

FDM and Pilot's Workload Estimation

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Outline today

1. Background (Why Workload Estimation?)
2. What can be picked up?
3. Structure of our method
4. Example Output
5. Applicability
6. Challenges for the future
7. Summary



Japanese National Organization for Aerospace Research and Development

JAXA R&D Directorates

Space Transportation
Mission Directorate

Satellite Applications
Mission Directorate

Human Spaceflight
Mission Directorate

Lunar and Planetary
Exploration Program Group

Institute of Space and
Aeronautical Sciences (ISAS)

Aerospace Research and
Development Directorate

Institute of Aeronautical Technology

Flight Test Facilities

Research Aircraft



HISHO (2012)



MuPAL-α (1988)



BK117-C2 (2013)

Flight Test Base



**Chofu Aerospace Center
Aerodrome Branch**



**Nagoya
Flight Research Center**



**Taiki Aerospace
Research Field**

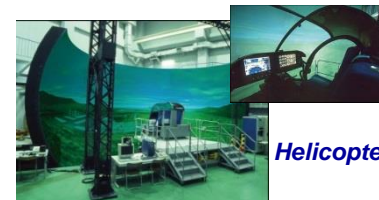
Flight Simulator



Airplane



FSCAT-A



Helicopter

FSCAT-B

Predictive?

Reactive?

Proactive?

Predictive!

- Accident/ Incident Countermeasure
- Reporting (Captain / Air Safety Report)

- FOQA
- LOSA
- Periodical Safety Audit

- Hardly found risk (Hidden Factor)
- from Normal Operation
- Dig in Big Data

- For further accident/ incident prevention, caring **Hidden Factors has importance.**
- One of hidden factors: **Pilots Workload** defined as our target.

- Why Flight Data Analysis?
 - No Observer required. (Less human resource)
 - Regularly available source. (regardless recognized event)
 - Existing infrastructure. (Less further budget)
 - Huge volume of stored data is pristine.



What can be picked up?

➤ Basically from recorded Parameters

➤ Combine with Other Resource

- SOP (Standard Procedure)
- Cockpit Layout / Design
- Etc...

➤ Look for common point of ...

- Frequently skipped / disordered procedure.
- Observed high density workload.
(Location, Waypoint, flight phase, etc...)

➡ Hidden risk factor for safety.

➤ Reconstruct Pilots' activities.

➤ Detect wrong procedure.

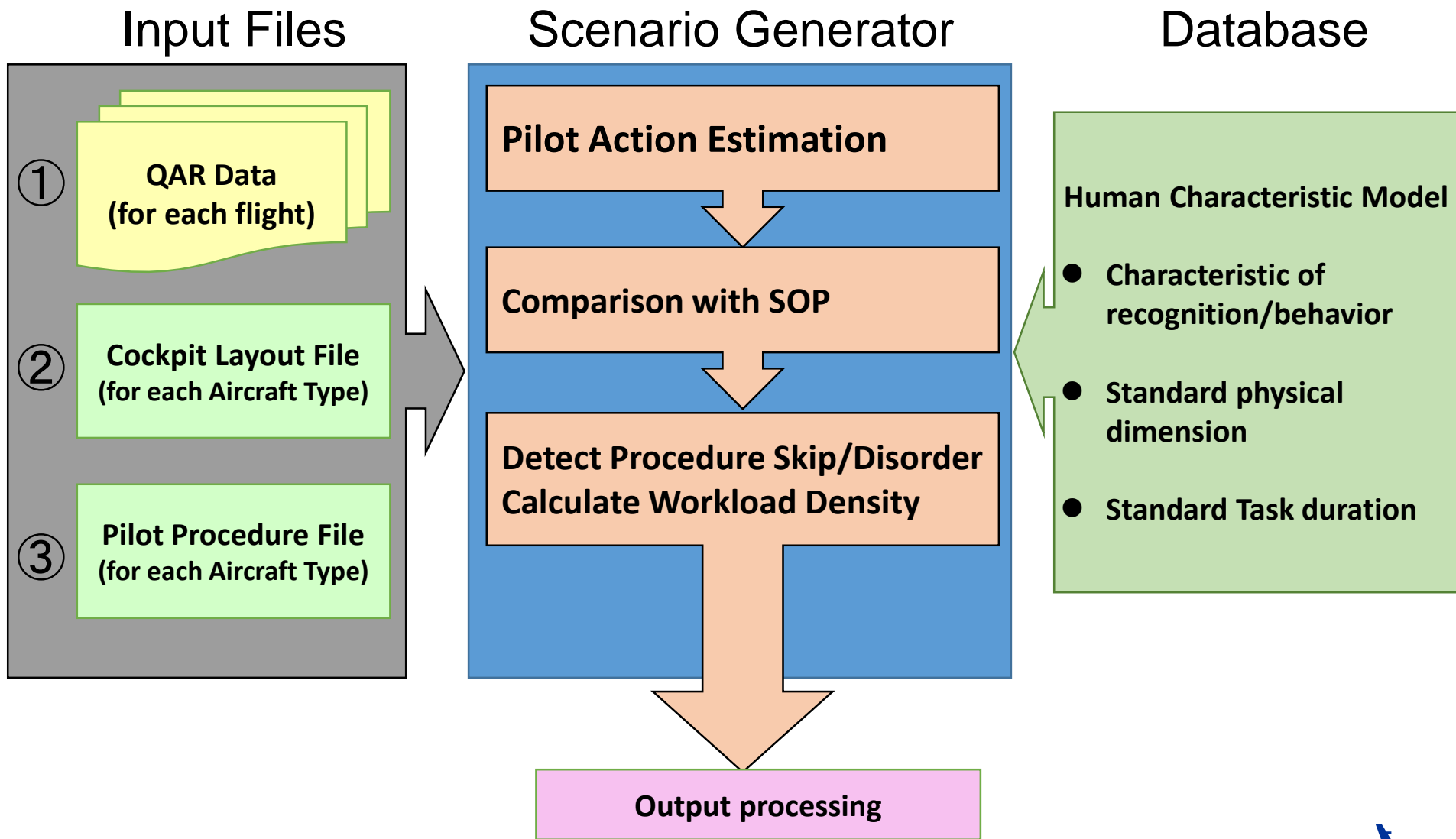
➤ Estimate pilot workload.

➤ Identify conducted STAR/SID/APP.

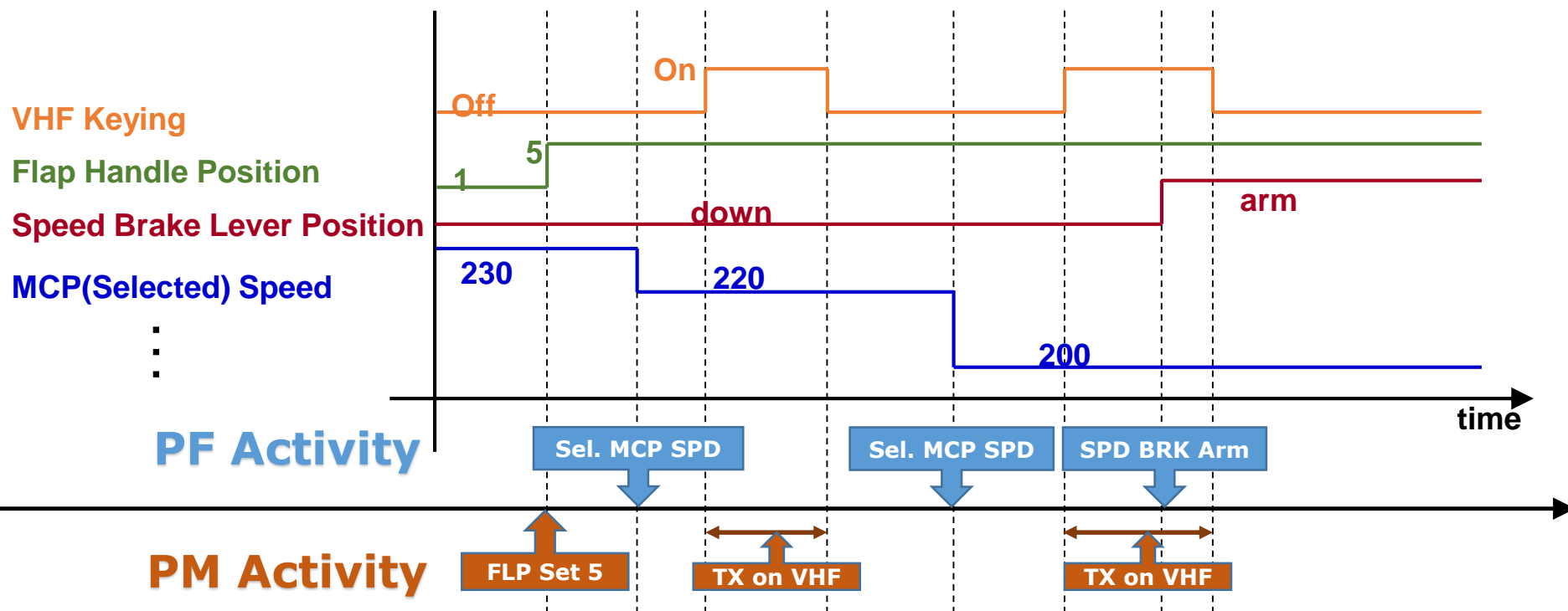
OPSAMS: Operational Procedure Safety Analysis Monitoring System

- Derive actual pilots' activities from daily flight data.
- Detect deviation from SOP, estimate pilots' workload.
- Pickup hazardous factor in daily operation through statistical analysis.

OPSAMS(Structure)



Reconstruct Pilots' Activity



Flight data recorded Pilots' Activity can be picked up.



Not all Pilots' Activity are recorded.

Timing of not recorded activity **can be estimated by combine with other resource.**
(ex. At 1000ft above AFE, "call One Thousand" for PM.)



Pilot Action Interpolation

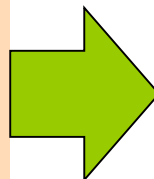
Pilots' activity can be disassembled (break-down).

Each activity consists of element actions interpolates described action.

Pilot Procedure File

PF Order, FlapLever, 15

PM Set, FlapLever, 15



After Interpolation

PF Order <Flaps 15>

+

PM Hear <Flaps 15>

+

PM Look "FlapLever"

+

PM Set "FlapLever":15

+

PM Confirm on Instrument Display

**Detectable from
Flight Data**

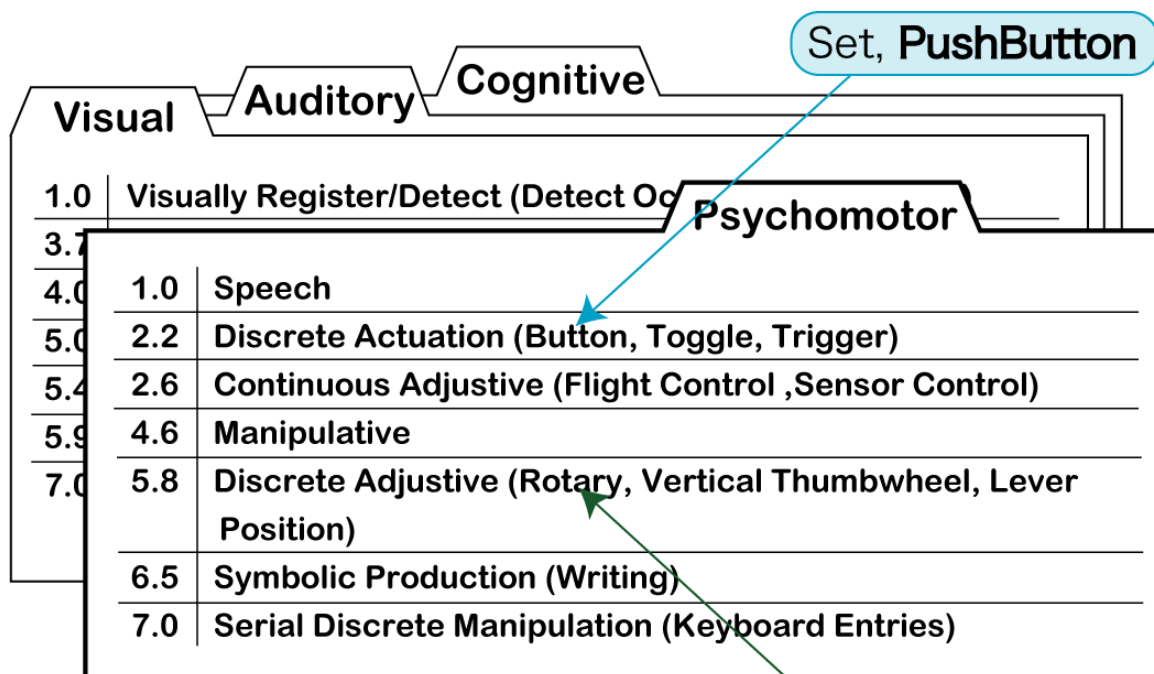
Workload estimation is based on required time for individual interpolated action.
OPSAMS has ability to process the function.



Workload Index Model

Workload:

- Physical and Mental load on person when the person perform any action.
- Assumed quantifiable by giving workload index to Combination of **V: Verb (what action) and O:(Operational Object)**.
(They are obtained from **S+V+O+C**, which defines procedure description)
(This method is following TAWL (Task Analysis Workload))



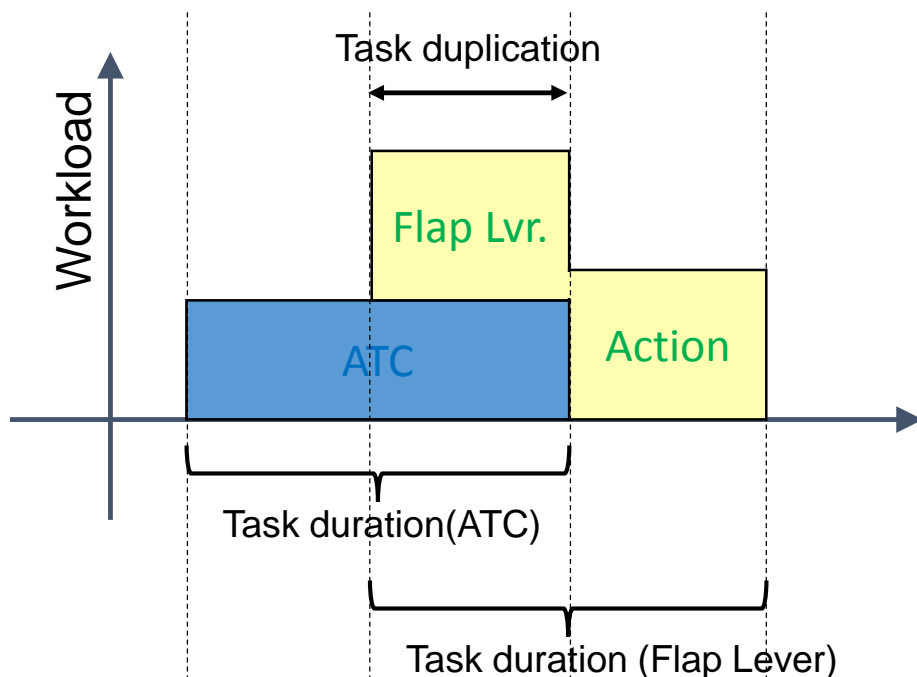
Workload has 4 categories.

V (Visual)
A (Auditory)
C (Cognitive)
P (Psychomotor)

Each category can have index value between 1.0 ~ 7.0.

Workload Calculation

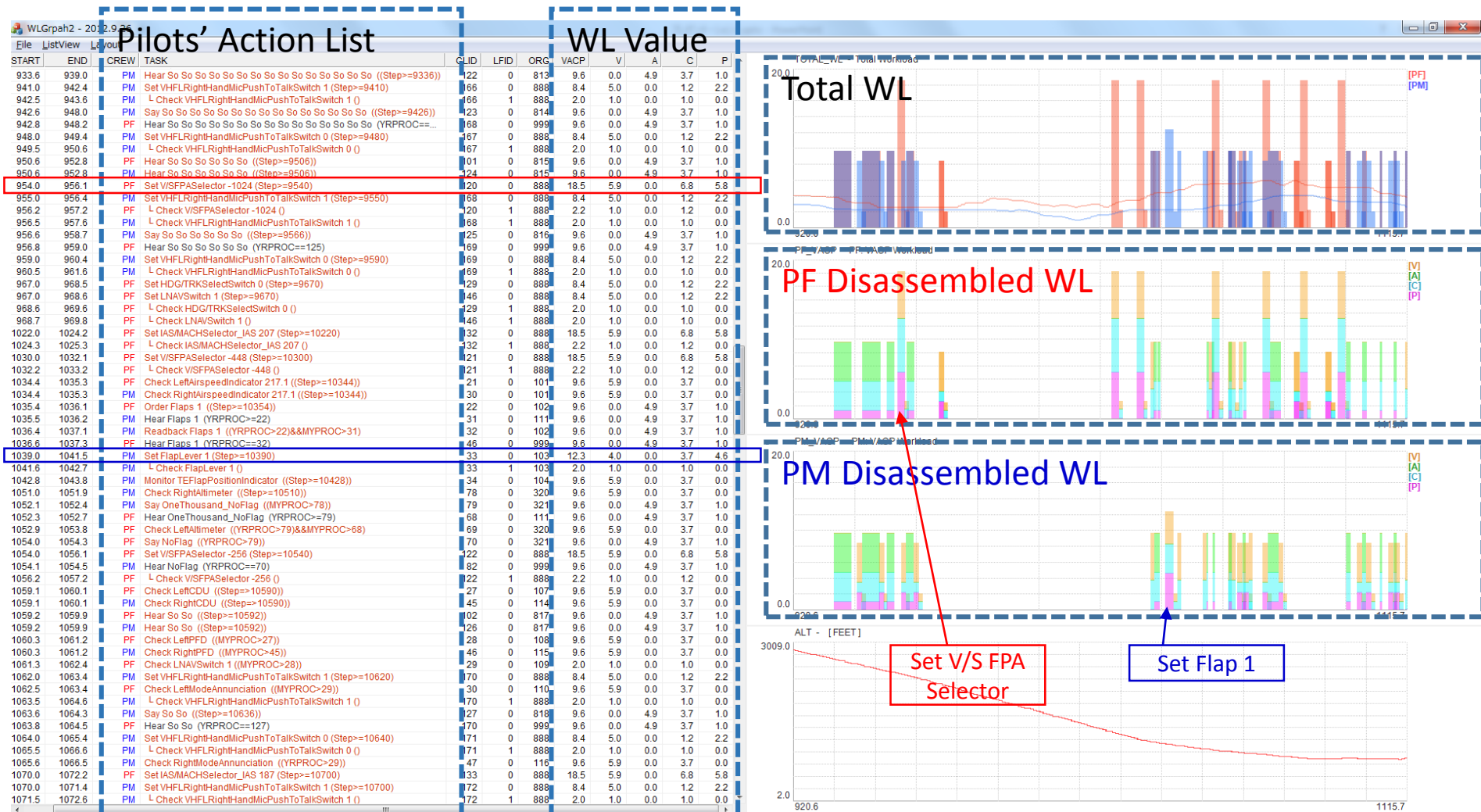
- Activity execution and its timing can be estimated from Flight Data combined with defined Standard Pilots' Procedure.
- Activity can be disassembled. (They consist of elemental pilots' action.)
- Assign "Required time" and "Workload" (based on "**Human Characteristic Model**") to each elemental pilots action.



Derivable value

- Workload Density
- Decrease/Increase/Peak of workload in time series
- Timing that task duplicated

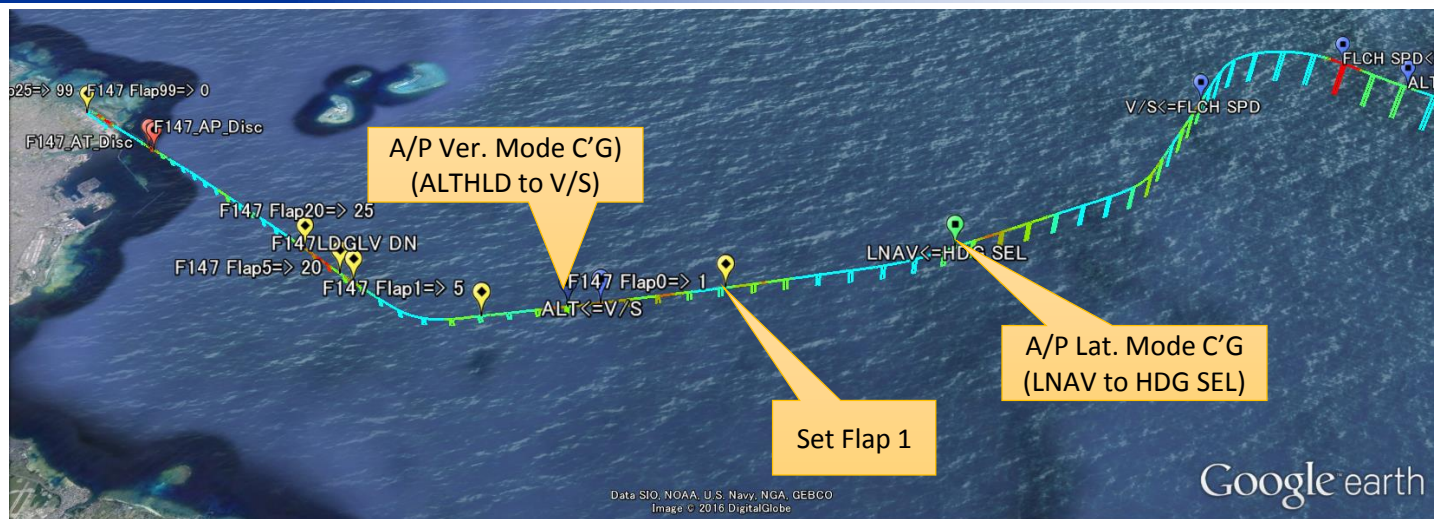
Example Output (Task Analysis)



Applicabilities

- Pick up hazards from (looks) **Normal Flights**.
≡ Health Check. (Can complement LOSA?)
- Event investigation in the view of
 - Pilots' Workload
 - SOP incompliance
- Look for another threshold value for other application (ex. FOQA,)
- Etc...

Example Output (Visualize One Flight)



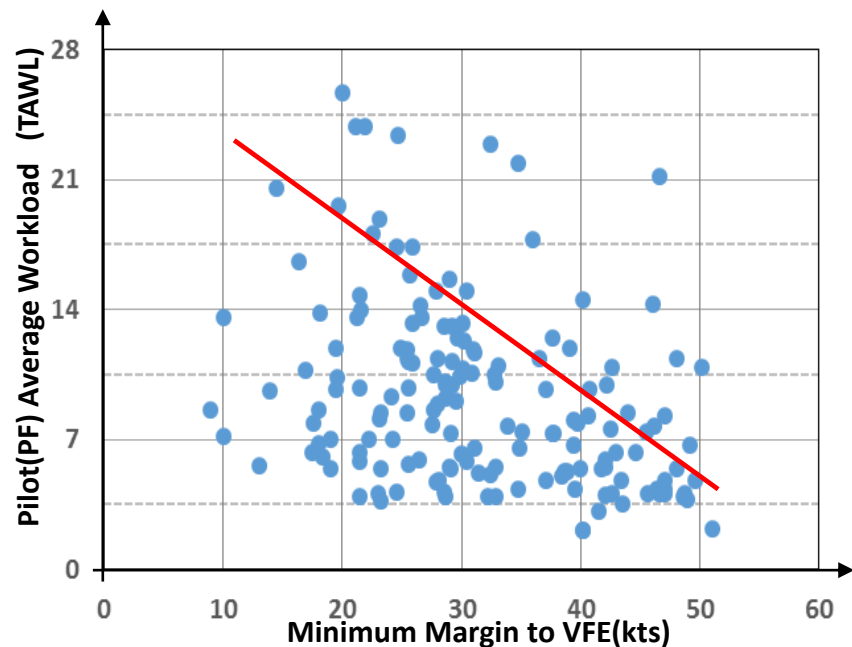
- 3D path shown on Google Earth(KML file)
- Contour with Workload Density
- Marked
 - Configuration change(Flap /Gear)
 - A/P, A/T Mode Change
 - Any other condition available....

Application Example

➤ WL vs Speed Margin

- Analyze 160 Flights (B777)
- QAR data provided from airlines

- An Example result
- Minimum Margin to VFE (Flap 5, Approach):
Minimum SPD **Margin to VFE** at a Flap Setting
- Pilot (PF) Average Workload:
Average Pilot's Workload during
10sec to Minimum SPD Margin



- A significant negative relationship was observed.
- **Higher Workload \Leftrightarrow Less VFE Margin**

Correlation Factor: $r = -0.34$

(Significance level: $\alpha = 1\%$

& Number of Sample : $N = 160$

$\Rightarrow r_{5\%} := 0.203$)

Challenge

- Estimated Workload
 - Visible
 - Recordable (QAR or Video)
 - Defined (Standard Procedure)

- Un-estimated Workload
 - Invisible
 - Un-recordable
 - Not cared in TAWL
 - Not defined (unstandardized)

➤ Estimate with Higher-accuracy.

- Activity Reconstruction
- Workload Estimation

➤ Further case studies required.

➤ Establish model of un-estimated workload.

- Detect specified condition
- Apply workload on Pilots

➤ Calibration should be required.

➤ Easier to use. (automation)

➤ Establish standard approach. (defined graph/table style)

- Workload can be estimated from reconstructed Pilots' activity.
 - Pilots' activity was reconstructed with QAR combine with SOP.
 - In the process, pilot activity was break down in to elementary action.
 - By assigning workload index value to those elementary action, Pilots' workload is estimated.
- Obtained pilots action, activity and workload were visualized.
 - On Google Earth (coloured 3D flight path), tabular and graph form.
- Existing correlations suggested between Workload and Speed Stability.
 - However, further study required.
- Further Challenging exists before actual use.
 - Handling un-estimated WL, calibration between actual and estimated value.
 - Further automation, user interface, standardized analysis method.