Preliminary data & gap analysis of the Makassar–Parepare Railway
Authors:
Prof. Andreas Ernst, Monash University
Prof. Nyoman Pujawan, Institut Teknologi Sepuluh Nopember
Prof. Siti Malkhamah, Universitas Gadjah Mada
Dr Simon Bowly, Monash University
Dr Ira Mutiara Anjasmara, Institut Teknologi Sepuluh Nopember
Dr Tony Dwi Susanto, Institut Teknologi Sepuluh Nopember
Dr Dyah Rahmawati Hizbaron, Universitas Gadjah Mada
Dr Imam Muthohar, Universitas Gadjah Mada

Report date: June 2021

Disclaimer: This report is the result of research funded by the Australian Government through the Australia-Indonesia Centre under the PAIR program. The report was edited by the Australia-Indonesia Centre (AIC). The report is not intended to provide exhaustive coverage of the topic. The information is made available on the understanding that the AIC is not providing professional advice. While care has been taken to ensure the information in this report is accurate, we do not accept any liability for any loss arising from reliance on the information, or from any error or omission, in the report. We do not endorse any company or activity referred to in the report, and do not accept responsibility for any losses suffered in connection with any company or its activities.

PAIR:
The Partnership for Australia-Indonesia Research (PAIR), an initiative of The Australia-Indonesia Centre, is supported by the Australian Government and run in partnership with the Indonesian Ministry of Research and Technology, the Indonesian Ministry of Transport, the South Sulawesi Provincial Government and many organisations and individuals from communities and industry.

The Australia-Indonesia Centre:
The Australia-Indonesia Centre is a bilateral research consortium supported by both governments, leading universities and industry. Established in 2014, the Centre works to advance the people-to-people and institutional links between the two nations in the fields of science, technology, education, innovation and culture. We do this through a research program that tackles shared challenges, and through our outreach activities that promote greater understanding of contemporary Indonesia and strengthen bilateral research linkages.

To discover more about the Centre and its activities, please visit: ausindcentre.org

To cite this report:
This report is the result of research funded by the Australian Government through the Australia-Indonesia Centre under the PAIR program. Visit ausindcentre.org

I am delighted to share our preliminary findings from the Partnership for Australia-Indonesia Research (PAIR). PAIR is a development initiative that brings together researchers, policymakers, business and community groups to find solutions to real problems. We do this in an integrated, collaborative and evidence-based way.

PAIR is a development initiative that brings together researchers, policymakers, business and community groups to find solutions to real problems. We do this in an integrated, collaborative and evidence-based way.

We anchor our research on a segment of Indonesia’s ambitious Trans-Sulawesi railway network – the new 145-kilometre railway line connecting two major port cities: Makassar and Parepare. The railway line will provide much-needed transport for people and goods. It also stands to stimulate the local economy, boost commodities and transform communities. Yet, experience shows that investments in connectivity do not necessarily benefit local communities if they are not people-centric – that is sustainable, affordable and accessible. Businesses are unable to realise the new railway’s potential without good planning and design of infrastructure. Poor intermodal connectivity, scheduling and intervention are unlikely to encourage use. Moreover, people are likely to remain disadvantaged if they lack the knowledge needed to take advantage of the opportunities that the railway line provides.

Our research explores four areas: commodities; transport, logistics and supply chain; young people, health and wellbeing; and young people and development. We investigate what the railway lines mean for local communities, how they respond to change, and how they can take advantage of new opportunities and resources, or the skills required to thrive.

温暖的问候，

Dr Eugene Sebastian

PAIR Program Director

The Australia-Indonesia Centre
The Government of Indonesia’s new Makassar-Parepare railway line presents opportunities for South Sulawesi and Indonesia as a whole. But to make the most of this new infrastructure, more research is needed to support an evidence-based policy.

Physical issues
- There is a relatively low risk of landslides, except along a section near Parepare which has not yet been built. The flood risk appears to be high to very high in some areas near Makassar and in Maros – but we have been unable to confirm the real conditions on site.
- Most of the railway is single track, limiting the number of trains that can be run per day. Mixing slower freight trains with faster passenger services would impact on capacity, with even four freight trains daily affecting the ability to run punctual passenger services. Running more than 10 freight trains a day, to meet our demand estimates, would make it impossible.
- Mobility is a focus for the Makassar Smart City Masterplan – but this has no link to the provincial level or masterplans for other local authorities (Parepare, Barru, Pangkajene and Maros). Even at the city level, there is a lack of coordination in the planning for different transport modes. This is already causing issues, including a bottleneck for large trucks headed to the port in Makassar.

Demand
- With population density rising along the railway line, demand for public transport could increase. However, most of the areas serviced by the line are dominated by industries where freight transport is of less benefit.
- The demand for freight transport is likely to be significantly less than was assumed in the railway’s business case. We predict a maximum of 6.2 Mtpa (million tons per annum), mostly from cement transport, while the business case forecast 7.5 Mtpa. The growth predicted by 2030, to 9 Mtpa, seems difficult to achieve.
- Whatever the latent demand for freight transport, significant investment in connectivity and enabling infrastructure is required.

The Strategic Integrated Project (SIP), due to be completed in 2021 and 2022, will focus on what is needed for the railway to be used for more than just transporting cement. Passenger transport may present the highest opportunity – but rail capacity remains an issue. New services connecting passengers with railway stations are required, as is a better understanding of passengers’ needs.

Capturing container freight would require building intermodal facilities and distribution centres along the railway track, as well as modelling the cost competitiveness of rail in this context.

The SIP aims to also make a useful contribution to the development of masterplans. It will seek to show what is needed for a connected, multi-modal transport network, and help local authorities produce more comprehensive and integrated transportation system plans.

Combined with the other projects developed under the PAIR Pilot, this study will make a significant contribution to our understanding of future development needs in the region.
The Makassar-Parepare rail line passes through regions of South Sulawesi with diverse landscapes and land use. Hazard and risk analysis along the rail corridor is essential to determining the vulnerability of local people, economic sectors, and the rail infrastructure itself to natural disasters.

Our analysis in this pilot project takes the following into account:

1. Topographical mapping data along the rail line from Makassar to Parepare, to assess potential hazards due to floods and landslides (Figure 1).

2. Demographic data (Bureau of Statistics, 2020), to determine the groups most vulnerable to any potential flood or landslide hazard along the railway development area. Population distribution could also help determine potential demand for urban transport.

3. Land use data (Satellite imagery interpretation, Google Image, 2020, SPOT 5), describing the distribution of land use along the railway. This will be used to evaluate the suitability of the region for regional rail transport, and the vulnerability of local livelihoods and industry to floods and landslides.

4. Productive sector data (Location Quotient analysis, 2020), to determine the sectors which contribute most to the local economy.
1.1. METHODOLOGY

Flood and Landslide Hazard Assessments

Data used for flood and landslide hazard assessments are presented in Table 1.

Figure 2: Scoring and Weight for each parameter in defining the landslide index

Low/Medium/High landslide hazard bands are assigned to regions based on the value of the landslide index. This index is computed as a weighted sum of scores assigned to environmental and land use factors, as given in the above table.

Figure 3 Scoring and Weight for each parameter in defining the flood risk

The same process as in Figure 2 is followed for determining flood risk, however a different set of scores is used.
Figure 4: Risk map for railway infrastructure

Figure 5: Shows the inputs, outputs and process of the risk map

Figure 4 and 5 show the inputs required to produce a risk map for railway infrastructure and local areas. The risk assessment combines estimates of hazard likelihood (floods, landslides) and the vulnerability of infrastructure, local communities and the local economy to each identified hazard. Our analysis is confined to an area within 5km of the railway line development in each of the 5 districts.
1.2. ANALYSIS AND RESULTS

Our study looked at land use along a 5km buffer around the railway development, across five districts. Local people are largely of working age and likely to contribute significantly to transport demand. The next stage of our work will identify specific vulnerable groups in the region.

The rapid urbanisation of the area over the last six years correlates with high demand for urban transport and greater potential for people to move between regions.

However, the dominance of the agriculture and fisheries sectors – which arguably require less movement between regions – presents a challenge for the railway in supporting local growth.

1.3. CONCLUSION

Three factors are critical if the railway is to support regional development: demographic breakdown, land use and key regional economic sectors.

The population size across the five districts indicates potential demand for regional travel on the new railway. Demand in Makassar is likely to be highest, due to the predominance of settled and built-up land use there. Other districts are predominantly used for fisheries/agriculture.

But none of the productive economic sectors has a high mobility pattern. Getting support for the railway development from each sector, in each district, could be a challenge.

Figure 6: The Flood (top) and Landslide (bottom) Risk Assessments Results
**PART 2.0. RAIL FREIGHT DEMAND GENERATION**

When completed, the Makassar to Parepare rail line will offer a new transport mode for both passengers and freight.

Its potential is high. While less flexible than road transport, rail is better in terms of costs and emissions. In Indonesia, rail travel is also generally more punctual than road, due to poor road infrastructure and heavy traffic.

In this study we intend to predict the demand for transporting freight by rail to provide the operator with a basis for planning capacity and scheduling trips.

**2.1. RELATED LITERATURE**

Understanding demand is an important prerequisite for strategic, tactical, and operational transportation planning. Numerous studies have tried to predict the level of demand, but there is always specificity which cannot be entirely replicated or adopted under a different situation.

The literature on passenger demand generation is at a more mature stage compared to that for freight demand generation (Regan and Garrido (2002)).

There are some relevant studies (Moments et al. (2017); Havenga and Simpson (2018); Garrido and Mahmassani (2000)) but few of the available methodologies are specifically dedicated to estimating freight demand for rail transport.

**2.2. METHODOLOGY**

The demand generation in this study considers different commodities that could be transported by rail, and their geographical spread. For passengers, the estimated demand is based on the spread of population near the rail line. This study follows the following major steps, as presented in Figure 7.

1. Collect land use data to predict commodity production. Each region is divided into smaller geographic units. The agricultural production will be used partly to satisfy local consumption with the rest transported to other regions or islands. Here, the generated and attracted volume are assumed to be equal, implying that the demand both ways are the same.

2. Significant freight demand is generated by two major cement plants in South Sulawesi – Bosowa and Tonasa. Data from these companies will be collected to find out the volume estimate.

3. Data on transportation rates will be collected and used to develop cost comparisons between rail and road goods transport.

4. All of this will be used to estimate the freight demand, in terms of number of trips per day or per week.

<table>
<thead>
<tr>
<th>Land use data to predict the Commodity Production (rice etc.)</th>
<th>Number of trips per day or per week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Each region is divided into smaller geographic units</td>
<td></td>
</tr>
<tr>
<td>Generated and attracted volume is assumed to be the same</td>
<td></td>
</tr>
<tr>
<td>Data from Bosowa and Tonasa, the estimated amount that could use rail</td>
<td></td>
</tr>
<tr>
<td>The freight cost comparison between current trucking costs vs assumed rail costs</td>
<td></td>
</tr>
</tbody>
</table>

Figure 7: The outline of methodology

The data analysis in this study depends largely on some assumptions. These include:

1. Geographic region: We have restricted our study to the area around the line, bounded by 5.237473°-3.952657° S and 119.362630°-119.827756° E. (Figure 5.)

2. No intra-regional transport: The assumption that little freight will be transported between towns in the region (compared to that moved to/from ports) is partly based on a lack of data. We are particularly focused on the ports of Makassar (Makassar New Port or MNP, officially called Soekarno-Hatta Port) and Garongkong Port in the Barru Regency. The former is a primary port for Indonesia and handles nearly all containerised freight for the area. Garongkong is significant for bulk commodity import and export, particularly cement manufacture.
We do not distinguish between freight transferred to/from ships at Makassar port and freight for local delivery in Makassar, considering it the same location from the perspective of rail freight transport. This assumption may need to be revisited in future research but, without more detailed information about freight origins and destinations, it is essential for our modelling.

3. No seasonal variation: Transport demand is assumed to be spread evenly through the year. In agricultural production, harvest times are peak periods for freight demand, so this assumption will be relaxed in future. However, to better understand seasonal variation in demand, we need to know more about agri-food supply chains.

Based on the above assumptions, freight transport demand is generated for three key sectors, discussed in more detail below: agricultural production, cement production and containerised freight.

2.3. RESULTS OF DEMAND GENERATION AND ANALYSIS

Transportation distances and costs

By estimating road distances and demand data we can compare travel times and costs by truck between locations. By comparing the cost of travel to the nearest railway station with that to Makassar we can also roughly estimate the amount of transport demand that might be captured by the railway.

Road distances have been calculated using publicly available road data. Travel distances were obtained between approximately 400 origins representing farms or villages across the area and the 18 train stations planned (Figure 9).

3. Rail cost is as yet unknown but assumed to be independent of distance (fixed costs dominate rail)

4. All stations are assumed to have an IMEX (intermodal exchange) facility that allows transfer from road to rail.

Semen Tonasa reported that truck transportation costs approximately IDR 90,000 per ton. Assuming 32-ton trucks and a distance of 60km each way, a roundtrip costs around IDR 90,625 per ton.

Agricultural production

GIS land-use information provides the basis for demand estimation. It assumes that production is broadly proportional to area, but little information is available about port throughput of various commodities. Our approach is simply a way of generating a geographic spread for demand in the absence of sufficient direct data.

The GIS data has labels for land use that include the following types of agricultural production (Figure 10):

- Fishponds (Tambak),
- Rice fields (Sawah) or rainfed rice (Sawah Tadah Hujan),
- Plantation/Garden (Perkebunan/Kebun), or
- Field/Farm (Tegalan/Ladang)
This data is used as the basis for the agricultural commodity production numbers.

Some areas of land use overlap, as seen in Figure 11. However, this was not considered significant enough to warrant more systematic cleaning of data for this research.

Figure 12 shows the total productive area by type and area, with rice clearly the most significant. We can convert the area to tons based on information provided by Indonesian Bureau of Statistics. This indicates that average rice paddy productivity in South Sulawesi is about 5.0 ton/hectare (5.021 in 2018 and 5.003 in 2019). For generating alternative scenarios it may be sensible to allow a wider range of production numbers, perhaps in the range of 4.5 to 5.5 ton/ha, to allow for differences in cultivation and yield in different years, but here we consider only the 5.0 ton/ha figure.

Figure 12: Total land use by Regency

Total rice production for South Sulawesi is 5-6 million tons, of which approximately 4 million tons would be produced in the area of interest. To determine the freight demand for rice we assume that around 90 per cent of the rice harvest is transported to Makassar for export or shipment to other parts of Indonesia.

Less information is available about other crops. We rely on 2015 data that specified that in Sulawesi overall, 2.29 million tons of soybean, corn, peanuts, green beans, cassava and sweet potato were harvested (67,192; 19,024; 40,787; 565,958; and 71,681 tons respectively) over 628,148 hectares. This gives an average yield of about 3.65 ton/ha, which we use as an average value for both areas marked as Plantation/Garden (Perkebunan/Kebun) and Field/Farm (Tegalan/Ladang). We estimate that 80 per cent is sent to Makassar for sale or export.

Looking at the amount of rail freight that might be generated from areas that can be served more cheaply by rail than by road transport:

• Rice production is approximately 412,000 tons a year, with about half in areas where rail transport may be competitive.
• Approximately 195,000 tons of other crops are produced, with about 93 per cent in areas where rail may be a competitive option.

Figure 13: Capture of rice transport demand by rail as a function of cost

In total, about five trains a week would be required for moving agricultural production – but the demand captured depends strongly on the cost of rail. Figure 13 shows the amount of rice transport demand that might be captured as a function of rail costs.

---

Cement production

Available information about cement production is limited, but based on information provided by Tonasa in July 2020, we assume the following:

1. Annual production volume is 5,702,498 tons which is split into 4,335,098 tons in bags and 1,367,400 bulk.

2. 29 per cent is transported by land and 71 per cent by sea.

3. Tonasa uses two ports, a private port (Biringkassi) and Pelindo in Makassar, with a share of 80 per cent and 20 per cent respectively.

4. It is possible to switch to rail. Trucks in South Sulawesi focus mainly on shipments in the range of 180,000-200,000 tons. The rest – about 140,000-170,000 tons – is shipped to other provinces in Sulawesi. Rail is expected to be effective for longer distances and would compete with sea freight.

5. The transportation rate for a 32-ton truck is roughly IDR 90,000 per ton per shipment, but shipment to Toraja is more expensive: up to IDR 150,000 per ton.

6. Cement production for Bosowa is approximately 4,200,000 tons per annum. We assume this also uses about 70 per cent sea transport, with 80 per cent to Garongong and 20 per cent to Makassar.

We assume that the inputs are obtained from the same ports where cement is delivered, with about 20 per cent coming from Makassar. All of the above are converted both into annual throughput in millions of tons (Mtpa) and approximate number of train trips per week based on trains carrying 1,500 tons. All this leads to the estimates shown in the Table 2. Biringkassi port, which currently serves the majority of Tonasa’s demand, is not counted as it is not expected to be connected by rail, at least in the medium term.

<table>
<thead>
<tr>
<th></th>
<th>Bosowa</th>
<th>Tonasa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ports</td>
<td>Cement Trains</td>
<td>Output MTPA</td>
</tr>
<tr>
<td>Garongkong</td>
<td>30.2</td>
<td>2.35</td>
</tr>
<tr>
<td>Makassar</td>
<td>7.5</td>
<td>0.59</td>
</tr>
<tr>
<td>Biringkassi</td>
<td>41.5</td>
<td>3.24</td>
</tr>
<tr>
<td>Local Delivery</td>
<td>3.3</td>
<td>0.26</td>
</tr>
<tr>
<td>TOTAL</td>
<td>41</td>
<td>3.19</td>
</tr>
</tbody>
</table>

Table 2: Cement transport needs (in average number of trains per week or Millions of tons per annum)

Containerised freight

Estimating the containerised freight demand has been relatively difficult. The study by Idris, Asdar and Sitepu (2017) relies on data from 2014. Dewa et al (2014) predicts container loading and unloading to grow at approximately 2.98 per cent per annum for domestic transport demand, with even faster growth for export/import demand, though from a much lower base. It predicts total containerised freight going through Makassar, South Sulawesi’s only container port, to be around 1.12 million TEUs per annum (TEU = Twenty-foot equivalent units, the standard measure of containerised freight volume). This includes containers loaded and unloaded from ships.

To translate this into approximate rail requirements we make the following assumptions:

- Freight volumes are proportionate to population. This may be more appropriate for import demands than for exports, but is a reasonable starting point given that imports dominate, and in the absence of more detailed information.
- Freight is split roughly 70 per cent imports and 30 per cent exports.
- Relatively short trains with just 70TEU capacity are used to transport containers.
- None of the containerised freight to or from Makassar itself will be moved by rail, as it is not competitive over a short distance, and 80 per cent of remaining freight is captured by rail.

The rail demand, based on these assumptions, is summarised in Table 3. In practice, the number of train trips from Makassar would dominate total trip numbers, as the return trips would be a mixture of empty containers and those that have been emptied and refilled with another product, possibly at a slightly different location.

<table>
<thead>
<tr>
<th>Regencies</th>
<th>Demands in TEUs</th>
<th>Train trips per week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From Makassar</td>
<td>To Makassar</td>
</tr>
<tr>
<td>Maros</td>
<td>25,019</td>
<td>10,722</td>
</tr>
<tr>
<td>Pangkajene</td>
<td>23,772</td>
<td>10,188</td>
</tr>
<tr>
<td>Barru</td>
<td>12,350</td>
<td>5,293</td>
</tr>
<tr>
<td>Parepare</td>
<td>10,288</td>
<td>4,409</td>
</tr>
<tr>
<td>TOTAL</td>
<td>71,430</td>
<td>30,613</td>
</tr>
</tbody>
</table>

Table 3: Containerised freight demand by province
Overall, this represents only a fraction of the overall container throughput at Makassar. Many logistics companies will probably operate significant distribution centres and warehouses in or near Makassar, even when the rail line is completed – so the demand for containerised freight to other regencies may be significantly overstated.

2.5. SUMMARY AND CONCLUSIONS

Unsurprisingly, the cement industry presents the biggest potential demand for rail freight services, as moving very heavy bulk materials by rail is far more efficient than any form of road transport.

However, the rail connection to the two cement producers, Bosowa and Tonasa, is somewhat at odds with the main thrust of the north-south connection between Makassar and Parepare. And without a connection to the Biringkassi port, only a small fraction of Tonasa’s freight demand would be captured. The greatest demand would be for freight transport between Bosowa and Garongkong port, about 30 train trips a week. Another 25 trips a week may be possible if imports of raw material to the cement factories and some exports via Makassar port, plus some local cement deliveries, could use rail.

Containerised freight (at most 20 train trips per week) and agricultural exports (perhaps five trips per week, about half involving rice) are less significant. At best, the total freight annual demand is about 6.2 Mtpa (million tons per annum), mostly from cement transport. This is significantly less than the 7.5 Mtpa forecast used in the 2018 Final Business Case for the railway’s initial operations (2020 figure).

It is possible – even likely – that rail may do little beyond taking some of the cement transport off the roads. For freight rail to be competitive, significant additional infrastructure would be necessary, and freight logistics systems and supply chains redesigned. This might involve building intermodal exchange facilities at rail stations, co-locating warehousing and distribution or manufacturing facilities nearby and looking at access roads to and from stations.

Also, the overall number of freight trains out of Makassar is likely to be relatively small (fewer than 10 per day). Public transport could be the bigger user of the line, assuming at least one passenger train an hour and more during peak times.

The SIP will look at both these areas: how to make a freight system succeed, and the design of the public transport network.

2.6. REFERENCES


PART 3.0. SCHEDULING AND CAPACITY ANALYSIS

The first services on the Makassar-Parepare rail line are expected to run in late 2021. The initial focus appears to be on freight transport, with the line linking the Makassar New Port (MNP) and Port of Parepare directly with regional areas, and cement producers Tonasa and Bosowa to both export ports and the Port of Garongkong.

The line could also provide inter-regional passenger transport. While rail is not traditionally a key transport mode for the region, it is important to understand the relative capacity of this new infrastructure for movement of both freight and passengers when considering its use within a larger transport network.

We have used mathematical modelling to study the potential impact of lower-speed freight transport on the capacity of the single-track line to carry higher-speed passenger services. For full details see Appendix A.

3.2. RESULTS

Figure 14 shows the delays caused to passenger services when introducing rail freight. In the scenarios shown here, passenger services are initially spaced at a 40-minute frequency, and only minor delays are observed, resulting from stops required for passing services in opposing directions. However, including two or three freight services during the same period of time causes a delay of more than 40 minutes, significantly disrupting the target schedule.

3.3. CONCLUSIONS

As the rail line is mostly single-track, freight traffic has a significant effect on passenger services. However, there are significant limitations in the study completed to this point, from the perspective of both system modelling and algorithm design. Further work is required.

There are also additional trip types to consider, in particular the shorter freight trips between Bosowa cement factory and port of Garongkong. If these (or similar) incomplete trips on the line dominate the freight traffic, the resulting line capacity may be higher. This will depend on whether the key bottlenecks in the line are found in the central section or around the ports/city limits.

We also assume that the only possible passing points are the proposed stations. Identifying bottlenecks in the line would inform recommendations on new passing loops or double-track sections.

At this stage in the railway construction, likely train speeds, mix of trains, and passing point locations may not be final. Further consultation with stakeholders as the line nears completion may help refine the model. We do not expect this to significantly impact the scheduling results, which are largely dependent on approximate travel times between stations.
The Makassar-Parepare rail line will connect five city locations: Parepare, Barru, Pangkep, Maros and Makassar city. In this section, we explore the potential for the line to service inter-regional passenger transport in South Sulawesi, which could stimulate economic growth in the region.

To be successful, a transport system must be integrated with the other aspects of the cities’ and province’s masterplans, including residential, commercial, tourism, and green area plans. Each city and South Sulawesi province should also develop programs to attract more people, trading, and investment between the regions.

Makassar city is a pilot project under “Gerakan 100 Smart City Indonesia”, a national program launched by the Indonesian government in 2017. Every Smart City candidate must create a Smart City Masterplan covering any innovation programs, budget, and collaboration between the local authority, private organisations, universities, citizens and mass media in six dimensions: Smart Governance, Smart Branding, Smart Economy, Smart Living, Smart Society, and Smart Environment (Figure 15).

In line with the Smart City Master Program, the railway system, MNP, and the other supporting plans should be combined in each of the five cities’ Smart City Masterplans, and the South Sulawesi Smart Province Masterplan. By doing so, each local government can allocate support and funding and be better placed to request resources from the national government and city stakeholders.

This section investigates whether the five cities and the South Sulawesi province government have a Smart City Masterplan in place. If so, does it cover the railway system and other supporting programs? And if not, how could this research help the local authorities to formulate policies to support the integrated transportation system?

Figure 15: Six dimensions of Smart City in Indonesia

1. **Smart governance**
   - Service
   - Bureaucracy
   - Policy

2. **Smart branding**
   - Appearance
   - Business
   - Tourism

3. **Smart economy**
   - Transaction
   - Welfare
   - Industry

4. **Smart living**
   - Mobility
   - Health
   - Harmony

5. **Smart society**
   - Community
   - Learning
   - Security

6. **Smart environment**
   - Protection
   - Welfare
   - Energy
4.1. CURRENT ISSUES WITH THE RAILWAY AND MAKASSAR NEW PORT PROJECTS

Current issues with the railway and MNP projects suggest the plans have not been integrated with Makassar city’s masterplan, or the South Sulawesi province masterplan.

Changes to the current location of the MNP and the Makassar City Masterplan 2010-2030 (see Figure 16 and Figure 17) have some implications. Road access is poor to the modern facilities of the MNP, currently located at Sultan Abdullah Raya Road, Kaluku Bodoa village, Tallo sub-district, Makassar city. There is regular traffic congestion along the narrow 16 km road between the MNP and highway gate. Container trucks (20’ and 40’) must go through traffic lights, densely populated houses, Beroangin cemetery, and Pannampu market.

The MNP project has sparked protests among local fishermen. They complain of reduced fish catches and job losses, and say the MNP sand mining causes murky water and abrasion. Residents, meanwhile, are seeking land compensation for the railway project.

To mitigate the negative impact and improve the potential success of the projects, the five cities and South Sulawesi province need comprehensive and integrated Smart City Masterplans.

4.3. ANALYSIS AND RESULTS

Our research involved online document searches, interviews with two officials of the Department of Communication and Informatics – Makassar city and South Sulawesi province via phone/WhatsApp, and a webinar about the e-government masterplan and Smart City Masterplan.

Of the five cities and South Sulawesi province, Makassar is the only city with a Smart City Masterplan (Figure 18). South Sulawesi has neither a Smart Province Masterplan nor an e-government masterplan.

Makassar’s Smart City Masterplan prioritises the transport system and the mobility of people and goods. The plan for integration of transportation systems is included at strategy and program level (Figure 19 and Table 4 and 5). However, we cannot find any Department-level programs relating to the port, railway, or integration of the people and logistics mobility modes in Makassar city (Tables 6 and 7).
# Action Plan: Makassar City For All

<table>
<thead>
<tr>
<th>Development goals</th>
<th>Policies and Institutions</th>
<th>Infrastructure</th>
<th>Applications and Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1. Integrating regional spatial planning with the surrounding area</td>
<td>a. Strategic business centre development</td>
<td>j. Environmental Sensor Network to improve safety, energy efficiency and other functions</td>
<td>m. Smart Open Space</td>
</tr>
<tr>
<td></td>
<td>b. Modelling urban land use, transport and economic interactions</td>
<td>k. Smart Green Open Space</td>
<td>n. Spatial planning and surveillance systems</td>
</tr>
<tr>
<td>1.2. Build a high quality health care system</td>
<td>c. Encouraging service quality and hospital operational standards</td>
<td>l. Smart Building Management System</td>
<td>o. City asset management</td>
</tr>
<tr>
<td>1.3. Build an intelligent intermodal integration transportation system</td>
<td>d. Access to high quality health services</td>
<td>m. Access Control Integrated System</td>
<td>p. Home care (Provincial Health Office)</td>
</tr>
<tr>
<td></td>
<td>e. Application of smart transportation systems</td>
<td>n. ICT Based Solution Building</td>
<td>q. Fast Emergency Room (Provincial Health Office)</td>
</tr>
<tr>
<td></td>
<td>f. Streamlining the flow of goods and services</td>
<td>o. Healthcare and online education, remote products and services for access to health and education</td>
<td>r. Man Centre, strategies for managing erectile dysfunction (Provincial Health Office)</td>
</tr>
<tr>
<td></td>
<td>g. Modelling network performance, mobility and travel behaviour</td>
<td>p. Medical and hospital equipment</td>
<td>s. Family Planning Hallway</td>
</tr>
<tr>
<td></td>
<td>h. Reducing private transportation</td>
<td>q. Insurance company</td>
<td>t. E-Nassami</td>
</tr>
<tr>
<td></td>
<td>i. Increasing public transportation</td>
<td>r. Transportation Management System</td>
<td>u. Smart traffic light</td>
</tr>
<tr>
<td></td>
<td></td>
<td>s. Intelligent Transport System</td>
<td>v. Lancarma</td>
</tr>
</tbody>
</table>
**Table 5: Makassar Smart City Programs**

<table>
<thead>
<tr>
<th>Comfortable City For All</th>
<th>Policies and Institution</th>
<th>Infrastructure</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quick Win</strong></td>
<td>a) Strategic business center development</td>
<td>a) Smart green open space (RTH)</td>
<td>a) Smart green open space</td>
</tr>
<tr>
<td>2018</td>
<td>b) Modeling of interactions between urban land use, transportation and the economy</td>
<td>b) Integrated access control system</td>
<td>b) Spatial planning and surveillance systems</td>
</tr>
<tr>
<td></td>
<td>c) Encouraging the improvement of service quality and hospital service operational standards.</td>
<td>c) Building based information and communication technology solutions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d) Compilation of an integrated transportation system management</td>
<td>d) Insurance company</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>e) Advanced traffic management</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>f) Alleyways</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>g) Additional area of green open space</td>
<td></td>
</tr>
<tr>
<td><strong>Short term</strong></td>
<td></td>
<td>h) Environmental sensor network</td>
<td></td>
</tr>
<tr>
<td>2018 – 2019</td>
<td></td>
<td>i) Online health and education services, remote products and services for access to health and education</td>
<td></td>
</tr>
<tr>
<td></td>
<td>e) Modeling network performance, mobility and travel behavior</td>
<td>j) Smart transportation system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>f) Reduction in the number of private vehicles</td>
<td>k) Provision of sufficient parking space</td>
<td></td>
</tr>
<tr>
<td></td>
<td>g) Reduction of the number of vehicles on main roads</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>h) Increasing public transportation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>i) Access to high quality health services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>j) Streamlining the flow of goods and services movement</td>
<td>l) Smart building management system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>k) Application of a smart transportation system</td>
<td>m) Medical and hospital equipment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>n) Passenger information system</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>o) Integrated asset management</td>
<td></td>
</tr>
<tr>
<td><strong>Medium term</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018 – 2023</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Long term</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018 – 2028</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Table 6: Department of Public Work Service’s Programs

<table>
<thead>
<tr>
<th>Work Program</th>
<th>Street Sweep Hole Movement (Gerakan Sapu Lubang)</th>
<th>Drinking Water</th>
<th>Towards 0% Inundation</th>
<th>Smart PJU</th>
<th>Application for monitoring and replacement of spare parts</th>
<th>Pangasseng Card</th>
<th>Monitoring application</th>
<th>Movement of 10,000 Certified Craftsmen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Potholes are handled within 3x24 hours, monitoring of damaged roads in real time, preparing clean water in each corridor, preparing clean water on all islands in Makassar city</td>
<td>• Clean Drainage Movement</td>
<td>• Real time monitoring of inundation points, use of LED street lights</td>
<td>To find out the identity of the public works supervisor</td>
<td>To find out in real-time the activities of the supervision of the public works office</td>
<td>Gather all data of craftsmen to be recorded</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Target</td>
<td>Convenience in traffic</td>
<td>The construction of a ready-to-drink water network</td>
<td>There is no inundation on the reader</td>
<td>Energy saving</td>
<td>Reduction of greenhouse gases</td>
<td>Database</td>
<td>Certifying craftsmen according to their expertise</td>
<td></td>
</tr>
<tr>
<td>Success Indicator</td>
<td>Potholes fixed within 3x24 hours</td>
<td>Each hallway and island, 1 drinking water</td>
<td>Handles inundation within 1 hour after rain</td>
<td>• Decreased payment of Public Street Lighting bills by 50%</td>
<td>Ability to function within 1x24 hours</td>
<td>All supervisors can use google drive to save 500 sheets or (1) ream of paper</td>
<td>Monitoring of the public works service 24 hours a day</td>
<td>10,000 Certified Craftsmen</td>
</tr>
<tr>
<td>Proposed budget</td>
<td>Regional Expenditure Budget (APBD)</td>
<td>APBD</td>
<td>APBD</td>
<td>APBD</td>
<td>APBD</td>
<td>APBD</td>
<td>APBD</td>
<td></td>
</tr>
<tr>
<td>Implementer</td>
<td>Public works office</td>
<td>Public works office</td>
<td>Public works office</td>
<td>Public works office</td>
<td>Public works office</td>
<td>Public works office</td>
<td>Public works office</td>
<td></td>
</tr>
<tr>
<td>Cooperation</td>
<td>Construction service center</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timeline</td>
<td>1 Year</td>
<td>1 Year</td>
<td>1 Year</td>
<td>1 Year</td>
<td>1 Year</td>
<td>1 Year</td>
<td>1 Year</td>
<td></td>
</tr>
</tbody>
</table>
Table 7: Department of Transportation’s Programs

| Makassar City Transportation Office | Public transportation users | The creation of a transportation system that is comfortable, effective and efficient An icon of public transportation that is expected to become an idol of the community as a safe, orderly, comfortable, integrated and sustainable public transportation Smart card one day one ticket one route | Transportation office |

| PETE-PETE SMART | Reducing traffic jams | Public transportation users | The creation of a transportation system that is comfortable, effective and efficient An icon of public transportation that is expected to become an idol of the community as a safe, orderly, comfortable, integrated and sustainable public transportation Smart card one day one ticket one route | Transportation office |

| PASIKOLA (public mini buses) | Reducing traffic jams | Public transportation users | The creation of a transportation system that is comfortable, effective and efficient An icon of public transportation that is expected to become an idol of the community as a safe, orderly, comfortable, integrated and sustainable public transportation Smart card one day one ticket one route | Transportation office |

| E-NASSAMI | Smart system used via android to determine mini buses movements | Parents of students Within Makassar City | Minibuses specifically transport students, scheduled with air conditioning facilities, drinking water, reading materials, trash bins and others Mini buses are guaranteed for the safety and security of students Supported by skilled and capable drivers | DISHUB |

| Transport officers visit schools | The transportation officers regularly visit schools and becomes supervisors, providing guidance on safe, secure, orderly, and smooth urban transportation. Promote the importance of safe, safe, comfortable and affordable transportation Appeals not to use motorbikes by students to school | Students Within Makassar City | Reliable and guaranteed on time to go home from school | DISHUB |

| Parents of students | Parents of students can monitor the movements of their children carried by mini buses Reliable and guaranteed on time to go home from school | DISHUB |

| Technical agency | Understanding the importance of roadworthiness for drivers and vehicles Minimising traffic accidents | DISHUB |

Parepare is also claimed as a smart city/regency. However, the only representation of this is the “Pretty”, a single web portal for public services and government administration systems (35 websites and 25 applications) at pareparekota.go.id (Figure 20).

For the railway to be a success, the five cities and South Sulawesi province must collaborate on a single comprehensive and integrated Smart City Masterplan that covers transportation infrastructure and everything that supports the mobility of people and goods. This will include innovation programs in economy, tourism, city area, environment, society and government services. With a Smart City Masterplan, the local authority will be able to allocate funding for city programs and find it easier to get support from central government and other city stakeholders.

While Makassar city has a Smart City Masterplan, it has not taken into account the port, railway, or integration of the people and logistic mobility modes in the city.

We plan to hold workshops for all local authorities involved, to motivate and facilitate them to create a comprehensive and integrated city/province masterplan, including one for the transportation system.

4.4. CONCLUSION AND NEXT RESEARCH ACTIVITIES

For the railway to be a success, the five cities and South Sulawesi province must collaborate on a single comprehensive and integrated Smart City Masterplan that covers transportation infrastructure and everything that supports the mobility of people and goods. This will include innovation programs in economy, tourism, city area, environment, society and government services. With a Smart City Masterplan, the local authority will be able to allocate funding for city programs and find it easier to get support from central government and other city stakeholders.

While Makassar city has a Smart City Masterplan, it has not taken into account the port, railway, or integration of the people and logistic mobility modes in the city.

We plan to hold workshops for all local authorities involved, to motivate and facilitate them to create a comprehensive and integrated city/province masterplan, including one for the transportation system.
APPENDIX A

Single-Track Scheduling

In the pilot project we have focused on the use of mixed-integer linear programming (MILP) models for the single-track rail scheduling problem as a method to estimate the capacity of the Makassar-Parepare rail line. In particular, we aim to understand the potential impact of lower-speed freight transport on the capacity of the line to carry higher-speed passenger services.

The limiting factor in operation of a single-track rail line is the number and location of possible passing points for train services. In this case we have assumed the planned station locations are the only possible passing points. The use of single-track sections and passing points by train services is modelled using a scheduling formulation, which captures the key requirement that a single-track segment can only be in use by one service at a time.

We further assume that the segment use is exclusive; headway requirements for all train services dictate that a train does not enter a single-track segment until the leading or passing train has left the segment. The alternative (timed headway) is generally only used in extreme long-haul freight transport so is unlikely to be applicable here. There is flexibility in this modelling approach to reduce required headway by allowing for more passing points on the line. Future modelling may address the question of the ideal locations to place additional passing loops or double track segments in the current design.

The following sections outline the basic model classes used to solve scheduling problems as applicable to single track rail. The formulations are intended to provide a rigorous description of the line scheduling requirements, document background research so far and will form the basis of further investigations carried out in the SIP. We have investigated multiple mathematical formulations of the single-track rail problem. This is necessary as different formulations offer different advantages, both in terms of their computational tractability and their ability to integrate other realistic constraints of the system. In particular while the sequencing variant (known as MISLP) provides the most “natural” description of the problem, it is known to be computationally challenging even at small scales.

Mixed Integer Sequencing Linear Program (MISLP)

The MISLP formulation mixes binary and continuous variables to explicitly capture both the time at which trains enter particular segments of track and the order in which different trains occupy each segment. This allows linear constraints to be used both to specify exclusive use of each segment, and to specify arbitrary constraints on arrival and departure times of particular services.

Various simplifications can be used where multi-track sections are explicitly or implicitly required. The problem is constructed using the concepts of disjunctive and alternative graphs, which requires linking binary sequencing variables to continuous time variables. The necessary disjunctive linear constraints are formulated using big-M constraint methods which can lead to numerical conditioning issues.

All formulations of this type have the following variables and constraints in common. Given a train \( i \) and track segment \( k \) which it must traverse, let

- \( s_{ik} \) be a continuous variable representing the time at which train \( i \) enters segment \( k \),
- \( \sigma_{ik} \) be the segment following segment \( k \) in the journey of train \( i \), and
- \( p_{ik} \) be the minimum time required for train \( i \) to traverse section \( k \).

Then the precedence constraint

\[ s_{ik} + p_{ik} \leq s_{i\sigma_{ik}} \]

handles the fixed sequence of track sections in the trip.

An MISLP model additionally requires sequencing constraints to model exclusive use of track sections. These take the form of linear disjunctions in one of the forms described below.
Non-blocking Schedule

This formulation considers only the single-track sections on the line and assumes passing points have infinite capacity. Given any pair of trains i and j which must both traverse the single-track section k, the linear disjunction:

\((s_{jk} \geq s_{ik} + p_{jk}) \vee (s_{jk} \geq s_{jk} + p_{jk})\)

does not explicitly modelled. Two trains travelling in opposite directions cannot pass one another, since the leading train i must enter section \(d_{ij}\) before the following train j can enter section k. Passing requires the introduction of additional track sections which don’t adhere to blocking, or sections otherwise with capacity greater than one.

Binary Programming - Occupancy Models

Binary occupancy models provide an alternative to sequencing formulations, where the scheduling window is discretised into small time intervals. Binary variables are used to represent whether a given service uses a given track segment at a given time. The resulting problem structure is computationally easier to handle, however the tradeoff is an explosion in problem size.

Define the following sets:
- the set of all rail trips \(R\)
- the set of all time intervals \(T\)
- the set of all track segments \(S\)
- the set of all time periods \(T_{r}\)

Define the following functions:
- the set of all time periods \(T_{r}\)
- the number of time periods \(S_{r}\)
- the required time \(t_{r}\)

Define the following binary variables:
- \(x_{r}\)
- \(y_{r}\)

The objective function is given as a function of the occupancy variables \(x\)

\[
\min \sum_{r \in R} \sum_{t \in T_{r}} \sum_{i \in I} c_{r}^{i} x_{r}^{i}\]

In order to minimise the total makespan one possibility is to set \(c_{r}^{i} = t\) for all \((r,i,t)\) where i is the final stop of train r and 0 otherwise.

In general the BIOP model is expected to be more computationally feasible than MISLP despite the increase problem size. However this is highly dependent on granularity; so far in practice both formulations are computationally challenging to solve exactly even at fairly small scales.

Capacity Analysis

The scheduling models described in the previous section can be adapted for capacity analysis by solving scenarios with different mixes of freight and passenger services. The base scenario generates a schedule with 10 passenger services running the full length of the line in each direction. Services are initially spaced by 20 minutes. The optimisation model aims to minimise total makespan, producing a feasible schedule which reduces the total time of trains spent in service.
To estimate the impact of slower freight services on passenger service frequency, freight trains are introduced into the schedule. Multiple scenarios were run with 0-4 freight services introduced in each direction. All services run the full length of the line. The completion time of the last passenger service is recorded (noted as the passenger makespan) in order to estimate the best possible service frequency for the scenario.

Table 8 gives the segment travel times used in the model, based on the planned station locations on the line. Train speeds are assumed to be 60km/h for passenger services and 40km/h for freight services (average speed including stops; actual track speed may be higher).

The scheduling model scenarios are formulated as non-blocking MISLPS, gives the results of these scenarios as solved using the Gurobi optimiser with a 20-minute time limit. Only the no-freight scenarios in general are solved within the time limit for this model; other models stall with a 5-10% gap to optimality. A core component of work on the SIP will be to improve solve times by implementing higher performance scheduling algorithms via heuristic and decomposition methods.

Figure 23 shows the effect of including freight trains on the service completion time for passenger services. Note that the models solved here are not solved to optimality, and improvements of up to 12% may still be possible with improved solution methods (according to the MIP gaps listed in Table 9). In general this result shows that attempting to schedule 5 freight services on the line can result in approximately a 20% reduction in passenger service frequency.

Figure 24 shows the delays caused to passenger services when introducing rail freight. In the scenarios shown here, passenger services are initially spaced at a 40-minute frequency, and only minor delays are observed, resulting from stops required for passing services in opposing directions. However, including two or three freight services during the same period of time causes a delay of more than 40 minutes, significantly disrupting the target schedule.
Program Management Team:

Dr Eugene Sebastian, PAIR Program Director
Helen Fletcher-Kennedy, AIC Chief Operating Officer
Dr Leonardo Pegoraro, PAIR Program Manager
Dr Hasnawati Saleh, PAIR Research Coordinator
Dr Martijn van der Kamp, PAIR Team Capability Coordinator
Marlene Millott, PAIR Program Officer
Fadhilah Trya Wulandari, PAIR Program Officer

Research Advisory Panel:

Alison Duncan, Minister-Counsellor (Economic, Investment and Infrastructure), Australian Embassy, Jakarta
Professor Budu, the South Sulawesi Provincial Government’s Development Acceleration Team (TGUPP)
Bronwyn Robbins, Australian Consul General in Makassar
Dr Elan Satriawan, Chief of Policy Working Group, National Team for the Acceleration of Poverty Reduction (TNP2K)
Dr(HC) Erna Witoelar, Former UN Special Ambassador for Millennium Development Goals (MDGs) in the Asia Pacific

Dr Eugene Sebastian, Executive Director, The Australia-Indonesia Centre
Dr Hasnawati Saleh, PAIR Research Coordinator, The Australia-Indonesia Centre
Professor Heri Hermansyah, Acting Director of Research and Community Engagement, Ministry of Research and Technology, Republic of Indonesia
Dr Ishak Salim, Co-Founder Indonesian Diffable Movement for Equality
Professor Jamaluddin Jompa, Advisor for Marine Ecology at the RI Ministry of Maritime Affairs and Fisheries
Jana Hertz, Team Leader at the Knowledge Sector Initiative
Muhammad Sani Azis, Regional Coordinator (South Sulawesi), Indonesian Seaweed Association (ARLI)
Dr Musdhailah Machmud, Deputy Minister for Food and Agriculture, RI Coordinating Ministry for Economic Affairs
Prakosa Hadi Takariyanto, Technical Director PT Pelabuhan Indonesia IV (Persero)
Pratiwi Hamdhan, Founder and Managing Director, Tenoon, Driver Engagement, Gojek Makassar

Professor Wihana Kirana Jaya, Special Staff to the RI Minister for Economic Affairs and Transportation Investment, Ministry of Transportation

Acknowledgements

The Australia-Indonesia Centre (AIC) acknowledges the Australian Government for its generous support of the Partnership for Australia-Indonesia Research (PAIR) through the Department of Foreign Affairs and Trade. The AIC also gratefully acknowledges the Government of Indonesia’s support for PAIR through its Ministry of Research and Technology. We also extend our gratitude for the support we receive from the following organisations:

Government of South Sulawesi
Ministry of Research and Technology / National Research and Innovation Agency RI
Ministry of Transport RI
Agence for Planning, Research and Development (BAPPELITBANGDA) South Sulawesi

Government of South Sulawesi
Transportation Office

Governor’s Team for the Development Acceleration (TGUPP) South Sulawesi

Government of Makassar City

Government of Maros District
Government of Pangkep District
Government of Barru District
Government of Parepare Municipality

PT Pelindo IV
Makassar New Port (MNP)

Regional Railroad Engineering Agency for Eastern Java
South Sulawesi Train Development Authority

PT Celebes Railway Indonesia

PT Semen Tonasa
PT Semen Bosowa