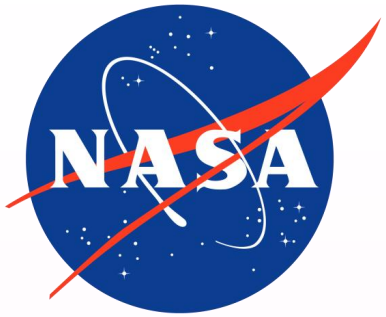


WEARABLE PROTECTIVE TECHNOLOGIES

Nicole Dugan

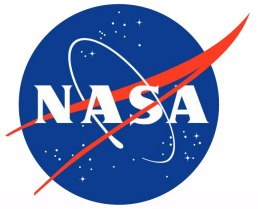
Sheila Thibeault

Crystal Chamberlain

OBJECTIVE

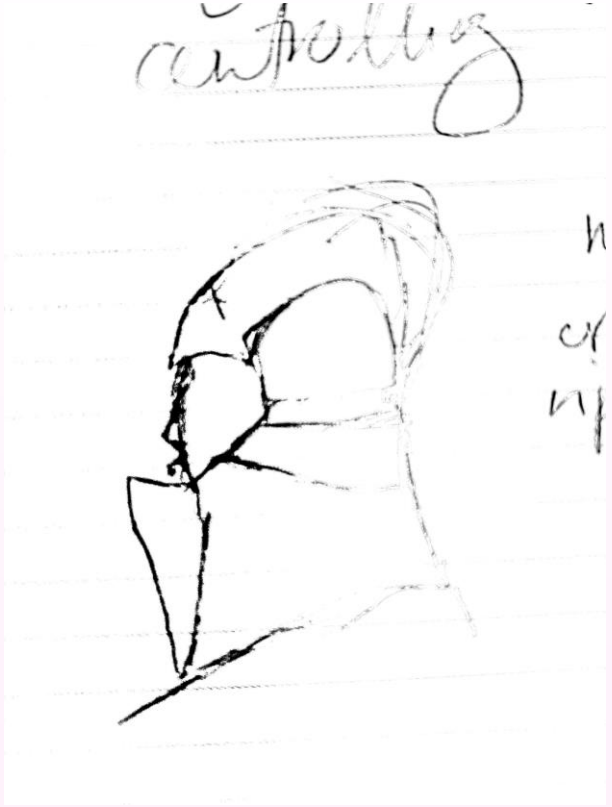
- We are currently creating protective garments to be worn during the duration of SPEs (solar particle events)[4]
- We have created several garment prototypes but have not focused as much on head protection
- Hood design needs to cover forehead and not have any gaps between the hood and neckline
- Areal density of radiation shielding needs to be at least 1.5 g/cm2 for head gear[4]

INSPIRATION



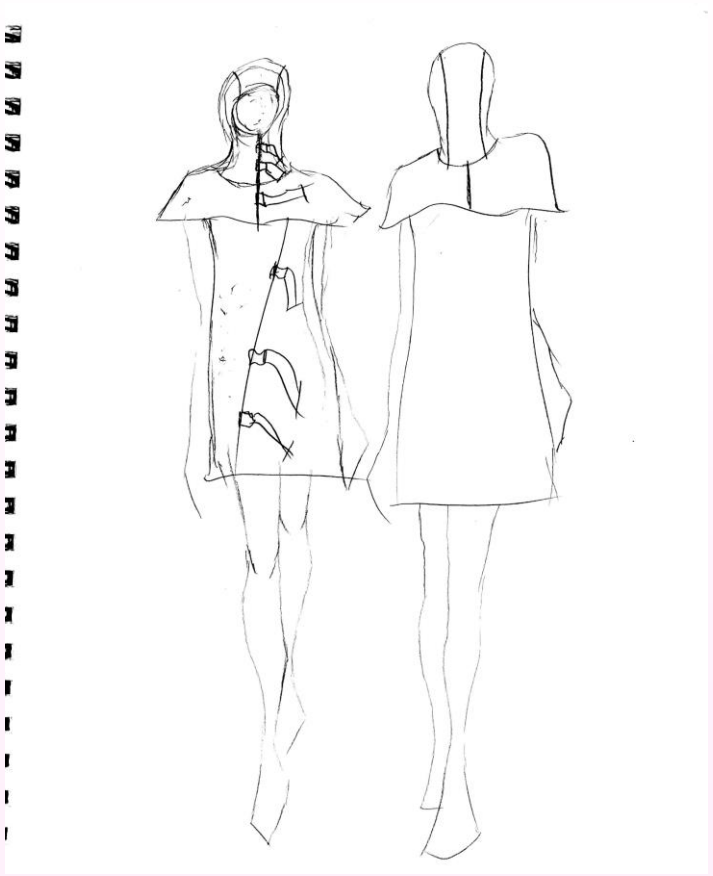
- Nike outerwear[15]
- Moncler Genius F 20 collections 4 (Simone Rocha)[11], 5 (Craig Green)[12], 6 (Alyx)[13]
- Marine Serre F/W 20[8]
- A-Cold-Wall S/S 19[1]
- Editorials and fashion that had futuristic, industrial, or space themes
- Game of Thrones[17]

SKETCHES



Early sketches of hoods.

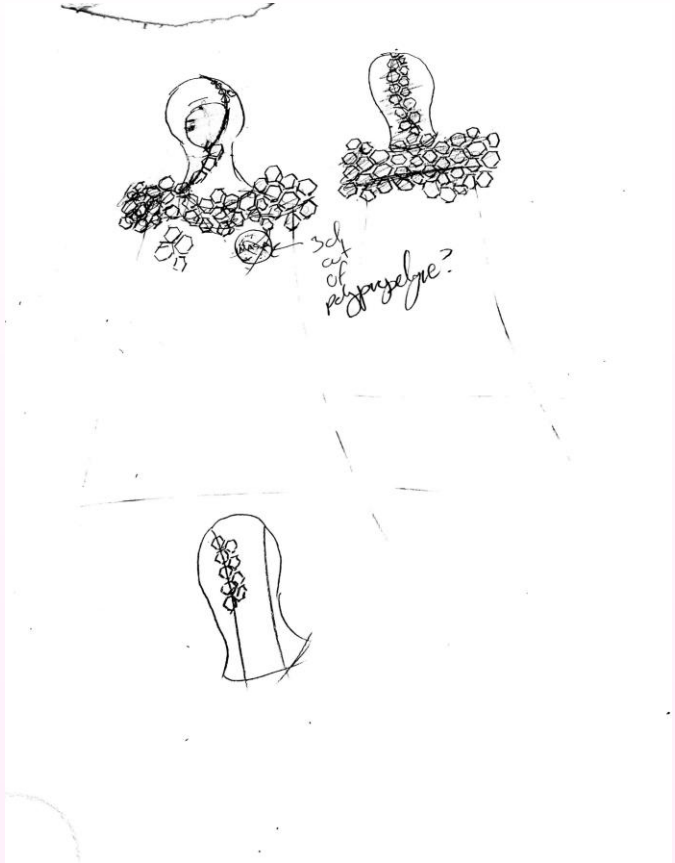
SKETCHES

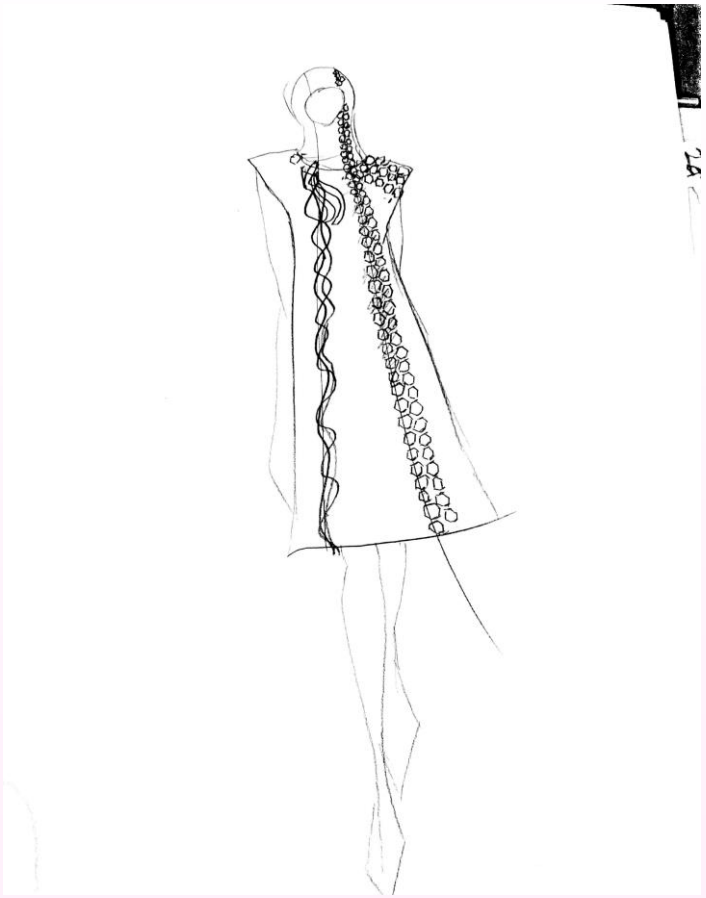


Center panel hood with kimono shoulder.

Hood incorporated into garment.

SKETCHES





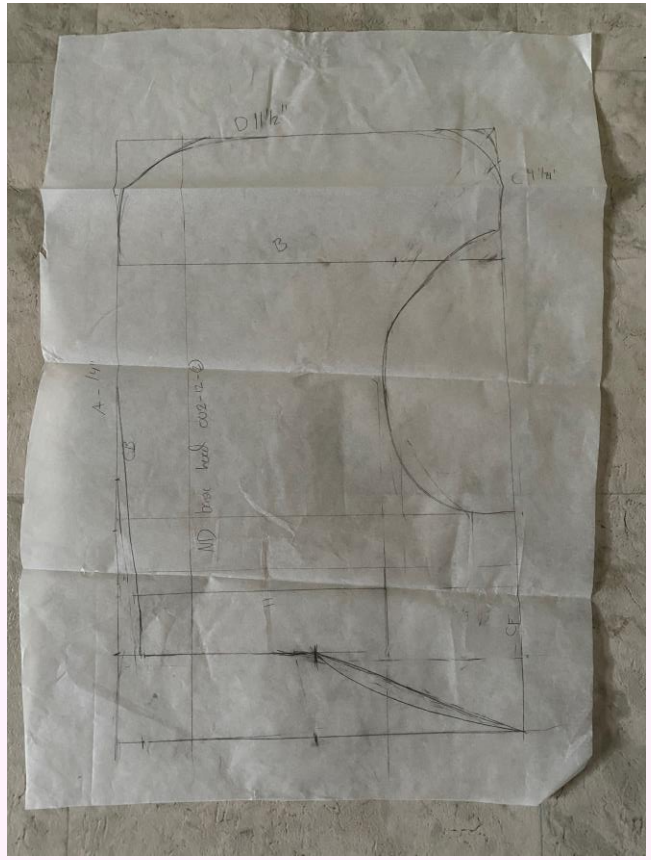
Incorporating 3d printed polypropylene into designs.

HOOD PATTERN DEVELOPMENT

Took several measurements of the head and neck:

- Circumference of head to base of neck
- Width of head at eye level (head depth)
- Circumference of head just above eyebrows
- Forehead length
- Chin to base of neck

HOOD PATTERN DEVELOPMENT



Basic hood pattern.[2]

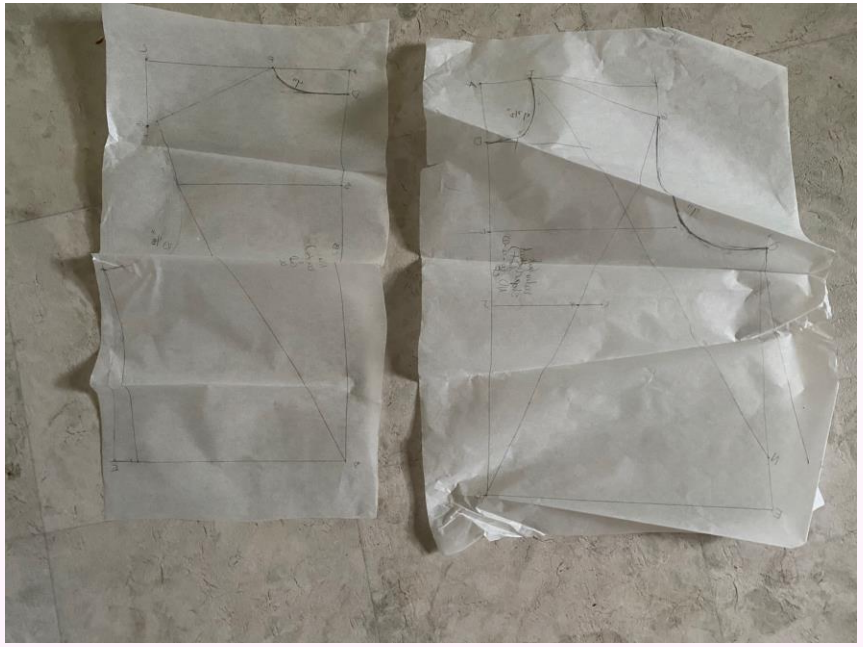
First version of hood with center panel.[5]

Side hood panels with fitting corrections.

SHOULDER PATTERN DEVELOPMENT

- Created basic bodice sloper without bust darts[6]
- Neckline and shoulders
- Used basic sloper to create shoulder drape
- Shoulder drape is based on all in one kimono sleeve[6]
- Center back seam is the only seam in this design
- Used neckline of this to create neckline of hood

SHOULDER PATTERN DEVELOPMENT



Shoulder and neckline sloper.[6]

Kimono style shoulder.[6]

RADIATION SHIELDING

- Previous prototypes have used polyethylene film, but it has many challenges when incorporated into garments
- Researched different materials to incorporate into headgear design as radiation shielding
- 3D printed polypropylene hexagon and lattice structure
- Polypropylene and Kevlar fabric were used in a study for radiation shielding on the ISS – and the results were that Kevlar was comparable[14]

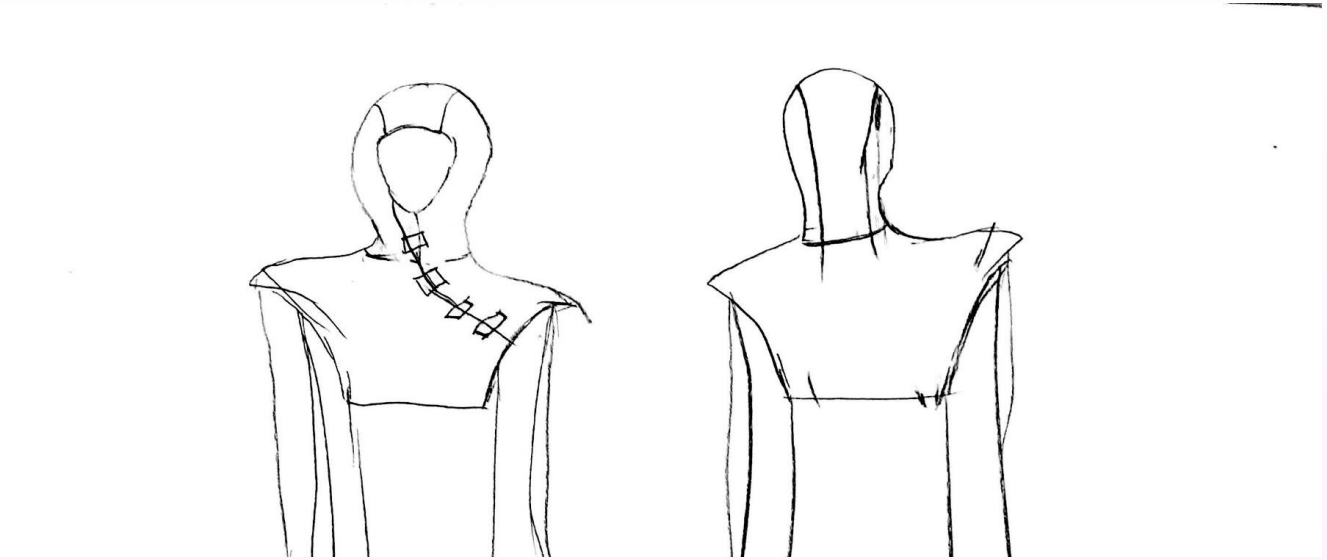
RADIATION SHIELDING

- Materials for space radiation shielding need to be hydrogen rich in order to be effective[4]
- Many common textile fibers are made out of or have hydrogen rich polymers
- Polyester – chemically similar to polypropylene and polyethylene[9]
- Cotton – 95% cellulose ($C_6H_{10}O_5$), an abundant natural polymer[9]
- Silk – 45% of chemical makeup is amino acid glycine (H-)[9]
- Any time a fabric is used the garment will most likely be more wearable, flexible and comfortable than just relying on forms of polypropylene or polyethylene for shielding

RADIATION SHIELDING

- GSM (grams per square meter) is commonly used to measure the weight of fabrics, and is a form of areal density
- Lightweight fabrics – less than 135 GSM[7]
- Mediumweight fabrics – 135-200 GSM[7]
- Heavyweight fabrics – over 200 GSM[7]
- More accurate way to judge the shielding of a fabric because it considers both the weave of the textile and density of the fiber

PLANNED PROTOTYPE DESIGN



Center panel hood with asymmetric kimono style shoulder drape.

PLANNED PROTOTYPE PATTERN

Asymmetrical variation of center panel hood and kimono shoulder patterns.

PLANNED PROTOTYPE MATERIALS

- Outer fabric – bottomweight cotton twill[19]
- Lining – matte jersey[18]

Inner shielding:

- 6 layers of 3D printed polypropylene sewn onto front and back of 3 layers of denim[3]

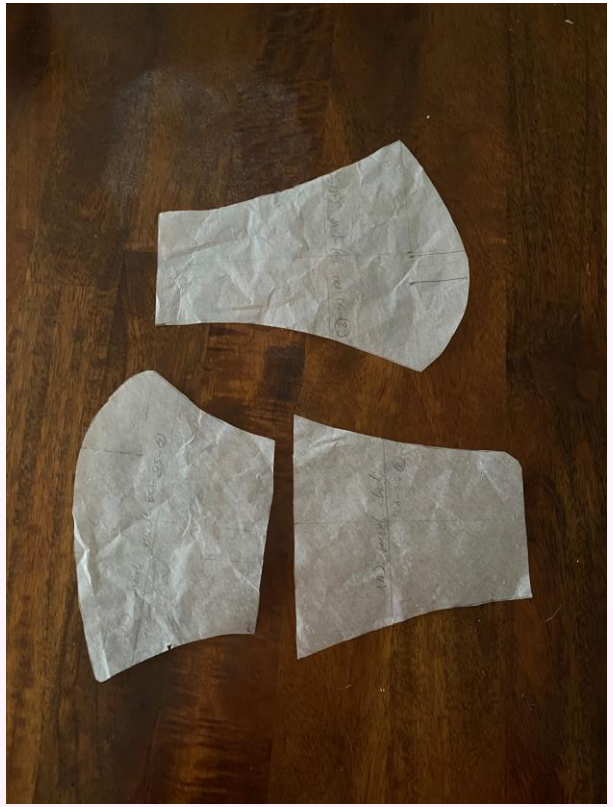
PLANNED PROTOTYPE MATERIALS

Areal density of materials:

- 3d printed polypropylene - .291 g/cm^2
- Cotton denim - .406 g/cm^2 [3]
- Cotton twill - .268 g/cm^2 [17, 19]
- Polyester jersey - .156 g/cm^2 [10, 18]
- (6*.291)+(3*.406)+.268+.156=3.39 g/cm^2

Total areal density of headgear materials- 3.39 g/cm^2

MASK EFFORT



Mask patterns.

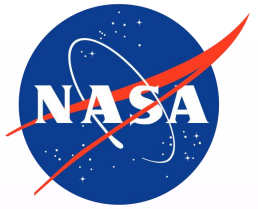
Front view of mask.

Back view of mask.

NEXT STEPS

- Making more patterns and prototypes
- Incorporating 3D printing
- Incorporating polyethylene film
- Digitizing patterns
- Creating more combinations of materials
- Kevlar, Nomex, other fabrics mentioned previously
- Putting more ideas into production

ACKNOWLEDGEMENTS



Sheila and Crystal

Martha, Julie, Sesh, and Charlie

Juliana and Wes

D307

AES/Radworks

Kelvin Boston

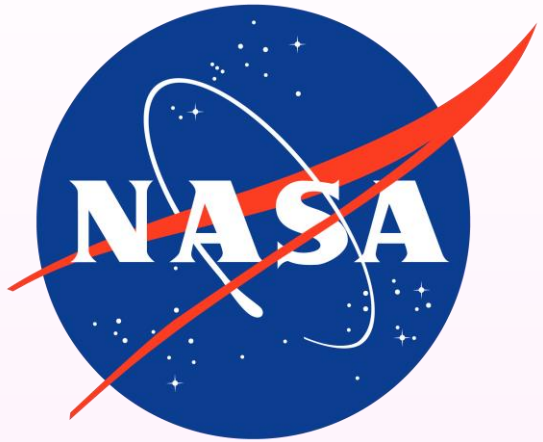
Makerspace

NIFS coordinators

Iowa State University

REFERENCES

1. *A-cold-wall* ss19*. (n.d.). Dazed. Retrieved April 17, 2020, from https://www.dazeddigital.com/fashion/gallery/25298/15/a-cold-wall-ss19
2. *Basic hood, the pattern drafting*. (n.d.). Retrieved April 17, 2020, from https://www.youtube.com/watch?v=akMjRmijQsA
3. *Bottomweight denim fabric 57"-blue texture | joann*. (n.d.). Retrieved April 20, 2020, from https://www.joann.com/bottom-weight-denim-fabric--12-oz-blue-texture/1287929.html#q=denim&start=1
4. Hanson, J., Clowdsley, M., & Thibeault, S. (2020, January 28). *NASA Wearable Equipment for Averting Radiation (WEAR) Challenge 2020 Online Student Webinar*.
5. *Hood pattern modification*. (2017, August 1). Youtube. https://www.youtube.com/watch?v=TZaSgGryJAc
6. Joseph-Armstrong, H. (2010). *Patternmaking for fashion design* (5th ed). Pearson Education/Prentice Hall.
7. Kadolph, S. J., & Marcketti, S. B. (2017). *Textiles* (Twelfth edition). Pearson.
8. *Marine serre fall 2020 ready-to-wear fashion show*. (2020, February 25). Vogue. https://www.vogue.com/fashion-shows/fall-2020-ready-to-wear/marine-serre
9. Mather, R. R., & Wardman, R. H. (2011). *The chemistry of textile fibres*. Royal Society of Chemistry.
10. *Mellow Yellow Matte Jersey*. (n.d.). Retrieved April 20, 2020, from https://www.moodfabrics.com/mellow-yellow-matte-jersey-326072
11. *Moncler 4 Simone Rocha Fall 2020 Ready-to-Wear Collection*. (2020, February 19). Vogue; Vogue. https://www.vogue.com/fashion-shows/fall-2020-ready-to-wear/moncler-4-simone-rocha
12. *Moncler 5 craig green fall 2020 ready-to-wear fashion show*. (2020, February 19). Vogue. https://www.vogue.com/fashion-shows/fall-2020-ready-to-wear/moncler-5-craig-green
13. *Moncler 6 1017 alyx 9sm fall 2020 ready-to-wear fashion show*. (n.d.). Vogue. Retrieved April 17, 2020, from https://www.vogue.com/fashion-shows/fall-2020-ready-to-wear/moncler-6-1017-alyx-9sm
14. Narici, L., Casolino, M., Di Fino, L., Larosa, M., Picozza, P., Rizzo, A., & Zaconte, V. (2017). Performances of Kevlar and Polyethylene as radiation shielding on-board the International Space Station in high latitude radiation environment. *Scientific Reports*, *7*(1), 1644. https://doi.org/10.1038/s41598-017-01707-2
15. *Nike x mmw sherpa jacket. Nike. Com*. (n.d.). Nike.Com. Retrieved April 17, 2020, from https://www.nike.com/t/mmw-sherpa-jacket-7B70Tt/CK1541-010
16. *Rag & Bone Sturdy Cotton Twill*. (n.d.). Retrieved April 20, 2020, from https://www.moodfabrics.com/rag-bone-navy-sturdy-cotton-twill-326113
17. Renfro, K. (n.d.). *Inside the new battle-ready looks of the "Game of Thrones" queens*. Insider. Retrieved April 17, 2020, from https://www.insider.com/game-of-thrones-costume-designer-michele-clapton-interview-2017-6
18. *Sew classic knit jersey fabric-super matte | joann*. (n.d.). Retrieved April 20, 2020, from https://www.joann.com/sew-classic-knit-black-super-matte-jersey/prd32707.html#srule=best-sellers&start=1
19. *Sportswear apparel stretch twill fabric solids | joann*. (n.d.). Retrieved April 20, 2020, from https://www.joann.com/sportswear-apparel-stretch-twill-fabric-solids/zprd_15775323a.html#srule=best-sellers&sz=90&start=1


NASA