Helicopter Safety Data

By:

Sean Mulholland, Director of Safety, AirEvac Lifeteam & SevenBar Aviation
Cliff Johnson, Research Program Manager/Engineer, FAA

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Helicopter Safety
Why does it matter?
Rotorcraft Safety Information Video

Double Click Icon to Play Video
Aviation Safety Infoshare

• Hyatt Regency St. Louis at The Arch 315 Chestnut Street St. Louis, Missouri 63102

• Rotorcraft Session is scheduled for Wed. Apr. 27, 2022 from ~ 8:30 am-4:45 pm

*Note: If interested in attending, please contact Sean Mulholland – Infoshare Industry Co-Chair, 7Bar Aviation/AirEvac Lifeteam/Global Medical Response

Email: Sean.Mulholland@gmr.net

Phone: 817-875-8856
Aviation Safety Information Analysis and Sharing
(Rotorcraft Update, 2022)

- Conducted Rotorcraft Session @ Infoshare Nov. 2021
- Rotorcraft Issue Analysis Team (R-IAT) meeting bi-monthly.
- Data Standardization (DSWG) and Outreach Working Groups meeting tri-weekly.
- ASIAS Executive Board (AEB) incorporation of rotorcraft reps (USHST Co-Chairs).
  - Awaiting Approval of ASIAS Loss of Control Directed Study
- Expanding collaboration and involvement with USHST, helicopter air ambulance operators, air tour operator safety organizations (i.e. TOPS/HTOC, business aviation, other industry organizations (i.e. HSAC, HeliOffshore, etc.)
- Next Meeting Infoshare Apr. 27, 2022
Directed Study Updates

• **Unintended Flight Into Instrument Meteorological Conditions (UIMC)**
  • Testing Flight Rule Component (i.e. Logic for Classification of VFR/IFR Flights)
  • Examining various sources of trajectory data (i.e. radar, ADS-B, threaded track, etc.)
  • Ingesting additional HRRR weather data for testing and production of the metric

• **Loss of Control (LOC)**
  • Data Standardization Working Group (DSWG) supporting and aligning with Directed Studies
  • Continuing development of LOC Metrics with GDIT and other analytical entities
  • Prioritizing List of LOC Conditions
Active Safety Enhancements

Technology Initiatives

- Stability Augmentation System & Autopilot (70)
- Helicopter Flight Data Monitoring (82)
- Enhanced Helicopter Vision Systems (91)
Rotorcraft Mission Segments

- Air Tour
- External Load
- Airborne Law Enforcement
- Aerial Firefighting
- Search and Rescue
- Helicopter Air Ambulance
- Training
- Offshore
- Corporate/VIP Transport
Helicopter Flight Data Monitoring (HFDM) Research for ASIAS

**Research Purpose**
- Conduct research to develop analytical tools, collect HFDM data, and solicit participation from diverse mission segments to incorporate rotorcraft data into ASIAS.

**Sponsors & Key Stakeholders**
- Accident Investigation, Analysis, and Prevention (AVP), Rotorcraft Directorate (ASW)
- United States Helicopter Safety Team (USHST)
- Vertical Aviation Safety Team (VAST)
- National Transportation Safety Board (NTSB)
USHST Top 3 Fatal Accident Occurrence Categories

1. Loss of Control
2. Unintended Instrument Meteorological Conditions
3. Low Altitude Operations
Interest in Loss of Control events

- 30% of all accidents involve Loss of Control (LOC)
- Going after major LOC categories
Safety Metrics for Rotorcraft Operations

• Metrics Investigated:
  • Proximity to Obstacles
  • Proximity to Weather
  • Dynamic Roll-over
  • Autorotation Detection
  • Vortex Ring State Detection
  • Unstabilized Approach (VFR)
  • Mast Bumping

• In Progress:
  • Loss of Tail Rotor Effectiveness (LTE)
  • Unstabilized Approach (IFR)
  • Autorotation Phases
  • Vortex Ring State Recovery

• Future Work:
  • Retreating Blade Stall
  • Helipad Overrun
Un-stabilized Approach Safety Metric

**Approach phases identification**

- Identified Approaches
- Alt. Profile of Flight Data

**Deviation from Ideal Profile**

- 3D flight path
- 2D approach path
- 50% of total path distance

**Average location of changes in approach parameters**

- Most of parameter changes occur during first half of approach (away from touchdown point)

**Clustering of Approaches by Stability Levels Using Data Mining (k-mean)**

- Most unstable
- Rather stable
- Most stable

**Altitude Deviation Indicator**

**Approach Steepness Categorization**

- Shallow
- Normal
- Steep

**Frequency**

- Distance to touchdown (nm)
- Number of approaches

**Un-stabilized Approach Safety Metric**

- Frequency of Altitude Deviation Indicator
- Altitude Deviation Indicator
- Approach Angle Deviation Indicator

**Approach Angle**

- Altitude
- Vertical Speed

**50% of total path distance**

**Close to Center**

- Most of parameter changes occur during first half of approach (away from touchdown point)
Un-stabilized Approach Safety Metric

- **Safety Impacts to the NAS**
  - Un-stabilized Approaches result in:
    - A higher % of Missed Approaches/Go-Arounds
    - A higher # of TCAS Traffic Advisories/Resolution Advisories (TA’s/RA’s)
    - Loss of Separation events
    - Near-MidAir collisions
    - CFIT encounters
    - Increased susceptibility to obstacles, wire strikes, or bird strikes

- **Adherence to Rotorcraft Pareto**
  - Loss of Control is the #1 Fatal Accident Causal Factor
  - Un-stabilized Approach is a significant contributor to LOC fatal accidents

- **Risk**
  - Probability: High
    - Can occur on any approach (visual or instrument)
  - Severity: High
    - Unstable approaches can result in high descent rates, vortex ring state encounters, go-arounds/missed approaches, or accidents/incidents

- **Pros/Cons**
  - Includes:
    - Powerful tool to detect approach events and allow for baseline/trending of SOP’s across fleets/mission segments
    - For analysis of Helicopter Point-In-Space Approaches (i.e. Specials) need IAP’s which are often proprietary
    - Not every HFDM recorder captures torque or control positions which are key parameters for Un-stabilized Approach analysis
ANOMALY DETECTION (KNOWLEDGE DISCOVERY) USING ADS-B DATA
Anomaly Detection in Flight Data Records

- Traditionally, anomaly detection in flight data records is based on exceedance analysis
  - Define parameter thresholds not to be exceeded
  - Combine parameters into safety events
  - Thresholds may depend on mission, helicopter make/mode, operator, event severity, etc.

- With large amounts of data, anomalies can be detected by observing patterns in the data

- Group data based on take-off and landing airports

Flight grouping using data features (such as take-off and landing airports, time of flight, surface area covered, etc.)

365 flight trajectories after data cleaning and preparation
UIMC Event Detection Process (EIM)

**Event Logging (EL) Function**
- ID = unique TFMS flight identifier
- TAIL = aircraft registration
- DATE = flight start date
- START = flight start time
- #FP = number of flight plans
- #TC = number of transponder codes
- TC = transponder code
- FR = flight rule
- %FR = flight rule confidence
- LAT = aircraft latitude
- LON = aircraft longitude
- TIME = flight progression time
- ALT = aircraft altitude (AGL)
- HDG = aircraft mag. heading
- MC = met. conditions code
- %MC = met. conditions confidence
- ∆ALT = altitude change over time
- EVENT = event array

**Flight Rule (FR) Component**
- #FP>1
- TC=120
- #TC
- TC=1200
- AC=V

**Met. Cond. (MC) Component**
- MC
- %MC
- LAT
- LON
- TIME
- ALT
- HDG
- FR
- TC

**Pipeline**
- Flights
- Archive

**Flight Queue (FQ) Component**
- ID
- TAIL
- DATE
- START

**Plan & Squawk (PS) Function**
- #FP
- #TC
- TC
- FR
- %FR

**Aircraft Cert. (AC) Function**
- AC
- FR
- %FR

**TFMS**
- EXIT
- #FP=1 & FR=I

**OpSpec**
- Interval (Optional)
- TAIL
- DATE
- START

**Aircraft Position (AP) Component**
- HRRR
- ASOS

**Surveil.**
- NOP
- ADSB
- TTFS

**USHST United States Helicopter Safety Team**
UIMC Event Check Process (RAISE)

RAISE
- Pipeline
- Archive

Flight Queue (FQ) Component

Flight Info. (FI) Function

EIM Bridge

Track Matching (TM) Component

Events

EVENT = event array

ID = unique HFDM flight identifier
TAIL = aircraft registration
DATE = flight start date
START = flight start time

HFDM

Archive

Pipeline

Analysis Results (AR) Function

RAISE Bridge

Event Check (EC) Function

Events

Data Vis. (DV) Component

FUTURE
- Event Detect (ED) Process

NULL EXIT

EXIT

EXIT

EXIT

EXIT

EXIT

EXIT

Pipeline Archive

Flight Queue (FQ) Component

Flight Info. (FI) Function

EIM Bridge

Track Matching (TM) Component

Events

Data Vis. (DV) Component

Analysis Results (AR) Function

RAISE Bridge

Event Check (EC) Function

Events

ID = unique HFDM flight identifier
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EVENT = event array
Aviation Safety Report Ingest & ETL Processing

ETL

Sample RASRs

Report Loop

Standardization & Mapping

Deidentification

Entity Extraction

Topic Modeling & Auto Class

RADS

RASR Repo

Target Entities

Safety Analytics
Artificial Intelligence/Machine Learning for Rotorcraft Safety

AI Algorithms

Deep Learning Neural Network

Instrument Panel Gauge Detection

Aircraft Attitude (Pitch, Yaw, and Roll) Prediction

Study Pilots’ Attention (Eye/Gaze Tracking)

Helipad Detection
Loss of Tail-Rotor Effectiveness/Unanticipated Yaw

- Critical low-speed aerodynamic flight characteristic
- Occurs when the angle/speed of the air flow through the tail rotor is altered
- Can result in un-commanded rapid yaw rate and/or loss of aircraft control

Federal Aviation Administration, “Unanticipated right yaw in Helicopters”, Advisory circular 90-95
LTE – Running Out of Pedal

- Thrust (T)
- Weight (W)
- Airspeed (Vinf)
- Groundspeed (GS)
- Yaw attitude (psi)

- Rotor angular speed (omega)
- Rotor radius (R)
- Blade chord (c)
- Number of blades (Nb)

- Wind direction (WD)
- Wind speed (WS)
- Air density (rho)

Python FILE
LTE – Running Out of Pedal

LTE
Running Out of Pedal
Flag
Loss of Tail Rotor Effectiveness (LTE) Post-flight data analysis

Flight risk on 3D map

Flight variable profiles

Event table

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Questions?
Thank You!

USHST Technical Center Aug 8 2017