The Evolution of Airport Terminal Wayfinding Technologies

Bonnie Powell
National Renewable Energy Laboratory (NREL)

Webinar: Enhancing the Airport Experience with Wayfinding
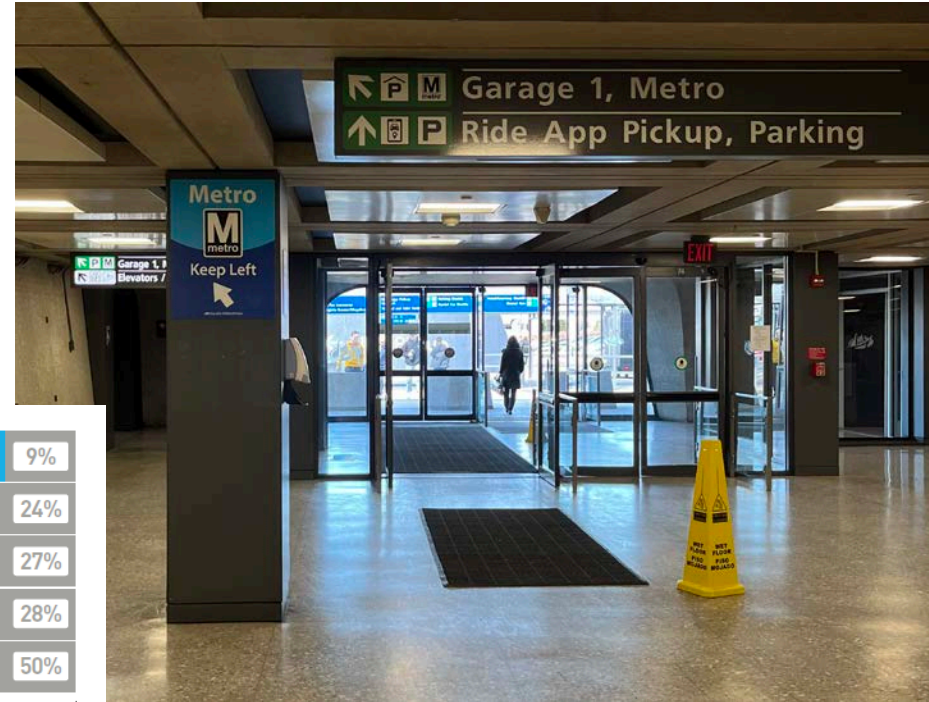
May 23, 2024

Bonnie Powell

✈ Researcher / energy engineer

✈ Collaborates with the Energy Security & Resilience Center and the Center for Integrated Mobility Sciences within NREL
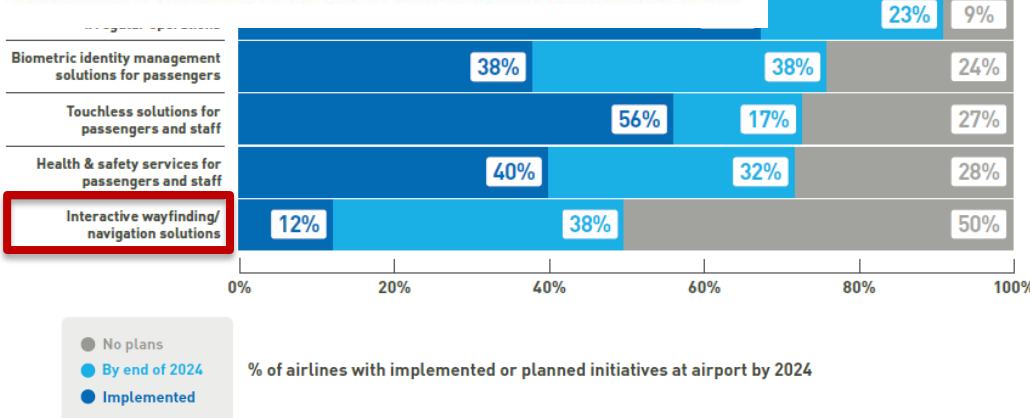
Photo by Werner Slocum, NREL

Wayfinding Motivation

- Improve passenger experience
- Reduce congestion
- Reduce energy consumption (e.g., through making public transit easier to locate)

AIRLINE INVESTMENT PRIORITIES AT AIRPORT

	Implemented	By end of 2024	No plans
	23%		9%
Biometric identity management solutions for passengers	38%	38%	24%
Touchless solutions for passengers and staff	56%	17%	27%
Health & safety services for passengers and staff	40%	32%	28%
Interactive wayfinding/ navigation solutions	12%	38%	50%

- No plans
- By end of 2024
- Implemented

% of airlines with implemented or planned initiatives at airport by 2024

Source: SITA. 2021. *Air Transport IT Insights 2021*.

Washington Dulles International Airport: Metro wayfinding signs
Photo by Bonnie Powell, NREL

Wayfinding Technology Timeline

Photo from Getty Images 515236823
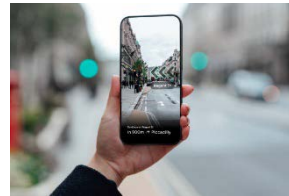
Photo from Getty Images 1336123688

Photo by Stan Young, NREL

Considerations:

- **Integration** of numerous technologies
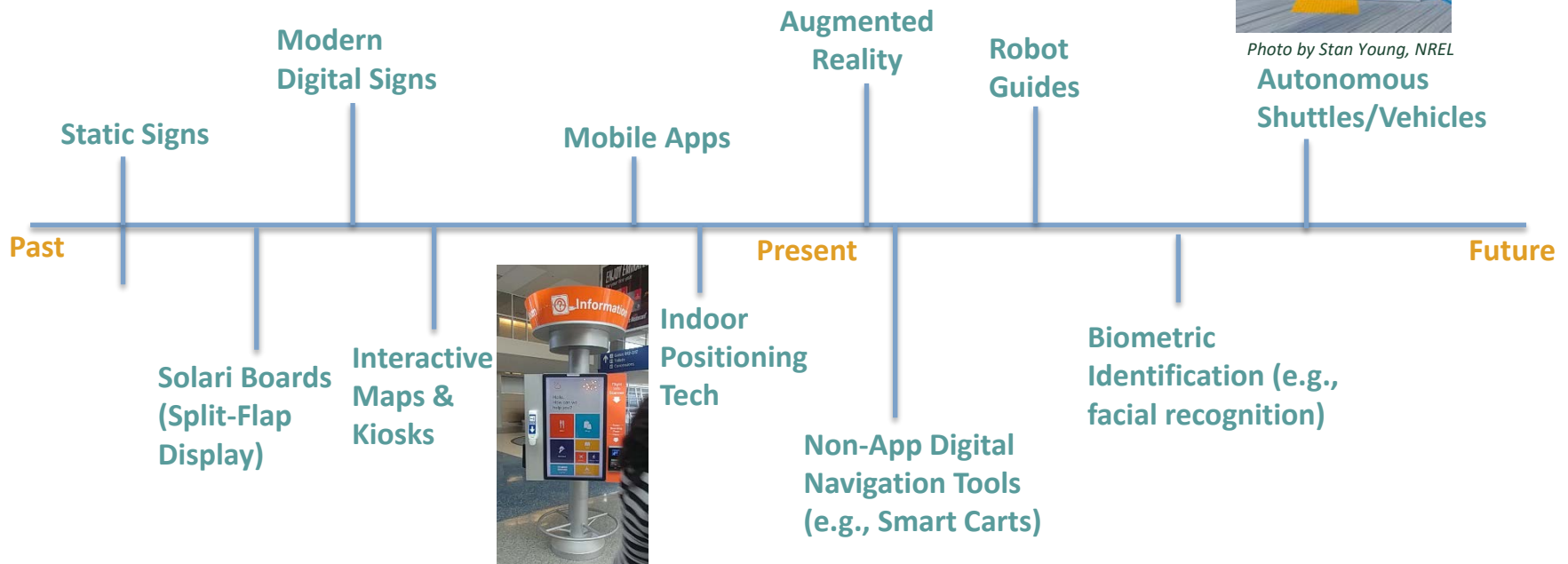- Many wayfinding technologies do not disappear; additional technologies are added

Timeline (Past → Present → Future):

- **Static Signs**
- **Modern Digital Signs**
- **Mobile Apps**
- **Augmented Reality**
- **Robot Guides**
- **Autonomous Shuttles/Vehicles**
- **Solari Boards (Split-Flap Display)**
- **Interactive Maps & Kiosks**
- **Indoor Positioning Tech**
- **Non-App Digital Navigation Tools (e.g., Smart Carts)**
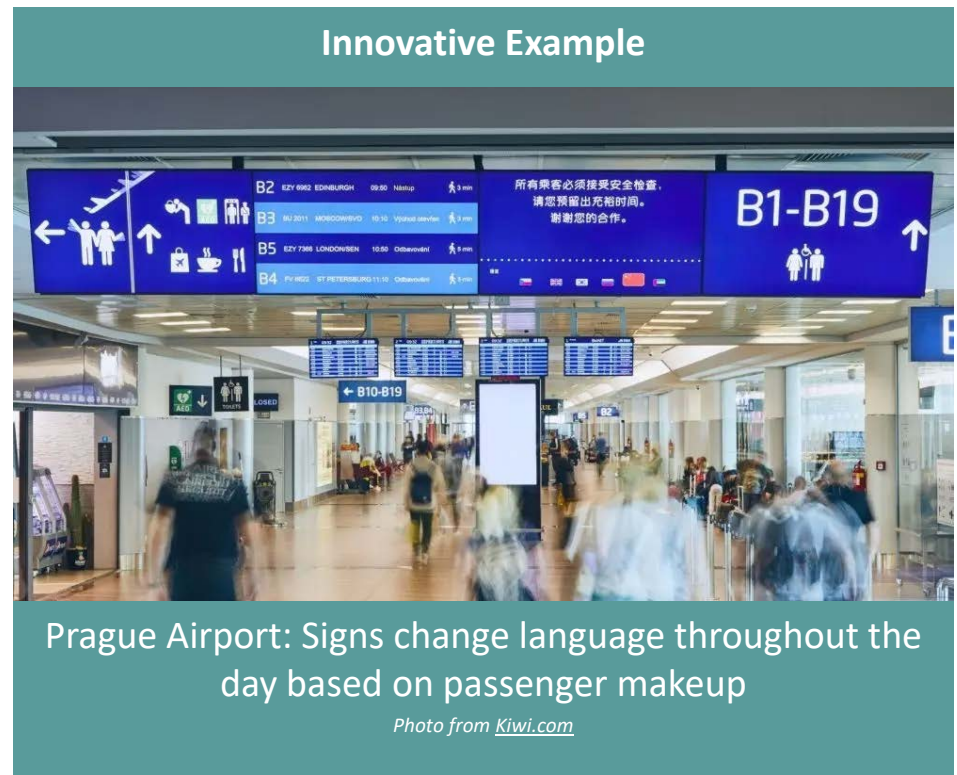- **Biometric Identification (e.g., facial recognition)**

Photo by Stan Young, NREL

Wayfinding Technologies

1. **Static and digital signs:**
   - Key long-term fixtures
   - Digital signs prevalent for dynamic information
   - Can have multiple purposes (e.g., advertising + directions)
   - U.S. Federal Aviation Administration has design guidelines for signage in terminals
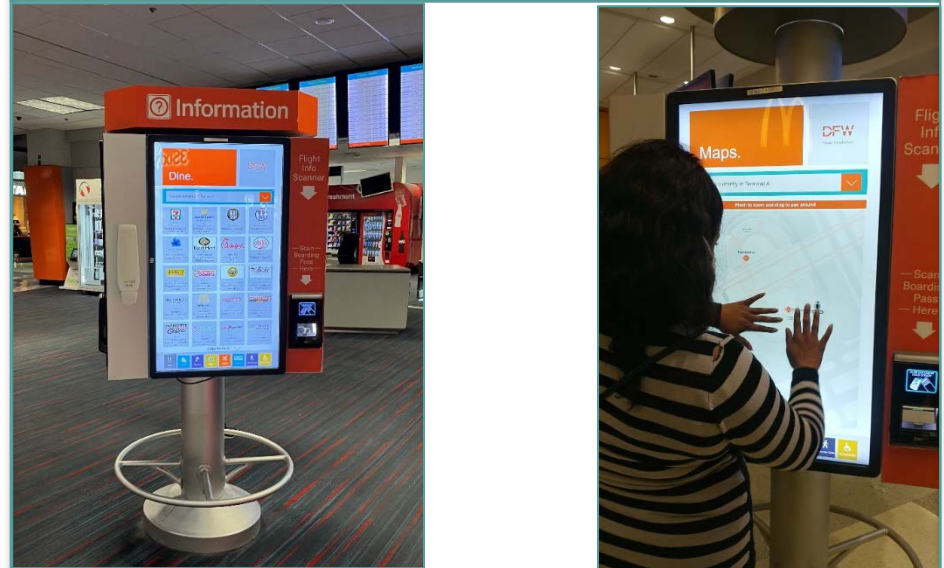   - Languages displayed are a key consideration

Innovative Example

Prague Airport: Signs change language throughout the day based on passenger makeup

Photo from Kiwi.com

Wayfinding Technologies

2. Interactive displays:

- User input

- Allow for more personalized information

- However, only one person can use a display at a time

Innovative Example

Dallas Fort Worth International Airport (DFW):
Interactive information kiosks

The user scans their boarding pass to get personalized directions.
Photos by Bonnie Powell, NREL, May 2023 (left), and Stan Young, NREL, Nov. 2021 (right)

Wayfinding Technologies

3. Floor-based navigation:

- Painted lines or arrows
- Sign projection systems:
  - Can change placement or language based on the passenger makeup, time of day
- Can be useful for certain groups (e.g., wheelchair users with a lower field of vision)
- May catch the attention of travelers looking at their smartphones while walking

Innovative Example
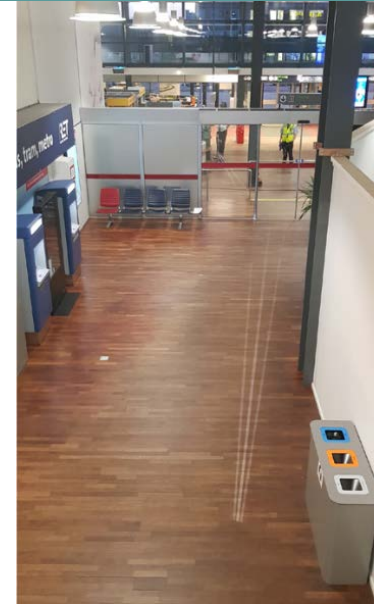
Rotterdam The Hague Airport (Netherlands): Projection directing travelers toward the exit

The color contrast between the ground and the digital projection and animating the projection were key considerations.

Photo from a field study conducted by Tezcan and Hiemstra-van Mastrigt (2019)

Wayfinding Technologies

4. Employee-provided guidance:

— Information desks have become less staffed over time, sometimes replaced with help chats and mobile apps
— Volunteer airport ambassadors are often still prevalent
— Digital and employee guidance can be combined

Ronald Reagan Washington National Airport: Information desk
Photo by Bonnie Powell, NREL.

Innovative Example

Our Customer Service Team is Ready to Assist you!

Call, text or video chat with a Customer Service Agent 6 a.m.-10:30 p.m. daily.

Our customer service team is knowledgeable about all things DEN. They can even help you navigate the airport! Phone: 720-730-IFLY (4359). Text chat: 720-902-9351 or video chat through the button below.

Open Chat | Open Video Chat

Denver International Airport: Live video or chat help
Screenshot from flydenver.com

The National Academies of
SCIENCES · ENGINEERING · MEDICINE
TRB
TRANSPORTATION RESEARCH BOARD

ACRP | AIRPORT COOPERATIVE RESEARCH PROGRAM

Wayfinding Technologies

5. Mobile apps: Airlines & Airports

– Major non-budget airlines have airport maps integrated into their apps for the airports they service

Example

American Airlines app with turn-by-turn directions for Miami International Airport

Screenshots from Bonnie Powell, NREL

Wayfinding Technologies

5. Mobile apps: Airlines & Airports (cont.)

– Some airports have apps that include terminal maps

– Maps are just one feature of the app

United Airlines email with information about their terminal guide

Screenshot from Bonnie Powell, NREL

Wayfinding Technologies

5. Mobile apps: Third-parties

- E.g., Google, Apple
- Some airports and airlines have private partnerships to develop apps
- Apps are moving toward one-stop shops for multiple customer needs during travel
 - But many apps still focus only on a few parts of the travel experience

Example

DFW Terminal D interior on Google Maps (left) and Apple Maps (right)
Source: © 2022 Google, map data; © 2022 Apple, map data
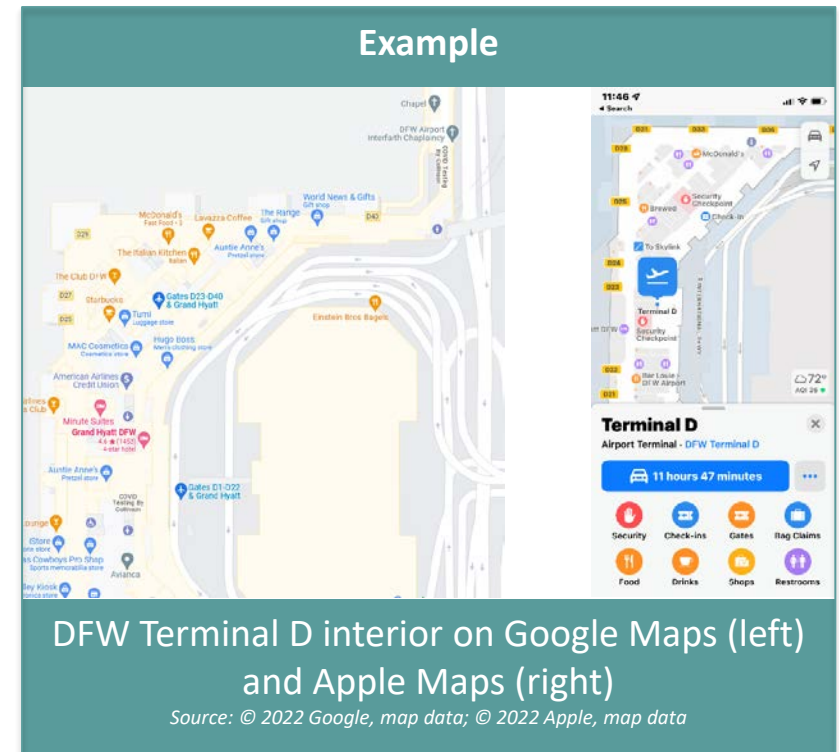
Wayfinding Technologies

5. Mobile apps: Third-parties (cont.)

- Indoor Google Maps (live view) launched in March 2021:

  - Uses a smartphone's camera to scan location, then shows directions on the screen (augmented reality)

  - Compares images to a database of facility images to determine the traveler's orientation

  - Displays directions superimposed on the camera image

Innovative Example
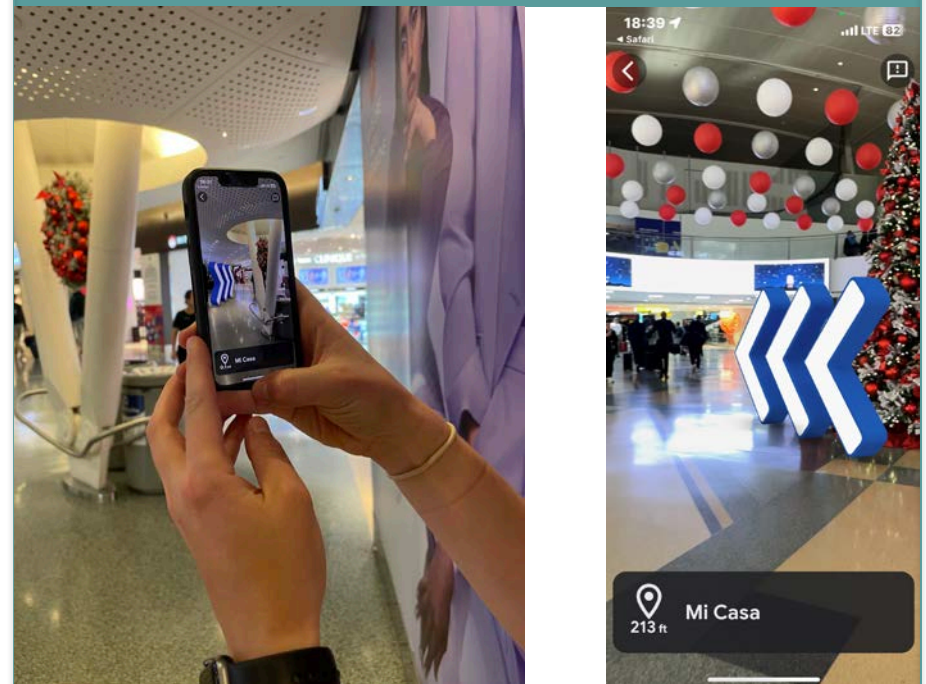
Indoor Google Maps live view augmented reality directions in John F. Kennedy International Airport Terminal 4

Photo and screenshot from Bonnie Powell, NREL

Wayfinding Technologies

5. Mobile apps (cont.):

- Challenges:

    - **Balancing holding a phone** and other items while moving

    - Not all travelers **have or can easily operate** a smartphone

    - Potential for **conflicting information** between the app and the built environment

    - Potential for **conflicting interests** (e.g., commercial interests and traveler interests)

Photo from Getty Images 1502942937

Wayfinding Technologies

6. Indoor positioning technology:

- GPS technology revolutionized outdoor navigation
- No comparable solution for indoor navigation yet

Examples

- Comparing smartphone digital camera image to a database of building photos (e.g., Google)
- **Bluetooth Low Energy (BLE)** and **Ultra-Wideband (UWB) beacons:**
  - Common-Use Beacon Registry (set up by SITA), aids app developers.

Considerations:

- **Customer experience**—risk of notification fatigue
- Customer and employee **privacy**
- **Competition** among airport, airlines, and third parties for data.

Wayfinding Technologies

7. Biometric technology:

- Facial recognition can be used for purposes beyond security

- Concerns about privacy and increased inaccuracies among certain groups (e.g., those with darker skin, women, and older adults)

- Example:

  – Delta Air Lines' Parallel Reality technology displays personalized information on a screen to multiple passengers at the same time

Innovative Example

Delta Air Lines' Parallel Reality experience at the Detroit Metropolitan Airport
Photo provided by Bonnie Powell, NREL

Wayfinding Technologies

8. Robot guides:

Example
Incheon International Airport
Photo from Korea JoongAng Daily

9. Miscellaneous digital navigation tools:

Examples

- Cairo International Airport, Chicago O'Hare International Airport, Cincinnati/Northern Kentucky International Airport (and more): Self-guided **online virtual tours** to familiarize travelers with an airport prior to arrival
- San Diego International Airport: **Airport carts** with screens displaying personalized information and directions
- Cincinnati/Northern Kentucky International Airport: **3D hologram** planned to guide travelers in the correct direction when exiting an escalator
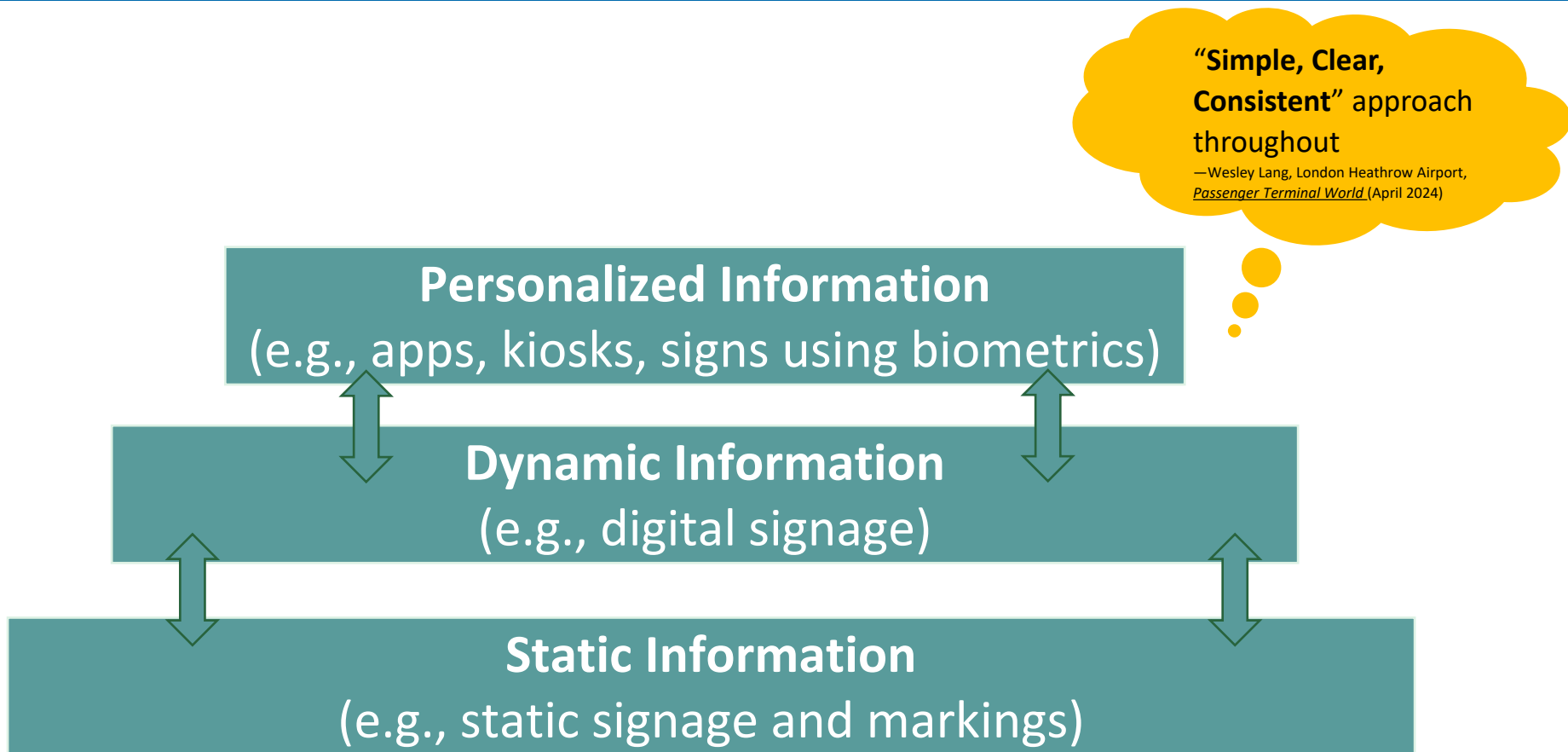
Other Key Considerations
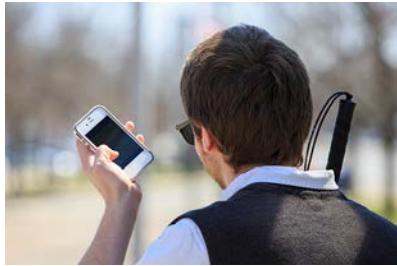
Photo from Getty Images 586892139

Photo from Getty Images 2081480435

- **How technologies impact different groups of travelers** (such as those who are disabled, visually impaired, elderly, traveling with small children, etc.)
  — Tailoring wayfinding technologies so they work for more groups of people
  — Developing targeted wayfinding technologies for certain groups (e.g., San Francisco airport deployed a navigation app for visually impaired travelers)

- **Legal considerations related to privacy and sharing data in modern wayfinding:**
  — Compliance with privacy laws
  — Public opinion related to collecting and sharing data
  — Potential tensions among airlines, airports, and third-party app developers vying to cater to the same customer market

- **Human behavior and human-technology interactions:**
  — Passenger surveys and studies are crucial
  — Feedback should be incorporated into technology choices and systems
  — Ideally, this should be an iterative process

Framework

"**Simple, Clear, Consistent**" approach throughout
—Wesley Lang, London Heathrow Airport, *Passenger Terminal World* (April 2024)

Personalized Information
(e.g., apps, kiosks, signs using biometrics)

Dynamic Information
(e.g., digital signage)

Static Information
(e.g., static signage and markings)

Conclusion

Rapidly changing area

Smartphone apps and push notifications are the anticipated path forward, but they have challenges:
- Notification fatigue: Apps can overload travelers
- Difficult to balance smartphone navigation in dynamic situations
- Must overcome "local positioning problem" for widespread adoption

Electronic wayfinding does not replace but rather **augments traditional methods:**
- Well-designed, easy to navigate airport is the foundation
- Effective, concise, up-to-date static signage remains essential
- Electronic bridges to interactive and customized wayfinding capabilities

Powerful partnership opportunities moving forward

Human behavior studies are critical to any plan or investment—they could prevent the deployment of costly and ineffective technologies and improve existing strategies

FOR ADDITIONAL INFORMATION

The Evolution of Wayfinding Within Airports

Bonnie Powell, Stanley E. Young, and Andrew Duvall

National Renewable Energy Laboratory

https://www.nrel.gov/docs/fy24osti/83211.pdf

Bonnie Powell
Bonnie.Powell@nrel.gov

Stan Young
Stanley.Young@nrel.gov

Andy Duvall
Andrew.Duvall@nrel.gov

The National Academies of
SCIENCES · ENGINEERING · MEDICINE
TRB
TRANSPORTATION RESEARCH BOARD

NREL/PR-5R00-89833

ACRP
AIRPORT COOPERATIVE RESEARCH PROGRAM