Check it

• **System V&V builds on**
  – requirements, design
  – **unit test**
  – inspection
• **AKA “QA”, “Testing”**
• **Alternative: “User Testing”**
Verification

- System operates according to requirements
- System implements design
- “Did we build the product right?”
- “It's just what I asked for, but not what I want”
Validation

- System actually works in wanted/intended way
- “Did we build the right product?”
- How to validate early?
  - work products
  - prototypes
Test is not validation

- You can't validate a system by testing it
  - System test cases are generated from requirements
  - Valid system = verification + valid requirements
- User-generated tests help capture requirements
Efficient, thorough testing

- Big issue: how to find small test set with big leverage
  - Use inspection to eliminate uninteresting pieces
  - Use formal methods to “prove” big domains correct
  - Test what's left as best you can can
Inspecting for test

- Most code is boring; just moves data around
- **Unit test works well on boring code**
- Code without many defects doesn't need much test
- Simple requirements don't need much test
Subdomain proofs

- Example (Massey / Haertel)
  - Print / round FP numbers = base conversion problem
  - *Most* numbers round right way automatically
  - *Prove* that rounding is right on all but special inputs
  - *Test* and *special-case* those
More about coverage

- How do we estimate / measure that a set of test cases is “good”?  
  - Domain coverage
  - Code coverage
  - Fault seeding / mutation
Branch coverage

• Branches taken each way

```java
if (true) {
    x = 3;
}
```

• Exercises conditionals

• Subsumes statement coverage (cf dead code)
Path coverage

- **All paths covered (4 here)**

```
x1 = 2;
if (c1) {
    x1 = 3;
}
```

```
x2 = x1;
if (c1) {
    x2++;
}
```

- **Exercises data paths**
Bayes' Rule

- It's worse than you think

\[ Pr(H|E) = \frac{Pr(E|H) \cdot Pr(H)}{Pr(E)} \]

- Even if you find a bug, finding a fix is hard
Risk

- Risk equation

\[ R = \langle V(F) \rangle = \sum_{f \in F} \text{Pr}(f) \cdot V(f) \]

- Risk management = minimizing \( R \) through decreasing \( \text{Pr}(f) \) for various \( f \)
Various things that don't work in practice

- Testing only (must have recovery plan)
- Random testing only (must do other testing)
- 100% test coverage
- Multiple independent implementations
Has SW quality improved?

- Heck yes. Over the last 25 years we have learned to
  - routinely build programs > largest 1980 programs
  - ship programs to naïve end users in unrepairable systems
  - routinely build mission / safety critical systems
What are current woes?

- Inappropriate tech for application (esp language)
- Insufficient application of
  - formal methods
  - inspection
  - root cause analysis
- Emphasis on fast vs good