ATC Communication HANDBOOK

- For preventing the runway incursions -



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Purpose of this handbook

It is vital for both pilots and controllers to secure the operational safety of aircraft. However, it may not be achieved only by launching a fancy motto.

However, it actually is a crucial event that might be led to a fatal accident. So far, the hardware has significantly been improved such as by introducing the runway status lights (RWSL) for preventing the runway incursions. However, the communications between pilots and controllers (referred to as the "ATC communications" hereafter) still include various threats that would induce human errors. ATC communications are considered as the last resort of safety.

After analyzing ATC communications in 11 runway incursions and incidents on the runway occurred within a little bit less than a couple of years beginning with September 2007, we started to understand the "mechanism of runway incursion" and the "required countermeasures by pilots and controllers" that are essential for preventing the incidents.

We compiled a handbook which includes some specific ideas for preventing the runway incursions. We hope this broche will be helpful to construct the common idea among pilots and controllers.

What to learn from failures

The vast majority of runway incursions have been attributed to errors in communications relating to ATC instructions. Therefore, pilots primarily need to respond adequately after understanding ATC instructions exactly in order to eradicate the runway incursions. Meanwhile controllers issue instructions observing the provisions in most cases, however, a pilot's error is induced due to ambiguity of the instruction in some cases. In these cases, the intension of the controller would not have been conveyed correctly.

According to the reality, both pilots and controllers should consider and perform effective countermeasures "How to prevent the runway incursions" step by step instead of investigating "Who is to blame". In other words, controllers are required to learn the skills how to convey instructions without prompting misunderstanding, and confirm pilot's responses in order to manipulate aircraft as they desire while sticking to the "Manual of ATC Service". Pilots are also, required to acquire something else besides the procedures prescribed in the operations manual in order to comprehend and perform ATC instructions exactly like controllers intend. We wish both pilots and controllers stop to look around what is additionally necessary.

To get a knack for ATC communications

Mechanism of the runway incursion and a panacea

- ➤ The most important thing for the controllers is providing adequate information using the prescribed phrases correctly after grasping and judging the situation accurately. Decay of this premise is the first step of the runway incursion.
- So far, any runway incursion hardly ever occurred as long as a pilot maneuvers accordingly after an instruction is correctly understood. Confirmation is essential along with understanding the instruction accurately in order to perform an ATC instruction precisely.
- ➢ In the two-man cockpit, a pilot who does not operate the aircraft (PM: Pilot monitoring) used to personally be in charge of ATC communications years ago, however, the logic of the "communication loop" has currently been established for assured ATC communications by a pair of pilots. The communication loop looks like a silver bullet, however, the logic actually was inoperative in some incidents.
- ► Even if the communication loop is not completely established, pilots generally read almost all the instructions back voluntarily in order to confirm whether they are accurately received or not.
- The "read-back" looks like a panacea to confirm the contents of ATC instruction. However, confirmation is often not achieved in some cases according to our analyses. We assume this result is attributed to the lack of controller's hear-back in many cases.
- ➢ In addition, a pilot sometimes behaves wrongfully, even if an instruction is correctly received, confirmed and accurately comprehended. In order to deal with this kind of inconveniences, certain procedures have been established for requiring two pilots to confirm instructions with each other verbally since everyone understands there are many such pitfalls.

An instruction might wrongfully be understood and overlooked throughout the process with ATC communications by PM solely. In order to deal with this kind of inconvenience, the "communication loop in the cockpit" has been proposed through the discussions by a group of pilots in the active service. And then, this idea is being gradually propagated after adopted in the annual training programs of major airlines in 2007.

The communication loop is a logic which recognize the contents of instructions surely and correctly, however, it would be rather difficult to practice during actual flight operations. The biggest reason is, that both two pilots must be well familiar with the logic. Also, everyone tends to think, "When communications are very busy situation, such a cumbersome procedure is impractical" as well as the authority gradient in the cockpit. Even if, the logic is not practiced, the quality of ATC communications would be vastly different between a crew familiar with the logic but it is not practiced inevitably, and the other crew ignorant of it.

What is the communication loop in the cockpit?

- 1 First of all, an instruction is transmitted by a controller. The controller uses prescribed ATC phrases. When general teams are used, it is transmitted in a proper manner.
- 2 Both PF and PF listen to the instruction with independent audio control panels to grasp the contents. It is vital that PF and PM should neither discuss nor confirm with each other even if any part of the instruction was incomprehensible. This system enables to reduce the possibility to commit "the common misunderstanding" of the two pilots by monitoring a pilot by the other pilot.
- 3 PF shows his or her comprehension by showing a specific cue such as a thumb up or saying "Roger". PF will request a re-transmission saying "Say again", if the contents were not clearly understood. Also, PM will request a re-transmission of a relevant part saying such as "Say again intersection" when any part was not understood, even if a positive reply had been received from PF.
- 4 After receiving a positive cue from PF and the contents were understood, PM will read the "contents understood by PM" back. PF also confirms the comprehensions of PF and PM concur.
- 5 PF compares own comprehension with PM's comprehension by monitoring the read-back, and then, requests PM to confirm whenever the comprehensions do not concur. This cycle is known as "hear-back in the cockpit". The significance here is that the controller's hear-back is complemented by the hear-back in the cockpit.
- 6 In the meantime, the controller confirms whether his or her intension was correctly received or not by hearing back PM's read-back. If the contents were not correctly received or some important part was missed, the controller was required to point it out, or instruct to read the significant part back again.
- 7 Also, PF vocalizes his or her comprehension that "PM's read-back concurs with my comprehension" by listening to the read-back as a means of reconfirmation in the cockpit. This process has not been included in the communication loop so far. Because, at the completion of the fifth stage, it used to logically be considered that "PM's' read back is correct and concurs with my comprehension" as long as no comments are returned. The success or failure of the communication loop wholly depends on the PF in this stage, however, recognizable is "No comments" which have a positive meaning. In other words, hear-back and sharing of PF's comprehension were devoid when the communication loop had been completed. For this reason, another step has been added in order to confirm "Let PM to confirm PF's comprehension by vocalizing what he or she gets" as the redundancy in the confirmation processes.

The most crucial points of the communication loop in the cockpit are; No.2, "Two pilots listen to ATC instructions independently without consulting with each other", and No.5, "PF adequately hear backs PM's read-back". Number of the communication errors would dramatically been reduced by achieving these two points.



"The skills of the communication loop" explained above, is the logic which demands two pilots correctly understand and deal with the ATC communications, however, a more significant objective is an interface of the pilots and aircraft when ATC communications have been completed. In some cases, a pilot wrongfully operated an aircraft despite his or her correct comprehension. In order to prevent this kind of inconvenience, PF inputs data on FMS along with vocalizing any instruction or change of the mode based on his or her comprehension while PM confirms by monitoring PF's behavior. In addition, both pilots vocalize any changes on PFD presentation such as aircraft attitude or navigational control data commanded by FMS or other relating devices. This series of procedures is established as the "Verbal communications" in some airlines. However, we deliberately designate it as the "Verbal verification" considering actual processes wherein "Recognition and behavior are verbally verified".

The "verbal verification" is a crucial step in this broche not only for the man-machine interface, but also for the human relationship such as when confirming an instruction verbally whether it was "Cross runway" or "Hold short of runway" before crossing the runway.

The communication loop in the cockpit is being propagated mainly in major airlines, however, the "Communication loop" and "Verbal verification" were not inoperative in 11 incidents from September 2007 to January 2009 according to our analyses of ATC communications. Therefore, we propose further propagation of the "Communication loop in the cockpit" and "Verbal verification".

Is the read-back really a panacea ?

The system of read-back is established in the verbal ATC communications in order to prevent miss-communications. The read-back policy (what contents and what extent) is published in the AIP, and then the read-back is mostly achieved as the fundamental in the actual flight operations. Since the air traffic control service has been started with verbal communications, readback has been regarded as a panacea which prevents miss-communications effectively. However, read-backs hardly ever help to improve quality of the communications. Read-back is really effective when followed by hear-back which confirms whether the read-back is correctly exercised or not. Read-back is meaningless, if hear-back is not properly done.

As explained in the communication loop in the cockpit, hear-back for pilot's read-back is properly exercised as long as the communication loop is completed as a means of redundancy for controller's hear-back. However, one thing is not covered by hear-back in the communication loop. It is no longer helpful when both PF and PM equally misunderstand the contents. If the controller misses the hear-back in such a case, the misunderstood contents become correct in their ideas, and



it is very likely to be regarded as correct even by the verbal verification thereafter. At this moment, the last resort to prevent misunderstanding is only controller's hear-back. Also, single piloted aircraft without having the communication loop has to entirely rely on the controller's hear-back.

It is indistinctive whether the hear-back was correct or not, since no inconveniences occurred as long as read-back was properly exercised (an instruction was correctly received) even in the 11 events. However, either an error was not pointed out or read-back was not requested for a wrongful read back when totally opposite read-backs triggered a runway incursion in all the 11 events.

Also, we found some wrongful read-backs for general communications that were not corrected, but fortunately not relevant to any incident. However, these wrongful read backs were hardly ever pointed out. Assuming such a reality, we have to say controllers often would not listen to the read-back properly.



There might be various reasons when hear-backs were incomplete, however, we assume No.1 cause is distraction and insufficient awareness of controllers in a very busy situation. A controller is required to listen to a read-back in order to confirm that an issued instruction has been properly understood while it is sent, however, he or she is additionally necessary to divert the attention to other aircraft to construct additional instructions in the next scene. Hear-back may not totally be devoid, however, this kind of dual tasks make controllers difficult to be concentrated in hearing back.

Importance of the read-back has been emphasized in verbal ATC communications for many years, however, no specific procedures have been proposed for the effective hear-back.

By the case study, it becomes crystal clear the most crucial elements are unambiguous instructions and effective hear-back by ATC in order to reduce incidents attributed to the controllers. Therefore, we hereby propose some specific hints for better ATC communications.

Six suggestions for assured ATC instructions and effective hear back

- 1 When transmitting instructions or information, controllers should consider the possibility that "a pilot may misunderstand a specific part". In other words, even if proper phrases are used, a controller prudently should streamline excessive amount of information or emphasize a specific instruction.
- 2 A controller should assume what kind of instruction a pilot anticipates. When an instruction is unlikely expected, he or she should be careful of a deformed pilot's read-back with wishful hearing. It would be helpful to achieve assured hear back.
- 3 A serious outcome would be brought about by an instruction responded by an unintended receiver. If a controller would be well familiar with this kind of situation or it is clearly distinctive, a controller should be better to prepare for the similar call signs to a certain extent. It is possible only for controllers, but not for pilots.
- 4 Errors increase exponentially, if a single instruction includes multiple elements. A very significant instruction should be sent without any other elements.
- 5 A controller should be aware of the "Keyword" which is the most crucial in each circumstance (Fatal outcome would be brought about, if it is wrongfully understood). (Generally, the keyword stands for any important instruction, however, call signs of aircraft are regarded as the keywords as well when two or more aircraft are expecting the same kind of instruction). A pilot would easily understand what is important by recognizing the key word when it is naturally emphasized. As a result, number of misunderstandings and errors will be reduced.
- 6 Assured hear-back would be possible by utilizing the keyword. The workload would be significant, if verbatim hear back is required, however, it would be rather easily done by checking whether the keyword is correctly used or not in a read-back.

Case study of the incidents including runway incursions attributed to ATC communication

The purpose of the case study is not to find "Who is to blame (accusation)", but to establish the countermeasures considering "If the same kind of incident occurs right now". Therefore, we delete the date of occurrence, and adopt fictional locations, names of the airlines and call signs. Also, our comments are wholly based on the current "Manual of Air Traffic Control Service" instead of the effective one at the time. In addition, our comments based on the analyses of incidents are introduced in the "Summary of the countermeasures" from page 19.

1 Unauthorized Crossing runway/Taxiing via runway

1 - a. After a bird strike happened on RWY32L at Yamato airport, an arrival aircraft was instructed to "Hold short of RWY32R" after landing on RWY32L. However, a read-back was "Cross RWY32R". As a result, the arrival aircraft crossed the runway while nobody realized of the wrongful read back.

	FASTAIR 345	
☆ TRANSC	RIPTION :	
09:07:20	TWR	FASTAIR 345, RWY32L, cleared to land, wind 040 at 6.
	FASTAIR 345	RWY32L, cleared to land, FASTAIR 345.
09:08:40	GLOBAL 2400	Yamato tower, GLOBAL 2400, 5NM, RWY32R.
	TWR	GLOBAL 2400, RWY32R, cleared to land, wind 330 at 6.
	GLOBAL 2400	RWY32R, cleared to land, GLOBAL 2400.
09:09:30	TWR	FASTAIR 345, turn right W9, hold short of RWY32R
		for arrival traffic. \bigstar_1
	FASTAIR 345	Roger, W9, cross RWY32R, FASTAIR 345, verify
		No carcass is found. \bigstar_2
	TWR	Roger, thank you. \bigstar_3
09:10:30	TWR	GLOBAL 2400, this time, go around, traffic on the RWY.
	GLOBAL 2400	Roger, this time, go around, GLOBAL 2400.
09:10:40	FASTAIR 345	Yamato Tower, FASTAIR 345, crossing WY32R,
	TWR	contact ground. FASTAIR 345, I believe I said to hold short of RWY32R as we had a departure····
	FASTAIR 345	Ahhh · · · · ? Roger.

☆ Critical points in ATC communications :

• A pilot wrongfully read "Hold short of RWY32R" back in \bigstar_1 with the opposite mean-

ing likewise in \bigstar_2 , however, a controller never pointed out the error in the read-back.

 Meanwhile, pilots regarded the read-back was correct in the cockpit as no corrections had been forwarded by the controller. The communication loop was highly unlikely completed possibly by misunderstanding of the two pilots or distracted by searching a carcass of the bird.

Was it really Hold short?

- If the controller properly heard it back, a totally opposite contents shouldn't have been overlooked. So, I would say the hear-back was perfectly inoperative. It is assumed because the hear-back hardly ever have
- mentioned in \bigstar_3 , and the gratitude was extended for the information elating to the event.
- Both controller and pilots were distracted by overly concentrated in the obstruction on the runway as another aircraft reported "There may be a carcass of the bird on the runway as we experienced bird strike" a few minutes before FASTAIR345 landed.

☆ Outcome that likely has been prevented :

- If the controller regarded the keyword of \bigstar_1 is the "Hold short instruction which is crucially important", the possibility of misunderstanding would also have been lowered, and the wrongful read-back was unlikely overlooked.
- If both controller and pilots were not distracted by the happening, the error should have been detected by hear-backs in the cockpit and by the controller in the communication loop.
- **1 b**. After landing on RWY32L at Yamato airport, an arrival aircraft mistook an instruction of "Contact GND" as for him which was issued to a helicopter landed earlier. When the arrival aircraft established communications, GND instructed to taxi to the assigned spot. Eventually, the aircraft crossed RWY32R without an ATC authorization.

☆ TRANSCRIPTION : —Omission—

☆ Critical points in ATC communications :

- The aircraft landed on RWY32L mistakenly responded to the instruction to the other aircraft (the communication loop did not function, otherwise both PF and PM misunderstood it was for them).
- The controller did not realize the read-back was not returned from the helicopter (incomplete hear back).

☆ Outcome that likely has been prevented :

- The controller would have realized that the other aircraft responded, if the hear-back was properly exercised.
- The controller would have confirmed the responded aircraft, if the pilot questioned the procedure to transfer to GND without issuing an instruction to cross the runway.
- The arrival aircraft would have confirmed GND, if the verbal verification had been exercised likewise "Cross runway. Is it OK?" in the cockpit before entering RWY32R.

- This incident would have been prevented, if any kind of intracommunications has been established within the tower.
- 1 C. A single piloted aircraft entered the runway with the "line up and wait" instruction. This aircraft taxied out of the apron close to the RWY18 approach end with the instruction of "Taxi to RWY36, and hold short of RWY36", and it was read back simply as "Hold short of RWY36". The aircraft needed to backtrack the runway to taxi to the approach end of RWY36 as no parallel taxiways were established. The aircraft entered RWY18 and started to backtrack to RWY36.

☆ TRANSCRIPTION : —Omission—

☆ Critical points in ATC communications :

- A more precise instruction was necessary as no communication loop existed in the single piloted aircraft. The number of the runway in use is generally used in an instruction, therefore, pilots tend to misunderstand "Taxi to the vicinity of the approach end of RWY36, and hold" when instructed "Taxi to RWY36 and hold short of RWY36". The instruction should have included "Hold short of runway" additionally as long as it did not permit to enter the runway since the runway holding position marking was placed with white letters of **18** in the red square.
- The instruction of "Taxi to RWY36" was quite ambiguous, therefore, "RWY36, hold short of RWY18" was more desirable.

Outcome that likely has been prevented :

• It is unclear whether the pilot forgot to "hold short of runway" or misunderstood to hold at the south end of the runway. However, the runway incursion was very unlikely to happen, if the instruction was "RWY36, hold short of RWY18" instead of "Taxi to RWY36, and hold short of RWY36".

2 Entering the runway for departure despite the "Hold short of runway" instruction

2 - **a**. At Yamato airport, a departure aircraft from RWY24L entered the runway violating the holding position marking only replying "Ready" for the instruction of "Hold short of runway, report when ready".

☆ TRANSCRIPTION :

12:38:47	TWR	GLOBAL 927, Yamato Tower, RWY24L, continue
		approach, wind 220 degrees at 8 knots.
	GLOBAL 927	Continue approach, GLOBAL 927.
12:40:33	TWR	FASTAIR 143, Yamato Tower.
12:40:39	FASTAIR 143	Yes, ah•••143?
12:40:44	TWR	FASTAIR 143, hold short of RWY 24L, report when ready. \bigstar_1
12:40:47	FASTAIR 143	We are fully ready now, FASTAIR 143. \bigstar_2
	TWR	FASTAIR 143, roger, hold short of RWY 24L, expect
		departure after one arrival 5 mile. \bigstar_3

12:40:58	FASTAIR 143	Say again for FASTAIR 143?
	TWR	FASTAIR 143, hold short of RWY 24L.
12:41:04	FASTAIR 143	We hold short 24L, FASTAIR 143.
12:41:09	FASTAIR 143	It's too late for FASTAIR 143. We are on the runway now.
	TWR	FASTAIR 143, roger.
12:41:16	FASTAIR 143	We confirm we can line up 24L now?
	TWR	GLOBAL, ah••••FASTAIR 143, hold position.
12:41:23	TWR	GLOBAL 923, go around.
12:41:27	TWR	GLOBAL 927, go around.
12:41:29	GLOBAL 927	Going around, GLOBAL 927.

☆ Critical points in ATC communications :

• The pilot did not read back the "Hold short of runway" instruction which had been issued by ATC. Also, the communication loop was very unlikely to exist. Perhaps, the pilot's attention would have almost been

diverted to the phrase of "Report when ready". Hold when ready" implied "Takeoff is authorized when we are ready". Therefore, the pilot would have considered "We should prepare for departure in the runway, as we are ready now". The pilot's reply of "Say again for FASTAIR143?" sounds like "What the hell! It's too late to hold short" rather than "Please repeat your message".



- Should the controller have told "Report when ready"? Even if it was necessary, the controller should have instruct to read "Hold short of runway" back recognizing it was omitted by his hear-back. In other words, the controller should have called attention of the pilots. However, the controller simply replied "Roger" for the report of "We are fully ready now". At this moment, the pilot should have been quite confident for "Departure soon". The controller instructed "Hold short of runway" again, and informed its departure would have been after the arrival, however, the pilot should have strongly been preoccupied that the takeoff was possible soon. As a result, the pilot mentally blocked all other messages thereafter.
- The controller should have launched FASTAIR143 responding to the message of "We are fully ready now", if he was planning to "Release it before the arrival at 5 miles on final, if it is ready". Otherwise, "Report when ready" was unnecessary, if the controller was planning to launch it after the arrival aircraft. An indecisive judgment of the controller would have misguided the pilot to imagine "Takeoff soon" despite the "Hold short of RWY" instruction.
- The majority of instructions was not read back by the pilot of FASTAIR143. Every pilot tends to take messages conveniently and miss a crucial part to a certain extent. Therefore, a very important instruction should not be issued along with misguiding information or other insignificant instructions.
- Controllers should request to read back the "Hold short of runway" instruction whenever it is devoid.

☆ Outcome that likely has been prevented :

- The pilot should never have crossed the holding position marking, if "Hold short of RWY24L" were solely instructed.
- The incident would have been prevented, if the pilots understood only a part of the logic of the communication loop. At least, read-backs of the instructions were essential.
- **2 b**. At Yamato airport, a departure aircraft was instructed to "Report when ready" instead of "Hold short of RWY" upon an initial contact with the tower when taxiing to RWY24L. While the tower was exchanging several messages between an arrival aircraft for the landing clearance, the departure aircraft mistakenly entered the runway violating the holding position marking, and then reported "We mistakenly have lined up RWY24L". The controller instructed the arrival aircraft to go around.

TRANSCRIPTION : — Omission—

☆ Critical points in ATC communications :

- The tower did not instruct to "Hold short of runway" when the communications were established with the departure aircraft. Pilots tend to regard as "Takeoff anytime when we are ready", if instructed "Report when ready" instead of "Hold short of runway" likewise in the case **a**.
- The pilots should understand the relevant provision that any aircraft cannot enter the runway without "Line up and wait" or "Cross runway" instruction or the takeoff clearance. Of course, the pilot would have understood the provision, however, he first realized of the runway incursion when the arrival aircraft was instructed to go around. The phrase of "Report when ready" would have strongly influenced the pilot to violate the ATC regulation easily.

☆ Outcome that likely has been prevented :

- The pilot would have understood that taxiing is not authorized beyond the holding position marking without takeoff clearance or an instruction to line up or cross the runway. Therefore, the incident would have been prevented, if the communication loop and the verbal verification were exercised in the cockpit.
- The incident would have been prevented, if the controller did not instruct to "Report when ready" upon the initial contact.
- The runway incursion would have been prevented, if the controller regarded "Hold short of RWY24" as the keyword and requested to read it back in order to emphasize the instruction in the communication loop.
- **2**-**c**. A departure aircraft requested an intersection departure via A3S while taxiing to RWY36 at Yamato airport. A controller replied "A3S available" along with the instruction of "Hold short of RWY36". The departure aircraft read it back accordingly, however, it intruded the runway.

☆ TRANSCRIPTION : —Omission—

☆ Critical points in ATC communications :

• The pilot questioned "How about this position enter the runway?" hoping the departure with the shortest taxiing distance. The controller replied "A3S available, but hold short of RWY36". However, it should have been "Taxi to A3S, hold short of RWY36", if the controller planned the intersection departure via A3S. When the pilot asked "Enter the runway?", he expected a positive reply, therefore, the phrase of "A3S available" would have been regarded as "You may enter the runway via A3S". The following "but, hold short of RWY36" would have easily been overlooked by the pilot (at least by PF) who was strongly expecting a positive reply to "Enter the runway?". PM read the recollected part of "Hold short of RWY36" back, however, it would not really have been understood.

☆ Outcome that likely has been prevented :

- Controllers should not use any ambiguous expressions that are comprehended whether instruction, permission or information such as "Available" for the pilots unfamiliar with ATC communications. It would have been complied with, if a clear-cut instruction were separately issued in each step as necessary.
- 2 d. A departure aircraft was instructed to "Hold short of RWY24L" at Yamato airport, however, a pilot mistakenly read it back as "To position 24L", and actually entered the runway. In the meantime the controller was issuing a landing clearance to an arrival aircraft, after instructing the departure aircraft to hold short of the runway. About one minute later, the arrival aircraft confirmed the landing clearance, and the controller responded by repeating the landing clearance. However, the controller instructed the arrival aircraft to go around after learning the departure aircraft was in the runway.

TRANSCRIPTION : —Omission—

☆ Critical points in ATC communications :

- The controller seemed to launch the departure aircraft ahead of the arrival aircraft until just before the incident happened judging from the contents of the communications. The pilot of the departure aircraft would also have understood the controller's intension and thought to depart immediately as the reply was received accordingly when the controller asked whether "ready or not". Later, the pilot answered "That's affirmative. We read it back to you cleared to position 24L" when the controller challenged "Did I tell you to line up and wait?" The controller obviously instructed "Hold short of RWY24L", however, it was understood adversely.
- The departure aircraft should have understood the instruction of "Hold short of runway" precisely without the preoccupation created by "Ready for departure". No evidences of the communication loop were found in either read-backs or responses to ATC.

- The beginning part of "to position 24L" as a response for "Hold short of RWY24L", was really obscure that "Cleared" was inaudible. However, the controller failed to request another read-back despite it was so unclear that the keyword of "Hold" was not confirmed.
- The controller should have visually confirmed what happened outside. "Plan, Do, See" is essential in the ATC service, however, "See" was devoid in this incident.

☆ Outcome that likely has been prevented :

- The primary cause of the incident was that the departure aircraft misunderstood the instruction of "Hold short of RWY" as "To position 24L". However, there might have been several opportunities to learn discrepancy of the ideas in the cockpit, if the communication loop had been understood and practiced.
- If the controller heard it back properly, misunderstanding of the departure aircraft would have been corrected.
- The controller had confirmed the departure aircraft "Ready for departure" 10 seconds prior to the incident happened. Also, he acknowledged for "Ready" and instructed "Hold short of runway" in the same transmission. They are totally different elements, however, the controller's attitude was obviously the "change of planning" assuming the flow of ATC communications. Actually, the landing clearance was issued to the arrival aircraft with informing the planning had been changed. The controller solely instructed the departure aircraft "Hold short of RWY24L" instead of "Line up and wait" or "Cleared for takeoff". However, the departure aircraft already obsessed for takeoff would have heard likewise "Cleared to position 24L". When issuing an instruction, the controller should be well cautious to predict such a possibility that pilots would be trapped in a pitfall.
- If his planning intended the arrival aircraft was first to use the runway prior to the departure aircraft, it was meaningless and dangerous to confirm "Ready for departure". If the controller judged the arrival aircraft was first after the confirmation, he should have informed the departure aircraft of change of the planning with emphasizing "Hold short of RWY".

3 Intruding the runway by misunderstanding the line up instruction to the other aircraft

3 - **a**. FASTAIR68 which was holding short of RWY32L at Yamato airport mistook the instruction of "Line up and wait" to a similar call sign of FASTAIR682 holding short of RWY32R as for him, and entered the runway while reading it back. A wrong runway number and ambiguous call sign were included in the read-back, however, the controller did not point them out. No prescribed countermeasures had been taken for the similar call signs.

☆ TRANSCRIPTION :

10:15:40	FASTAIR 68	FASTAIR 68 request cross 32R.
10:15:50	TWR	FASTAIR 68 TWR, cross 32R hold short of 32L.
10:16:10	TWR	GLOBAL 1604 TWR, report 5DME RWY32L.
	GLOBAL 1604	Wilco GLOBAL 1604.

— In the	meantime, 13 comm	nunications between TWR and other aircraft are omissioned —
10:18:20	FASTAIR 682	Yamato Tower, FASTAIR 682 with you.
	TWR	FASTAIR 682 Yamato Tower, hold short of 32R
	FASTAIR 682	Holding short of 32R
— In the	meantime, 10 comm	nunications between TWR and other aircraft are omissioned —
10:19:30	GLOBAL 1604	GLOBAL 1604.
	TWR	GLOBAL 1604, traffic landing roll RWY32L continue approach.
	GLOBAL 1604	Wilco.
10:19:50	TWR	GLOBAL 523, contact Yamato DEP 119.5.
10:19:53	TWR	FASTAIR 682, RWY32R line up and wait,
		traffic 5 miles landing 32L. \bigstar_1
	FASTAIR 68	32L line up and wait
		FASTAIR 682 ah $\cdot \cdot 68$. \bigstar_2
10:20:00	TWR	GLOBAL 3172 right turn W6,
		hold short of 32R for departure.
	GLOBAL 3172	GLOBAL 3172, W6, hold
		short of 32R.
	FASTAIR 682	TWR, FASTAIR 682
		confirm line up and wait 32R.
10:20:10	TWR	Affirm.
	FASTAIR 682	TWR, FASTAIR 682 line up and wait 32R.
	FASTAIR 68	68 line up and wait 32L?
10:20:20	TWR	Negative 682. \bigstar_3
10:20:30	TWR	FASTAIR 68, did you pass the stop line?
	FASTAIR 68	Yes, we did, FASTAIR 68.
	TWR	Roger, Break, Break, GLOBAL 1604 go around.

☆ Critical points in ATC communications :

- FASTAIR68 mistook the instruction of \bigstar_1 for FASTAIR682 as for him. In the cockpit of FASTAIR68, both pilots were likely to misunderstand the instruction for FASTAIR682 as for them, however, they should have had some opportunities to be suspicious of the line up instruction before the arrival aircraft landed, if the crew was monitoring communications between the tower and the arrival aircraft properly.
- The PM's read-back in \bigstar_2 was awkward and unnatural like stating the call sign of the other aircraft, and corrected it to own call sign thereafter. It is hard to think both pilots had commonly misunderstood the instruction. Therefore, we analyzed the first step of the communication loop which dictates "Monitor independently and never consult and confirm with each other" would not have been properly exercised.
- When responded likewise \bigstar_3 , the aircraft already had intruded the runway, and the controller mistook the call sign possibly by being upset. It would not have directly contributed to the incident, however, tranquility is one of the essential requirements for the controllers.

☆ Outcome that likely has been prevented :

• While FASTAIR68 was holding short of RWY32L, GLOBAL1604 was on the approach to the same runway with being requested to report 5 DME. When a

call up was initiated, GLOBAL1604 was told to "Continue approach" as the other aircraft was on its landing roll. It was crystal clear that takeoff was impossible before these two arrival aircraft, if the communications were properly monitored.

- If, the communication loop was properly exercised in the cockpit, confirmation to ATC would have been prompted for preventing the incident by a subtle discrepancy in the comprehensions of PF and PM.
- If the controller's hear-back was appropriate, it should have easily been found that the read-back of \bigstar_2 was obviously from FAST68 but not from FAST682 by the facts of; 1) the wrong runway number in the instruction and; 2) the call sign of FASTAIR682 was restated as FAST68. Since the controller would have instinctively understood such an error might brought a serious outcome, the first priority should have been telling FASTAIR682 simply "Negative". However, in the next moment, the controller instructed GLOBAL3172 to vacate from W6, and he was very unlikely to hear back the read-back of \bigstar_2 .
- FASTAIR682 confirmed a "Line up" instruction, however, the controller would have understood what was happening, if the pilot stated the read-back was from the other aircraft along with the confirmation.
- FASTAIR 68 and FASTAIR 682 quite resemble with each other. The controller seemed to be overly familiar with the similar call signs in daily operations, however, the incident would have been prevented, if he complied with the prescribed procedures in the Manual of ATC Service.
- The misunderstanding should have been prevented, if the controller understood the keywords were the call signs when issuing the "Line up" instruction two or more aircraft were waiting for departure.
- **3 b**. A departure aircraft holding short of RWY32L entered the runway without receiving a "Line up" instruction at Yamato airport. This is an example quite similar to the case **a**. FASTAIR18, was instructed to hold short of RWY32L in the departure sequence after crossing RWY32R. Meanwhile, each two aircraft took off and landed on RWY32L, and additional two aircraft landed on RWY32R. While a similar call sign of FASTAIR181 was holding short of RWY32R, it was cleared for takeoff in a succession of the line up instruction. GLOBAL2200 on the approach of RWY32L was cleared to land thereafter, however, it was re-instructed to go around after the pilot reported the aircraft on the runway. Also, the takeoff from RWY32R was cancelled. FASTAIR18 was in the RWY32L at that moment, however, it was unaccounted for when and how the runway was intruded as no communications were exchanged between FASTAIR18 and the controller.

☆ TRANSCRIPTION : —Omission—

☆ Critical points in ATC communications :

• Likewise FASTAIR68 in the case \mathbf{a} ., FASTAIR18 would have mistaken the instruction of "Line up and wait" for FASTAIR181 as for him. As FASTAIR18 had a strong expectation that "We are the next to go", both pilots would have misheard the similar call sign. In such a case, the runway number would also have been misheard as RWY32L by their preoccupations. An

important mechanism of the communication loop is a hear-back by PF while PM practices a read-back in order to confirm the concurrence of their comprehensions. It is hardly ever imagined PM of FASTAIR18 did not return either the read-back or a receipt, however, only the read-back from FASTAIR181 was recorded.

☆ Outcome that likely has been prevented :

- This incident would have been prevented, if the controller properly understood the similar call signs of FASTAIR 18 and FASTAIR 181. The relevant procedure dictates an alphabet can be suffixed to the call sign by a controller as necessary, however, it was not exercised.
- If the controller was reminded the most crucial point was to let the pilots "Receive and comprehend messages properly", FASTAIR18 would not have been mistaken the instruction for FASTAIR181 as for him. The call signs are really important as the keyword when two or more aircraft are waiting for the takeoff sequence. If the controller properly understood to "Instruct one of the similar call signs", the incident would have been prevented using another way of expressions.
- According to the communication record, FASTAIR18 incurred the runway without returning a read-back, however, the reason is still undefined. The incident would have been prevented, if the read-back and monitoring (hearback) were properly exercised using the communication loop.

4 Landing on the unauthorized runway

FASTAIR754 had been cleared to land RWY32R at Yamato airport, however, a tower controller misunderstood the aircraft's report making an approach along the localizer of RWY32L as a request to transit to RWY32L. Eventually, the controller cleared it to land RWY32L. When he instructed GLOBAL2441 a departure aircraft, to line up and wait RWY32R, the pilots confirmed, if they had an arrival aircraft on RWY32R. The controller never replied to the inquiry, and the arrival aircraft landed on RWY32R before GLOBAL2441 entered the runway.

☆ TRANSCRIPTION :

17:42:15	FASTAIR 754	Yamato TWR, FASTAIR 754 on LLZ 32L. \bigstar_1
19	TWR	FASTAIR 754, roger, report outer marker RWY32L.
25	FASTAIR 754	Report outer marker, FASTAIR 754.
17:44:45	GLOBAL 2441	Yamato TWR, GLOBAL 2441.
49	TWR	GLOBAL 2441 cross, correction
		hold short of 32R.
55	GLOBAL 2441	Hold short of 32R, GLOBAL
		2441.
58	TWR	FASTAIR 754, RWY32L
		cleared to land. \bigstar_2
17:45:04	FASTAIR 754	RWY32L, Ahh 32R cleared for,
		Ahh, cleared to land, FASTAIR 754. \bigstar_3

- 17:46:15 TWR GLOBAL 2441, report when ready.
 - 18 GLOBAL 2441 Roger 2441 now ready.
 - 20 TWR GLOBAL 2441, roger, RWY32R line up and wait
 - 24 GLOBAL 2441 Roger GLOBAL 2441 RWY32R, line up and wait.
 - 57 GLOBAL 2441 TWR, confirm line up and wait.
- 17:47:01 GLOBAL 2441 32R traffic.

15

- 12 GLOBAL 2441 TWR, 2441.
- In the meantime, FASTAIR754 landed on Runway 32 Right
 - TWR GLOBAL 2441, line up and wait, thank you very much. We have a landing RWY32L assigned.
 - $48 \ \ \, GLOBAL\ 2441 \ \, GLOBAL\ 2441, RWY32R \ line\ up\ and\ wait.$

☆ Critical points in ATC communications :

- The controller misunderstood the arrival aircraft was requesting landing on RWY32L by the report of "On localizer 32L" in \bigstar_1 , and then he cleared it to land RWY32L without either confirming or instructing the runway change as explained in \bigstar_2 .
- As PM restated "32R" with negating "32L", he was highly likely to deform the contents during the read-back. If PF vocalized "Cleared to land RWY32R", PM tended to read back in the same way intuitively. Therefore, it is strongly required to "Monitor independently" and "PM read it back as he had understood". In this incident, the communication loop would have decayed in the cockpit.
- "RWY32L" had initially been mentioned in the read-back in \bigstar_3 , however, it was restated as "RWY32R" later, possibly by a mistake or confusion. However, the controller failed to detect it by his hear-back.

☆ Outcome that likely has been prevented :

- If PF properly monitored the PM's read-back and ordered reconfirmation by pointing out its ambiguity, the controller would have been salvaged from his misperception.
- Change of the landing runway would have been correctly understood, if the controller heard it back properly.

5 Unauthorized takeoff run while holding in the runway

A departure aircraft started its takeoff run before an arrival aircraft exited the runway. After, GLOBAL2503 landed on RWY01R, FASTAIR51 a departure aircraft, was instructed to "Line up and wait" with an RVR value. The aircraft had waited for about four minutes after lining up, and then the tower informed "Expect immediately takeoff, traffic landing roll, and inbound traffic six miles". The departure aircraft started its takeoff run simply responding "Roger, FASTAIR51". The controller instructed the departure aircraft to stop immediately, as the arrival aircraft was not yet clear of the runway. Eventually, the arrival aircraft was instructed to go around.

☆ TRANSCRIPTION :

10:28:41	TWR	FASTAIR 51, RWY 01R line up and wait, and RVR
		touchdown 750m.
	FASTAIR 51	RWY 01R line up and wait, FASTAIR 51.
10:29:18	TWR	GLOBAL 2503, turn left B2, end of RWY, cross RWY 01L.
	GLOBAL 2503	GLOBAL 2503, B2, cross RWY 01L.
10:32:40	TWR	FASTAIR 51, expect immediately take off,
		traffic landing roll and inbound
		traffic 6 miles. \star_1
	FASTAIR 51	Roger, FASTAIR 51. \bigstar_2
10:32:59	TWR	FASTAIR 51, stop
		immediately, FASTAIR
		51, stop immediately,
		traffic landing roll.
	FASTAIR 51	FASTAIR 51.

☆ Critical points in ATC communications :

- The phrase of "Expect immediately take-off" in \bigstar_1 was extremely dangerous as the pilot would easily have been misled to "Takeoff immediately" being preoccupied as "The controller is expecting an immediate takeoff".
- Not only an inappropriate word of "Takeoff", but also the contents were quite misleading in the information in \bigstar_1 . It was quite likely to start the takeoff run immediately, if such a kind of information was provided to the aircraft which had been frustrated for departure.
- Only the call sing was enough as a response in \bigstar_2 , as \bigstar_1 is simply the information. In addition, PM should have intervened the PF's takeoff operations, if he had understood it simply was the information. Otherwise, PM should have read it back, if it were comprehended as the clearance of "Immediate takeoff". The pilots should not respond to the ambiguous contents with an equally ambiguous word "Roger".

☆ Outcome that likely has been prevented :

- As the full throttles were required for starting the takeoff operations, it is very hard to imagine PM had understood "Takeoff is not yet authorized". In other words, PM also, should have returned a read-back likewise "Cleared for takeoff" or "Taking off", if he thought the takeoff had been cleared. If the communication loop functioned properly in the cockpit, the controller would have promptly respond ed FASTAIR51 accordingly saying "Negative".
- If, the information like \bigstar_1 were not provided, the incident should have been prevented. This kind of information did not violated the "Manual of ATC Service" at that time, however, the controller should have understood dangers to trigger the misperception of the pilots in such a circumstance. Every controller should be extremely cautious anytime when a serious outcome could be brought about with only a partial misheard.

Countermeasures for the runway incursions learned from the case study

1 Communication techniques of the pilots

- It is vital to understand and exercise skills of the communication loop in all the ATC communications that include any instruction.
- Any incident relating to the runway incursion hardly ever happens, if the runway is not intruded. A pilot should strongly be reminded one of "Cross runway", "Line up and wait", "Cleared for take off" or "Taxi via/Backtrack runway" is always necessary when entering the runway. Most of the runway incursions would have been prevented by the "Verbal verification" which demands to vocalize obtained instructions in the cockpit.
- When crossing the runway, the verbal verification should customarily be exercised whether to "Hold short" or "Cross runway".

2 Communication techniques of the controllers

- No runway incursions would occur as long as a proper instruction is adequately exercised by functions of the communication loop and the verbal verification. However, "To err is human". Therefore, the controllers should not endanger aircraft operations by discerning any situation wherein pilots may commit an error.
- This kind of knack would really be fostered through the experiences. Controllers may accumulate skills and knowledge by scrutinizing each instruction, aircraft situation and expected outcome.
- When a controller is conscious of the keyword, pilots would understand significance of the messages most surely. When a controller is keen "What is the keyword" in his or her instruction, pilots would more properly understand a significant part. After all, any keyword would be stressed by recognizing the most important part or any part required to convey very accurately as the keyword. Eventually, pilots understand "What the most significant is".
- When two or more aircraft are waiting for the same kind of instructions (especially, "Line up and wait"), other aircraft are likely to take it as for them mistakenly. Similar call signs would significantly increase the possibility of misheard. In such a case, both PF and PM often commit an error in the same way to create a wrong common perception by the cockpit's communication loop. A runway incursion is very likely to happen in such a situation. Therefore, "Who is paged?" is the key point when issuing an instruction to enter the runway while two or more aircraft are expecting the same kind of instruction.
- It would be difficult for controllers to hear back word by word, however, an accuracy of the hear-back would significantly be improved by being conscious of the keyword. The reason is simple. A hear-back would be done quite easily and effectively by checking any keyword in a read-back.

• Logically, a controller guarantees "Read back is correct" when no responses are returned as a result of the controller's hear-back. Also, a mechanism of the communication loop tells "PM's read back is correct", if PF returns no responses to PM's read-back in the communication loop. However, a lack of hear-back is often overlooked, even though when a hear-back is regarded as properly practiced. Therefore, we strongly recommend vocalizing own comprehension as the means to secure redundancy. Controllers often do not exercise a hear-back correctly overlooking their errors, therefore, we suggest them talk to themselves such as "Oh! yes" for confirmation especially when no positive replies are sent back to pilots. Of course, a controller should request to read back again, if any significant part is not read back, or a readback was incomprehensible.

3 Knowledge and attention to prevent the runway incursions by pilots

- When crossing the runway, a pilot should be strongly reminded that either "Cross runway" or "Hold short of runway" is instructed when approaching the runway. It is considered as one of the practices of the verbal verification.
- A pilot should be aware that a local controller ("Tower") is always the authority of the runway in the airport operations. Such a stance would be helpful to find pilot's errors.
- Any existing threats should be commonly understood between two pilots through the situational awareness created by monitoring communications of other aircraft.

4 Knowledge and attention to prevent the runway incursions by controllers

- In about a quarter of the analyzed examples, when any favorable replies had been expected, a phrase of "Hold short of runway" was mentally blocked by the pilots despite it had been explicitly instructed. We assume it was attributed to misleading replies by the controllers. It was basically a pilot's error, however, ambiguous instructions would have triggered the pilot's errors. The "tasks prescribed in the Manual of ATC service" may be insufficient for preventing accidents and incidents. Therefore, one of the important factors for the controllers is learning the communication skills that never mislead the pilots.
- Sometimes, the instruction of "Hold short of runway" should not accompany other instructions or information. Pilots often tend to comprehend a preferable part of the instructions conveniently without paying attention to the entire instruction. In fact, pilots tend to expand preferable part advantageously when a significant instruction includes any negative information. When an instruction of "Hold short of runway" accompanies another instruction or traffic information such as "Report when ready" or "Intersection available" that implies a prompt departure, a pilot would likely be entering the runway with a strong expectation. Of course, it is a pilot's error, however, controllers should be well aware of the danger created by misleading instructions or information, even if it does not violate the prescribed standards or procedures.

- In some cases, accidents or incidents may not be prevented only by the provisions and procedures covered by the "Manual of ATC service". When any special attention is required for a specific pilot;
 - 1 Not to leave the pilot to judge by the provided information. Instead, each action is separately and clearly instructed.
 - 2 Avoid sending two or more instructions in a single transmission, and request to read each piece back separately.
 - 3 Keep watching the aircraft closely, and re-instruct aircraft just before executing the relevant instruction.
- When any irregular events such as bird strike occurred, communications would be concentrated in the event with neglecting the essential ATC service. Especially, attentions of both pilots and controllers would be diverted, if an ATC instruction and the event information are transmitted in a single communication. Any appropriate back up system should be prepared in order to reduce the controller's workloads, if the occurred event is so significant to deal with.



As mentioned before, most runway incursions were attributed to communication errors by pilots, however, both pilots and controllers would equally have had opportunities to prevent the incidents.



According to our analyses, most analyzed incidents occurred even though the controller's procedures were mostly conformed to the Manual of ATC service. We assume both pilots and controllers would be keen to reduce the increasing number of incidents. A knack and skills that are not covered by the Manual of ATC service would be necessary for the controllers to prevent accidents and incident. In fact, continuous efforts are required for the controllers to establish the genuine ATC communications that hardly ever mislead the pilots.

How to prevent the incidents relating to the runway incursion. We conclude the following countermeasures are crucial.

- $\bigcirc\,$ Practice the "Communication loop" and the "Verbal verification" as a team the two-man cockpit.
- Controllers should be well cautious how to issue instructions by foreseeing the possibility of pilot's errors and exercise the hear-back without any fail being conscious of the keywords with mobilizing a knack and skills that are covered by the Manual of ATC service.

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