WG21 2020-02 Prague
Minutes of Meeting

ISO/IEC JTC1 SC22 WG21 N4855— 2020-02-22

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Chair: John Spicer

1. Opening activities

John Spicer opened the meeting at 9:01AM UTC+1.

1.1 Opening comments, welcome from host

John Spicer presents.

Hana Dusíková presents.

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, your NB representative or a subgroup chair.
Everyone is expected to abide by these rules.
John opens the discussion about CoC.

1.3 Membership, voting rights, and procedures for the meeting

John Spicer presents voting rights.

Hal Finkel reminds the room to sign attendance sheet and to wear name tags.
If you need a paper number, please use the isocpp.org website. There is an information about the paper number system on the meeting independent section of the wiki.

If you are representing an organization that is considering formally joining PL22.16, or your organization is already a member and you wish to change your voting status, please inform an officer.

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 subgroups 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 remaining NB comments. In addition, there may be some work done on library fundamentals TS features.

PL22.16 motion to approve the meeting agenda.
Barry Hedquist 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	N4850	N4849
Library Fundamentals TS	N4841	N4840

PL22.16 motion to approve the working drafts.
Barry Hedquist moves. Marshall Clow seconds. The motion is unanimously approved by PL22.16.

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

1.7 Approval of the minutes of the previous meetings

Meeting	Minutes
WG21 Belfast	N4839
PL22.16 Belfast	pl22.16-2019-00 0011
WG21 pre-Prague administrative telecon	N4851

PL22.16 motion to approve minutes of the previous meeting.
Barry Hedquist moves. Marshall Clow 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

Jens Maurer presents.

Jens presents the meeting times.
Jens presents the meeting rooms.
Jens presents evening activities.

6. WG and SG sessions

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. Please pay attention to the polls. If you have any questions or concerns, please raise them as soon as possible with the appropriate WG chair. We want to avoid surprises on Saturday morning.

Meeting adjourned at 9:54 AM UTC+1.

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

Review of the meeting postponed to 9:00 AM due to long queues for the checkout at the hotel.

John Spicer opens the meeting at 9:00am UTC+1.

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.

WG and SG status and progress reports.

- ## SG1: Concurrency (Giroux)

Bryce Adelstein Lelbach presents.
At this meeting, executors design approved in LEWG. In Varna we expect wording review in LEWG. Target is to have executors ready to merge to IS in Kona in order to have executors and features that depend on executors ready for C++23.

When we're not working on executors wording we will be doing design on :
• Concurrent algorithms.
• Parallel algorithms with executors.
• Coroutine interop.
• Future interop.
And more...

We will also be consulting on:
- Networking
- Asynchronous I/O

- ## SG2: Modules (Stone)

No report.

- ## SG4: Networking (Snyder)

Jeff Snyder presents.
SG4 met for day and a bit. We reviewed one paper. We received various feedback on the Networking TS to modernise it and bring it up to the latest version of C++ . We're not blocked on wording of executors, we can do our work toward having an API which will work seamlessly with the executors.

- ## SG5: Transactional memory (Boehm)

Hans Boehm presents.
SG5 made progress this week, in spite of not meeting. SG1 started the wording review of transactional memory lite proposal. We hope to make it into a TS.

- ## SG6: Numerics (Lippincott)

Lisa Lippincott presents.

We processed one national body comment and four papers during our meeting on Monday. During the joint evolution discussion we lacked quorum, but had productive discussions of two other papers.
Tuesday we met in joint session with LEWGI, processing ten papers, including the linear algebra and physical units papers. We had further discussions of linear algebra with LEWGI on Thursday. Friday, we met in joint session with SGs 14 and 19, processing five mathematics papers, and held a very productive evening discussion on the physical units library.
The linear algebra and physical units efforts have proceeded nicely this week. Several major contributors to the Numbers TS were unavailable this meeting, and we made less progress on that front.

We have a random number generator on the horizon that is highly tuned for parallel execution and easy moving of the generator to another host.
We are also having discussions related to statistical functions.

- ## SG7: Compile-time programming (Dusíková)

Hana Dusíková presents.
SG7 met on Thursday, we discussed naming of reflection keywords, but we didn't decide anything.

We looked at JIT compilation and ask authors to research possibilities of unifying API with reflection. We also discussed reflection-based lazy-evaluation.

We also had lengthy discussion of compile-time programming model of C++ and decided we don't want to have ability to run any arbitrary code during compilation inside a compiler.

- ## SG10: Feature test (Revzin)

No report.

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

Gabriel Dos Reis presents.
SG12 met for three days. On Monday we had a joint session with MISRA. On Tuesday we had a joint session with WG23. Michael Wong chaired the session.

On Wednesday we discussed undefined behaviour. There were 6 papers, 2 of which mostly informative. There was one paper that we will move forward to core. It is an attempt to enumerate all known core undefined and unspecified behaviour. After that review, we decided to have an update to the process in EWG to ask proposal authors to provide an example and rationale if we are introducing new undefined behaviour.

Michael Wong presents.
On Monday we met with MISRA and considered single exit, exceptions and dynamic memory, brace initialisation, volatiles and others. MISRA is close to being published.
On Tuesday we spent all day on adding guidelines for templates and generics. This was a complex session, we wanted to show that templates is a good facility for type safety and to correctly categorise the issues. We are getting close to publishing the guidelines. There are 2 or 4 guidelines we haven't looked at yet.

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

Roger Orr presents.
SG13 had a brief presentation of extracts from the 2019 CppCon keynote featuring Ben Smith showing web assembly in use.

We looked at [A Brief 2D Graphics Review] and encouraged exploration of work towards a separable color proposal, likely using on linear algebra .

Finally we worked through the use cases in [Audio I/O Software Use Cases]. We have a couple of weeks before the post meeting mailing deadline to collect additional use cases and will then solicit feedback on them from WG21 and the wider C++ community.

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

Michael Wong presents.
SG14 and SG19 met on Friday morning and Friday afternoon.
We looked at two papers on linear algebra and we want them to progress concurrently through LEWG and LWG.

We got a report back on the freestanding utilities. Given the fact that a lot of changes to the freestanding would not be acceptable, we decided to pick parts that will work out and we think that direction is working out well.
We reviewed the current and past status of SG14 and SG19 papers. It is now in a spreadsheet table which tells you which features got in and which features we are advancing, as well as features we are watching.
We looked at the progress of affinity and executors.
We got feedback from the financial group on how they would like to be able to pin separate threads.
We discussed a Low-cost Deterministic C++ Exceptions for Embedded Systems paper. It shows how current exception handling system can be implemented so it gives you deterministic bounds. You can find it on SG14 wiki.

As usual, these were joint session between SG14, SG19, and SG6

- ## SG19: Machine Learning (Wong)

Michael Wong presents.
We started looking at simple statistical function. The authors have been ping ponging between two designs. We have decided to set a high level goal and have the authors follow that goal and come back. There was a lot of feedback from SG6 and the Polish delegation. We will try to enlist these people to improve the paper.
We also looked at graph library paper which is progressing well.
The third paper we looked at is about automatic differentiation. This is an extremely important topic in machine learning. The paper needs direction between having a language or a library design. We would like to partly base this on a library design, but some of it will depend on the work SG7 is doing. We advised the authors to follow the progress of SG7 reflection design.

- ## SG15: Tooling (Adelstein Lelbach)

Bryce Adelstein Lelbach presents.
We met all day Friday. We looked at 6 papers. 4 were related to Modules Ecosystem TR. This is the second meeting where we have seen proposals unrelated to modules, this time we saw two papers related to the coroutines debugging experience. I suspect we will see more papers in this space in the future.

We asked the authors of the following papers to produce a
combined P-number initial draft for review at Varna:

P1689 Dependency Information Format
P1788 Module Recipe and BMI Reuse
P1838 User-Facing Lexicon and File Extensions

The intention is that such a P number paper will be a target for other content for a tooling TR.

We had two guest chairs, Michael Spencer and Ben Boeckel. They both did an excellent job.

- ## SG18: LEWGI (Adelstein Lelbach)

Bryce Adelstein Lelbach presents.
We met on Monday, Tuesday, Wednesday, and part of the day on Thursday. We had a joint session with SG6 Numerics on Tuesday and Thursday. We worked on a variety of numerics proposal.

We saw 22 papers, 14 of which are early proposals and 8 we have seen before.

No consensus to pursue - 2 papers
Further LEWGI direction review - 4 papers
Further LEWGI design review - 7 papers
Sent to LEWG - 8 papers
No action or sent to other group - 1 paper

Major work done :

P1883/P1031 Level I/O (LLIO)

Numerics TS
P1385 Linear Algebra
P1350/P1300 Units

Concurrency TS v2
P0260/P1958 Concurrent Queues

We had four guest chairs who did an excellent job. They were Billy Baker, Nevin Liner, Ryan McDougall, and Fabio Fracassi.

- ## SG16: Unicode (Honermann)

Tom Honermann presents.
SG16 met for one and half days. We struggled with quorum because of std::optional-ref discussion. Thank you to the scribes.
The most interesting topic we discussed involved the interaction between execution character sets and compile time evaluation as in the std::embed proposal and reflection. We found the answer in UTF-8 and are continuing in that direction.
We looked at 7 papers. 6 have progressed. Several went to EWG, and some will come back in Varna.
We had to turn down a std::regex proposal due to severe ABI considerations. We have a number of volunteers to bring a proposal to deprecate std::regex.

- ## SG17: EWG Incubator (Ballo)

Botond Ballo presents.

SG17 met for 3 days. We looked at approximately 23 papers.

Forwarded to EWG
● P2025R0 (Guaranteed copy elision for named return objects)
● P0870R1 (A proposal for a type trait to detect narrowing conversions)

Forwarded to EWG with modifications
● P1858R1 (Generalized pack declaration and usage)

- P2044R0 (Member templates for local classes)
- P1112R3 (Language support for class layout control)
- P1912R1 (Types with array-like object representations)
- P2008R0 (Enable variable template template parameters)
- P2013R0 (Freestanding language: optional ::operator new)
- P1949R1 (C++ identifier syntax using unicode standard annex 31)
- P1144R5 (Object relocation in terms of move plus destroy)

Gave feedback, did not forward
- P2011R0 (A pipeline-rewrite operator)
- P1985R0 (Universal template parameters)
- P2034R0 (Partially mutable lambda captures)
- P1609R3 (C++ should support just-in-time compilation)
- P1029R3 (move = bitcopies)

Forwarded to other subgroups
- P2069R0 (Stackable, thread local signal guards) − ---> SG1, LEWG-I
- P1905R0 (In-source mechanism to identify importable headers) − ---> SG15

May return after significant revisions / additional motivation
- P1818R1 (Narrowing and widening conversions)
- P1920R0 (Proposal of namespace templates)
- P1848R0 (Improve rules of standard layout)
- P2068R0 (Using ?: to reduce the scope of constexpr if)

No consensus at this time
- P1881R1 (Epochs: a backward-compatible language evolution mechanism)

◦ SG20: Education (van Winkel)

JC van Winkel presents.
SG20 met all day on Friday and we had a very productive day. In the morning we enjoyed a presentation by Peter Sommerlad about Class design & special member functions and a report by Mike Spertus on his experience with teaching C++ with the subject of pointers delayed as much as possible. Finally we had a good discussion with Scott Schurr about education and undefined behavior.

The entire afternoon we spent on ironing out a skeleton for education guidelines for a "module topic". In these topics we discern foundational and more advanced aspects and where the border lies for a curriculum (don't teach things that would be for the super experts only, rather mention what a student could explore by themselves by referring to other materials). We also started work on two of these topics from our module document p1725 to be used as example for authors of guideline topics. These topics were user defined literals and copy semantics.

We will have regular telecons and our main focus will be having volunteers creating topic education guidelines using the examples and the skeleton. We encourage

people who are interested in writing education guidelines for topics mentioned in p1725 to contact us.

- ## SG21: Contracts (Spicer)

John Spicer presents.
SG21 met for half a day on Friday. We had a presentation by Ville on previous disagreements. We also saw a paper from Herb on assert vs assume. We took a number of directional polls based on that.
We are planning to have a telecon between now and Varna. We are planning to have a two half day sessions in Varna.

- ## ABI group (Vandevoorde)

No report.

- ## Evolution (Bastien)

JF Bastien presents.
EWG had a joint session with LEWG regarding ABI break policy.
Some polls are difficult to interpret. We decided not to promise ABI stability.
Most people are saying we should consider incremental ABI for every C++ release. This is not saying we will do it, this is saying we will consider it.
We did not have a consensus for a big ABI break for C++23, but it's important to notice a lot of people are in favour of it.
There were far more people in favour of a big ABI break at some point in time, but there were still 14 strongly against votes. Technically, this is not a strong consensus, but I think it's strong enough of a consensus to consider such a break. Considering something doesn't mean we will do it.
We also took a poll that says when we are unable to resolve a conflict between performance and ABI compatibility, we should prioritize performance. There were more positive votes than negative, but a lot of strongly against votes.

We addressed all NB comments.
We reviewed 36 papers. We saw all EWG papers, including some EWG-i papers.
Two papers had no consensus to change.

Papers of note :
- P1000 C++ IS schedule
- P0592 To boldly suggest an overall plan for C++23
- P1999 Process - double check evolutionary material via a Tentatively Ready status. This means that every paper we approve, we will make tentatively ready and wait one meeting before it goes to core.
- P2118: Documenting Core Undefined or Unspecified Behavior

Herb Sutter : P1999 is a very important paper for our process. The purpose of that extra meeting is to allow everyone to keep an eye out for all the new features coming in and to raise concerns early.

Tentatively ready papers (following our new process)
• P1847 Make declaration order layout mandated
• P2025 Guaranteed copy elision for named return objects
• P1949 C++ Identifier Syntax using Unicode Standard Annex 31

- **Library Evolution (Winters)**

Titus Winters presents.

Summary
We resolved all 3 remaining NB comments. We got through around 41 papers.
~10 design fixes for C++20.
There are still 40 papers left unreviewed. There is a significant backlog since Belfast.

Policy changes related papers :
Approved
P1999 - Process proposal: double-check evolutionary material via a Tentatively Ready status
P0592 - To boldly suggest an overall plan for C++23
P1851 - Guidelines For snake_case Concept Naming
P1656 - Throws: Nothing should be noexcept
P1000R4 - C++ IS schedule
Discussed
P1863 - ABI, Now or Never / P2028 - What is ABI and What Should WG21 Do About It?
P2027 - Moved-from objects need not be valid
P2065 - naming and aliases
Policy Changes

Tentatively ready papers :
P1901 - Enabling the Use of weak_ptr as Keys in Unordered Associative Containers
P1413 - Deprecate std::aligned_storage and std::aligned_union
P0401 - Providing size feedback in the Allocator interface

Forwarded to LWG
P2081 - Rebase the Library Fundamentals v3 TS on C++20
P1202 - Asymmetric Fences

Discussed but not forwarded

Executors
P0443 - A Unified Executors Proposal for C++

We approved (Unanimously) the design for Executors. We are awaiting draft wording, and will do a detailed review of the wording-design when that is available (presumably in Varna).

Discussed but not forwarded
P0901 - Size feedback in operator new
P1678 - Callbacks and Composition
P1619 - Functions for Testing Boundary Conditions on Integer Operations
P1028 - SG14 status_code and standard error object for P0709 Zero-overhead deterministic exceptions
P0211 - Allocator-aware library wrappers for dynamic allocation
P2037 - String's gratuitous assignment
P1899 - stride_view
P1843 - Comparison and Hasher Requirements
P1790 - Networking TS changes to enable better DynamicBuffer composition

Discussed but not forwarded
P1843 - Comparison and Hasher Requirements
P1406 - Add more std::hash specializations
P1425 - Iterators pair constructors for stack and queue
P1927 - Add std::is_partitioned_until algorithm
P1030 - std::filesystem::path_view

Varna will be my last meeting as chair. Chair appointment news will be forthcoming.

- ## Core (Miller)

Mike Miller presents.
Our primary task for this week was to resolve NB comments started. We started with 27 and had a couple more come in from EWG. There are currently no open NB comments. Everything we considered ended on polls page. In addition to NB comments, we had several new features and changes that have been approved previously by EWG. In spare time we looked at those and you will see them in the polls. The order they appear on a polls page is the way we process them during the week.
I would like to call out poll number 8 (P2092R0). The instruction we got from EWG is to get this in C++20 if possible. We thought it was a bug fix level change, but it does deal with the definition of the language, rather than just wording. The issue resolves an ambiguity in the syntax.
We also had a few issues resolutions in between features and NB comments. You will see a collection of those in poll number 9.

Poll number 13 depends on changes that are in polls 1 and 3. The resolution from core is if either of them fails, we will withdraw poll number 13.
Poll number 17 depends on poll number 16. Poll number 17 has alternative wording based on whether 16 passes or fails.
We hoped to look at P1787, a massive rewrite of the look up rules. This has been a problem area for a long time and Davis is trying to find a unified approach. We took a brief look at and decided we can't deal with it in C++20 time frame. We think we can make progress in Varna and may very well pushback against new feature requests in order to spend a significant time progressing it. We want to get this early in C++23 and get some experience with it.
We will have 2 issues processing teleconferences to make some progress with open issues

CWG Polls

1. Apply the changes in P2103R0 (Core Language Changes for NB Comments at the February, 2020 (Prague) meeting) to the C++ working paper (addressing US028, US033, US041, CA104, CA107, US115, and US117) and accept the changes for US028 and US041 as Defect Reports.

No objection to unanimous consent.
Motion passes.

2. Apply the changes in P1779R3 (ABI isolation for member functions) to the working paper (addressing US090).

No objection to unanimous consent.
Motion passes.

3. Apply the changes in P1857R3 (Modules Dependency Discovery) to the C++ working paper (addressing US026, US121, US125, GB126, US127, US128, US136, US137, US138, US139, and US140).

No objection to unanimous consent.
Motion passes.

4. Accept as a Defect Report and apply the changes in P0593R6 (Implicit creation of objects for low-level object manipulation) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

5. Accept as a Defect Report and apply the changes in P1957R2 (Converting from T* to bool should be considered narrowing (re: US 212)) to the C++ working paper (addressing US212).

Objections in the room.

Herb Sutter explains the voting rules.

In favour : 51
Opposed : 0
Abstain : 22

Motion passes.

6. Apply the changes in P2104R0 (Disallow changing concept values) to the C++ working paper (addressing GB046).

No objection to unanimous consent.
Motion passes.

7. Apply the changes in P2107R0 (Core Issue 2436: US064 Copy semantics of coroutine parameters) to the C++ working paper (addressing US064).

Objections in the room.
In favour : 41
Opposed : 1
Abstain : 27

Motion passes.

8. Apply the changes in P2092R0 (Disambiguating Nested-Requirements) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

9. Accept as Defect Reports and apply the changes in P2108R0 (Core Language Working Group "ready" Issues for the February, 2020 (Prague) meeting) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

10. Apply the changes in P2109R0 (US084: Disallow "export import foo" outside of module interface) to the C++ working paper (addressing US084).

No objection to unanimous consent.
Motion passes.

11. Apply the changes in P2082R1 (Fixing CTAD for aggregates) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

12. Apply the changes in P2113R0 (Proposed resolution for 2019 comment CA 112) to the C++ working paper (addressing CA112 and US120).

No objection to unanimous consent.
Motion passes.

13. Apply the changes in P2115R0 (US069: Merging of multiple definitions for unnamed unscoped enumerations) to the C++ working paper (addressing US069).

No objection to unanimous consent.
Motion passes.

14. Apply the changes in P1815R2 (Translation-unit-local entities) to the C++ working paper (addressing US035, US133, and US134).

No objection to unanimous consent.
Motion passes.

15. Apply the changes in P2095R0 (Resolve lambda init-capture pack grammar (CWG2378)) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

16. Apply the changes in P2002R1 (Defaulted comparison specification cleanups) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

17. Apply the changes in P2085R0 (Consistent defaulted comparisons) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

18. Apply the changes in P1908R1 (Reserving Attribute Namespaces for Future Use) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

19. Apply the changes in P1937R2 (Fixing inconsistencies between constexpr and consteval functions) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

- ## Library (Clow)

Marshal Clow presents.
Our goals were: NB Comment processing, and to Rebase LFTS to C++20.
We accomplished both of them. Started the week with 48, and ended up with 1.
“Resolve all open Library issues”

We’re moving 25 C++ papers this week, and one LFTS paper.
Two issues papers, totaling 123 issues resolved (incl NAD/Resolved)
Finished Mandating the library clauses (Yay!)
Many papers resolving NB comments

Thanks to everyone who participated, and especially to the scribes.

This is my final meeting as LWG Chair. Keeping with the tradition that LWG chair serves for five years. My first meeting as chair was Lenexa (May 2015). Jonathan Wakely will serve as LWG chair starting as soon as plenary is over.

I did some looking back at the LWG bug list, and I discovered out that I have failed at whittling down the bug list.

In the pre-Lenexa mailing, there were 292 open bugs (1722 total).
In the post-Prague mailing, there should be ~290 open bugs (2921 total).

Thank you for all your help!

LWG Polls

Library Fundamentals
1. Apply the changes in P2081R1 (Rebase the Library Fundamentals v3 TS on C++20) to the Library Fundamentals TS working paper.

No objection to unanimous consent.
Motion passes.

Issues
2. Apply the changes in P2051R0 (C++ Standard Library Issues to be moved in Prague) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

3. Apply the changes in P2117R0 (C++ Standard Library Issues Resolved Directly In Prague) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

C++20

4. Apply the changes in P2045R1 (Missing Mandates for the standard library) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

5. Apply the changes in P1460R1 (Mandating the Standard Library: Clause 20 - Utilities library) to the C++ working paper.

No objection to unanimous consent.
Motion passes.

6. Apply the changes in P1963R0 (Fixing US 313) to the C++ working paper. This resolves US313 and LWG issue 3156

No objection to unanimous consent.
Motion passes.

7. Apply the changes in P1983R0 (Wording for GB301, US296, US292, US291, and US283) to the C++ working paper. This resolves GB301, US296, US292, US291, US283, and LWG issue 3278.

No objection to unanimous consent.
Motion passes.

8. Apply the changes in P1981R0 (Rename leap to leap_second) to the C++ working paper. This resolves DE345.

No objection to unanimous consent.
Motion passes.

9. Apply the changes in P1982R0 (Rename link to time_zone_link) to the C++ working paper. This resolves DE346.

No objection to unanimous consent.

Motion passes.

10. Apply the changes in P2101R0 ('Models' subsumes 'satisfies' (Wording for US298 and US300)) to the C++ working paper. This resolves US298, US300 and LWG issue 3345.

No objection to unanimous consent.
Motion passes.

11. Apply the changes in P1115R3 (Improving the Return Value of Erase-Like Algorithms II: Free erase/erase if) to the C++ working paper. This resolves DE231, GB234.

No objection to unanimous consent.
Motion passes.

12. Apply the changes in P2102R0 (Make 'implicit expression variations' more explicit (Wording for US185)) to the C++ working paper. This resolves US185.

No objection to unanimous consent.
Motion passes.

13. Apply the changes in P1994R1 (elements_view needs its own sentinel) to the C++ working paper. This resolves resolves LWG3386.

No objection to unanimous consent.
Motion passes.

14. Apply the changes in P1868R2 (width: clarifying units of width and precision in std::format) to the C++ working paper. This resolves US228 and LWG issue 3290.

No objection to unanimous consent.
Motion passes.

15. Apply the changes in P1956R1 (On the names of low-level bit manipulation functions) to the C++ working paper. This resolves PL326, US327, GB332, US328, GB331.

No objection to unanimous consent.
Motion passes.

16. Apply the changes in P1976R2 (Fixed-size span construction from dynamic range) to the C++ working paper. This resolves PL250.

No objection to unanimous consent.
Motion passes.

17. Apply the changes in P1964R2 (Wording for boolean-testable) to the C++ working paper. This resolves US198, US195, US196 and GB197.

No objection to unanimous consent.
Motion passes.

18. Apply the changes in P2091R0 (Issues with range access CPOs) to the C++ working paper. This resolves GB275, LWG issues 3258, 3299, 3368.

No objection to unanimous consent.
Motion passes.

19. Apply the changes in P0586R2 (Safe integral comparisons) to the C++ working paper, with the change of the name of the feature test macro from __cpp_lib_cmp_equal to __cpp_lib_integer_comparison_functions. This resolves DE208.

Objections in the room.
In favour : 70
Opposed : 1
Abstain : 8

Motion passes.

20. Apply the changes in P1831R1 (Deprecating volatile: library) to the C++ working paper. This resolves CZ004, CA210, US211.

No objection to unanimous consent.
Motion passes.

21. Apply the changes in P1973R1 (Rename "_default_init" Functions, Rev1) to the C++ working paper. This resolves DE002.

Objections in the room.
In favour : 44
Opposed : 3
Abstain : 28

Motion passes.

22. Apply the changes in P1243R4 (Rangify New Algorithms) to the C++ working paper. This resolves FR305, US318, US307.

No objection to unanimous consent.
Motion passes.

23. Apply the changes in P2106R0 (Alternative wording for GB315 and GB316) to the C++ working paper. This resolves GB315 and GB316.

No objection to unanimous consent.
Motion passes.

24. Apply the changes in P1739R4 (Avoid template bloat for safe_ranges in combination with "subrange-y" view adaptors) to the C++ working paper. This resolves DE288, US272

No objection to unanimous consent.
Motion passes.

25. Apply the changes in P2116R0 (Remove tuple-like protocol support from fixed-extent span) to the C++ working paper. This resolves LWG issue 3212

No objection to unanimous consent.
Motion passes.

26. Apply the changes in P1970R2 (Consistency for size() functions: Add ranges::ssize) to the C++ working paper. This resolves DE269.

No objection to unanimous consent.
Motion passes.

- ## Direction Group (Wong)

Michael Wong presents.
Thank you to Howard Hinnant for chairing the group before me.
We have published a new paper P2000R0, which is a continuation of P0939. We added a new section to help authors write papers. We would like to see up-to-date rationales in the proposals.

WG21 polls
~~**1. Apply the changes in D1732R3, "Do not promise support for function syntax of operators" to SD8.**~~
~~**2. Apply the changes in D1919R3c, "Expanding the Rights in SD8" to SD8.**~~

Herb Sutter : First two polls have been stricken because they were not well formed and referred to D papers. We will bring those two back in Varna.

3. Appoint a review committee composed of Marshall Clow, Davis Herring, Mike Miller, and Ville Voutilainen to approve the correctness of the C++ working paper as modified by the polls approved at this meeting, and to direct the Convener to transmit the approved updated working paper for DIS ballot.

Objections in the room.
In favour : 79
Opposed : 0
Abstain : 1

Motion passes.

Herb Sutter presents ISO process and what comes next.

4. Approve P1000R4 "C++ IS Schedule" as the official schedule for C++23.

No discussion.
No objection to unanimous consent.
Motion passes.

5. Approve P0592R4 "To boldly suggest an overall plan for C++23" as an official plan for C++23.

Objections in the room.
In favour : 48
Opposed : 8
Abstain : 18

Motion passes.

8. Closing activities

8.1 Issues delayed until today

No discussion.

8.2. PL22.16 motions, if any

No discussion.

9. Plans for the future (PL22.16)

9.1 Next and following meetings

2020-06-01/05: Varna, Bulgaria (N4825)

2020-11-9/14: New York, NY USA (N4848)

2021-02-22 to 27: Kona, HI, USA; Standard C++ Foundation, Plum Hall, Jens Maurer

2021-07-12 to 17: Montreal, Canada; Morgan Stanley

2021-autumn: (tbd)

2022-02-07 to 12: Portland, OR, USA; Intel

9.2. Mailings

- 2020-03-02: Post-Prague
- 2020-05-04: Pre-Varna

10. Adjournment

Thank you the host and the sponsors.

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

John Spicer adjourns the meeting at 11:52 am UTC+1.

11. Attendance

Name	Organisation	National body
Aaron Ballman	GrammaTech Inc	United States
Aditya Kotwal	VMware Inc	United States
Agustin Berge	Louisiana State University	United States
Alan Talbot	LTK Engineering Services	United States
Alexandru Voicu	AMD	United States
Andreas Fertig		

Name	Organisation	National body
Andreas Weis	BMW AG	
Andrew Sutton	Lock3 Software	United States
Andrzej Krzemieński	Sabre	Poland
Anton Filimonov	Kaspersky	
Antony Peacock		United Kingdom
Antony Polukhin		Russian Federation
Arvid Norberg		
Attila Nagy		
Avi Lachmish		
Barry Hedquist	Perennial	United States
Barry Revzin	Jump Trading LLC	United States
Ben Boeckel	Kitware, Inc.	
Ben Craig	National Instruments	
Ben Saks	Saks \& Associates	United States
Bengt Gustafsson	Context Vision	
Bernhard Gruber	CERN	
Billy Baker	FlightSafety International	United States
Billy O'Neal	Microsoft Corporation	United States
Bjarne Stroustrup	Morgan Stanley	United States
Bob Steagall	KEWB Computing	United States
Botond Ballo	Mozilla	Canada
Bruno Lopes	Apple	United States
Bryce Adelstein Lelbach	NVidia Corporation	United States
Caleb Sunstrum	Edison Design Group	United States
Casey Carter	Microsoft Corporation	United States
Chandler Carruth	Google	United States
Chanyoung Park	Facebook	Canada
Charles Barto	Microsoft Corporation	United States
Chris Kennelly	Google	United States
Chris Kohlhoff		United Kingdom

Name	Organisation	National body
Chris Tapp	LDRA	
Christian Trott	Sandia National Laboratories	United States
Christof Meerwald	Programming Research Ltd	United States
CJ Johnson	Google	United States
Colin MacLean	Lawrence Berkeley National Laboratory	United States
Conor Hoekstra	NVidia Corporation	United States
Conrad Poelman	Stellar Science	United States
Corentin Jabot		France
Damien Lebrun-Grandie	Oak Ridge National Laboratory	United States
Dan Raviv		
Daniel Klíma		
Daniel Krügler	Braker	
Daniel Sunderland	Sandia National Laboratories	United States
Daniela Engert	GMH Prüftechnik GmbH	
Daryl Haresign	Bloomberg	United States
Daveed Vandevoorde	Edison Design Group	United States
David Goldblatt	Facebook	United States
David Hollman	Sandia National Laboratories	United States
David Olsen	NVidia Corporation	United States
David Sankel	Bloomberg	United States
David Stone	Uber	United States
Davis Herring	Los Alamos National Laboratory	United States
Dawid Pilarski		Poland
Detlef Vollmann	Vollmann Engineering	Switzerland
Dietmar Kuhl	Bloomberg	United States
Dmitry Duka	NVidia Corporation	United States
Eric Niebler	Facebook	United States
Erich Keane	Intel Corporation	United States
Fabio Fracassi	CODE University Berlin	Germany

Name	Organisation	National body
Federico Kircheis		
Florian Sattler		
Frank Birbacher	Bloomberg	United Kingdom
Gabriel Dos Reis	Microsoft Corporation	United States
Gašper Ažman	Citadel Securities Europe	United Kingdom
Geoffrey Romer	Google	United States
Gor Nishanov	Microsoft Corporation	United States
Gordon Brown	Codeplay	United Kingdom
Graham Lopez	Oak Ridge National Laboratory	United States
Grzegorz Gach	Motorola Solutions	Poland
Guilherme Hartmann		United Kingdom
Guy Davidson	Creative Assembly	United Kingdom
Hal Finkel	Argonne National Laboratory	United States
Hana Dusíková	AVAST	
Hans Boehm	Google	United States
Herb Sutter	Microsoft Corporation	United States
Howard Hinnant	Ripple Labs	United States
Hubert Tong	IBM Corporation	United States
Iain Sandoe		United Kingdom
Ilya Burylov	Intel Corporation	United States
Inbal Levi	Solar Edge	Israel
Ivan Čukić	KDAB	
Ivan Komitov		Bulgaria
J. Daniel Garcia	University Carlos III of Madrid	Spain
J.C. van Winkel		Netherlands
Jakub Klener	Alteryx	
James Berrow		
James Dennett	Google	United States
James Touton	Blizzard	
Jamie Allsop		United Kingdom

Name	Organisation	National body
Jan Bečvář		
Jared Hoberock	NVidia Corporation	United States
Jason Liu	IBM Corporation	United States
Jason Merrill	IBM Corporation	United States
Jean-Francois Bastien	Apple	Canada
Jean-Paul Rigault	Université de Nice S.A.	France
JeanHeyd Meneide		Netherlands
Jeff Garland	Crystal Clear Software	
Jeff Snyder	PDT Partners	United Kingdom
Jeffrey Ira Mendelsohn	Bloomberg	United States
Jens Maurer	Edison Design Group	United States
John Biddiscombe		
John Lakos	Bloomberg	United States
John Spicer	Edison Design Group	United States
Jolanta Opara		Poland
Jonathan Caves	Microsoft Corporation	United States
Jonathan Coe		United Kingdom
Jonathan Madsen	Lawrence Berkeley National Laboratory	United States
Jonathan Müller		
Jonathan Wakely	IBM Corporation	United Kingdom
Jorg Brown	Google	United States
Joshua Berne	Bloomberg	United States
Juan Alday	GreenWireSoft	United States
Justin Bogner	Apple	United States
Karel Malý		
Kirk Shoop	Facebook	United States
Kristof Beyls	ARM Ltd	United Kingdom
Lars Gullik Bjønnes	Cisco Systems Inc	United States
Lawrence Crowl	Perennial	United States
Leonid Lysiuk	Alteryx	

Name	Organisation	National body
Lewis Baker	Facebook	United States
Li-Ta Lo	Los Alamos National Laboratory	United States
Lisa Lippincott	Tanium	
Loïc Joly	Sonar Source	France
Louis Dionne	Apple	Canada
Łukasz Bondyra	Motorola Solutions	
Maged Michael	Facebook	United States
Marc Mutz	KDAB	
Marcin Grzebieluch	Sii Poland	Poland
Marco Foco	NVidia Corporation	United States
Marina Efimova	Bloomberg	United States
Markus Mayer	Brainlab AG	
Marshall Clow	The C Plus Plus Alliance Inc	United States
Martin Hořeňovský	Lochsley.CZ	
Martinho Fernandes		
Mateusz Pusz	EPAM Systems Inc	Poland
Mathias Stearn	MongoDB Inc	United States
Matt Calabrese	Google	United States
Matt Zauber		
Matthew Butler	Laurel Lye	United States
Michael Hava	RISC Software	Austria
Michael Spencer	Apple	United States
Michael Spertus	Amazon Corporate LLC	United States
Michael Voss	Intel Corporation	United States
Michael Wong	Codeplay	Canada
Michał Dominiak	NVidia Corporation	Poland
Mihail Mihaylov	VMware Inc	Bulgaria
Mikael Kilpeläinen	CryptoTec	
Milind Girkar	Intel Corporation	United States
Morris Hafner	Codeplay	

Name	Organisation	National body
Mykola Garkusha	JP Morgan	
Nathan Burgers	Bloomberg	United States
Nathan Myers	Maystreet	
Nathan Sidwell	Facebook	United States
Nathaniel Goodspeed	Linden Research, Inc	United States
Neil Horlock		United Kingdom
Nemanja Boric	Amazon Corporate LLC	United States
Nevin Liber	Argonne National Laboratory	United States
Nicholas DeMarco	Adobe Systems Inc	United States
Nick De Breuck	Creative Assembly	
Nicolai Josuttis		Germany
Nina Ranns	Edison Design Group	United Kingdom
Norbert Wenzel		
Odin Holmes	Auto-Intern GmbH	
Oliver Kowalke	Secunet	
Olivier Giroux	NVidia Corporation	United States
Pablo Halpern	Halpern-Wight Inc	United States
Pal Balog		
Paolo Carlini	Oracle	United States
Pascal Menuet		France
Paul McKenney	Facebook	United States
Peter Bindels	TomTom	Netherlands
Peter Sommerlad	HSR	Switzerland
Petr Petyovsky		
Phil Nash		United Kingdom
Philip Craig		United Kingdom
Richard Corden	Programming Research Ltd	United States
Richard Smith	Google	United States
Robert Douglas	Aquatic Group LLC	United States
Robert Leahy		

Name	Organisation	National body
Robert Simpson	Qualcomm Inc	United States
Roger Orr		United Kingdom
Roland Schulz	Intel Corporation	United States
Ronan Keryell	Xilinx	
Ruslan Arutyunyan	Intel Corporation	United States
Ryan McDougall	Aurora Innovation	Canada
Sasha Sitnikov	Veeam	
Scott Hart	Google	United States
Scott Schurr	Ripple Labs	United States
Sebastian Büttner		
Sergei Vinogradov	Intel Corporation	United States
Simon Stienen	KARL STORZ	
Sophia Poirier	Apple	United States
Stefan Richter	HSR	
Stephanie Even	MBRDNA	
Stephen Michell		
Thomas Köppe	Google	United States
Thomas Scogland	Lawrence Livermore National Laboratory	United States
Tim Song	Jump Trading LLC	United States
Timur Doumler		United Kingdom
Titus Winters	Google	United States
Tobias Loew		
Tom Honermann	Synopsys Inc	United States
Tomáš Hering		
Tomasz Kamiński	Sabre	Poland
Tony Van Eerd	Christie Digital	Canada
Vassil Vassilev		
Victor Zverovich	Facebook	United States
Ville Voutilainen	Plum Hall Inc	Finland
Vincent Reverdy	Paris Observatory	France

Name	Organisation	National body
Vito Castellana	Pacific Northwest National Laboratory	
Vittorio Romeo	Bloomberg	United States
Volker Dorr	Cascade GmbH	
Volker Kokula		
Walter E Brown	Brown	United States
Wesley Maness	Schonfeld Tools LLC	United States
William Miller	Edison Design Group	United States
Wyatt Childers	Lock3 Software	United States
Zach Laine	Cadence	
Zhihao Yuan	SimpleRose Inc	United States
Zoe Carver		