



Quick-Turn, Low-Cost Spacecraft Development Principles

April 20, 2016

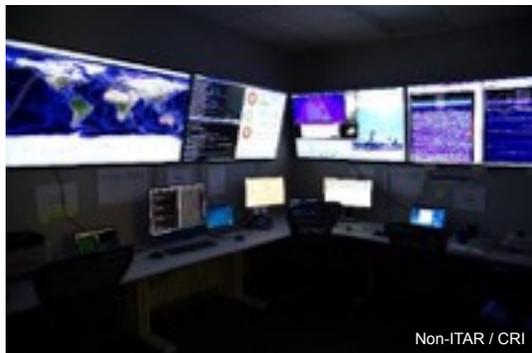
13th Annual CubeSat Developers Workshop

Tyvak Introduction

The Tyvak team represents the leaders in aerospace miniaturization, specializing in:

- developing miniaturized spacecraft, launch solutions, and data technologies for commercial, government, and scientific programs.
- providing cost-effective solutions by utilizing agile processes and leveraging advanced commercial-off-the-shelf (COTS) electronic components.
- designing and manufacturing optimized embedded software electronic devices to address advanced avionics and payload requirements.

To date, Tyvak has supported 56 programs with 100% customer retention.



Tyvak: Satellite Solutions for Multiple Organizations

- Facts and Figures

- Tyvak Nanosatellite Systems founded in 2011
- Holding Terran Orbital Corp. founded in 2014
- Tyvak International founded in 2015
 - Fully independent European establishment

- 3 locations, > 40 employees

- Irvine, CA
- San Luis Obispo, CA
- Torino, Italy

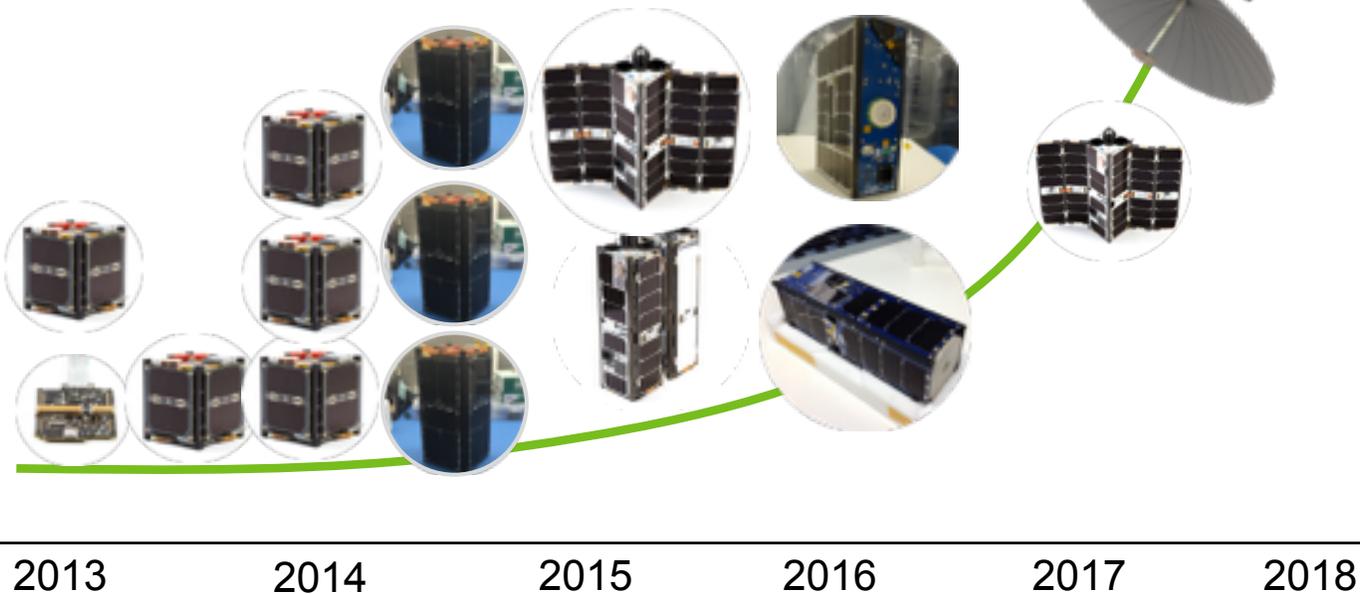


Current Complexity Trends for Tyvak

Multiple applications

- GPS Radio Occultation
- Advanced Optics Demonstrations
- Atmospheric Science
- RF Signal Processing
- Technology Demonstrations

Complexity & Size



Time (and company growth)

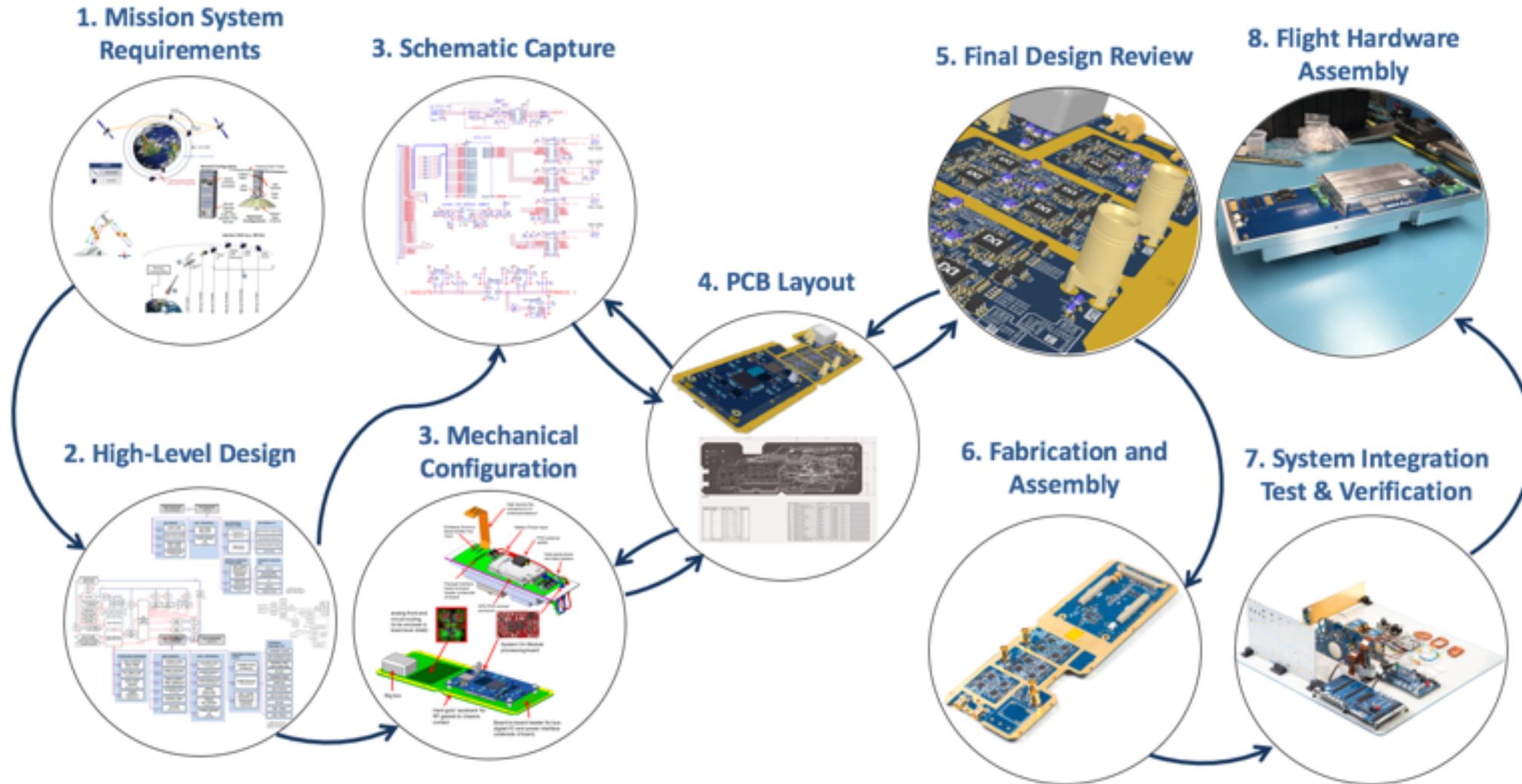
Challenges faced

- Large variety of mission requirements
 - Mission-driven complexity
- Diverse customer base
- High throughput
 - 11 satellites in 2016
 - 20+ in 2017

Addressing the challenges...

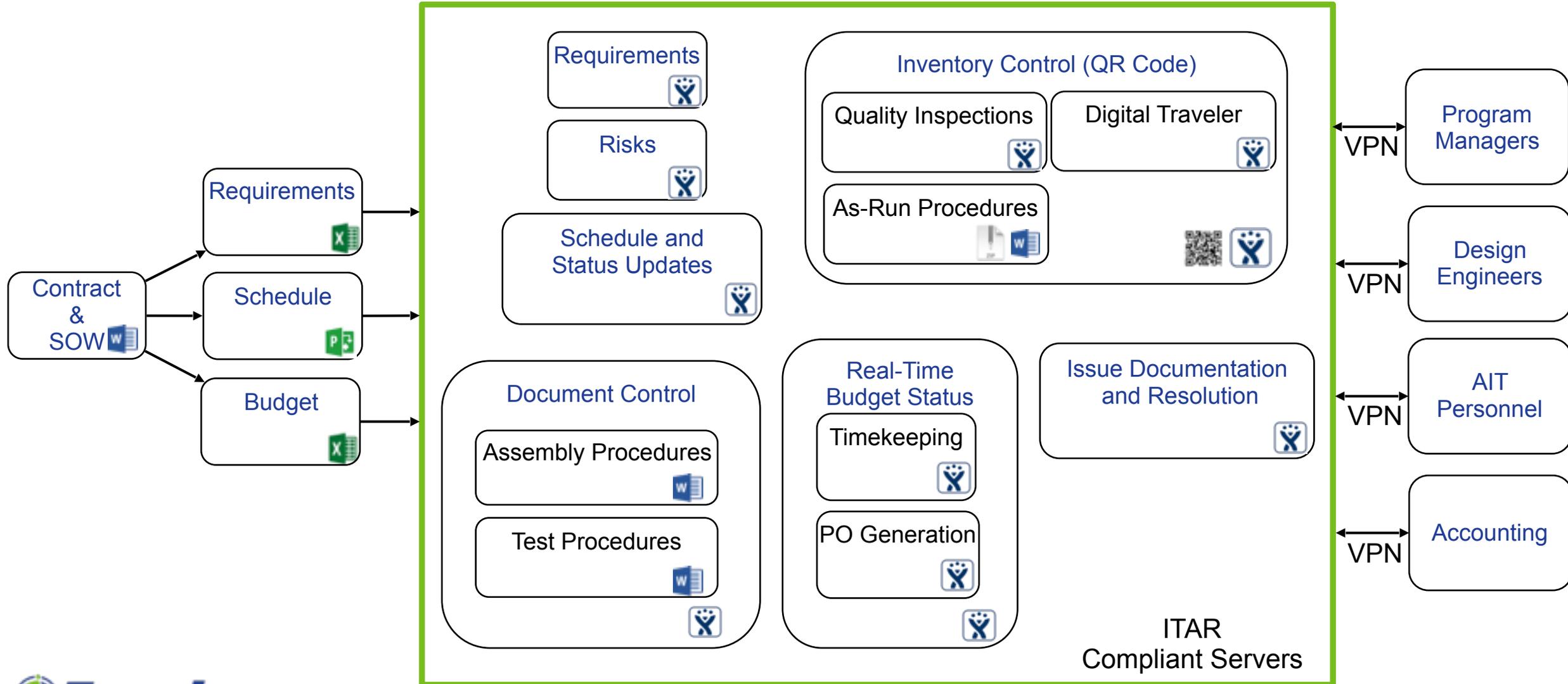
- Company structure, processes, and mission assurance are key
 - Tyvak focused on addressing these challenges early on, developing strengths in these areas to lead the competition and ensure mission success.
- Day-to-day operations focused to minimize common problem areas that can typically lead to schedule delays and cost over-runs
 - PCB and Mechanical Design Checks
 - Inventory control process
 - Assembly Integration and Test
- Support tools introduced to maintain efficiency throughout the entire development process with particular focus during AI&T:
 - Budget (materials and time-keeping)
 - Purchase Orders
 - Schedule
 - Requirements
 - Risks
 - Document Control and Approvals
 - Inventory and supplier conformance

PCB and Mechanical Design Checks



... and now flying first revision hardware is becoming routine.

Assembly Integration and Test Mission Assurance

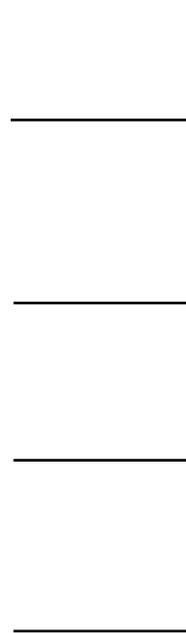
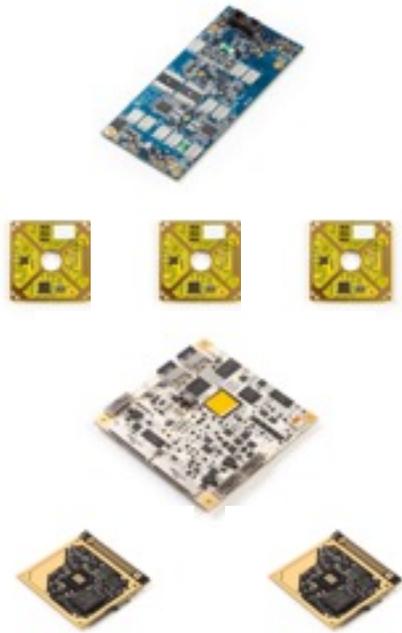


Case Study

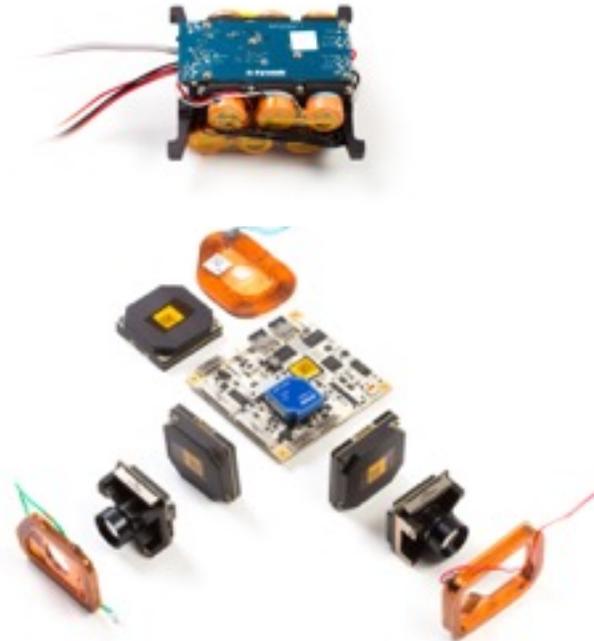
- Using a common tool for all aspects of mission assurance is extremely powerful.
 - All engineers have access to this information. Technical communication is tracked via the tools, and not lost in email.
- Complete traceability within a function
 - Inventory System: Inventory nesting allows 100% coverage of all inspections, tests, modifications and approvals within a spacecraft while adding very little additional overhead.
- Cross-cutting searches
 - View requirements test coverage across all programs against current documents under revision control.
 - View all AI&T related tasks across all programs to get a snapshot of equipment and personnel load balancing
- Real-time budget keeping
 - Hours are tracked against schedule and issue items, and rolled up into a program cost. POs are automatically allocated to the projects. Program Managers can view any project budget or cross-section of any budget.

Inventory System Example

Components



Assemblies



Satellites



Incoming Quality Control

(Mechanical Parts, PCBs, Solar Cells, COTS Items)

1. Assign QR Code (digital traveler)
2. Visual Inspection
3. Assign to Inventory or Project
4. Record component specific info
5. Attach as-run test or modification procedures

Higher-Level Assemblies

1. Assign QR Code (digital traveler)
2. As-run Assembly Procedures
3. As-run Test Procedures

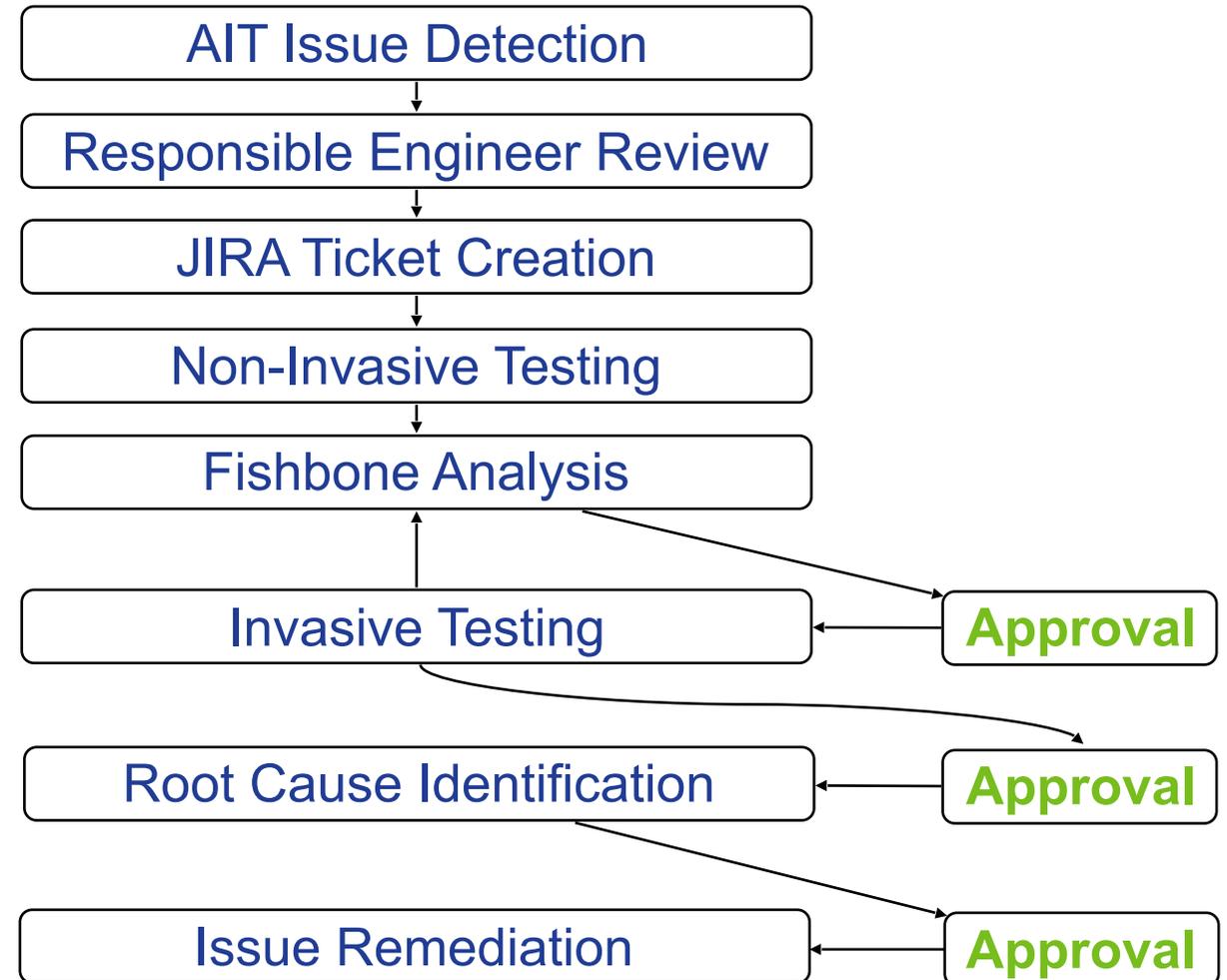
Final Vehicle Assemblies

1. Assign QR Code (digital traveler)
2. As-run Assembly Procedures
3. As-run Test Procedures

The final satellite build QR code includes a nested list of every assembly, and component contained within it, tracing a complete time-tagged history of hundreds of parts.

Issue Resolution

- When working with flight hardware, anomaly detection and resolution must be formalized.
- One mistake could lead to weeks or months of delays at the vehicle level.
- All plans for path forward, and approvals, are stated as comments in the tickets.
- JIRA is the ultimate repository for the investigation. It is 100% transparent and fully traceable with many media attachments.



Conclusion

- Controlled growth is enabled by program execution, and firm company processes.
- Strong Mission Assurance practices and low-overhead tools make employee on-boarding much simpler.
- Program Management uses a consistent approach, and project feedback is instantaneous.
- With all that said, the tools won't solve the problem. The whole team needs to buy in, and appreciate the importance of the processes.
- Our European office is also leveraging these tools and practices to provide solutions to an international customer base.