# Standardizing C++

## How the sausage is made

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# Where does C++ come from?

* Released by Bjarne Stroustrup in 1985

* Standardized as ISO/IEC 14882

* Working Group 21

* Part of ISO/IEC JTC 1/SC 22

    * Programming languages, their environments and system software interfaces

    * Secretariat: American National Standards Institute (ANSI)

* Technical committee: ISO/IEC JTC 1

    * Information technology

* Supported by the ISO C++ Foundation

# C++ versions

* Latest is C++23:

  * https://www.iso.org/standard/83626.html
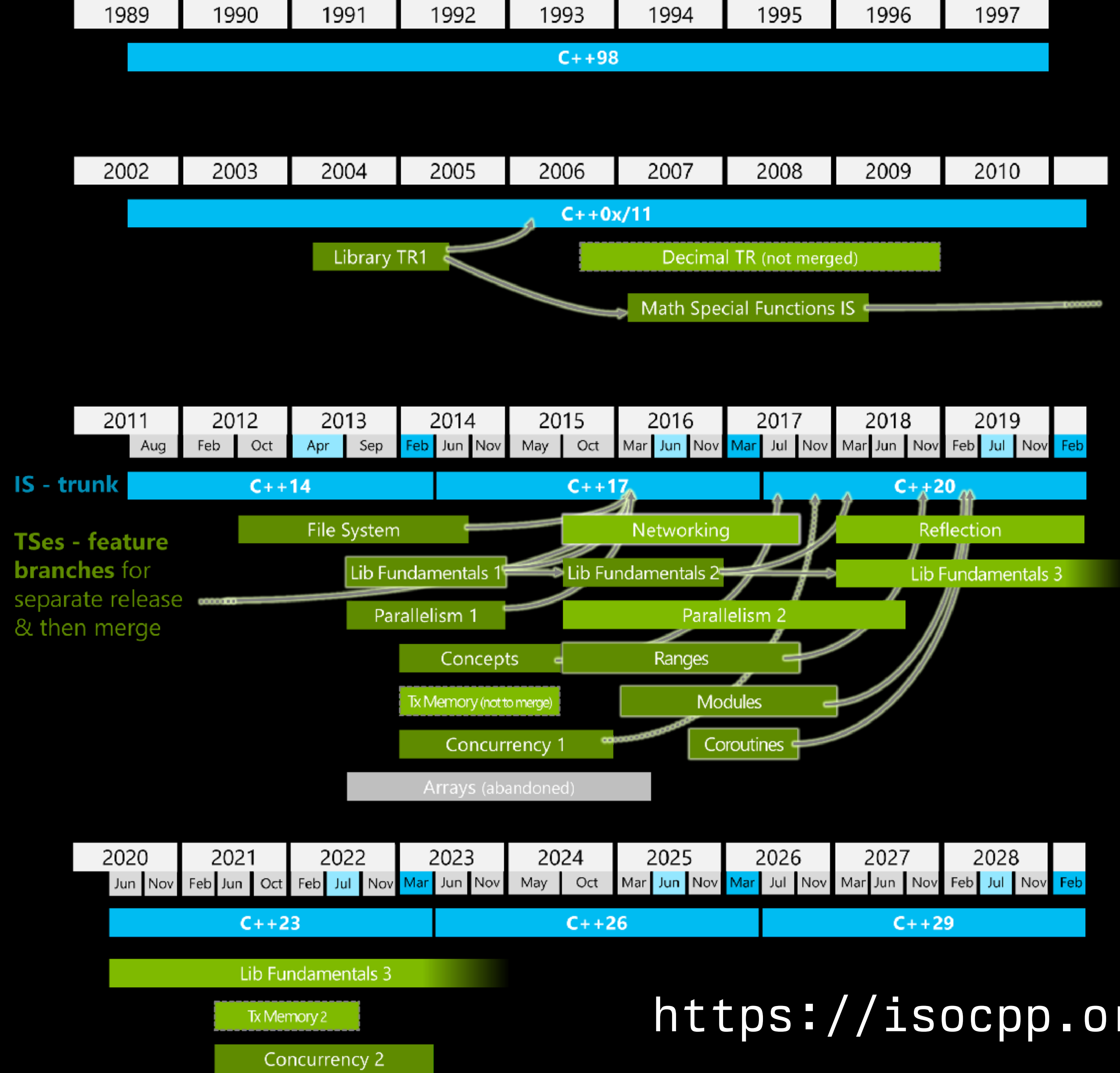
* Previous: C++98, C++03, C++11, C++14, C++17, C++20

* Nowadays, C++ is on a 3 year cadence: wg21.link/p1000

* C++26 is "feature complete", wording being finalized

* Technically, older standards are withdrawn and no longer exist, but the Committee still fixes some issues as "defect reports"

* Quiz: what's after C++26?

| 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|------|------|------|------|------|------|------|------|------|

**C++98**

| 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 |
|------|------|------|------|------|------|------|------|------|

**C++0x/11**

Library TR1
Decimal TR (not merged)
Math Special Functions IS

| 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | |
|------|------|------|------|------|------|------|------|------|--|
| Aug | Feb / Oct | Apr / Sep | Feb / Jun / Nov | May / Oct | Mar / Jun / Nov | Mar / Jul / Nov | Mar / Jun / Nov | Feb / Jul / Nov | Feb |

**IS - trunk**

| C++14 | C++17 | C++20 |
|-------|-------|-------|

**TSes - feature branches** for separate release & then merge

File System
Networking
Reflection
Lib Fundamentals 1
Lib Fundamentals 2
Lib Fundamentals 3
Parallelism 1
Parallelism 2
Concepts
Ranges
Tx Memory (not to merge)
Modules
Concurrency 1
Coroutines
Arrays (abandoned)

| 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | |
|------|------|------|------|------|------|------|------|------|--|
| Jun / Nov | Feb / Jun / Oct | Feb / Jul / Nov | Mar / Jun / Nov | May / Oct | Mar / Jun / Nov | Mar / Jul / Nov | Mar / Jun / Nov | Feb / Jul / Nov | Feb |

**C++23**
**C++26**
**C++29**

Lib Fundamentals 3
Tx Memory 2
Concurrency 2
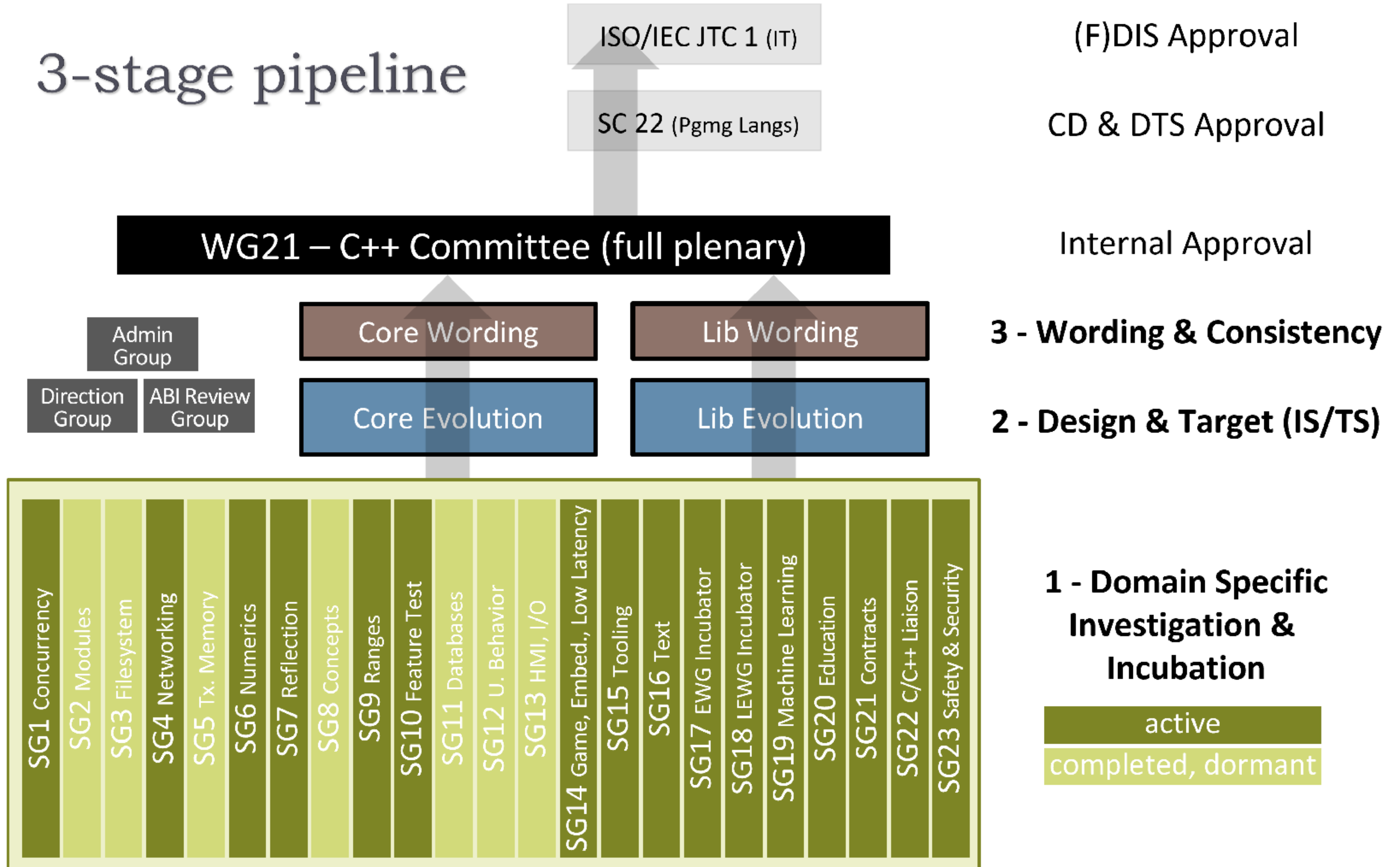
https://isocpp.org/std/status

# C++ implementations

* Language: GCC, clang, MSVC, EDG

* Library: libstdc++, libc++, MSVC STL

* https://en.cppreference.com/w/cpp/compiler support


Implementors participate heavily in the standardization process, and their input is highly valued. Major features usually do not progress without implementation, and sometimes deployment experience.

# C++ organization

* 4 working groups to handle language and library work

  * 2 wording & consistency: CWG / LWG

  * 2 design & target: EWG / LEWG

* 23 domain specific investigation & incubation study groups

* Each with a chair and sub-chair(s)

* https://isocpp.org/std/the-committee

* https://isocpp.org/std/standing-documents/sd-3-study-group-organizational-information

# 3-stage pipeline

ISO/IEC JTC 1 (IT)

SC 22 (Pgmg Langs)

(F)DIS Approval

CD & DTS Approval

**WG21 – C++ Committee (full plenary)**

Internal Approval

Admin Group

Direction Group | ABI Review Group

Core Wording

Lib Wording

**3 - Wording & Consistency**

Core Evolution

Lib Evolution

**2 - Design & Target (IS/TS)**

SG1 Concurrency
SG2 Modules
SG3 Filesystem
SG4 Networking
SG5 Tx. Memory
SG6 Numerics
SG7 Reflection
SG8 Concepts
SG9 Ranges
SG10 Feature Test
SG11 Databases
SG12 U. Behavior
SG13 HMI, I/O
SG14 Game, Embed., Low Latency
SG15 Tooling
SG16 Text
SG17 EWG Incubator
SG18 LEWG Incubator
SG19 Machine Learning
SG20 Education
SG21 Contracts
SG22 C/C++ Liaison
SG23 Safety & Security

**1 - Domain Specific Investigation & Incubation**

active
completed, dormant

# C++ roles

* Convener, vice-convener

* Secretary

* Project editor

* Chairs, co-chairs

* Participants

* Expert guests

# C++ work venues

* There are 3 in-person meetings per year

    * 6 day duration (Monday opening plenary, Saturday closing plenary)

    * Support for hybrid participation

    * 100-250 participants per meeting

    * Many concurrent & parallel discussion in different rooms

    * Hosted by volunteer organizations (company, university, ISO C++)

    * https://isocpp.org/std/meetings-and-participation/upcoming-meetings

    * https://isocpp.org/std/standing-documents/sd-5-meeting-information

* Many teleconferences between meetings

# C++ participation

* Participants can be guests of the convener for 2
  meetings, but must otherwise be registered with ISO
  through a National Body (NB)

* Different NBs have different rules for joining

* 31 National Bodies represented, including:

  * Austria, Bulgaria, Canada, China, Czech Republic,
    Denmark, Finland, France, Germany, Ireland, Israel,
    Italy, Japan, Kazakhstan, Republic of Korea,
    Netherlands, Norway, Poland, Portugal, Romania,
    Russia, Slovakia, Spain, Sweden, Switzerland,
    United Kingdom, and United States

* https://isocpp.org/std/meetings-and-participation

# C++ participation
## Without being a member

* Committee members are on the internet and listen

  * Social media

    * Twitter, Mastodon, Bluesky, LinkedIn, StackOverflow, r/cpp

  * Email such as https://lists.isocpp.org/mailman/listinfo.cgi/std-proposals

  * Conferences

    * CppCon, Meeting C++, ACCU, Core C++, C++ on Sea, CppNow, NDC, etc

* https://isocpp.org/std/submit-issue

* You don't actually need to be a committee member to write a paper!

# C++ decision making

## During meetings

* Working groups and sub-groups → one person, one vote

  * Chair decides polls, determines consensus (not majority vote)

  * https://github.com/cplusplus/LEWG/wiki/Interpreting-Polls

* Some groups do online polls

* Plenary: convener determines consensus


* The goal is always to increase consensus, and address sustained objections.

# C++ decision making
## Published documents

* Committee Draft (CD)

    * NBs can send comments

    * The committee addresses comments to increase consensus

* [Final] Draft International Standard ([F]DIS)

    * Ideally no more comments, directly approve based on consensus

* International Standard (IS) project 14882 🥳

* https://isocpp.org/std/iso-iec-jtc1-procedures

# C++ work outcomes

* "P" papers: proposal documents

* "N" papers: documents supporting standardization

* Work item tracking

* LaTeX draft

* Meeting notes

* Emails

* Chat

# C++ work outcomes
## "P" papers: proposal documents

* Usually a proposal for a change to the standard

* Should make a normative change (add/remove SHALL)

* Contains edit history, justification, wording, references

* Publish any time, but needs to be in the "pre-meeting mailing" a month before an in-person meeting to be considered

  * https://isocpp.org/std/submit-a-proposal

  * https://isocpp.org/std/the-life-of-an-iso-proposal

  * https://isocpp.org/std/standing-documents/sd-7-mailing-procedures-and-how-to-write-papers

# C++ work outcomes

## "P" papers: proposal documents

* Anyone can write a "P" paper, but submitting it requires either a committee member submitting the proposal, or obtaining an isocpp account

* Someone needs to champion a proposal at the committee, this can be done by convener guests

* These are *the* main way C++ is modified

* Papers can go through multiple revisions, and are sometimes inter-related

# C++ work outcomes

## "N" papers: documents supporting standardization

* Official ISO document

* A draft

* Editor report

* Official minutes

# C++ work outcomes

## Work item tracking

* We track everything as GitHub issues

* Papers and issues and NB comments are here

* Status, assigned group, polls

* https://github.com/cplusplus/papers/issues


"N" and "P" papers can be found through wg21.link/Pxxxx

There's a nice index: https://wg21.link/index.html

Mara wrote it in Rust 🤭

# C++ work outcomes
## LaTeX draft

* The entire standard is on GitHub as LaTeX

* Non-normative changes can just be pull requests

* Normative changes are handled by editors as pull
  requests after they have been voted through plenary

* https://github.com/cplusplus/draft

# C++ work outcomes

## Meeting notes

* Official meetings have notes published as "N" papers

* The rest (most of the discussions) are published in a
  wiki which only ISO members can access

  * https://wiki.edg.com/

* "Persistent" wiki with information for newcomers

  * https://wiki.edg.com/bin/view/Wg21PersistentInformation/WebHome

# C++ work outcomes
## Emails

* There are public and private lists

* Public ones are here: https://isocpp.org/std/forums

* Other lists can be found through the persistent wiki

* r/cpp: kinda like email, but not

  * https://old.reddit.com/r/cpp/

# C++ work outcomes

**Chat**

* There's a MatterMost chat instance for ISO members

* We moved off IRC! 🎉

# C++, the other bits

* Technical Specification (TS)

* Technical Report (TR)

* Whitepaper

# C++, intellectual property

* ISO owns the copyright to the final standard

* https://www.iso.org/iso-standards-and-patents.html

# C++, read more!

* https://isocpp.org/std/standing-documents/sd-4-wg21-practices-and-procedures

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always null-terminate your talks

lest you get UB and go OOB