OAK RIDGE National Laboratory

Fortran Standardization Process and The Road to F202Y

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U.S. DEPARTMENT OF ENERGY

Outline

- Fortran standardization process
- Development work for “F202Y”
- Some feature preview of Fortran 202Y

Fortran Standardization Efforts

- Standards are published by International Organization for Standardization (ISO); ISO JTC1/SC22/**WG5** is the ISO working group for Fortran
  - consists of multiple "national bodies" (NB) **https://wg5-fortran.org/**
  - active NBs: Japan, U.K., Germany, U.S.

- INCITS is the U.S. NB, serving as Technical Advisory Group to the JTC1
  - INCITS/Fortran Technical Committee is responsible for the technical development of the standards https://www.incits.org/committees/pl22.3
  - Formerly known as ANSI X3J3, a.k.a **"J3"**

https://j3-fortran.org/

- ***In practice***, WG5 provides general directions & advice, while INCITS/Fortran (J3) does the technical work

Fortran Standardization Efforts

- INCITS/Fortran (J3) members are
  - application developers, compiler writers, libraries & tools developers, academics, anyone with passions for & interests in Fortran
  - US National labs, federal agencies, vendors / companies, Universities, other organizations, individuals
  - Significant overlap between WG5 and J3 members (including non-US members)
- Development are done openly (meetings are members-only)
  - Three meetings per year (1-2 virtual); at least one face-to-face, held adjacently with WG5 meeting
  - j3-fortran.org, wg5-fortran.org (credit to Steve Lionel aka "Dr. Fortran" for website donation & maintenance)
  - https://github.com/j3-fortran/
- Contribute!
  - Join your NB
  - Join INCITS/Fortran
  - Join the J3 mailing list

Fortran Standardization Efforts

- INCITS/Fortran (J3) and WG5 works by **consensus** building
  - Contrary views are seriously considered. Time were taken to resolve objections.
  - "What is needed to change a 'no' vote to 'yes'?" Results are typically better for this.

- j3-fortran.org
  - Papers are organized by meeting and by year
  - Papers document the developments of a feature (use case, rationale / discussion, requirements, specifications, edits)
  - Papers are discussed and "passed" (by voting) at J3 meetings
  - "Standing document" are long-lived documents spanning multiple meetings "007" is the committee working draft; "010" is Workplan (currently F202Y)
- wg5-fortran.org
  - the working home of ISO WG5
  - document WG-5 yearly meeting minutes & decisions

Fortran Standardization Efforts

- Performance and numerical centric
  - work hard such that feature specifications does not hamper optimization
- Continues evolution to accommodate development in scientific computing
  - while trying to avoid chasing passing fads
- Backward compatibility
  - previous standards is proper subset of current standards
  - with some features deemed obsolescent

Fortran 202Y (Goal is Y==8)

- The committee is working on the next standard, informally called F202Y
- An initial list of features was approved by NBs at 2023 WG5 ISO Fortran Meeting (N2222), including
  - Generic programming with Template
  - Auto-Generic subprograms
  - Standardize Fortran preprocessor
  - Improved rank-independent functionality
  - Feature list updated in N2249
- J3 is actively developing these features

Fortran 2028 WG5 Strategic Plan (WG5 N2248)

ISO/IEC JTC1/SC22/WG5 N2248

Revised strategic plans for WG5

Steve Lionel, June 27, 2025

1. Interpretations

Processing of interpretations against ISO/IEC 1539-1:2023
will continue, and Corrigenda constructed as appropriate.

2. Revision of ISO/IEC 1539-1:2023 (Fortran 2023). This schedule
has not changed since 2024.

Final choice of technical content	2024-06
CD constructed	2026-06
CD ballot initiated	2026-07
CD ballot results available	2026-09
DIS constructed	2027-02
DIS ballot initiated	2027-03
DIS ballot results available	2027-09
DIS revised	2027-11
FDIS constructed	2028-02
FDIS ballot initiated	2028-05
FDIS ballot results available	2028-08
Standard published	2028-10

F202Y Current Status (j3-fortran.org standing doc 010)

F202Y Workplan

Live doc link

Label	Short Desc	Level (see 24-167)	Background / Use Cases	Subgroup	Rationale / Discussion Papers	Requirements	Specifications	Syntax	Edits
JP01	Include generic subprograms described in N2217	5	N2217 (WG5) 25-102 25-150	Data	24-140r2 (info, straw votes) 24-184r1 24-188r1 24-180 24-181 25-115	23-223r2 24-147r1 25-163r2	23-244r1 24-148r1 25-103 25-128 25-129 25-164r2	24-139r2 25-103 25-128 25-168r2	
US01	Obsolete default implicit typing	2	23-177	JOR					25-192r2
US02	Obsolete D format edit descriptor	2	23-178	JOR					25-113
US03	Add note that the real model is not IEEE 754	1	23-180	JOR					25-193r1
US04	Asynchronous Collective Subroutines		N2245 (WG5)	HPC		25-162r2	25-165r1	25-166r2	
US05	Add extended floating-point types defined in ISO C23 to ISO_C_BINDING	3	23-176	HPC		25-189r1	25-189r1		
US06	Provide a mechanism to specify global binding name for non C-interoperable	3	23-201	HPC					
US07	Improve rank-independent functionality	4	23-184r1	Data / JOR					
US08	Polymorphic PURE function results	4	23-186	Data		25-116r1	25-116r1 25-178	25-116r1 25-178	25-153r1
US09	Allow I/O of enumeration type names	4	23-151r1	JOR					25-126r1
US10	Define a standard Fortran preprocessor	6	23-192r1, 24-108, 24-109	FPP		25-114r2	25-142r2		
US11	Provide intrinsics for source location	3	23-193r1	JOR					
US12	Add maximum rank/corank constants to ISO_FORTRAN_ENV	3	23-194	Data (JP01)					
US13	Remote access to module entities	3	23-196r1	Data	25-119r1				
US14	Provide scoped access to enumeration enumerators	4	23-197	Data		25-180	25-180	25-180	
US15	Readonly pointers: a new attribute be application to pointers that determined whether the target of the pointer cannot be changed trhough the pointer	4	23-198	Data		25-179r1	25-179r1	25-182r1	25-197r2
US16	Provide a facility to specify the default kinds within the program unit	3	23-199	Data					
US17	Generic programming using templates	8	23-148, 23-103	Generic	23-211r1 23-212r2 23-213r2 23-214r3 23-215r1 25-158r1	24-105r3	24-105r3	24-125r5 24-126r4 24-127r4 24-159r4	25-109r2 25-135r2 25-136r2 25-172r1 25-173r1 25-174r2
US18	Allow Polymorphism in Coarrays	4	23-217	HPC (?)					
US19	Add more math functions from IEEE-754	4	23-234r2	JOR		25-143	25-143		
US20	Add Intrinsic and collective subroutines for prefix operations (formerly "SCAN" and "CO_SCAN")	4	23-235r2, 24-157	HPC + JOR	25-195r1	25-144r1 (co_*) 25-145r1 (local)	25-177r1 (co_*) 25-186r2 (sum) 25-196r1 (reduce)	25-177r1 (co_*) 25-186r2 (sum) 25-196r1 (reduce)	
US23/DIN4	Add generic processing of assumed-rank object	5	24-136r1	Data	24-169	24-171 24-172	24-183r1	24-183r1	24-183r1
US24	Add rank-independent looping	4	24-143	Data + JOR					
US25	Add ability to interpret complex as real and vice versa	5	24-129	Data		24-173	25-188r1	25-188r1	
DIN1	Add execution of collective procedures on a specified team	4	N2230 (WG5) 25-125r1	HPC		25-127r1	25-127r1	25-127r1	25-127r1
DIN3a	Add support for atomic operations in local memory	5	N2230 (WG5)	HPC					

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Fortran 202Y Preview

F202Y **Preview**: Generic Programming

Details are subject to change

A motivating _AXPY example:

```
subroutine axpy(a, x, y)
  real, intent(in) :: a
  real, intent(in) :: x(:)
  real, intent(inout) :: y(:)
  y = a*x + y
end subroutine axpy
```

In Fortran 2023, supporting AXPY for different data types require user to write similar subroutines with suitable interface for each supported data types.

F202Y **Preview**: Auto-Generic Procedures

Details are subject to change

Original proposed feature with use-cases: WG5 N2217

There shall be a mechanism for defining an auto-generic procedure, with a single procedure body rather than a set of specific procedures.

- have *generic* name but no *specific* name
- may have zero, one, or more "generic" dummy arguments
- an anonymous set of specific procedures is implicitly defined, one for every combinations of **type**, **kind-type** parameter, and **rank** → "generic combinations"
- rest of requirements: 24-147r1

Provide a relatively simple way to leverage existing compile-time polymorphism ("genericity") already existed in the language.

F202Y **Preview**: Auto-Generic Procedures - AXPY Example

Details are subject to change

```
generic subroutine axpy(a, x, y)
  type(real([real32, real64, real128]), &
     integer([integer_kinds]), intent(in) :: a
  typeof(a), dimension(:), intent(in) :: x
  typeof(a), rank(rank(x)), intent(inout) :: y
  …
end subroutine axpy
```

generic dummy argument

generic-dependent

credit: Malcolm Cohen (NAG), Hidetoshi Iwashita, John Reid

F202Y **Preview**: Auto-Generic - Kind & Rank Genericity Examples

Details are subject to change

```
generic subroutine lift(x,y)
  type(integer([int32,int64]), real), rank(1:2), allocatable :: x
  type(integer([int32,int64]), real), rank(1:2), allocatable :: y
  typeof(x), rank(rank(y)), allocatable :: z
  !-- Defines 36 specific procedures with generic name “lift”
end subroutine
```

```
generic subroutine lift(x,y)
  type(integer([int32,int64]), real), rank(1:2), allocatable :: x
  typeof(x), rank(rank(x)), allocatable :: y
  typeof(x),rank(rank(y)),allocatable :: z
  !-- Defines 6 specific procedures with generic name “lift”
end subroutine
```

F202Y **Preview**: Auto-Generic - Rank Genericity Examples

Details are subject to change

```
generic function fun(x) result(y)
  type(type1), rank(0:7) :: x
  typeof(x), rank(rank(x)) :: y

  select generic rank (x)
  rank (0)
    !! code if x is a scalar
  rank (1:3)
    !! code if x is an array of 1 to 3 dimensions
  rank default
    !! code if x is an array of 4 to 7 dimensions
  end select
end function fun
```

F202Y **Preview**: Auto-Generic - Type Genericity Examples

Details are subject to change

```
module example
  interface operator(.myop.)
    procedure s ! all of the specific procedures of s.
  end interface
contains
  generic function s(a,b) result(c)
    use iso_fortran_env
    type(real,complex), intent(in), rank(1:max_rank()) :: a
    typeof(a),rank(rank(a)), intent(in) :: b
    typeof(a), rank(rank(a)) :: c, temp
    …
    select generic type (a)
      declared type is (real)
         temp = temp * (1-b)
      declared type is (complex)
        ! just this once, we want the conjugate.
        temp = temp * (1-conjg(b))
    end select
    …
    c = temp
  end function
end module
```

F202Y **Preview**: Generic Programming with Template

Details are subject to change

A motivating _AXPY example:

```
subroutine axpy(a, x, y)
  real, intent(in) :: a
  real, intent(in) :: x(:)
  real, intent(inout) :: y(:)
  y = a*x + y
end subroutine axpy
```

In Fortran 2023, supporting AXPY for different data types require user to write similar subroutines with suitable interface for each supported data types.

F202Y **Preview**: Generic Programming with Templates

Details are subject to change

```
requirement bin_op { T, Op }
  deferred type :: T
  deferred interface
    elemental function Op ( a, b )
      type ( T ), intent ( in ) :: a, b
      type ( T ) :: op
    end function
  end interface
end requirement
```

```
integer, parameter :: SP = kind ( 1.0 ), DP = kind ( 1.d0 )

real(sp) :: f_A, f_X ( 10 ), f_Y ( 10 )
real(dp) :: d_A, d_X ( 10 ), d_Y ( 10 )
integer  :: i_A, i_X ( 10 ), i_Y ( 10 )

instantiate axpy_tmpl { real(sp), operator(+), operator(*) }
instantiate axpy_tmpl { real(dp), operator(+), operator(*) }
instantiate axpy_tmpl { integer, operator(+), operator(*) }

...

call axpy ( f_A, f_X, f_Y )
call axpy ( d_A, d_X, d_Y )
call axpy ( i_A, i_X, i_Y )
```

```
template axpy_tmpl { T, plus, times }

  private
  public :: axpy
  require bin_op { T, plus }
  require bin_op { T, times }
  generic :: axpy => axpy_

contains

  subroutine axpy_ ( A, X, Y )
    type ( T ), intent ( in ) :: A
    type ( T ), dimension ( : ), intent ( in ) :: X
    type ( T ), dimension ( : ), intent ( inout ) :: Y

    Y = plus ( times ( A, X ), Y )
  end subroutine

end template
```

credit: Tom Clune (NASA), Brad Richardson (NASA), & INCITS/Fortran Generic Subgroup

F202Y **Preview**: Generic Programming with Templates

Details are subject to change

```
requirement bin_op { T, Op }
  deferred type :: T
  deferred interface
    elemental function Op ( a, b )
      type ( T ), intent ( in ) :: a, b
      type ( T ) :: op
    end function
  end interface
end requirement
```

Library writer - avail. to user

```
integer, parameter :: SP = kind ( 1.0 ), DP = kind ( 1.d0 )

real(sp) :: f_A, f_X ( 10 ), f_Y ( 10 )
real(dp) :: d_A, d_X ( 10 ), d_Y ( 10 )
integer  :: i_A, i_X ( 10 ), i_Y ( 10 )

instantiate axpy_tmpl { real(sp), operator(+), operator(*) }
instantiate axpy_tmpl { real(dp), operator(+), operator(*) }
instantiate axpy_tmpl { integer, operator(+), operator(*) }

...

call axpy ( f_A, f_X, f_Y )
call axpy ( d_A, d_X, d_Y )
call axpy ( i_A, i_X, i_Y )
```

User

```
template axpy_tmpl { T, plus, times }

  private
  public :: axpy
  require bin_op { T, plus }
  require bin_op { T, times }
  generic :: axpy => axpy_

contains

  subroutine axpy_ ( A, X, Y )
    type ( T ), intent ( in ) :: A
    type ( T ), dimension ( : ), intent ( in ) :: X
    type ( T ), dimension ( : ), intent ( inout ) :: Y

    Y = plus ( times ( A, X ), Y )
  end subroutine

end template
```

Library writer

credit: Tom Clune (NASA), Brad Richardson (NASA), & INCITS/Fortran Generic Subgroup

Auto-generic Procedures and/or Template?

- Some overlap in functionalities, but can also be complementary
- Auto-generic is conceptually simpler
  - extension of current genericity in Fortran with which users are already familiar
- Template is more extensible and powerful
  - can be written for future-/user-defined types as long as `requirements` are satisfied
- Both are compile-time resolvable → no/minimal runtime impact
- Edge-cases, integrations, and compositing these features will still need to be ironed out in the standardization process

F202Y **Preview**: Asynchronous Collectives

F202Y introduces asynchrony for collective subroutines

```
CO_BROADCAST (A, SOURCE_IMAGE  [, STAT, ERRMSG])
CO_BROADCAST (A, SOURCE_IMAGE, COMPLETION [, STAT, ERRMSG])
CO_BROADCAST (A, SOURCE_IMAGE, TEAM [, STAT, ERRMSG])
CO_BROADCAST (A, SOURCE_IMAGE, TEAM, COMPLETION [, STAT, ERRMSG])

CO_MAX/MIN/SUM (A [, RESULT_IMAGE, STAT, ERRMSG] )
CO_MAX/MIN/SUM (A [, RESULT_IMAGE], COMPLETION [,STAT, ERRMSG] )
CO_MAX/MIN/SUM (A [, RESULT_IMAGE], TEAM [,STAT, ERRMSG] )
CO_MAX/MIN/SUM (A [, RESULT_IMAGE], TEAM, COMPLETION [,STAT, ERRMSG] )

CO_REDUCE (A, OPERATION  [, STAT, ERRMSG])
CO_REDUCE (A, OPERATION, COMPLETION [, STAT, ERRMSG])
CO_REDUCE (A, OPERATION, TEAM [, STAT, ERRMSG])
CO_REDUCE (A, OPERATION, TEAM, COMPLETION [, STAT, ERRMSG])

COMPLETE (COMPLETION [, FINISHED])
```

TEAM: if appear, collective operation over the specified TEAM

COMPLETION: if appear, initiate an asynchronous collective operation.

Asynchronous collective operation needs to be wait-ed on, or its status can be queried by call to `COMPLETE ()`

What other features are planned for F202Y?

See WG-5 N2249 document for full list, or j3-fortran.org standing doc 010.

Some features to mention:

- US07. Improve rank-independent functionality.
- US10. Define a standard "Fortran-friendly" preprocessor.
- US16. Define default KIND values to use throughout a program unit.
- US19. Add more math functions from IEEE-754
- US20. Add Intrinsic and collective subroutines for prefix operations
- US23/DIN4 Add generic processing of assumed-rank object
- … and more

What other features are planned for F202Y?

F202Y Workplan

Live doc link

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US01	Obsolete default implicit typing	2	23-177	JOR					25-192r2
US02	Obsolete D format edit descriptor	2	23-178	JOR					25-113
US03	Add note that the real model is not IEEE 754	1	23-180	JOR					25-193r1
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US05	Add extended floating-point types defined in ISO C23 to ISO_C_BINDING	3	23-176	HPC		25-189r1	25-189r1		
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US18	Allow Polymorphism in Coarrays	4	23-217	HPC (?)					
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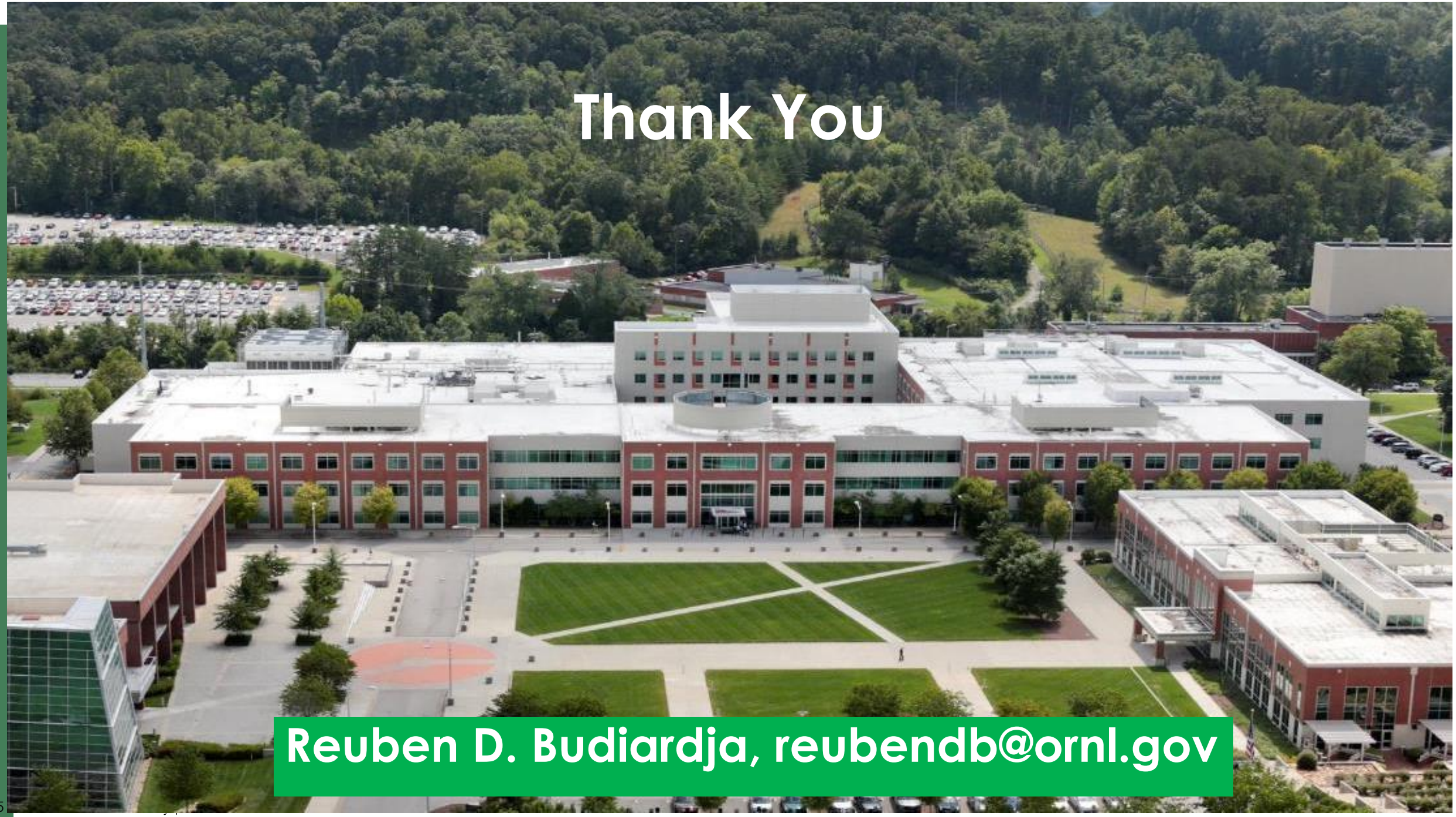
US23/DIN4	Add generic processing of assumed-rank object	5	24-136r1	Data	24-169	24-171 24-172	24-183r1	24-183r1	24-183r1
US24	Add rank-independent looping	4	24-143	Data + JOR					
US25	Add ability to interpret complex as real and vice versa	5	24-129	Data		24-173	25-188r1	25-188r1	
DIN1	Add execution of collective procedures on a specified team	4	N2230 (WG5) 25-125r1	HPC		25-127r1	25-127r1	25-127r1	25-127r1
DIN3a	Add support for atomic operations in local memory	5	N2230 (WG5)	HPC					

Conclusions & Acknowledgements

- We are well on our way to Fortran 2028.
  - INCITS/Fortran (J3) and WG5 are working very hard to publish the standard in 2028
- More contributions from community are welcomed
  - join the standardization process
  - share your wishlists / pain points
  - contribute / write “papers” to J3

Thank you to all the INCITS/Fortran (J3) and WG5 members for their contributions to the development of the Fortran standard.


Thank You
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