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## Case Studies

CSE 403, Spring 2003  
Software Engineering

<http://www.cs.washington.edu/education/courses/403/03sp/>

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## Readings and References

- *Introduction to the 5ESS Switching System*, Martersteck, Spencer
  - » *AT&T Technical Journal*, v 64 n 6, July-August 1985
- *Parallel Changes in Large Scale Software Development: An Observational Case Study*, Perry, Siy, Votta
  - » <http://citeseer.nj.nec.com/462.html>
- *Challenges in Evolving a Large Scale Software Product*, Siy, Perry
  - » <http://citeseer.nj.nec.com/siy98challenges.html>
- *Boeing's 777 Systems Integration Lab*, Lansdaal, Lewis
  - » *IEEE Instrumentation & Measurement Magazine*, V 3, issue: 3, Sep 2000
- *Boeing 777 Flies on 99.9% Ada*
  - » <http://www.adaic.org/atwork/boeing.html>
- *Software Development for the Boeing 777*, Pehrson
  - » <http://www.stsc.hill.af.mil/crosstalk/1996/01/Boein777.asp>

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## Readings and References

- *Tackling TB with cellphone technology*, Janet Heard
  - » *The Sunday Times*, Cape Town, South Africa
  - » <http://www.sundaytimes.co.za/2002/06/02/news/cape/nct01.asp>
- *The Compliance Service uses SMS technology for TB treatment*
  - » [http://www.bridges.org/iicd\\_casestudies/compliance/index.html](http://www.bridges.org/iicd_casestudies/compliance/index.html)
- The Bandwidth Barn
  - » “The barn is a unique incubation model where the stability of anchor tenants is coupled with a dynamic and evolving set of incubytes. We are an open-platform model of incubation... the linux of incubators.”
  - » <http://www.bandwidthbarn.org/barn/index.html>

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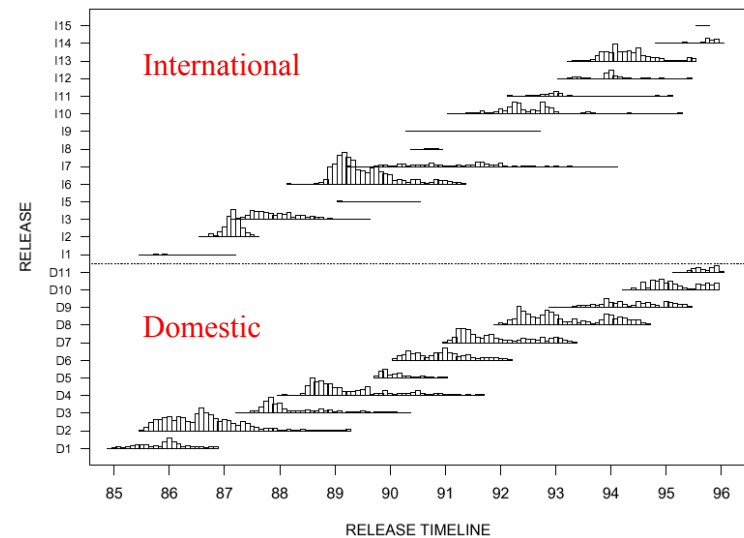
## 5ESS Telephone Switching System



## 5ESS Telephone Switching System

- Large real-time system for telephone switching
- More than 10 Million lines of code
  - » divided into 50 subsystems
  - » more than 3000 developers
  - » runs on Unix, written in C
- Worldwide application and sales (and doodads)
  - » “The Lucent 5ESS® switch provides an extensive portfolio of services ... These services will generate additional revenue and increase customer satisfaction.”

DELTAS PER MONTH



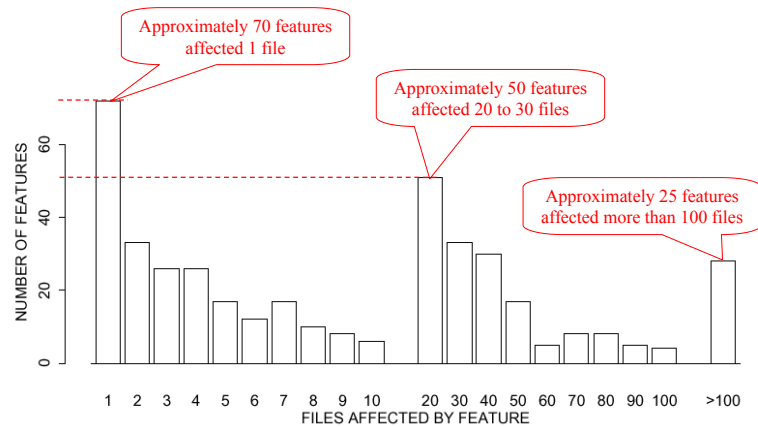
## Change implementation

- Extensive change management process
  - » Initial Modification Request, Modification request
- Coding Process
  - » Make a private copy of necessary files
  - » Try out the changes within private copy
  - » Commit the changes as deltas
  - » Put private copy through code inspection, unit test
  - » Submit for load integration, feature and regression testing

## Concurrency

- Concurrent release activity is high
  - » 3-4 major releases in work at the same time
- Concurrent change activity is high
  - » some files being changed for 10 concurrent MRs
- Nearly 30% of MRs for release discarded
  - » duplicate problems already fixed
  - » unnecessary fixes requested by developers who misunderstood system requirements

## Open files per feature implementation



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## Build cycle

- Central build team
  - » announce freeze date, MRs submitted
  - » depending on errors, build takes 1 to 7 weeks
- Distribute and bring up the new load
  - » test lab environment changes with build
  - » almost 20% of faults in test environment or setup
- Feature and Regression testing
  - » if test fails immediately, significant time has been lost in doing all the build and setup

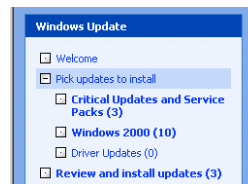
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## Managing Installed Changes

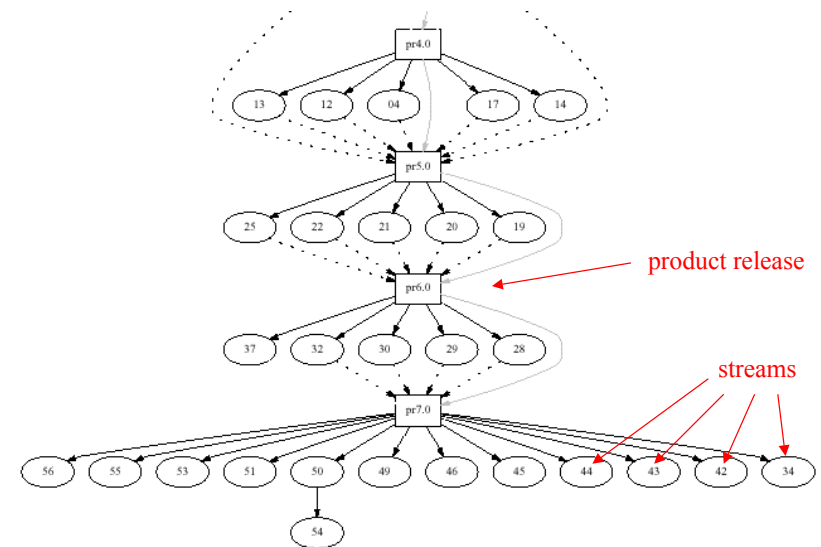
- Product releases are the “standard product”
- Software updates provided between releases
  - » do *you* apply every WinOS update?
  - » should you apply every update?
  - » Telcos don't want to
- 5ESS is maintained as streams
  - » major release plus selected updates
  - » about 100 concurrent streams being maintained



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Release I12 streams genealogy.

## Issues in parallel evolution

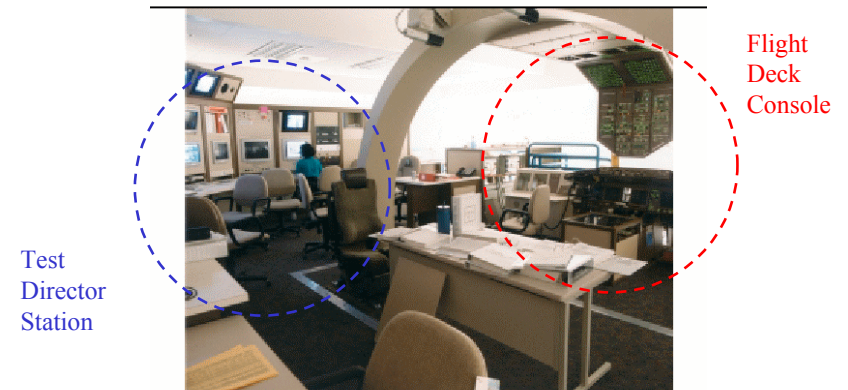
- Costs of build problems: backtracking to source, lost setup/test effort, lost calendar time
- Tradeoff between benefits of frequent builds and costs of setup and test
- Ensuring change compatibility with all versions
- Propagating change to all versions that need it
- Feature migration across product lines and streams



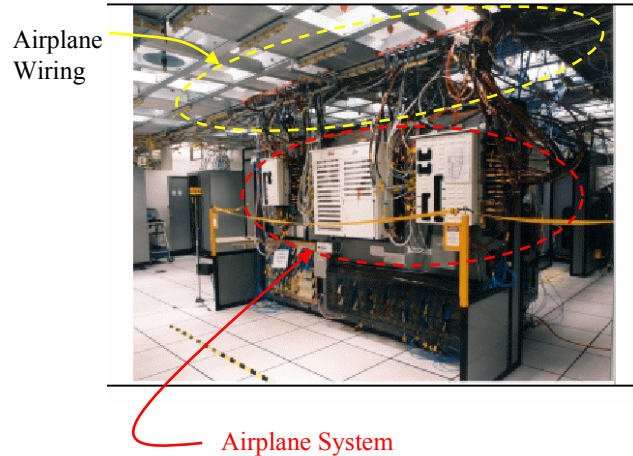
## Boeing 777 Systems Integration Lab

- Modern airplanes are flying networks of integrated computers
  - » 100 major line replaceable units, plus 300 minor
  - » 15 ARINC-629 multiplexed data buses
  - » 169 ARINC-429 dedicated data buses
- Integration test system to model airplane and dynamic environment
  - » integrated “flight” through simulated conditions
  - » dynamic power system operating conditions

## SIL Flight Deck



## SIL Electrical / Equipment Bay



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## Systems

- Airplane systems
  - » total approximately 2.5 M source lines of code
    - power system: 80,000 SLOC
    - info mgmt: 613,000 SLOC, 550 developers
- Lab systems
  - » 500,000 SLOC for simulation and test
  - » simulation host, I/O nodes, I/O subnodes
  - » 4+ supervisors, 170 engineers/technical designers
    - 1,000,000 labor hours for design and build

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## Benefits of Development and Testing

- Development
  - » independent review and use of design information
  - » interface specifications, pin-out differences, etc
- Testing
  - » System-level tests - verify operation in context
  - » Airplane-level test - validate all-up operation
  - » Manufacturing and Customer service tests - validate factory operations, maintenance

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## Results

- Extensive test program
  - » before 1<sup>st</sup> flight: 2500 hours including 550 flight hrs
  - » total: 6500 hours including 1700 flight hrs
  - » per hour cost approximately 1/3 of airplane
- Highlighted or identified many problems
  - » 5,000 problem reports
  - » approximately 2/3 were actual airplane problems
- Lab was mothballed then dismantled after cert

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## SMS technology for TB patients

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Working in the TB capital of the world, Dr Green sends daily automated SMS messages to patients with cellphones to remind them to take their life-saving pills - - five times a week for six months



## Who wants it?

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- Cape Town, South Africa, has one of the world's highest incidences of TB
  - » poverty and cold wet weather
- TB patients must strictly follow a difficult drug regime -- four tablets five times a week for six months
- TB patients often do not take their medication simply because they forget

## What does it do for us? How?

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- Dr. Green uses SMS (Short Messaging Service) to alert patients to take their medication
- Healthcare professional were skeptical whether the uptake of cell phone technology was high enough to justify the project
- But, at one clinic where the pilot study was conducted, 71% of TB patients had access to a cell phone. At another, 30% had access.

## Who'll support it?

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- Dr. Green twisted the arm of City of Cape Town health director Ivan Toms, who authorized funding for the SMSs, at a cost of R11.80 a patient a month.
- On-Cue provides a system which automates the construction and delivery of SMSs (text messages) to recipients' cellphones at predetermined times.
  - » <http://www.compliance.za.net/products.html>

## Modify the product as needed

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- "Take your Rifafour now."
- When patients complained about the boring message, Dr. Green sent them a variety of alerts, including jokes and lifestyle tips
- He now has as database of over 800 messages that he changes on a daily basis. Of the 138 patients involved in the pilot, there was only one treatment failure.

## Is it scalable?

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- The World Health Organization has cited the project as an example of "international best practice"
- The City Council of Cape Town has decided to extend the pilot project to other City clinics where the cell phone ownership of patients is high
- The South African Government is considering the technology for nationwide use



- 7 Habits of Highly Effective ICT-Enabled Development Initiatives
  - » Implement and disseminate best practice
  - » Ensure ownership, get local buy-in, find a champion
  - » Do a needs assessment
  - » Set concrete goals and take small achievable steps
  - » Critically evaluate efforts, report back to clients and supporters, and adapt as needed
  - » Address key external challenges
  - » Make it sustainable

## Is it sustainable?

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- The Compliance Service is based at the UUNET Bandwidth Barn which provides small IT businesses with affordable office rentals, shared office facilities, and reduced Internet connectivity costs.
  - » <http://www.bandwidthbarn.org/barn/index.html>
- He deliberately kept the price of his service low so that more people can use and benefit from the technology.