WG21 2019-11 Belfast
Minutes of Meeting

ISO/IEC JTC1 SC22 WG21 N4839— 2019-11-11

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04-09 November 2019, Belfast, UK

Chair: John Spicer

1.   Opening activities

John Spicer opened the meeting at 9:09AM UTC.

1.1 Opening comments, welcome from host

Jamie Allsop welcomes the group.

John Spicer presents the meeting agenda.

1.2 Meeting Guidelines

Every participant is responsible for understanding and abiding by the following:
- [The INCITS Antitrust Guidelines](#) (PL22.16)
- [The INCITS Patent Policy](#) (PL22.16)
- [The ISO Code of Conduct](#)
- [The IEC Code of Conduct](#)
- [The WG21 Practices and Procedures, and Code of Conduct](#)

John Spicer presents meeting guidelines.
Please make sure you are familiar with these documents.
If you have any CoC concerns you can bring them to me (John Spicer), Herb Sutter, or your NB representative.

1.3 Membership, voting rights, and procedures for the meeting

John Spicer presents meeting guidelines.

John Spicer presents voting rights.

Hal Finkel reminds the room to sign attendance sheet.

If you need a paper number, please use the isocpp.org website.

1.4 Introductions

Officers, WG chairs and SG chairs introduce themselves.
First time attendees introduce themselves.
John Spicer welcomes first time attendees.

1.5 Agenda review and approval

John Spicer presents the agenda for the meeting. The meeting will finish no later than 2pm on Saturday, but WGs may continue working.

The meeting goals described above are derived from the schedule adopted in 2018 and described in: P1000R3

John Spicer presents the meeting goals. Primary goal is resolving NB comments. In addition, there may be some work done on library fundamentals TS features.

PL22/16 motion to approve the meeting agenda.
Daveed Vandevoorde moves. Marshall Clow seconds. The motion is unanimously approved by PL22/16.

WG21 motion to approve the meeting agenda.
The motion is unanimously approved by WG21.

1.6 Editor's reports, approval of working drafts

Document	Editor's report	Prospective WD
C++20 Standard	N4836	N4835

WG21 motion to approve the working draft.
The motion is unanimously approved by WG21.

1.7 Approval of the minutes of the previous meetings

Meeting	Minutes
WG21 Cologne	N4826
PL22.16 Cologne	pl22.16-2019-00005
WG21 pre-Belfast administrative telecon	N4838

PL22/16 motion to approve minutes of the previous meeting.
Daveed Vandevoorde moves. Barry Hedquist seconds. The motion is unanimously approved by PL22/16.

WG21 motion to approve minutes of the previous meeting.
The motion is unanimously approved by WG21.

2. Liaison reports, and WG21 study group reports (see pre-meeting WG21 telecon minutes)

No discussion.

3. WG progress reports and work plans for the week (Core, Evolution, Library, Library Evolution; see pre-meeting WG21 telecon minutes)

No discussion.

4. New business requiring action by the committee

No discussion.

5. Organize working groups and study groups, establish working procedures

John Spicer presents.

The WG and SG chairs must arrange for any proposals to be written up in the form of a motion, and made available by 8:00 PM Friday. Everybody is encouraged to put the papers on the straw poll page as soon as possible so people can get familiar with it. If you have any questions or concerns, please raise them as soon as possible with the appropriate WG chair.

6. WG and SG sessions

Jens Maurer presents room assignments.
Jens presents evening sessions. Evening sessions should finish by 10pm.

Herb Sutter presents. We have several new Study Group chairs since Cologne.
Lisa Lippincott for SG6.
Barry Revzin for SG10
Hana Dusíková for SG7 at this meeting.
Botond Ballo for EWGI.
Jeff Snyder for SG4.
Thank you to all the chairs.

The purpose of the NB comment resolution stage is to get NB comments from all the national bodies, including those who do not attend. It gives us an opportunity to improve the quality of the document before we ship it. We will still do issues processing. Editorial comments resolution can be done by the editors. For the technical changes we will need input from the SGs. SGs do not make the final decision, but they can give recommendations. If there is no technical consensus for a change in the main working groups, the comment is not accepted. A comment that is not accepted may still result in an issue raised, which will be handled in the usual way. NB comments are not meant for big changes. Any change we make needs to increase consensus. If a comment is revisiting previously made decisions, asking for new features, or removing a feature, we will need near unanimity and no NB strongly opposed to make sure we are not decreasing consensus.
There were few papers approved by EWG and LEWG, but that didn't get through the wording groups. I would like EWG and LEWG to re-affirm that they still want them in C++20. NB comments take priority over those papers in the wording groups.

Meeting adjourned at 10:08 AM UTC.

7. Review of the meeting (Saturday 8:30 AM)

John Spicer opened the meeting at 8:30am UTC. Make sure you have marked the attendance sheet, if you have not already done so.

Herb Sutter explains the voting rights.

If you are a member of an NB, you can vote.
If you only represent a US company, only one person can vote.

Two NB comments, US227 and DE002, will go back to LEWG in Prague.

So far we have 201 closed issues. Closed issue means we are done with that NB comment. This includes editorial issues for which we do not need a plenary vote. It also includes duplicate issues, and issues which were considered and for which there was no consensus to change. In addition, there are is a number of issues we are moving at this meeting.We are in very good shape with NB comments.

WG and SG status and progress reports.

- ◦ **SG2: Modules (Stone)**

David Stone presents.
SG2 met for day and a half, we had had 41 NB comments to get through. We discussed 30 in SG2 directly.

Main progress at this meeting :
• Partially defined global initialization order
• Improved ability for scanners to find dependencies

Those NB comments which we didn't discuss in SG2, we discussed in EWG. We discussed all modules related NB comments this week.

- ◦ **SG4: Networking (Snyder)**

Jeff Snyder presents.
SG4 discussed & approved design of Networking TS improvements related to:
- [completion tokens](https://wg21.link/p1943r0). This will be coming
back to SG4 with wording.
- [executors](https://wg21.link/p1322r0). This will have wording added
and go to LEWG.
- [dynamic buffers](https://wg21.link/p1790r0). This will have wording
added and go to LEWG.

We also had an initial discussion about whether and how secure networking
(i.e. TLS/DTLS) should be supported in C++.

The result was that we will aim to include secure networking in C++23,
but that we will ship networking support without secure networking if it
is not ready in time for C++23.

- ○ **SG5: Transactional memory (Boehm)**

SG5 didn't meet at this meeting.

- ○ **SG6: Numerics (Lippincott)**

Lisa Lippincott presents.
SG6 processed 6 NB comments and 12 papers. We had three joints sessions with LEWGI, and one with SG14. We have three major numerics project in the pipeline : linear algebra, which comes in two parts, and some work on new number types. We do have an SG6 mailing list, it's called sci. Please sign up for it if you are interested.

- ○ **SG7: Compile-time programming (Carruth)**

Hana Dusíková presents.
We had 9 papers including 2 late ones and we were able to discuss all of them. We discussed updates on reflection implementations, specifically side effects of compile-time programming. We got new feedback around what the underlying model should be. It will require significant effort to understand it and describe it.
We discussed reflection related topics about unicode and reflection over attributes/ properties. We chose to prefer library features implemented with reflection over new language features.

- ○ **SG10: Feature test (Revzin)**

Barry Revzin presents.
SG10 met on Tuesday am, discussed:
P1902 (Missing feature-test macros 2017-2019)
P1641 (Freestanding Library: Rewording the Status Quo)
P1642 (Freestanding Library: Easy [utilities], [ranges], and
[iterators)

We resolved 6 NB comments. We're adding/changing 6 language and 30 library macros.

There is a new policy for constexpr language.

No new macros, just increment __cpp_constexpr for
- virtual calls (P1064)
- try/catch (P1002)
- dynamic_cast (P1327)
- change active member of union (P1330)
- asm (P1668)
- default init (P1331)

Major constexpr extensions get their own feature.

- P0784 (More constexpr containers) adds dynamic allocation to the library, that's a big deal: __cpp_lib_constexpr_dynamic_alloc

Minor extensions (just add constexpr to things) get one macro per header named __cpp_lib_constexpr_headername, which will be bumped on each new addition

- Except for the preexisting __cpp_lib_array_constexpr and __cpp_lib_constexpr_algorithms
- e.g. P1645 (constexpr for <numeric>) adds __cpp_lib_constexpr_numeric

You can find all this at https://wg21.link/sd6

- ## SG12: Undefined and unspecified behavior (Dos Reis)

Gabriel Dos Reis presents.
SG12 met for two days and two half days. We processed 16 NB comments, mostly related to undefined behaviour in the pre processor. We rejected them, but the intent is to fix all of those issues after C++20. On Wednesday SG12 met with MISRA and WG23. There was lots of active discussions with MISRA chair. We reviewed issues integrated from Autosar with Misra and examined questions from MISRA to C++: optimisations which lead to deadcode, essential type. We reviewed a paper by Peter Sommerlad on Class Natures: Kinds of safe types. We plan to have a draft for MISRA after Easter and we will continue to have joint session for the next two meetings.
On Thursday we met with WG23 Almost 4/5 done with WG23 Programming Vulnerability C++ document. We handled the following topics this week: type system, operator precedence and associativity, side effect and order of evaluation, uncontrolled format string, floating point, generics and templates. We will continue the review in Prague.

- ## SG13: HMI & I/O (Human/Machine Interface) (Orr)

Roger Orr presents.
SG13 met on Wednesday morning for half a day. We had 3 papers to look at. One was on webview, for which we gave feedback. We voted strongly to see the update to that paper. For the 2D graphics paper, we had an update with appendices with more detailed response to some of the earlier feedback paper. We also had a new paper on the audio proposal, which identified 6 use cases. We split one of them into two cases. We took a vote on whether to make those critical cases. This helps identify the direction and what is or isn't important at this stage.

- ## SG14: Games & low latency (Wong)

Michael Wong presents.
SG14 met on Friday morning. We discussed linear algebra and the feedback we got from other groups.
The other project we have is heterogenous programming. We reviewed the progress of affinity. We also looked at fiber context paper.
We considered some feedback on exception handling data we received in the evening session, collating the ideas that were reviewed. We want to strengthen the data set so anyone can download it and start testing on their own systems. This is not ready yet.

◦ SG19: Machine Learning (Wong)

Michael Wong presents.
We considered two major papers, as well as a third proposal without a paper. The two proposals were statistical math function and graph data structures. Both were given feedback. It will probably take another meeting, but then we may be able to release them.
We also had the author for the implementation of automatic differentiation, but without a paper. We did an early review of what the direction could be. We hope to have a paper from the author's group so we can progress this topic. Feedback and guidance from EWG and LEWG would help.

◦ SG15: Tooling (Adelstein Lelbach)

Bryce Adelstein Lelbach presents.
Tooling Mission Statement :
• Represent the positions and opinions of those who develop tools that interact with C++.
• Review and respond to C++ evolutionary changes that will impact tools that interact with C++.
• Identify and comment on opportunities for tools to influence C++ language evolution.

We met at CppCon 2019 for 1 day, looked at 7 papers. There were 18 attendees. We discussed :
• Modules: Scanners and Mappers
• std::breakpoint
• P1864 Target Tuplets

We met in Belfast for half a day and looked at 4 papers. There were 16 attendees. We discussed :
• P1788 Module Recipe and BMI Reuse
• P1905 Indicating Header Importability
• P1881 Epochs

- ◦ **SG16: Unicode (Honermann)**

Mark Zeren presents.
Thank you to the scribes (Mark Zeren, Peter Bindels, Steve Downey).
We planned to meet for 1 day, but added another 1/2 day, and still ran short on time. We may need to plan for two days in Prague.
We reviewed 7 NB comments, all of which we recommended "accept" or "accept with modification".
We reviewed 12 papers, 4 of which addressed NB comments.
Of the remaining 8 papers, we forwarded 2 and look forward to revisions of 5 more.
There were 4 papers we planned to review but did not get to, each of which we have discussed previously. For three of those, some requested feedback was provided out of session.
We will continue to host telecons every two weeks or so. Paper authors touching on features discussed in P1253R0, the SG16 guidelines for review paper, such as character encodings, locales, text I/O, or file names, are encouraged to request review of their proposals at a telecon prior to a face-to-face meeting.

- ◦ **SG20: Education (van Winkel)**

JC van Winkel presents.
We have met all of Thursday. Thank you to the scribes.
We have been talking about our goal of the project and how to achieve that.
We are creating a project plan that aims to have a standing doc for isocpp.org at the end of 2020, to be fleshed out in the coming weeks.
The guidelines characteristics:
• Iterative and incremental
• Consumer then producer
• Consider the audience
• Have motivating use-cases
• Have actionable learning objectives

We worked out what the structure of the standing doc will be, how the subtasks will be divided among volunteers.
We have decided on a module-based approach with multiple topics per module.
These modules will be accompanied by outcomes for curriculum designers ("An Instructor Should Be Able To") and student outcomes (A Student Should Be Able To) that are action-driven and measurable. They will include what is in scope and what is not.
The topics will include an audience table (http://wg21.link/p1700) and dependencies on other subjects.
The idea is that we are not prescribing - a curriculum designer will get food for thought; they can/should pick their own journey and choose examples and exercises from their own experiences

- ◦ **SG21: Contracts (Spicer)**

John Spicer presents.
We had our first face-to-face meeting. About 20 people attended. We collected use cases since Cologne and we had a discussion about those and their priorities. We worked on identifying the areas of disagreement that we will need to get resolved in order to have consensus on the proposals going forward. We have at least 7 papers that people have signed up for to be looked at in Prague.

- ◦ **SG1: Concurrency (Giroux)**

Olivier Giroux presents.
Handling of issues on GitHub is really helpful for scheduling.
We had 41 people at peak attendance, 30 on average.
We had 18 NB comments : 13 non-duplicate, 10 adopted (by SG1), 3 declined.
We adopted the design of P0443R11 for ship vehicle TBD (i.e. new papers should be written assuming it is the baseline they build upon or modify). The poll had strong consensus. We are hoping to get this in C++23, and we would like it to get in early.

We had a great evening session, 71 people attended.

Other directions that may be of interest :
We like simplifying Transactional Memory implementations.
We are recommending to zap the Pointer Lifetime-End Zap (P1726).

Thank you to the scribes.

- ◦ **SG17: EWG Incubator (Ballo)**

Botond Ballo presents.
SG17 met for 2.5 days. We reviewed around 18 papers.

Outcomes:
Forwarded to EWG
•P1401R2 (Narrowing contextual conversions to bool)
•P1061R1 (Structured Bindings can introduce a Pack)
•P1908R0 (Reserving Attribute Names for Future Use)
•P1029R2 (move = relocates)

Recommend handling as a Core issue:
•P1839R1 (Accessing Object Representations)

Forwarded to EWG with modifications
•P0876R9 (fiber_context - fibers without scheduler)

•P0917R3 (Making operator?: overloadable)
•P1847R1 (Make declaration order layout mandated)
•P1774R1 (Portable optimisation hints)

Gave feedback, did not forward
• P1906R0 (Provided operator= return lvalue-ref on rvalue)
• P1936R0 (Dependent Static Assertion)
• P1858R0 (Generalized pack declaration and usage)
• P1609R2 (C++ Should Support Just-in-Time Compilation)
• P1912R0 (Interconvertible object representations)
• P1881R0 (Epochs: a backward-compatible language evolution mechanism)
• P1112R2 (Language support for class layout control)

Forwarded to other subgroups :
To SG7(Reflection)
• P0957R3 (PFA: A Generic, Extendable and Efficient Solution for Polymoprhic Programming)

There are some papers we weren't able to see this time, but we will see those in Prague.

Herb Sutter : thank you to all the new chairs. SG7 will now be run by Hana Dusíková. Lisa Lippincott is now the SG6 chair.

◦ **Evolution (Bastien)**

David Stone presents.
EWG had approximately 97 NB comments, 56 non-modules. We got through all NB comments.
Summary or work done :
• std::vector may be possible to implement
• Changed how non-type template parameters work: allow types with all public members, all of which can themselves be used as NTTPs. This allows array members, reference members, pointers and references to subobjects, floating-point, and unions.
• Several concepts NB comments: allow requires clauses on non-template friend functions of class templates
• Several coroutines NB comments, most rejected, a few sent away to write a paper
• Several comments forwarded from the UB group, but they were preferred for C++23
• A few feature test macros comments
• Tons of modules NB comments: including fixing issues around header units, did not postpone modules for C++23
• Began discussing some papers targeted at C++23

We found that it was very helpful to have a study group discuss module NB comments and come back with guidance to the whole group. It saved us time and allowed us to process more NB comments.

- ◦ **SG18 LEWG Incubator (Adelstein Lelbach)**

Bryce Adelstein Lelbach presents.
This was the longest LEWGI meeting: 5 days, 30 hours. We saw 20 papers, which is the smallest number of papers we've seen, but we have given more time to each paper. We had about 12 to 23 people throughout the week.
11 were new paper that were given direction review, 9 papers were papers that we have seen before and they were given design feedback.

No consensus to pursue : 3
Further LEWGI direction review : 1
Further LEWGI design review : 8
Sent to LEWG : 4
No action or sent to other group : 4

Major Work by LEWGI:
P1750 Process Management
P1883/P1031 Low Level I/O (LLIO)
P1889/P1890 Number Types
P1673/P1385 Linear Algebra
P1350/P1300 Units
P1729 Text Parsing

LEWGI changes in Belfast :
More generous timeboxes to all proposals.
Joint Numerics/LEWGI session.
LEWGI Chair Training Program - please contact me if you want to try chairing.

Planned LEWGI Telecons :
P1883/P1031 Low Level I/O (LLIO)
P1889/P1890 Number Types
P1350/P1300 Units

Future LEWGI Plans :
LEWG's backlog is long.
~65 papers ready for LEWG in GitHub.
We must continue refining and incubating proposals; LEWG time must be used efficiently.

Thank you to the scribes and everyone who participated. There will be a post Belfast LEWGI feedback survey.

- ◦ **Library Evolution (Winters)**

Titus Winters presents.
At the start of the week we had 129 NB comments. At the
end of the week we had 0 unprocessed NB comments. Thank you to everyone who
participated.

Spent ~4 hours discussing Executors (P0443R11) and related APIs. We will prioritize study of P0443R11 with the (non-binding) goal of forwarding that in the next
meeting (Prague). We encourage SG1/P0443 authors to write supplemental material.

Forwarding P1919R1 to update SD-8. We also had additional discussions about
SD-8 wrt. operator syntax.

I've got 4 or 5 more meetings in my tenure. I will start test-runs on new chairs.
Email titus@google.com if you want to be considered to take up LEWG chair starting in late 2021.

Pablo Halpern : What is SD-8 ?
Titus : It is a public-facing document stating what rights the standard library reserves for changes it will make, for example we reserve the right to add new names
to std.

- ◦ **Core (Miller)**

Mike Miller presents.
CWG spent most of its on NB comments. A number of NB comments had to go
through several levels of pre review before CWG. We spent some time waiting for
those to arrive to CWG. We also faced challenges because some NB comments
had dependencies on people and their availability. We got through all NB comments
that were initially triaged to CWG. We did not reject any NB comments, some were
accepted with modification. You will see motions for some today. 24 are assigned
for drafting before Prague, we hope to see them in motions at the next meeting.

We deferred US212 calling for making conversion from pointer or pointer-to-member to bool a narrowing conversion. We are in agreement with direction in that paper, the paper calls for categorising that as DR to C++11, which is beyond our
ability to do, as we can only deal with defects in the IS currently in force. It could
possibly be a guidance to the implementation as opposed to anything formal. We
would like to collect some information on the impact to existing code before Prague
in order to decide whether to propose it as a defect report.

We did some issue processing, and saw one C++23 proposal, which we expect to
move in Varna when we have a C++23 draft.

Since Cologne, we had 3 telecons. There are 19 issue resolutions that are tentatively ready. We are moving 4 issues that were resolved at this meeting. Calling out

issue 2382: if there is an array new expression, the implementation reserves some memory for the size of the array. Should that apply to std library non allocating version of placement new ? We proposed to say there is no array overhead for non allocating placement new. We are moving that issue today. If you have concerns, please raise them. We will have two telecons before Prague for issues processing.

P1971 contains some NB comments we are moving today. There is a problem discovered with one of the resolutions. We will remove that resolution from the motions page today and will look at it in Prague. The others should go forward. In addition to P1971, there are 7 papers that were either written as drafting at this meeting or are preexisting papers that were revised at this meeting. Those are addressing NB comments and we will be moving them today.

CWG Motions

Motion 1
Move to accept as Defect Reports all issues in P1969R0 (Core Language Working Group "ready" Issues for the November, 2019 (Belfast) meeting) and apply the proposed resolutions to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 2
Move to accept as Defect Reports all issues in P1968R0 (Core Language Working Group "tentatively ready" Issues for the November, 2019 (Belfast) meeting) and apply the proposed resolutions to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 3
Move to apply the changes in P1971R0 (Core Language Changes for NB Comments at the November, 2019 (Belfast) meeting) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 4
Move to apply the changes in P1972R0 (US105 Check satisfaction of constraints for non-templates when forming pointer to function) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 5

Move to apply the changes in P1975R0 (Fixing the wording of parenthesized aggregate-initialization) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 6
Move to apply the changes in P1874R1 (Dynamic Initialization Order of Non-Local Variables in Modules) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 7
Move to apply the changes in P1946R0 (Allow defaulting comparisons by value) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 8
Move to apply the changes in P1907R1 (Inconsistencies with non-type template parameters) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 9
Move to apply the changes in P1979R0 (Resolution to US086) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 10
Move to apply the changes in P1980R0 (Drafting for CA096: Declaration matching for non-dependent requires-clauses) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

  ◦ **Library (Clow)**

Marshall Clow presents.
This week was all C++20, all the time.

We started with about 80, got 50+ sent our way during the week.
We rejected 9 of them; and closed ~10 as duplicates.

We looked at a lot of papers, and we're moving 31 here today.
Those papers resolve a total of 51 NB comments.

We also have about 20 NB comments as LWG issues in status "Ready", which will be moved in Prague.

We still have about ~50 NB comments to resolve.

We're moving 8 of the "Mandates" papers this meeting. One more to go.

Thanks to everyone who participated, led small groups, provided wording, scribed.

LWG Motions

Issues

Motion 1
Move to apply the changes in P1917R0 (C++ Standard Library Issues to be moved in Belfast) to the C++ working paper. These issues resolve NB comments: GB166, US297, and US261

No objection to unanimous consent.
Motion passes.

Papers

Motion 2
Move to apply the changes in P1855R0 (Make <compare> freestanding) to the C++ working paper. This resolves NB comments US158, US159, GB160, PL161, RU009, and FI010

No objection to unanimous consent.
Motion passes.

Motion 3
Move to apply the changes in P1690R1 (Refinement Proposal for P0919 Hetero-geneous lookup for unordered containers) to the C++ working paper. This resolves NB comments US235, US236, US278, and PL237

No objection to unanimous consent.
Motion passes.

Motion 4

Move to apply the changes in P1872R0 (span should have size_type, not index_-type) to the C++ working paper. This resolves NB comments FR240, PL248, and US245

There are objections in the room.
Herb Sutter polls the room.
In favour : 55
Opposed : 3
Abstain : 10

Herb Sutter polls the room.
Is this a design change ?
In favour : 2

Motion passes.

Motion 5

Move to apply the changes in P1965R0 (Blanket Wording for Specifying "Hidden Friends") to the C++ working paper. This resolves NB comment DE165 and LWG issue 3239.

No objection to unanimous consent.
Motion passes.

Motion 6

Move to apply the changes in P1716R3 (ranges compare algorithm are over-constrained) to the C++ working paper. This resolves NB comments PL312, US306, US267, and GB183

No objection to unanimous consent.
Motion passes.

Motion 7

Move to apply the changes in P1869R1 (Rename condition_variable_any interruptible wait methods) to the C++ working paper. This resolves NB comment PL363

No objection to unanimous consent.
Motion passes.

Motion 8

Move to apply the changes in P1961R0 (Harmonizing the definitions of total order for pointers) to the C++ working paper. This resolves NB comments US176 and US220

No objection to unanimous consent.

Motion passes.

Motion 9
Move to apply the changes in P1878R1 (Constraining Readable Types) to the C++ working paper. This resolves NB comments US263, US264, US268 and LWG issue 3279

No objection to unanimous consent.
Motion passes.

Motion 10
Move to apply the changes in P1871R1 (Concept traits should be named after concepts) to the C++ working paper. This resolves NB comment US257

No objection to unanimous consent.
Motion passes.

Motion 11
Move to apply the changes in P1456R1 (Move-only views) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 12
Move to apply the changes in P1391R4 (Range constructor for std::string_view) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 13
Move to apply the changes in P1394R4 (Range constructor for std::span) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 14
Move to apply the changes in P1664R1 (reconstructible_range - a concept for putting ranges back together) to the C++ working paper.

Herb Sutter : Is there any objection to withdrawing this motion ?

No objections in the room.

Motion withdrawn.

Motion 15
Move to apply the changes in P1862R1 (Ranges adaptors for non-copyable iterators) to the C++ working paper. These five papers (together) resolve NB comments US272 and DE288

No objection to unanimous consent.
Motion passes.

Motion 16
Move to apply the changes in P1870R1 (forwarding-range<T> is too subtle) to the C++ working paper. This paper resolves NB comments US279 and GB280.

No objection to unanimous consent.
Motion passes.

Motion 17
Move to apply the changes in P1865R1 (Add max() to latch and barrier) to the C++ working paper. This resolves NB comment US365.

No objection to unanimous consent.
Motion passes.

Motion 18
Move to apply the changes in P1960R0 (NB Comment Changes Reviewed by SG1) to the C++ working paper. This resolves NB comments US355, US358, US359, US356, and US364

No objection to unanimous consent.
Motion passes.

Motion 19
Move to apply the changes in P1902R1 (Missing feature-test macros 2017-2019) to the C++ working paper. This resolves NB comments FI015, GB146, US150, US167, DE168, ~~and LWG issue 2334~~

No objection to unanimous consent.
Motion passes.

Motion 20

Move to apply the changes in P0883R2 (Fixing Atomic Initialization) to the C++ working paper. This resolves NB comments CA353, US351, DE018, and RU006 and LWG issue 2334

No objection to unanimous consent.
Motion passes.

Motion 21
Move to apply the changes in P1959R0 (Remove std::weak_equality and std::strong_equality) to the C++ working paper. This resolves NB comments US170 and CA173

No objection to unanimous consent.
Motion passes.

Motion 22
Move to apply the changes in P1892R1 (Extended locale-specific presentation specifiers for std::format) to the C++ working paper. This resolves NB comment GB226

No objection to unanimous consent.
Motion passes.

Motion 23
Move to apply the changes in P1645R1 (constexpr for <numeric> algorithms) to the C++ working paper. This resolves NB comment US320

No objection to unanimous consent.
Motion passes.

Mandating

Motion 24
Move to apply the changes in P1718R2 (Mandating the Standard Library: Clause 25 - Algorithms library) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 25
Move to apply the changes in P1719R2 (Mandating the Standard Library: Clause 26 - Numerics library) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 26

Move to apply the changes in P1686R2 (Mandating the Standard Library: Clause 27 - Time library) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 27

Move to apply the changes in P1720R2 (Mandating the Standard Library: Clause 28 - Localization library) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 28

Move to apply the changes in P1721R2 (Mandating the Standard Library: Clause 29 - Input/Output library) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 29

Move to apply the changes in P1722R2 (Mandating the Standard Library: Clause 30 - Regular Expression library) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 30

Move to apply the changes in P1723R2 (Mandating the Standard Library: Clause 31 - Atomics library) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

Motion 31

Move to apply the changes in P1622R3 (Mandating the Standard Library: Clause 32 - Thread support library) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

- ○ **Direction Group (Hinnant)**

Howard Hinnant presents.

Direction Group met briefly. We're pleased with the quality and speed of progress. We are encouraged by the process, we are continuing to improve the process. The direction paper has been updated in the pre-meeting mailing, please take a look at it. We support and agree with Ville's plan for C++23, and some of it is in the directions paper.

The new direction paper number will be P2000. We don't know when it will come out yet.

If you are planning a proposal for C++23 and you are not already gathering field experience, you probably should.

- **ABI Group (Vandevoorde)**

Daveed Vandevoorde presents.

We will start very soon. I was approached with some questions, thank you very much. Please send me an e-mail to remind me. If you have some doubts about ABI, please contact us.

8. Closing activities

8.1 Issues delayed until today

8.2. PL22.16 motions, if any

No discussion.

9. Plans for the future (PL22.16)

9.1 Next and following meetings

2020-02-10/15: Prague, Czechia (N4817)

Please book the hotel soon.

2020-06-08/13: Varna, Bulgaria (N4825)

2020-11-16 to 21: New York, NY, USA; Bloomberg
Details will be in the post-meeting mailing
The dates may change.

2021-02-22 to 27: Kona, HI, USA; Standard C++ Foundation, Plum Hall, Jens Maurer
The details are already available.

2021-summer: (Montreal, Canada)
2021-autumn: (tbd)
2022-02-07 to 12: Portland, OR, USA; Intel

9.2. Mailings

- 2019-11-25: Post-Belfast
- 2020-01-13: Pre-Prague

10. Adjournment

Walter Brown presents.
Thank you the host and the sponsors.
Thank you to everyone that participated and those who helped us participate.

PL22.16 motion to adjourn.
Marshall Clow moves. Barry Hedquist seconds.
Approved by unanimous consent.

John Spicer adjourns the meeting at 11:14 am UTC.

11. Attendance

Name	Organization	National Body
Aaron Ballman	GrammaTech Inc	
Alan Talbot	LTK Engineering Services	
Alex Christensen	Apple	
Alisdair Meredith	Bloomberg	
Andreas Fertig		
Andreas Weis	BMW AG	DE
Andrzej Krzemienski	Sabre	PL
Anton Polukhin	Yandex.Taxi	RU

Name	Organization	National Body
Antony Peacock		
Arvid Norberg		
Attila Feher	Bloomberg	
Axel Naumann	CERN	CH
Barry Hedquist	Perennial	
Barry Revzin	Jump Trading	
Benjamin Craig	National Instruments	
Benjamin Saks	Saks & Associates	
Billy Baker	FlightSafety International	
Billy O'Neal	Microsoft Corporation	
Botond Ballo	Mozilla	CA
Brian Van Straalen	Lawrence Berkeley National Laboratory	
Bruno Lopes	Apple	
Bryce Adelstein Lelbach	NVidia Corporation	
Caleb Sunstrum	Edison Design Group	
Casey Carter	Microsoft Corporation	
Chandler Carruth	Google	
Chanyoung Park	Facebook	CA
Charles-Henri Gros	Synopsys Inc	
Chris Kennelly	Google	
Chris Kohlhoff		GB
Chris Tapp		
Christian Trott	Sandia National Laboratories	
Christof Meerwald	Programming Research Ltd	
Christopher Di Bella		GB
Christopher Earl	Lawrence Livermore National Laboratory	
CJ Johnson	Google	
Clive Pygott		
Colin A MacLean	Lawrence Berkeley National Laboratory	
Conor Hoekstra	NVidia Corporation	

Name	Organization	National Body
Corentin Jabot		FR
Damien Lebrun-Grandie	Oak Ridge National Laboratory	
Daniel Sunderland	Sandia National Laboratories	
Darius Marian		
Daryl Haresign	Bloomberg	
Daveed Vandevoorde	Edison Design Group	
David Goldblatt	Facebook	
David Hollman	Sandia National Laboratories	
David Olsen	NVidia Corporation	
David Sankel	Bloomberg	
David Stone	Uber	
Davis Herring	Los Alamos National Laboratory	
Dawid Pilarski		PL
Detlef Vollmann	Vollmann Engineering	CH
Dietmar Kühl	Bloomberg	
Domagoj Šarić	Microblink Ltd	
Duygu Cakmak		
Elias Kosunen		
Ellen Hedrick	Edison Design Group	
Eric Niebler	Facebook	
Erich Keane	Intel Corporation	
Fabio Fracassi	CODE University Berlin	DE
Felix Hellmann		
Frank Birbacher	Bloomberg	
Gabriel Dos Reis	Microsoft Corporation	
Gašper Ažman	Citadel Securities Europe	GB
Geoffrey Romer	Google	
Glenn Lee	Schonfeld Tools LLC	
Gor Nishanov	Microsoft Corporation	
Gordon Brown	Codeplay	
Graham Lopez	Oak Ridge National Laboratory	
Grzegorz Gach	Motorola Solutions	PL

Name	Organization	National Body
Guy Davidson	Creative Assembly	GB
Hal Finkel	Argonne National Laboratory	
Hana Dusíková	AVAST	CZ
Hannes Hauswedell		
Hans Boehm	Google	
Herb Sutter	Microsoft Corporation	
Howard Hinnant	Ripple Labs	
Hubert Tong	IBM Corporation	CA
Iain Sandoe		
Ilya Burylov	Intel Corporation	
J. Daniel García	University Carlos III of Madrid	ES
J.C. van Winkel		NL
James Dennett	Google	
James Touton	Blizzard	
Jamie Allsop		GB
Jared Hoberock	NVidia Corporation	
Jason McGuiness		
Jason Merrill	Red Hat Inc	
Jean-Francois Bastien	Apple	CA
Jean-Paul Rigault	Université de Nice S.A.	FR
JeanHeyd Meneide		
Jeff Garland	Crystal Clear Software	
Jeff Snyder	PDT Partners	GB
Jeffrey Mendelsohn	Bloomberg	
Jens Maurer	Edison Design Group	
John Lakos	Bloomberg	
John McFarlane	JLR	GB
John Spicer	Edison Design Group	
Jonathan Brian Coe		GB
Jonathan Caves	Microsoft Corporation	
Jonathan Wakely	Red Hat Inc	GB
Joshua Berne	Bloomberg	

Name	Organization	National Body
Josko Nikolic		
Juan Alday	GreenWireSoft	
Kristof Beyls	ARM Ltd	
Lars Gullik Bjønnes	Cisco Systems Inc	
Lawrence Crowl	Perennial	
Lee Howes	Facebook	
Lewis Baker	Facebook	
Li-Ta Lo	Los Alamos National Laboratory	
Lisa Lippincott	Tanium	
Louis Dionne	Apple	CA
Łukasz Wojakowski	Nokia	PL
Maged Michael	Facebook	
Marcin Grzebieluch	Sii Poland	PL
Marco Foco	NVidia Corporation	
Mark Hoemmen	Sandia National Laboratories	
Mark Zeren	VMware Inc	
Marshall Clow	C Plus Plus Alliance Inc	
Martin Janzen		
Mateusz Pusz	EPAM Systems Inc	PL
Mathias Stearn	MongoDB Inc	
Matt Calabrese	Google	
Matthias Kretz	GSI	DE
Matti Rintala	Tampere University	FI
Mauro Bianco	CSCS	CH
Michael McLaughin		
Michael Spencer	Apple	
Michael Spertus	Symantec	
Michael Voss	Intel Corporation	
Michael Wong	Codeplay	CA
Michał Dominiak	NVidia Corporation	PL
Mihail Mihaylov	VMware Inc	BG
Mike Herrick	Edison Design Group	

Name	Organization	National Body
Milind Girkar	Intel Corporation	
Mingxin Wang	Microsoft Corporation	
Nathan Burgers	Bloomberg	
Nathan Sidwell	Facebook	
Nathaniel Goodspeed	Linden Research, Inc	
Neil Horlock		GB
Nevin Liber	Argonne National Laboratory	
Niall Douglas		
Nicolai Josuttis		DE
Nina Dinka Ranns	Edison Design Group	GB
Olga Arkipova	Microsoft Corporation	
Olivier Giroux	NVidia Corporation	
Pablo Halpern	Halpern-Wight Inc	
Pal Balog		
Paolo Carlini	Oracle	
Paul McKenney	Facebook	
Peter Bindels	TomTom	
Peter Brett	Cadence	GB
Peter Sommerlad	HSR	CH
Petter Wahlman	Cisco Systems Inc	
Richard Corden	Programming Research Ltd	
Richard Smith	Google	
Robert Douglas	Aquatic Group LLC	
Robert Leahy		
Robert Schumacher	Microsoft Corporation	
Robert Simpson	Qualcomm Inc	
Robert Steagall	KEWB Computing	
Roger Orr		GB
Ronan Keryell	Xilinx	
Rostislav Khlebnikov	Bloomberg	
Ruslan Arutyunyan	Intel Corporation	
Ryan McDougall	Aurora Innovation	CA

Name	Organization	National Body
Sebastian Büttner		
Shuo Feng Liu	IBM Corporation	CA
Simon Cooksey		
Sophia Poirier	Apple	
Stéphanie Even	MBRDNA	
Stephen Michell		
Stephen Schurr	Ripple Labs	
Steve Downey	Bloomberg	
Thomas Köppe	Google	
Thomas Scogland	Lawrence Livermore National Laboratory	
Thomas Wise	Microsoft Corporation	
Tim Northover	Apple	
Tim Song	Jump Trading	
Tim van Deurzen		
Timothy Costa	NVidia Corporation	
Timur Doumler		GB
Titus Winters	Google	
Tom Honermann	Synopsys Inc	
Tomasz Kamiński	Sabre	PL
Tristan Brindle		
Vasil Vasilev	BDS	BG
Victor Zverovich	Facebook	
Ville Voutilainen	Plum Hall Inc	FI
Vincent Reverdy	Paris Observatory	FR
Vito Giovanni Castellana	Pacific Northwest National Laboratory	
Vittorio Romeo	Bloomberg	
Walter Brown	Brown	
William Miller	Edison Design Group	
William Seymour	Seymour	
Zach Laine	Cadence	