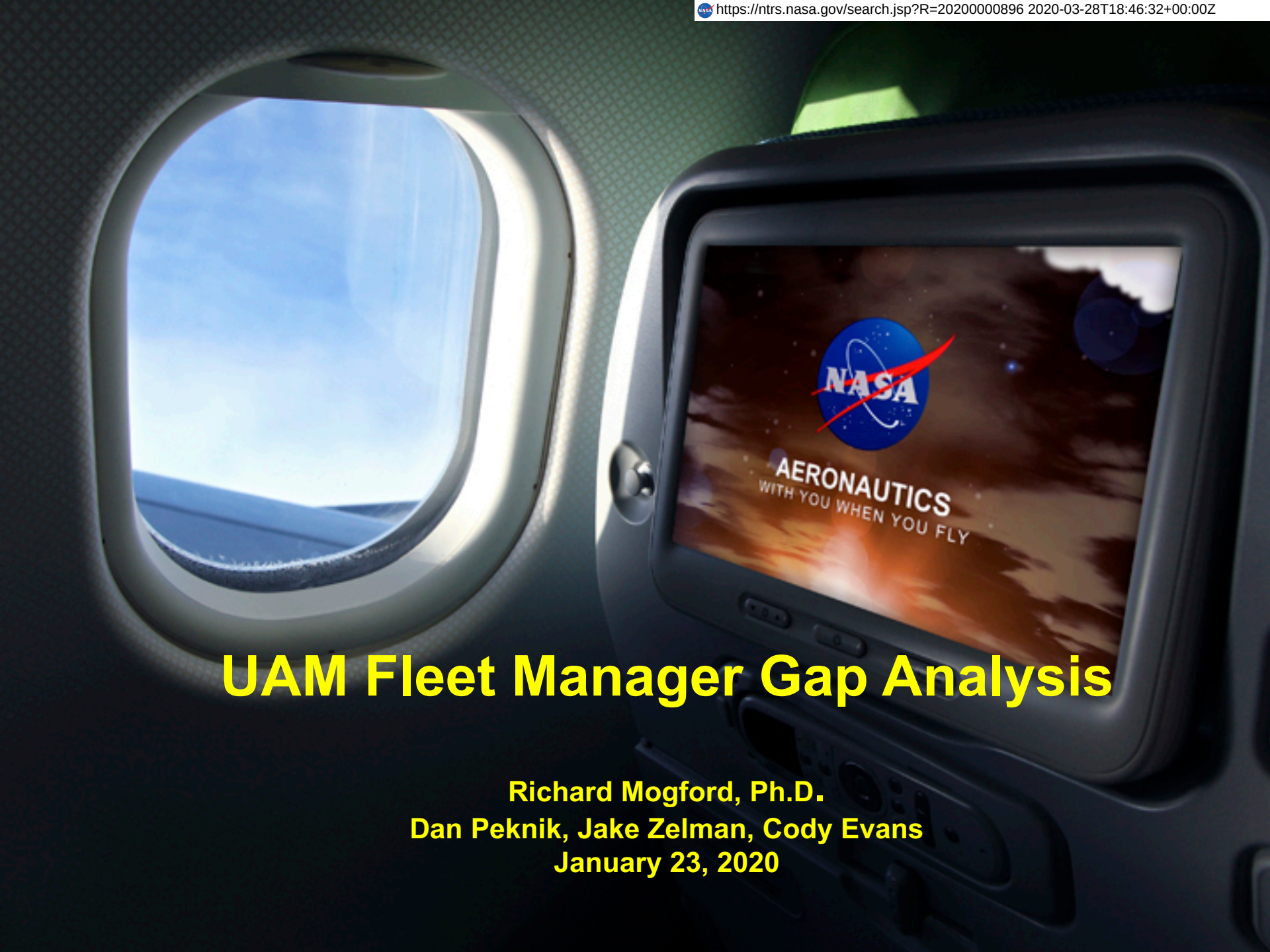


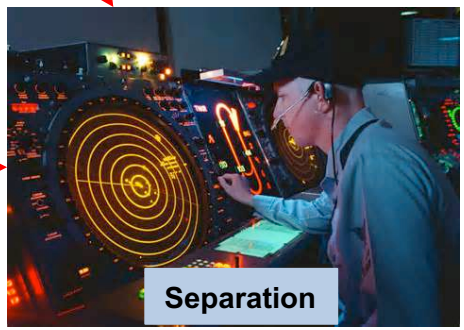
UAM Fleet Manager Gap Analysis

Richard Mogford, Ph.D.
Dan Peknik, Jake Zelman, Cody Evans
January 23, 2020

Dispatchers for UAM

- How do the functions of a UAM dispatcher (“Fleet Manager” or FM) compare with the airline dispatcher (AD)?
- Listed tasks for AD and FM and identified differences
- Created a list of software functions and information requirements for the FM
- Started a user interface (UI) design for an FM software tool

Who is the Airline Dispatcher?



What Do Airline Dispatchers Do?

- ADs are airline employees who manage all flights
- Dispatchers have the authority to originate and terminate flights
- Generate flight plans and monitor flights throughout their routes
- Manage contingencies (weather, air traffic control, and maintenance)
- ADs work in an airline operations center (AOC)
- AOCs also provide other functions, such as crew scheduling and maintenance management

Airline Operations Center

Southwest Airlines Network Operations Control

Airline Dispatcher Tasks

- ADs are licensed airman certified by the FAA
- Have joint responsibility with the captain for operational control of a flight
- Manage safety, economics, fuel planning, passenger service, and support the brand of the airline
- Closely analyze and evaluate meteorological information to determine potential hazards to the safety of flight
- Deeply versed in federal regulations for aviation
- The AD makes recommendations to continue to destination, or to divert if needed

Flight Planning

- Software automatically generates fuel/time efficient flight plan
- Contents of flight plan:
  - Weight and balance of the aircraft
  - Fuel load
  - Alternate airports
  - Load manifest
  - Passenger load/count
  - Weather
  - Filed route
  - Maintenance items

```
FLIGHT 3407          COMPUTER FLIGHT PLAN                  TODAY
-------------------------------------------------------------

ORG  DEST  ALT1 ALT2 T/OALT A/C TYPE    TAIL    BOW       INDEX

PHL  DCA                   EMB-170NXXXXX  48300 -02.15

SPEED SCHEDULES
CLIMB 290/M74           CRUISE M78              DESCENT M74/290

           FUEL   TIME        PLAN         STRUC    FLT SKD
 BURN      1739   00.26  BOW   48300.....          DEP PHL NOW   Z
 RESERVE   3200   00.45  PYLD   6599.....          ARV DCA LATER Z
 ALT/         0   00.00  ZFW   54899..... 65256
 HOLD         0   00.00  FOB    6400..... 20734
 MIN       4939   01.13  TOW   61299..... 81964
 TANKER    1461   00.21  BURN   1739
 TAXI       400   00.20  LGW   59560..... 72310
 RAMP      6800   01.34  FOD    4661


ROUTE 001    P NOW Z    FL 120  AVG WIND 016004       ETE 00.26
PHL..DQO.V166.BELAY.V378.BAL..DCA

CONTINGENCY SUMMARIES
FL   AVG/WIND  ETE    BURN   MIN   RAMP  PYLD  LDG WT
 80   049005  00.26   1772   4972  6800   6599 59527
 60   065006  00.26   1808   5008  6800   6599 59491
 40   072006  00.26   1853   5053  6800   6599 59446

          TIME  DIST                                  FUEL
          LEG   LEG    IAS  MCH  MC    ALT  WIND     LEG     SCORE
WAYPOINT  TOTAL TOTAL  TAS  G/S  HDG   IOAT ISA      TOTAL TIME/FUEL
KPHL      ----  ----   ---  ---  ---   ---
          00.26  109   ---  ---  ---   ---

TOC       00.02   11   232  ---  ---   120 043005    360   ..../....
          00.02   11   273  278  248     8  P10      360
```

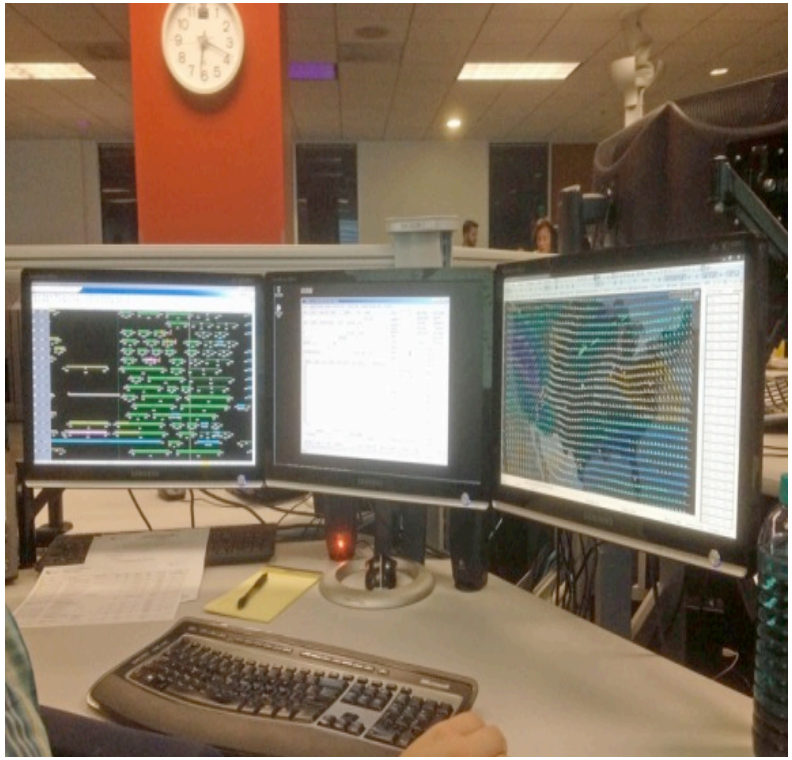
Flight Release

- An AD prepares a Dispatch Release for each respective flight
- Dispatch Release (or Flight Release) is a legal document
- The AD and pilot in command formally agree to the operational control of the flight by signing the Dispatch Release

```
NAS:
FP SWA40 B733/Q 426 DAL P2220 370
DAL.TEX1.MLC..SGF.TRAKE8.STL/0129 EQP DGILORVWZ SRV S NAV/ RNVD1E1A1

MEL/CDL     NO ITEMS

                Fuel    Time    Plan              Structural
                                                    Limit
TAXI            0005
ENROUTE BURN    0077    01:29   OEW      074446
CONTINGENCY     0026    00:30   PLYD     030500
ALTERNATE       0000    00:00   ZFW      104900   MZFW   1050
FAR RESERVE     0035    00:45   FOB      013800   MFW    0356
******************
MINIMUM FUEL    0143    02:44   TOW      118700   MTOW   1360
******************
TANKER          0000    00:00   BURN     007700
PLAN FOB        0143    02:44   LGW      111100   MLGW   1140

PLANNED ARRIVAL FUEL  0061      ESTIMATED MAX QUICK TURN WGT  1199

AVG WIND M031   MXSH 05/SGF     FUEL BIAS + 3.9%    CRZ  C20/W
NFUEL BURN ADJUSTMENT FOR 1000LBS DECREASE IN TOW : 0054 LBS
```

Dispatcher Workstation

- Left Screen: Fleet management
- Middle Screen: Flight Planning, general information, and Aircraft Communications Addressing and Reporting System (ACARS) messaging
- Right Screen: Weather, flight tracking
- Phone/air-ground radio contact other personnel and aircraft in flight
- About 20 to 40 flights per dispatcher at any given time – follow tail numbers



Maintenance

- Uses Minimum Equipment List (MEL) for each type of aircraft in the fleet
- Checks errors/faults to determine if aircraft can fly
- Receives messages from dispatch and pilots about MEL items
- Has a direct voice line to the flight deck if troubleshooting is needed
- Responsible for scheduling maintenance at the airport

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

MASTER MINIMUM EQUIPMENT LIST

AIRCRAFT: BOEING B-777	REVISION NO: 20 DATE: 04/14/2014	PAGE: 21-9

1. SYSTEM & SEQUENCE NUMBERS / ITEM	2. NUMBER INSTALLED	3. NUMBER REQUIRED FOR DISPATCH	4. REMARKS OR EXCEPTIONS
21 AIR CONDITIONING			
-27-16 Flight Deck Equipment Cooling System (777F) C	1	0	(M)(O) May be inoperative provided: a) Equipment cooling three-way valve is deactivated closed, and b) Procedures are established and used to verify main deck cargo compartment remains empty or contains only ballast, empty cargo handling equipment (ballast may be loaded in ULDs), or fly away kits. NOTE: Operator MELs must define which items are approved for inclusion in the fly away kits and which materials can be used as ballast.

UAM and the Dispatcher

- For UAM, a human dispatcher will be necessary during operations (initially)
- Duties include flight planning, flight following, contingency management (e.g., weather, maintenance, and air traffic control)
- There are differences between UAM and airline operations, but there are many similar tasks

Domains Compared

Present Day Aviation	Urban Air Mobility
Large aircraft (B777 is 774,600 pounds)	Small aircraft (2,000 - 4,000 pounds)
Many passengers (hundreds)	Two to four passengers
Highly structured airspace	Less structured airspace
Local and high-altitude weather data	Detailed weather data for low altitudes
Voice radio communications	Digital data and voice communications
Operations segregated from public	Operations integrated with public
Robust performance in weather	Highly susceptible to weather
NAS-wide air traffic control (ATC) services	Operator-provided ATC services
Scheduled operations	Unscheduled operations
Avoids urban areas	Operates in urban areas
Sophisticated airports	Simple landing pads or “land anywhere”
Highly trained flight crews	Minimal flight crew training
Partial reliance on automation	Heavy reliance on automation
Complex maintenance requirements	Simple maintenance requirements

Comparison of Tasks

2. Gap Analysis

In Table 2, current airline dispatcher tasks are listed with the comparable FM task. Tasks in bold have significant differences compared to conventional dispatcher tasks.

Airline Dispatcher Task	Fleet Manager Task
Dispatcher arrives for their shift and is briefed by the outgoing dispatcher.	**The outgoing FM uses their software to note and communicate issues to the incoming FM. The FM's workstation should have a software tool that summarizes all of the important information to be passed on to the relief FM. The next shift may be manned at a different office in another part of the country.**
Electronically logs into the dispatcher workstation.	The FM logs into their workstation.
Launches flight planning system.	**FM plans the flight with different information compared to that used for large aircraft. The UAM route structure will most likely use lat/longs for waypoints, pre-defined routes, corridors, etc.**
Launches aircraft situational display (ASD) system.	**FM launches their ASD. The ASD is a primary tool for the FM. However, due to the shorter range of an air taxi, the ASD must be refined to have the ability to view geographical and weather data on a micro scale, using new sensor suites.**
Launches communication console.	FM launches the UAM communications console (e.g. radio, cell phone, text messaging, etc.).
Identifies any electronic messages that were not observed during the turnover process.	FM uses their communications console to identify any new messages.

Main Findings (Gaps)

- FM needs software tool for shift change (different locations)
- Flight planning will have different parameters (lat/longs for waypoints, pre-defined routes, corridors, etc.)
- FM's situation display must present very detailed geographical and weather information
- Weather data are focused on low altitude operations
- FM manages low altitude traffic over urban areas
- FM will need to handle on-demand flights
- Payload and weight balance will be critical for small aircraft

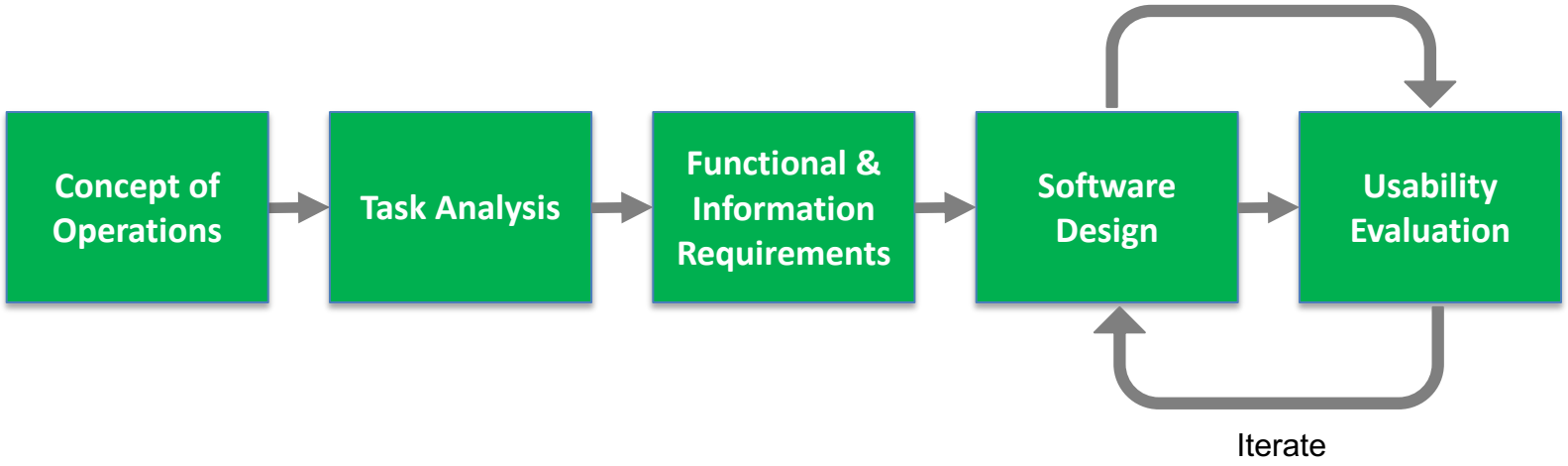
Main Findings (Gaps)

- Standard (recurring) routes will need to be checked due to constantly changing low altitude environment
- Altitude selection for flights may be very limited
- Flight plan may be an “Operation Plan,” similar to UTM
- Submits Operation Plan to a service supplier rather than the FAA
- FM does not coordinate with the FAA but with corporate service provider traffic management

UTM = Small Unmanned Aircraft System Traffic Management

Software Requirements

- List of FM tasks defines functions and information requirements to support the operator
- Enables software design
  - Functions (tools)
  - Displays
  - User interaction



Software Functions: Operations

- Flight planning
- Flight following
- Flight path manipulator (in the event of a contingency)
- Conflict prediction and status
- Alternate route suggestions
- Airspace corridor saturation monitor
- Weather integration into decision-making
- Aircraft energy/consumption monitor
- In flight route optimizations

Software Functions: Communications

- Voice and text links with pilot
- Messaging with passengers
- Voice and data communications with air traffic management/local authorities
- Data communications with service suppliers
- Two-way data contact with aircraft (equipment status, fuel/battery level, etc.)
- Voice and text with vertiports
- Voice and text with maintainers

Software Functions: System

- Replacement vehicle availability
- Live repair turnaround estimates
- Role management and delegation
- Alarms or warnings of upcoming system downtime and faults
- Backup pilot for emergency events

Data Requirements: Map

- Aircraft position, identifier, speed, heading, altitude, and flight plan
- Flight corridors
- Speed and descent profiles
- Trip length
- Human-made and natural obstructions (e.g., buildings, trees, hills, etc.)
- Temporary Flight Restrictions
- Special Use Airspace
- Landing area issues
- Noise regulations that affect vehicle choices
- Other aircraft position, identifier, speed, heading, altitude, and flight plan
- Reception obstruction areas
- Vertipad/vertiport detailed map view with traffic
- Vertipad/vertiport status
- Emergency and safety related notices affecting flights

Data Requirements: Weather

- Very detailed weather information for the altitudes and areas of concern
- Very rapid surface to 5000 feet weather changes
- Micro-scale weather detection and prediction
  - Barometric pressure
  - Temperature
  - Relative humidity
  - Dew point
  - Wind speed and direction
  - Icing
- Detailed wind flows for urban canyons, structures, topographical areas, vegetation (e.g., forests, valleys, bridges, etc.) with a few meter resolution
- Ice formation on the ground
- Localized ceiling and fog

Data Requirements: Aircraft

- Aircraft type
- Fuel/battery capacity, range, and remaining
- Time to charge battery
- Payload:
  - Aircraft capacity
  - Weight
  - Manifest
  - Loading notes
- Routing
- Human pilot or ground pilot
- Safety procedures
- Deferred maintenance items
- Repair and maintenance data
- Onboard system status

Data Requirements: Communications

- Downloads of updated regulations, management advisories, etc.
- Information about crew schedule changes
- Security or emergency items (terrorism threats, reroutes, medical emergencies)

Data Requirements: System

- Company system status (communications, facilities, personnel, etc.)
- Gate assignments
- Crew changes
- Curfew issues
- Noise footprint
- Noise abatement
- Backup pilot for emergency events

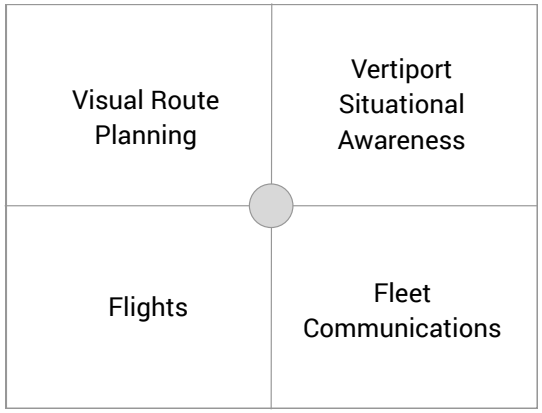
Software Design Philosophy

- FMs may be challenged by the number of flights they must handle
- Complex, low-altitude vehicle management
- Information displays should be forward-looking and provide decision support
- UI architecture provides two modes:
  - Recommended actions based on user tasks
  - Background data behind decisions, if requested
- System capabilities include:
  - Optimize FM to vehicle management ratio
  - Predictive interactions as a core design principle
  - Decrease training needs of FMs vs. ADs
  - Enhance safety of low altitude, automated flight conditions

UI Design

- FM UI uses a single, large, windowed display
- Information in the interface is integrated:
  - User chooses a route
  - Software creates the route
  - Map graphically shows a problem with the route
  - Computer generates suggested solution
  - User communicates the chosen action to others, logs the issue, and monitors the flight path
- Software supports prediction, monitoring, and execution

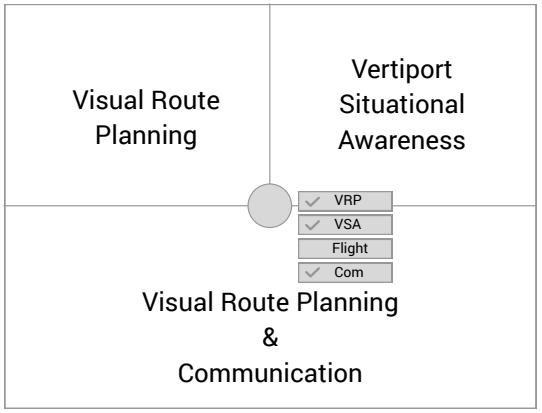
Interface layout 1



The maximum number of windows is four. The user can drag and drop the controller at center (indicated by a gray circle) to resize all windows simultaneously.

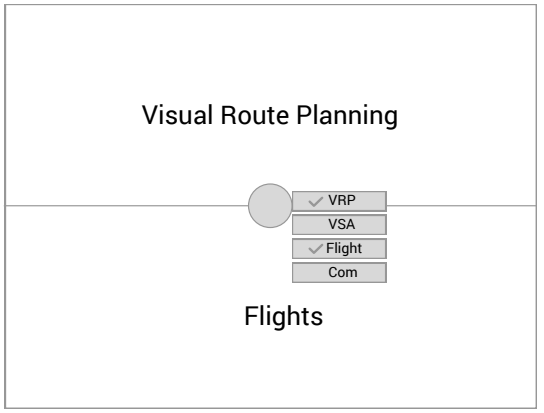
Starting with the top left quadrant and going clockwise:
- Visual Route Planning for assisted optimization
- Vertiport Situational Awareness for monitoring
- Flight monitoring
- Fleet Communications

Interface layout 2



To change the number of windows, right-click on the controller (indicated by a gray circle). A menu appears allowing users to toggle on/off each of the four windows. Toggling off a window results in a three window view as in the example above.

Interface layout 3



Toggling two windows off results in a split view as shown in the example above. Users may toggle on/off windows as necessary.

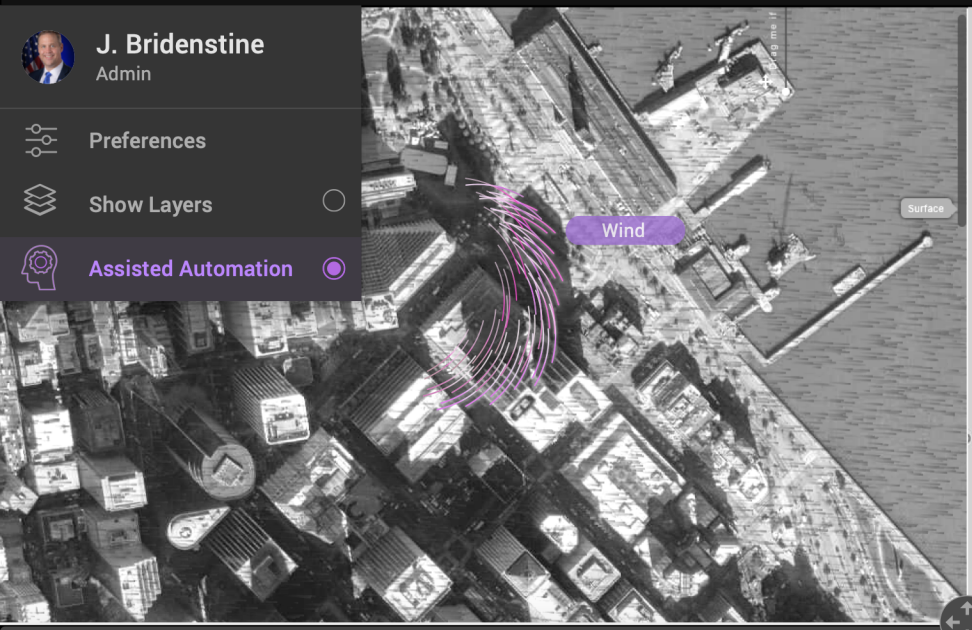
Flight Awareness Collaboration Tool

J. Bridenstine
Admin

Preferences

Show Layers

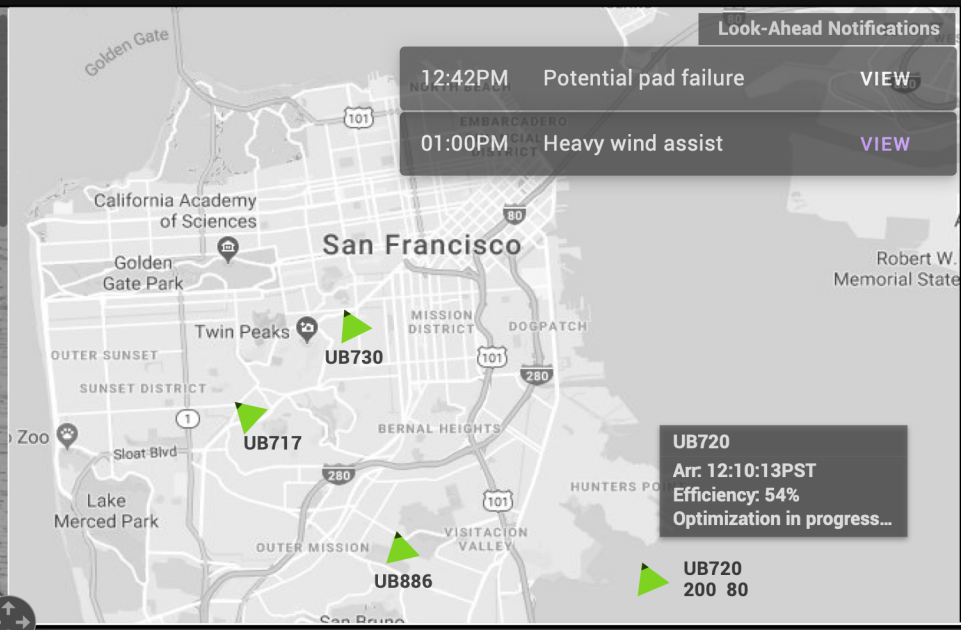
Assisted Automation



Look-Ahead Notifications

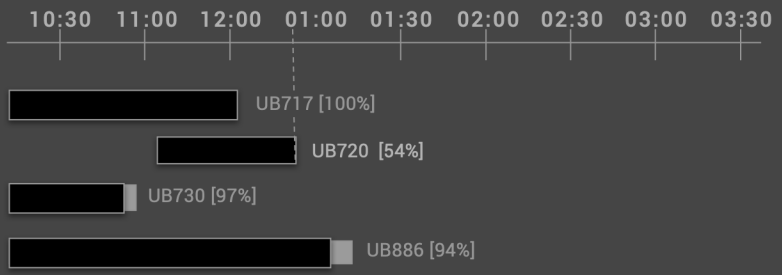
12:42PM Potential pad failure VIEW

01:00PM Heavy wind assist VIEW



UB720 Optimization Profile

FLIGHT#	SEGMENT DISTANCE	TIME AT SEGMENT
UB717	11.2 miles	12:12PM 100% optimized
UB720	11.1 miles	12:12PM 54% calculating options



ACCEPT MODIFY

ISSUES CHAT NOTES

Potential pad failure at SFO, to be advised as situation progresses — Pad

Weather cell forming in the Pacific

Police line at 19th and Wawona

Heavy winds reported via microweather sensor [4th Street] — Wind

Passenger requests additional stop at Embarcadero Center

Dispatch calls in a delay due to late passenger arrival

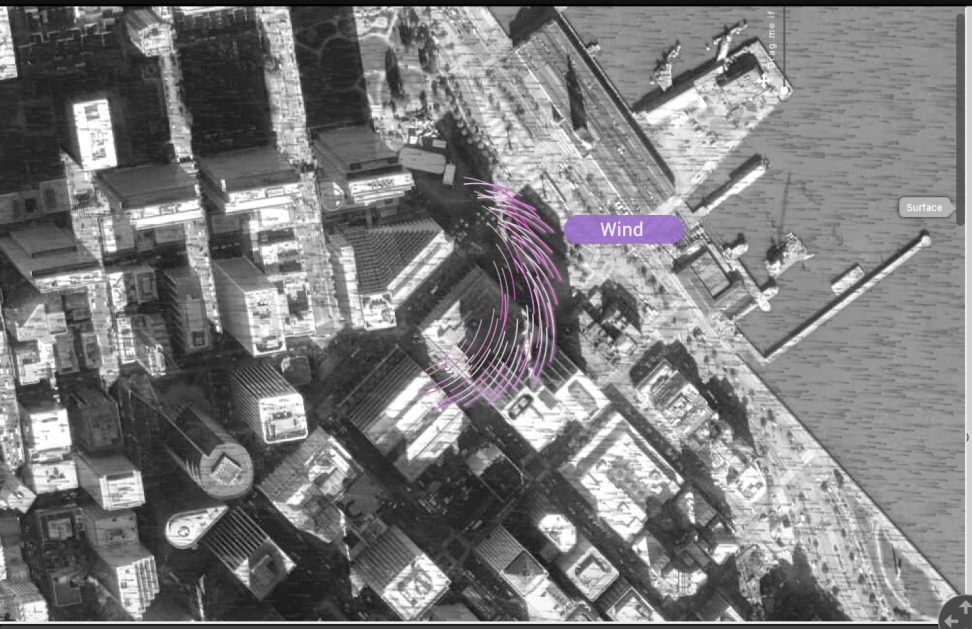
Traffic backing up highway 101 at Monterey Blvd

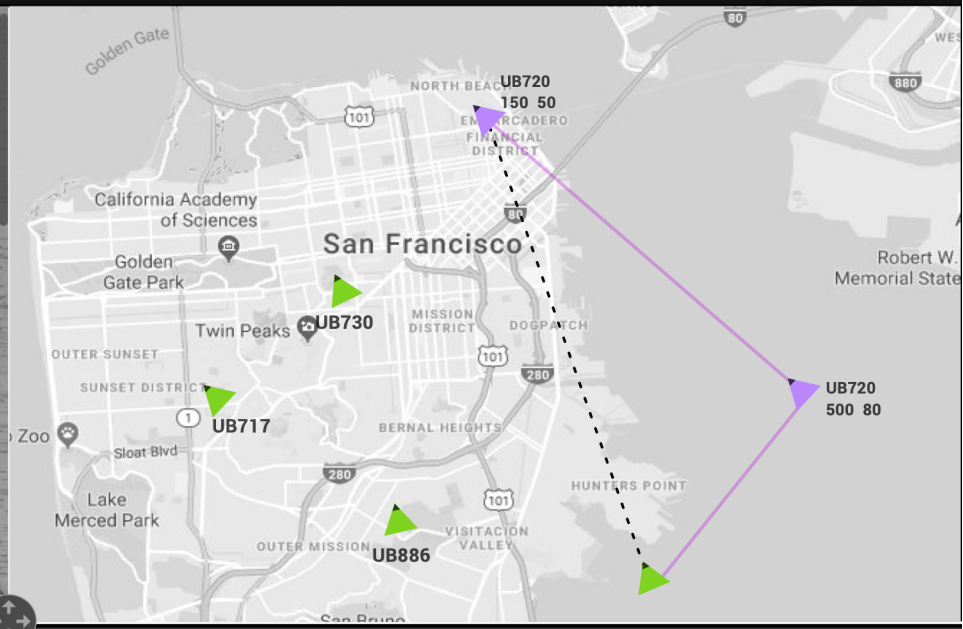
Evening operations shift change

Route change due to passenger sickness

Passenger left Ham radio in air taxi

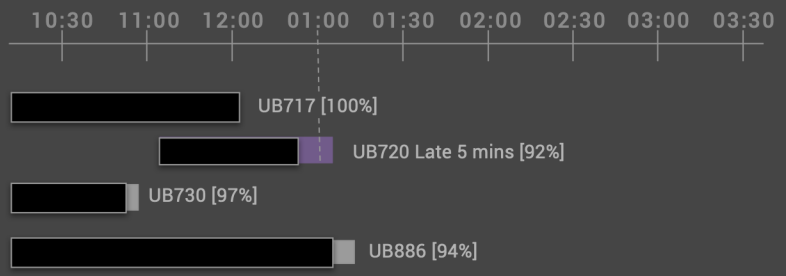
Flight Awareness Collaboration Tool





UB720 Optimization Profile

FLIGHT#	SEGMENT DISTANCE	TIME AT SEGMENT
UB717	11.2 miles	12:12PM 100% optimized
UB720	12.6 miles	12:17PM 92% optimization available



ACCEPT MODIFY

ISSUES CHAT NOTES

- Potential pad failure at SFO, to be advised as situation progresses — Pad
- Weather cell forming in the Pacific
- Police line at 19th and Wawona
- Potential re-route due to heavy winds — Wind
- Passenger requests additional stop at Embarcadero Center
- Dispatch calls in a delay due to late passenger arrival
- Traffic backing up highway 101 at Monterey Blvd
- Evening operations shift change
- Route change due to passenger sickness
- Passenger left Ham radio in air taxi

Next Steps

- Additional UI design
- Sent Gap Analysis to Uber
- May be interested in collaboration later in the year

Questions?