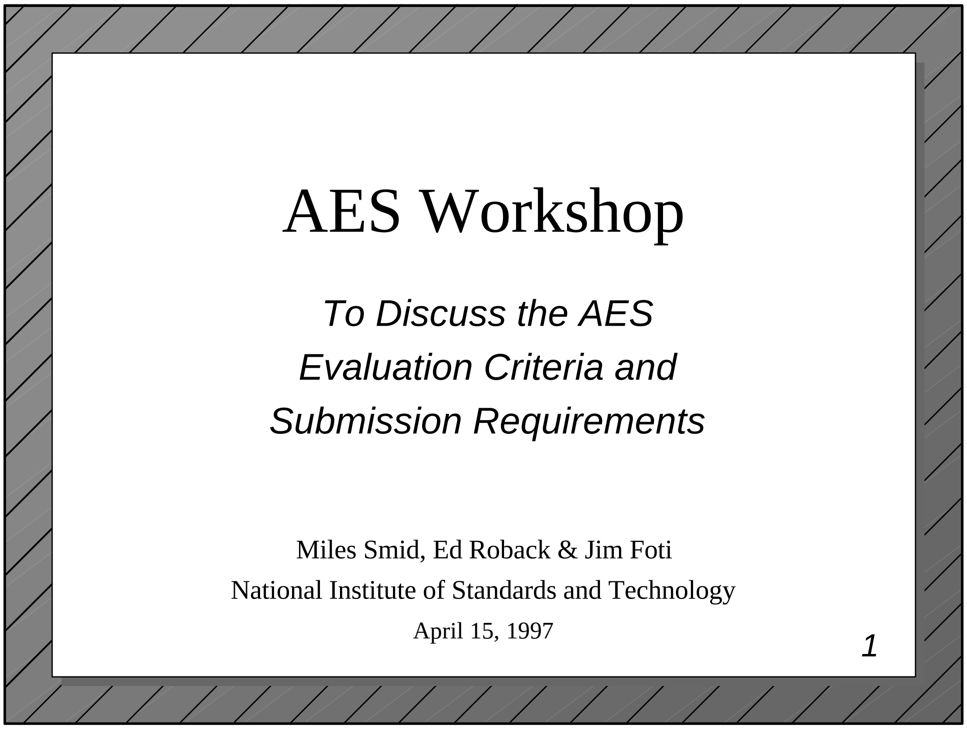
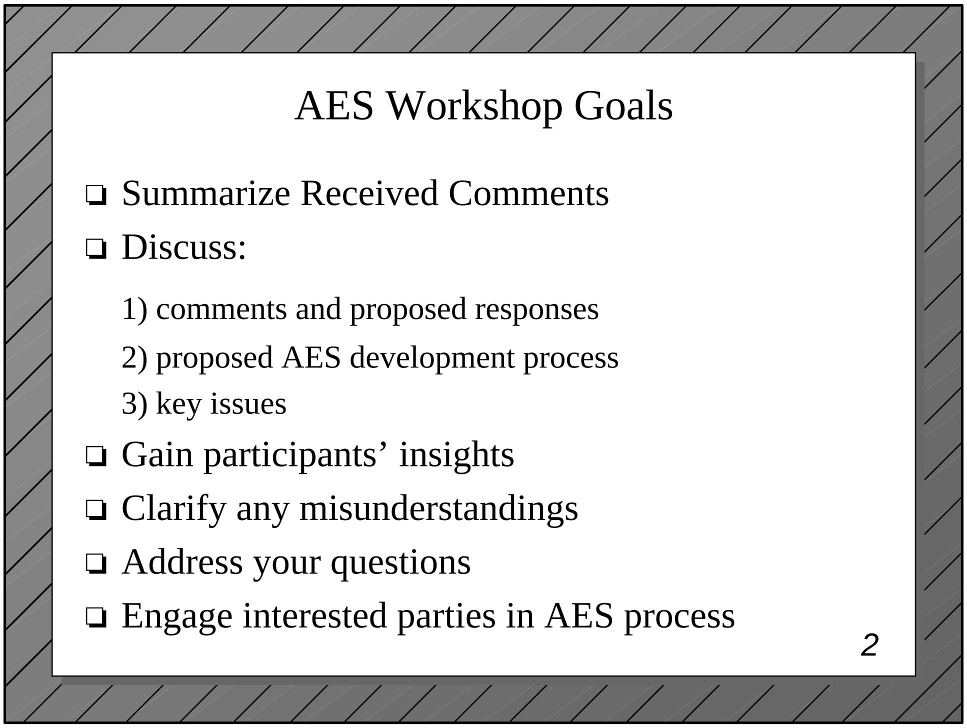


AES Workshop

To Discuss the AES Evaluation Criteria and Submission Requirements

Miles Smid, Ed Roback & Jim Foti
National Institute of Standards and Technology

April 15, 1997



AES Workshop Goals

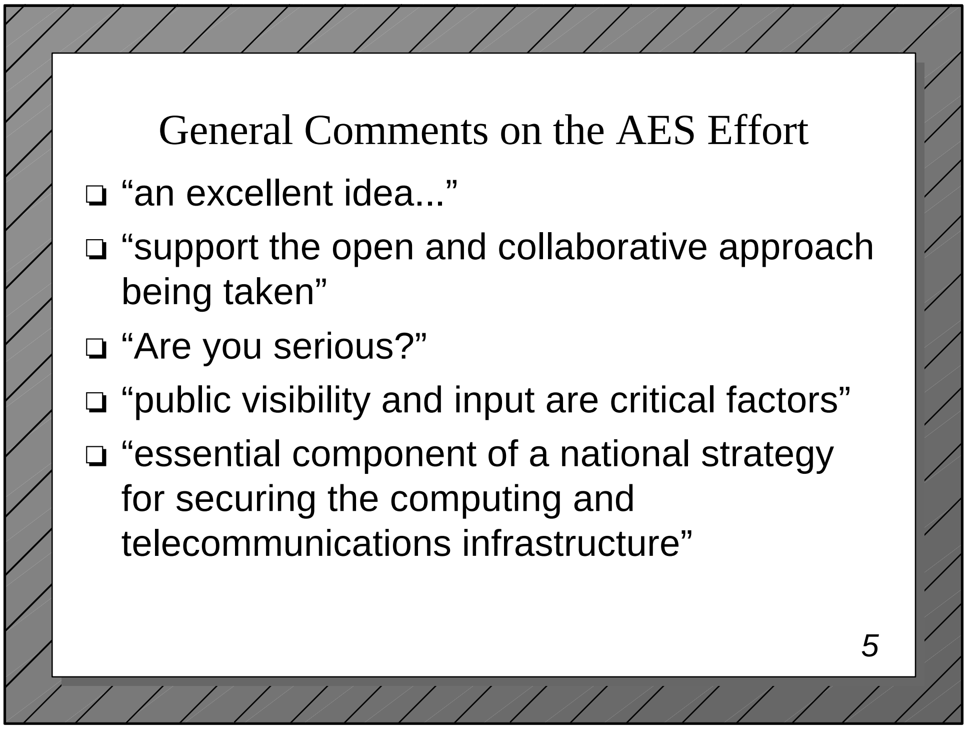
- ❑ Summarize Received Comments
- ❑ Discuss:
  1) comments and proposed responses
  2) proposed AES development process
  3) key issues
- ❑ Gain participants’ insights
- ❑ Clarify any misunderstandings
- ❑ Address your questions
- ❑ Engage interested parties in AES process

AES Announcement of January 2

- ❏ Intent to Develop AES
- ❏ Proposed Minimum Acceptability Requirements and Evaluation Factors
- ❏ Proposed Draft Submission Requirements
- ❏ April 15 Workshop Announced
- ❏ Call for Comments (by April 2)
- ❏ Total of 33 Comments Received

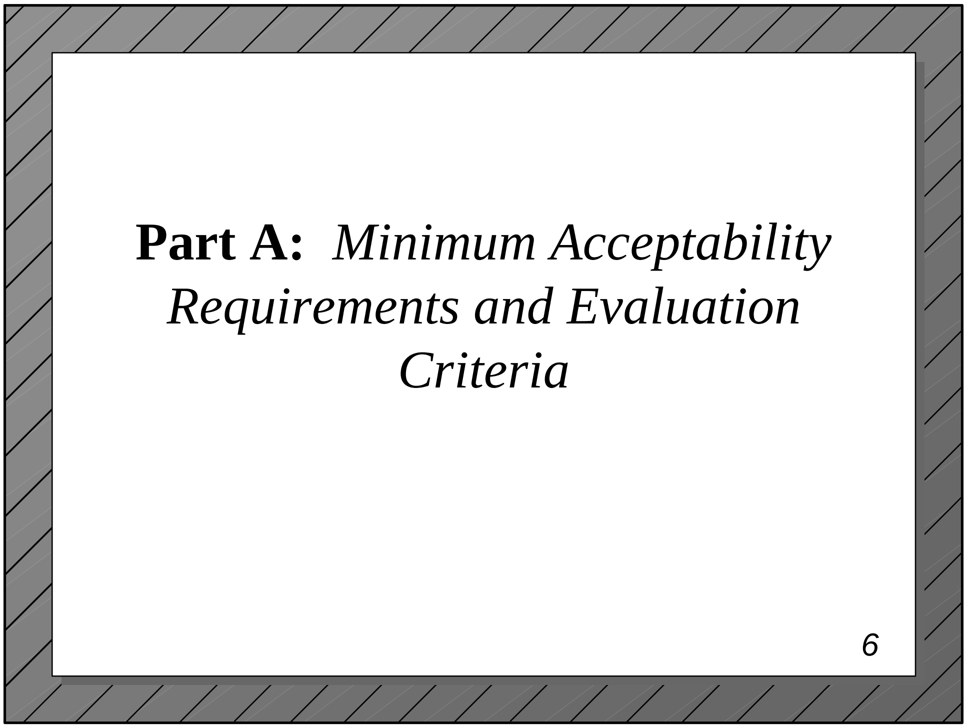
Initial NIST Goals

- ❏ Strong Cryptoalgorithm for Government and Commercial Use
- ❏ Support of Standard Codebook Modes
- ❏ Significantly more Efficient than DES^3
- ❏ Variable Key Size so that security could be increased when needed
- ❏ Selected in a Fair and Open Manner
  - – Publicly Defined
  - – Publicly Evaluatable

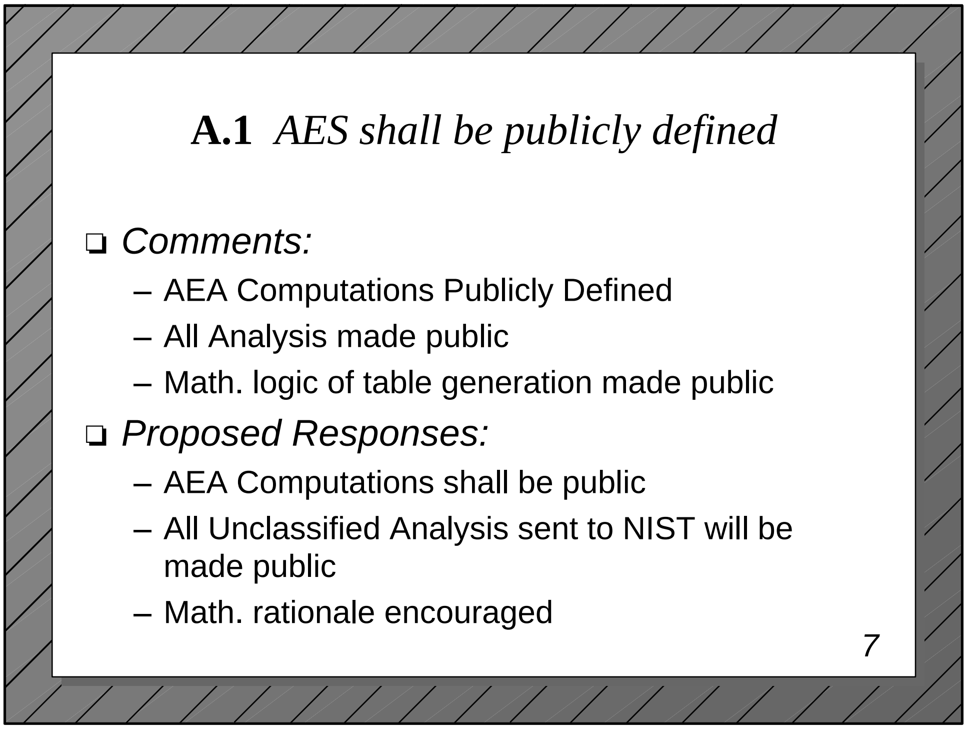


General Comments on the AES Effort

- ❑ “an excellent idea...”
- ❑ “support the open and collaborative approach being taken”
- ❑ “Are you serious?”
- ❑ “public visibility and input are critical factors”
- ❑ “essential component of a national strategy for securing the computing and telecommunications infrastructure”

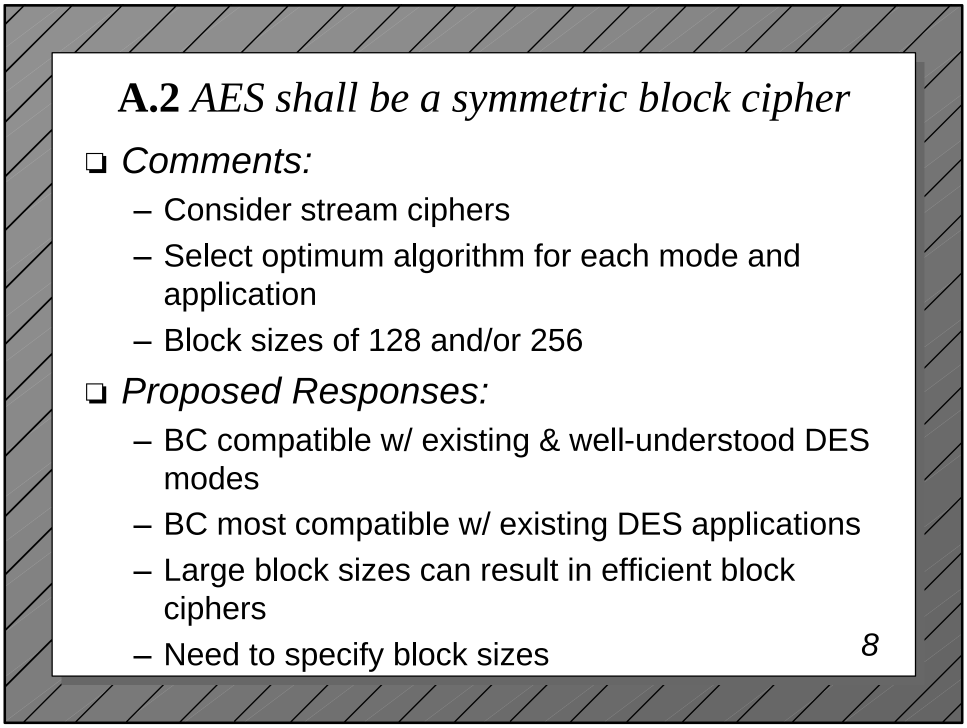


Part A: *Minimum Acceptability Requirements and Evaluation Criteria*



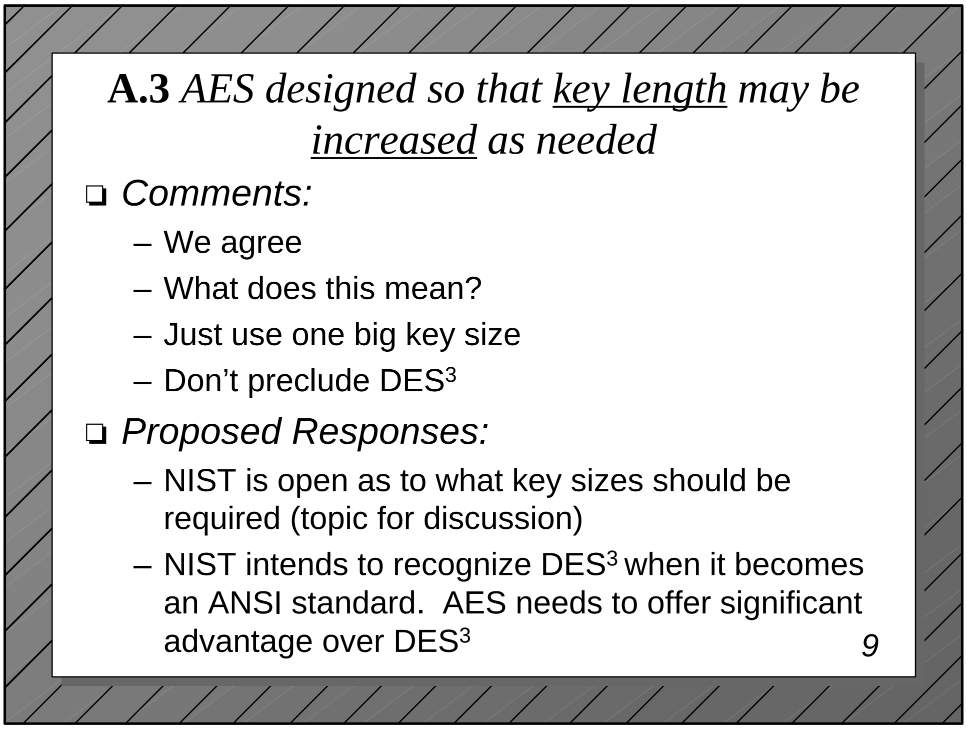
A.1 *AES shall be publicly defined*

- ❑ *Comments:*
  - – AEA Computations Publicly Defined
  - – All Analysis made public
  - – Math. logic of table generation made public
- ❑ *Proposed Responses:*
  - – AEA Computations shall be public
  - – All Unclassified Analysis sent to NIST will be made public
  - – Math. rationale encouraged



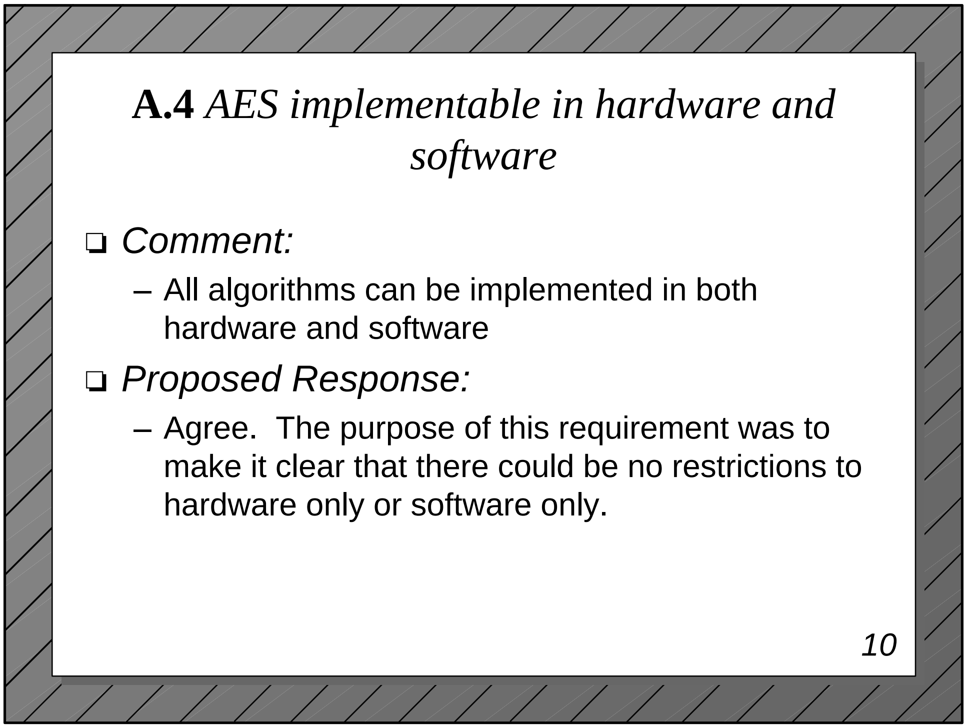
A.2 *AES shall be a symmetric block cipher*

- ❑ *Comments:*
  - – Consider stream ciphers
  - – Select optimum algorithm for each mode and application
  - – Block sizes of 128 and/or 256
- ❑ *Proposed Responses:*
  - – BC compatible w/ existing & well-understood DES modes
  - – BC most compatible w/ existing DES applications
  - – Large block sizes can result in efficient block ciphers
  - – Need to specify block sizes



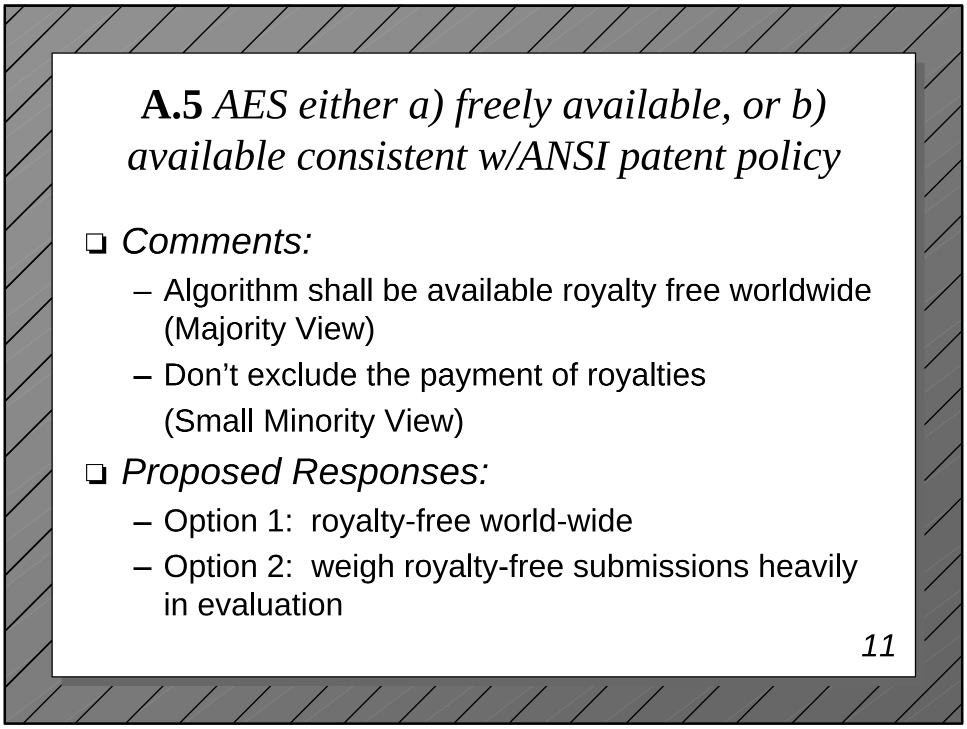
A.3 *AES designed so that key length may be increased as needed*

- *Comments:*
  - – We agree
  - – What does this mean?
  - – Just use one big key size
  - – Don’t preclude DES^3
- *Proposed Responses:*
  - – NIST is open as to what key sizes should be required (topic for discussion)
  - – NIST intends to recognize DES^3 when it becomes an ANSI standard. AES needs to offer significant advantage over DES^3



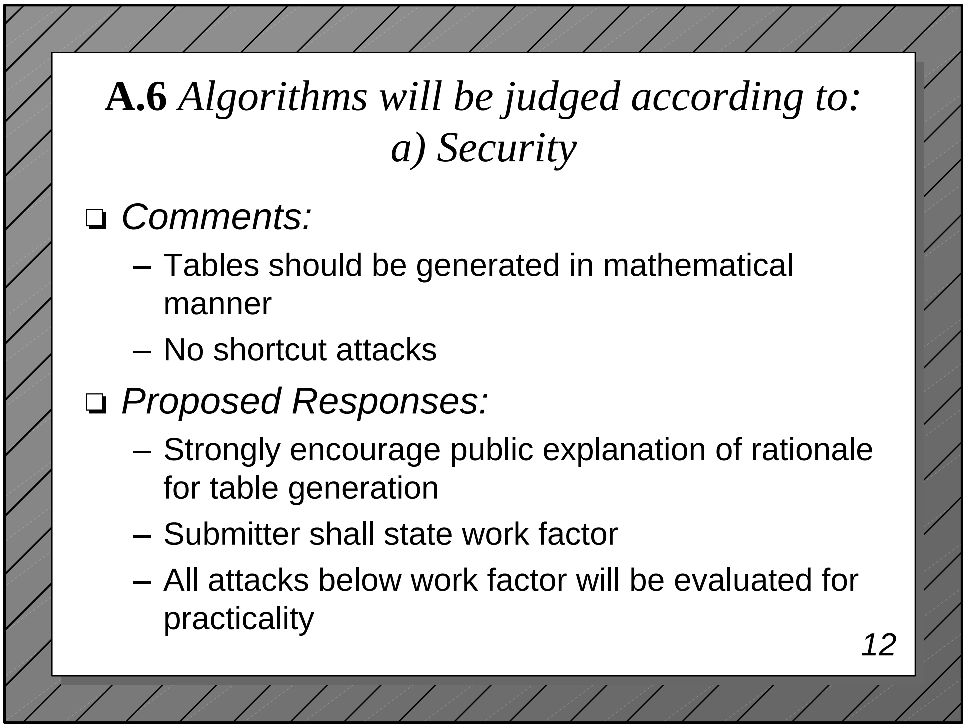
A.4 *AES implementable in hardware and software*

- *Comment:*
  - – All algorithms can be implemented in both hardware and software
- *Proposed Response:*
  - – Agree. The purpose of this requirement was to make it clear that there could be no restrictions to hardware only or software only.



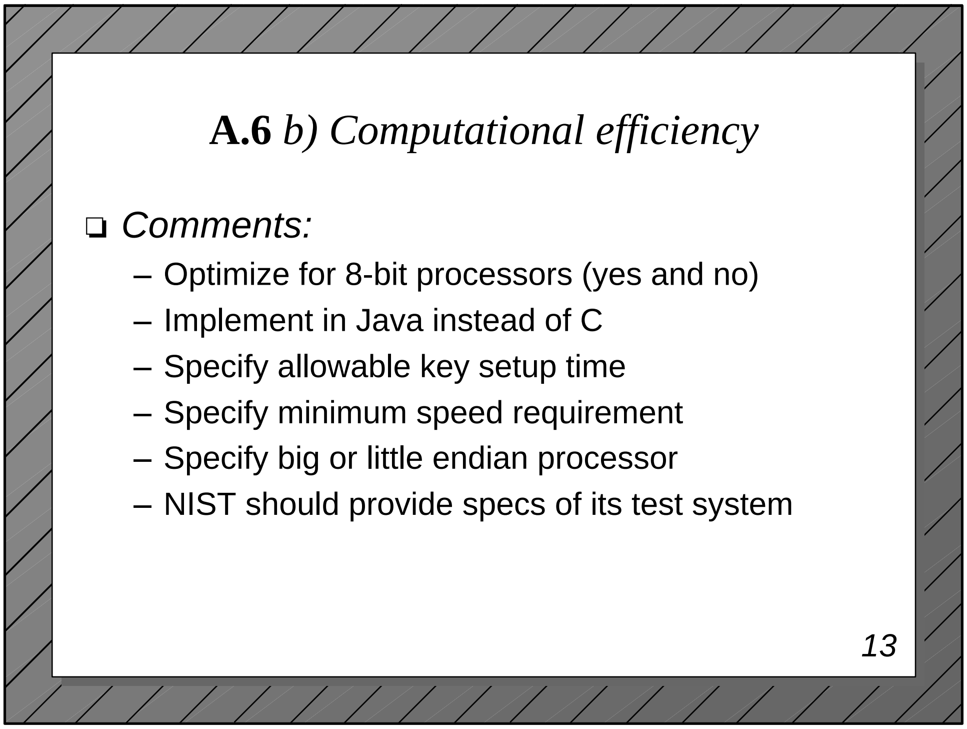
A.5 *AES either a) freely available, or b) available consistent w/ANSI patent policy*

- ❏ *Comments:*
  - – Algorithm shall be available royalty free worldwide (Majority View)
  - – Don’t exclude the payment of royalties (Small Minority View)
- ❏ *Proposed Responses:*
  - – Option 1: royalty-free world-wide
  - – Option 2: weigh royalty-free submissions heavily in evaluation



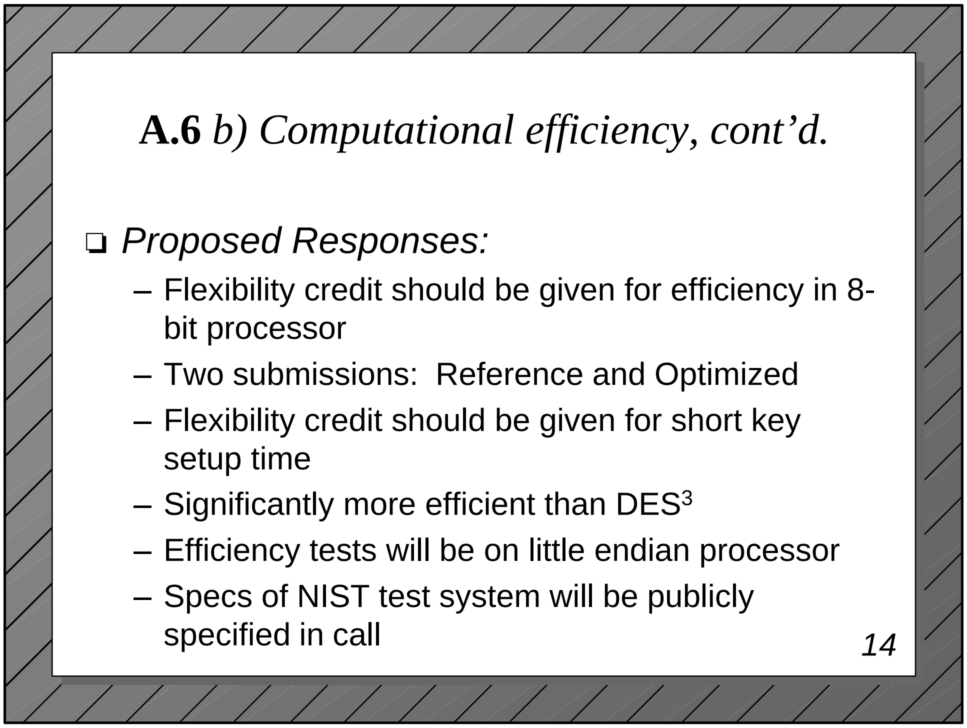
A.6 *Algorithms will be judged according to: a) Security*

- ❏ *Comments:*
  - – Tables should be generated in mathematical manner
  - – No shortcut attacks
- ❏ *Proposed Responses:*
  - – Strongly encourage public explanation of rationale for table generation
  - – Submitter shall state work factor
  - – All attacks below work factor will be evaluated for practicality



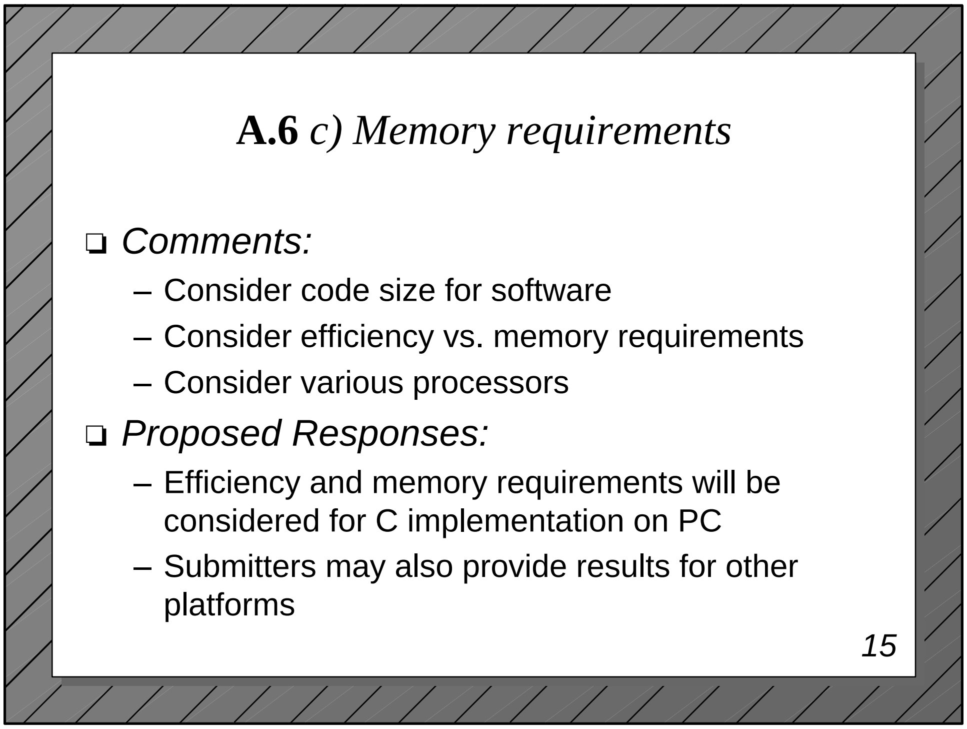
A.6 *b) Computational efficiency*

- *Comments:*
  - – Optimize for 8-bit processors (yes and no)
  - – Implement in Java instead of C
  - – Specify allowable key setup time
  - – Specify minimum speed requirement
  - – Specify big or little endian processor
  - – NIST should provide specs of its test system



A.6 *b) Computational efficiency, cont'd.*

- *Proposed Responses:*
  - – Flexibility credit should be given for efficiency in 8-bit processor
  - – Two submissions: Reference and Optimized
  - – Flexibility credit should be given for short key setup time
  - – Significantly more efficient than DES^3
  - – Efficiency tests will be on little endian processor
  - – Specs of NIST test system will be publicly specified in call



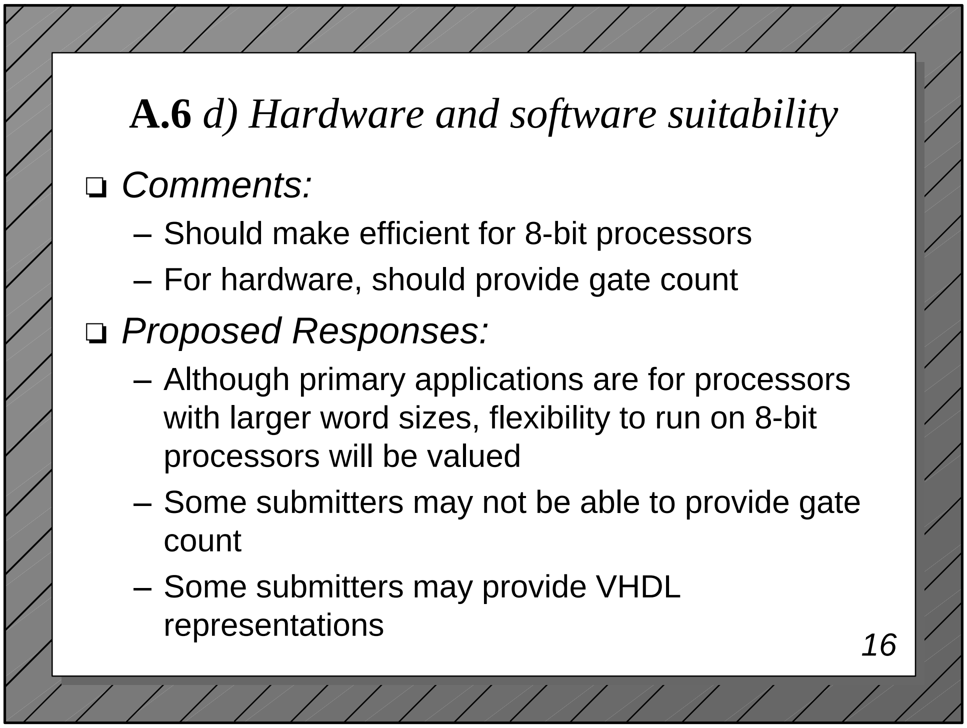
A.6 *c) Memory requirements*

❑ *Comments:*

- Consider code size for software
- Consider efficiency vs. memory requirements
- Consider various processors

❑ *Proposed Responses:*

- Efficiency and memory requirements will be considered for C implementation on PC
- Submitters may also provide results for other platforms



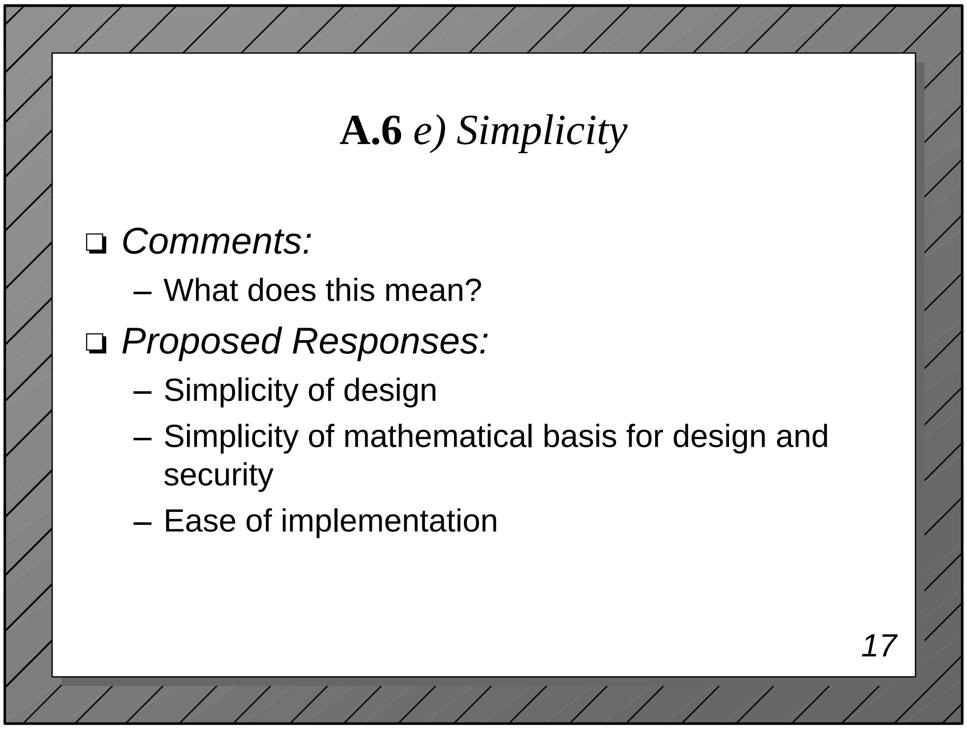
A.6 *d) Hardware and software suitability*

❑ *Comments:*

- Should make efficient for 8-bit processors
- For hardware, should provide gate count

❑ *Proposed Responses:*

- Although primary applications are for processors with larger word sizes, flexibility to run on 8-bit processors will be valued
- Some submitters may not be able to provide gate count
- Some submitters may provide VHDL representations



A.6 *e) Simplicity*

- *Comments:*
  - What does this mean?
- *Proposed Responses:*
  - Simplicity of design
  - Simplicity of mathematical basis for design and security
  - Ease of implementation

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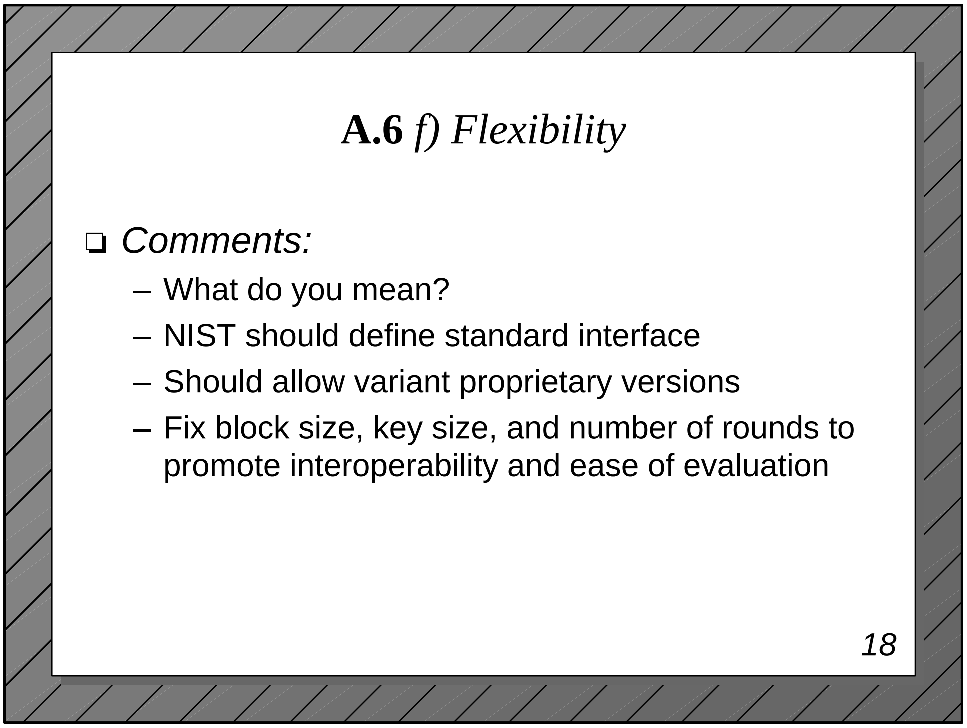

A.6 *f) Flexibility*

- *Comments:*
  - What do you mean?
  - NIST should define standard interface
  - Should allow variant proprietary versions
  - Fix block size, key size, and number of rounds to promote interoperability and ease of evaluation

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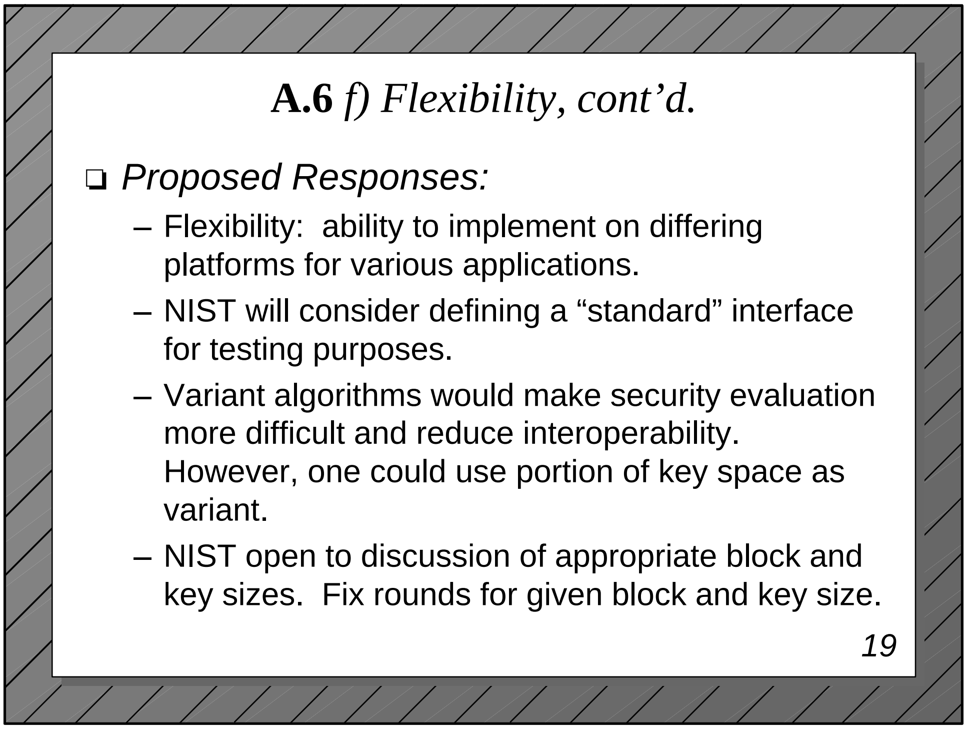
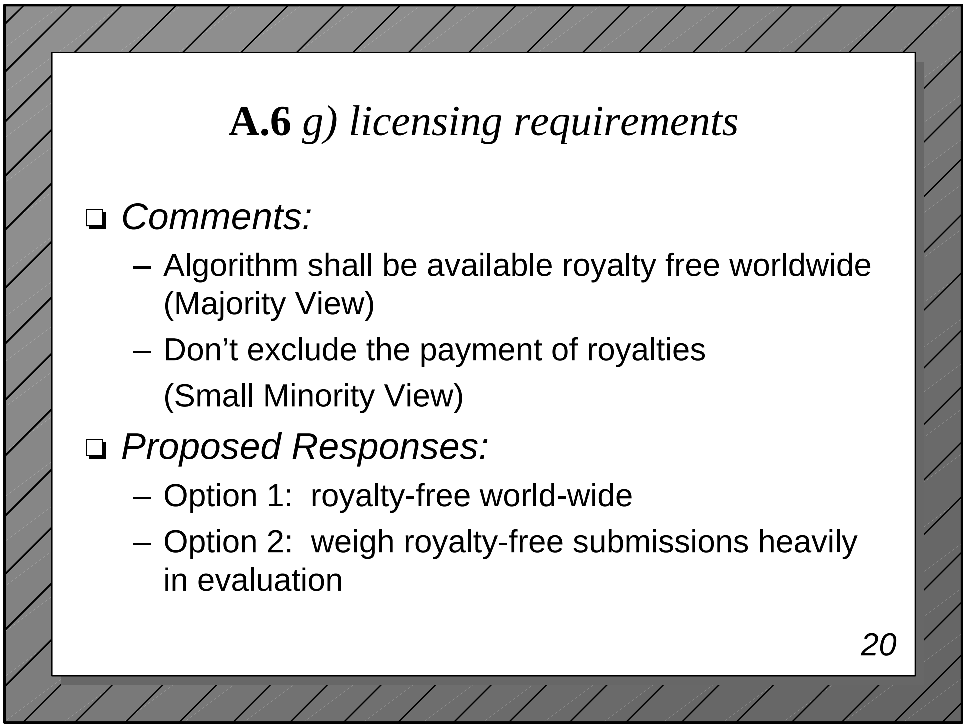


A.6 *f) Flexibility, cont’d.*

❏ *Proposed Responses:*

- – Flexibility: ability to implement on differing platforms for various applications.
- – NIST will consider defining a “standard” interface for testing purposes.
- – Variant algorithms would make security evaluation more difficult and reduce interoperability. However, one could use portion of key space as variant.
- – NIST open to discussion of appropriate block and key sizes. Fix rounds for given block and key size.



A.6 *g) licensing requirements*

❏ *Comments:*

- – Algorithm shall be available royalty free worldwide (Majority View)
- – Don’t exclude the payment of royalties

  (Small Minority View)

❏ *Proposed Responses:*

- – Option 1: royalty-free world-wide
- – Option 2: weigh royalty-free submissions heavily in evaluation

General Comments

❑ *Comments:*

- Lifetime of the algorithm should be 20-30 years
- The A.6 evaluation factors could be grouped into three categories: Security, Efficiency, and Cost
- The A.6 evaluation factors should be ranked in order of importance
- Submitted Algorithms should not be export controlled
- Algorithm development should be independent of export control considerations

General Comments, cont'd

❑ *Proposed Responses:*

- Agree (lifetime)
- Agree (grouping)
- Agree
  - ✦ Security > Efficiency
  - ✦ Efficiency = Cost
- Export policy is beyond NIST control
- Export laws must be complied with
- AEA should be at least as strong as DES[3]

Questions?

Part B: *Proposed Draft Submission Requirements*

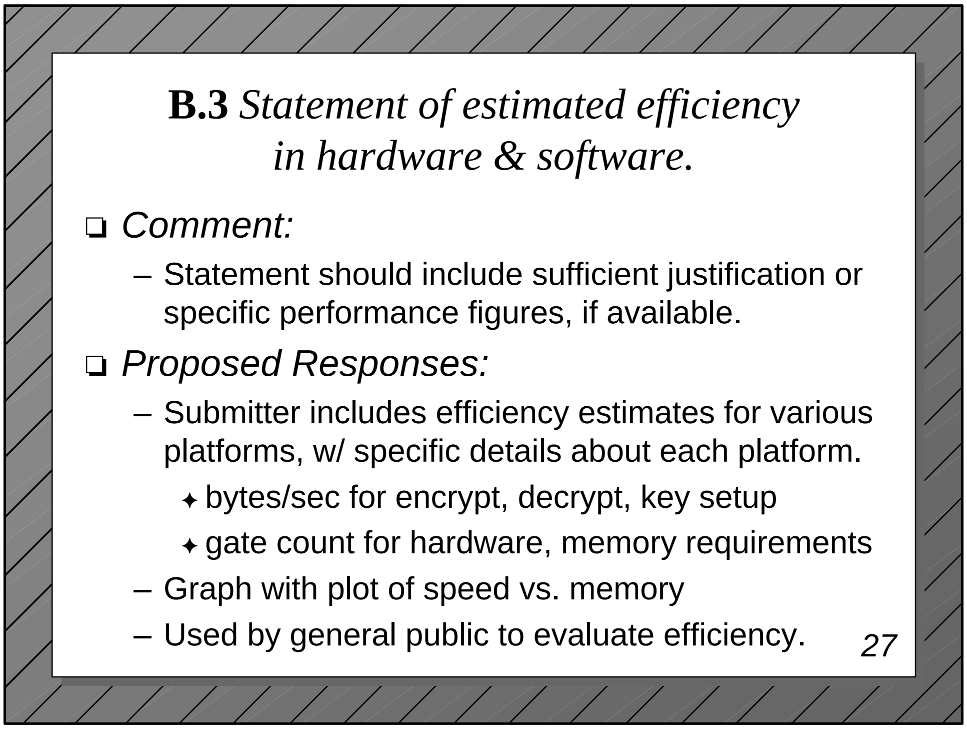
(Contents of the Submission Package)

B.1 *Complete written specification of the algorithm & necessary parameters, tables, equations.*

- *Comments:*
  - Minimum values for security parameters should be specified by NIST.
  - Complete design rationale should be required.
- *Proposed Responses:*
  - Key & Block size values will be specified in the call
  - Submitter encouraged to provide non-proprietary design rationale.

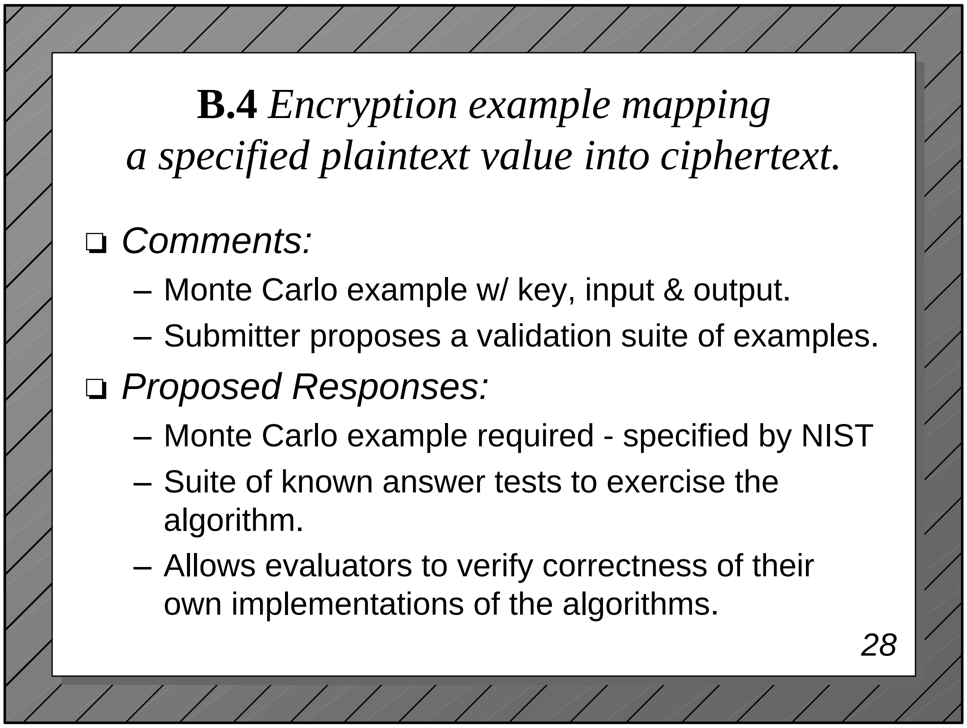
B.2 *Provide software implementation & source code in ANSI C, for a PC - used for comparison of algorithms.*

- *Comments:*
  - Reference AND Optimized implementations.
  - Specify configuration to be used by NIST for eval.
  - Specify medium for submissions.
- *Proposed Responses:*
  - Reference implementation (ANSI C and/or Java?)
  - Optimized implementation (ANSI C) suitable for IBM-compatible PC running Win95, with 16MB RAM, Pentium XXMHz processor.
  - One 3.5” 1.44MB floppy for each impl. (max.)



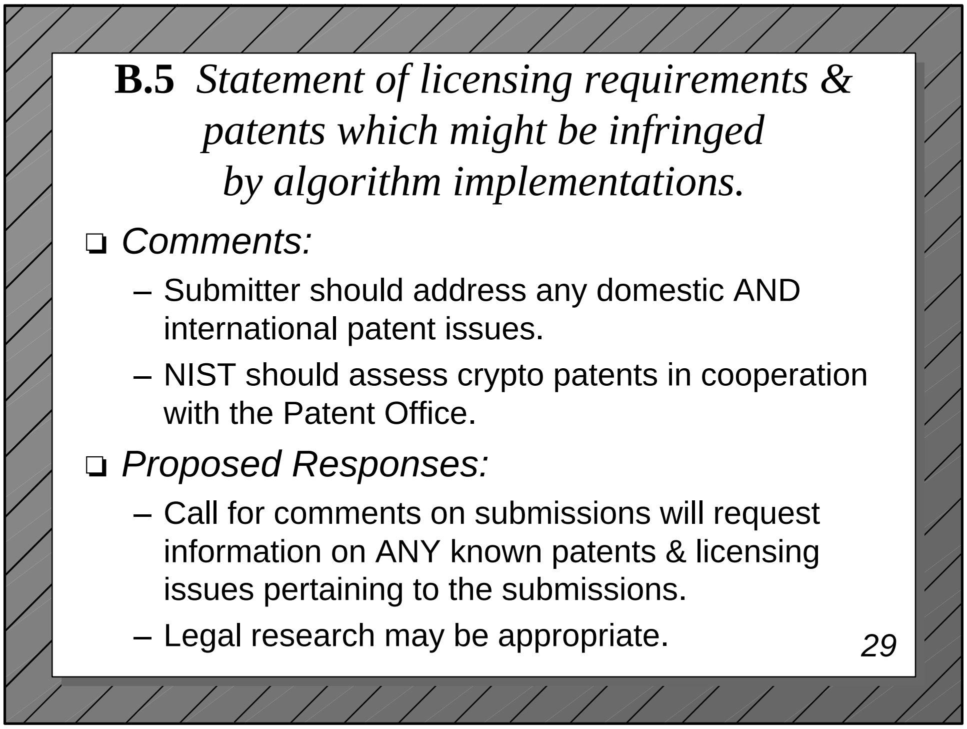
B.3 *Statement of estimated efficiency in hardware & software.*

- *Comment:*
  - Statement should include sufficient justification or specific performance figures, if available.
- *Proposed Responses:*
  - Submitter includes efficiency estimates for various platforms, w/ specific details about each platform.
    - bytes/sec for encrypt, decrypt, key setup
    - gate count for hardware, memory requirements
  - Graph with plot of speed vs. memory
  - Used by general public to evaluate efficiency.



B.4 *Encryption example mapping a specified plaintext value into ciphertext.*

- *Comments:*
  - Monte Carlo example w/ key, input & output.
  - Submitter proposes a validation suite of examples.
- *Proposed Responses:*
  - Monte Carlo example required - specified by NIST
  - Suite of known answer tests to exercise the algorithm.
  - Allows evaluators to verify correctness of their own implementations of the algorithms.



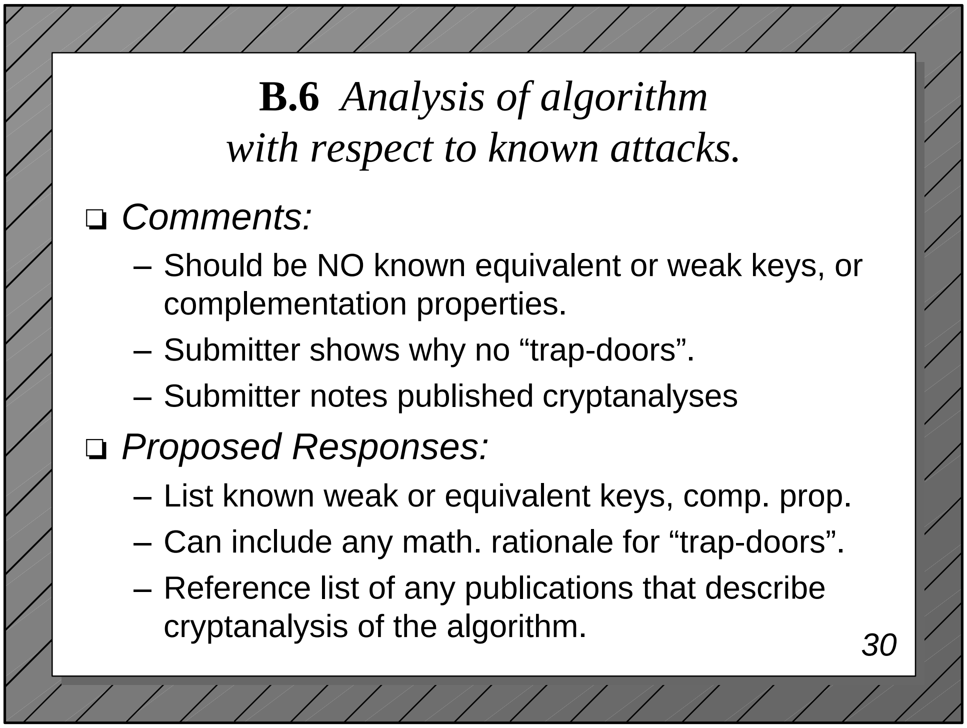
B.5 *Statement of licensing requirements & patents which might be infringed by algorithm implementations.*

❑ *Comments:*

- Submitter should address any domestic AND international patent issues.
- NIST should assess crypto patents in cooperation with the Patent Office.

❑ *Proposed Responses:*

- Call for comments on submissions will request information on ANY known patents & licensing issues pertaining to the submissions.
- Legal research may be appropriate.



B.6 *Analysis of algorithm with respect to known attacks.*

❑ *Comments:*

- Should be NO known equivalent or weak keys, or complementation properties.
- Submitter shows why no “trap-doors”.
- Submitter notes published cryptanalyses

❑ *Proposed Responses:*

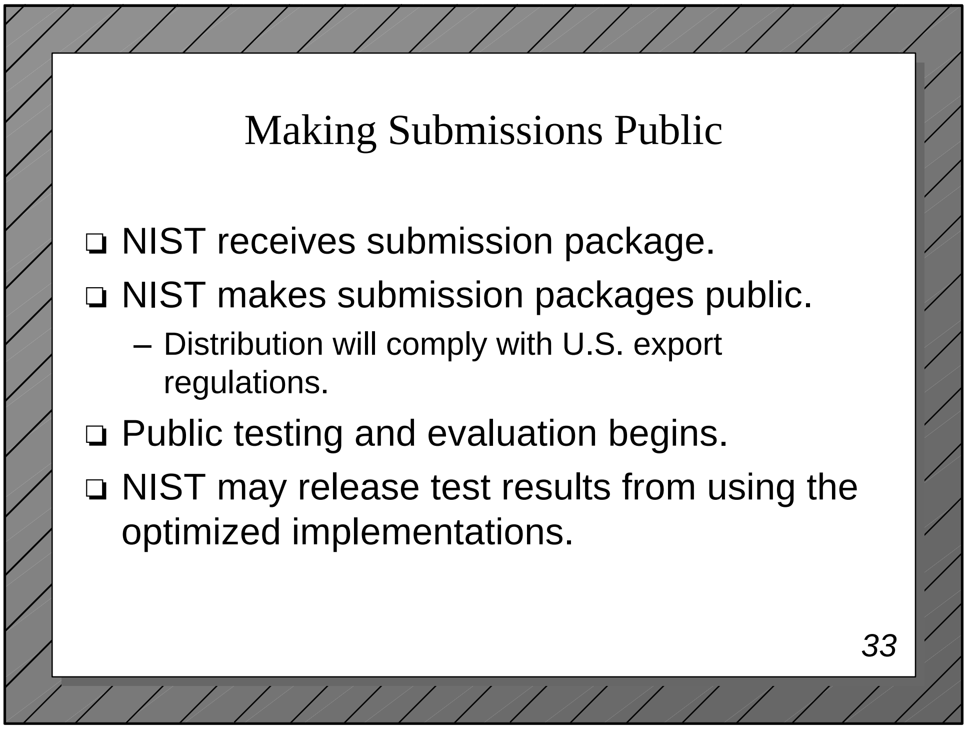
- List known weak or equivalent keys, comp. prop.
- Can include any math. rationale for “trap-doors”.
- Reference list of any publications that describe cryptanalysis of the algorithm.

B.7 *Advantages and limitations of the submitted algorithm.*

- ❑ *Comment:*
  - – What are some examples?
- ❑ *Proposed Response:*
  - – Addresses efficiency & flexibility criteria.
  - – Description of features and advantages offered, with mathematical justification. For Example:
    - ✦ mathematically designed S-boxes,
    - ✦ variable key setup time
    - ✦ fast in 8-bit processors and PCs, etc.

Additional “B” Items (Proposed)

- ❑ NIST will not accept any info marked “proprietary” or equivalent (except possibly for optimized implementation).
- ❑ Submitter’s Statements:
  - – Submitting algorithm as a candidate with the understanding that it might not be selected for inclusion in the proposed FIPS.
  - – Submitter agrees to waive copyright on submitted materials (but could maintain intellectual property interests for optimized implementation).
  - – Statement of expected strength of the algorithm, with supporting rationale.



Making Submissions Public

- NIST receives submission package.
- NIST makes submission packages public.
  - Distribution will comply with U.S. export regulations.
- Public testing and evaluation begins.
- NIST may release test results from using the optimized implementations.

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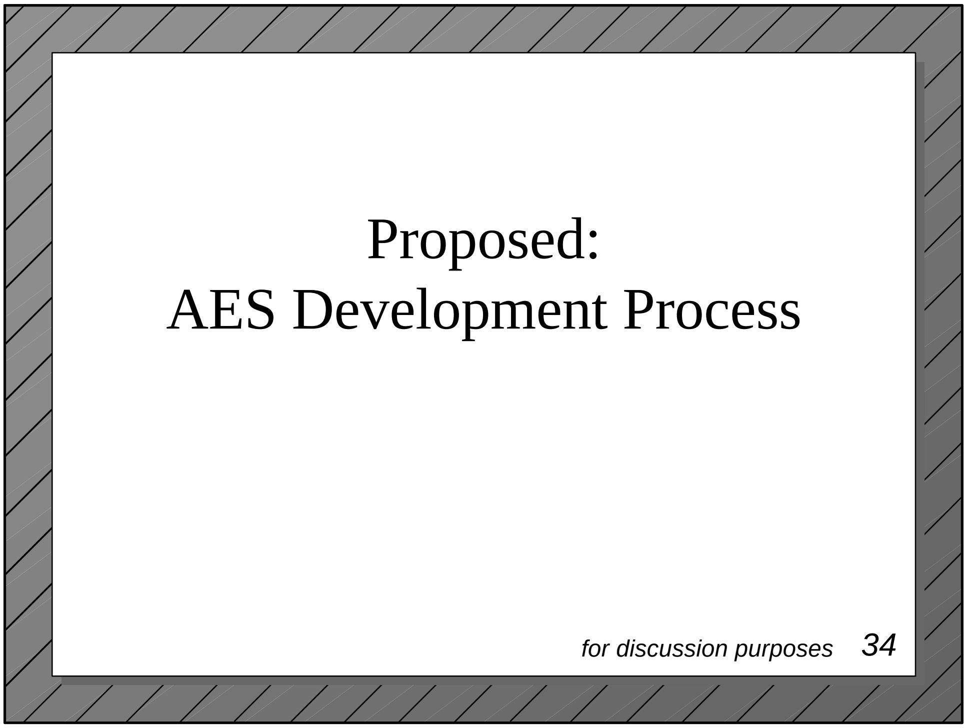
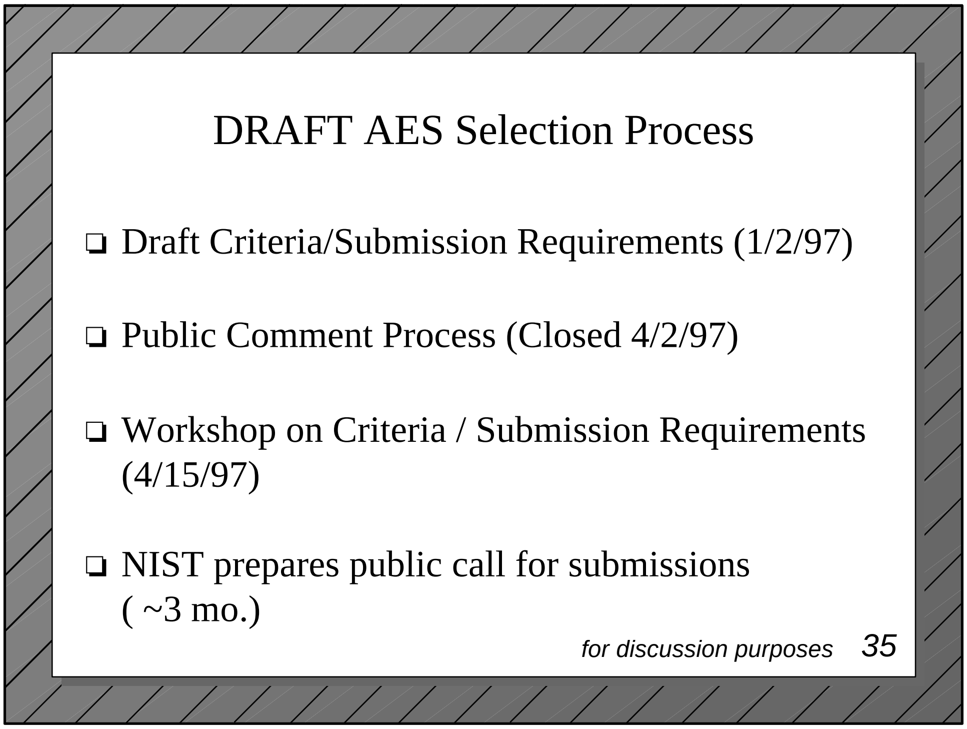


Proposed:
AES Development Process

for discussion purposes 34



DRAFT AES Selection Process

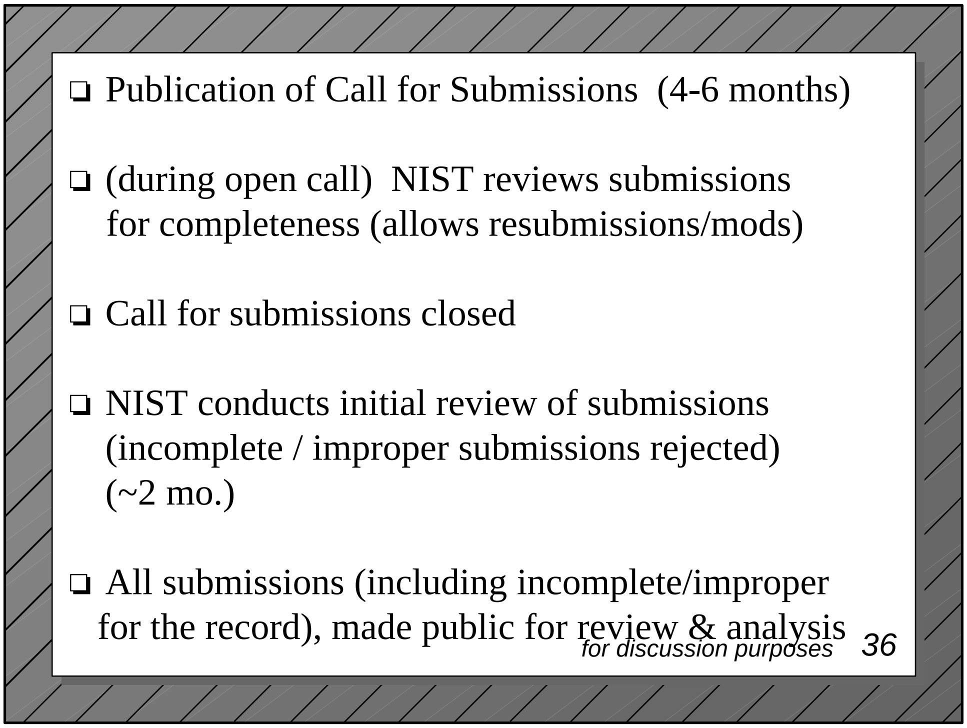
❑ Draft Criteria/Submission Requirements (1/2/97)

❑ Public Comment Process (Closed 4/2/97)

❑ Workshop on Criteria / Submission Requirements (4/15/97)

❑ NIST prepares public call for submissions (~3 mo.)

for discussion purposes 35



❑ Publication of Call for Submissions (4-6 months)

❑ (during open call) NIST reviews submissions for completeness (allows resubmissions/mods)

❑ Call for submissions closed

❑ NIST conducts initial review of submissions (incomplete / improper submissions rejected) (~2 mo.)

❑ All submissions (including incomplete/improper for the record), made public for review & analysis

for discussion purposes 36

❏ Comments accepted on all competing submissions

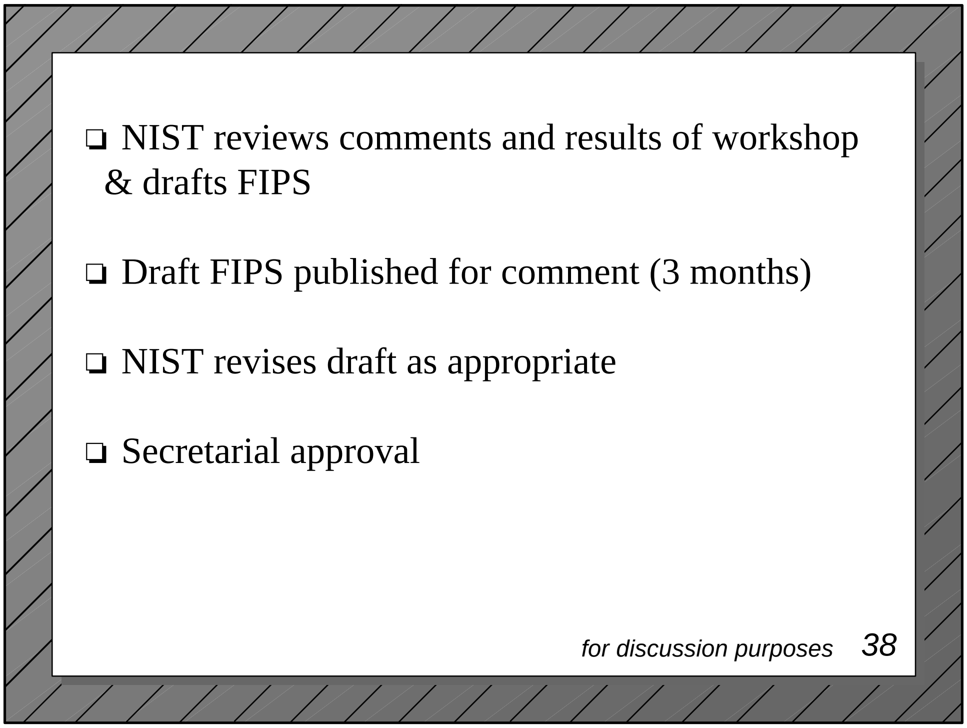
❏ (after 6 months) Interim Workshop

❏ NIST reviews comments and results of workshop (~3 months)

❏ Narrowed Candidates published

❏ Comments accepted on remaining candidates

❏ (6-9 months from narrowing) Final Workshop

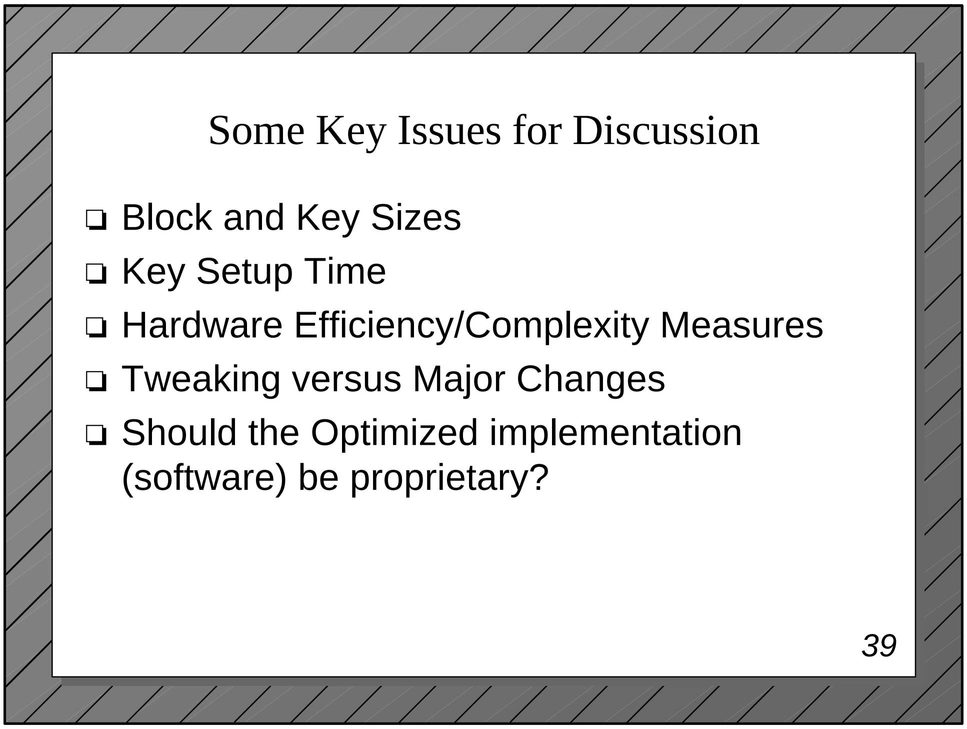


❏ NIST reviews comments and results of workshop & drafts FIPS

❏ Draft FIPS published for comment (3 months)

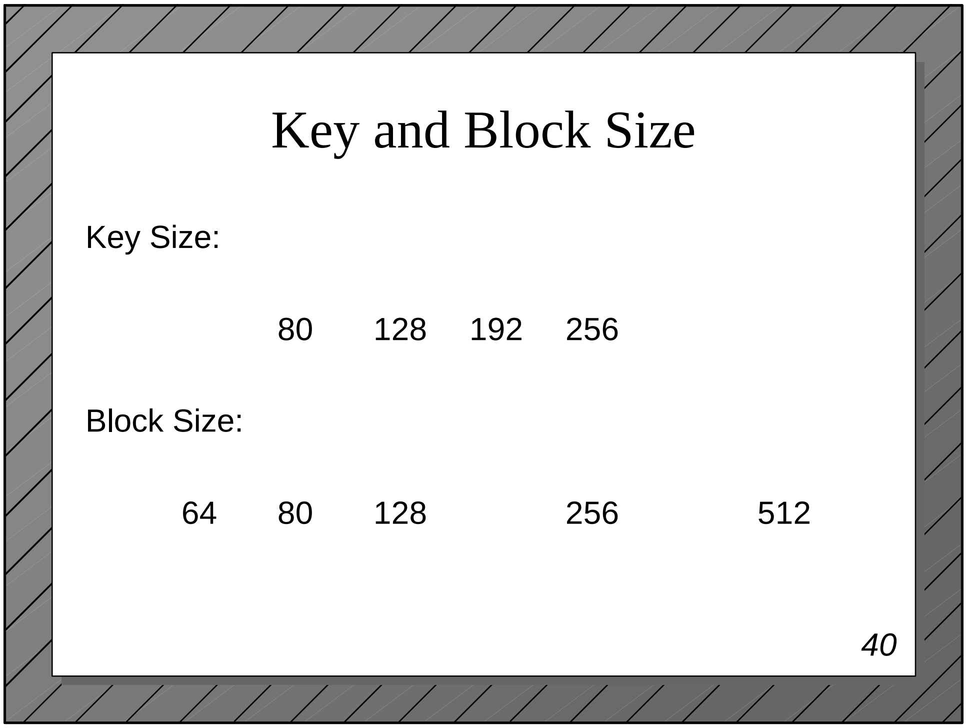
❏ NIST revises draft as appropriate

❏ Secretarial approval



Some Key Issues for Discussion

- ❑ Block and Key Sizes
- ❑ Key Setup Time
- ❑ Hardware Efficiency/Complexity Measures
- ❑ Tweaking versus Major Changes
- ❑ Should the Optimized implementation (software) be proprietary?



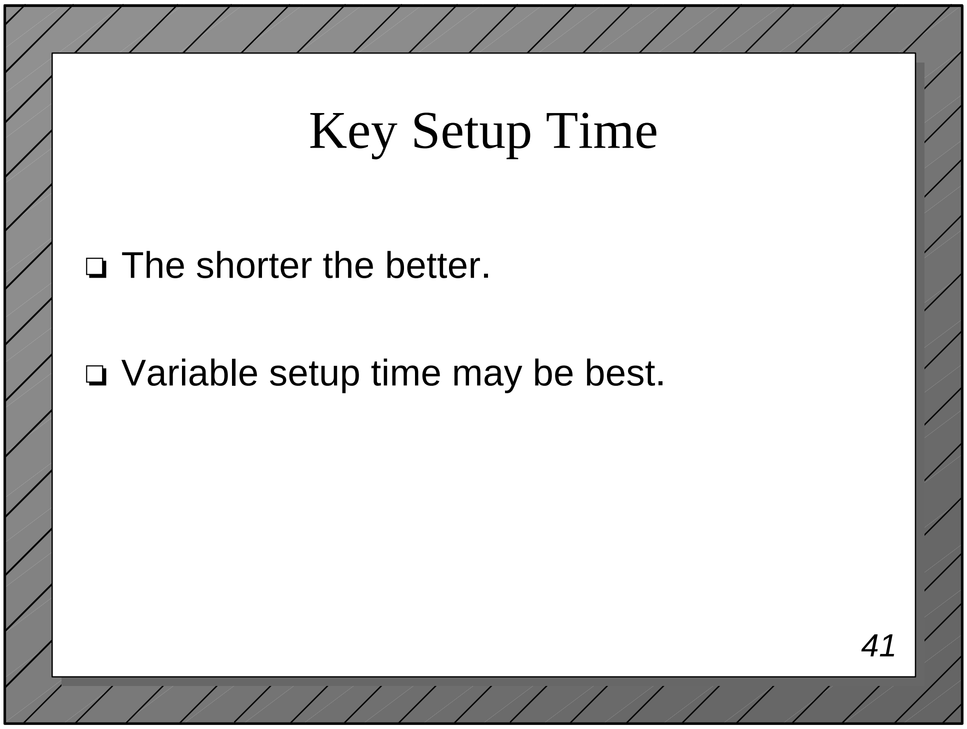
Key and Block Size

Key Size:

80 128 192 256

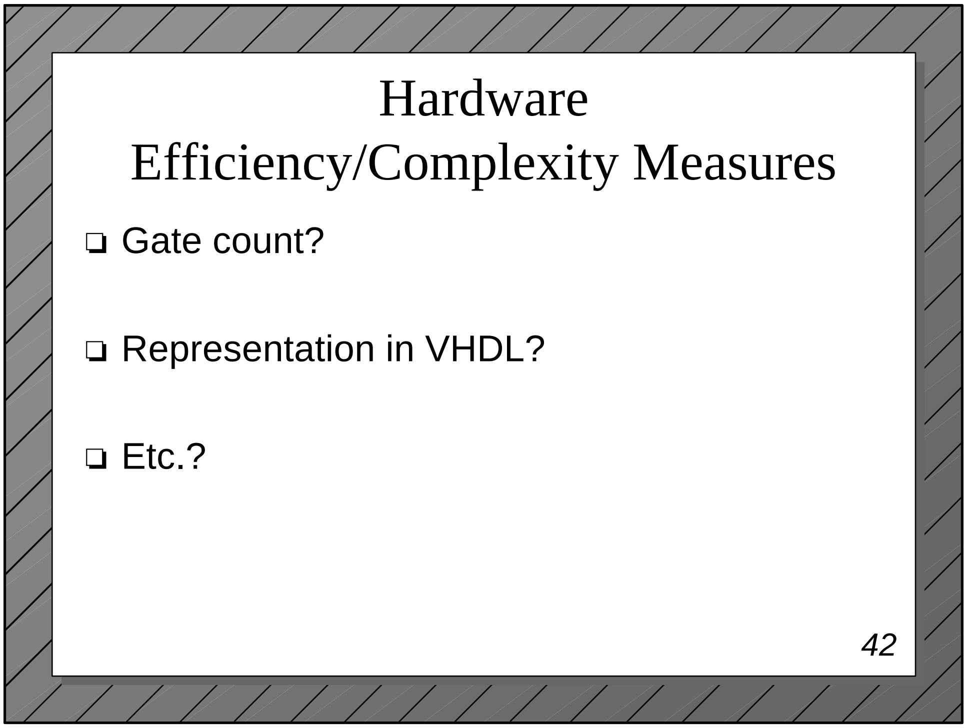
Block Size:

64 80 128 256 512



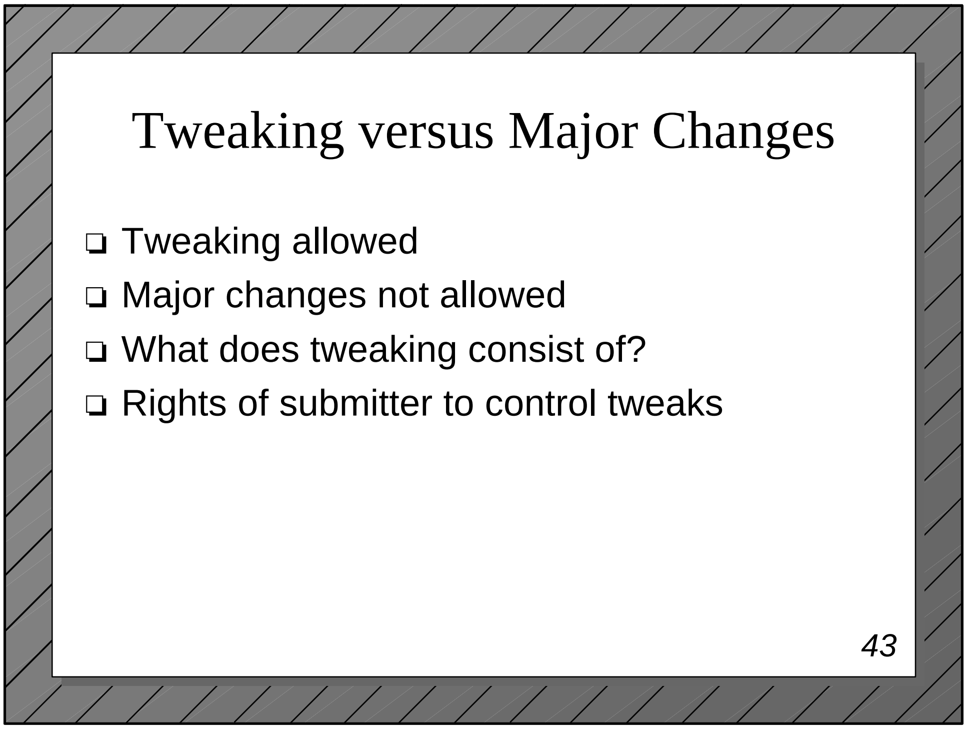
Key Setup Time

- ❑ The shorter the better.
- ❑ Variable setup time may be best.



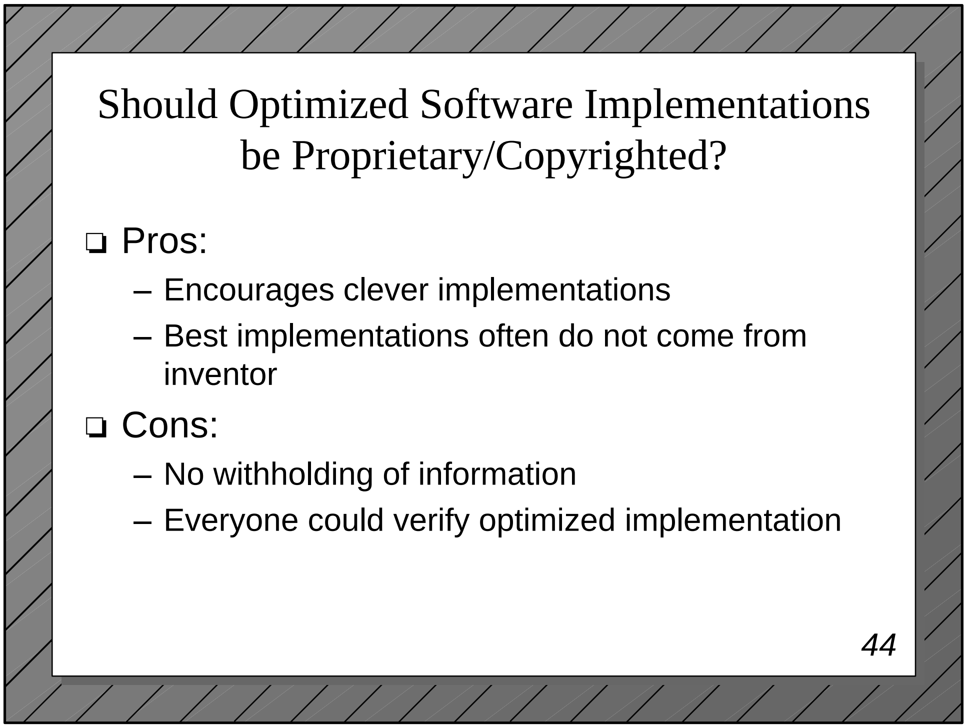
Hardware Efficiency/Complexity Measures

- ❑ Gate count?
- ❑ Representation in VHDL?
- ❑ Etc.?



Tweaking versus Major Changes

- Tweaking allowed
- Major changes not allowed
- What does tweaking consist of?
- Rights of submitter to control tweaks



Should Optimized Software Implementations be Proprietary/Copyrighted?

- Pros:
  - Encourages clever implementations
  - Best implementations often do not come from inventor
- Cons:
  - No withholding of information
  - Everyone could verify optimized implementation