19)



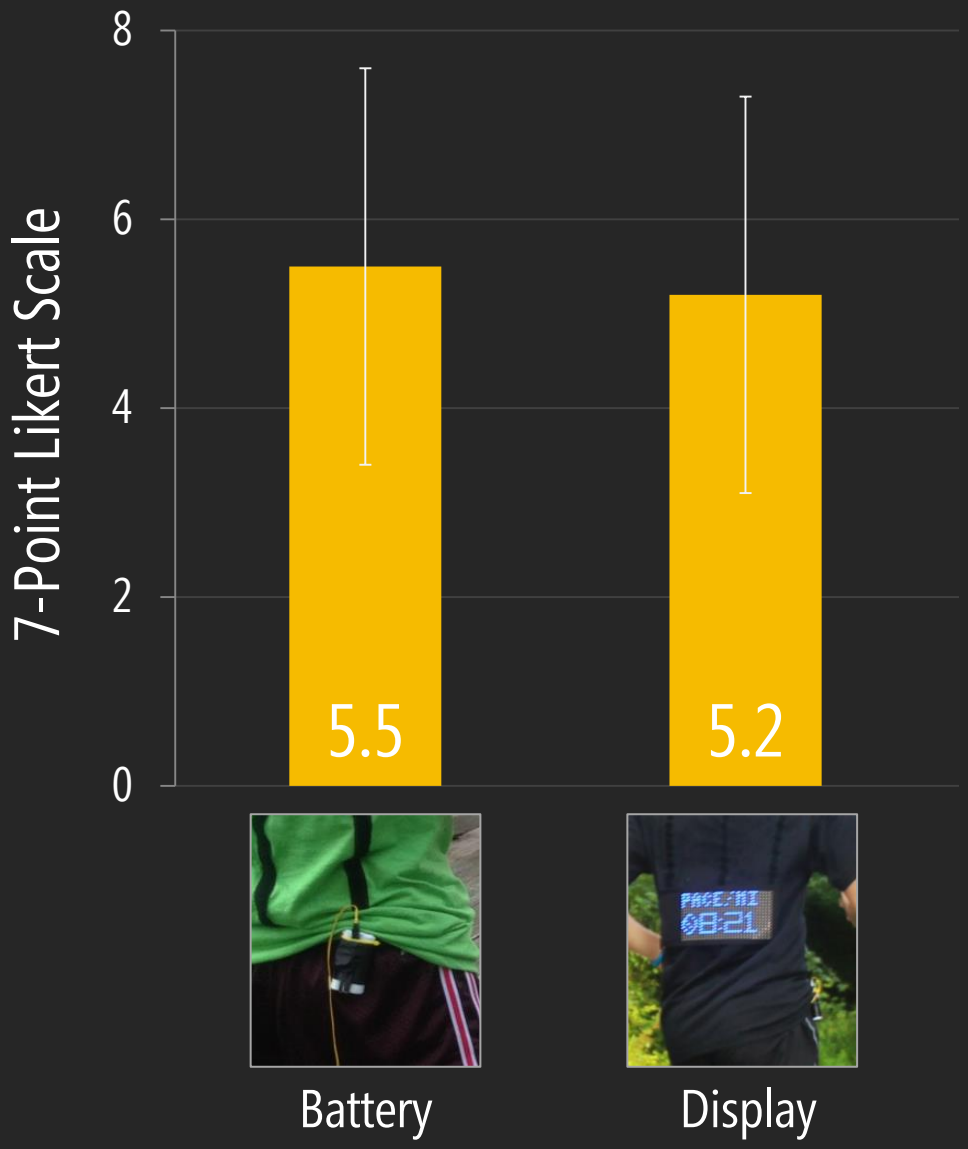
Field Study Results

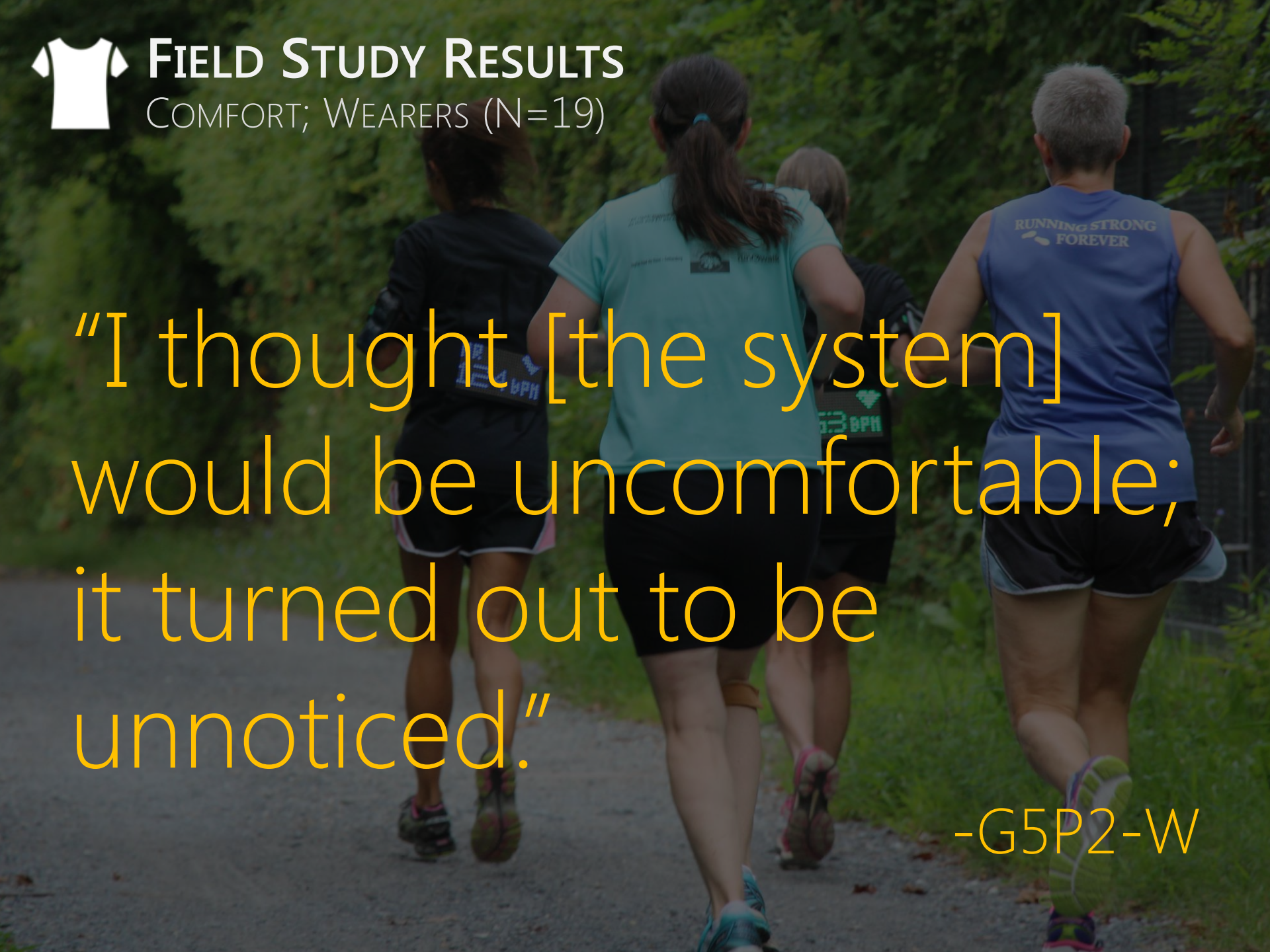
Comfort; Wearers (N=19)



Field Study Results

Comfort; Wearers (N=19)





Field Study Results

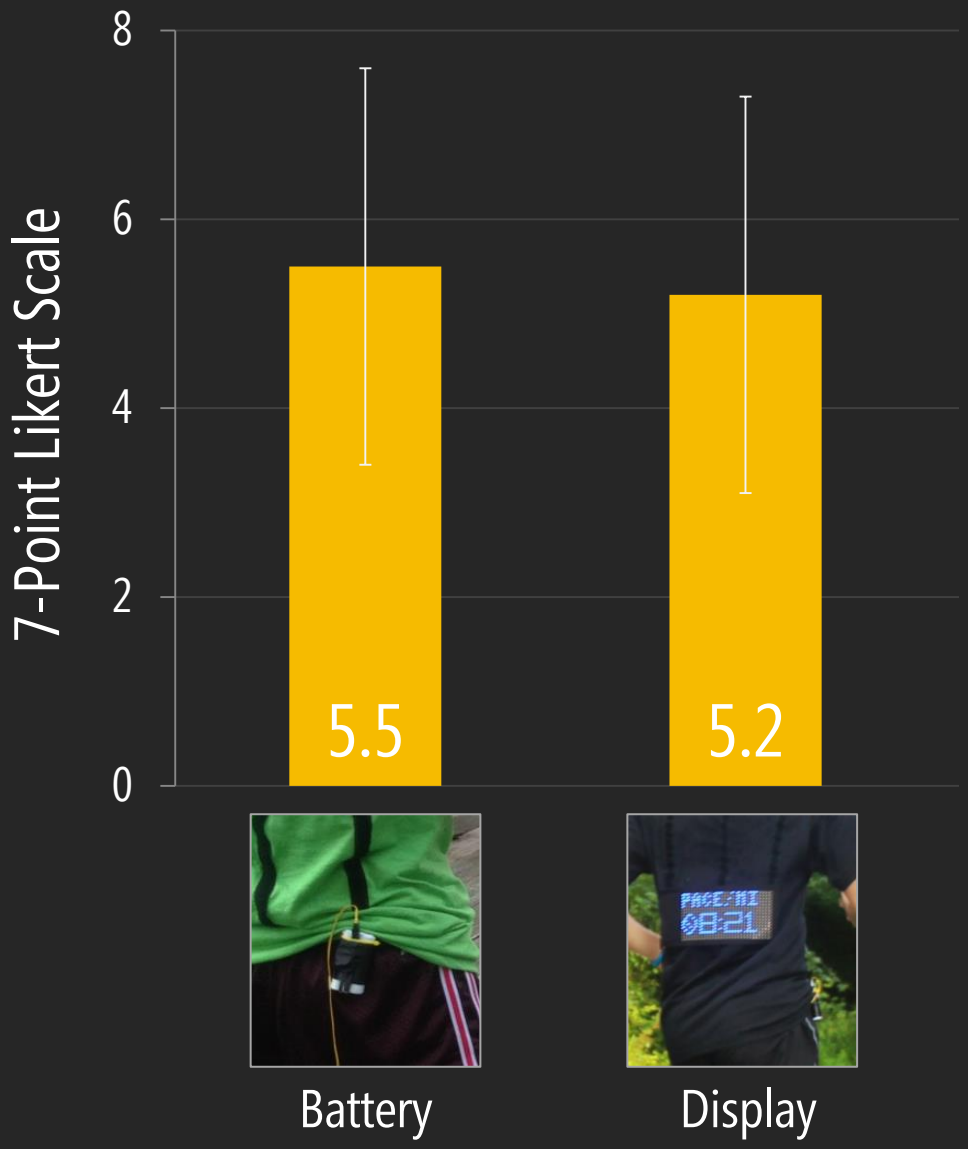
Comfort; Wearers (N=19)

"I thought [the system] would be uncomfortable; it turned out to be unnoticed."

-G5P2-W

Field Study Results

Comfort; Wearers (N=19)



Field Study Results

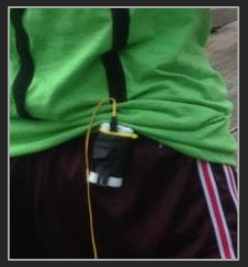
Comfort; Wearers (N=19)

Higher is better

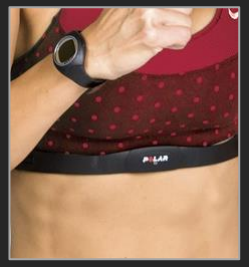
7-Point Likert Scale

8
6
4
2
0

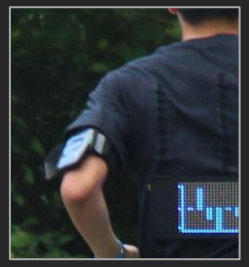
5.5
5.2
5.1
4


Battery

Display



Heart Monitor


Armband

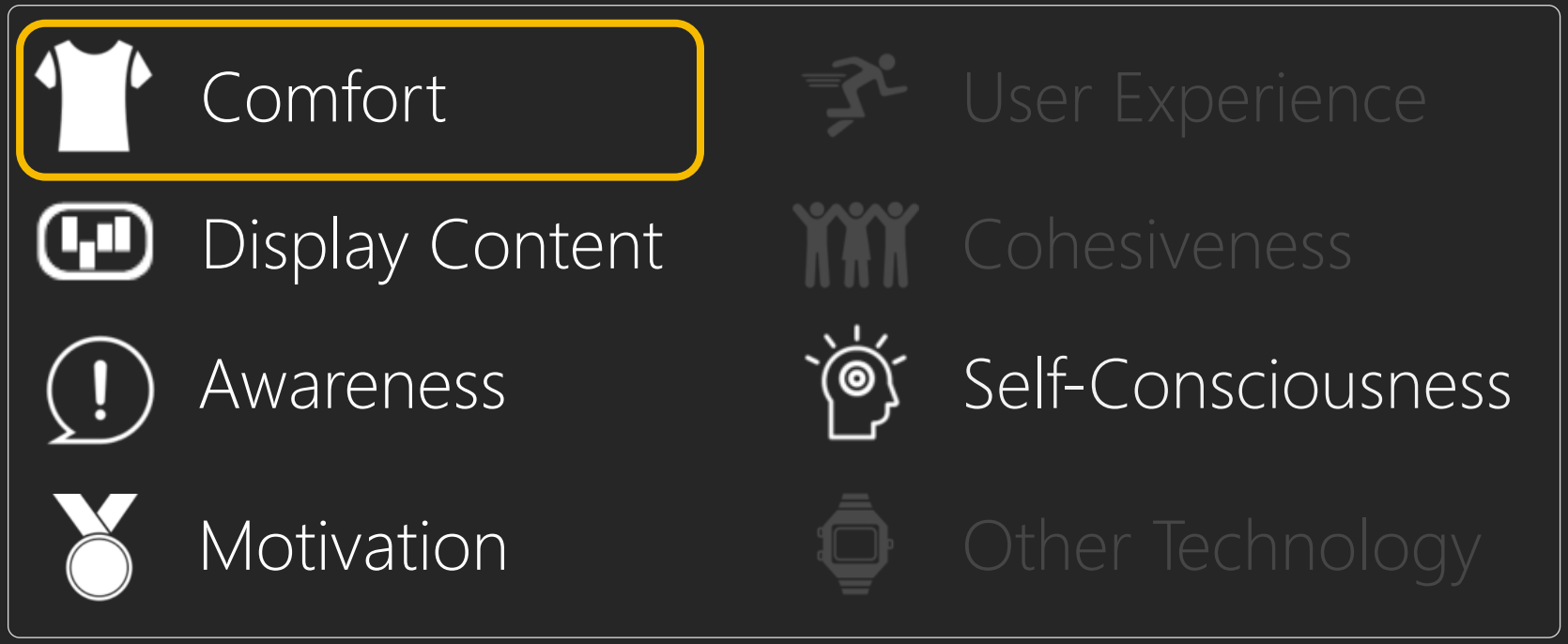
Field Study Results

Comfort; Wearers (N=19)

"Armband is heavy; other [equipment] was fine…"

-G2P1-W

SFF: Field Study Results



SFF: Field Study Results

Comfort

Display Content

Awareness

Motivation

User Experience

Cohesiveness

Self-Consciousness

Other Technology

Field Study Results

Display Content; All (N=52)

Rank Order List		Average Scores
Pace		1.5
Distance		2.2
Duration		3.1
Visualization		3.9
Heart Rate		4.3

SFF: Field Study Results

Comfort

Display Content

Awareness

Motivation

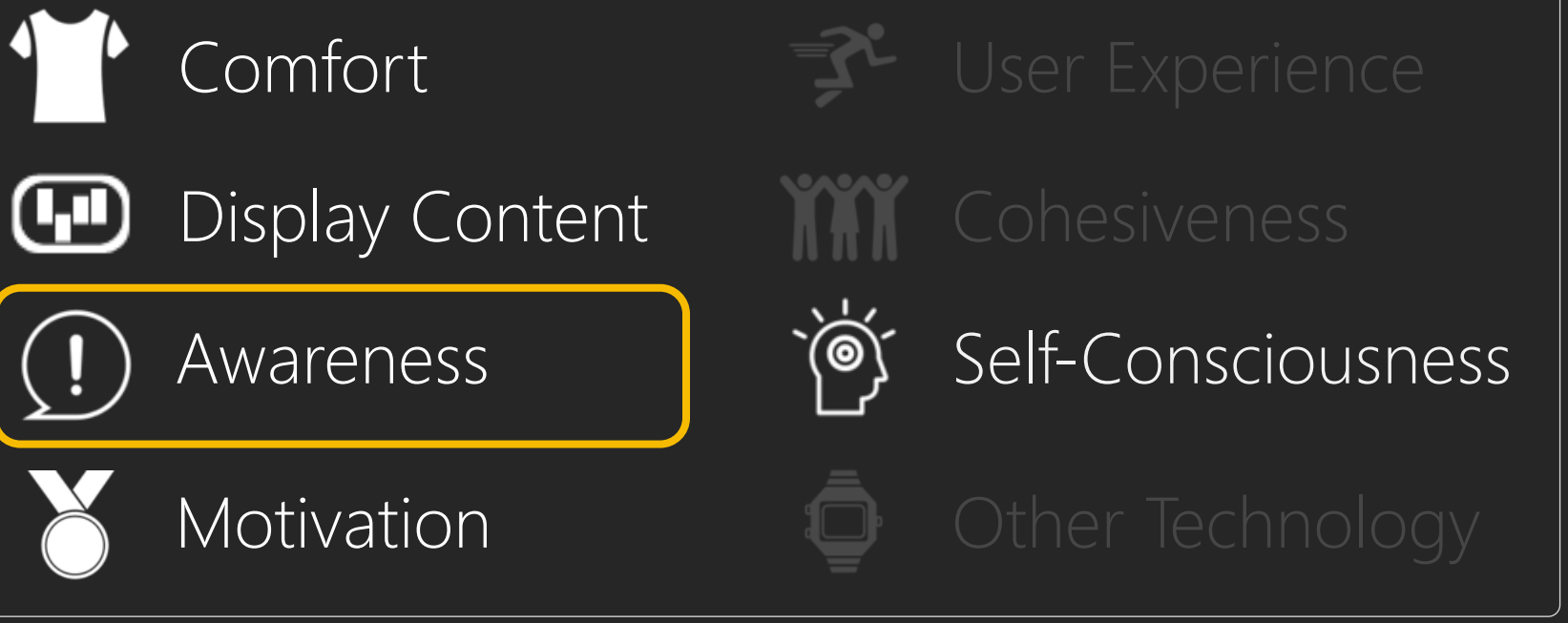
User Experience

Cohesiveness

Self-Consciousness

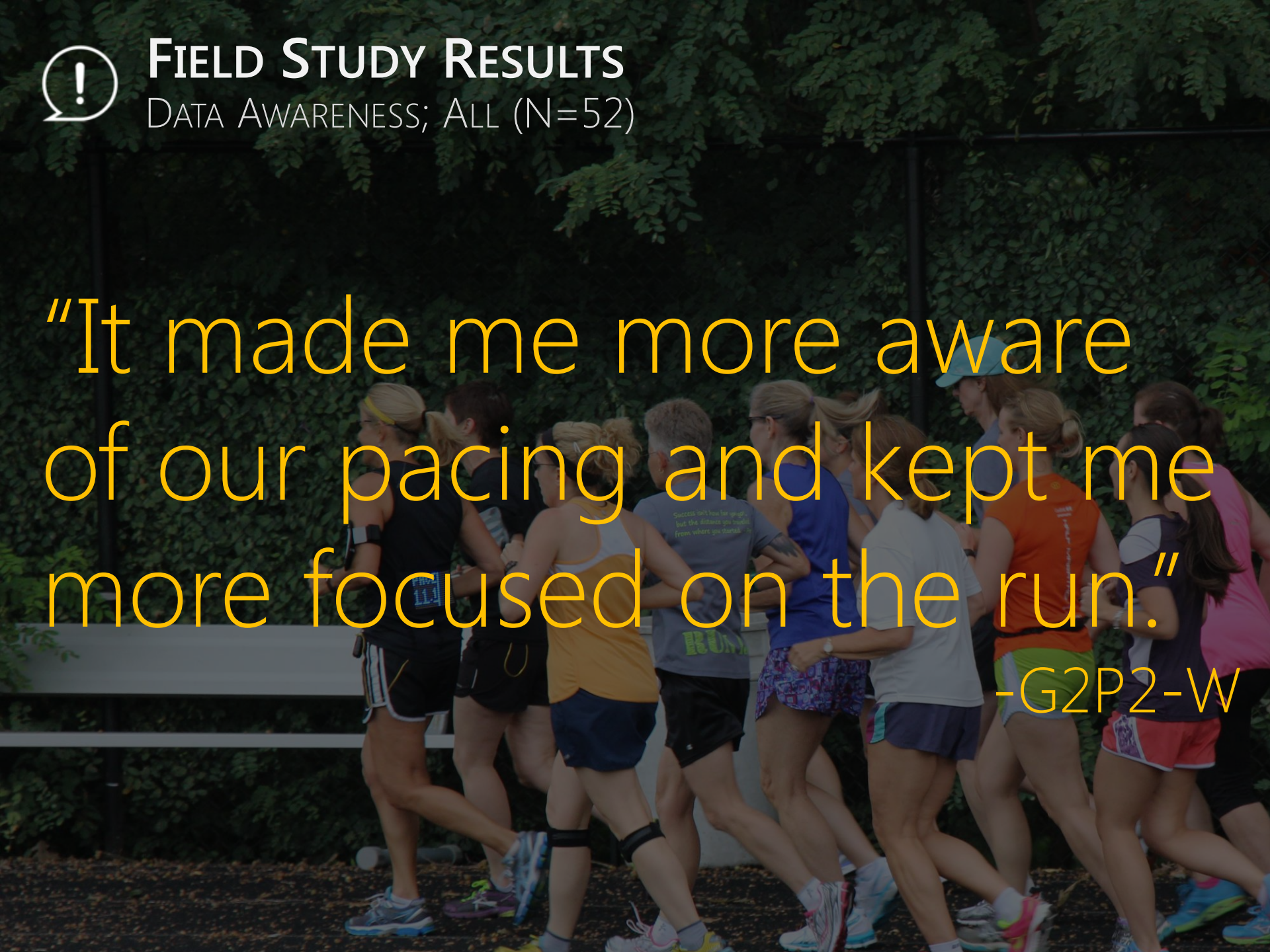
Other Technology

SFF: Field Study Results



Field Study Results

Data Awareness; All (N=52)



"It made me more aware of our pacing and kept me more focused on the run."

-G2P2-W

SFF: Field Study Results

Comfort

Display Content

Awareness

Motivation

User Experience

Cohesiveness

Self-Consciousness

Other Technology

SFF: Field Study Results

Comfort

Display Content

Awareness

Motivation

User Experience

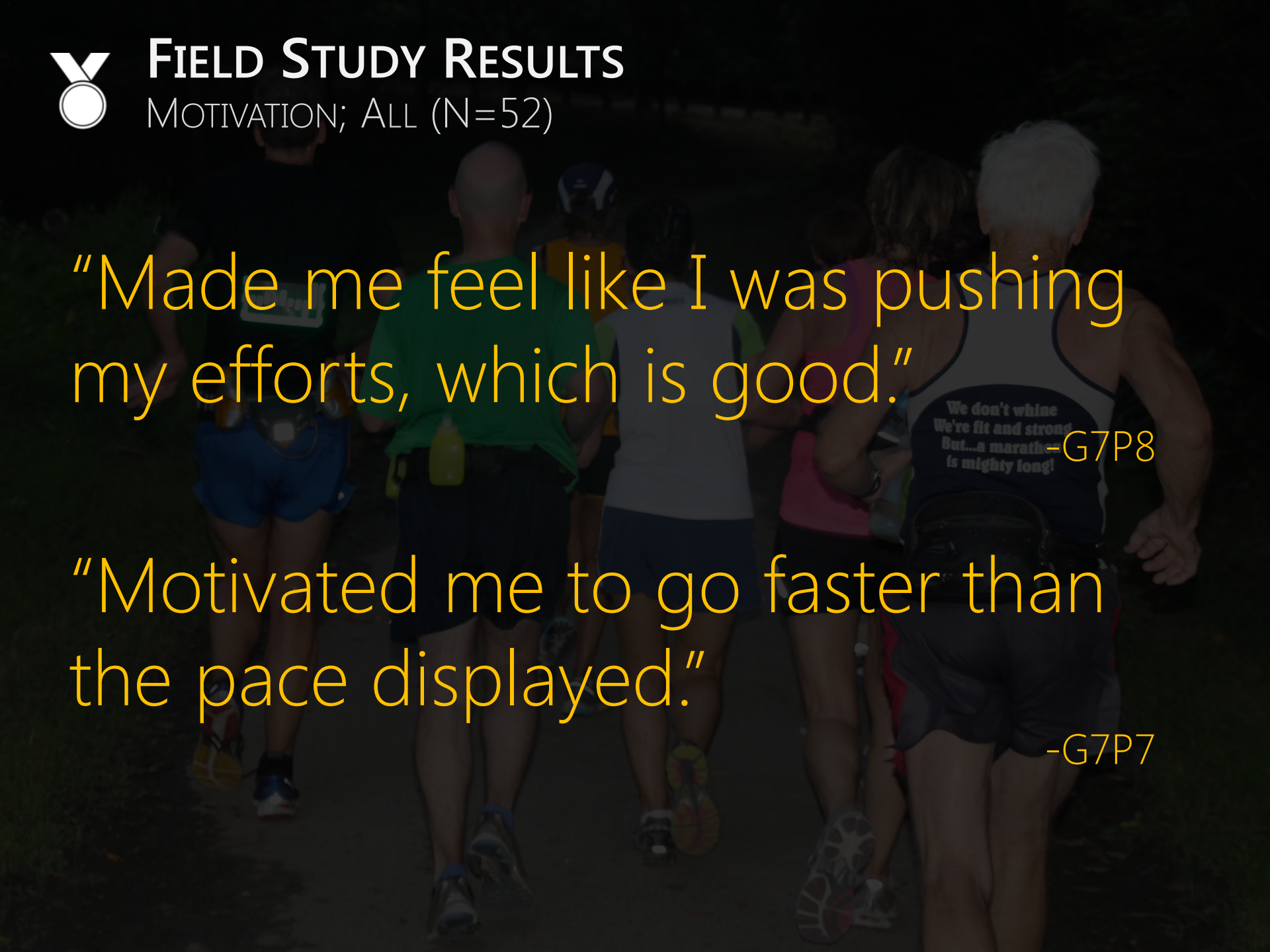
Cohesiveness

Self-Consciousness

Other Technology

Field Study Results

Motivation; All (N=52)



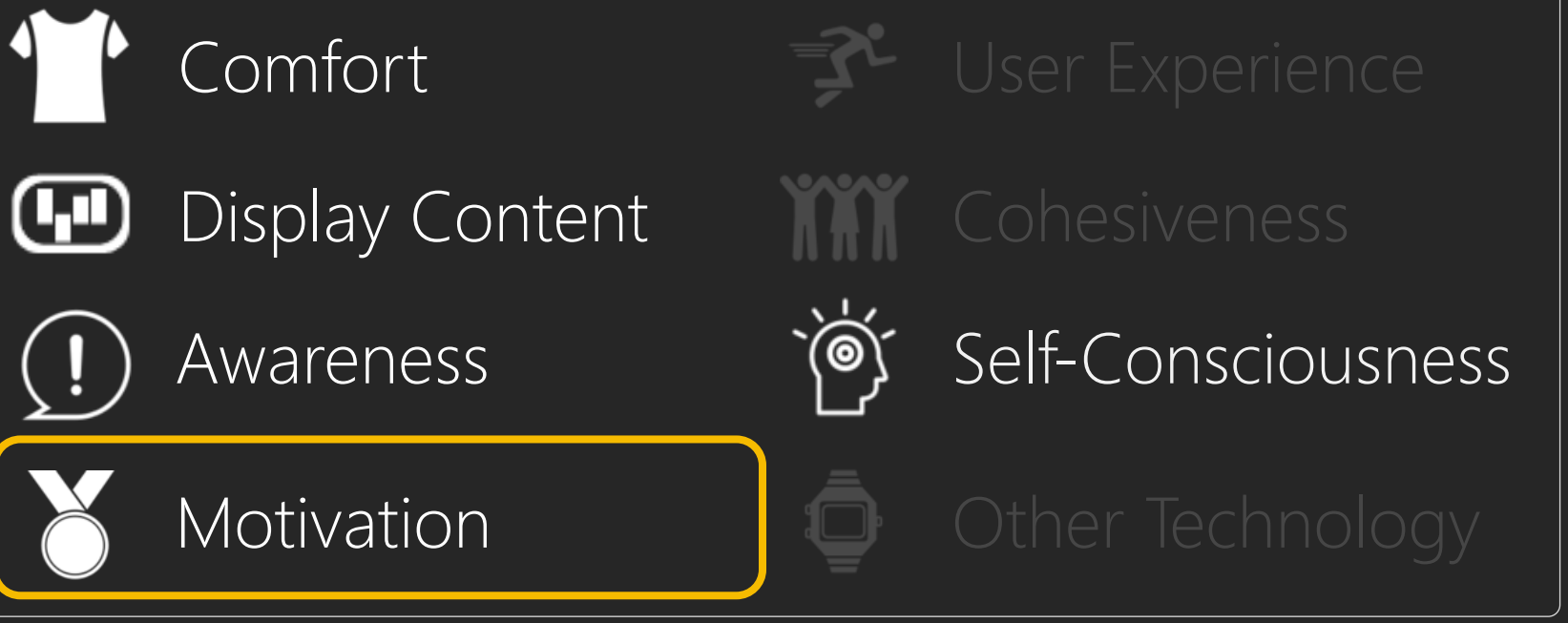
"Made me feel like I was pushing my efforts, which is good."

-G7P8

"Motivated me to go faster than the pace displayed."

-G7P7

SFF: Field Study Results



SFF: Field Study Results

Comfort

Display Content

Awareness

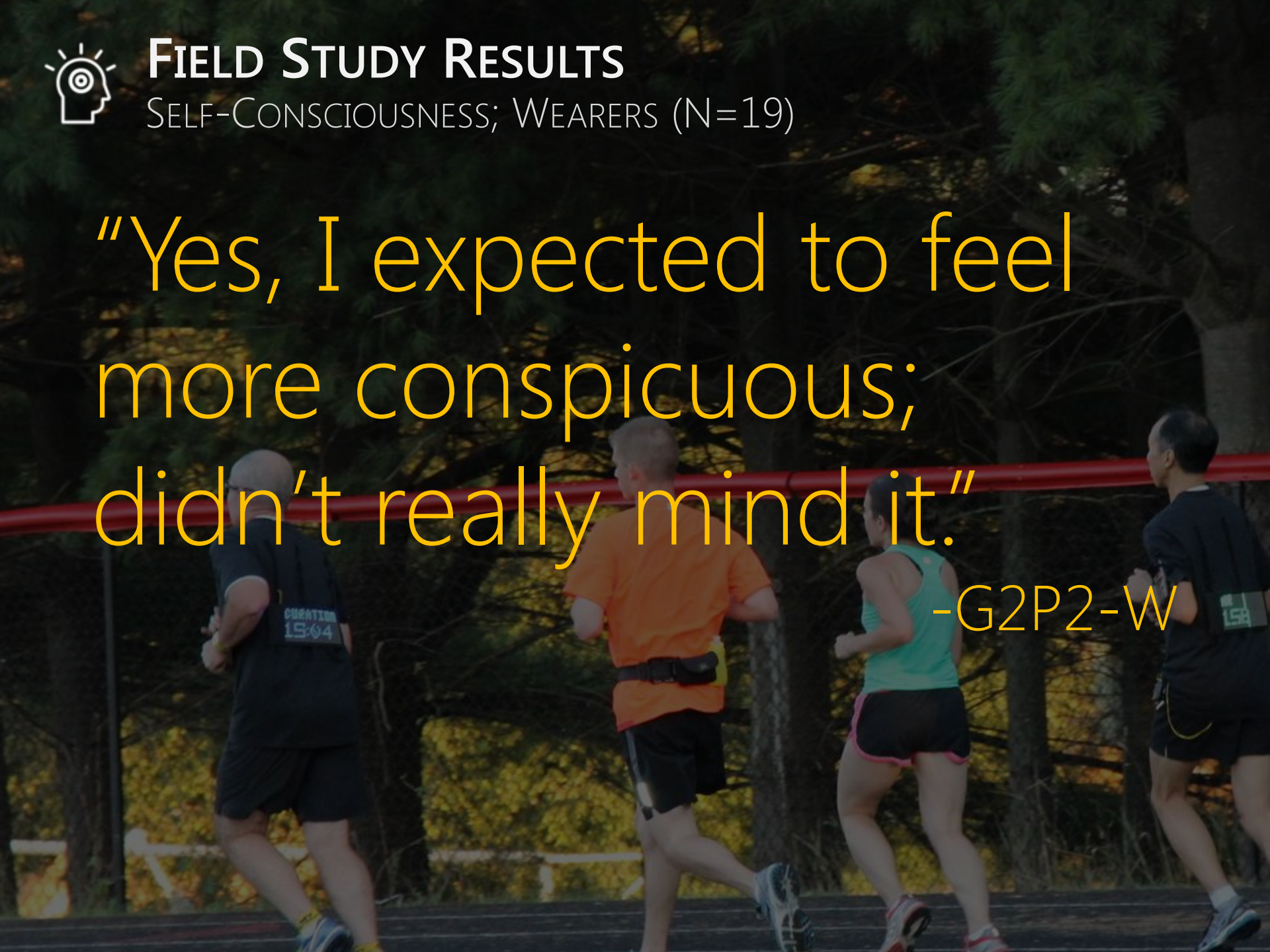
Motivation

User Experience

Cohesiveness

Self-Consciousness

Other Technology



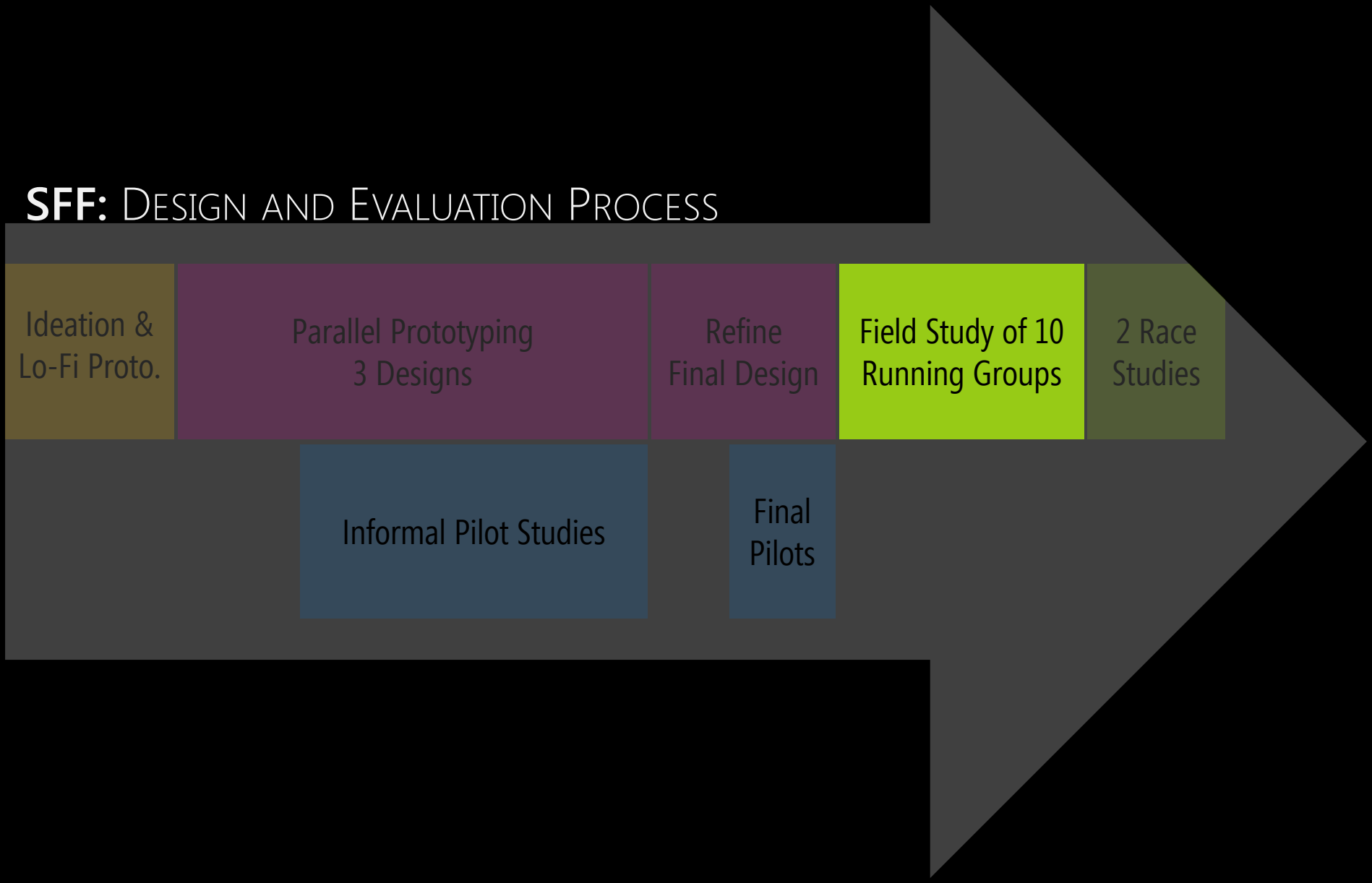
Field Study Results

Self-Consciousness; Wearers (N=19)

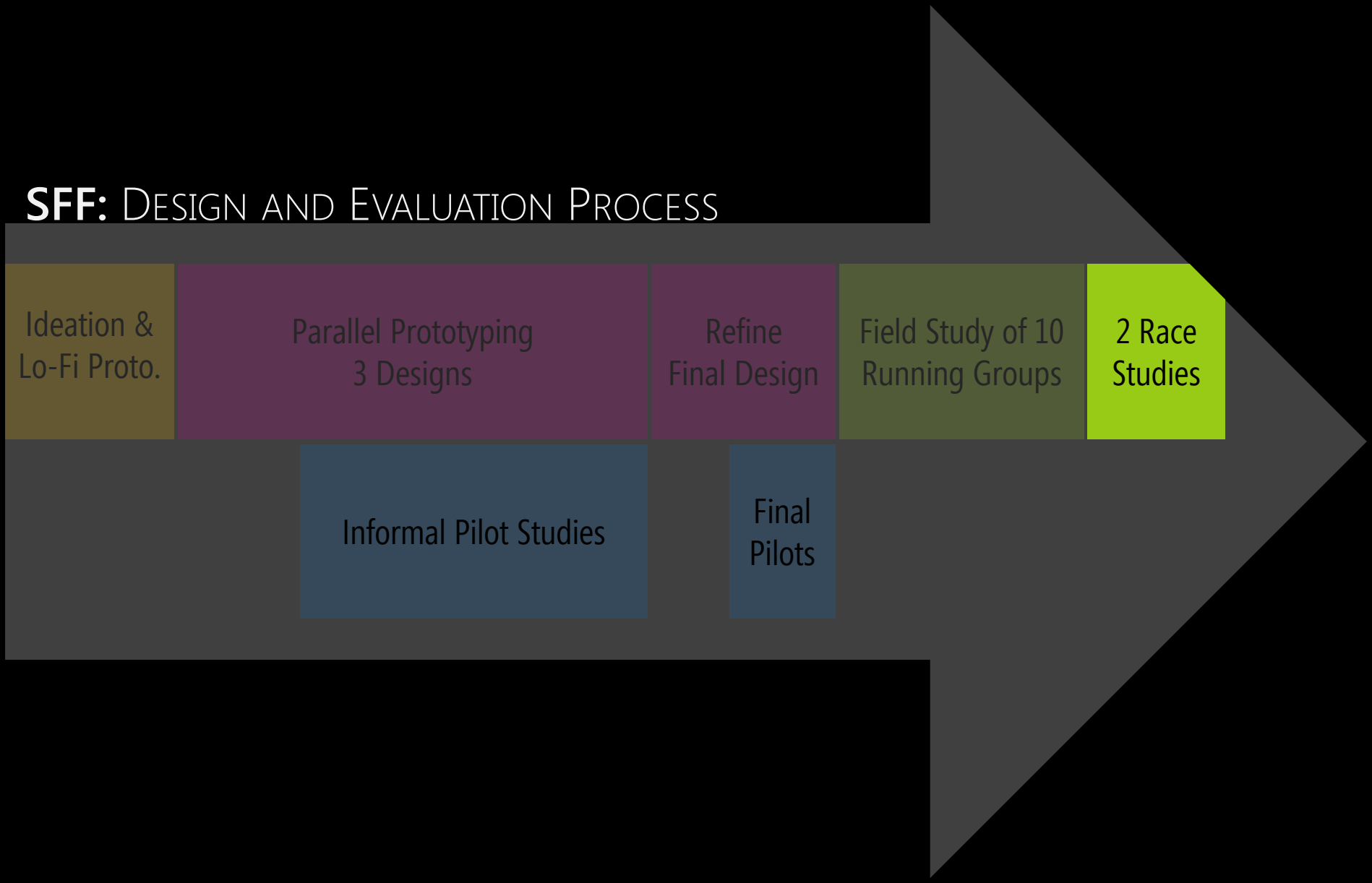
"Yes, I expected to feel more conspicuous; didn't really mind it."

-G2P2-W

SFF: Design and Evaluation Process



SFF: Design and Evaluation Process



Race Study Participants

4 Individuals (1 Female)

Male, 34

Target Pace: 6:10

County 8K

Female, 33

Target Pace: 8:20

County 8K

Male, 26

Target Pace: 7:45

Labor Day 10K

Male, 18

Target Pace: 8:30

Labor Day 10K

Race Deployment

Competitive Interactions

Gold Medal
Step Away from Cancer
5K Run/Walk
prevent cancer

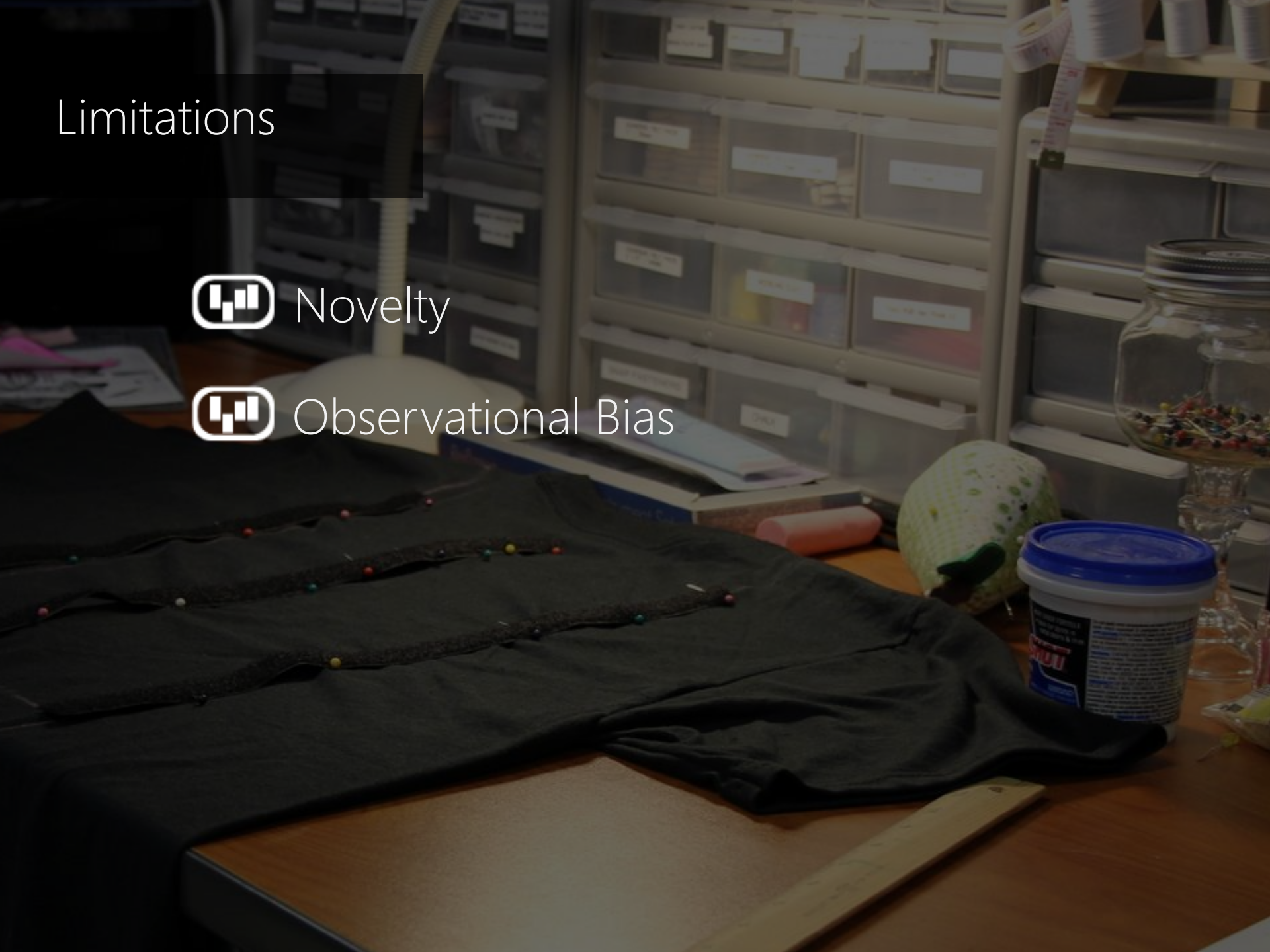
Race Study Results

Motivation; Wearers (N=4)

"It made me run faster because my performance was on display."

-R2P1-W

Limitations

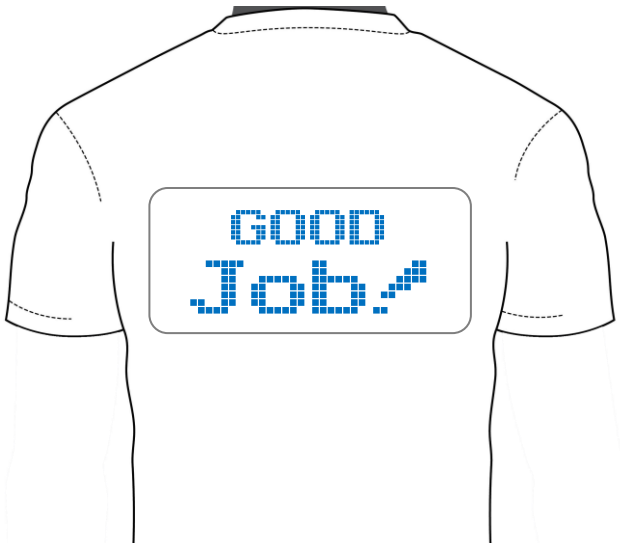


Limitations

- Novelty
- Observational Bias

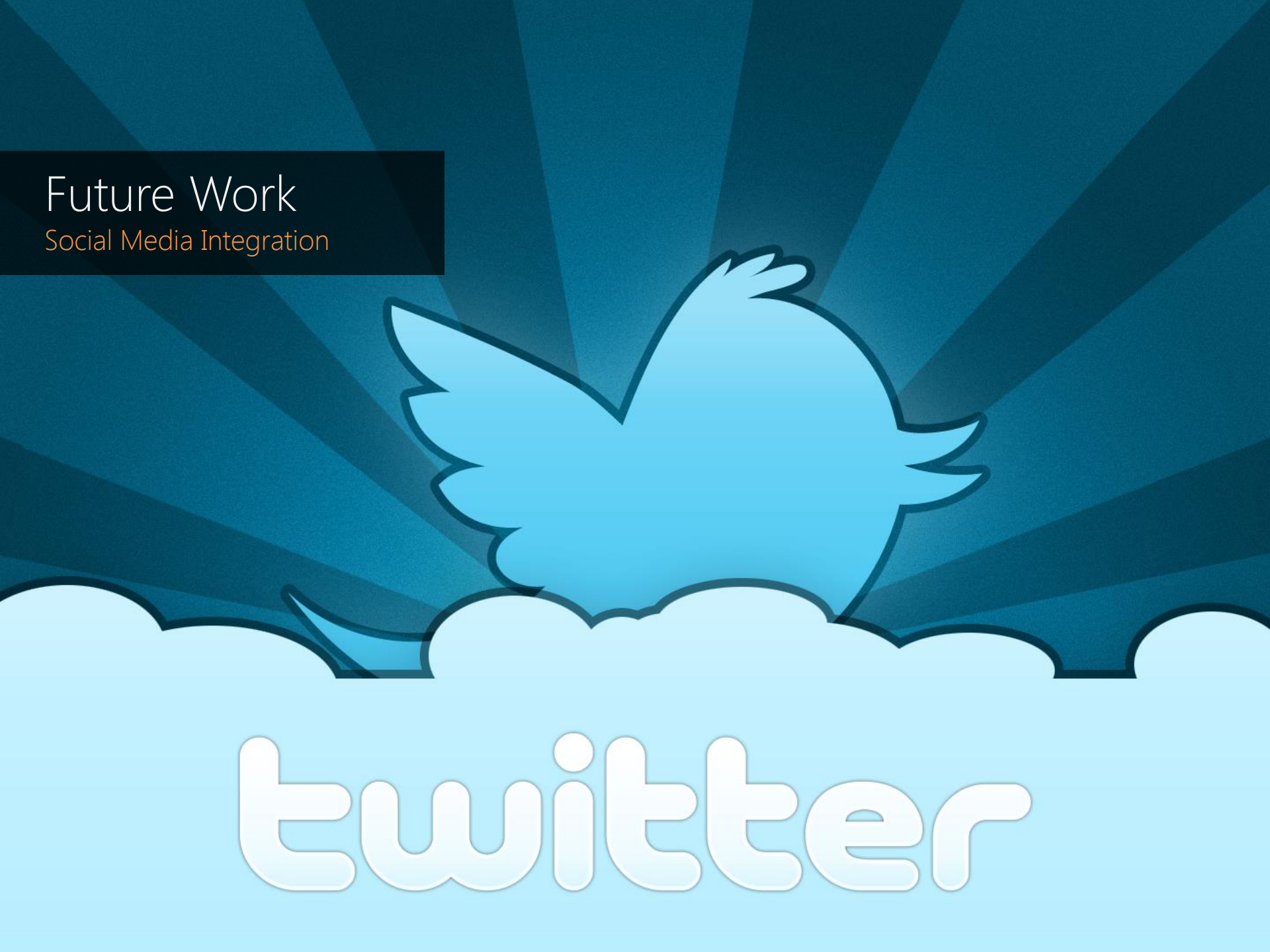
Future Work

Encouragement



Future Work

Social Media Integration



Future Work

Spectator Sports

Future Work

Cross Domains

Summary

This work contributes to two rapidly growing areas: personal informatics and wearable technology.

Through parallel prototyping, iterative design, and exploratory studies we demonstrate the potential to motivate group fitness performance with wearable technology.

Our Research Team:

Matt Mauriello
@mattm401

Michael Gubbels
@mokogobo

Jon Froehlich
@jonfroehlich

Thanks to our collaborators:
RunKeeper and **Erogear**

Thanks to **Nokia** for funding

Noun Project Icon Credits

Tshirt
Nithin Viswanathan
http://thenounproject.com/term/tshirt/25531/

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http://thenounproject.com/term/fire/8023/

Warning
Christopher Holm-Hansen
http://thenounproject.com/term/warning/52375/

Running
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http://thenounproject.com/term/running/17825/

Notepad
Lemon Liu
http://thenounproject.com/term/notepad/8155/

Education
Chris Matthews
http://thenounproject.com/term/education/3012/

Medal
Andrew J. Young
http://thenounproject.com/term/medal/3798/

Celebration
Scott Lewis
http://thenounproject.com/term/celebration/6215/

Awareness
Ivan Colio
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Watch
Kiran Malladi
http://thenounproject.com/term/watch/20778/

Weight Lifting
Nithin Viswanathan
http://thenounproject.com/term/weight-lifting/50882/

Calendar
Edaward Boatman
http://thenounproject.com/term/calendar/6730/

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"Marathon"	US Road Sports
"Watch"	Garmin Ltd.
"Mobile Application"	MapMyFitness, Inc.
"Group Running"	Unknown
"Goffman"	Open Library
"E39"	Under Armour, Inc.
"Reebok Checklight"	Reebok International
"TeamAWear"	*Pervasive Computing*, 2007
"Adidas miCoach Elite"	Adidas America Inc.
"iPhone"	Apple Inc.
"Google Maps"	Google Inc.
"Heart Rate Monitor"	Polar Electro
"Twitter"	Twitter Inc.
"Swimming"	International Olympic Committee