Integrated Diagnostics (ID) Closed Loop Knowledge System (CLKS)

Steve Head

Objective

ID CLKS

- **Develop ability for ID engineer/analyst to gain domain knowledge from integrated data stores**
- **Develop closed loop knowledge system where data is presented and exploited to actively influence**
  - Authoring/monitoring/adjusting of smart diagnostics
  - Engineering/analyst/maintenance technician judgment
- **Maximize use of current transactional databases, domain experience and past successes on aircraft/system programs**
- **Significantly improve sharing and integration of related information across business disciplines to enhance decision making processes**
- **Utilize results and lessons learned from previous Boeing ID data mining studies (2001 and 2002) to better the outcome of ID CLKS**

Traditional Integrated Diagnostics

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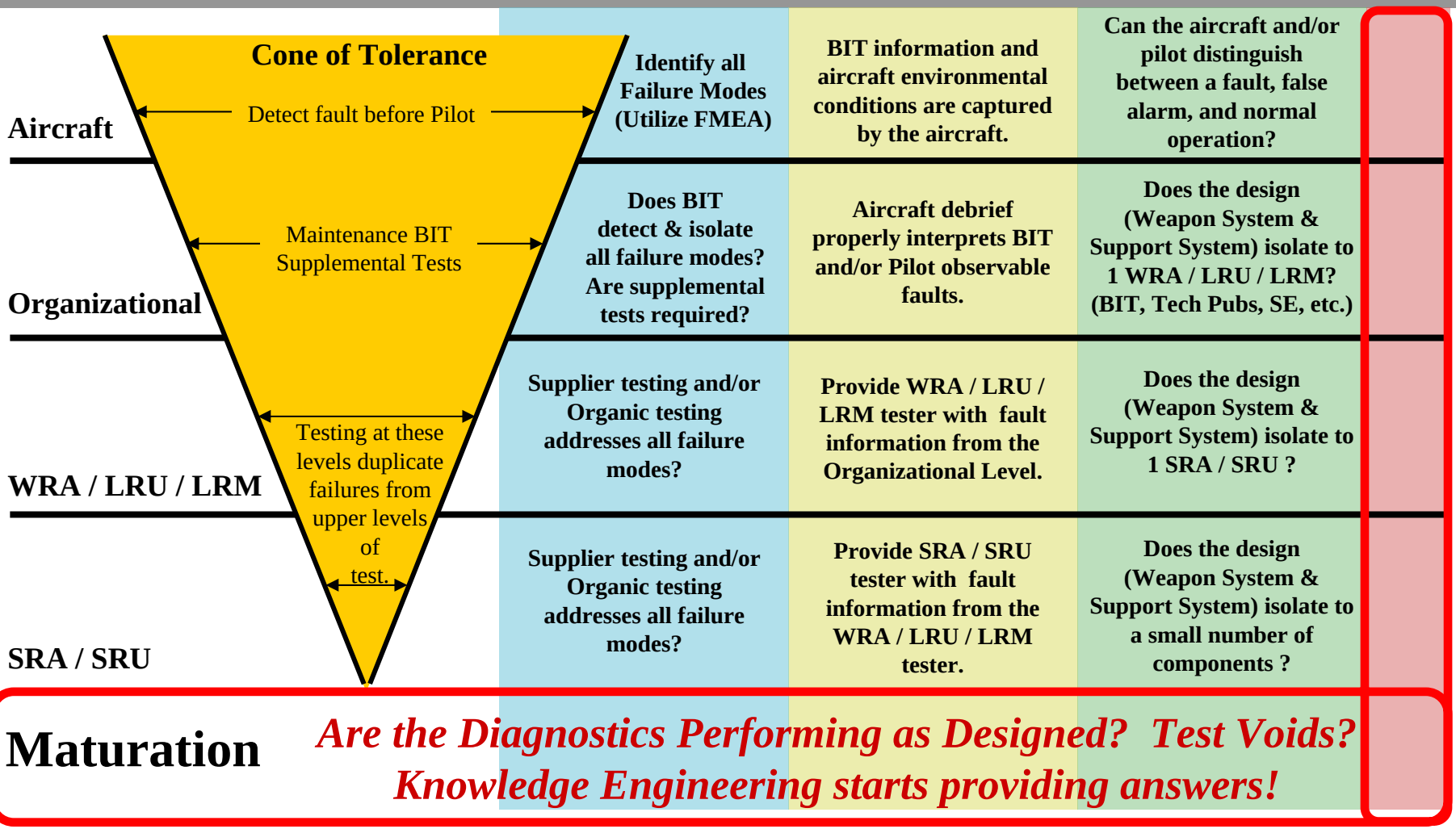

Why Care About ID Knowledge?

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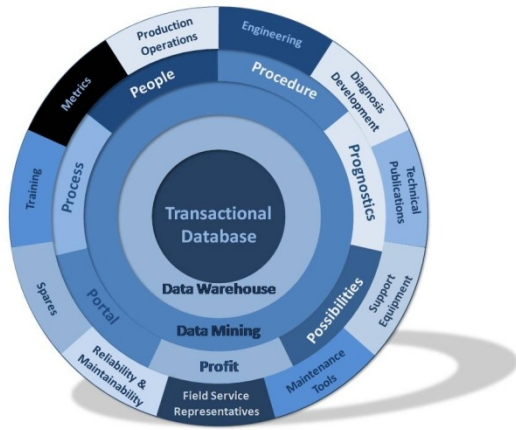
- **Mining data is mining knowledge**
  - Data mining utilizes automated search algorithms (patterns, similarities, correlations or text matching). Data results are visually presented to the user (better understanding and improved judgments).
- **Knowledge has potential**
  - Properly maintained
    - Optimized for use (IT independent)
  - Valued
    - Trying to tell us something - are we listening?
    - Look into the crystal ball - what do you see?
  - Categorized
    - Impact and message
      - Good, missing, dirty or bad data
  - Available at the point of use and to the next specialty
    - Timely and meaningful manner
    - DATA?



Previous Boeing Knowledge Study Results

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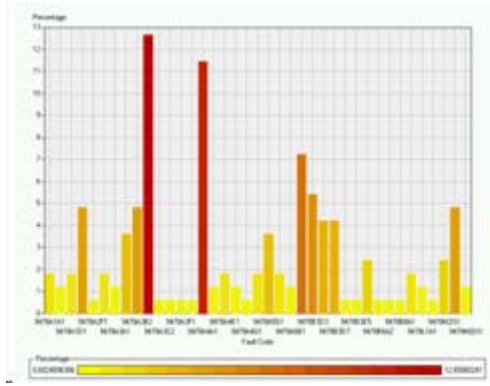
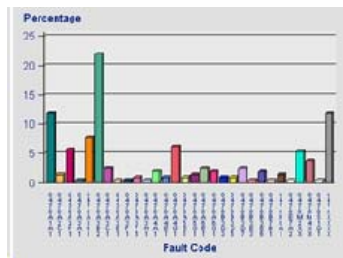
- **Aircraft Program Knowledge Discovery 2001**
  - Discovered correlations between aircraft/system events
  - Identified emerging system issues/trends
  - Identified cause of part/system failure

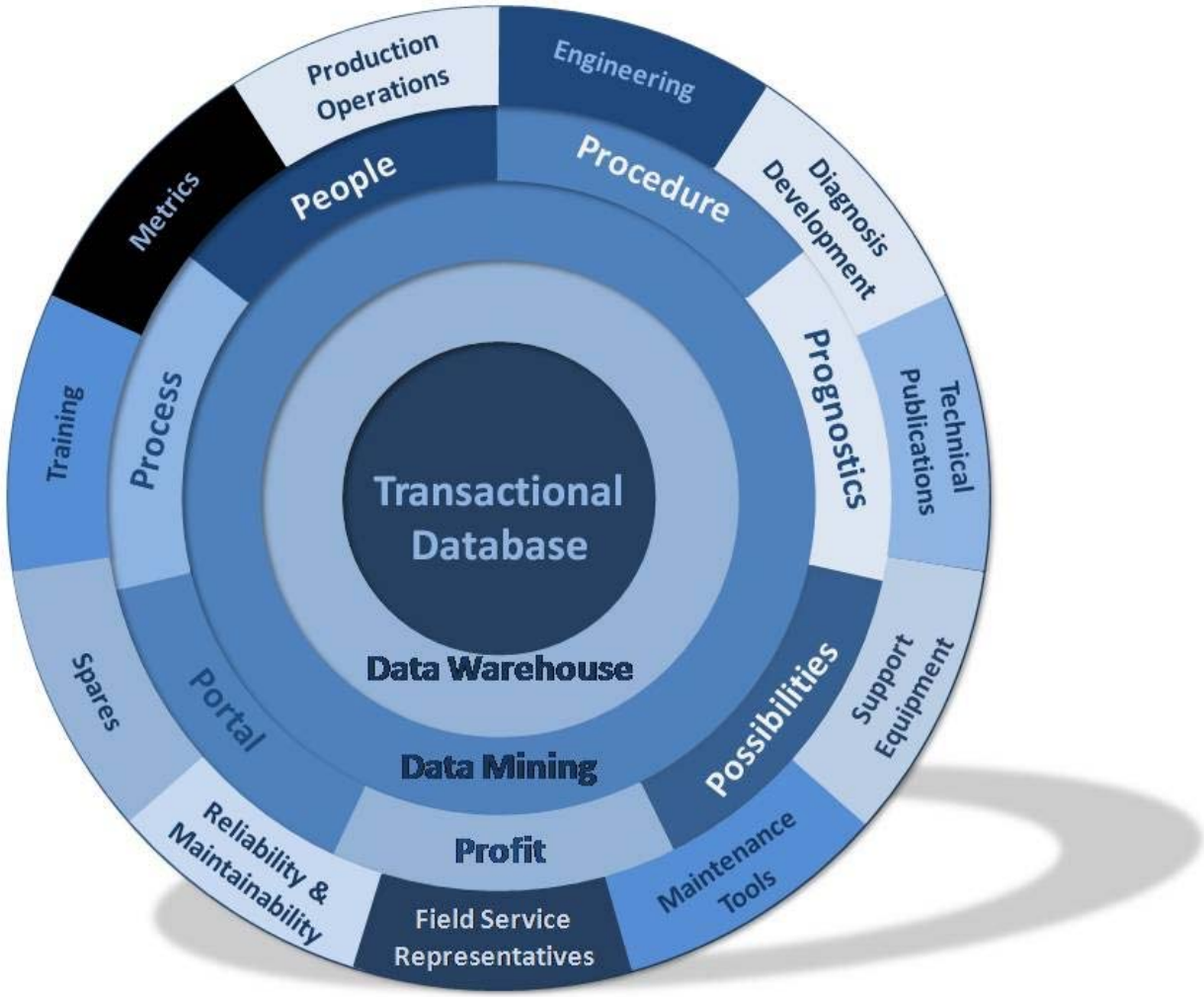


- **Aircraft Program Data Mining Study Results 2002**
  - Identified aircraft with significant failure clustering
  - Identified recurrent faults with specific underlying relationships to aircraft parametric data
  - Identified separate nuisance fault codes for consolidation
  - Identified ideas of improving data quality for wiring faults



Knowledge Wheel

ID CLKS



Transactional (Operational) Databases

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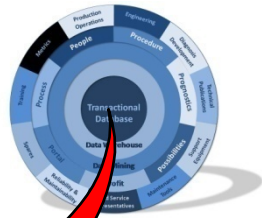
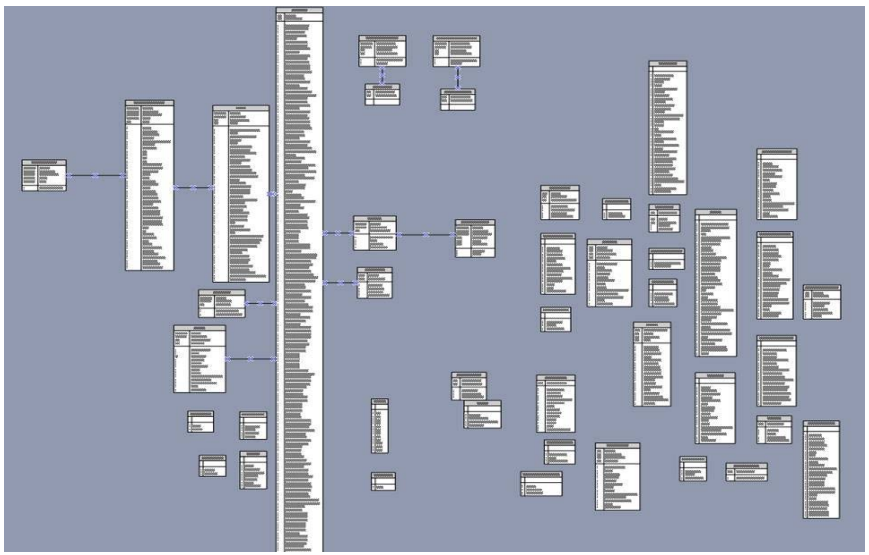
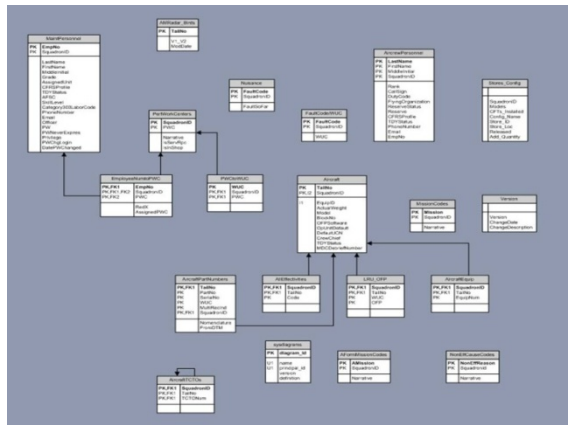
- **MANY databases used for day to day business functions**
  - But NOT a data warehouse







Transactional Sources of Data

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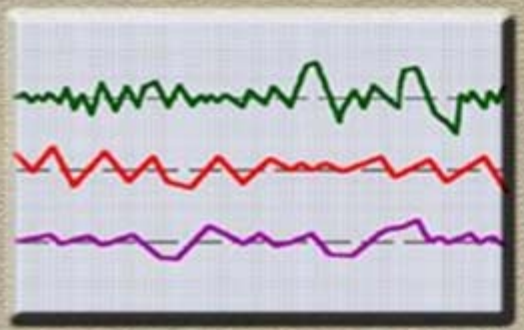
Fault data
- Fault code
- System component performance
- Operational context parameters
- Flight data recording



- Flight data for single aircraft past flights
- Specific squadrons
- Bases/geographic regions
- Correlation to specific flight text
- Frequency of occurrence

Maintenance data
- Pilot debrief
- Procedures used
- Actions taken/parts replaced
- Time for action/personnel
- Subsystem/component test results

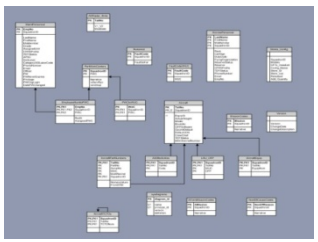
Logistics data
- Aircraft/part identification and configuration
- Aircraft part usage (sorties, hours)
- LRU/component history
- Spares disposition

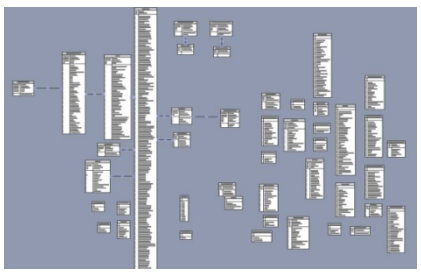
Manufacturing data
- Lot number
- Acceptance test results
- Aircraft configuration
- Component lot number
- Maintenance actions
- Personnel experience
- I level test results
- Number/pattern of CNDs and RTOKs

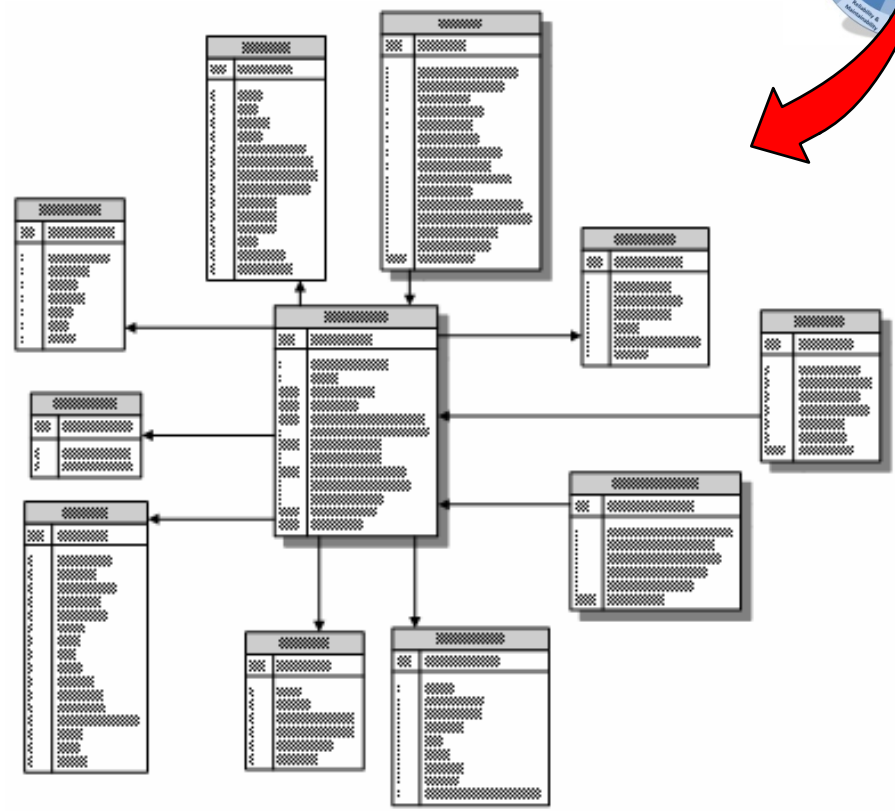
Data Warehouse

ID CLKS

- **Database designed to support data mining process**
  - Extract, Transform and Load (ETL Process)

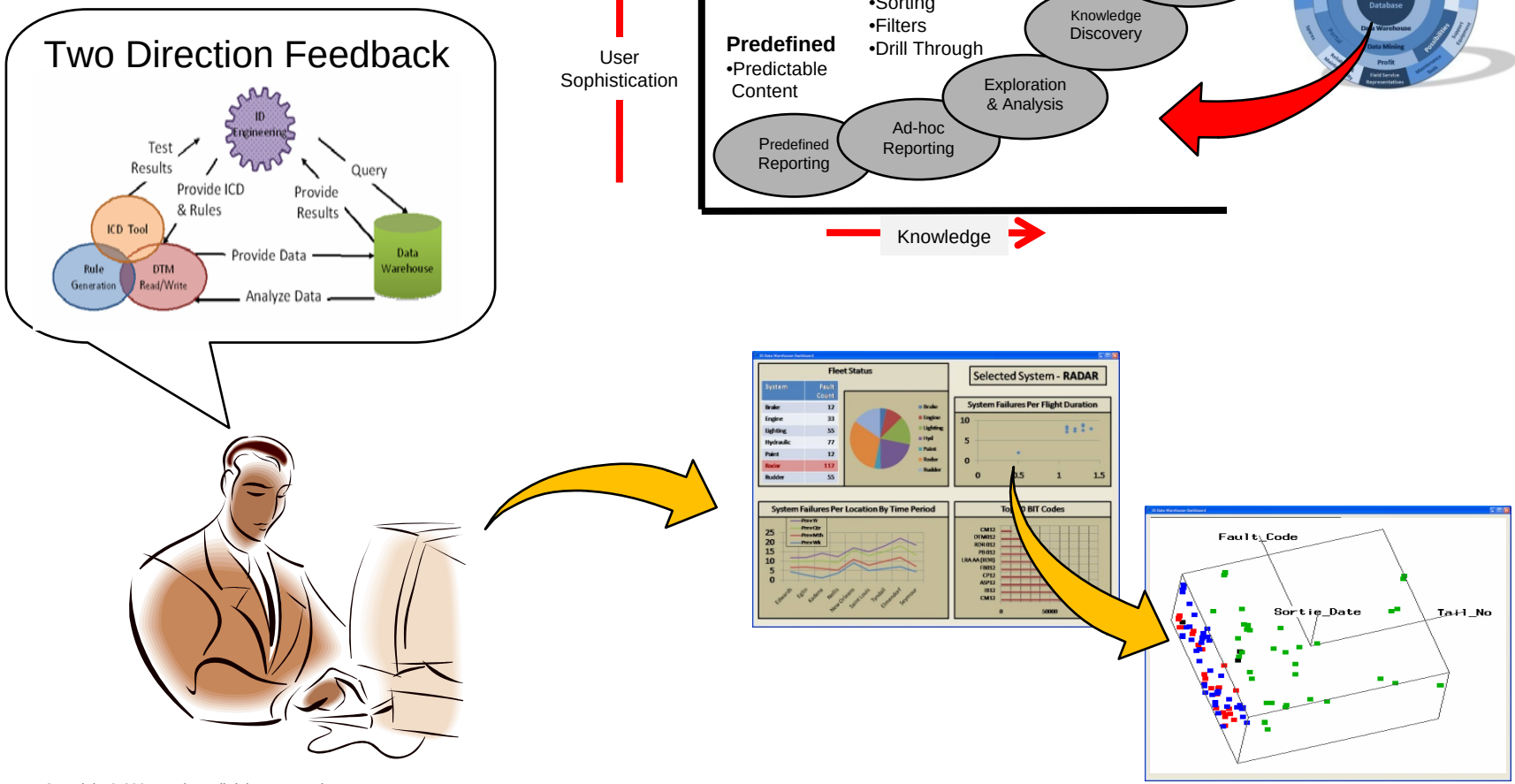






Data Mining and Aircraft Failure Visualization

ID CLKS



7 P's Visual Knowledge and Results Opportunities

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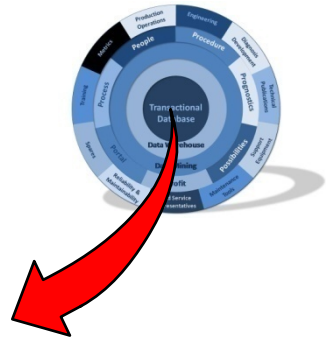
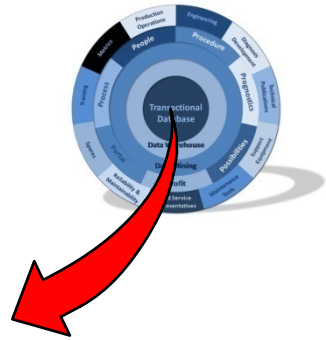
- **People**
  - Is there a training or staff issue driving the poor diagnostics, Can-Not-Duplicate, Bench-Check-OK, etc?
  - Are required entries within maintenance system filled out completely and correctly?
  - Is there an opportunity to update the maintenance system?
- **Process**
  - Business process improvement? Is process too complicated, not accessible?
  - Could a LEAN approach provide a better solution?
- **Procedure**
  - Does the maintenance procedure need updating or smart diagnostics updated?
  - Is there a false alarm that needs masking?
- **Portal**
  - One web, one login, common user interface?



7 P's Visual Knowledge and Results Opportunities (cont)

ID CLKS

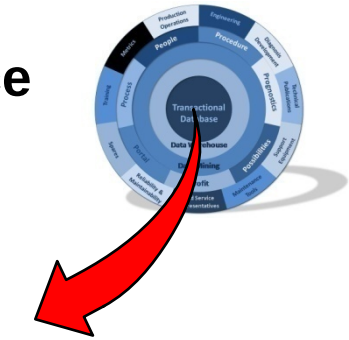
- **Prognostics**
  - If A and B are bad, then C will fail with a certain period?
- **Profit**
  - Is the knowledge discovery or change the exception or the rule?
  - Too costly?
- **Possibilities**
  - What is the data and/or the metrics trying to tell us?
  - Share the knowledge with subject matter experts from applicable business disciplines. Knowledge drives capturing of focused domain knowledge?
  - If a wiring repair maintenance action, compare job closeout WUC with text mined closeout narrative. Flag due to incorrect WUC assignment (LRU instead of wire repair). Unnecessary LRU failures which drives spares?
  - If relationships between flight parameters, generated failures and human observables exist, consider updating diagnostics accordingly?



Knowledge Wheel Disciplines

ID CLKS

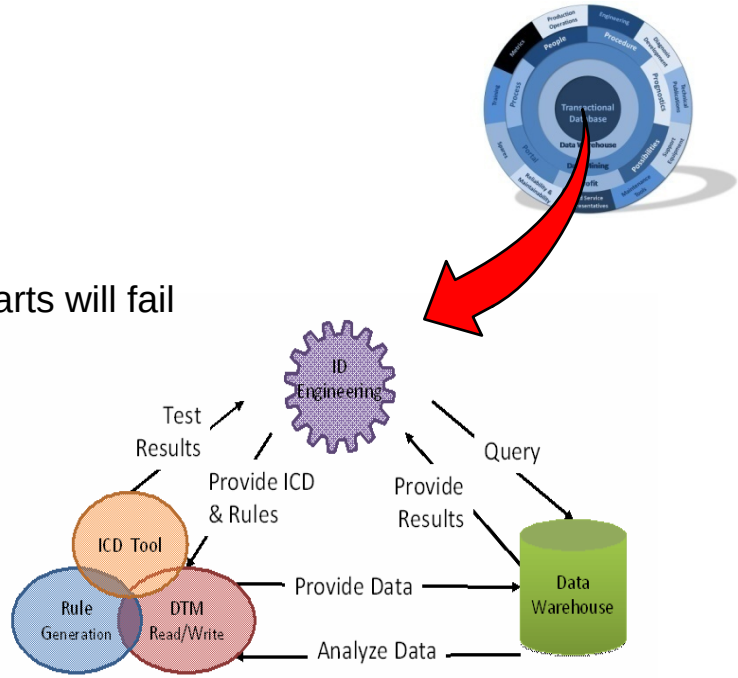
- **Knowledge collaboration of related information between business disciplines improves ID influence and maturity including quality and timeliness of applicable decision making processes**
  - Engineering
  - Diagnosis Development
  - Technical Publications
  - Support Equipment
  - Maintenance Tools
  - Field Service Representatives
  - Reliability and Maintainability
  - Spares
  - Training
  - Metrics
  - Production Operations



Who benefits?

ID CLKS

- **Boeing**
  - Integrated Diagnostic Engineers
    - Fast & accurate fault rule implementation
  - CFRS/IMIS/AME/SMART TPS
    - Consistent ICD and rule creation
  - Spares & Provisioning
    - Can more accurately predict what and when parts will fail
  - Reliability & maintainability
    - Access to more accurate failure
  - Field Service Reps
    - Fleet reports, trends and proactive information
  - Training
    - Focused Curriculum Updates
- **Customer**
  - Aircraft Pilots
    - More reliable and predictable aircraft
  - Maintainers at Various Levels of Maintenance
    - View of what to expect and complete aircraft history
    - Use of BIT data with Automated Test Sets (Directed TPS)



Summary

- **Challenge**
  - Implement an effective method of ID knowledge use and integration across specialties
    - Provide accurate and up-to-date diagnostics
    - Reduce disruptive maintenance problems
    - Reduce cost of maintenance
    - Aid planning for support of future missions

- **Solution**
  - Develop data warehouse and utilize data mining
  - Use predictive modeling to cluster defects and define influences
  - Build on past studies and lessons learned
- **Future Benefits**
  - Enhanced domain knowledge capture, training and transfer
  - Evaluated hidden relationships and cost saving opportunities
  - Increased smart diagnostics maturation and decreased false alarms
  - Knowledge builds upon knowledge

Knowledge is Power - When properly Engineered

ID CLKS