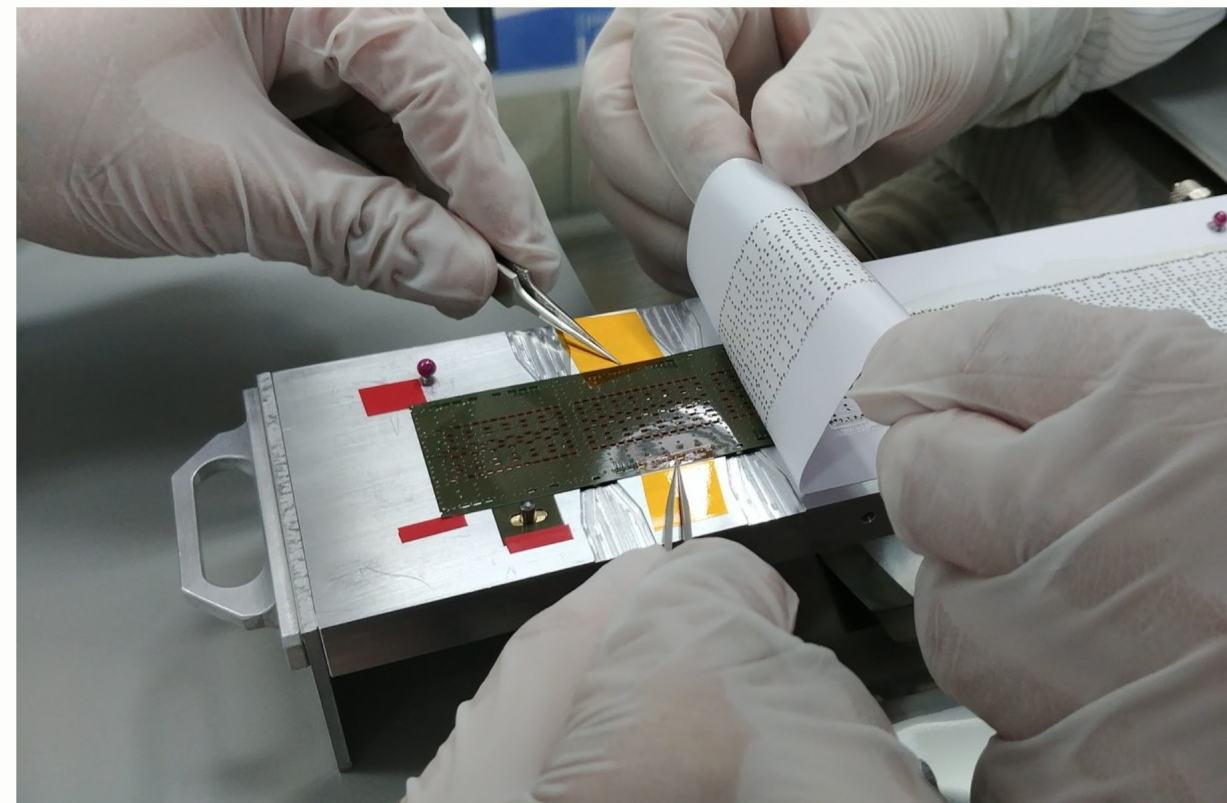


Lessons from ITS HIC Production: Why Automation Matters at a University Site

Bong-Hwi Lim

CNS, The University of Tokyo (RIKEN Wako)
formerly Pusan National University — Pusan-INHA ITS
Upgrade team



HIC gluing practice at the Pusan site, August 2017

One university site, two production jobs

Pusan National University + Inha University, Korea · 2016 – 2019

ALPIDE mass chip test (2017 –)

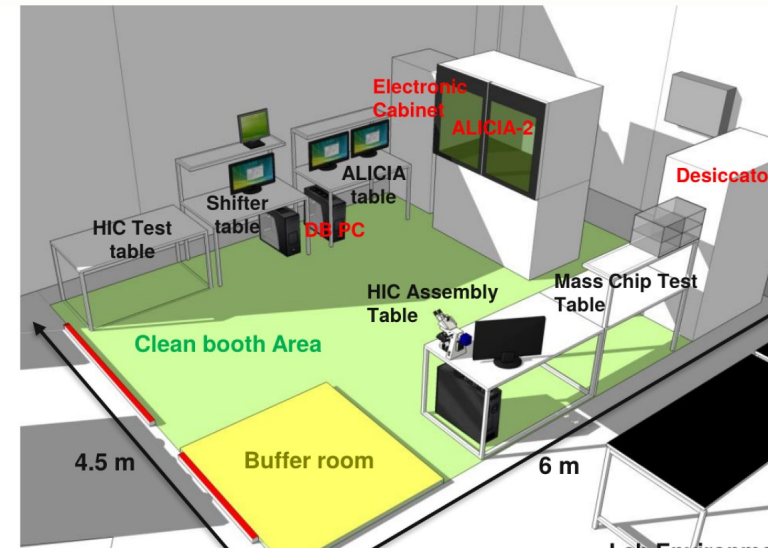
- ~30k Outer Barrel chips on ALICIA-2, an automatic probe station

OB HIC assembly & QA (2017 – 2019)

- 14 chips + FPC glued on the same machine; bonding outside; QA on site
- One of five OB HIC sites worldwide

My role

- Local organizer: lab, training, shifts, issues, schedule
- 3 professors + ~13 students



27 m² clean booth: ALICIA-2, chip test and HIC assembly tables, HIC test table



ALICIA-2 acceptance test, Nov 2016 · test material arriving, 2017

How it went, 2016 – 2019

2016 · Build



- Clean booth, ESD, gas, vibration survey
- Machine delivered, accepted in Nov
- 3 weeks of training at CERN

2017 · Start



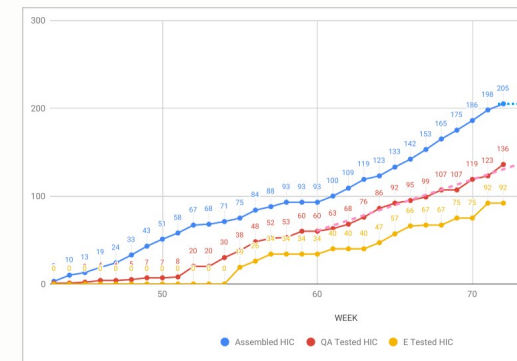
- Bari training, readiness review
- Chip test from July, two shifts
- First dummy HICs; glue leakage

2018 · Series



- Stops: vacuum, glue, chip yield
- 2 HICs/day from June
- FPC flattening, table replaced

2019 · Endgame



- Assembly ahead of test
- QA pushed 5.9 → 15 per week
- Done around June

What we planned, and what happened

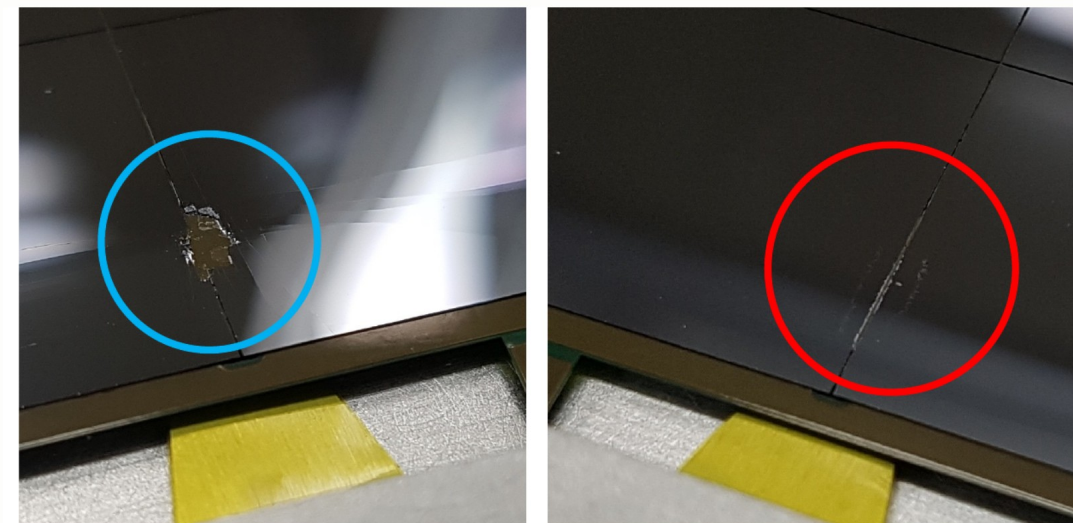
Item	Plan	Reality
Chip test	4 min/chip, 240/day	4–5 min/chip held; ~120/day in an 11 h day, ~90/day sustained
HIC rate	1/day, then 2–3/day	Reached — but QA stayed at 5.9/week until the endgame
HIC yield	—	70% passed QA at first; 86% after vacuum pump and glue mixer
Uptime	Vendor + remote expert	One motor cost ~2 months; "Machine Error" 1–2× a week
Supply	From CERN / Bari	Stopped in Mar 2018 for lack of glue; bonding in 2-week batches
Crew	2 shifts × 2 people	Roster changed every semester; HIC crew rotated 3 times

The automated test cycle was the one number that behaved. Everything around it moved.

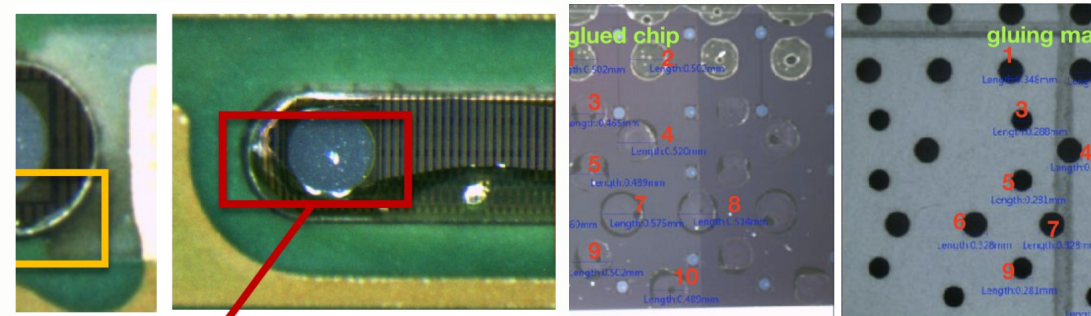
Case 1 — the manual step: glue leakage

- Machine placed chips and aligned the FPC — never a rejected HIC
- Glue was mixed, dispensed and the mask peeled **by hand** — this is where HICs failed
- No glue parameters were recorded at first, so each dummy HIC was one experiment
- Logged two parameters, wait time and remix → zero leaks in three tries

Dummy	Wait	Remix	Bad / Worse / Worst
#3	30 min	no	4 / 8 / 3
#5	60 min	yes	2 / 1 / 0
#8	60 min	yes	0 / 0 / 0



Chip broken on the HIC table, glue leaked between chips



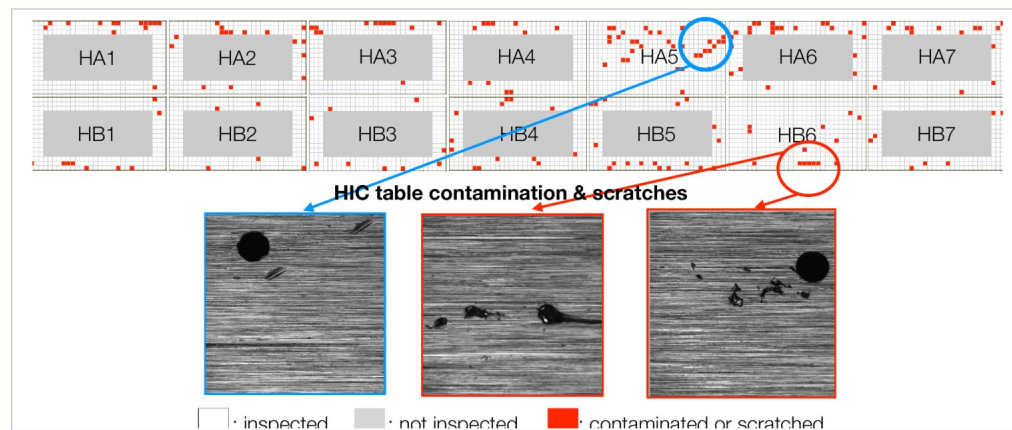
Pad leakage grades · glue dots ~150% wider than the mask holes

Case 2 — the automated machine: ALICIA-2

JIRA issues, Mar 2017 – Jan 2018	Count
No impact	7
Loss of efficiency	8
Production stop	9

- Chip handling was hands-free and the most reliable step
- Still the biggest loss: one focusing motor failed twice, ~2 months down
- Year two: table replaced, gripper re-aligned, markers recalibrated

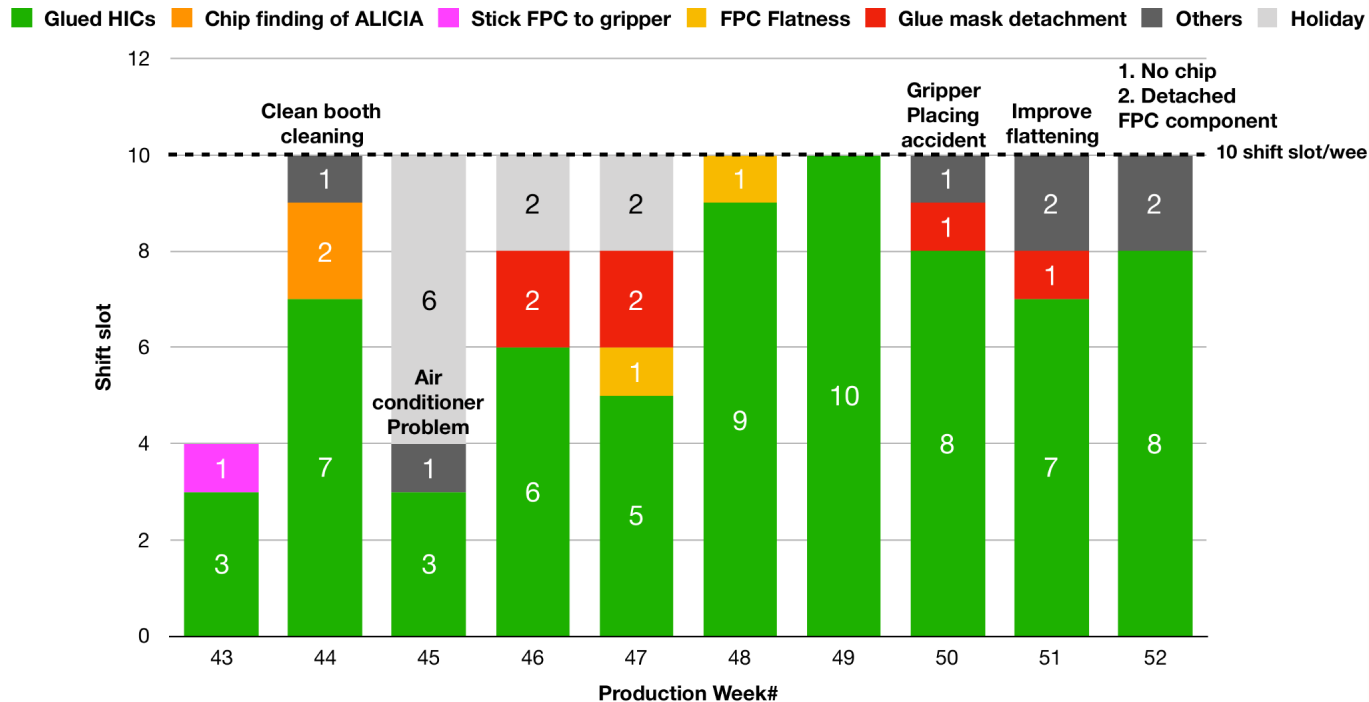
What kept us running: an issue tracker, our own troubleshooting manual, remote experts, spare parts. Automated is not unattended.



Nov 2018: table surveyed position by position, then replaced

Case 3 — where the shift slots went

Ten weeks of 2018, ten gluing slots a week — 79% produced a HIC



- Achieve 79.3% gluing rate in Pusan sites.

Green = a HIC glued. Every other colour = a slot lost

- FPC flattening by hand
- Glue mask peeling — 9 FPCs lost
- FPC stuck to the gripper
- Dirty reference markers
- Booth cleaning, air-conditioner, holidays

Almost none of it is the machine's cycle time. Each colour is a candidate for a tool, a jig or a sensor.

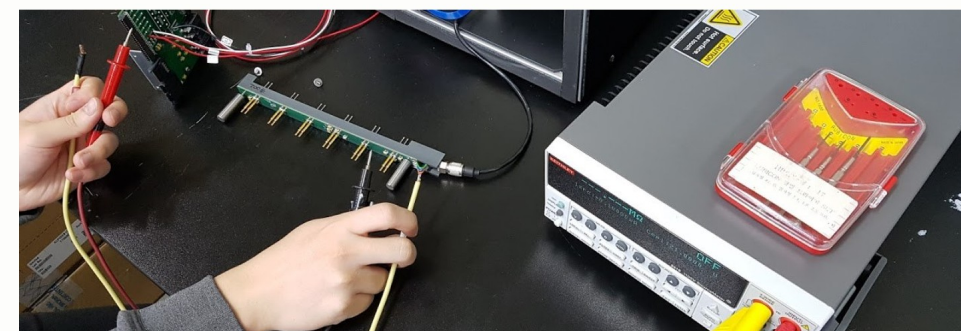
Throughput was tied to people, people to the semester

- Two shifts of two people; five trays took ~11 hours a day
- Undergraduates only in vacation; INHA students around coursework
- HIC crew changed three times in 18 months, each pair retrained
- Yonsei, the other Korean test site, ran a more automated station: fewer hands per shift, steadier output

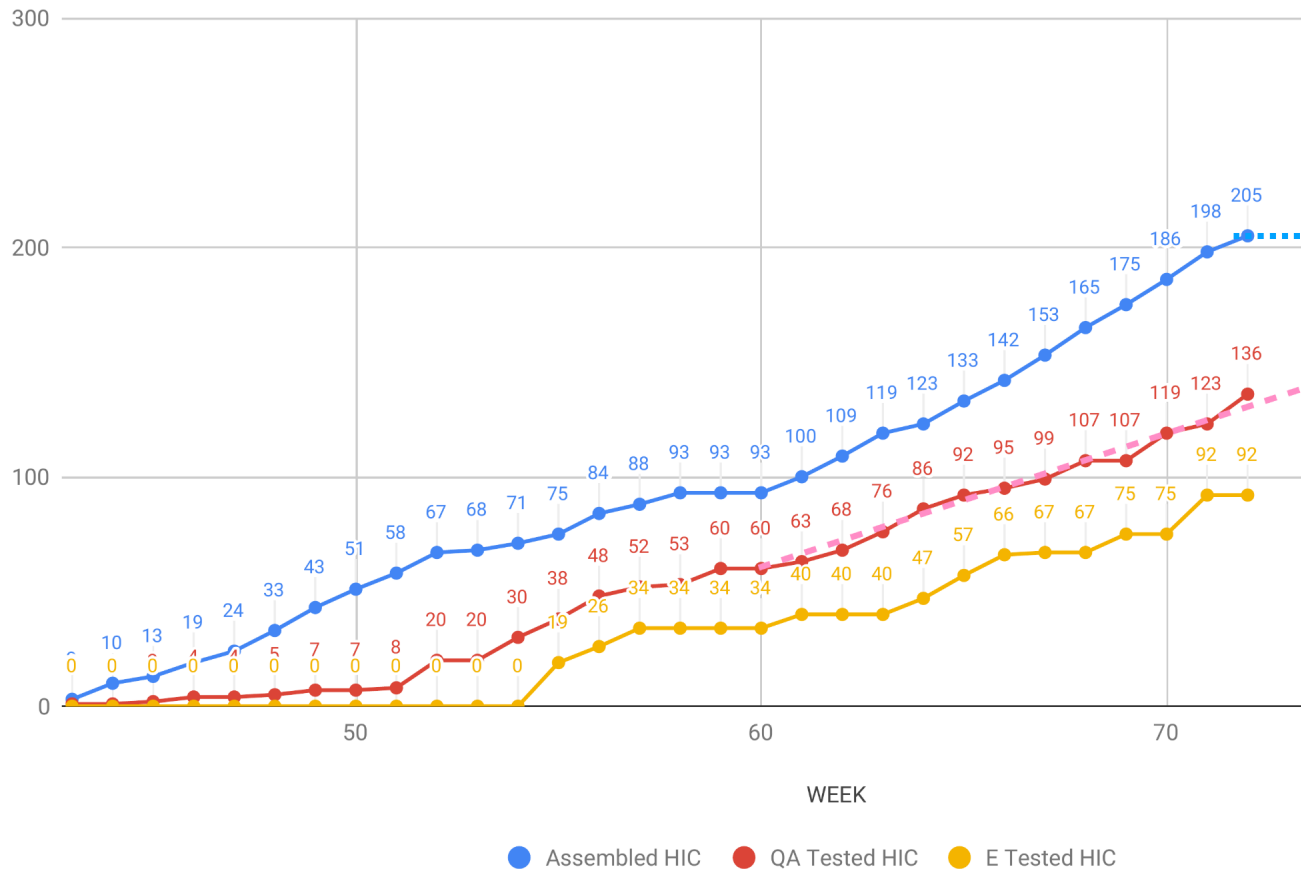
Trained hands were the scarcest, least stable resource. The less a part is touched, the less the rate depends on who is in the room.



HIC test setup built by the student crew, autumn 2017



The bottleneck moved three times



Assembled (blue) vs QA-tested (red) vs endurance-tested (yellow), Apr 2019

2017 — chip test

Everything waited for tested chips

2018 — supply and hands

Glue, vacuum, chip lots; then FPC flattening and mask peeling

2019 — QA

205 glued, QA at 5.9/week; 3-day endurance test caps at 3.3/day

Automate the current bottleneck. For a module factory, test and QA usually pay first.

We could plan because the data was already there

Week	Date	HIC Production	Bonding HIC Arrival	Bonded HIC stock before test	QA Test	Total QA Tested HIC	QA Tested HIC	Endurance Test
72	2019. 4. 3	2		22	3	133	10	10
72	2019. 4. 4	1		19	3	136	3	0
72	2019. 4. 5	0		16	3	139	6	0
73	2019. 4. 8	0		13	3	142	9	0
73	2019. 4. 9	1		10	3	145	12	10
73	2019. 4. 10	2		7	3	148	5	0
73	2019. 4. 11	2		4	3	151	8	0
73	2019. 4. 12	4	31	1	1	152	9	0
74	2019. 4. 15	2		31	3	155	12	10
74	2019. 4. 16	2		28	3	158	5	0
74	2019. 4. 17	2		25	3	161	8	0
74	2019. 4. 18	2		22	3	164	11	10
74	2019. 4. 19	3		19	3	167	4	0
75	2019. 4. 22	0	19	16	3	170	7	0
75	2019. 4. 23	0		32	3	173	10	10
75	2019. 4. 24	0		29	3	176	3	0
75	2019. 4. 25	0		26	3	179	6	0
75	2019. 4. 26	0		23	3	182	9	0
76	2019. 4. 29	0		20	3	185	12	10
76	2019. 4. 30	0		17	3	188	5	0
76	2019. 5. 1	0		14	3	191	8	0
76	2019. 5. 2	0		11	3	194	11	10
76	2019. 5. 3	0	20	8	3	197	4	0
77	2019. 5. 6	0		25	3	200	7	0

- Every chip and HIC had a barcode and a record in the central ITS production database
- On top of it we tracked daily rates — glued, bonded, QA, endurance — on a shared board (Trello) and sheets
- So in April 2019 we could lay out three endgame scenarios in an afternoon: stop at 205, push to 225 or 245

Data structure first. It cost almost nothing and it is what made every production decision possible.

Endgame plan, April 2019: one row per working day, three scenarios

Five things I would tell a new production site

1. **Manual steps are where yield is lost.** Automate for reproducibility and logging before speed.
2. **Automated is not unattended.** Design in diagnostics, remote access, spares, an issue tracker.
3. **Decouple rate from manpower.** Trained hands follow the semester.
4. **Follow the bottleneck.** Ours moved from test to supply to QA.
5. **Structure the data first.** Central DB, barcodes, daily tracking.

Speed was the one thing the machine already had. Everything we lacked was around it.

What I would automate first for SVT modules

#	What	Why, from ITS
1	Test & QA pipeline	Unattended sequences, results straight to the DB. Our last and hardest bottleneck
2	Repetitive hand steps	Adhesive, mask, vacuum tooling — same parameters every module, and recorded
3	Inspection	Camera + model instead of grading glue leaks by eye
+	Machine health	Motor / vacuum / focus monitoring, shared issue tracker, spares

- **From day one:** central production DB, barcodes, issue tracker, daily tracking board
- **My position:** the fewer hands a module passes through, the better. SVT sites will be the same student labs on the same semester cycle

Summary and outlook

Summary

- Pusan-INHA ran chip test and HIC assembly for ALICE ITS, 2016–2019, with a student crew
- The automated test cycle held; yield and rate were lost in hand steps and infrastructure
- The machine failed too — logging, remote experts and spares saved us
- The bottleneck moved; test automation would have paid most

Outlook for SVT

- Automate for reproducibility and resilience first; speed follows
- Test & QA → hand steps → inspection, with machine health alongside
- DB, tracker and tracking board before the first module
- Write every procedure so a new student can run it in a week

Thank you — happy to share the issue log, shift plans and tracking sheets.