Interacting Loops of Risk Perception and Risk Management

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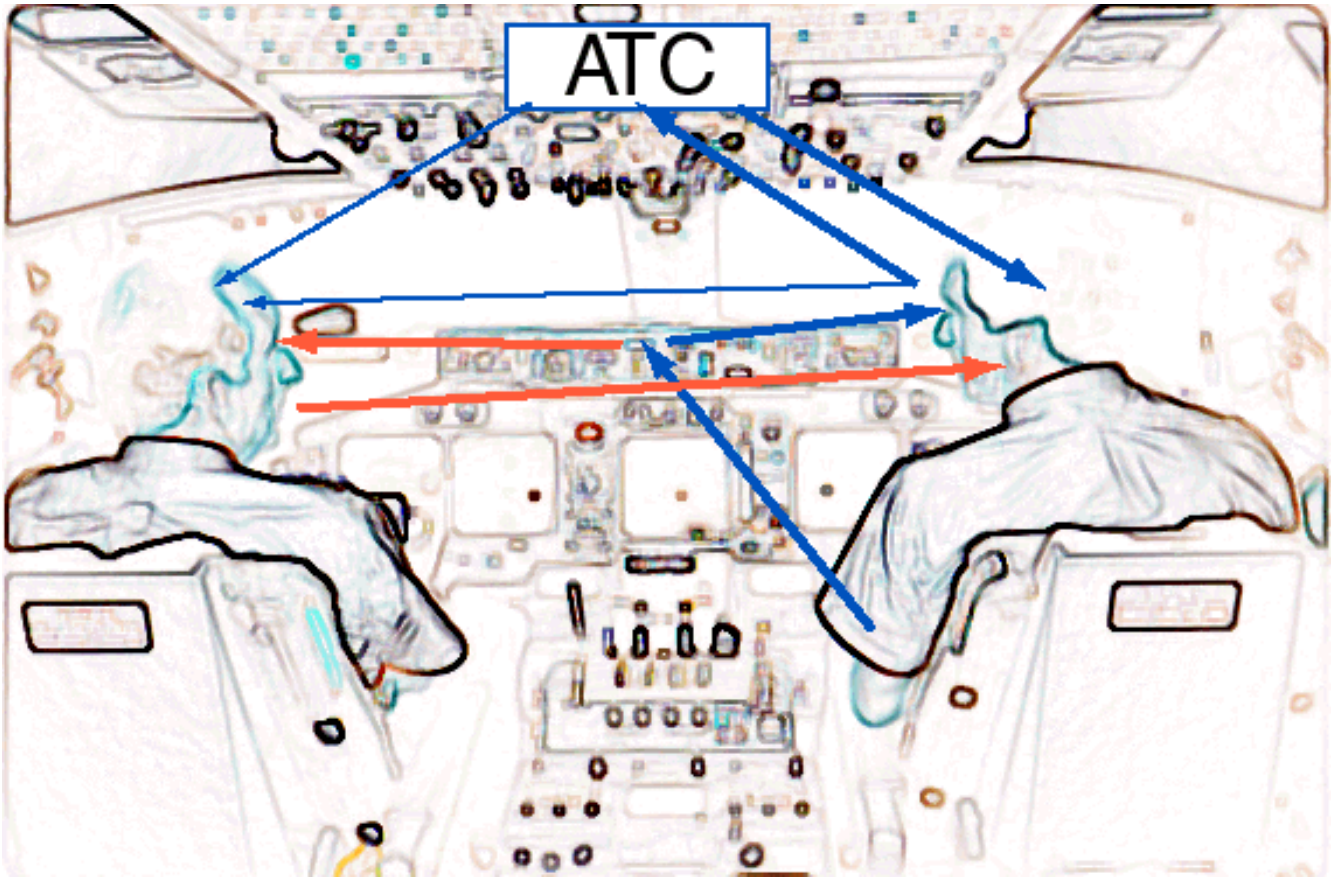
A small change in procedure changes the cognitive properties of the flight deck system



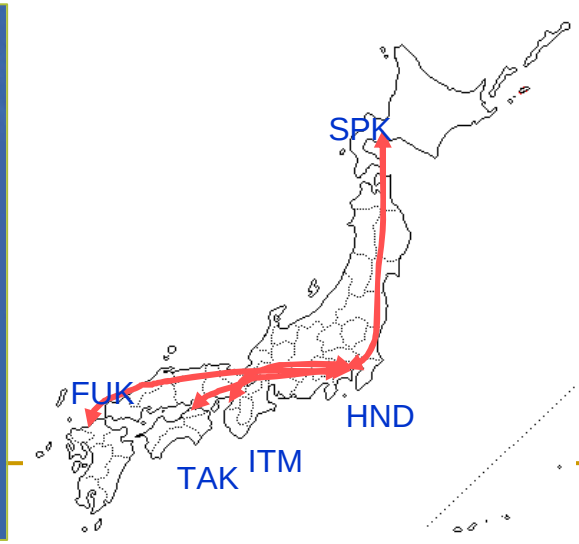
What information goes where when in what form?

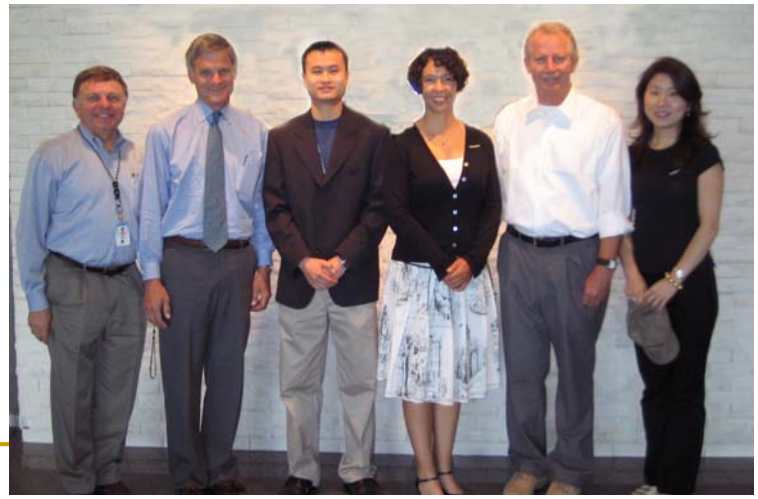
Launching the Boeing 787 as an airplane for the world's pilots

Data Collection: Ethnographic field trips

		Revenue Flights		FSS Training	
		# of flights	# of pilots observed	Hours observed	# of pilots observed
Japan	Aug. 2005	22 legs	22 pilots	15 hours	7 pilots
N. America	Oct. 2005	------	-----	37 hours	3 pilots
New Zealand	Nov. 2005	21 legs	14 pilots	4 hours	2 pilots
	Oct. 2006	11 legs	12 pilots	8 hours	4 pilots

Aircraft: Boeing 777, 747-400, 737-300





Data Collection in Simulator

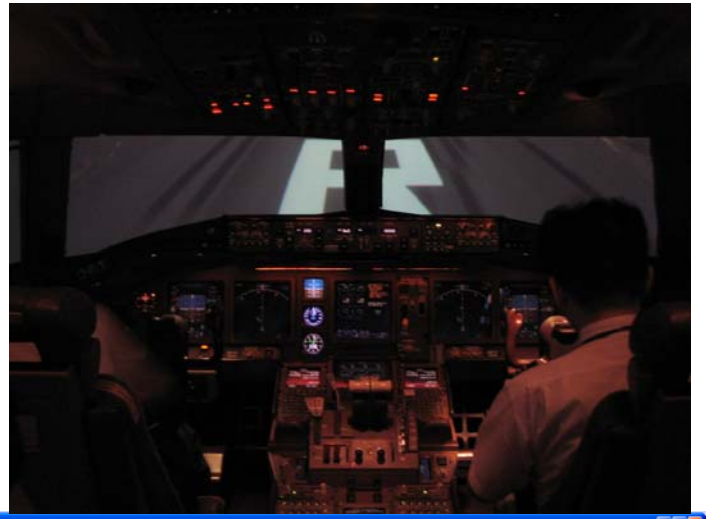
1. Record briefing/debriefing sessions (digital audio)

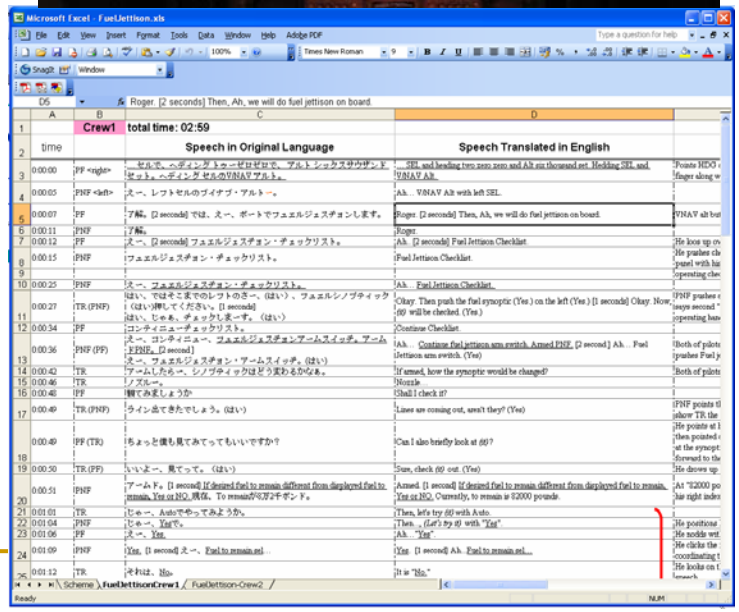
2. Record simulator sessions (digital video) with two lapel microphones (Captain and FO)

3. Digitize data to PC
   - From MiniDV -> avi file -> MPG

4. Transcribe using Excel (Japanese and English)

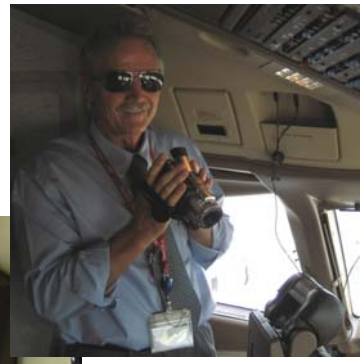
5. Analyze data
   - Analytical foci:
     - Language use
     - Coordination of information (e.g. loading FMS, performing non-normal checklist, etc)
     - Crew coordination

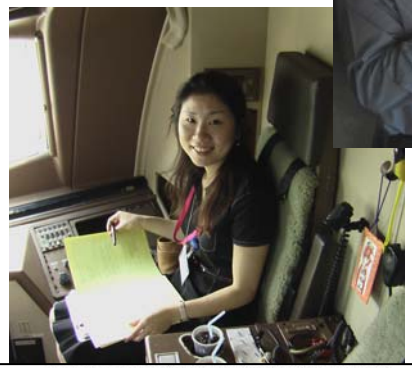


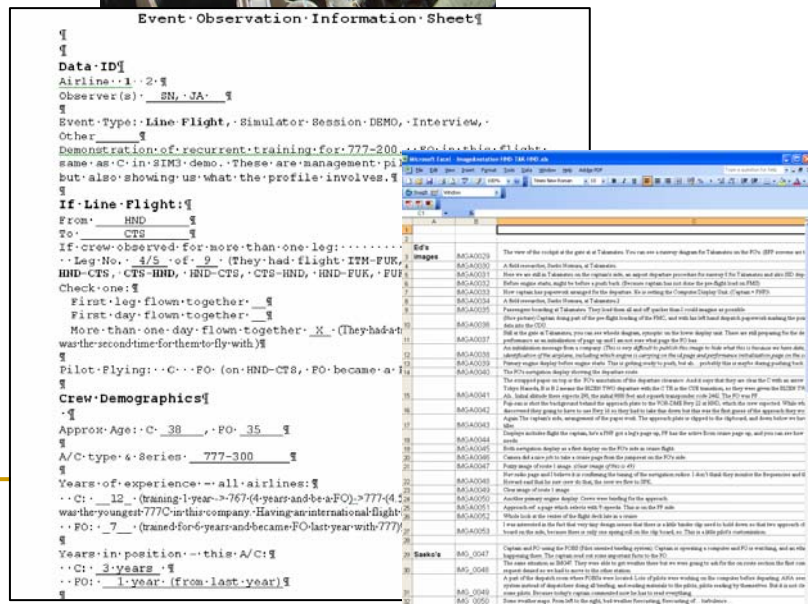


Data Collection in Actual Flights

- Each flight was observed by two researchers
- While observing…
  - Take notes and photos
  - Collect paperwork
    - Dispatch papers, ATIS printouts and written notes
  - Fill out EOI (event observation information) and paper distribution forms
- After the observation…
  - Audio record a debriefing with co-observer to discuss what we saw in the flight deck
  - Dictate audio annotations of the photos we took in the flight deck
- After the fieldwork…
  - Digitize all paper data
  - Transcribe audio debrief and annotations
  - Merge handwritten notes with debriefing and annotations to create the final field notes







Event Observation Information Sheet

Data ID

Airline 1 2

Observer(s) SN, JA

Event Type: Line Flight, Simulator Session DEMO, Interview, Other

Demonstration of recurrent training for 777-200

same as C in SIM3 demo. These are management pi

but also showing us what the profile involves.

If Line Flight:

From HND

To CTS

If crew observed for more than one leg:

Leg No. 4/5 of 9 (They had flight ITM-FUK, HND-CTS, CTS-HND, HND-CTS, CTS-HND, HND-FUK, FUK

Check one:

First leg flown together

First day flown together

More than one day flown together X (They had at

was the second time for them to fly with)

Pilot Flying: C PO (on HND-CTS, PO became a

Crew Demographics

Approx Age: C 38, PO 35

A/C type & Series 777-300

Years of experience - all airlines:

C: 12 (training 1 year -> 767 (4 years and be a PO) -> 777 (4

was the youngest 777 C in this company. Having an international flight

PO: 7 (trained for 6 years and became PO last year with 777)

Years in position - this A/C:

C: 3 years

PO: 1 year (from last year)

Ed's images

Saeko's

Our Field Notes

1. Digitize (scanned) all related maps, charts, and collected papers.
2. Make hyperlinks to supporting documents
3. Combine everything we collected.

Field Note HND-TAK-HND on July 16, 2005

Saeko Nomura and Edwin Hutchins

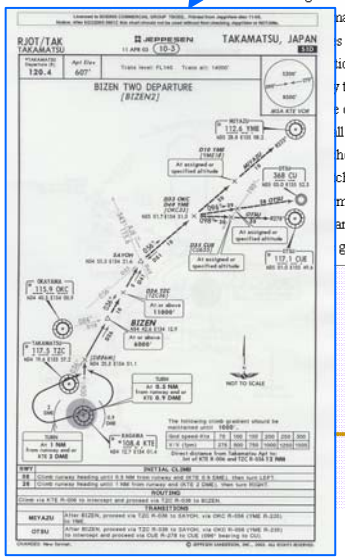
HND – TAK: **Departure HND: RWY16L**, ZAMA SIX DEPARTURE
Arrival TAK: OLIVE RNAV (DME/DME), ILS RWY26

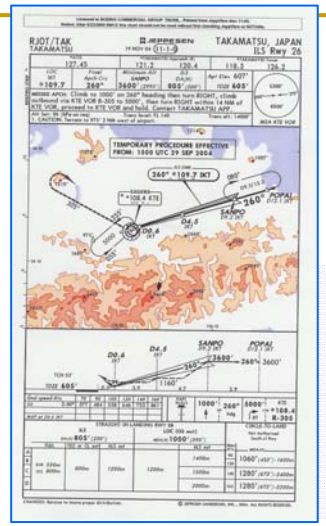
TAK – HND: **Departure TAK: RWY 8**, BIZEN TWO DEPARTURE
Arrival HND: JONAN SOUTH ARRIVAL, VOR DME-C (Rwy 16L)

Weather: HND: fine, 28C TAC: fine, 27C

HND – TAK

Our host at the airline met us at the reception area where we were iss
us to the flight operations office/dispatch room. There we were issue
our positions as observers on the specified outbound flight. We woul
return trip in the operations office at the destination. Our host introdu
tells them that our observations are not a line check. We introduced c
The crew meet in the dispatch room where they checked today's wea
and inbound flights) using the POBS (Pilot Oriented Briefing System
looked very energetic and stern, and FO was a tall, big guy having a
used casual Japanese to FO when they talk about informal topics, but
formal conversations such as briefings, both of them used polite Japa
FO's attitude toward C was very polite: using crispy short ending spe
The crew showed us how to use the POBS; logged into the PC-based
clicked the flight numbers to proceed to the next pages [See image[2]].
the screen from the right side, though both of them pointed the screer
nation and COMPUTERIZED FLIGHT P
s in total. When Ed saw the C using the sy
ions with it. Saeko asked C about the usal
this April (3 months ago), and for C, this
of trial uses in April, he had difficulties v
ll the information the POBS provides. In
her (a person), using documents provided
cher's speech) and eyes (dispatcher's gest
mation by themselves, using a computer s
are now responsible for finding all of the r
getting used to the new computerized syst





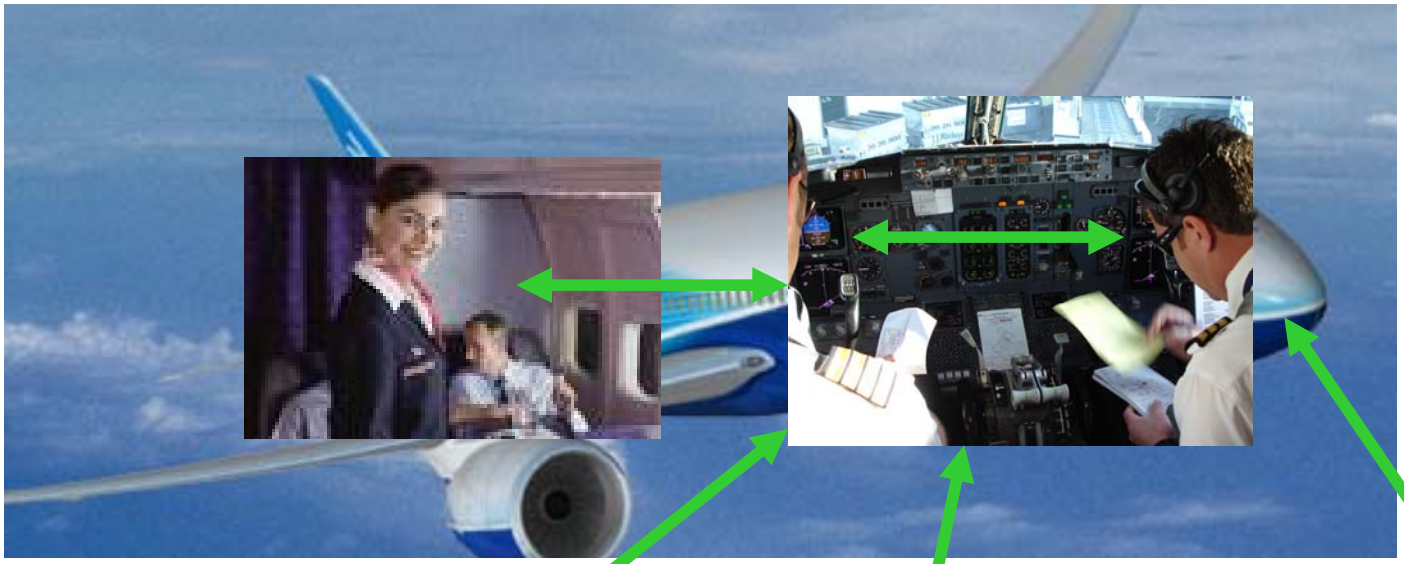
	Next, C sets up the MCP. He arms LNAV/VNAV, turns the speed select knob to set V2 speed and the HDG select knob to set runway heading. He also checks radio frequencies on his radio control panel. C selects 10 mile range on his navigation display. (Could not see FO's display from my seat).
8:07	C calls out, "5 minutes." FO makes ACARS request for RJTT ATIS. FO then types a free text ACARS message to company dispatch, "CMD FLX R16R W3" using the COMMS page display on the lower DU. This is a request for flex info for RWY 16R. One concern voiced by the Boeing team was that some pilots were slow on alpha character input in free text input. This FO was quite fast on both alpha and numeric input. C and FO then do a careful cross-check of the route. C has RTE 1 LEGS page on his CDU. FO is holding the NAVIGATION LOG paperwork. They step through the route one waypoint at a time confirming that the route in the FMC corresponds to the dispatch route. C takes the latest ACARS RJTT ATIS N off the printer. He folds the paper as ⊠, and puts it on above the CDU display. FO prints a second copy of ATIS and places it on the large clip board.
8:09	Flex info for 16R arrives (see collected paperwork) and FO prints it. Both C and FO consult Perf Init pages on their CDUs. They don't complete this page. They still need the correct FLEX INF. FO types another free text message to company. This time requesting flex info for RWY 16L. I do not know why he requested 16R information the previous time. Did the C notice something and tell him to get info for the correct runway?
8:10	FO prints out the FLEX INF for RWY 16L from ACARS printer. C confirms the information and puts it around the communication radio interface, just on the dispatch paper filled with FA's information.
8:11	Final weight and balance arrive via ACARS. FO prints it (see collected paperwork). After that, FO tells C, "Let's do '5 minutes before'." C and FO jointly review Perf Init page checking every field together. C holds the Wt&Bal printout and monitors his CDU while FO does data entry. C calls out "348900" while FO enters GWT 348900 on his CDU. Note that critical numbers such as GWT are printed on the paperwork both as numeral and as words: "THREE FOUR EIGHT NINE ZERO ZERO." C's CDU remains on Perf Init. Then FO goes to TO REF page and selects the V-speeds while C watches. Each pilot spoke the Vspeeds aloud as the speeds were selected. After entering the information, FO puts the wt & balance printout on the window clip board on his right side [Image].
8:12	FO communicates with ATC about the push back.
8:13	The crew does a **take-off briefing** using dispatch papers and ACARS ATIS. C explains to FO how to handle engine failure after taking off. C includes discussion of rejected takeoff procedures, procedures for immediate return to the field and expected procedures for climbout. C finishes briefing consulting RTE 1 LEGS page to say something about the TAK airport. He then consults ACT 148KT CLIMB page. C holds ATIS while talking to FO, then picks up dispatch paper and continues briefing. Consults NOTAMS in dispatch paperwork, then FLEX INF printout and compares at info to the THR LIM page and Thrust limit shown on EICAS. This is a very nice example of the use of talk and gesture to coordinate multiple representations – on paper, on CDU, and on EICAS.

```
2310Z     ACARS MSG
[redacted]      RJTT/RJOT     JA8199
                              152309
-----------------------------------------
            FLEX INF
[redacted]RJOT JA8199 152309Z
TTOW:388.8 DW: 3.0            STS:-
QNH:3004 OAT: 26 WIND:T130/06 AT 23:00Z
RWYC:DRY       AC:ON

        FL  / CL  /FLEX
RWY16L    /TO2/F5 /IND
 TW 0:454.7/393.9/44 (FOUR FOUR)
 TW 5:433.2/393.9/44 (FOUR FOUR)
 TW10:411.7/393.9/44 (FOUR FOUR)

RWY16LC9 /TO2/F5 /028
 TW 0:431.8/395.4/43 (FOUR THREE)
 TW 5:410.8/395.4/43 (FOUR THREE)
 TW10:393.0/399.4/42 (FOUR TWO)

RWY16LC8 /TO1/F15/080
```

Language use contexts

English

Language use contexts (Mexico domestic)



Spanish

Language use contexts (Mexico international)

Spanish ⟷

English ⟷

Language use contexts (Japan)

Japanese ⟷ **English** ⟷

Flight Deck Operations: Takeoff Briefing

Radical Code Mixing

- Captain: では、Takeoff briefingやります。
- FO: はい。
- Captain: {FO}: えー、weather information、**Quebec** 了解。えー、using **runway three-four right**。{はい}。先ほどperformance確認しました。えー、いちーごーいちいち、**braking action、poor**。
- えー、五十九万八千**pound**。{はい}。ということで、plan weightとほぼ同様と。えー、fuel minus百ですけれども、{はい}現在recoverして、まぁ二万二千{はい}、order fuel、同様。{はい} えー、performance、check。えー、**TOKYO HANEDA**は、えー、above take off、えー、below landing minimum {はい}。Takeoff alternateはNARITA、{はい} [2 seconds] えー、とります。

- Captain: *Then, Let's do* Takeoff briefing.
- FO: *OK.*
- Captain: {FO}: *Let's see.* Weather information, **Quebec**, *roger*. *Well*, using **runway three-four right**. {*Yes*}. *(We have) already checked* the performance *before*. *Uhhh*, *one-five-one-one*, **braking action, poor**.
- *Well,* ***five hundred and ninety-eight thousand*** **pounds**. {*Yes*}. *So*, *(it) is almost the same as* plan weight. *Ah*... fuel *is* minus *one-hundred, though*, {*Yes*}, *it is* recovered *now*, *and* ***about twenty-two thousands***, {*Yes*}, order fuel *is the same*. {*Yes*}. *Well*, performance, check. *Uhh*, **TOKYO HANEDA** *is, uhh*.., above take-off, *ahh,* below landing minimum {*Yes*}. NARITA *is* [2 seconds] *ahh taken as* a takeoff alternate {*Yes*}.

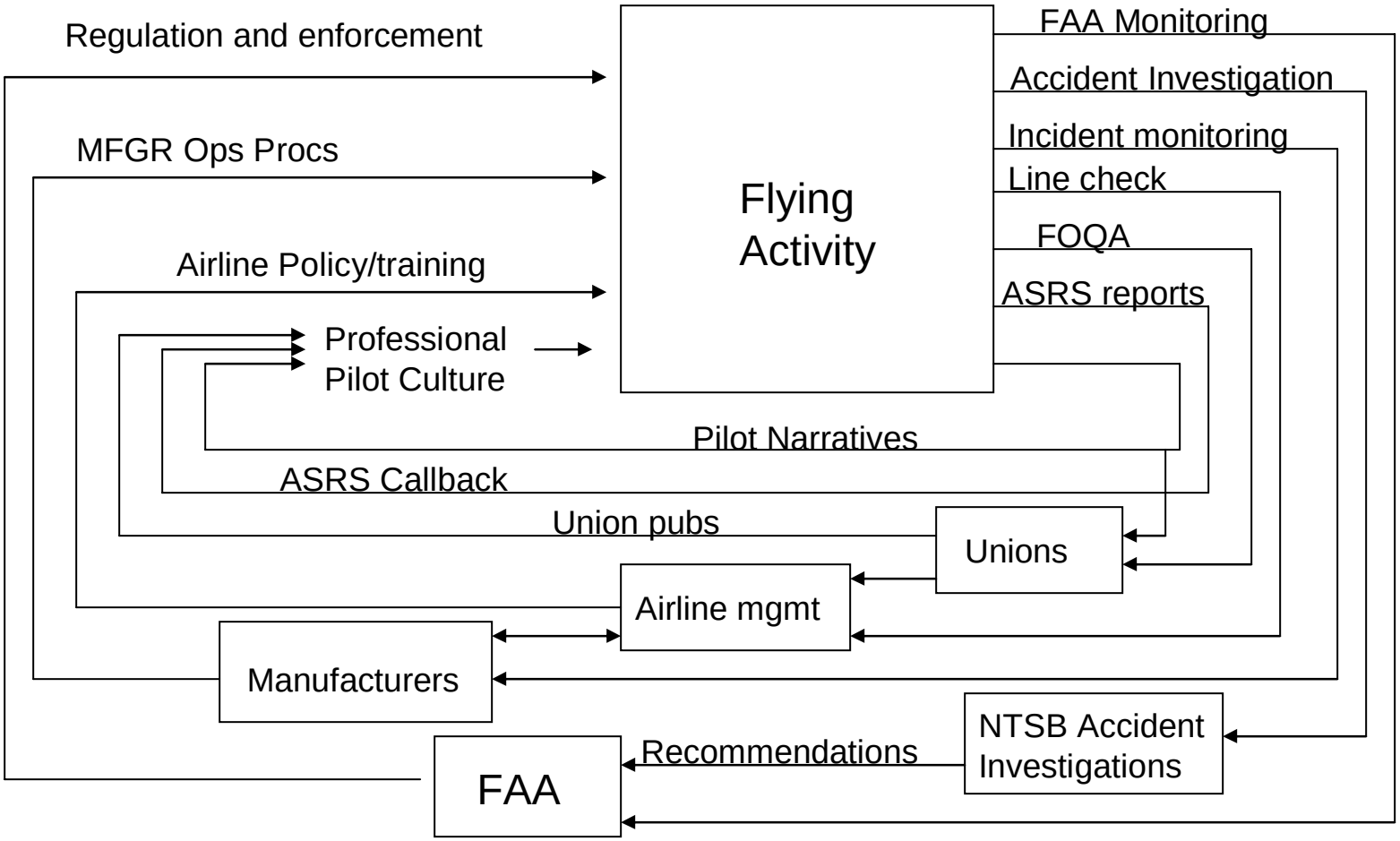
Bold = displayed; Underline = number; *Italic* = Japanese in original

Exogenous Factors

- Policies of Nations
  - Education and language practices
  - ATC language
- International Agencies
  - ICAO's "Aviation English" initiative
- Manufacturer and Airline Policies
  - Flight deck displays and labels
  - Operating and training manuals
  - Checklists (Electronic Checklist)

How shall we understand
the relations between
what is in the flight deck
and
what the flight deck is in?

Learning Loops Mark I



What's at risk?

- Pilots
- Fleet managers/Operators
- Manufacturers
- Regulators
- Unions
- Public/passengers

- Reputation/job
- Safety/performance/ profitability
- Reputation/sales
- Effectiveness/funding
- Work conditions/jobs
- Safety/convenience

Ready or protected?: Airbus autothrust use policies

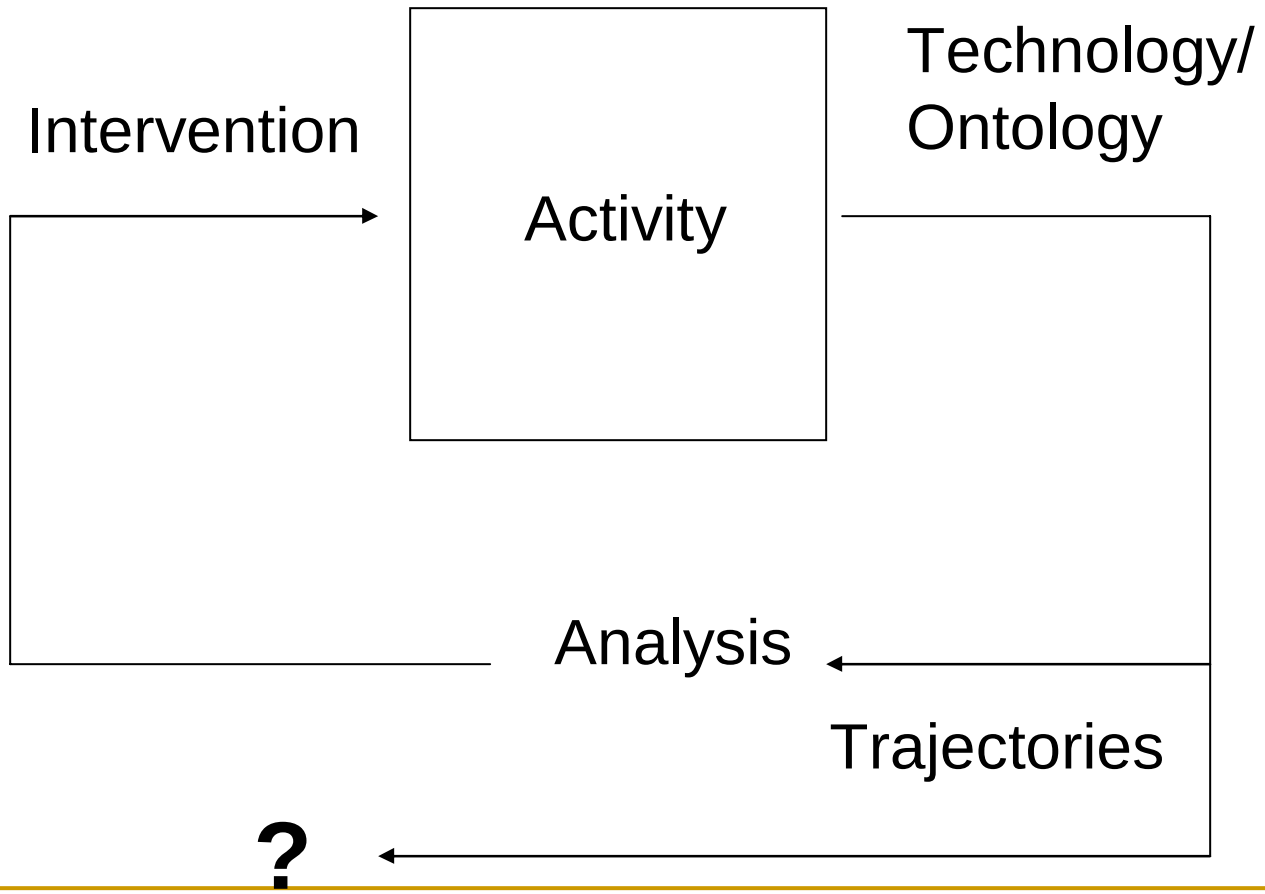
- A320 autothrust system and protections
- Line pilots' perspective
  - Need experience (practice) to be ready to perform. Cannot risk being unprepared in the event of system failure.
- Fleet managers' policies:
  - No dispatch with A/T inop. No flight with A/T disconnected. Cannot risk loss of protections.

Use of FPA for guidance on visual approaches

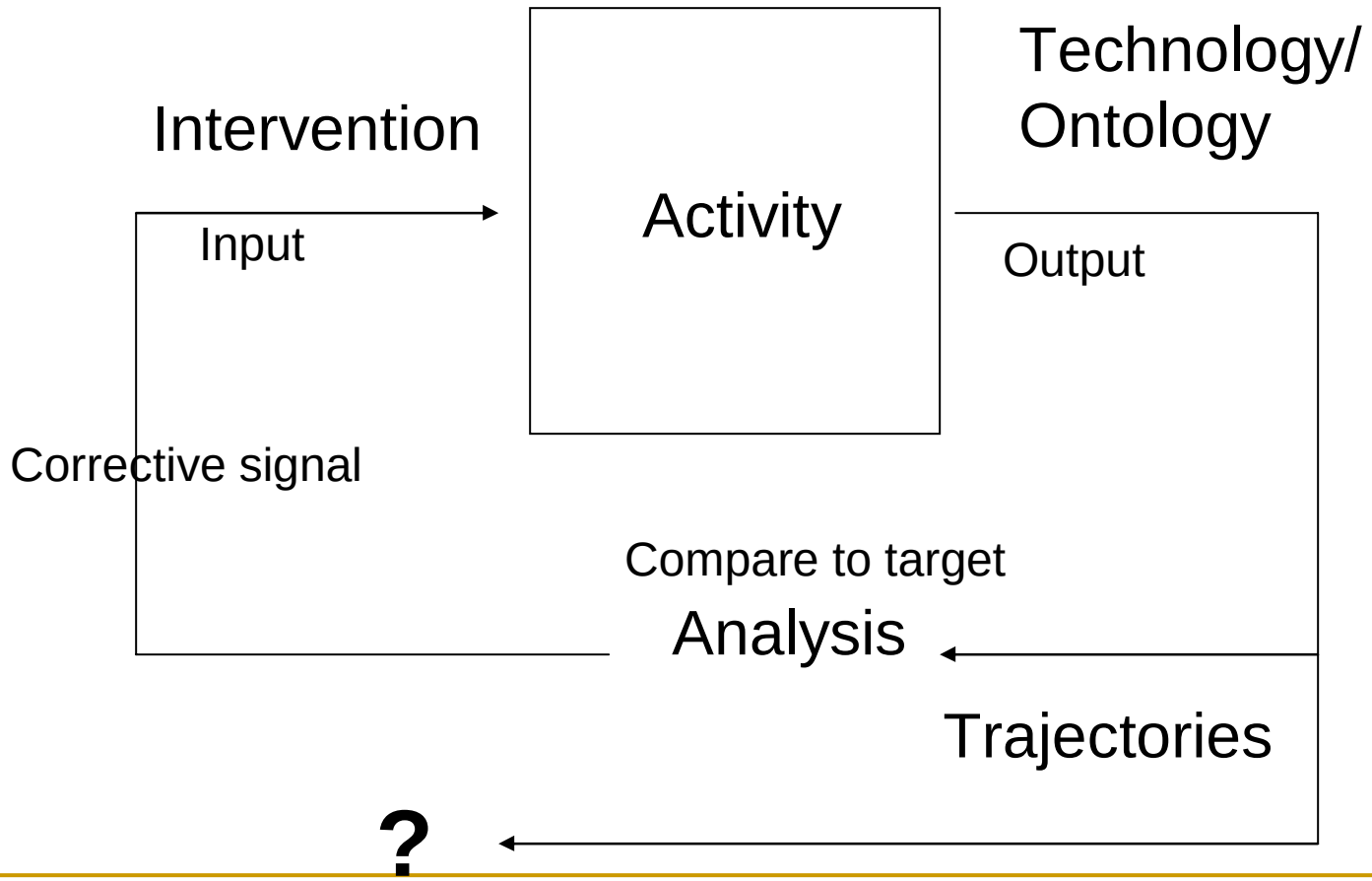
- Airline: it increases the likelihood of stabilized approaches and successful landings. (reduces probability of go around).

- Manufacturer: it’s an unsafe practice, no criteria for discontinuing if visual contact is lost.

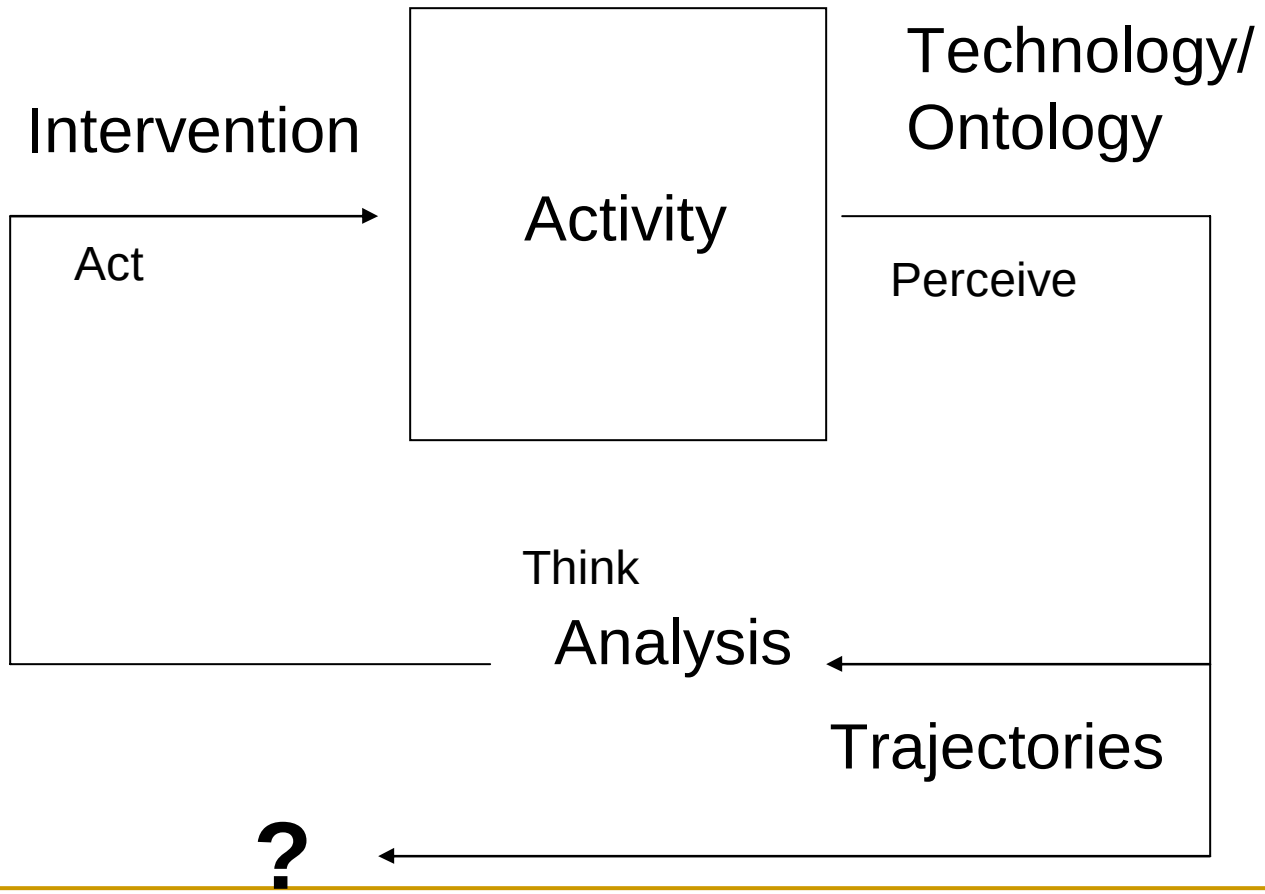
Generic Learning Loop Properties



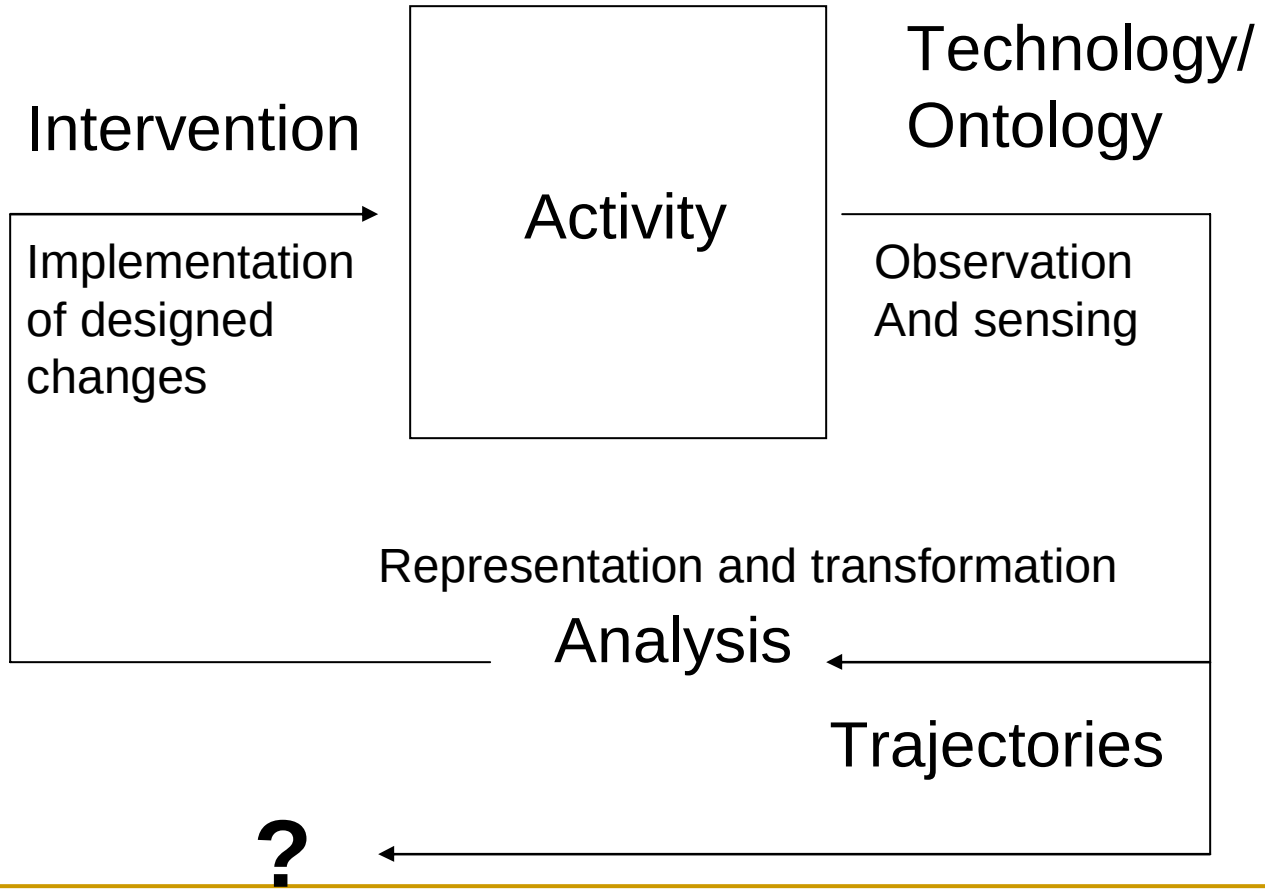
Cybernetic control



Individual cognition



Organizational learning



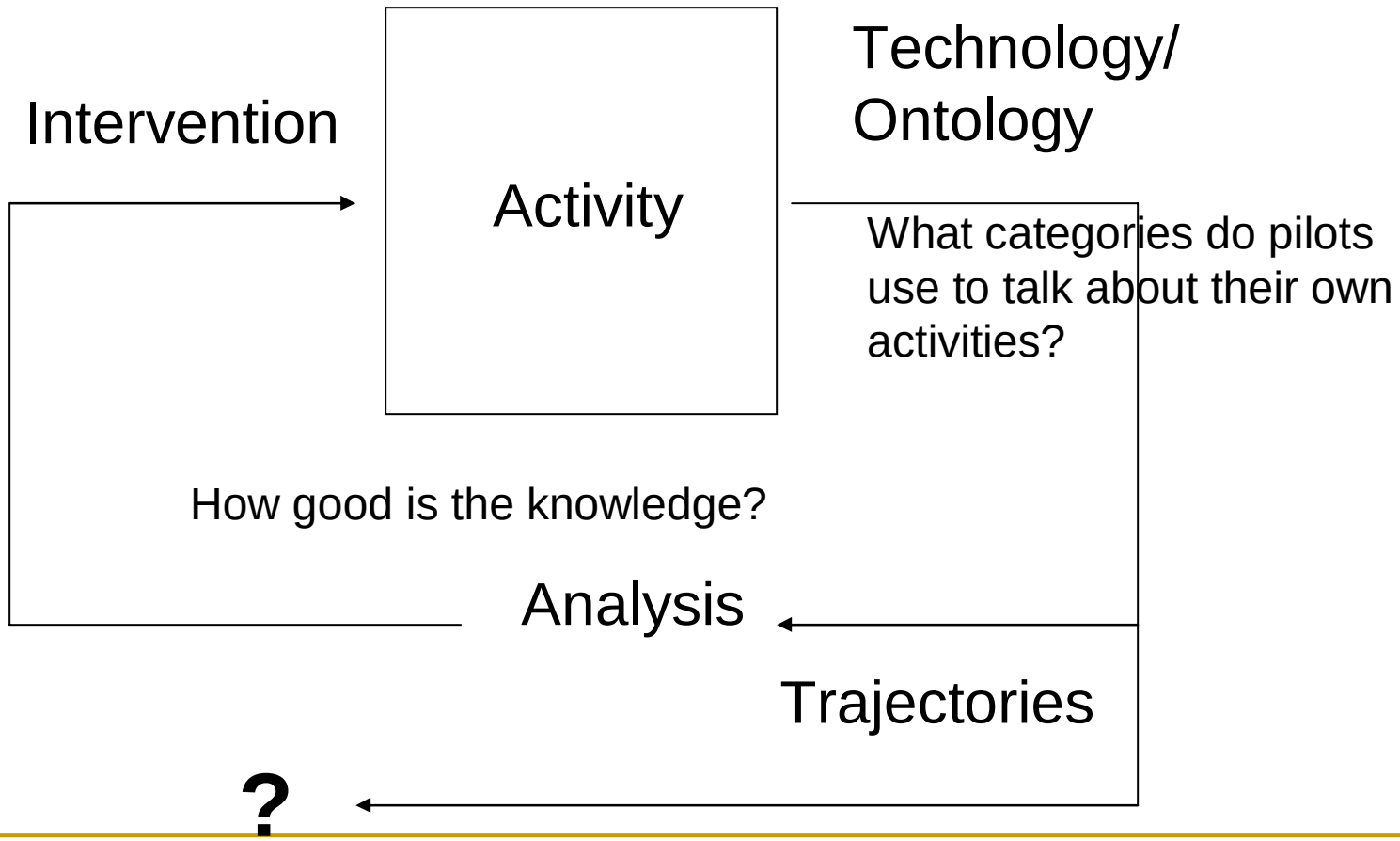
Loops Mark II

- Pilot experience
- Line Observations
- Flight Data Monitoring
- Accident Investigation

Pilot Experience Loops

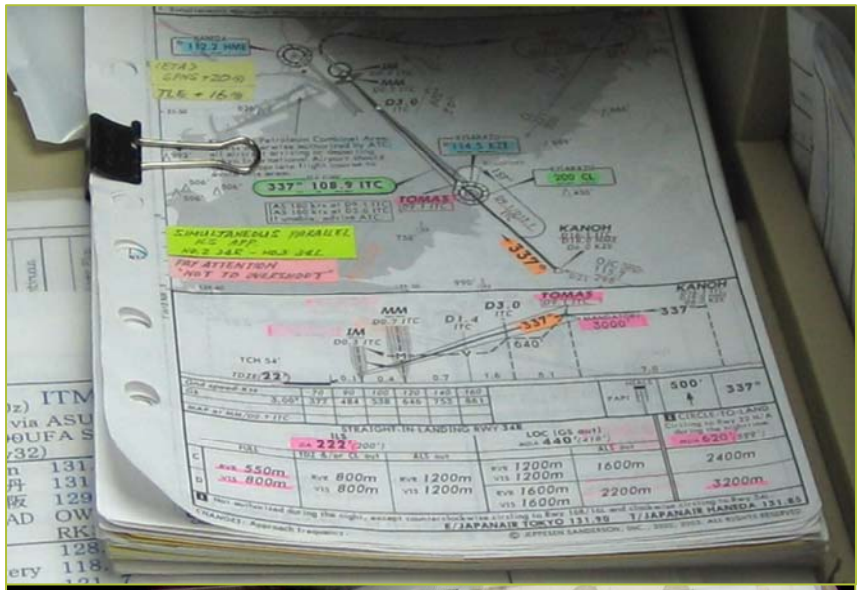
- Hangar Flying, Bluecoat Digest, etc.
- Log books and handovers
- ASRS/ASAP

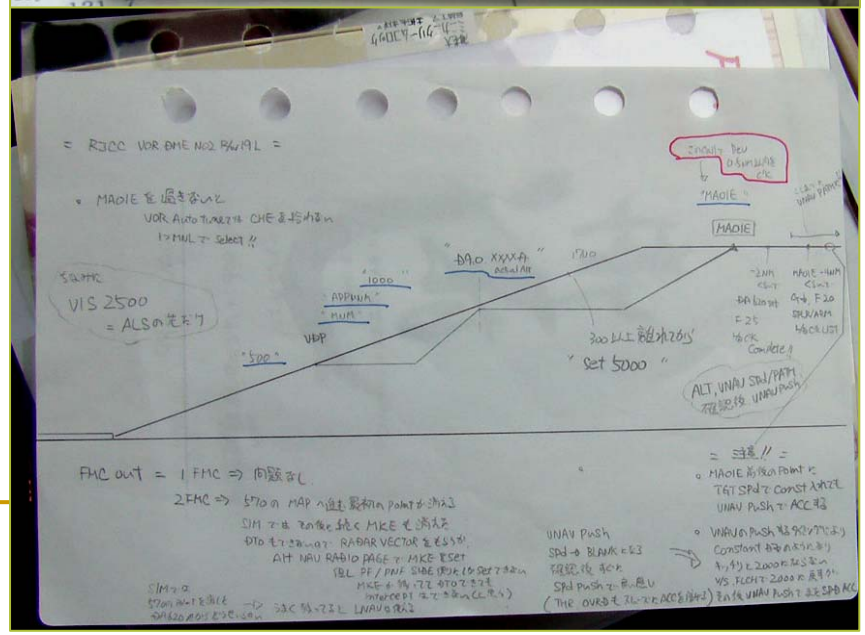
Pilot Reflection and narratives



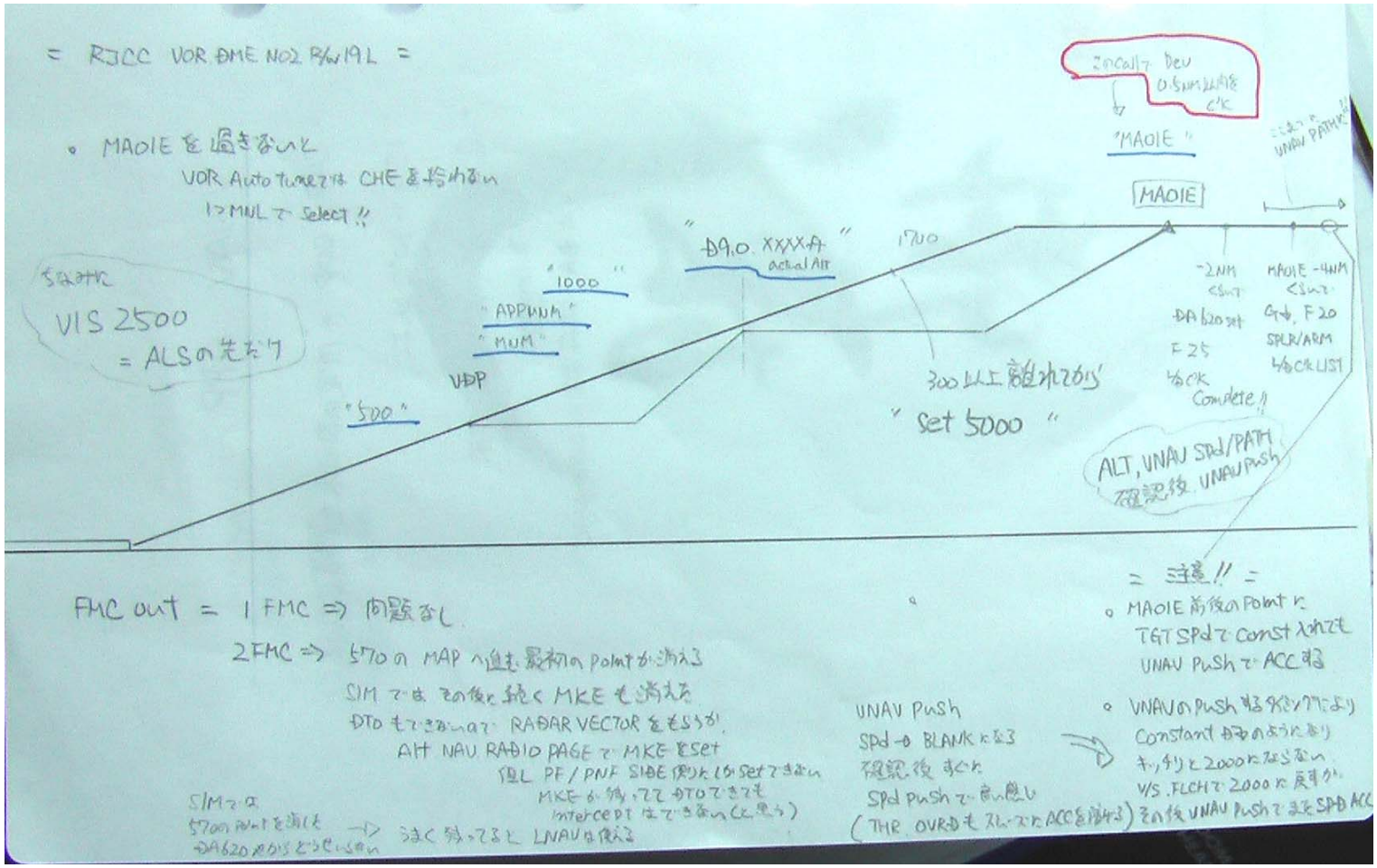
Document personalization

- Bring all paperwork home to review the flight
- Annotate own charts and flight manuals
  - Draw attention to the specific numbers and letters
  - Facilitate visual search
- A hand-drawn VNAV approach guide
  - A complex mix of English and Japanese
    - English: callouts, communication with ATC, etc.
    - Japanese: comments, interpretations, tips, etc.





How to fly an non-precision approach using RNAV

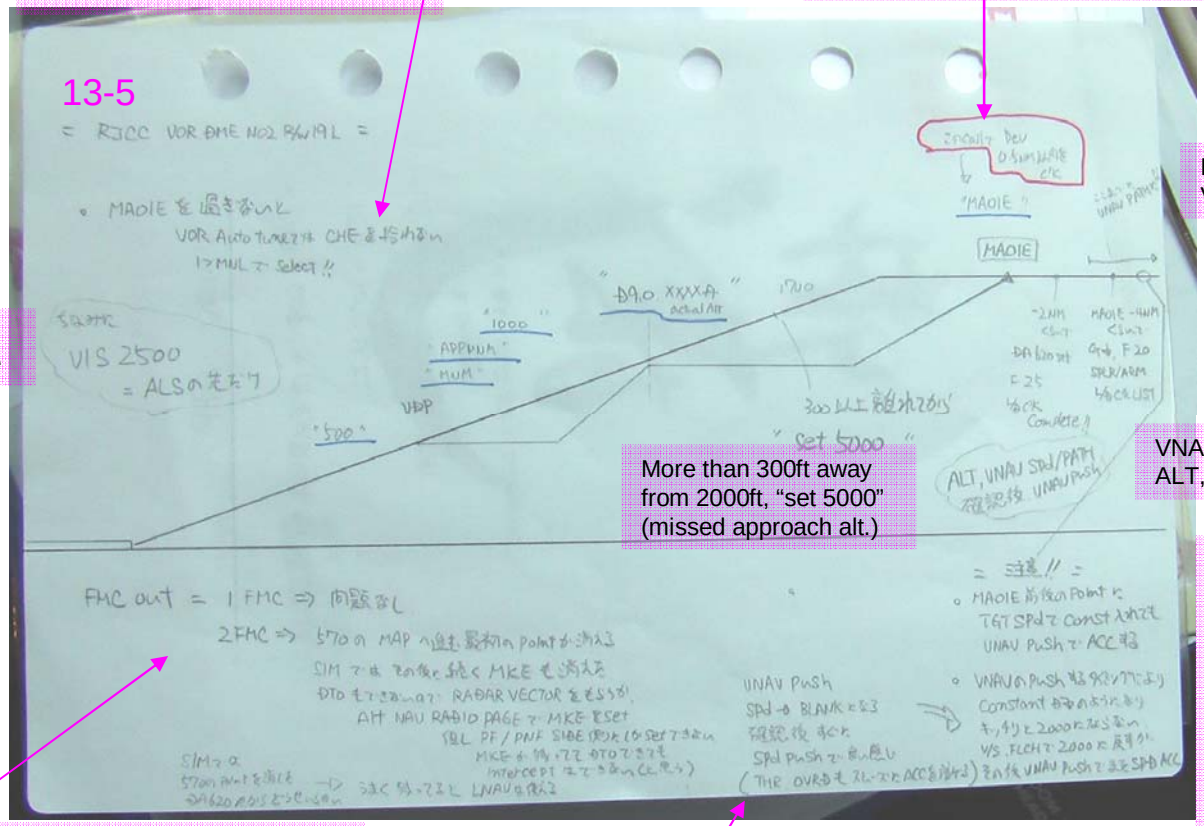


Unless past MAOIE, CHE is not captured with VOR Auto tune. Select with one manual!!

With this all, less than 0.5 mile check (Nav accuracy)

By this point, be sure that VNAV PTH is on FMA.

On chart 13-5, VIS 2500 required with ALS in service



More than 300ft away from 2000ft, "set 5000" (missed approach alt.)

VNAV push after confirming ALT, VNAV, Spd/PATH

= CAUTION!! =

- Near MAOIE, even if target speed is constrained (constraint?), pushing VNAV may produce acceleration.
- Depending on the timing of VNAV push, A/C should begin a constant descent. But it might fly away from 2000' too soon. In that case, use V/S or FLCH to get back to 2000'. Then push VNAV again to accelerate speed.

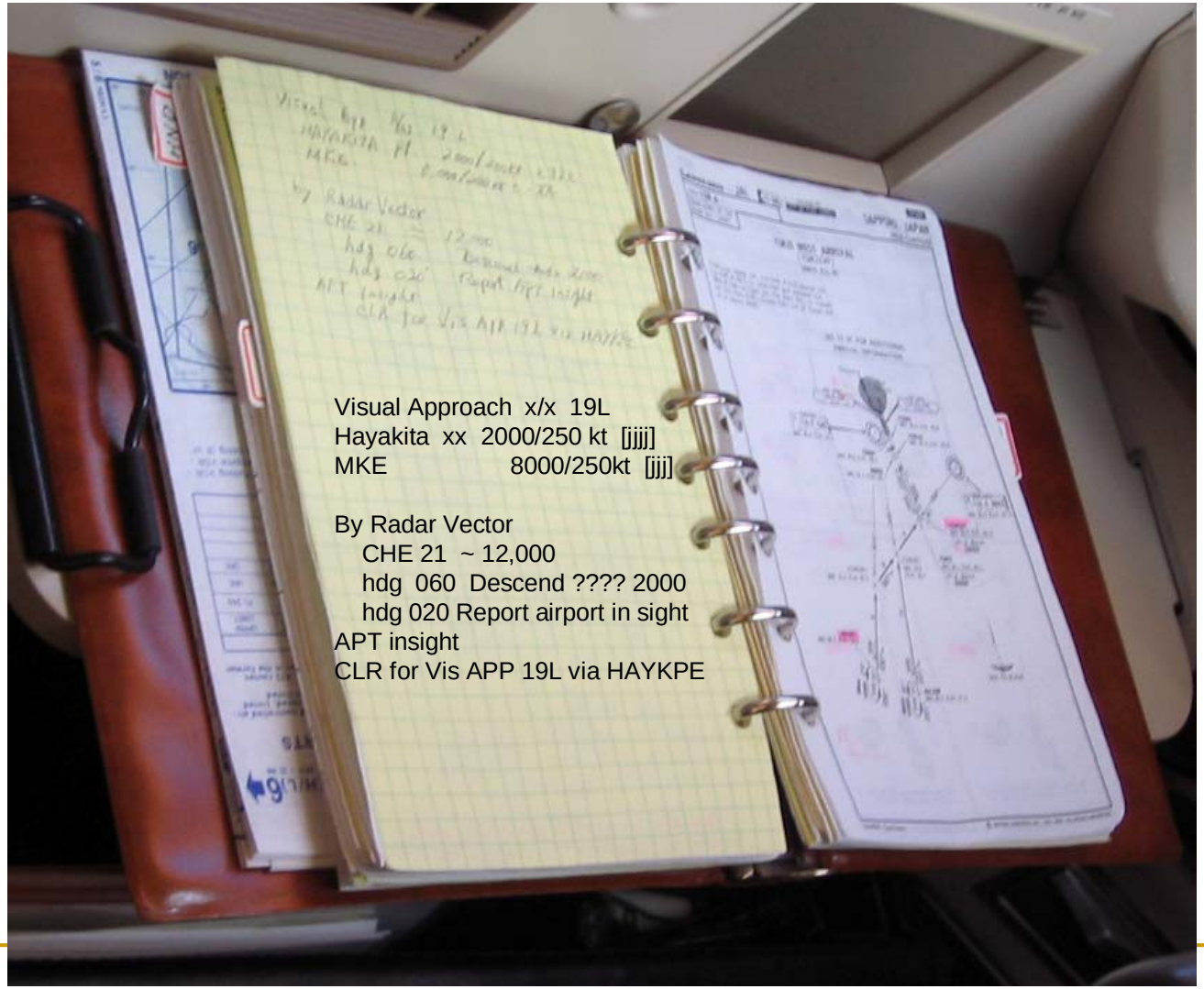
With 1 FMC out, no problem.
With 2 FMC out, proceed to 570' RA, or MAP. The first point will disappear (from RTE Legs page?). In the SIM MKE also disappeared. Direct to MKE can be done. Or get radar vectors or manually select MKE on Alt NAV Radio Page. However, depending on the side you set MKE, even through you can go direct, you might not be able to do the intercept (I think).

When VNAV is pushed, speed window blanks. After confirming that, speed selector can be pushed immediately. (Thrust override can also be used to smoothly control acceleration.)

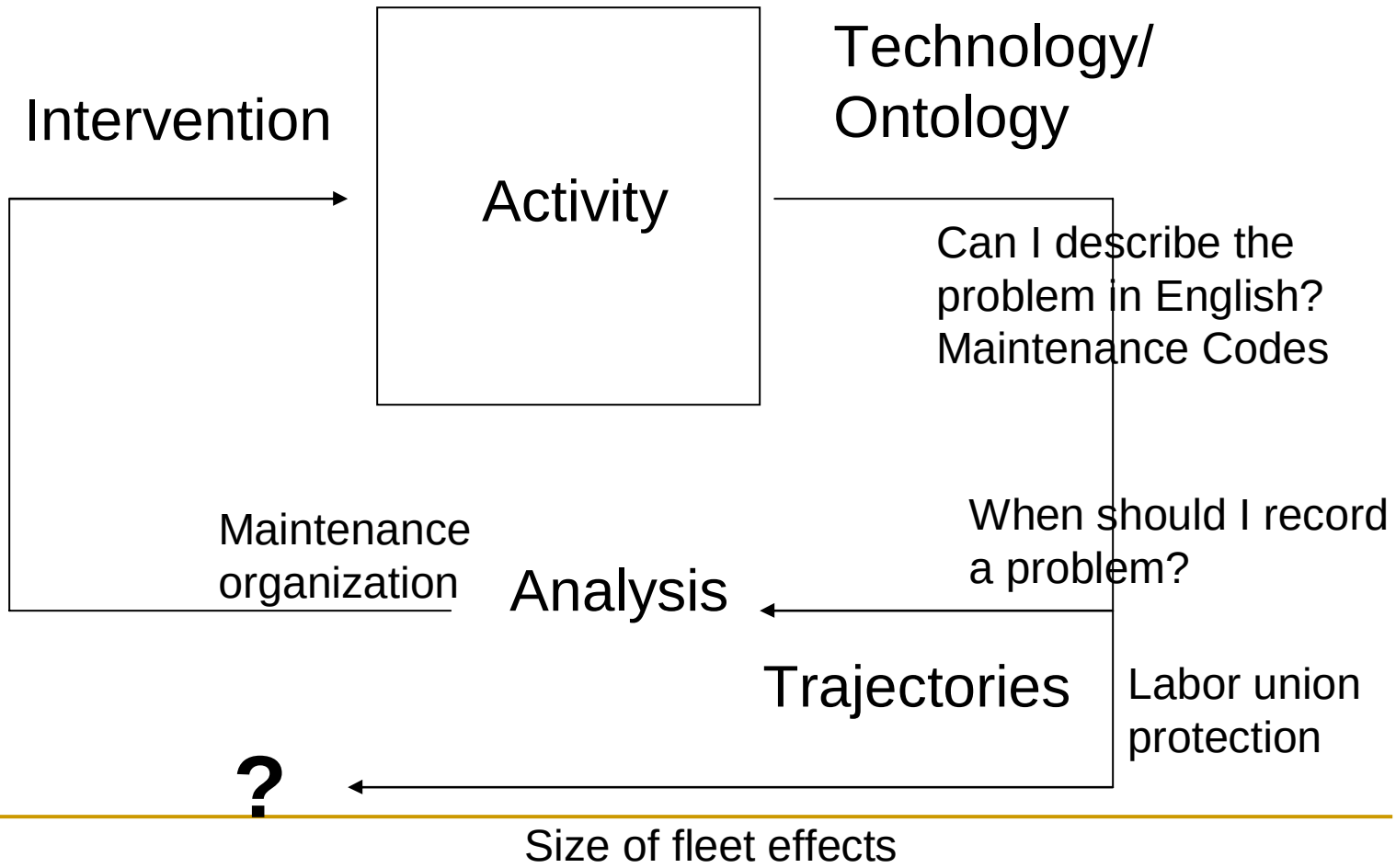
C'K: Check
MUL: Manual
MUM: Minimum

MDA: Minimum Descent Altitude
DA: Decision Altitude

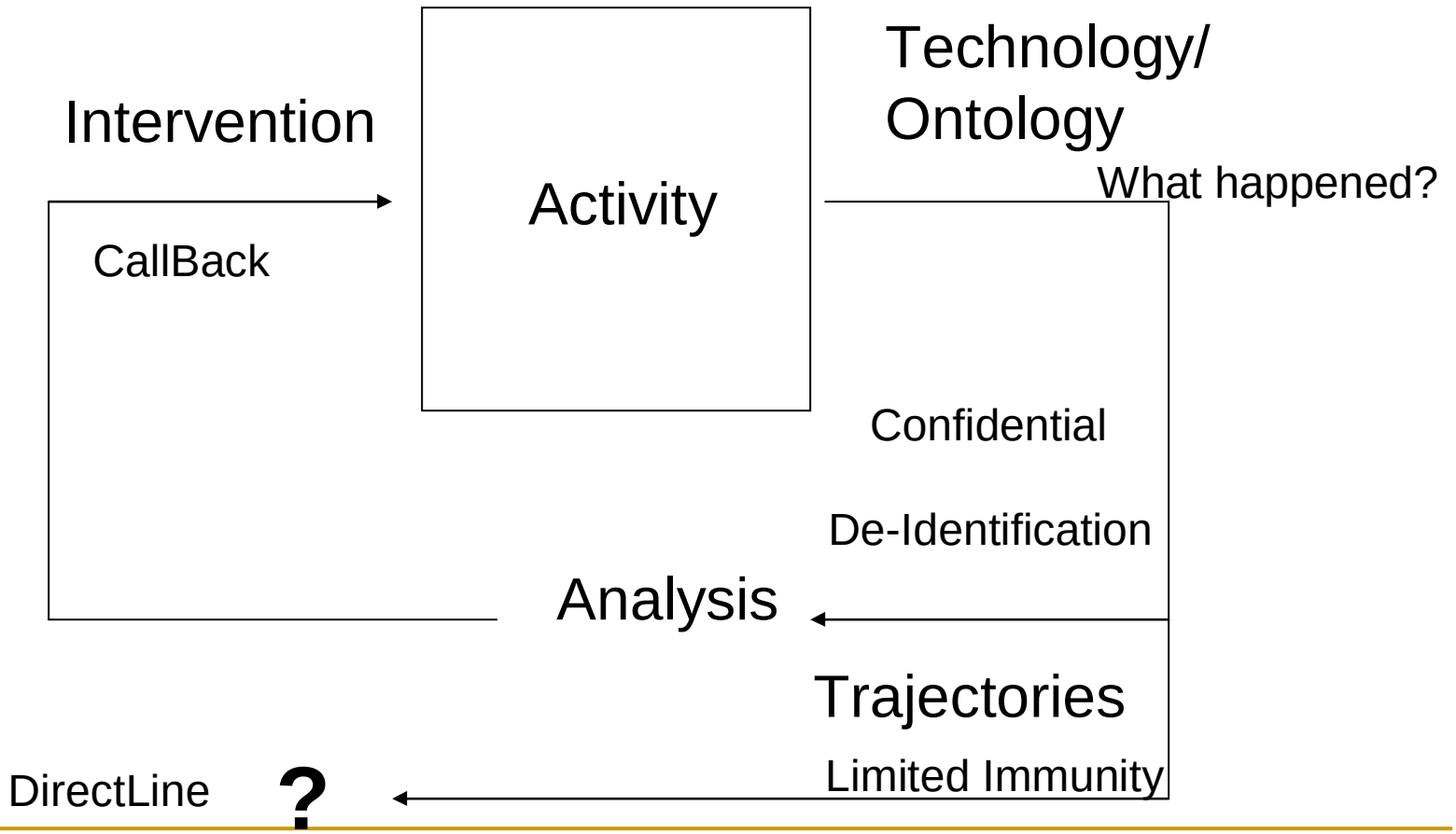
What to expect during an approach



Aircraft Handovers and LogBooks



ASRS/ASAP


Intervention
Activity
Technology/
Ontology
What happened?
CallBack
Confidential
De-Identification
Analysis
Trajectories
Limited Immunity
DirectLine
?

Pilot perceptions of risk are culturally constructed

- Physical risk
  - More Experience -> less risk
    - Built into FARs, recent experience.
  - Exposure -> barriers -> less risk
    - A formal model that has been incorporated into pilot culture – assimilated to preexisting concepts. Protection.
  - Longer exposure -> more risk
  - Physiological responses to risk create more risk
- Administrative risk (career, certificate, liability)
- Reputation at risk: Unsafe or unseemly?

Separate Investigation from Enforcement

- The FAA determined that the ASRP effectiveness would be greatly enhanced if the receipt, processing, and analysis of raw data were accomplished by NASA rather than by the FAA. This would ensure the anonymity of the reporter and of all parties involved in a reported occurrence or incident and, consequently, increase the flow of information necessary for the effective evaluation of the safety and efficiency of the system.

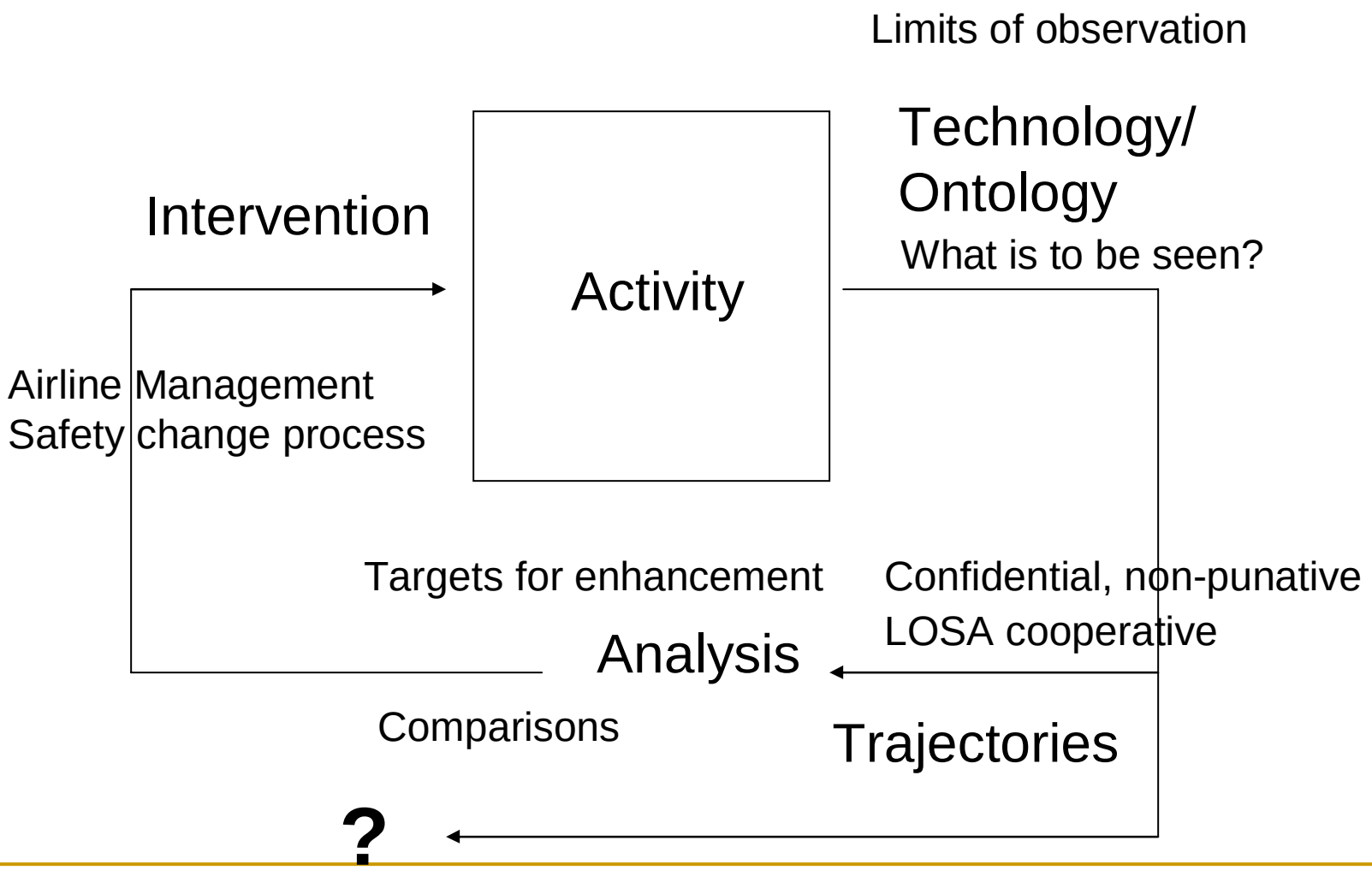
Immunity Policy

- The effectiveness of this program in improving safety depends on the free, unrestricted flow of information from the users of the NAS.
- Based on information obtained from this program, FAA will take corrective action as necessary to remedy defects or deficiencies in the NAS.
- FAR prohibits the use of any reports submitted to NASA under the ASRS (or information derived therefrom) in any disciplinary action, except information concerning criminal offenses

Line Observation Loops

- Air carrier line checks
- Manufacturer Flight Operations Support
- Line Operations Safety Audit (LOSA)
- Cognitive Ethnography?

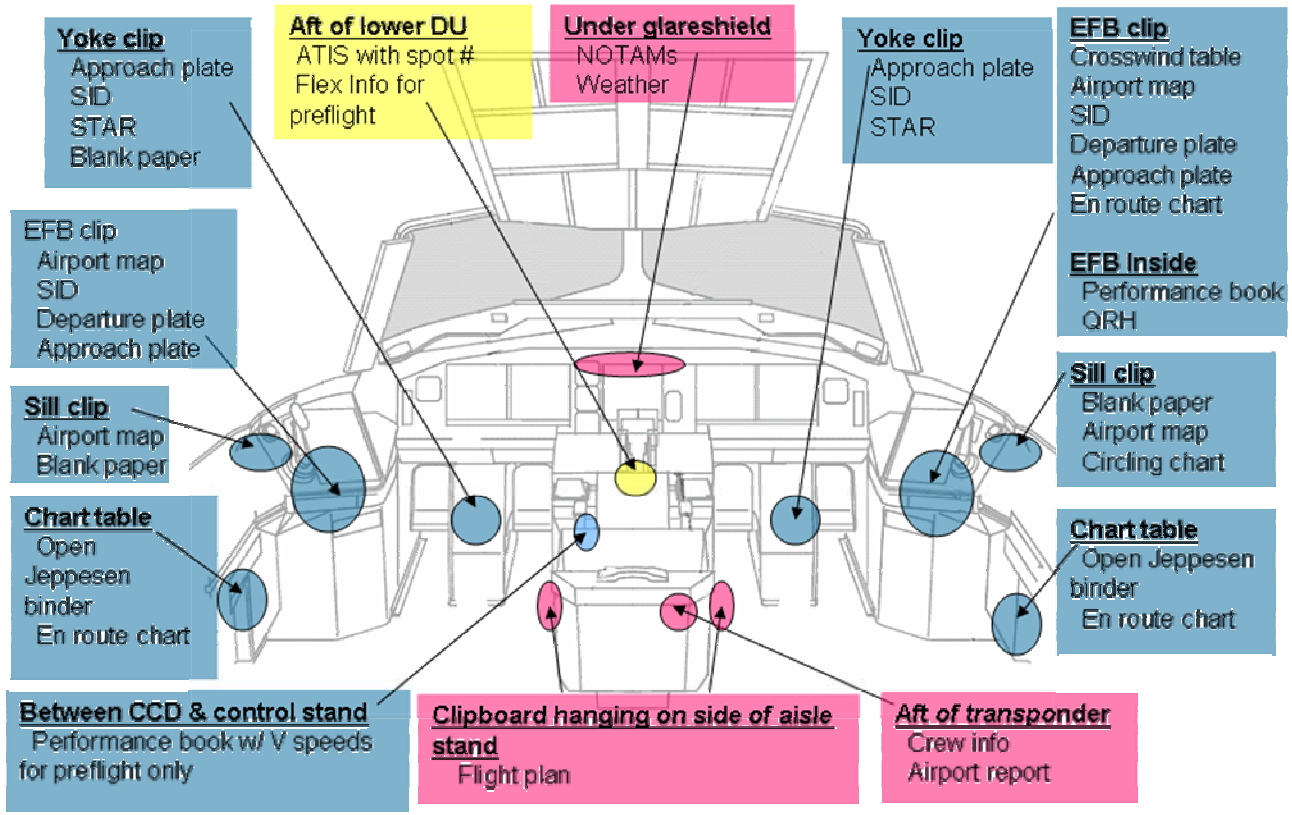
LOSA


Limits of observation
Technology/
Ontology
What is to be seen?
Intervention
Activity
Airline Management
Safety change process
Targets for enhancement
Confidential, non-punative
LOSA cooperative
Analysis
Comparisons
Trajectories
?

Can paper be eliminated?
Ethnography of current paper use practices

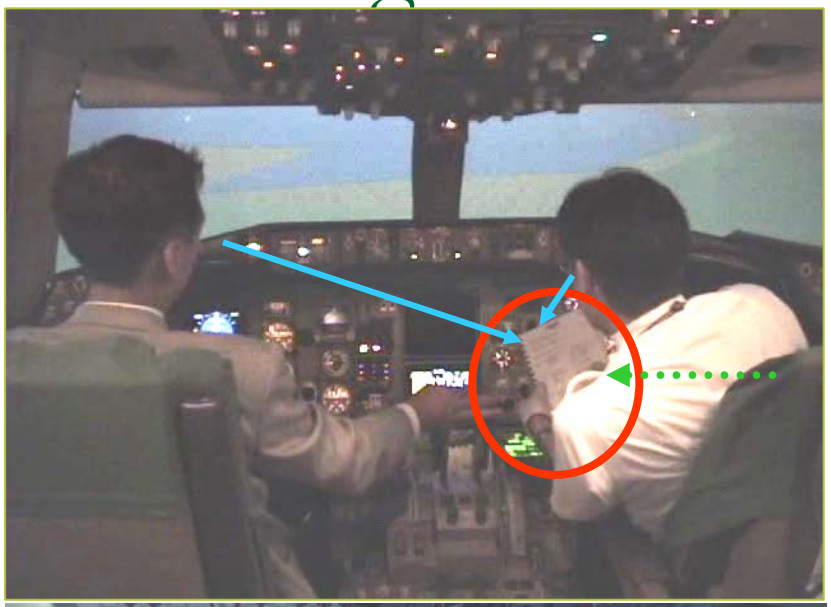
- Designers and Engineers think that:
  - Papers are old-fashioned.
    - Paper documents weigh too much
    - Difficult to search information
    - Inflexible
      - E.g. paper maps are not connected to GPS
  - Electronic Flight Bags (EFB) can replace paper documents in the flight deck.
    - Electronic charts
    - Electronic documents
    - Taxi positional awareness
    - (Performance calculation)
    - (Flight deck entry surveillance)

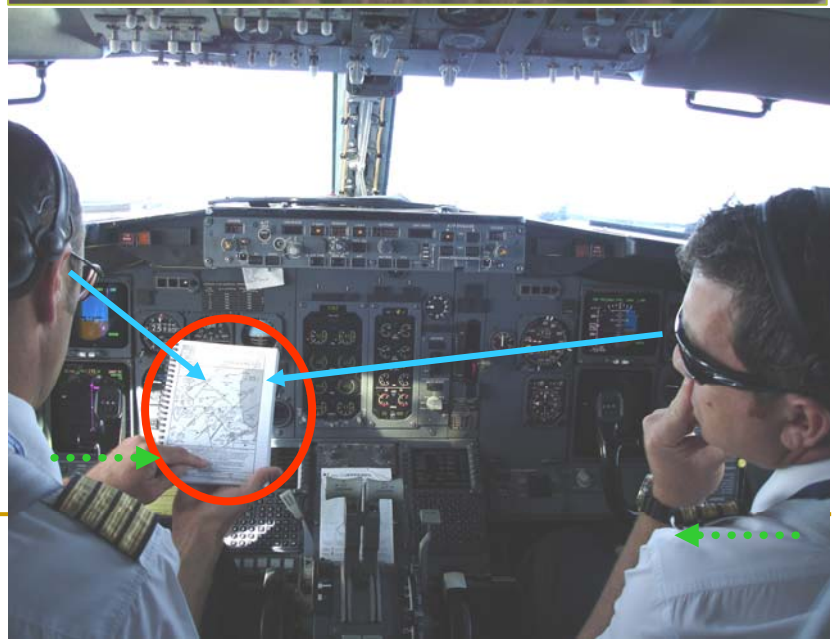
Typical Flight Deck paper layout



Crew coordination in the flight deck

- Written representations are easier to comprehend than spoken representations
  - Especially for non-native English speakers
  - Both pilots read the checklist together
  - In addition to the spoken representation
  - Facilitate the establishment of common-ground understandings

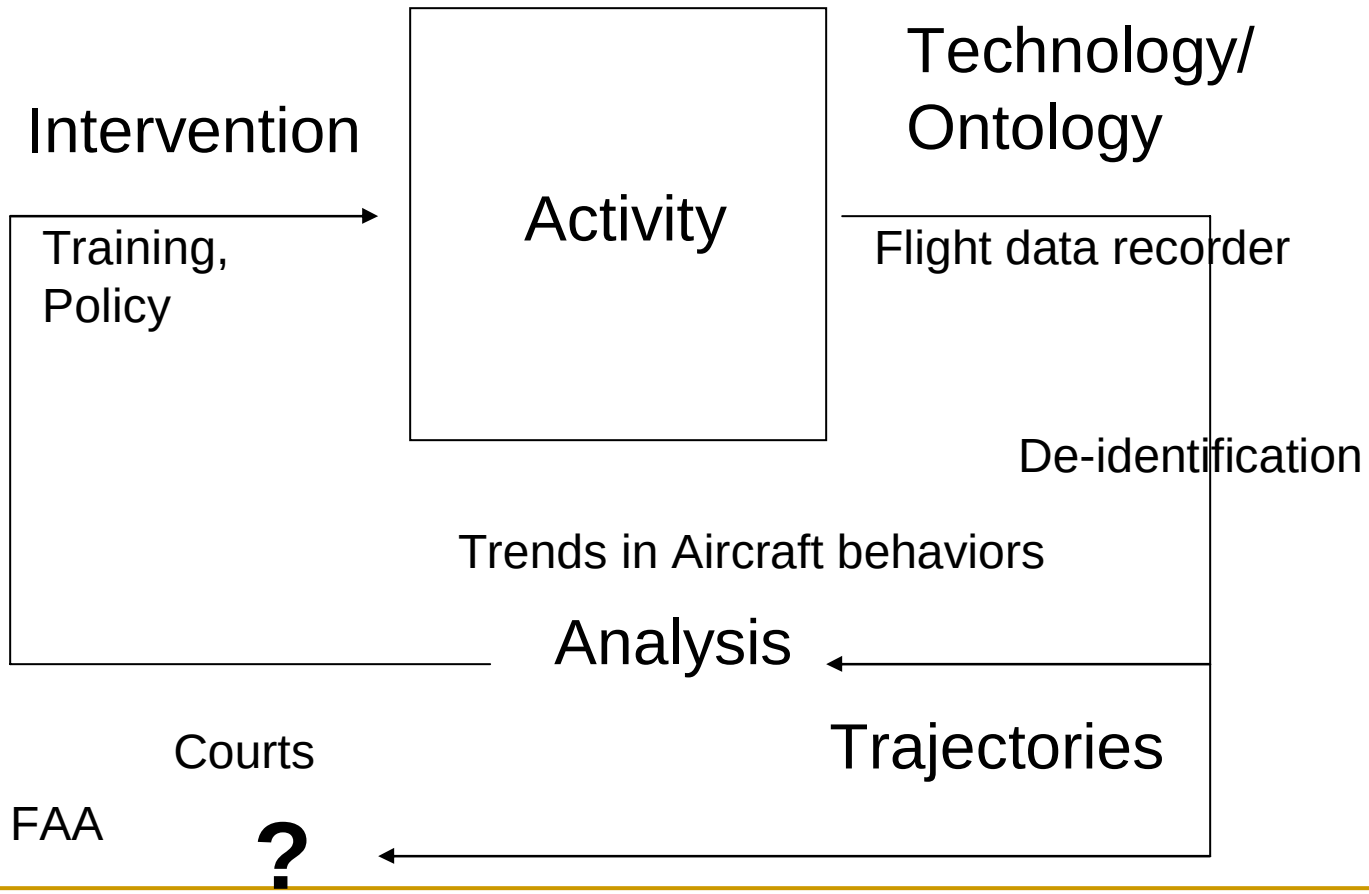




Cross-reference of data on paper

- Takeoff V-speed computation with Performance Takeoff Certificate (PTOC)
  - Use also ATIS, airport chart, and flight operation manual
  - FO completes the form, Captain confirm the computation
  - Data are input to FMC
- "Depth of Processing" of information
- Paper distribution during an approach
  - Scan across multiscale representations in order to imagine the location of the aircraft
    - En route chart, approach charts, the destination airport maps, and a note pad

Flight Data Monitoring



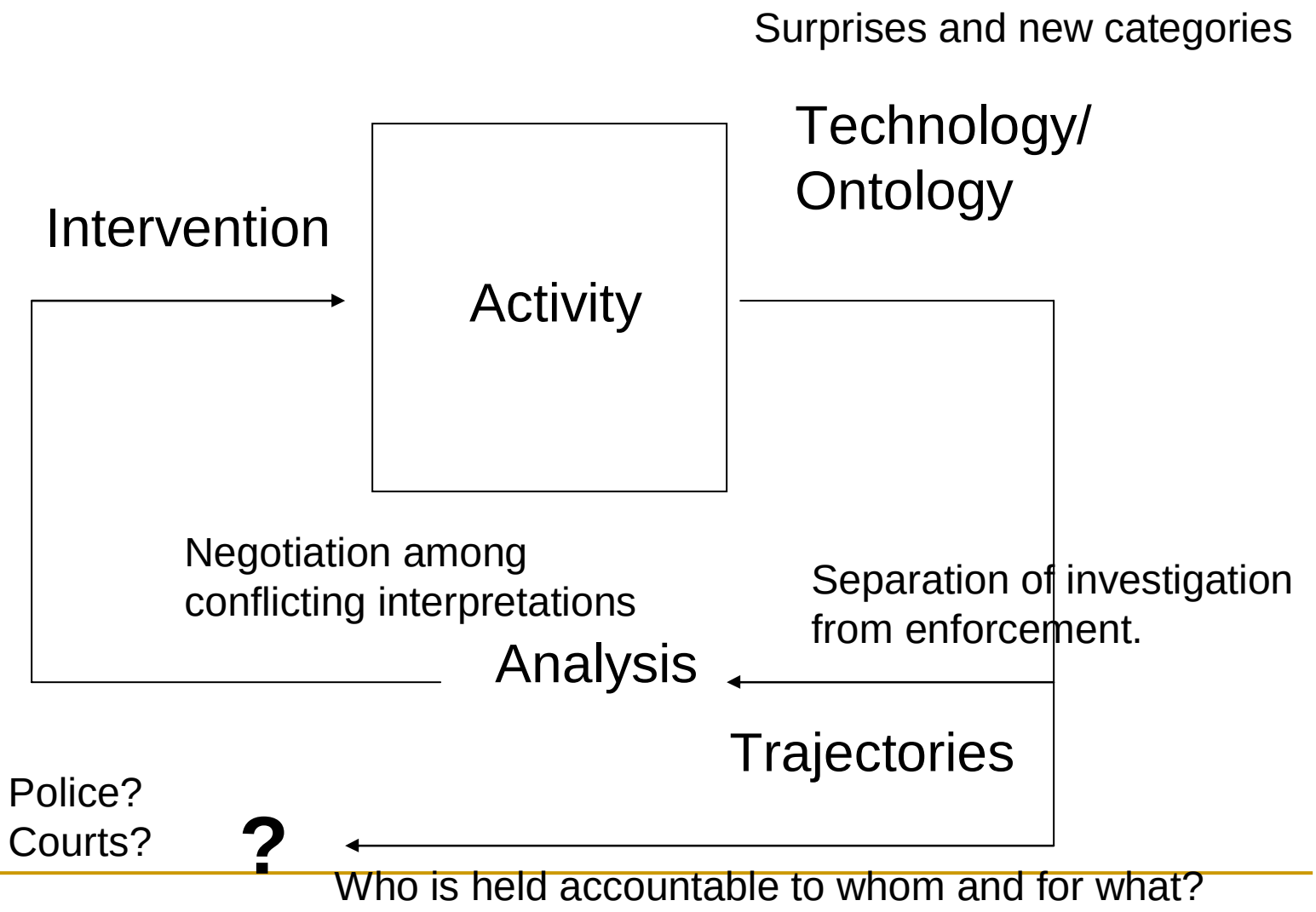
FOQA: risk management technologies may create new risks

- Operators manage operational risk by monitoring pilot activity. A learning loop.
- Union manages risk of damage to pilots' careers by guaranteeing that the data are "de-identified"
- Public may sue for access to data to establish negligence. Another learning loop.

Separating operational data and analysis from enforcement/punishment

- To protect sources of information
  - ASRS (pilot report/FAA enforcement)
  - Unions FOQA (pilot behavior/Airline personnel actions)
- To protect the perspective on the information in the loop
  - NTSB/FAA (understand accident causes/punish the perpetrators)

Accident Investigation



It’s going to be different out there. Will our loops be up to the task?

Technology and Ontology

- Are we ready to perceive the important properties of the global aviation system?

- The value of video
- The symbolic danger of video
- Controlling the ontology

“ final the rudder is…”

1. Inst: Your airspeed was much better than two days ago, okay?
2. Pilot A: Uh, huh.
3. Pilot A: Final the **rudder is (.) .hhhh**

Gesture takes the place of words

((the right hand palm down wagging hand at wrist from left to right to represent the yawing of the airplane as the pilot made rudder inputs.))

4. Inst: Yeah.
5. Pilot A: **Right?**

Confirmation (speech and head movement)

((looks up to the instructor’s face))

6. Inst: Rudder was, rudder was lot of work.

Together, the pilot and the instructor have jointly produced a single declarative statement.

Police expert providing the jury a new ontology in the first Rodney King Trial

A prediction

- Video is coming
- Smart institutional parties will establish ontologies and analysis practices that are appropriate to their interests.

Trajectories

- Democratic institutions for healthy organizational learning
  - FOIA, whistleblowers, bill of rights
  - FAA's two stage rule making process
- What information should (not) go where, when, and in what form? (*Infotopia*)
- Who is accountable to whom and for what are they accountable?
- How should this be decided?

What should we value?

- Diversity of institutionally supported loops
- Quality and commitment to understanding process
- Separation of analysis from enforcement

Analysis

- Analysis as institutional memory
  - Constructed
  - Selective
- Technologically induced amnesias
  - Recording technology, coding schemes, observational frameworks
- How can theory grow to keep up with the changes in the global system?

Intervention: the hard part

- What processes create interventions?
- What sorts of interventions are needed?
  - From now on the primary challenges are human and social.
- What are the consequences of interventions?
  - Alphabet soup of piecemeal fixes and additions

Global and local systems

- Flight deck operations are embedded in larger systems.
- What happens in the flight deck depends in part on the organization and operation of those systems.
- Aviation researchers and practitioners have little influence over many of the surrounding systems.

Complex interactions

- The global aviation system is large, complex, and only partly explained or governed by formal risk assessment procedures.
- The observed patterns emerge from the interacting but sometimes uncoordinated efforts to understand and manage flight deck activity.
- These efforts are built on different assumptions, serving different goals, and lead to different decisions by various actors.

Adaptive processes operate and interact simultaneously at all levels in the cognitive ecology

- Institutional adaptation
  - These set the cognitive task demands, the constraints that individual practice must satisfy
- Cultural adaptation
  - Cultural processes produce the resources that individuals have available to meet performance constraints
- Individual adaptation
  - Individual pilots use their minds, and bodies, and cultural resources to construct courses of action that meet the institutionally defined performance constraints of the activity.
  - “In the moment of the act, what is at play is not the avoidance of risk, it is the will to succeed.” (Michel Jouanneaux, 2003)

Reflection on the future health of loops

- Technology and Ontology:
  - Transition from disembodied cognition to distributed, embodied, situated cognition.
- Trajectories:
  - Value democratic institutions
- Analysis:
  - Dynamics, adaptation, and emergence at many levels
  - More resources, more exploration!
- Interventions:
  - Humility in the face of complexity
  - Attention to the cumulative effects on what is in the flight deck

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