

# SCIMMA: Real-time Orchestration of Multi-Messenger Astrophysical Observations

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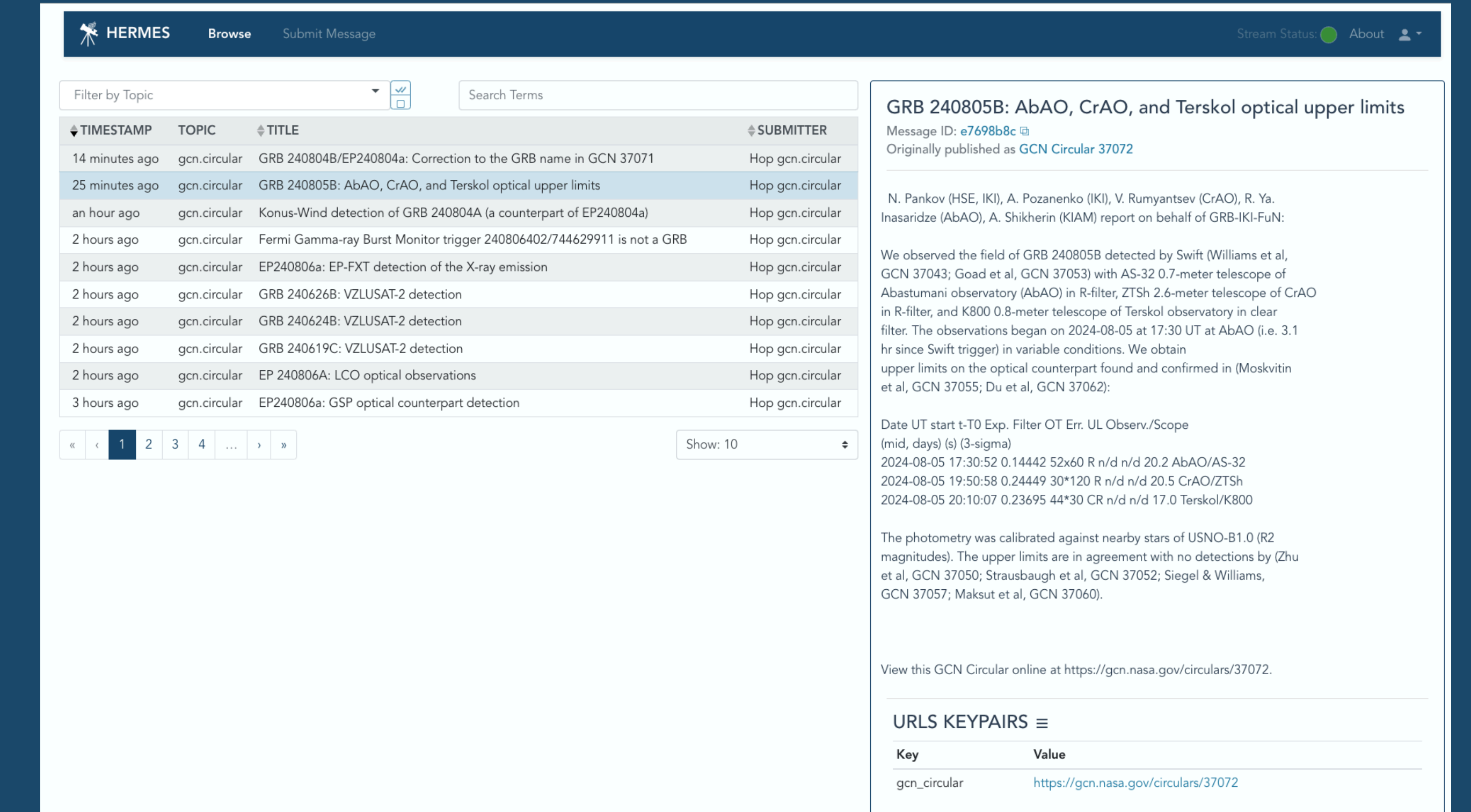
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## Scientific Rationale

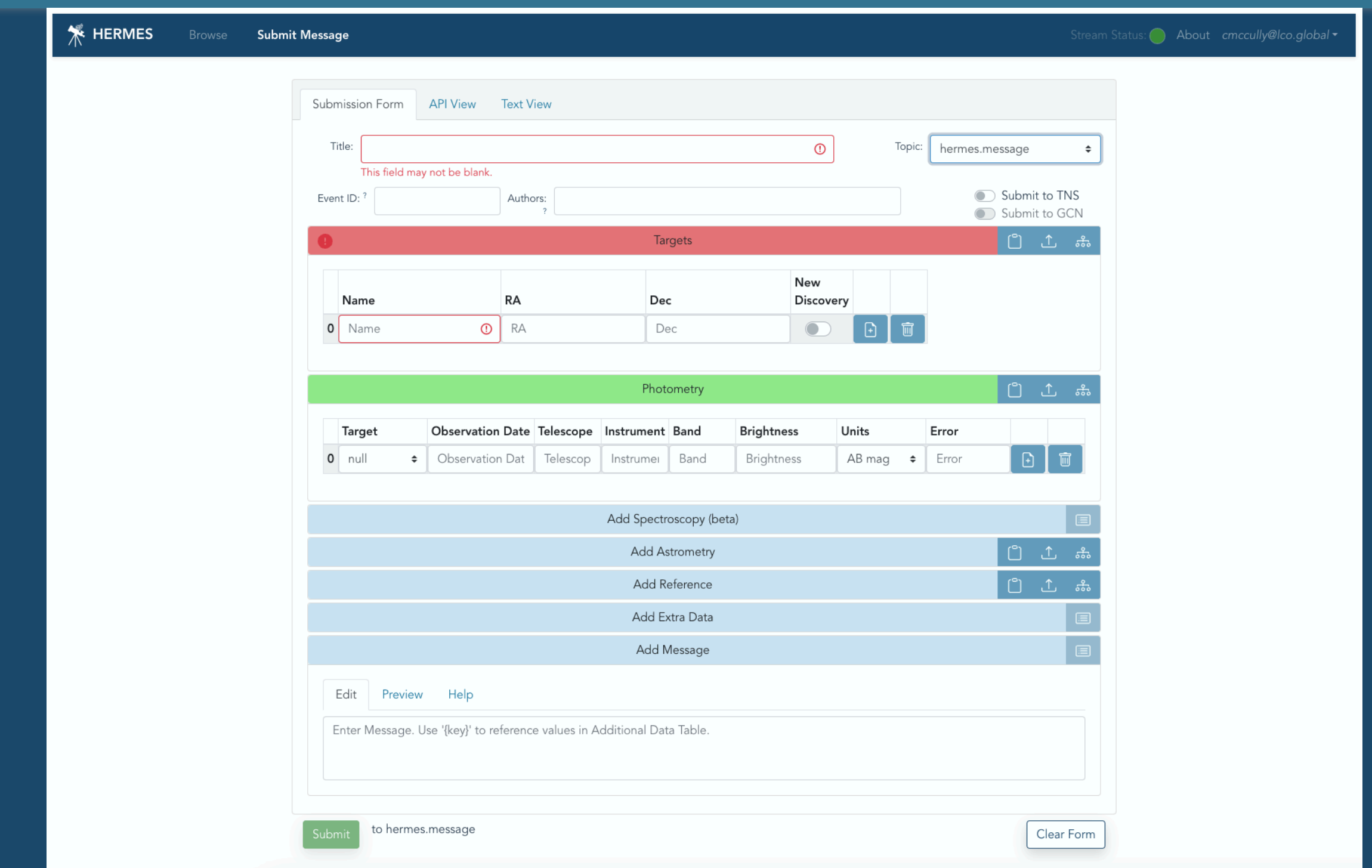
The discovery of the first electromagnetic counterpart to a gravitational wave (a kilonova) event was watershed moment for astrophysics. This event was observed by a large fraction of the astronomical community, in all wavelength bands from radio to gamma rays, enabling direct studies of r-process element production, the equation of state of neutron stars, and a novel determination of the Hubble constant.

The kilonova faded in a matter of days, necessitating unprecedented coordination between facilities and individual observers. The era of Multi-Messenger Astronomy (MMA) has begun!



## HERMES

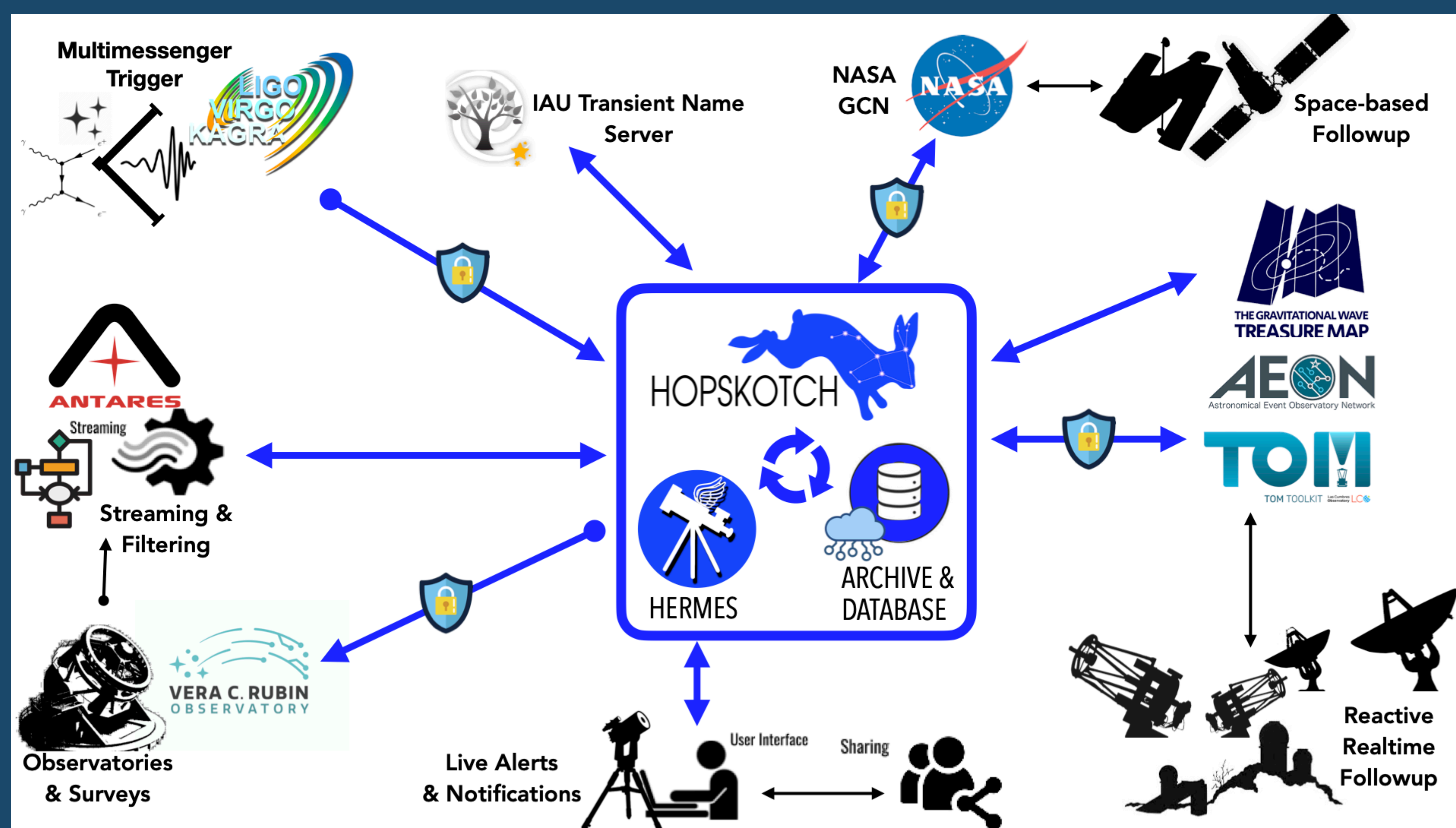
The HOP-Enabled Rapid Message Exchange Service (HERMES) provides a frontend interface to HOPSKOTCH, collating messages from different streams like GCN and TNS.



HERMES provides a web-based frontend to submit messages to HOPSKOTCH, adding validation to message content, encouraging a format that is both machine and human readable. With this, SCIMMA has provided a messaging system for MMA to the astronomical community that is both general and accessible.

## SCIMMA

The Scalable CyberInfrastructure for Multi-Messenger Astronomy (SCIMMA) is a consortium of gravitational wave physicists, observational astronomers, and computer scientists building the infrastructure necessary for multi-messenger astronomy. Our team is developing the cyberinfrastructure to support real-time alerts and analysis from heterogeneous data streams by global teams.

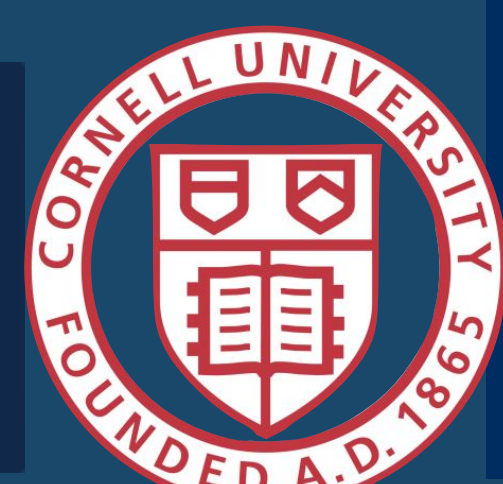


## HOPSKOTCH

SCIMMA provides HOPSKOTCH, a Kafka-based publish-subscribe system, that forms a backbone for the MMA ecosystem. Our implementation provides high-uptime, low-latency, and scaling for high-throughput via the AWS cloud. HOPSKOTCH consumes and can post to other existing streams, like GCN (<https://gcn.gsfc.nasa.gov/>) and TNS (<https://wis-tns.weizmann.ac.il/>), making it a one-stop shop for MMA messaging. The LIGO-Virgo-Kagra (LVK) gravitational wave (GW) observatories have adopted HOPSKOTCH for igwn-alert, their internal communication and external alerts for the MMA community.

## MMA Ecosystem

SCIMMA has interfaced with the community to integrate with externally developed projects to encourage interoperability between MMA services. We have developed a plugin for the Target and Observation Manager (TOM) Toolkit to send messages via the HERMES API from the same system astronomers use to store their data. SCIMMA hosts the Blast service ([blast.scimma.org](https://blast.scimma.org)) that automatically characterizes the host galaxies of newly discovered explosive transients. HOPSKOTCH includes an Identity and Access Management (IAM) system to send both private and public messages, which has been extended to be used across the astronomical community, leveraging existing university accounts via CILogon. SCIMMA now manages the OpenMMA email distribution list and meetings which is the primary interface between the LVK GW observatories and the electromagnetic follow-up community.



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