



RECOMMENDED PRACTICE AND
TARGET SPECIFICATIONS
FOR SETTING UP A
LIVE STREAMING DEPARTMENT

for the Teatro alla Scala's Live Streaming Initiative
April 2021

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Title: <https://www.wikipedia.com> Official entry of the Teatro alla Scala.

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Chapter 1

Introduction

In the past ten years and starting with the beacon project of the *Berlin Philharmonic Orchestra* the importance of internet streams from cultural institutions such as concert halls and opera houses has grown considerably. Not least because of the Corona pandemic this topic has gained further momentum. At this point it is not only important and desirable to involve a worldwide audience in cultural work via internet streaming at little financial expense but also for their own regular audience, the internet stream is the only way to participate in the work of cultural institutions. This is an offer that cannot possibly be presented with such regularity by any public service broadcaster.

On the other hand it seems absolutely mandatory especially for the younger audiences that audio-visual content is being broadcast into the social networks and the digital world in general. Live broadcasts to cinemas, public places and the internet in general are attracting a diverse audience. While the most opera- and concert houses already have departments for social media workflow, expertise for the production and distribution of internet live streams is usually needed.

To date only a few houses around the world manage to produce regular live streams completely autonomous. This however with great success. Examples are the *Berlin Philharmonic Orchestra*, the *Vienna State Opera* and the *Cologne Philharmony* – institutions which have been significantly supported by the authors of this paper in setting up their streaming facilities.

Against the background described above, we are increasingly observing efforts in concert halls and opera houses to also take the step into the area of video broadcasting that has already been taken for decades in audio broad-

casting. The necessary production facilities should be integrated directly into the opera house or concert hall and be available immediately. Simultaneously, the technical standard is to correspond to the broadcasting standard of the public broadcasters and the state television, making both high-quality in-house productions and co-operations with broadcasters smoothly possible. At the same time, the artistic in-house workflows should at best not be disturbed at all - which is often not the case with TV productions.

Until a few years ago, the necessary technology was far too expensive and required a large team of experts. In the meantime, developments in the streaming market have established a technology that allows for excellent results at reasonable investment costs, as long as it is operated by a highly qualified, specialised team.

Highly specialized light weight remote technology with virtually invisible cameras ensure high-quality broadcasts – almost completely unobtrusive and nearly not noticeable for artists and audience. Summarized we see the following advantages:

- Stage content will be available adequately and on the highest possible level to an audience world wide.
- The power of decision making and also the rights of use and exploitation remains with the houses board of directors who also makes all other decisions and who knows their audiences best.
- With the integration of in-house live streaming many positive interactions between already existing departments are possible.
- Concert and Opera houses gain artistic and economic autonomy with regard to broadcast media productions.

Against this background we recommend the following practice and target specifications.

March 2021, Robert Gummlich, Alexander Törzs

Chapter 2

Recommended Practice

2.1 Description of a workflow for opera and concert recordings and streams

- The task of a successful operatic stream lies in the translation of the stage act into another media. This is achieved by directing the audience's attention by means of *image selection* and *editing*.
- Everything that happens on the stage is decisively directed and planned. That is why the live-stream follows the orchestra score translating the event on stage into an adequate video sequence. And so does the director's video editing list resulting from it.
- As opposed to a traditional operatic TV broadcast, live-streaming comes with a compact team with a high degree of specialisation and a knowledge of operatic procedures.
- Our aim is: The craft of TV making shall not be noticed at all by neither the in-house audience nor the on-screen audience. Quite on the contrary it is the audience that shall immerse fully into the live experience.

2.2 Team structure and distribution of tasks

A successful *Streaming Department* employs the following creative and technical personnel:

- **Director** Prepares the orchestra score, Head of broadcasting, vision mixing, communication within the team.

- **Assistant Director** Generates the editing lists from the director's orchestra score and manages the resulting task distribution for the camera operators.
- **Orchestra Score Assistant** Follows the score and cues the edits during rehearsal and live-stream.
- **3 x Camera Operator** Operating the remote cameras.
- **Vision Engineer** Operates all technical devices, responsible for ingest and play-out, signal quality control.
- optional – highly recommended **Director of Photography** Takes charge of the photographic management during elaborate and complex productions or for third party producers and public or state TV co-productions.
- **Production Manager** Manages and organises time schedules and team. Liaison with all other departments of the opera. Maybe a supplementary task for one of the above team members.

2.3 Necessary qualifications for the creative and technical personnel

During our time at the *Vienna State Opera* we have made very good experiences with a *rotational system*. Practically speaking we have awarded more than one task to a single team member. For example Director in combination with Score Assistant, Director in combination with Assistant Director, Camera Operator in combination with Director in combination with Score Assistant. The result is that the *core proficiencies* of each team member are about the same. Core proficiencies are:

- On-going or finished professional education in an audiovisual TV craft (broadcast trainees, media students or junior professionals).
- Extensive understanding and love for the opera and classical music.
- Score reading abilities - at least knowledge of musical notation.
- Practical musical experience highly desired.
- Basic knowledge of non-linear editing.

Exception: The *vision engineer* shall not be trained by us. Instead an experienced professional must be hired on location in Milan. Extensive experience in the maintenance of image technology, image quality control, on-air management, ingest and play-out, the non-linear editing suite, on-air audio and streaming is required.

For a continuous information flow during the training period carried out by the *Gummlich & Törzs GbR* it is absolutely mandatory that all members of the *Scala Stream Team* have a command of the English language that lies above average.

Please note that the streaming team of an opera house is a highly specialised group of individuals. It follows that good personnel planning and management is obligatory if a continuous programme flow is desired.

2.4 Team building - a look-out

A team that meets the above requirements must then be trained in the specific workflow of remote technology. This requires the teaching of the following *core seminars*:

- Musical, visual, organizational, and technical basics of opera and music broadcasting.
- Turning the orchestra score into an image dramaturgy.
- Editing dramaturgy.
- Camera work and photographic image creation.
- The study of the orchestra and the instruments (organology).
- Post production workflow for opera and classical recordings.

After all candidates have taken part in the core seminars, a number of test streams shall be produced. At this stage Robert Gummlich (in close cooperation with members of the *Vienna Stream Team*) will direct live streams with the future trainee directors working as assistant directors. If this stage is successfully reached the new team should be able to work independently. However we recommend regular annual training workshops to maintain and improve the quality of the stream team.

2.4.1 Future Remote Coaching

Constant professional training for existing and new members of the *Teatro alla Scala's Stream Team* is a time consuming and costly endeavour. For this reason a *Remote Coaching Facility* which allows the members of the staff to transmit simultaneously the PGM, camera split, live audio via *SRT* and intercom signals over IP to Robert Gummlich in Berlin and Alexander Törzs in Hamburg may be a feasible and cost effective option. Thus a creative improvement of productions in the years to come is possible without generating travelling costs.

Chapter 3

Target Specifications

3.1 Overview

The extensive equipping of the *Teatro alla Scala* opera house with video and streaming technology is intended to enable streaming and broadcast transmissions from both the large auditorium and adjacent rooms alternatively as well as in combination for larger events. Broadcasts from the large auditorium cover mainly opera, ballet and orchestral concerts.

Four production modes shall be technically and artistically implemented :

- Live stream or live recording exclusively with remote cameras produced at the in-house control room by the streaming team of the *Teatro alla Scala* (*Scala* workflow).
- Live stream or live recording with remote cameras plus additional manned broadcast cameras in the large auditorium produced at the in-house control room by the streaming team of the *Teatro alla Scala* or a *Rai* production team or a combination of both (*Scala* workflow).
- Broadcasts of the *Rai* with manned broadcast cameras in the large auditorium produced at the in-house control room by a *Rai* production team only (*Rai* workflow).
- Broadcasts utilising an outside broadcasting van with manned broadcast cameras in the large auditorium. Here all relevant signals are only passed on by the in-house Central Technical Utility Room to the OB van. All *Rai* personnel (*Rai* workflow).

All audio signals of the above production modes are being produced either in the *Rai's* own audio studio or in the *Teatro alla Scala's* in-house audio studio. Thus a coupling of all three studios (Control room *Scala*, audio studio

Scala, audio studio *Rai*) with a synchronous signal and a time code signal is mandatory at any time.

Additional rooms in which productions shall take place individually or in combination with broadcasts from the large auditorium:

- Ridotto Toscanini
- Ridotto Galleria
- Museo
- The main foyer

Content produced here will encompass talks, introductory lectures, press conferences, recitals, chamber music and if applicable preliminary programmes and interludes for opera and concert streams.

All signals referring to the above production modes shall be recorded and stored for an optional subsequent extensive post production.

To solve the above tasks we recommend – as desired by the opera house – the in-house installation of a UHD based broadcasting studio in connection with a *Central Technical Utility Room* close to the studio. All PTZ remote cameras and standard broadcast cameras are addressable through the *Central Technical Utility Room* – either alternatively or in conjunction. The *Central Technical Utility Room* links to all signals for video, intercom, camera tally, camera remote and camera telemetry from the large auditorium of the opera house as well as the smaller adjacent rooms. Additionally a camera and intercom signal transfer to an *Outside Broadcasting Van* shall be realised (either to an *Outside Broadcasting Van* location under the central technical utility room's window or to an *Outside Broadcasting Van* location at the *Largo Antonio Ghiringhelli*). A linkage to the live programme audio from the in-house audio department as well as for the *Rai's* audio department to various points near the stage (intercom to the stage manager) shall be realised too.

The complete image signal flow should be UHD compliant. If - at the end of the signal chain - an HD compliant picture or a dual standard UHD/HD shall be broadcast at a certain time, the UHD programme signal must be down-converted.

Please find below the proposed studio control room and its corresponding workplaces. Each workplace should be equipped with monitors that can be tilted and swiveled to adjust to the operators needs. All split monitors must be individually configurable with regard to signal routing and on-screen position of the signal content according to the requirements of the operator. All split monitors must be capable of displaying an individual tally signal for the current on-air camera.

3.1.1 Director

- Vision mixing console dimensioned for about 20 individually routeable SDI sources (cameras, graphics for title, ingest, play-out).
- Camera preview split-monitor with at least 32" in diameter.
- Additional sources preview split-monitor with at least 32" in diameter.
- PGM / preview monitor at least 24" in size.
- Intercom panel which shall be realised as an extension of the existent opera intercom system.
- Headset amplifier and headset with routeable audio mounted under the desk.
- Transparent script board and adjustable reading light.
- Small audio monitors - for example *Genelec 8010* plus volume control close at hand.

It shall be possible to move the vision mixer panel to an individual comfortable position with regard to each director's demands. The easiest way to realise this is to just position the panel on the desk. An individual cut-out in the desk is not necessary.

3.1.2 Orchestra Score Assistant

- Space of at least 60cm x 40cm for the orchestra score.
- Headset amplifier and headset with routeable audio mounted under the desk.
- Small video monitor for the conductor's camera (conductor spy).

- Intercom panel which shall be realised as an extension of the existent opera intercom system.
- Adjustable reading light.

3.1.3 Camera Operators 1-3

- 24" broadcast monitor with tally.
- 32" broadcast split monitor for all cameras and PGM. To be installed above camera monitor.
- Remote panel *Panasonic RP-150* with **access to all** PTZ cameras.

It is mandatory that the remote panel *Panasonic RP-150* triggers a router that distributes the selected camera and it's (embedded) tally to the camera monitor. Please note that this is a non-trivial task which needs the attention of an engineer. For details please refer to 3.1.3.1

Furthermore it is mandatory that all camera operators and the vision engineer are granted access to *all all* remote cameras at all times **simultaneously**.

It shall be possible to move the *Panasonic RP-150* panel to an individual comfortable position with regard to each camera operator's demands. The easiest way to realise this is to just position the panel on the desk. An individual cut-out in the desk is not necessary.

3.1.3.1 Camera Selection and Tally for Camera Operator's Monitors

In order for the camera operators to be able to control the cameras optimally, it is imperative that they can see the camera currently selected for control on their full-screen monitor. This means that via the *Camera Selection* on the remote panel *RP 150* not only the control of the camera is selected, but also a video signal selector is controlled at the same time, which switches the video signal of the corresponding camera to the camera operator's monitor. In addition, the tally information (i.e. the signal that indicates which camera is "On Air" on the vision mixer at that moment) must also be displayed on the full-screen monitor and switched according to the *Camera Selection*. Thus pressing one button on the *RP 150* switches a combination of three different types of signals:

1. Control of the selected camera.
2. Video image of the selected camera.
3. Tally information of the image mixer.

The following signal flow chart shows this schematic signal flow. It is explicitly not a technical specification or the technically best solution but an exemplary representation of the necessary signal combination. This signal flow must be implemented at each workstation with an *RP 150* panel (3 x Camera Operator + 1 x Vision Engineer). Within the complex signal setup of the *Teatro alla Scala* in cooperation with the *Rai* it is quite conceivable that this task can be performed as part of a higher-level solution such as the *VSM* system by *Lawo*.

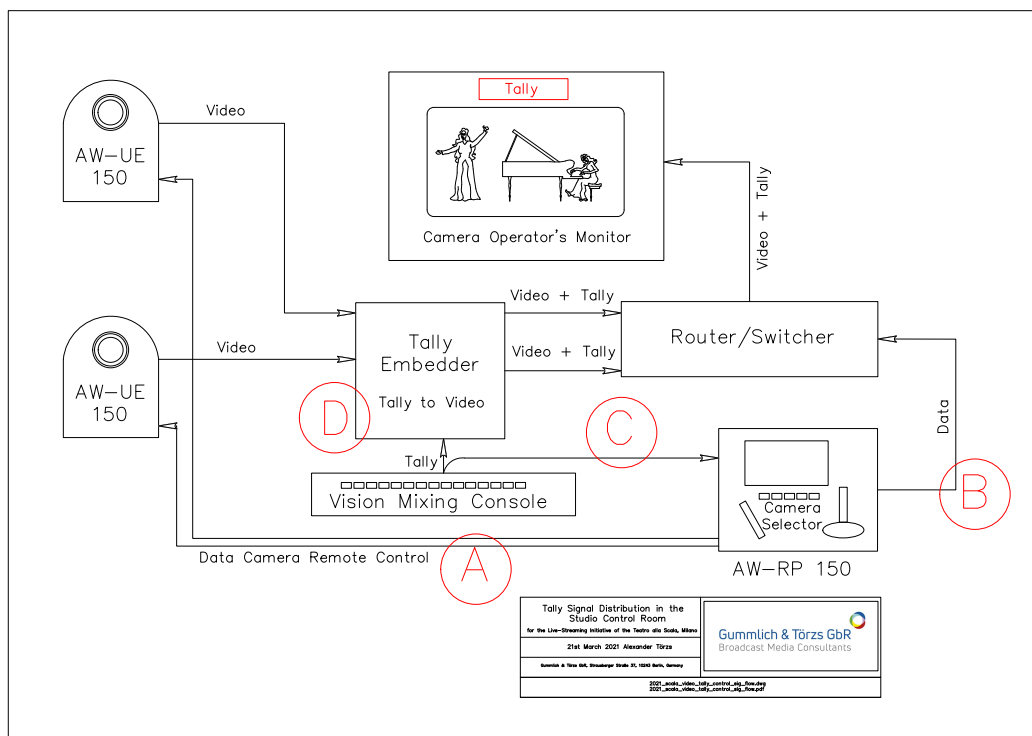


Figure 3.1: Tally Signal Flow in the Studio Control Room.

Explanation of signals involved:

- A. The "Camera Selector" button of the *RP 150* establishes the control connection (DATA) to the selected camera.

- B. The "Camera Selector" button of the *RP 150* simultaneously switches the video signal of the selected camera to the camera operator's full screen monitor.
- C. The vision mixer console sends out the tally of the current "on-air camera" to the embedder and simultaneously to the *RP 150* according to the director's edit decision.
- D. The tally-to-video embedder combines video signal with a tally signal and routes it via the router/switcher to the camera operator's monitor which can read out and display the tally.

Please find below a tabular representation of the interaction of the vision mixer signal PGM out + Tally + *RP 150* + video signal on the camera operator's monitor (exemplary for 4 cameras):

Vision Mixer PGM-Output „On Air“ Signal	Camera selected on RP 150	Tally on RP 150	Video Signal on Cam Op's Monitor	Tally on Cam Op's Monitor
Cam 1	Cam 1	ON	Cam 1	ON
Cam 1	Cam 2	Off	Cam 2	Off
Cam 1	Cam 3	Off	Cam 3	Off
Cam 1	Cam 4	Off	Cam 4	Off
Cam 2	Cam 1	Off	Cam 1	Off
Cam 2	Cam 2	ON	Cam 2	ON
Cam 2	Cam 3	Off	Cam 3	Off
Cam 2	Cam 4	Off	Cam 4	Off
Cam 3	Cam 1	Off	Cam 1	Off
Cam 3	Cam 2	Off	Cam 2	Off
Cam 3	Cam 3	ON	Cam 3	ON
Cam 3	Cam 4	Off	Cam 4	Off
Cam 4	Cam 1	Off	Cam 1	Off
Cam 4	Cam 2	Off	Cam 2	Off
Cam 4	Cam 3	Off	Cam 3	Off
Cam 4	Cam 4	ON	Cam 4	ON

Figure 3.2: Truth Table for the camera's *Control-Tally-Video* signals.

Finally it is obligatory that the tally of the corresponding cameras is also displayed on **all** split monitors in the *Studio Control Room*.

3.1.4 Assistant Director

- 2 Split monitors for all cameras and PGM.
- Headset amplifier and headset with routeable audio mounted under the desk.

- Intercom panel which shall be realised as an extension of the existent opera intercom system.
- Adjustable reading light.

3.1.5 Production Engineer 1 (Master)

- Broadcast monitor with router/selector for all signal sources.
- 2 Split monitors.
- Waveform monitor and vectorscope.
- RCPs for all remote cameras.
- 1 x *Panasonic RP150* to control each individual camera with **access to all cameras**.
- Intercom panel which shall be realised as an extension of the existent opera intercom system.
- Wireless production intercom (walkie talkies) linked to main intercom.
- Computer workstation with SDI connexion to the vision mixing console. The workstation shall be equipped with a non-linear editing system, software for playing out still graphics and video content.
- Downlink monitor with a discrete receiver (Smart-TV, Android device, notebook computer, **not** the production engineers workstation).
- Small audio mixer for PGM live audio and play out audio including audio signal metering.
- Headset amplifier and headset with routeable audio.
- Small audio monitor - for example *Genelec 8010* plus volume control.
- Complete access to video- audio- and intercom signal routing.
- Control and monitoring of all recording devices.
- Adjustable reading light.

The *Production Engineer's* workplace shall be scaleable. It should be possible to extend it's capabilities for additional cameras or more elaborate *Rai* productions.

3.1.6 (Spare) Vision Engineer or Director of Photography

- RCP spare slots for additional cameras.
- Waveform monitor and vectorscope.
- Intercom panel which shall be realised as an extension of the existent opera intercom system.
- Broadcast monitor with router/selector for all signal sources.
- Split monitor.

3.2 Distribution of Workplaces within the control room

For the distribution of workplaces within the control room we favour a rectangular desk which can provide enough space for all key personnel with the relevant positions facing each other. Thus eye contact is secured. Within traditional broadcast studio design this approach seems unorthodox however we think that it supports the flow of communication.

Please bear in mind: all rooms must be equipped with an *adequate*, draught-free and silent air-conditioning system. The Control Room must have low reverberation as well as have the possibility to block all outside light.

The final positioning of the control room's desk is to be announced by *Gummlich & Törzs* after assessment of the actual location.



Figure 3.3: View of the proposed workplaces within the Control Room - From left to right: Production Engineer, Cam Op 3, Cam Op 2, Assistant Director, Cam Op 1 (not proportional - no scale - draught idea only).



Figure 3.4: View of the proposed workplaces within the Control Room - From left to right: Score Assistant, Director, opt. Vision Engineer, Production Engineer (not proportional - no scale - draught idea only).

Please find a detailed distribution of workplaces in the sketch below and in the file `2021_scala_workplaces_dist_gtconsultants.pdf`

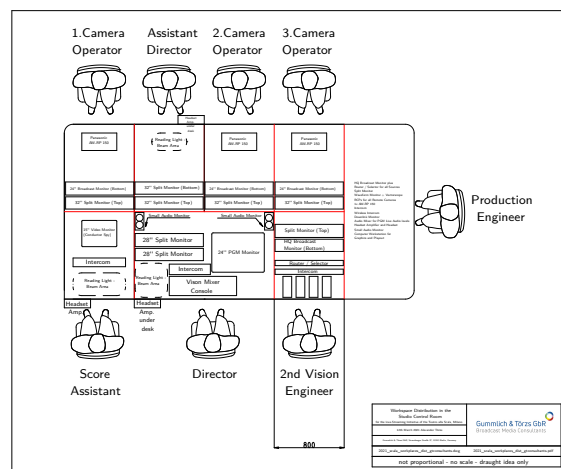


Figure 3.5: View of the proposed workplaces within the Control Room - top view (not proportional - no scale - draught idea only).

3.3 Remote camera technology

Although we rarely give recommendations for specific hardware brands it is our experience that presently only one camera serves the demands of operatic live streaming. This is the **Panasonic AW-UE 150** in connexion with the control panel **Panasonic AW-RP 150**. All other camera systems offer a poorer image quality and poorer remote access. Larger and more efficient camera systems will generate costs of a factor 10 to 15 higher and are therefore not to be recommended at the present stage.

3.4 Proposal for manned cameras for an extended studio utilisation with production partners

In terms of image dramaturgy the referred PTZ cameras offer all the necessary possibilities to broadcast opera and concerts in a sophisticated way. This is based on our experiences at the *Vienna State Opera* and elsewhere. However third-party co-producers often place value on a different image dramaturgy with an addition of close-ups and different perspectives. In those cases it is recommended that regular broadcast cameras (e.g. SONY, Grass-Valley, Ikegami) shall be connected to the control room as well. As mentioned above the control room must be devised to integrate all current broadcast

camera systems including video, tally, telemetry and intercom.

3.5 Camera positions

The following 9 camera positions are required for the transmission of operas and ballets from the large auditorium, plus a beauty shot from the highest balcony (10). The cameras are permanently installed in these positions. For now we advise against the positions at the top left in the portal and in the Lampadario, because the technical effort and the resulting costs will be very high in relation to the benefit of these two beauty shots (moreover with the Lampadario it is not even certain whether a camera image is possible at all). Both positions can be evaluated at a later point in time and integrated into the system. Please refer to the groundplan and photos below.

For the streaming of orchestral concerts, depending on the musical line-up, up to 4 additional mobile cameras are required. These are located in the area of the orchestra shell (which will be set up for concerts in the front area of the stage). It shall be possible to mount these cameras on flexible, vibration-resistant stands (a monopod for loudspeakers or similar, alternatively a camera tripod).

The *Rai's* camera positions are not suitable for the remote cameras. However the camera positions on the balcony in the middle at the back are definitely desirable for the mixed operation of remote and manned broadcast cameras. Positions for the 9 principal remotely controlled 1 inch sensor cameras for operatic streaming are located in the level of the first balcony. This is roughly 2,60 m above stage level. Within the files

2021_scala_cam_pos_top_view_gtconsultants.pdf and
2021_scala_cam_pos_front_view_gtconsultants.pdf

as well as in the sketch below please find the *ideal* positions of the 9 principal cameras. The focal lengths given and their equivalent angle-of-view is based on the optical characteristics of the 1 inch camera sensor of the *Panasonic AW-UE 150*. Additionally to these 9 positions 4 signal hubs for concert streaming (orchestra on stage) shall be installed stage left and right.

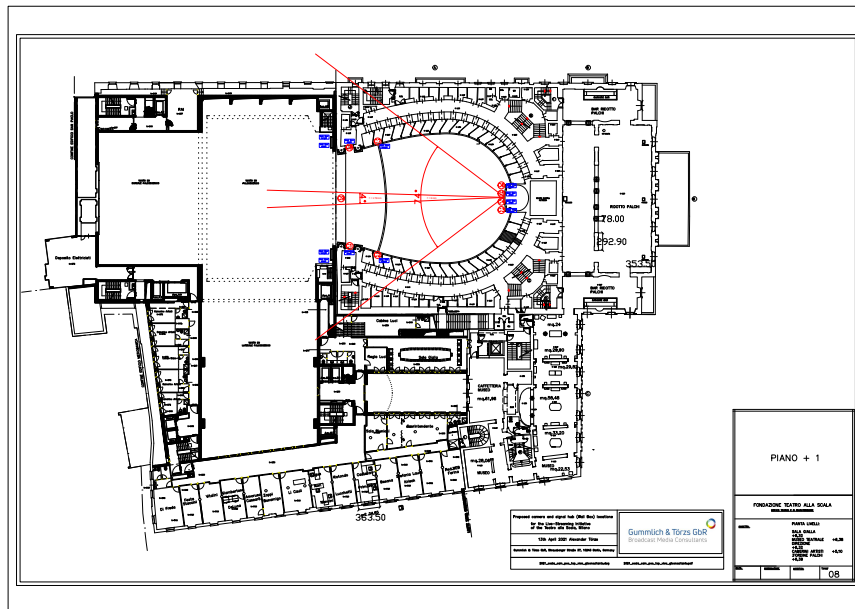


Figure 3.6: Schematic top view of the proposed locations for cameras and signal hubs (Wall Boxes).

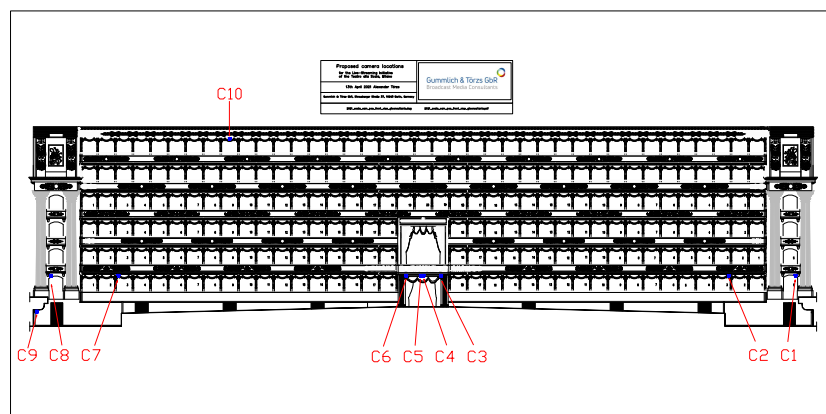


Figure 3.7: Schematic front view of the proposed locations for cameras and signal hubs (Wall Boxes).

For additional pictures to further clarify the positions of cameras 1 to 6 please refer to the appendix A. and B.

The approximate weight of the recommended camera type is about 3kg and the levelling head about another 2 kg. From experience it seems to us absolutely mandatory to install the cameras in a place that can be easily accessed at a later stage for maintenance and adjustment of the camera level.

A consideration of the technical possibilities and especially the requirements of the *Teatro alla Scala's* monument protection will of course govern the final decision.

3.5.1 Camera Signal Hubs "Wall Boxes"

To transport the signals from the cameras to the central technical utility room *wall boxes* are installed throughout the house which enable various signals to be connected. Although we would prefer that all wall boxes in the entire opera house offer the same connection options, the assessment on April 7th, 2021 showed that there are no matches in the positions of remote cameras and broadcast cameras (*Rai*). It was decided that the *Rai* would take care of the wiring of their own desired positions with SMPTE lines. In addition and due to lack of space it is not possible to implement all signals everywhere. For reasons of space the *Teatro alla Scala* should also install two different types of wall boxes.

Type 1 small: Connects 1 PTZ remote camera exclusively. To meet architectural demands Type 1 connexions can be realised as either small wall boxes or as a simple cable outlet.

- SDI video 12G
- SDI video 3G
- Camera genlock signal
- Camera remote LAN
- AC 230V 50Hz

Type 2 large: Connects 1 PTZ remote camera and enables connections for special use (intercom, audio for newscaster, additional hand held camera)

- All Type 1 connexions plus:

- Audio (specifications to be announced by head audio engineer of the *Teatro alla Scala*)
- Intercom
- LAN
- SDI Video
- Optical fibre
- AC 230V 50Hz

The distribution of wall boxes and simple cable outlets where applicable across the building shall be:

For the large auditorium:

- C1 - small (cable outlet)
- C2 - large (wall box)
- C3 - large (wall box)
- C4 - small (cable outlet)
- C5 - small (cable outlet)
- C6 - large (wall box)
- C7 - large (wall box)
- C8 - small (cable outlet)
- C9 - large (orchestra pit, wall box)
- C10 - large (beauty shot, wall box)

For the stage:

Portal left

- 1 x large (wall box)
- 1 x small (wall box)

Portal right

- 1 x large (wall box)
- 1 x small (wall box)

Please observe: Every camera must be supplied locally with AC Power at it's actual position. It is compulsory that the electrical power for cameras must **not** be delivered through CAT6 cables and switches due to reliability issues already encountered in Wien and Berlin. The *star* structure with switches and cameras connected with CAT6 cables is acceptable only for the distribution of the cameras control signals.

Please refer to file `2021_scala_cam_pos_top_view_gtconsultants.pdf` or to Figure 3.4 above for the approximate locations of the wall boxes.

3.5.2 Adjacent Rooms

After consultation with Mario Pan, the permanent installation of cameras in the adjacent rooms turns out to be very complicated for architectural reasons. Therefore, we recommend installing 4 wall boxes in each room (2 large and 2 small) and using mobile camera units only.

For high quality streams all of the above mentioned rooms and halls require a camera adequate lighting. The implementation or the adaption of an already existent lighting set up should be carried out on location by DoP Alexander Törzs.

For the camera positions in the adjacent rooms please refer to the sketches below or to the files:

`2021_scala_cam_pos_toscanini_gtconsultants.pdf`
`2021_scala_cam_pos_galleria.pdf`
`2021_scala_cam_pos_museo.pdf`
`2021_scala_cam_pos_foyer.pdf`

3.5.2.1 Ridotto Toscanini

- 4 wall boxes (2 large and 2 small)
- 4 mobile PTZ remote cameras plus tripod.

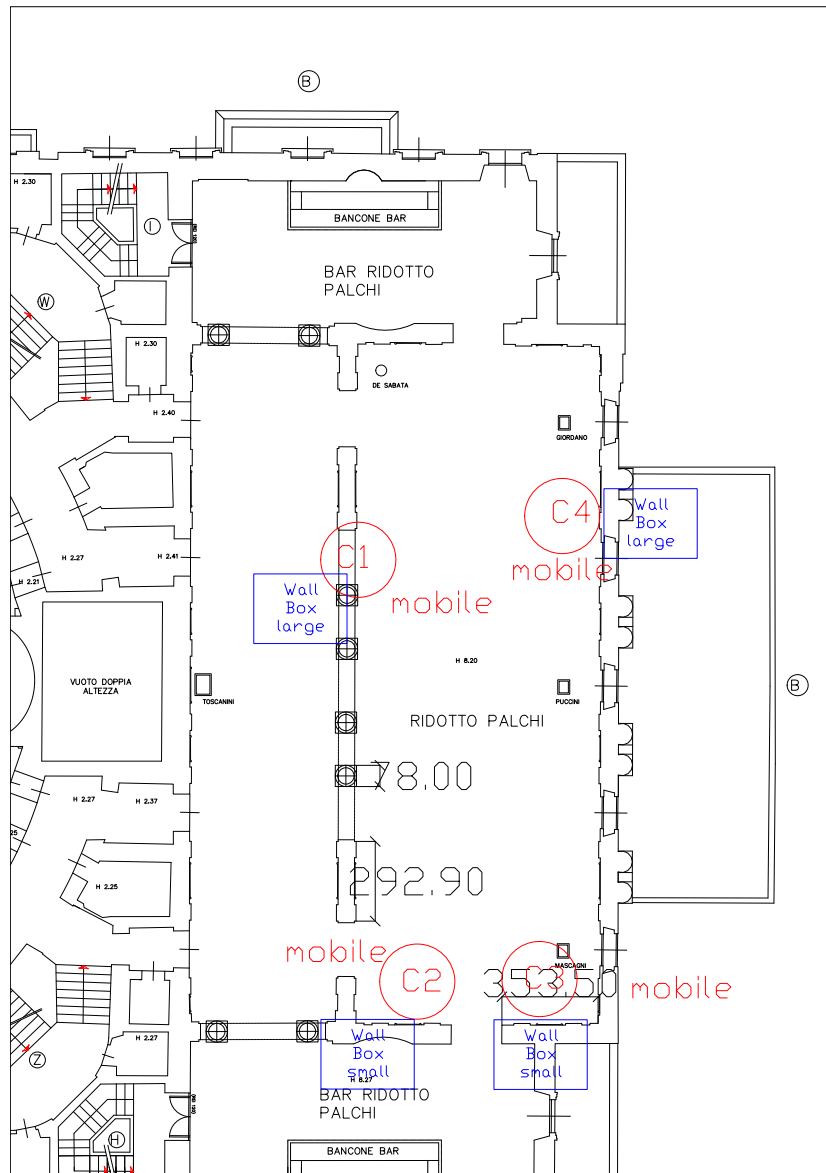


Figure 3.8: Schematic View of the proposed locations for cameras and signal hubs (Wall Boxes) at the Ridotto Toscanini.

3.5.2.2 Ridotto Galleria

- 2 small wall boxes by the door frame,
- 2 large wall boxes in the vicinity of the columns,
- 4 mobile PTZ remote cameras plus tripod.

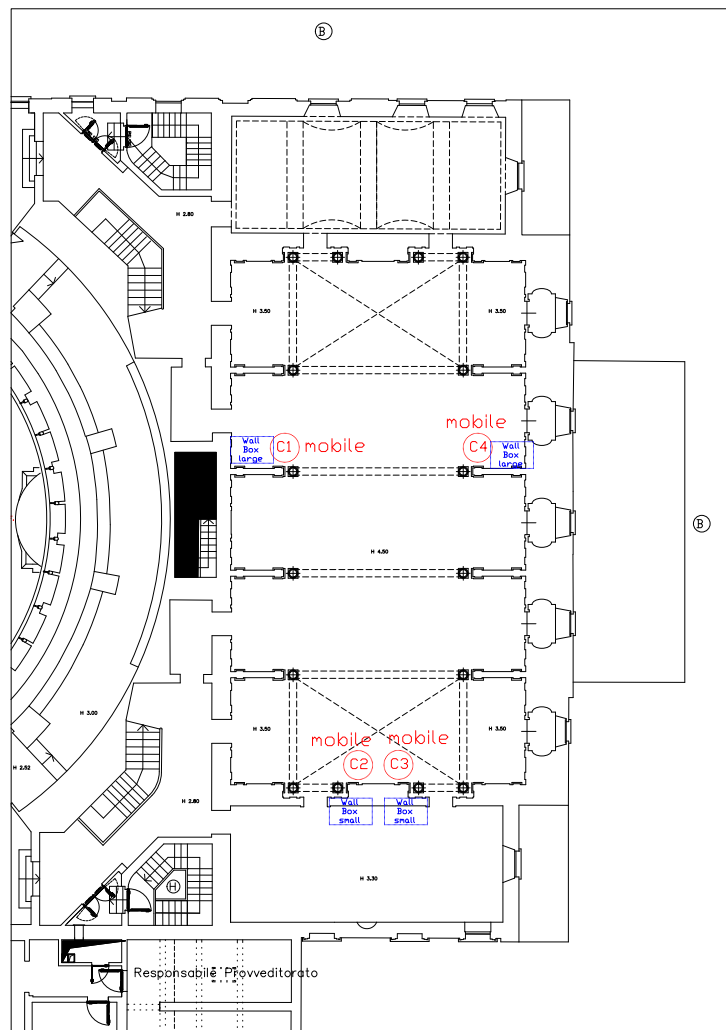


Figure 3.9: Schematic View of the proposed locations for cameras and signal hubs (Wall Boxes) at the Ridotto Galleria.

3.5.2.3 Museo

- 4 mobile PTZ remote cameras plus tripod.
- 3 small wall boxes
- 1 large wall box

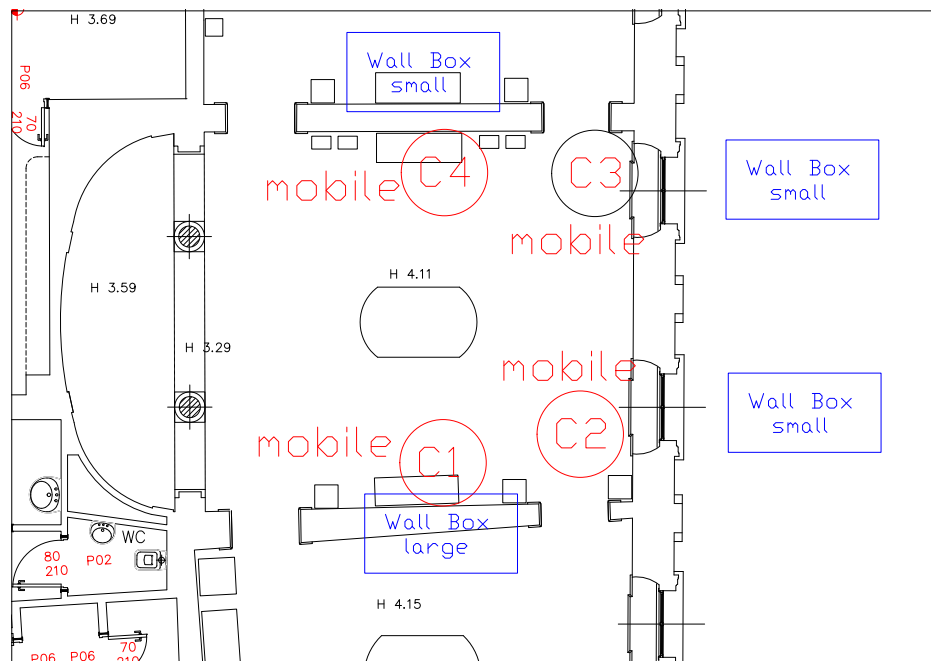


Figure 3.10: Schematic View of the proposed locations for cameras and signal hubs (Wall Boxes) at the Museo.

3.5.2.4 Main Foyer

- 4 wall boxes (2 large and 2 small)
- 4 mobile PTZ remote cameras plus tripod.

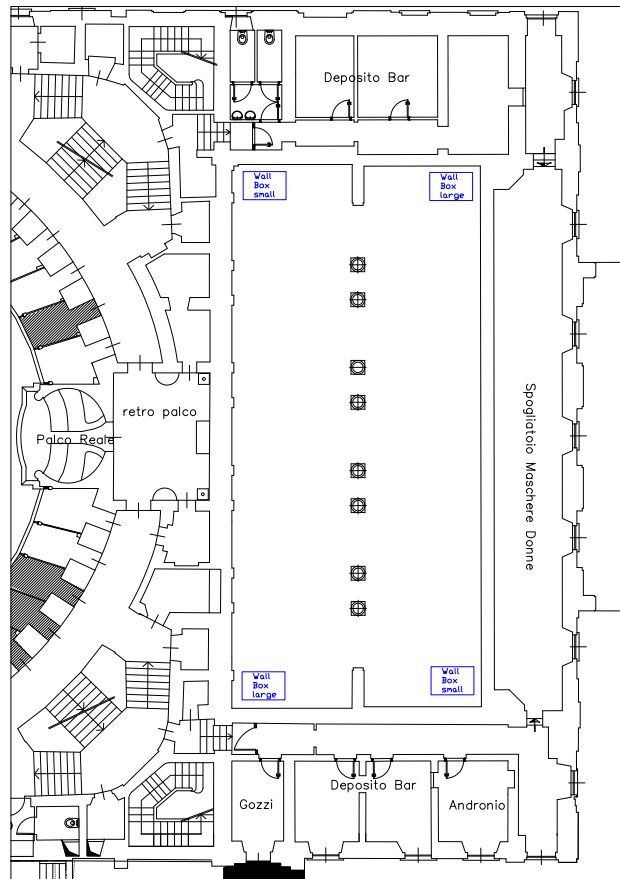


Figure 3.11: Schematic View of the proposed locations signal hubs (Wall Boxes) at the Foyer.

For further camera positions which denote either positions which are currently not being utilised for the live streaming operation or denote wall boxes / cable outlets for future cameras please refer to Mario Pan's drawing in the appendix or to the file:

Cameras positions - Floor plans and internal balconies view.pdf

3.5.3 Dual usage of camera positions by *Fonici* and the *Stream Team*

The in-house audio department of the *Teatro alla Scala* "Fonici" already uses two *Panasonic* remote cameras on top of the central balcony *Palco Arciducale* and in the orchestra pit (*Maestro*) to provide in-house services. To ensure operational reliability and avoid conflicts, we advise operating these cameras separately from the video department with the existing technology and avoiding double use by all means. In this way, the *Fonici's* ability to work in the proven workflow is guaranteed at all times. For the streaming department, a separate, additional *Panasonic AW-UE 150* camera (Camera 9) will be installed in the orchestra pit, which will be available exclusively to the video department. At the moment, the position on the *Palco Arciducale* is not absolutely necessary for the implementation of the streaming project. Nevertheless a wallbox shall be installed at this position for possible later use.

3.6 Signal distribution and Central Technical Utility Room

We recommend setting up a *Central Technical Utility Room* next to the control room, which shall be the centre of the signal distribution. The location of the control room is generally agreed upon by the *Teatro alla Scala* and the *Rai*. However a final decision can only be made after evaluation by the relevant professionals and specialists.

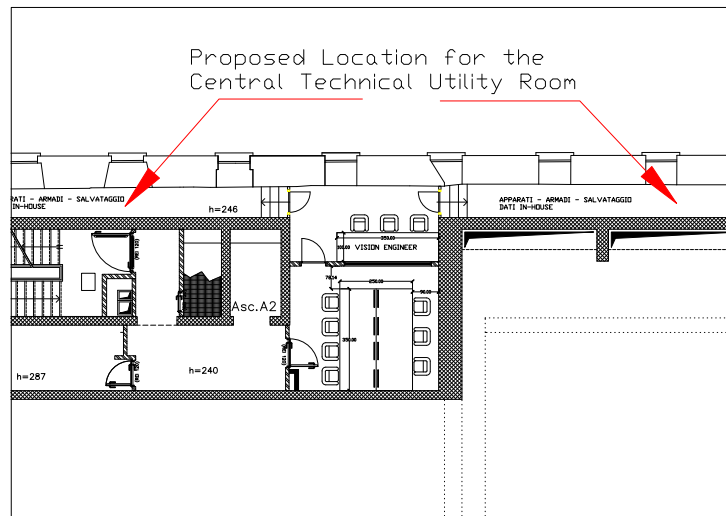


Figure 3.12: Location to be evaluated for the proposed Central Technical Utility Room.

The *Central Technical Utility Room* must be designed in such a way that it is always externally supplied with a sync signal and time code. Thus it is the *sync slave* in this respect at all times! Depending on the production situation, the sync signal and time code are supplied either from the in-house audio studios (*Fonici* or *Rai*) or in the case of a cooperation with an external OB van from its audio department. Corresponding technical switching options are to be provided (Patchbay).

The following signals run up at the *Central Technical Utility Room*:

- All relevant video-, audio- and control signals from the large auditorium, the stage area, the area behind the stage, Ridotto Toscanini, Ridotto Galleria, Museo, main foyer as well as the lighting control room (DMX and or ArtNet, MaNet).
- The *Central Technical Utility Room* supplies relevant in-house departments with video signals from the streaming department. These are in particular:
 1. The in-house audio department *Fonici* with a PGM signal. From here the opera house's in-house TV will be served on in-house TV's channel 37.
 2. The Subtitle Room will be provided with a PGM signal.

3. The Lighting Control Room will be provided with a PGM and a multicamera signal via fibre line for connexion to a high quality broadcast monitor and a router/selector.
- The *Central Technical Utility Room* is the *Stream Team's* central intercom node for the entire house.
 - Connection to the OB van parking space with dual requirement:
 1. Distribution of all discrete camera signals including intercom and tally.
 2. Distribution of PGM and intercom only when utilising the control room as sub-control for the OB van.

The *Central Technical Utility Room's* linkage to the OB van is entirely in the domain of the *Rai*.

The *Central Technical Utility Room* is also the location for the UHD and the HD encoders and the signal hand-over for the IP signal for streaming

From experience we highly recommend that the PTZ camera control IP network is **permanently** separated from all other networks.

Please find below a schematic overview of the Central Technical Utility Room or in the attached file `2021_scala_ctur_gtconsultants.pdf`

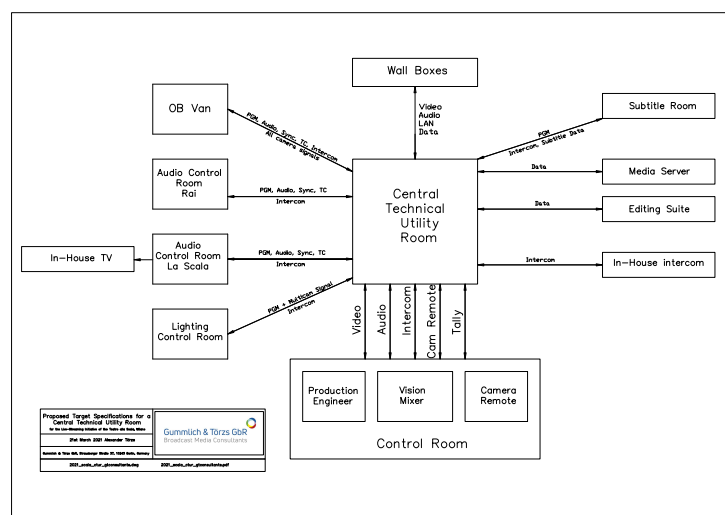


Figure 3.13: Schematic View of the proposed Central Technical Utility Room.

For an additional overview by Mario Pan emphasising the linkage to the *Rai* please refer to the Appendix or to file `Infrastruttura_streaming_Rev_4.pdf`

3.7 Recording and Storage

On the part of the opera house there is the requirement that all productions should be of a nature that allows subsequent and extensive post production. There is also the need to store completed productions for a longer period of time. Hence we are recommending two different necessary storage solutions: *short term storage* and *long term storage*.

3.7.1 Short Term Storage

With an assumed large amount of data per recording (at least 8 cameras + PGM) it is absolutely necessary to find a server-based solution on location at the *Teatro alla Scala*.

All in all a server based recording solution must have the following properties:

- The server must allow video multi channel parallel recording. It's recording codec should be or be comparable to the Apple ProRes standard. At the same time and during recording quality scalable proxy clips must be generated. These "proxies" must be available directly after the streaming event to departments who need them for reference as for example the tv director, the opera direction, the ballet school etc. All data must be available immediately via a download link or a physical data drive (USB stick or SSD).
- The capacity of the media server must be dimensioned in such a way that it allows the storage of approximately 10 opera productions. *One* opera production requires *two* recording sessions of 10 UHD sources at a resolution not lower then *Apple ProRes 422 HQ*.
- There shall be a link between the media server and the video editing suite.
- The recording on the media server shall be backed-up by a at least two separate recording devices for PGM and a wide shot.
- For a media server we have made good experiences with the *just:in* recording system by *ToolsOnAir* .

3.7.2 Long Term Storage

External long term storage is a feasible concept. For details please refer to Christopher Widauer.

3.8 Postproduction

A broadcast standard editing suite is required if in-house post production is desired. This suite should have the following qualities:

- Capable of multicam editing in a UHD workflow (e.g. DaVinci, Avid, Premiere, Edius) according to the standards utilised in Italy.
- Connexion to the media server through a 1 Gbit network line.
- Capability of sophisticated color correction and grading with broadcast standard video monitoring.

3.9 Integration Rai

Generally speaking there are many congruences between the ideas of the *Rai* (as proposed in their presentation) and our recommendations.

Yet the following aberrations are noticed. The major part of those however will be solved by the *Rai* itself:

1. The TV directors of the *Rai* generally require different types of camera positions as well as a different type of signal distribution. These extra camera positions will thus be equipped by the *Rai's* own signal distribution. The same is true for the signal distribution from the adjacent rooms and halls.
2. In the same way the *Rai* will provide for the linkage of the *Teatro alla Scala's Central Technical Utility Room* (and thus the control room) to the outside of the opera house (either through the window in *Via Guiseppe Verdi* or at the location at *Largo Antonio Ghiringhelli*).
3. These signal lines shall be available to the *Teatro alla Scala's* streaming team for the realisation of their own broadcast productions. Passing on signals to a satellite uplink or utilising broadcast cameras of their own should be possible at all times. This should be agreed upon.

4. With regard to the video mixing console the *Rai* desires the installation of a console providing 2 M/E busses. For a regular streaming production this however is not necessary.
5. While our idea to position all workstations facing each other around a rectangular desk found the *Rai's* endorsement, the workstation of the *Rai's* vision engineer (2nd vision engineer) is desired to be disengaged by an additional room dividing wall, door and window.

We recommend the setup below in order to enable the proximity and direct contact that is beneficial to our workflow on the one hand and to achieve the separation that *Rai* needs for it's workflow on the other. Following a contribution by Mario Pan this will be achieved by positioning both tables against the partition and installing a sliding window. For the *Rai's* workflow a permanent intercom connexion to video director and the rest of the team will thus be mandatory at all times. An additional intercom panel between camera operator 2 and camera operator 3 will be necessary.

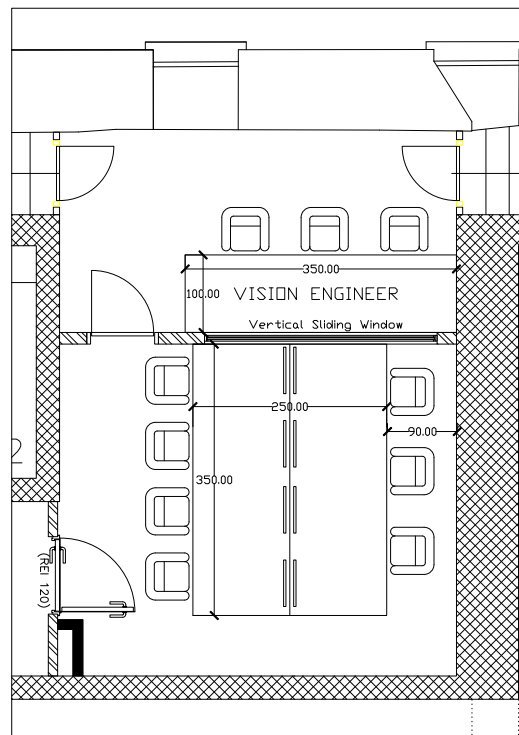


Figure 3.14: Proposal for the Rai for a control room division.

Appendix

A.

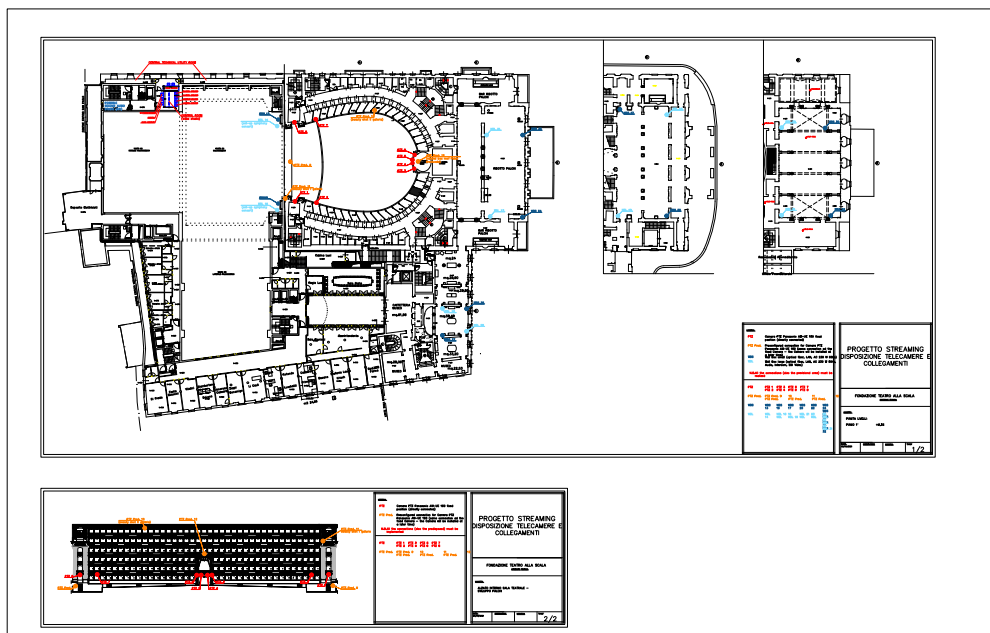


Figure 3.15: Camera Positions for Live Streaming and Desired Additional Camera Positions according to Mario Pan, Head of Maintenance.

B.

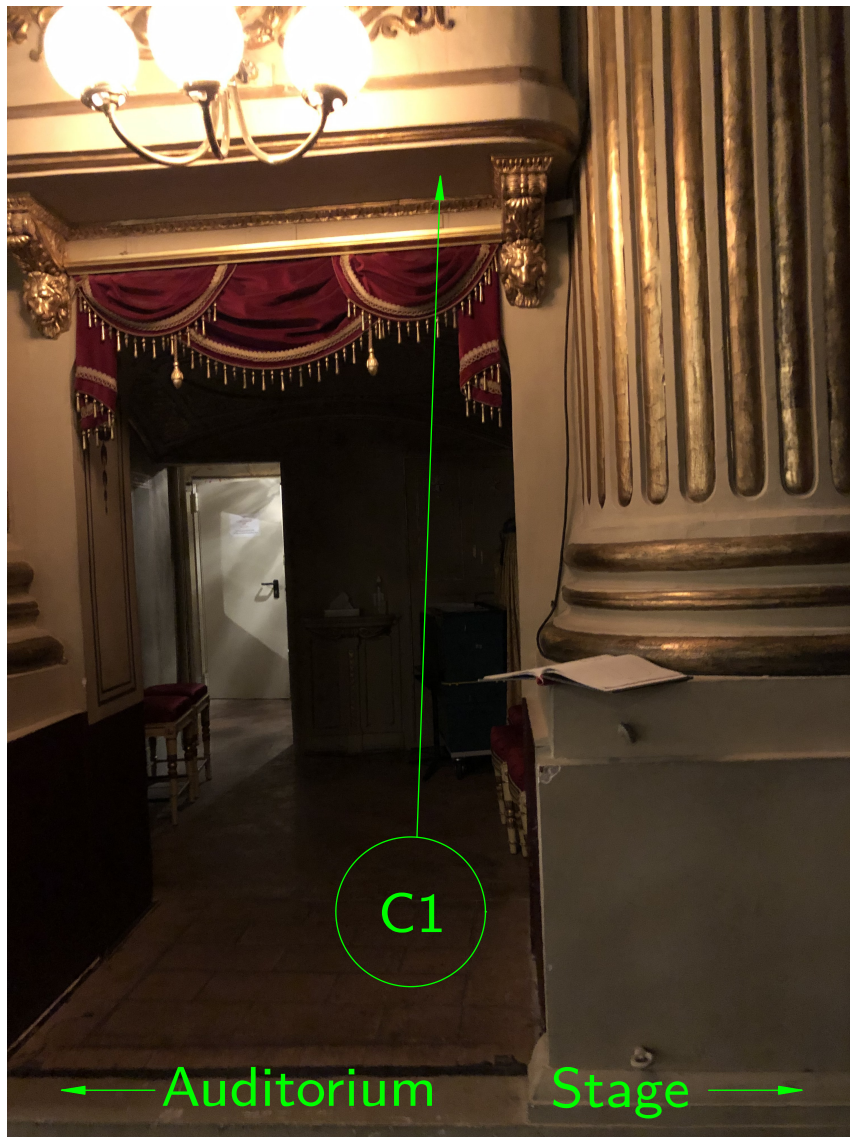


Figure 3.16: Proposed mounting for camera 1.

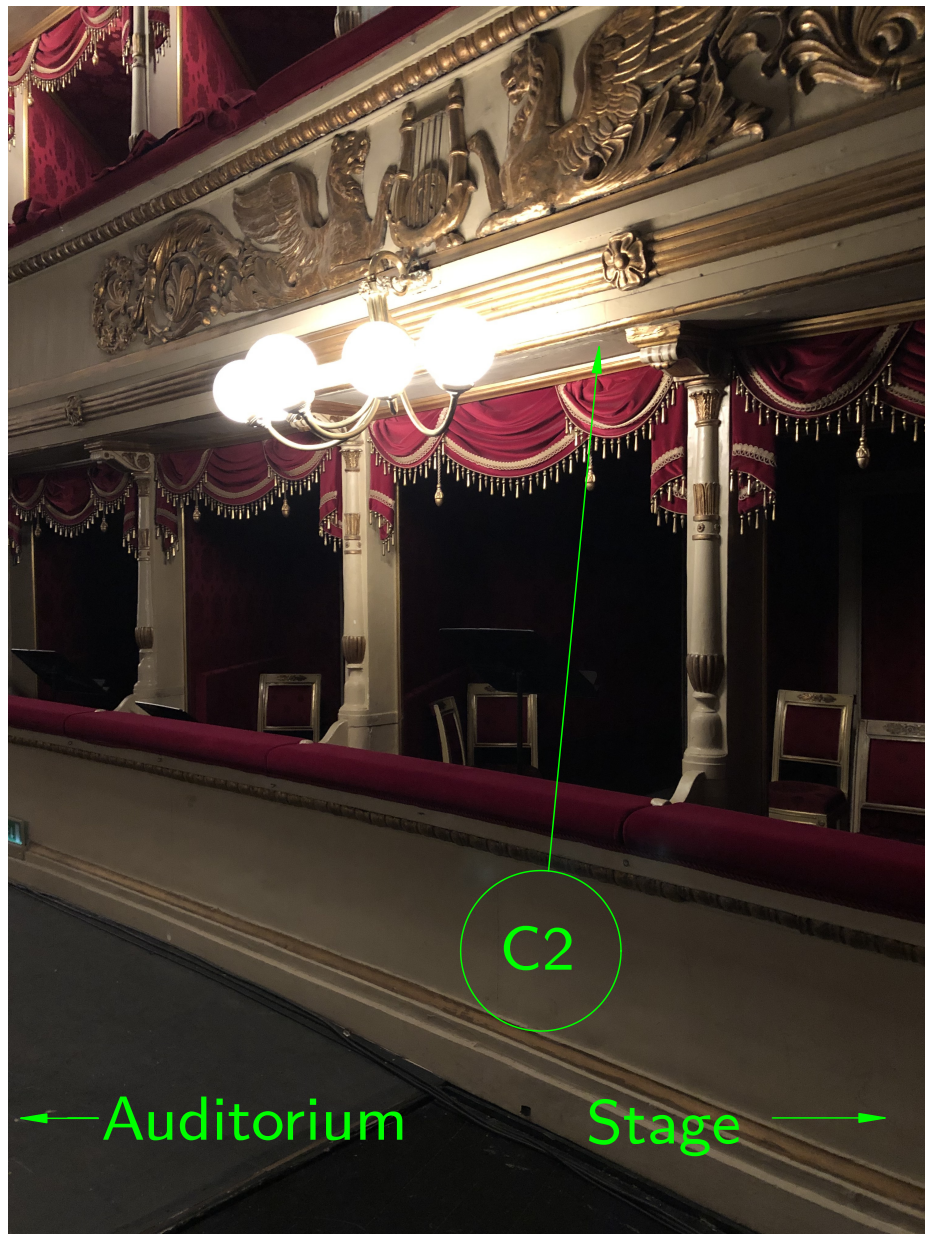


Figure 3.17: Proposed mounting for camera 2.

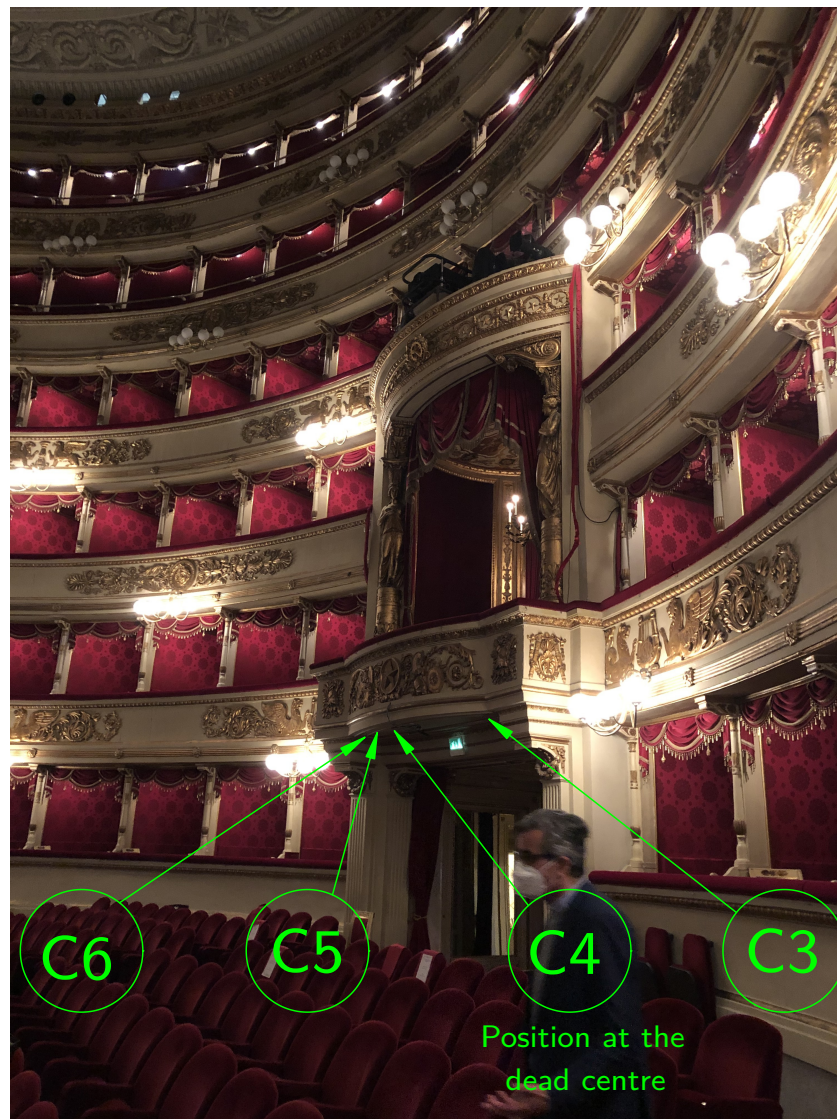


Figure 3.18: Proposed mounting for cameras 3 to 6.

Please realise that all cameras shall be mounted on the lower balcony arc's flat bottom. C3 left hand side of the arc. C4 dead centre. C5 directly to the right of C4. C6 right hand side of the arc.

Please also realise that C7 and C8 are mirror positions of C1 and C2.

C.

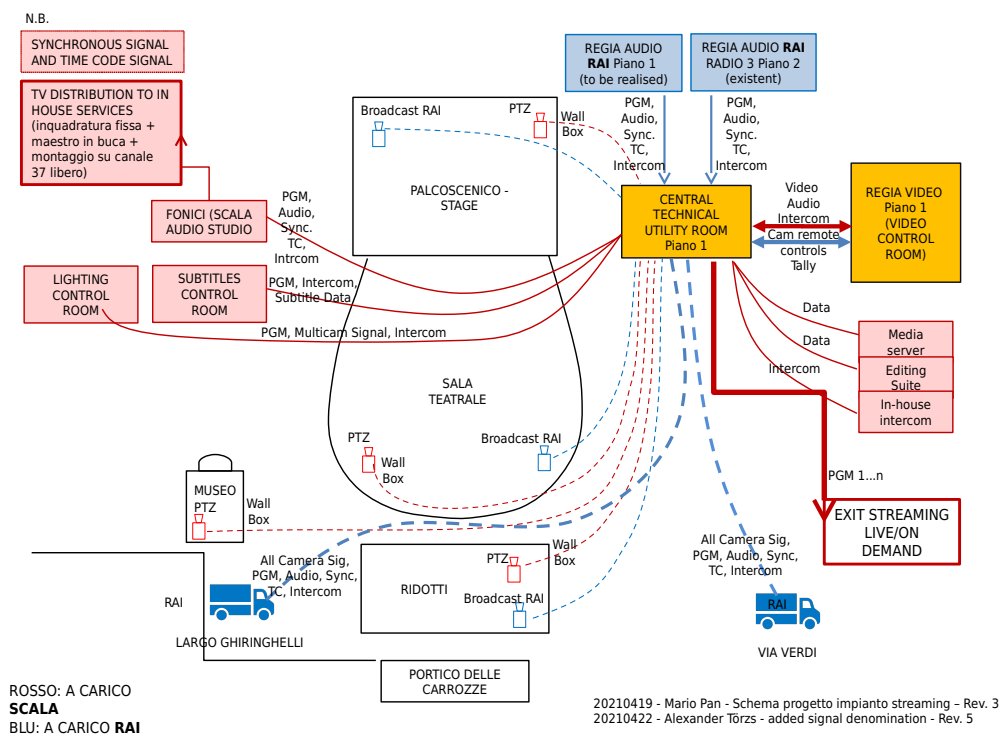


Figure 3.19: Distribution of Signals in the *Teatro alla Scala's* Live Streaming Environment.

Frequently used Terms and Abbreviations

ArtNet	A free protocol to transmit DMX information over the internet protocol using standard ethernet cables.
BNC	The <i>Bayonet Neill–Concelman</i> connector for co-axial cables is a quick connect plug for radio-frequency devices. In broadcasting it is used for transferring video signals.
CAT6	The <i>Category 6</i> cable is a standardized twisted pair cable for the Ethernet.
CCU	In broadcasting the <i>Camera Control Unit</i> is the first device after the camera in the camera signal chain. It processes the camera signal.
CTUR	In a television studio the <i>Central Technical Utility Room</i> is the location where all relevant signals utilised for broadcasting a specific programme come together.
DMX	In studio lighting <i>DMX</i> is a standard serial protocol to transmit information to dimmer packs, fog machines, moving head lights and the like. It utilises <i>XLR</i> connectors.

DoP	The <i>Director of Photography</i> takes over the technical and creative photographic direction of a production.
Embedded Audio	An audio signal which is modulated or digitally packed into a video signal.
Embedded Tally	A tally signal which is digitally packed into a video signal.
IP	The <i>Internet Protocol</i> is one of the oldest and most common way of transmitting data.
LAN	The <i>Local Area Network</i> is a connexion that links local computers and digital devices. Very often it utilises CAT6 cables and RJ45 connectors.
M/E	The <i>Mix / Effects</i> bus of a vision mixing console enables the user to create different layers of images, graphics and graphic effects.
MaNet	A proprietary network protocol by <i>MA Lighting</i> to transmit the <i>DMX</i> protocol over Ethernet.
OB Van	An <i>Outside Broadcasting Van</i> is a fully fashioned mobile television broadcasting studio.
PGM	Abbreviation for the programme signal. The final signal to leave the studio to be put on-air.

PoE	<i>Power over Ethernet</i> is a technology where not only a network signal is being transported over the eight wire CAT6 cable but also the electrical power to run the device.
Production Engineer	Chief Engineer of a TV production.
Production Manager	Head Business Manager of a TV production.
RCP	The <i>Remote Control Panel</i> is the vision engineers interface to the CCU.
PTZ	A Pan-Tilt-Zoom camera is a small remotely operated tv camera.
RJ45	The connector for the CAT6 cable.
SDI	The <i>Serial Digital Interface</i> is a standard by the <i>Society of Motion Picture and Television Engineers SMPTE</i> to transport digital video signals.
SRT	The <i>Secure Reliable Transport</i> is a video transport portocol that secures reliable streams over unpredictable networks.
SSD	The <i>Solid State Drive</i> is non-volatile silicon based data storage device.
Tally	An obligatory red coloured optical signal on cameras, monitors and wall cabinets to indicate an <i>on-air</i> state.

TC	The <i>Time Code</i> is an SMPTE recommended audio signal which is used to synchronise broadcast devices.
UHD	<i>Ultra High Definition</i> denotes the technically most sophisticated TV system currently available. It is fully described in the <i>ITU Recommendation 2020</i> .
USB	The <i>Universal Serial Bus</i> connects computers with external devices.
Vision Engineer	Works under the directive of the Production Engineer.
VSM	An IP based control and monitoring system for the distribution of signals across a broadcasting environment manufactured by <i>Lawo</i> .
XLR	A standard three or five pin connector type used for audio and DMX signals.

Disclaimer

The information herein represents an artistic concept. It does not claim to be the safest or technically best construction. During construction all applicable regulations must be observed. All dimensions are to be considered at their actual location. All data given without guarantee. We do not even claim that this paper is fit for a certain purpose.

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Alexander Törzs, Robert Gummlich, April 2021

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