Video presentation available at https://youtu.be/4irAvx-2CLg

Scientific Legacy Code Enhancement and Testing Strategies: Fortran Example

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Legacy Scientific Fortran Code

- Most of the currently in-production scientific code is
  - Written in Fortran
  - Developed several years ago, even with sections of code decades-old
  - Written with none or poor software development practices
  - Undocummented or almost undocummented
  - F77 or F77-like code, even with fixed source format (including non-indented source code)

Huge need of source code changes and updates

Legacy Scientific Fortran Code

- A few simple examples (actual code)

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```
DO I = 1, NNM
DO J = 1, NTBN
IF(A.EQ.I) THEN
A2 = SNORMP(J)
C = DCOS(AN)
S = DSIN(AN)
VN(I)=V1(I)*C+V2(I)*S
VT(I)=-V1(I)*S+V2(I)*C
if(CT.LT.16.0D0)VN(20)=0.0D0
END IF
END DO
END DO
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Shallow water simulation model

Legacy Scientific Fortran Code

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Fixed source format, unindented

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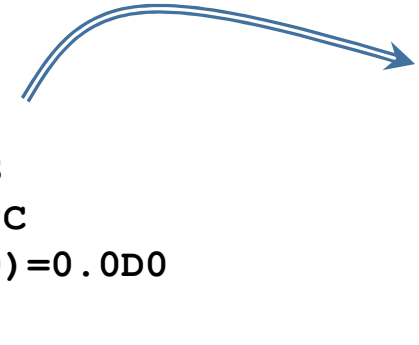

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DO I = 1, NNM
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```

Add indentation, aka “pretty printing”

Legacy Scientific Fortran Code

- A few simple examples (actual code)

```
      FUNCTION NGCD(NA, NB)
        IA = NA
        IB = NB
1       IF (IB.NE.0) THEN
          ITEMP = IA
          IA = IB
          IB = MOD(ITEMP, IB)
          GOTO 1
        END IF
        NGCD = IA
        RETURN
      END
```

https://en.wikibooks.org/wiki/Fortran/Fortran_examples

Legacy Scientific Fortran Code

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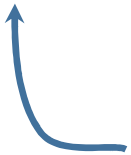

IF + GOTO instead of DO WHILE

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Legacy Scientific Fortran Code

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FUNCTION NGCD(NA, NB)
  IA = NA
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  DO WHILE(IB.NE.0)
    ITEMP = IA
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    IB = MOD(ITEMP, IB)
  END DO
  NGCD = IA
  RETURN
END
```

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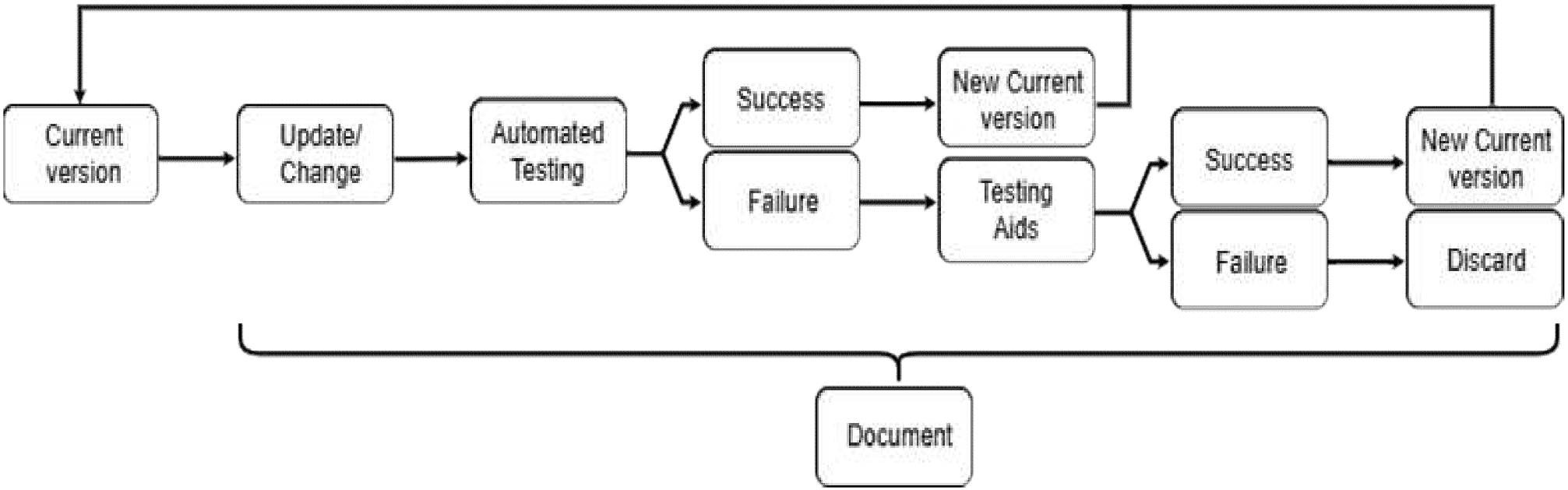
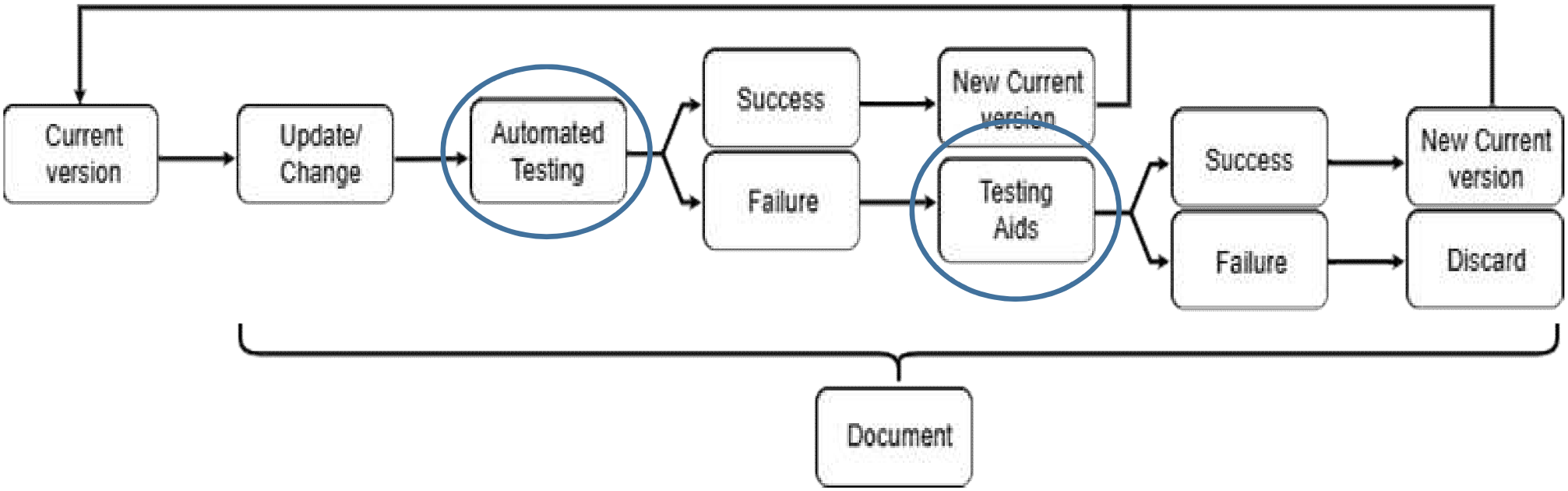
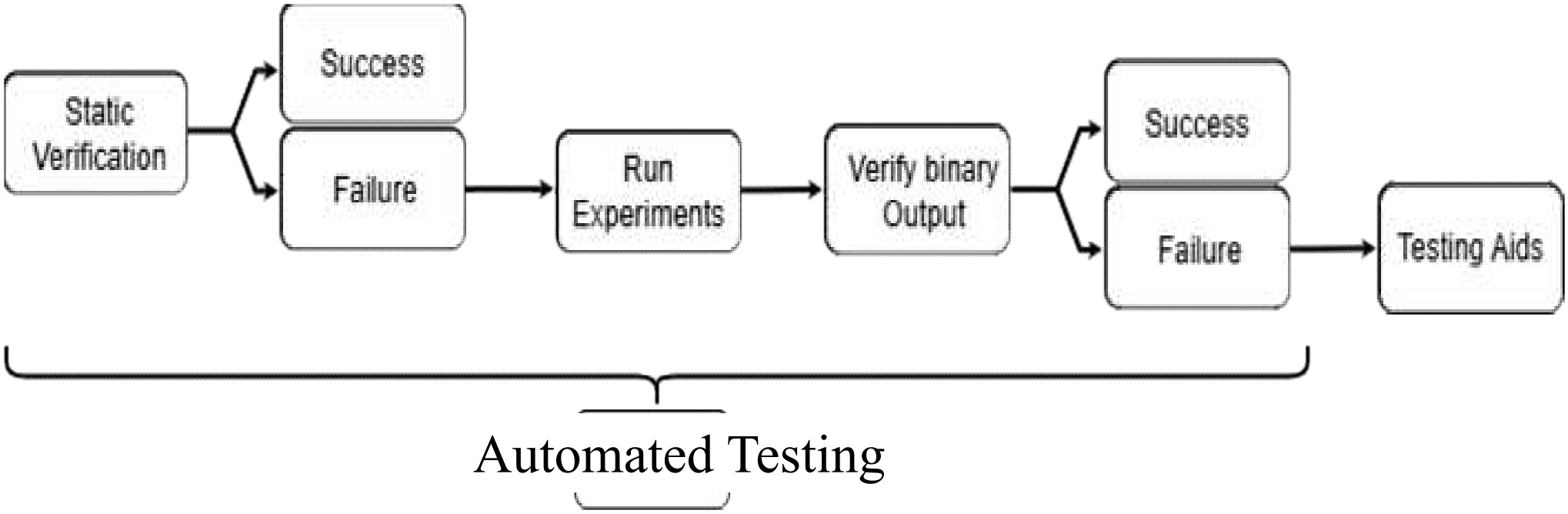
Source Code Pipeline/Cycle for Updates



Proposal Specific Contributions



Proposal Specific Contribution I



Proposal Specific Contribution I

- Automated Testing: current vs. new program version
  - Part I: Static Verification

```
For Each changed source code file
  Generate current version .asm file
  Generate new version .asm file
  Compare both .asm files
If some comparison fails
  ==> Dynamic Verification needed
Else
  ==> Successful Static Verification
```

Proposal Specific Contribution I

- Static Verification: successful testing

```
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    END IF
  END DO
END DO
```

Shallow water simulation model

Add indentation, aka “pretty printing”

Proposal Specific Contribution I

- Automated Testing: current vs. new program version
  - Part II (only if Static Verification fails): Dynamic Verification

```
Run Experiment with new program version
For Each output file
  Compare the output file with the corresponding
  output file of the current version
If some comparison fails
  ==> Dynamic Verification fails, run testing aids
Else
  ==> Successful Dynamic Verification
```

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     NGCD = IA
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    ITEMP = IA
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  END DO
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  RETURN
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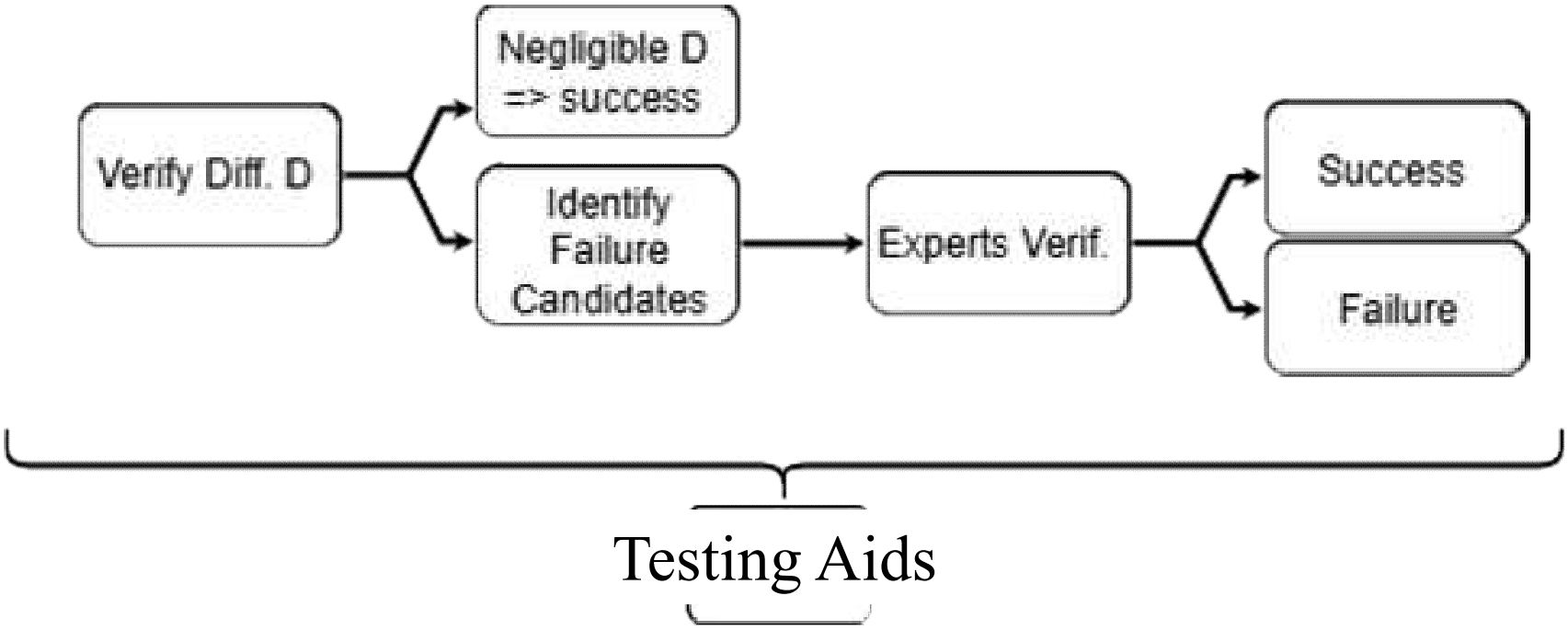
Proposal Specific Contribution II



Proposal Specific Contribution II

- Automated Testing: current vs. new program version
  - Part I: Analyze Numerical Differences
    - Get information from experts about output files of_i and aceptable diff. D_i

```
For Each output file of_i with numerical difference/s
  Check whether or not differences are minor than D_i
If some difference is greater tan D_i
  ==> Warn experts and implement further aids
Else
  ==> Successful Differences Verification
```

Proposal Specific Contribution II

- Automated Testing: current vs. new program version
  - Part II (only if differences are not acceptable): provide information
    - Get requirements from experts about important information on differences

```
For Each output file with differences
  Provide information about differences ≥ D_i
  Provide statistical information about differences
  Provide information required by experts (graphics?)
  Optional: provie information about differences ≤ D_i
```

Proposal Specific Contribution II

- Automated Testing: current vs. new program version
  - Part II (only if differences are not acceptable): provide information
    - Get requirements from experts about important information on differences

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For Each output file with differences
  Provide information about differences ≥ D_i
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  Provide information required by experts (graphics?)
  Optional: provie information about differences ≤ D_i
```

Expected to aid either in further development and updates or discard change just implemented

Conclusions and Further Work

- The general proposal is
  - Collecting experience from previous research work
  - Being applied on actual legacy code
  - Successfully helping in legacy code project management
  - Providing successfull automated testing, thus reducing development time
- Further work
  - Extensive usage on different legacy code, there are many
  - Add runtime performance analysis (current focus: functional, correct results)