

# Software Engineering for Additive Manufacturing

Stephanie Rosenthal, PhD



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# Software Engineering for Additive Manufacturing

Stephanie Rosenthal, PhD

Rick Kazman and Kurt Wallnau (SEI)

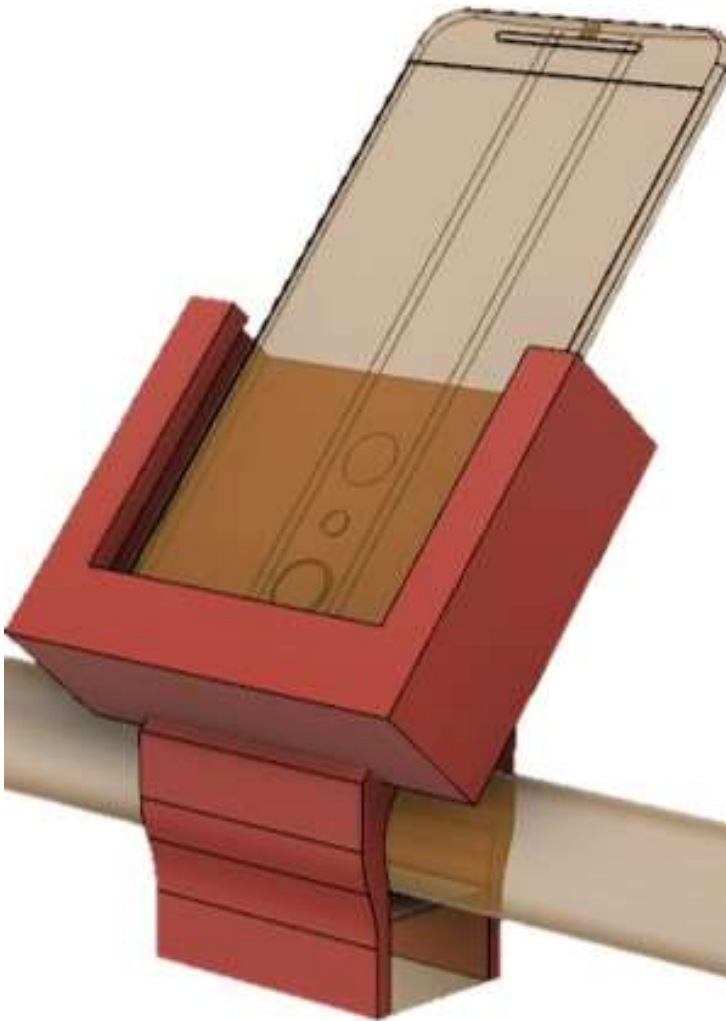
Megan Hofmann, Prof. Jennifer Mankoff,  
Prof. Scott Hudson (CMU HCII)

# 3D Printing Enables Manufacturing in Remote Areas

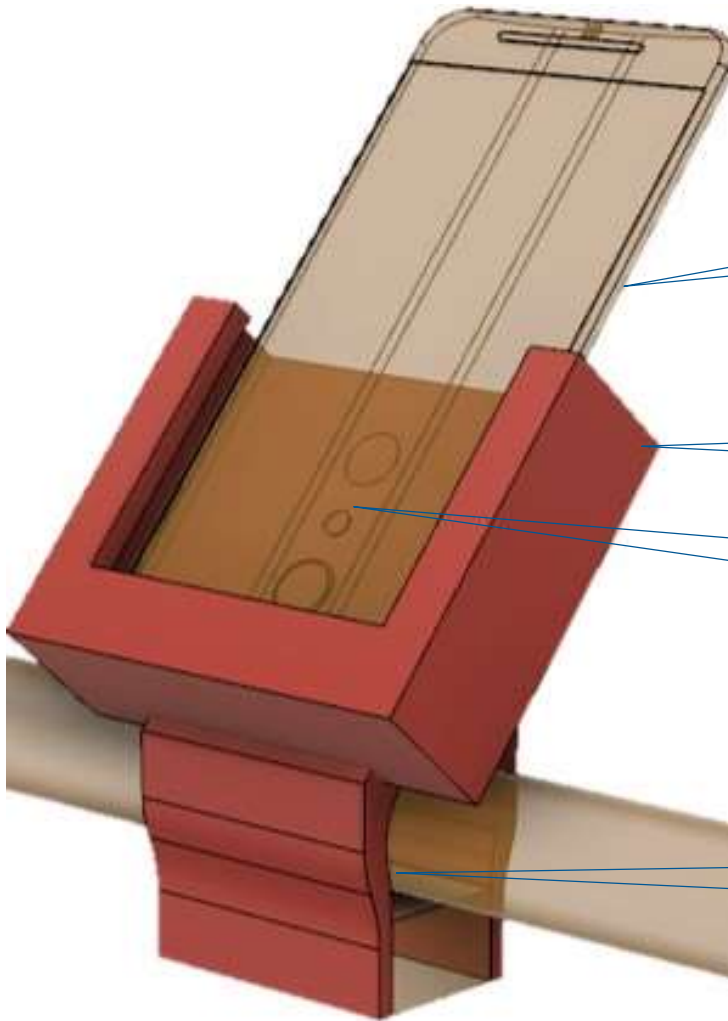




# 3D Modeling for Additive Manufacturing



# Why is 3D Modeling Hard?



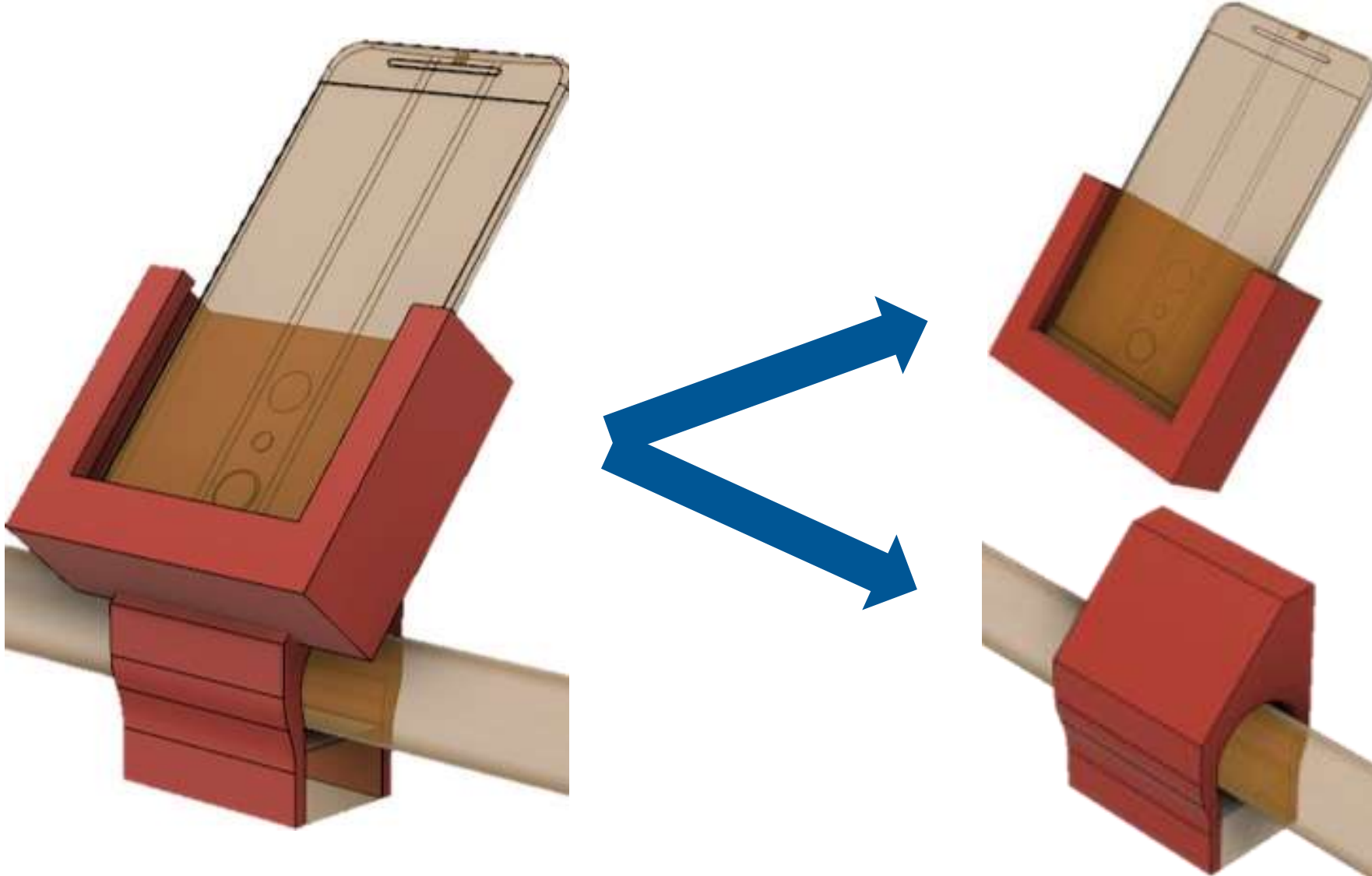
The model should fit tightly to the phone but not so tight that it does not fit

The print should be thick enough so that the object does not break with wear

The screen should be at a readable angle and should not be occluded

The clamp should fit tightly to the bar but not so tight that it does not fit

# Functional Modularity of 3D Models



# PARTs: Parameterizable Abstractions of Reusable Things

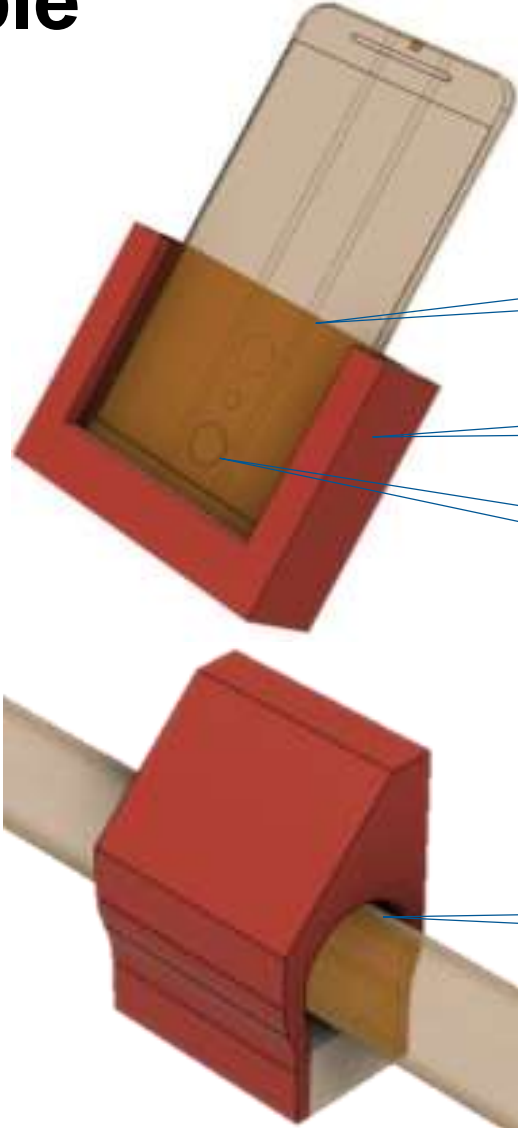


- 1) Allow modelers to decompose their complex models into components
- 2) Assign logic constraints to the geometry of the components to represent the modeler's intentions of how it is meant to interact with other models and physical objects
  - **Logical Assertions** – validatable rules about what components should look like and how they should be printed
  - **Integrators** – how to connect multiple models together (union, cut)



# PARTs: Parameterizable Abstractions of Reusable Things

## Example



The model should fit tightly to the phone but not so tight that it does not fit

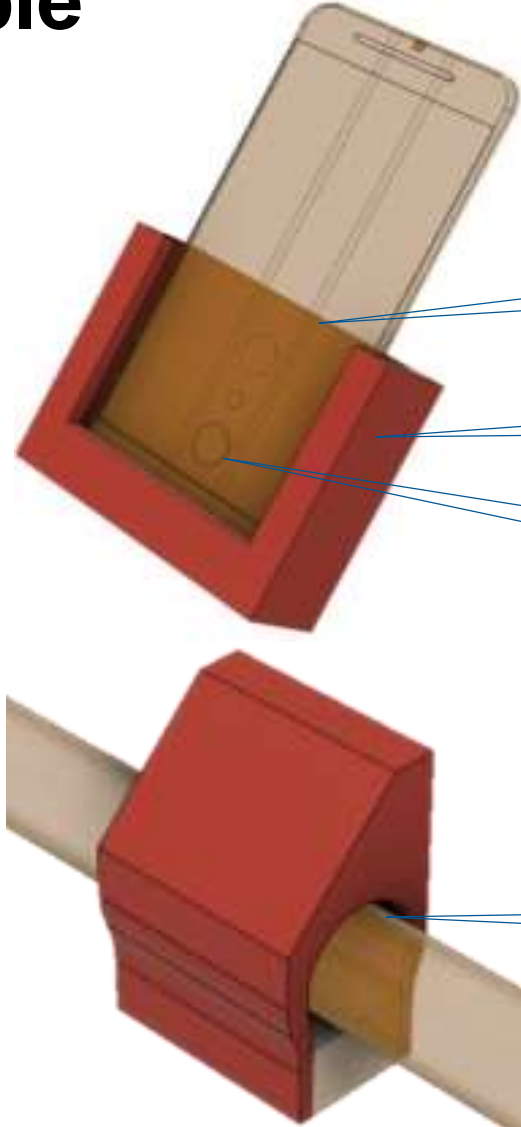
The print should be thick enough so that the object does not break with wear

The screen should be at a readable angle and should not be occluded

The clamp should fit tightly to the bar but not so tight that it does not fit

# PARTs: Parameterizable Abstractions of Reusable Things

## Example



Phone exterior + tolerance  
= Model interior

Model thickness > X mm

Phone screen + tolerance  
= Model front

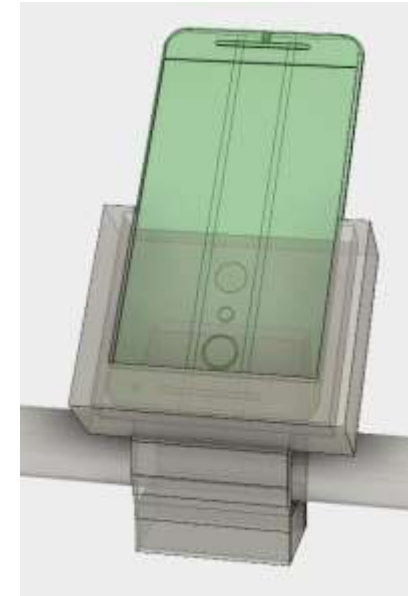
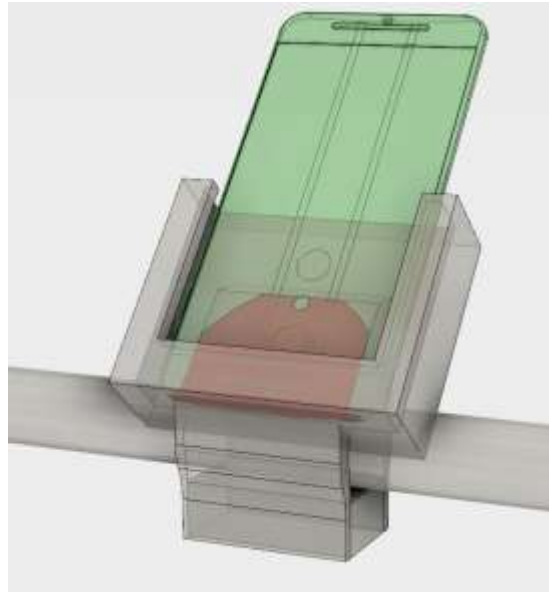
Bike radius + tolerance  
= Clamp radius

# PARTs: Parameterizable Abstractions of Reusable Things

## Example

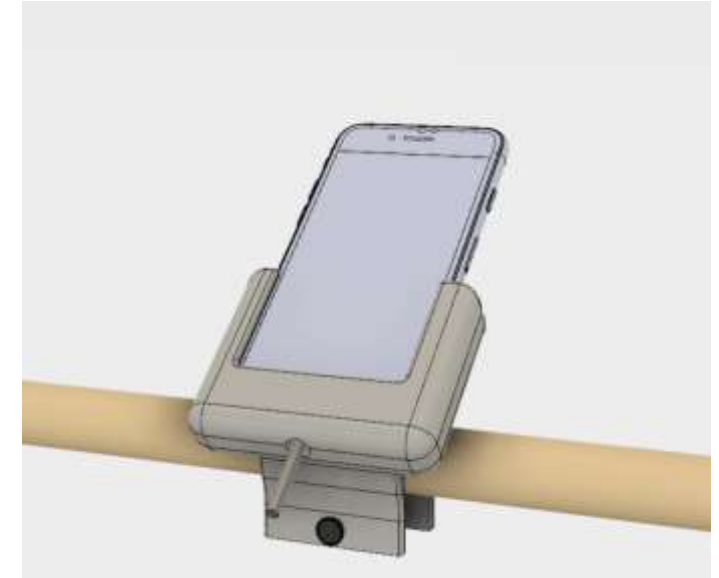


Each assertion is verified and flagged as red in the model if it is invalid individually and/or when composed



Valid models meet all assertion requirements set by the modeler

# PARTs Enable Modular Designs



Add a hole for headphones

Change the phone model  
and handlebar width



# PARTs Enable Modular Designs



## Contributions:

- 1) Allow modelers to decompose their complex models into components
- 2) Assign logic constraints to the geometry of the components to represent the modeler's intentions of how it is meant to interact with other models and physical objects

Implemented in Fusion360 computer aided design CAD software

Next steps: apply and formalize other software properties for 3D models

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srosenthal@sei.cmu.edu